United States
Department of
Agriculture

Forest Service

Timber Management

Washington, DC

Proceedings of the National Silviculture Workshop

Silviculture for All Resources

Sacramento, California
May 11-14, 1987

Acknowledgement

The 1987 National Silviculture Workshop was held in Sacramento, California, and the Eldorado National Forest. The purpose of the workshop was to discuss, review, and share information and experiences regarding how silviculture can serve as the tool to help accomplish the objectives of many resources.

The Washington Office Silviculture Group appreciates the efforts of our hosts from the Eldorado National Forest, Blodgett Experimental Forest, and the Pacific Southwest Regional Staff. We also extend our thanks to all who made presentations and participated during the session.

Silviculture Group
Timber Management Staff
Washington, D.C.

United States
Department of
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March 1989

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Bob Naumann, R.O.
P Jim Chew, R.O.
P Chris Reichert, Kootenai NF
John Hughes, R.O.

R-2

Gary Metcalf, R.O.
Don Foth, R.O.
Dave Stark, White River NF
P Willy Wisler, Black Hills NF
Mike Smith, Shoshone NF
P Melanie Malespin Woolever, R.O.
P Herb Mittmann

R-3

P Dick Bassett, R.O.
Bruce Greco, Coconino NF
Dayle Bennett, R.O.
Charlie Bechtel, Kaibab NF
Regis Cassidy, Kaibab NF
John Shafer, Apache-Sitgreaves NF

R-4

P Mike Ware, Payette NF
Phil Straub, Boise NF
P Elizabeth McGraw, Toiyabe NF
Doug Eggers, Bridger-Teton NF
Tom Haggen, R.O.
Dee Session, Toiyabe NF
George Roether, R.O.
P Al Ashton, Sawtooth NF
Jerry Hamilton, R.O.
David Winn, R.O.
Ron Hamilton, R.O.

R-5

Al Wright, Angeles NF
Rex Baumback, Eldorado NF
Dave Thomas, Eldorado NF
Jim Benson, Klamath NF
P Ernie Del Rio, Klamath NF
Ken Estes, Lassen NF
Marlin Johnson, Lassen NF
Skip Kowalski, Lassen NF
Dave Schreiner, Los Padres NF
Mike Walsh, Mendocino NF
Jim Harvey, Mendocino NF
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Dick Castaldini, Plumas NF
P Tom Ratcliff, Plumas NF
Bob Rogers, Sequoia NF
John Stewart, Sequoia NF
George Lottritz, Six Rivers NF
Larry Cabodi, Six Rivers NF
Terry Brumley, Shasta-Trinity NF
Lance Thornton, Shasta-Trinity NF
Gary Thompson, Sierra NF
Ken Sonksen, Sierra NF
Aileen Palmer, Stanislaus NF
Mike Rutty, Stanislaus NF
Joe Sherlock, Stanislaus NF
Dick Lund, Stanislaus NF
Bill Knispek, Tahoe NF
Phil Aune, Tahoe NF
Steve Weaver, Tahoe NF
Karen Jones, Tahoe NF
John Babin, Tahoe NF
Ed Matthews, Tahoe NF
Jim Schellenger, LTBMU
P Ken Denton, R.O.
Will Charter, R.O.
P Ray Weinmann, R.O.
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Mike Srago, R.O.
John Fiske, R.O.
Susan Matthews, R.O.
John Neisess, R.O.
John Borecco, R.O

<u>WORKSHOP ATTENDEES</u> cont'd

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	Ralph Jaszkowski, R.O.
	Don Connett, R.O.
P	Tom Turpin, Siuslaw NF
P	John Nesbitt, Fremont NF
P	Mike Znerold, Deschutes NF
P	Rob MacWhorter, Deschutes NF
P	Gaston Porterie, Umqua NF
	Wendall Jones, R.O.
P	Bill Terrill, Okanogan NF
	Dick Pedderson, R.O.
P	Tom Ortman, R.O.
	Ernie Meisenheimer, Olympic NF

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P	Roger Dennington, R.O.
	Robert Kitchens, R.O.
P	Edith Petrick, NF's in Florida
P	Marc Rounsaville, Sumter NF

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P	Mike Lanasa, Hiawatha NF
	John Murphy, R.O.
	Bob Blomquist, R.O.

R-10

	John Standerwick, R.O.
	Duane Fisher, Tongass-Ketchikan
	Bruce Wilson, R.O.
	Joe Rozich, Tongass-Stikine
	Dave Gibbons, R.O.

WO

P	Al West, S&PF
P	Dick Fitzgerald, TM
P	Dick Miller, TM
P	Dennis Murphy, TM
P	Dick Shaffer, TM
P	Dan Schroeder, TM
	Mark Delfs, TM
	Chris Holmes, CF
P	Dave Hessel, TM
	Hugh Black, WL&F
P	Nelson Loftus, TMR

BLM

P	Chris Maser

RESEARCH

P	Melinda Moeur, INT
P	Pete Owston, PNW
	Nancy Tilghman, PSW
P	Tom Ledig, PSW
P	Russell Graham, INT
P	Richard Lancia,NC
P	Mike Lennartz, SE
	Jim Lotan, INT
P	Fred Everest, PNW
P	Wayne Shepperd, RM
P	Glen Crouch, RM
	Bob Alexander, RM
P	Steve Shifley, NC
	Enoch Bell, PSW
	Ron Stewart, PSW
P	Dave Marquis, NE
	Dick Krebill, INT

FINAL AGENDA
1987 NATIONAL SILVICULTURE WORKSHOP
SACRAMENTO, CALIFORNIA
MAY 11-14, 1987

THEME: Silviculture For All Resources

PURPOSE: Discuss how silviculture can be the tool to help accomplish the objectives of many resources. Representatives of many Regions and Stations will present examples and experiences, with the emphasis on resources other than timber management.

Monday - May 11 (Indoors)

Moderator - Bruce Wilson, TM, R-10, (p.m.)

1 p.m.	Call to order	Dick Fitzgerald, WO
	Welcome and background on R-5	Zane Smith, Regional Forester, R-5
		Ray Weimann, Timber Director, R-5
	House Rules and Announcements	Ken Denton, Silviculture, R-5
	Purpose and Objectives of Meeting	Dick Fitzgerald, WO
2 p.m.	National Timber Management Issues	Dave Hessel Timber Director, WO
2:30 p.m.	Nursery and Tree Improvement Update	Dick Miller, WO
2:50 p.m.	Silvicultural Continuing Education Update	Dennis Murphy, WO
3:10 p.m.	Reforestation and TSI Update	Dick Shaffer, WO
3:30 p.m.	Break	

Technical Session - Silviculture for all Resources

Wildlife Emphasis

3:50 p.m.	Silviculture to Improve Big Game Habitat	Mike Smith, R-2 Melanie Malespin, R-2
4:20 p.m.	Timber Sale Design for Long-term Wildlife Habitat	Elizabeth McGraw, R-4
4:40 p.m.	Northern White Cedar Management and Whitetail Deer Habitat	Mike Lanasa, R-9

Tuesday - May 12 (Indoors)

Moderator - Hugh Black, WO, WL&F (a.m.)

Wildlife Emphasis (cont.)

8 a.m.	ID Development of Caribou Habitat (Role of the Silviculturist)	Art Zack, R-1
8:30 a.m.	Silviculture for Grizzly Bears	Chris Reichart, R-1
9 a.m.	Update on the Spotted Owl Situation in R-5 and R-6	Tom Ortman, R-6
9:30 a.m.	Sample Spotted Owl Stands	Tom Radcliff, R-5
9:50 a.m.	Break	
10:10 a.m.	Managing Ponderosa Pine for Bald Eagle Nesting	Rob McWhorter, R-6
10:40 a.m.	Management of Endangered Species, Creative Silviculture for Redcockaded Woodpecker	Mike Lennartz, SE Richard Lancia, NC State
11 a.m.	Woodpecker, Recreationists, and Lumbermen, Cheer Success of Artificial Regeneration in Longleaf Pine.	Marc Rounsaville, R-8
11:20 a.m.	Goal of Second Growth Silviculture in Riparian Zones for Fish Management	Fred Everest, PNW Dave Gibbons, R-10
11:50 a.m.	Linking Timber Management and Wildlife Cover Models	Steve Shifley, NC

12:10	Lunch 3	

Moderator - Don Foth, TM, R-2

Wildlife Emphasis (Cont.)

1:10 p.m.	Predicting Cover, Shrubs, and Relationships Between Stands for Evaluating Multi-Resource Silviculture	Melinda Moeur, INT
1:30 p.m.	Silviculture of Mixed Hardwoods for Wildlife and Other Resources in the Alleghenies	Dave Marquis, NE

Other Resource Emphasis

2 p.m.	Stocking Charts and their use for non-timber Management Objectives.	Dick Fitzgerald, WO Nelson Loftus, TMR, WO
2:30 p.m.	Successful Silvicultural Operations w/o Herbicides in a Multiple-use Environment	Tom Turpin, R-6
3 p.m.	Break	
3:20 p.m.	Coordinating Reforestation and Livestock Grazing	William Terrill, R-6
3:50 p.m.	Establishing a Resource Base for Multi-Research Management of Aspen in the Central Rocky Mountains	Glenn Crouch, RM Wayne Shepperd, RM
4:10 p.m.	Urban Interfaces/Local Government	Panel

Wednesday - May 13 (Outdoors)

7 a.m.-5 p.m. Field trip to Georgetown RD of Eldorado NF and Blodgett Experimental Forest (University of California).

7 p.m. Banquet - Holiday Inn ($16-$18)

Speaker: Tom Ledig, Pacific Southwest Research Station.
"Biotechnology: New Tools in Forestry"

Other Resources Emphasis (Cont.)

Thursday - May 14 (Indoors)

Moderator - Bobby Kitchens, TM, R-8

8 a.m.	Controlling Titi Encroachment in Florida	Edie Petrick, R-8
8:30 a.m.	Management for Non-Industrial Private Lands in the South	Roger Dennington, R-8

Recreation Emphasis

9 a.m.	Silviculture to Enhance Recreational Values in the Sawtooth NRA	Allan Ashton, R-4
9:20 a.m.	Silvicultural Prescriptions for VRM	Herb Mittmann, R-2
9:50 a.m.	Visual Management Plans	Ken Sonksen, R-5 Gary Thompson, R-5
10:20 a.m.	Break	
10:40 a.m.	Value of Silviculture for Ski Area Management	Dave Stark, R-2 Mike Ware, R-2

Silvicultural Operations

11:10 a.m.	Coordination of Forest Pest Actions on Forest Lands	Al West, Deputy Chief, S&PF, WO
11:40 p.m.	Using the HP 71 B for Stand Exams	Dick Bassett, R-3
12 noon	Lunch	

Silvicultural Operations (Cont.)

Moderator - Will Charter, TM, R-5

1 p.m.	Making Silvicultural Expertise Available	Jim Chew, R-1
1:30 p.m.	Expert Systems for Aspen Trunk Rot	Dan Schroeder WO-TM
1:50 p.m.	Multi-story Management of Ponderosa Pine	Mike Znerold, R-6

2:20 p.m.	Research on Unevenaged Management in the Central Rocky Mountain	Russ Graham, INT
2:50 p.m.	Break	
3:10 p.m.	Forest Residues	Chris Maser, BLM
3:40 p.m.	Reforestation Improvement Project	Dick Miller, WO-TM Pete Owston, PNW
4:10 p.m.	Risk Management in Reforestation	John Nesbitt, R-6
4:30 p.m.	Stewardship Contracting	Gaston Porterie, R-6 Ernie del Rio, R-5
5:00 p.m.	Wrap-up and Adjourn	Dick Fitzgerald

SILVICULTURE AND WILDLIFE

by

Melanie Malespin Woolever
Wildlife Habitat Relationships Coordinator
Regional Office, R-2

Mike Smith
District Silviculturist
Wind River RD-Shoshone NF

The Rocky Mountain Region is actively using silviculture to meet wildlife standards and guidelines for implementation of Forest Plans. We are in a unique position in Region 2 in that all of our Forest Plans are complete and we are now in the implementation phase of the process. All Forest Plans in the Region have uniform standards and guidelines for management of wildlife habitat at specific levels of potential. The following tool enables resource managers to address and achieve those standards and guidelines. Our presentation will consist of two parts. The first will be an overview of the process and the second will be a description of how that process was used for the Wolf Creek Sale on the Shoshone National Forest.

The process consists of two models which can be used independently or linked for large scale Plan implementation or for project planning at the Forest and District level. The first of the two models is a habitat capability model (R2HABCAP) which roughly automates the process described in Managing Forested Lands for Wildlife (Hoover and Wills, eds. 1984). It allows for vegetation cover type and structure to be expressed as the number of animals an area will support. The second (R2FSSIM) is a model which simulates the change in vegetation over time under alternative forms of treatment or as a result of succession.

Habitat capability models for sixty wildlife species are documented in Managing Forested Lands for Wildlife. The book was a cooperative effort between the Colorrdo Division of Wildlife and the USDA Forest Service. The purpose of that book was primarily to be "proactive." In the past, biologists within the Forest Service have been predominately reactive to all the other uses of the forests. They responded to Allotment Management Plans, Timber Sale Plans and so on. A tool was needed that would allow for design and scheduling of silvicultural prescriptions specifically to emphasize wildlife that would display the result of treatment as a quantitative value.

Information from two types of matrices in Chapter 3 is used to calculate habitat capability. The first defines maximum densities under optimum habitat conditions. The second models nine structural stages of vegetation succession: grass-forb, shrub-sapling, poles and mature trees with low, moderate and high canopy closures and old growth. Habitat capability coefficients of 1, 2 or 5 are assigned to each structural stage in each vegetation tupe for feeding and cover value provided to the described specie. A 1 indicates optimum, 2 is half as good and 5 is one-fifth as good. For example, it would take twice as many acres rated a 2 to provide the same value as one acre with a 1 rating.

Habitat capability coefficients for acres of each each structural stage by cover type are combined into a mean feeding and mean cover value. The mean feeding and cover values are then combined to result in an overall habitat capability index which ranges from 0 to 1.0. That value can then be translated to the number of animals that an area can support. The process is more thoroughly discussed in Managing Forested Lands for Wildlife.

The R2FSSIM simulates changes in habitat over time, based upon management specifications and succession rates. Initial conditions are classified by cover type, structural stage and suitability. Management controls and constraints from the Forest Plan are then applied to those suitable acres. In this manner guidelines for such things as old growth and opening size are met. The final acreages available for treatment are then input to the model. In this manner, vegetation structure can be tracked through time, with or without treatment activities. Through the use of this process, the composition of structural stages can be designed to achieve wildlife habitat capability goals and objectives specified in the Forest Plan over time, whether they be for elk or pine grosbeak.

WOLF CREEK HABITAT ANALYSIS
MANAGING FORESTED LANDS FOR WILDLIFE

In April, 1985, the Wind River District SHOSHONE NATIONAL FOREST used the Habitat Capability Model (described in Chapters 7 and 8 of Managing Forested Lands for Wildlife) to analyze wildlife habitat in the Wolf Creek area.

Wolf Creek is essentially a 3500 acre roadless area dominated by mature Engelmann spruce-Subalpine fir forest. The Shoshone National Forest Plan scheduled 1500 acres of timber harvest in this area for 1987. Issues raised by the proposed timber harvest and associated road construction included:

1. The concern that increased general public access would change the nature and use of the area.

2. The proposed timber harvest would damage the character of the surrounding Wilderness Study Unit.

3. Timber harvest and improved access would displace the "resident" elk herd, and disrupt the migration of 1500-2000 "Yellowstone" elk. In addition, the area provides moose winter range and occupied grizzly bear habitat.

Local wildlife and outfitter associations challenged the proposal as damaging to wildlife population levels. These groups withdrew their appeals after harvest units were adjusted to provide better migration corridors, and based on the information provided by the Habitat Capability Model.

Our summary recommendations and conclusions from using the model in Managing Forested Lands for Wildlife are:

1. The expression of wildlife habitat in quantitative values is the single biggest advantage of this process. It provides an ability to predict a 25% decrease in elk habitat caused by a road density of 0.5 miles/sq.mi.; or a 20% increase in deer habitat under a shelterwood harvest system versus a selection system.

Also, various management alternatives may be compared against each other and against present habitat conditions (See attached chart from the Wolf Creek Management Area.).

We realize that the figures presented on the chart probably cannot be used in a literal sense, but they do indicate relative merit and trends. This provides a far superior decision making tool when compared to such subjective analysis as "may affect" and "ALT-A will greatly decrease".

2. The forage, cover and density co-efficients for each wildlife species were changed to reflect the local characteristics. These changes in the computer program were made rather easily by trained personnel.

3. The "Book" process develops an average habitat capability value for a given prescription over the entire rotation. The habitat capability is determined by the percent of the rotation which is in the grass-forb stage or pole stage, etc. Average values for entire rotations are then compared between various prescriptions.

The approach which we used in our analysis compared the habitat existing at selected points in time (i.e., year 0, 20, 40, 80) under various alternatives. We felt that this approach gave a truer picture of habitat capability than comparing average habitat capability values over entire rotations.

4. The amount of time required to complete this process was one of our major concerns. Approximately 20 man-days were used to implement the habitat capability process for the Wolf Creek area (3,300 acres). Much of this time was spent reading the book, training, and trials and errors. We estimate that our second attempt at a similar project will only require 3 to 5 man-days over and above normal timber sale preparation time. Some of this additional time would be required any way to ensure that Forest Plan direction was met; specifically, Regional Standards and Guidelines applying to vegetation diversity and maintaining acceptable wildlife population levels.

We view the Habitat Capability Model as a useful tool for wildlife habitat improvement and timber sale planning. The model has the flexibility to be tailored to local characteristics and refined as better wildlife data becomes available. Although the model makes some broad assumptions and its output must be applied with professional judgement, it is certainly a step in the right direction.

HABITAT CAPABILITY

		Minimum * Acceptable	Present Condition	No Action Year 80	Alt "A" Year 0	Alt "A" Year 40
Beaver	Yr-Round		Incomplete Data			
Mountain Bluebird	Summer	278	385	303	373	365
Mule Deer	Summer	107	163	134	180	180
Mule Deer	Winter		66	66	103	113
Common Elk	Summer	40	39	38	42	46
Common Elk	Winter		17	16	23	30
Goshawk	Winter	0	1	1	1	1
Goshawk	Winter		1	1	1	1
Ruffed Grouse	Yr-Round		Insufficient Data			
Pine Grosbeak	Summer	952	2099	2690	1525	1429
Pine Grosbeak	Winter		2526	2722	2155	1724
Snowshoe Hare	Yr-Round	160	151	151	149	156
Pine Marten	Yr-Round	2	9	9	9	9
Moose	Yr-Round	2	2	2	3	3
S.Red-back Vole	Yr-Round	61,800	147,000	142,000	142,000	129,000
Hairy Woodpecker	Yr-Round		Incomplete Data			
Grizzly Bear	Yr-Round	0.08	0.08	0.08	0.13	0.13

Nonconsumptive use value is
Total consumptive use value.

Total Wildlife value is		65,928	59,860	79,540	86,346
Sawtimber Produced				(9.0 MMBF)	

*40% of Optimum in 2B Prescription Area
plus 80% of Optimum in 5B Prescription Area
equals Min. Acceptable for entire Management Unit

See next page for continuation........

HABITAT CAPABILITY (continued)

		Alt "A" Year 80	Alt "B" Year 0	Alt "C" Year 0	Alt "D" Year 0
Beaver	Yr-Round		Incomplete Data		
Mountain Bluebird	Summer	348	431	373	413
Mule Deer	Summer	169	202	182	178
Mule Deer	Winter	93	103	103	69
Common Elk	Summer	42	47	44	41
Common Elk	Winter	30	23	23	19
Goshawk	Summer	1	1	1	1
Goshawk	Winter	1	1	1	1
Ruffed Grouse	Yr-Round		Insufficient Data		
Pine Grosbeak	Summer	1429	1525	1425	1716
Pine Grosbeak	Winter	1823	2125	1989	2278
Snowshoe Hare	Yr-Round	146	172	156	159
Pine Marten	Yr-Round	8	9	9	9
Moose	Yr-Round	3	3	3	2
S.Red-back Vole	Yr-Round	132,000	142,000	137,000	139,000
Hairy Woodpecker	Yr-Round		Incomplete Data		
Grizzly Bear	Yr-Round	0.13	0.13	0.13	0.13
Nonconumptive use value is					
Total Consumptive Use VAlue					
Total Wildlife Value is		79,048	85,608	80,770	70,848
Sawtimber produced			(11.5 MMBF)	(10.0 MMBF)	(4.5 MMBF)

MILL CANYON - WILDLIFE HABITAT IN DIRECTED CHANGE

by

Elizabeth McGraw
Zone Wildlife Biologist
Toiyabe National Forest

This presentation is entitled "Mill Canyon - Wildlife Habitat in Directed Change," to emphasize the idea whether we choose to direct the change or not, habitats represented by dynamic vegetation communities inevitably change. This change may occur over a long enough period of time that we are essentially unaware of its effect on dependent wildlife. In this presentation I'd like to describe a conscious thought process that we used in designing a directed change for wildlife habitat in the Mill Canyon area.

I'd like to focus this discussion on three points which were important throughout this planning process. The first point is that of determining an area's potential. The second is that of setting project objectives which are realistic within the given potential. The third point is to share with you the types of evaluation tools we used in assessing this project.

First, a brief description of the project area. Mill Canyon is located 80 miles south of Reno, Nevada on the east slope of the Sierra Nevada Mountains. The valley floor is 6,600 ft. in elevation and the canyon ranges to 9,400 ft. The forested area of the canyon is predominately Jeffrey pine, (<u>Pinus jeffreyi</u>), intergrading into white fir, (<u>Abies magnifica</u>), then lodgepole pine, (<u>Pinus contorta</u>) as you gain elevation. At upper elevations brushfields are comprised of buckbrush (<u>Ceanothus velutinus</u>) and chokecherry (<u>Prunus emarginatus</u>). At lower elevations the brush community is predominatly sage (<u>Artemesia tridentata</u> spp.), bitterbrush (<u>Purshia tridentata</u>), mountain mahogany (<u>Cercocarpus ledifolius</u>) and snowberry (<u>Symphoricarpos albus</u>). There is an extensive dry meadow within the canyon.

This area is part of the transitional range used by the West Walker deer herd. Though it is used during the summer, the majority of deer use occurs during the fall prior to migrating to winter ranges and in the spring while the animals wait for the snow to recede in the higher elevations. During mild winters deer will remain in this area throughout the season. The increasing human development on winter range to the east also appears to be concentrating deer use within the transition zones for longer periods of time. Considering the critical nature of this area as a deer range, California Dept. of Fish and Game (CDFG) has purchased land adjacent to Mill Canyon to insure that management emphasis will be focused on maintenance of this key habitat.

Past timber harvests in the Mill Canyon area appeared to enhance bitterbrush and mountain mahogany establishment within the forest stands. With the closing forest canopy however forage species are becoming decadent, shaded by overstory trees. Given these vegetation conditions we felt we could improve deer habitat by perpetuating a mosaic of cover stands and forage conditions. We also felt, given the productivity of the site for timber, this could be effectivly accomplished through the timber sale process.

The wildlife objectives we established for the area are as follows: (1) Obtain a mix of vegetative types through timber harvest to improve deer cover to forage ratios and to enhance preferred browse species. Roads will be closed after logging and fuelwood activities are completed to insure habitat integrity. (2) Provide water in portions of the sale area where its current lack limits habitat use. (3) Maintain the stream and riparian zone area of Mill Creek in good condition in the process of implementing this habitat improvement project. Mill Creek is one of the future re-introduction sites for the Lahontan Cutthroat Trout, a federally listed threatened species. (4) Maintain some existing over-mature stands and designate future replacement stands which meet the needs of dependent wildlife, (5) Maintain an acceptable level of snags and replacement trees as habitat for dependent wildlife. The objectives are not strictly focused on deer but provide for wildlife dependent on other types of habitat as well.

After setting these project objectives, we needed to understand in greater detail what the area currently provided as existing habitat and formulate the desired future habitat conditions. We used our forest management indicator species (MIS) as a tool to predict the current habitat capability. This was accomplished through evaluating habitat transects representing homogeneous stands of vegetation (survey technique after McCarthy and Hargis 1984) and then comparing stand characteristics against habitat capability models developed for the MIS. Much of the information collected from the habitat transect follows level 3 compartment exam inventory. Additional habitat parameters which were measured include; canopy cover, understory plant species and distribution, abundence and condition of snags and down logs, and deer sight distance. This latter parameter is basicly the distance at which 90% of a standing deer would be obscurred from the observer.

The concept of the MIS approach is that we assume when habitat requirements are provided for the MIS, they will also be provided for other wildlife species which share a similar life history. The habitat capability models used (Hurley et. al. 1981, Shimamoto 1981) enabled us to rank habitat as primary, secondary or unsuitable for the species evaluated. The following MIS representing the respective habitat types were used in this evaluation: 1) mule deer, forest and brushland habitat, 2) goshawk and pine marten, over-mature forest habitat, 3) hairy woodpecker, coniferous forest snag conditions, 4) Williamson's sapsucker, lodgepole pine forest snag conditions, and 5) yellow-bellied sapsucker, riparian forest snag conditions.

For example mule deer habitat was evaluated by examining cover:forage ratios and cover quality in terms of hiding cover versus thermal cover. Stand characteristics which are associated with thermal cover are a minimum canopy closure of 50%, a sight distance of 125 feet or less, and a well developed understory of conifers and shrubs. On the Sierra Nevada east slope a well developed shrub understory is often the key to a stand providing thermal cover. Hiding cover characteristics include a minimum canopy closure of 30% and a sight distance less than 200ft. It follows when stand characteristics for thermal cover are met hiding cover is also provided.

Using the Terry Canyon Unit of the proposed evaluation area to further illustrate our point, current habitat was classified as forageing area; forested or open with a high, medium or low capability based on the forage plants present; or cover, thermal and hiding as previously described. Currently 74% of this unit qualifies as hiding cover with only 3% of the area represented as thermal cover. We established an objective to manage 40% of the unit as hiding/thermal cover with at least 10% meeting thermal cover requirements. Thermal cover will be developed by excluding designated stands from harvest thereby promoting canopy closure; or by promoting stand understory development through selective overstory removal. Of the current area providing hiding cover, 34% will be harvested in patchcuts to promote browse plant development and enhance the cover:forage mosaic.

This type of evaluation process was completed for each MIS. Habitat parameters which were especially critical for Goshawk included canopy cover, canopy height, number of trees greater than 18in. dbh, distance to an opening and overall habitat diversity. Pine Marten habitat was evaluated with respect to the number and size of down logs, understory development, distance to water and stand canopy closure. Primary habitat was limited to 30 acres within the drainage for these two species. It was recommended that a large area of secondary habitat be maintained within the drainage for the eventual development of primary habitat features.

The evaluation and recommendations for implementing the proposed wildlife habitat objectives were documented in a habitat capability report. At this time a project I.D. team was formed represented by specialists in soils, timber, fuels, engineering, hydrology, archeology, range, and forest planning. Project feasibility with regard to site potential and other viable alternatives were addressed by the team. The I.D. team participation on this project represents an additional tool used in determining project design. With some modification due to soil and water concerns the I.D. team adopted the wildlife capability report recommendations as the preferred direction for the Mill Canyon timber sale.

At this time I would like to switch the focus from the project area as a whole to the mechanics of producing the desired habitat conditions on an individual stand basis. As an example we'll use stand 1 within the Terry Canyon unit. This stand contains a gradient of habitat conditions, varying from a evenly spaced distribution of Jeffrey pine creating a parklike effect on the north end to a fairly clumped distribution of pine and mountain mahogany to the southern extent. The stand is long and linear bordering the meadow's edge on it's northern section. Through our habitat evaluation we determined this stand currently provides both hiding and thermal cover for deer with the exception of the northern edge. Given the stand's juxtaposition to the meadow and adjacent brushfields the objective for this stand will be perpetuation and developement of the hiding and thermal cover characteristics along the meadow's edge.

Utilizing a group selection regeneration method, the patchy characteristics of the stand and mountain mahogany rejuvenation may be enhanced. This type of treatment would not result in the desired response within the more open portions of the stand. An option to providing hiding cover along the meadow's edge would be to produce the screening effect provided by open grown trees which have not self-pruned in responce to stand competition. The concept of Reineke's stand density index (SDI) and Langseter's curves provides a useful tool for designing a density management regime to produce this type of stand (Long 1985). To maximize individual tree growth and reduce stand competition we would manage the stand border within Langseter's zone 1 (see Figure 1). This would allow management of the stand's edge between 15 and 30% of the maximum SDI.

To portray this situation we found a young Jeffrey pine stand which had regenerated on a site comparable to Mill Canyon. Tree characteristics were recorded from this comparable stand and entered into the Region 4 Prognosis Model (Wykoff et.al. 1982). Prognosis is a growth and yield simulation model containing specific varients which match different growing conditions within the region. This enables the user to model stand conditions over time including the desired harvest strategies. The regenerated stand which we modeled for stand 1 was allowed to grow for 20 years to a average stand diameter of 2.7 in.. At this time a precommercial thin will be completed leaving 170 trees per acre (see also Table 1). This type of thinning regime is frequently used on the Toiyabe National Forest and produces deer hiding cover. The stand will then be allowed to grow to age 60 when 30% of the maximum SDI will be attained. At this time the stand will have an average stand diameter of 12.7in. and will be commercially thinned to 85 trees per acre or 15% of the maximum SDI. At stand age 100 the SDI will again approach 30% of the maximum and a seed tree step of a shelterwood will be implemented. The average stand diameter will be 19.5in. and 15 trees per acre will be left to re-establish the stand and repeat this density management regime.

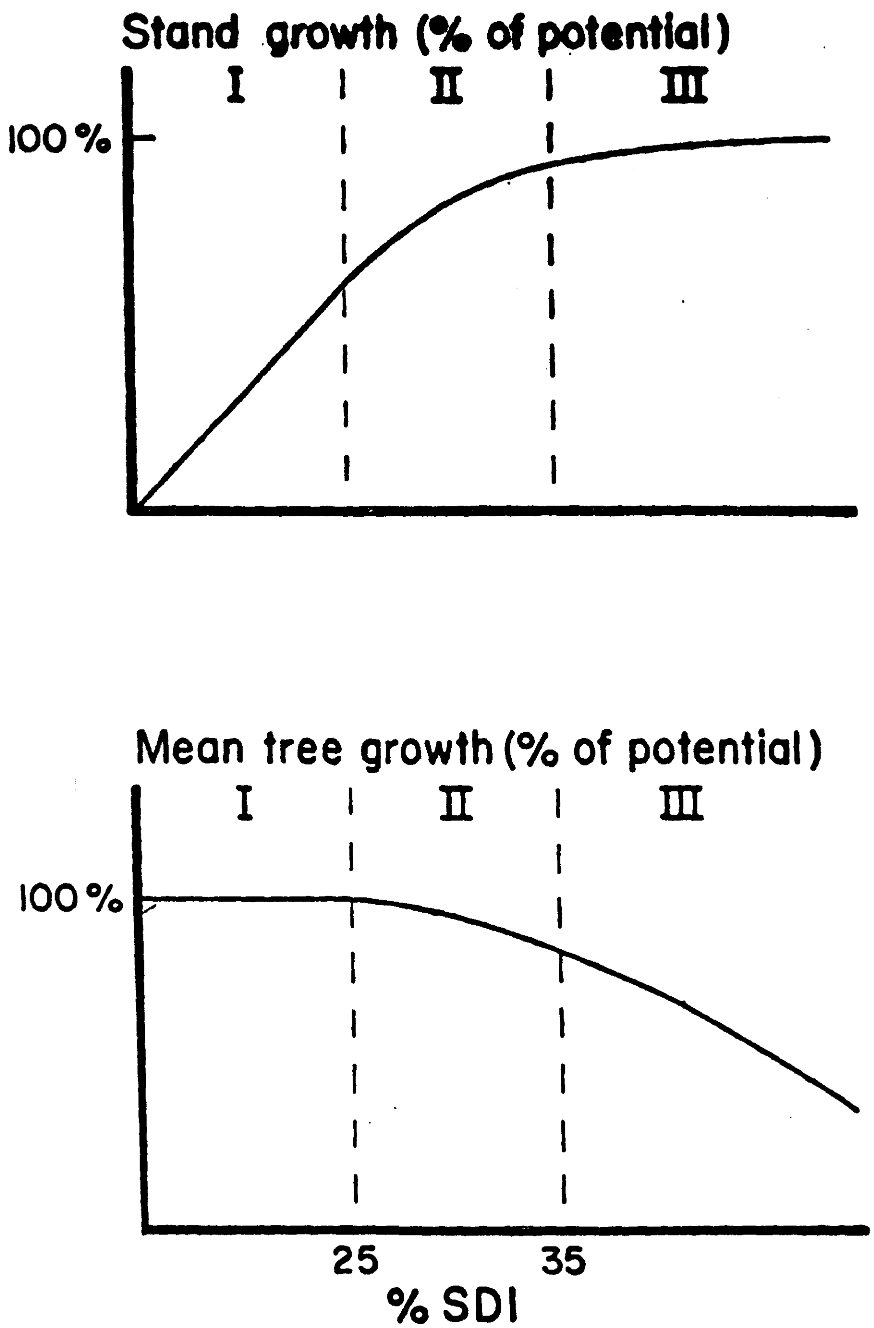

FIGURE 1. Langseter's curves depicting stand and individual tree growth as a percentage of maximum SDI, (after Long 1985).

TABLE 1. Stand Density Management Regime for Stand 1. A stand objective will be to manage the northern meadow border between 15 and 30% of the maximum SDI for Jeffrey Pine to emphasize individual tree growth and open grown form.

BEFORE				AFTER		
SDI	Dq	TPA		SDI	Dq	TPA
198	2.7	1,650				
			PCT	21	2.7	170
249	12.7	170				
			CT	125	12.7	85
249	19.5	85				
			SEED TREE CUT	44	19.5	15

Dq, average stand diameter; TPA, stand diameter; PCT, precommercial thin; CT, commercial thin.
The maximum SDI for Jeffrey Pine is 830, SDI at 15 and 30% of the maximum would then be 125 and 249 respectively.

At the onset of this rotation hiding cover will not be provided for 10 to 15 years following the initial seed tree cut. However the open grown characteristics of these trees should help provide cover after initial stand establishment. An additional tool available through Prognosis is the Elk Hiding Cover submodel. Through the use of this submodel we found that initially establishing a species mixture containing both Jeffrey pine and white fir would further enhance the desired screening effect of this meadow border. Habitat typing has not been completed for the east slope of the Sierra Nevada Mountains. Using current stand conditions as an indicator of site potential a few scattered white fir are present within the stand. Based on this species presence we will attempt to plant white fir within this section of the stand.

Within other stands in the timber sale area we will be attempting to; enhance deer browse species, retain cover types while reducing insect and disease outbreaks, and rejuvenate decadent aspen stands. In this discussion I've highlighted the importance of objectives, both on an overall project basis and from the perspective of the individual stand. The attainment of these objectives rests on how accurately we have assessed the area's potential. The tools we've used to assess potential and determine project design included; using MIS to evaluate wildlife habitat, specialist support through the ID team process, Density management regimes based on Reineke's SDI and Langseter's curves, growth and yield modeling available through Prognosis and its submodels and finally, an assessment of the area's potential based on the species which are already there. Perhaps this last tool contributes to what seasoned foresters and wildlife biologists like to term nature's intuition.

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Northern White-Cedar Management and Whitetail Deer Habitat

by

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Abstract: Northern white-cedar is a multiple use forest type that we need to maintain. It has inherent characteristics that make it valuable both for timber and winter deer habitat. Past management has not successfully regenerated cedar and change is needed. Cedar must be managed under longer rotations unless short-lived species are removed prior to regeneration of the stand. One hundred and fifty years is the recommended age. Cedar also must be managed more intensively than in the past. This species competes poorly and needs to have competition removed. Cedar requires specific seedbed conditions that are best obtained by prescribed burning. Winter habitat is critical to the deer herd in the Upper Peninsula of Michigan. The quality of this habitat depends on the composition of tree species present and white-cedar is the most valuable component. These yards have a limited carrying capacity of deer that can be supported. Management of both cedar and deer must be coordinated to provide the best combination of outputs.

Northern white-cedar is a valuable component of Lake States Forests. There are about two million acres of the type; about half of which is in Upper Michigan. Most of the type is found on poorly drained organic soils which are fairly low in productivity and require winter logging. Northern white-cedar has inherent qualities that make it valuable. Cedar wood has a natural rot resistance that causes it to be sought after for siding, fencing, and many other exterior uses. It is also becoming a popular material for log cabins. It has very good natural insulating qualities because of the large number of air spaces that occur in the wood. Logs of the size needed for cabins, siding or large boards are becoming increasingly rare. Along with its timber values wildlife biologists consider the type to be essential for winter deer range in the Upper Peninsula of Michigan. And even though we've been managing it for quite some time, we have only rarely regenerated the type. Most stands that have been harvested have converted to balsam fir, spruce, aspen or tag alder.

Since we have usually ended up with a stocked stand of some species why should we be concerned about getting cedar back. A cooperative effort between the State of Michigan and the three National Forests in Michigan identified the type as a critical component of winter deer habitat that should be managed to provide, cover and food. Many other animals in addition to deer benefit from these areas. As stated in the Michigan program for Fish and Wildlife habitat, "Winter deer range is essential habitat for carnivores, black bear, many rodents and many birds. Perhaps 75% of our wildlife in winter tend to concentrate in this habitat, which occupies 10% of the National Forests in Michigan. (1975 p.27)

What makes good winter deer range? An expert in the field, Louis Verme, of the Michigan Department of Natural Resources has found that a combination of winter cover and food are necessary. Cover is provided by an evenaged conifer stand that has a tight tall canopy. Such a stand moderates winter's extreme conditions. Temperatures remain higher, winds are reduced and snow depths are lower. The canopy traps alot of snow that does not reach the ground and also increases the moisture content of that which does accumulate reducing its depth. Deer choose areas that moderate winter extremes in preference to areas having plentiful browse. Although food is vital, deer behave as if the greater peril is that of inadequate protection from bad weather (Verme 1965).

Deer obtain food in two ways. They feed on browse they can reach in the yards consisting of shrubs, regeneration and lower branches of trees. They also use tops of trees felled during winter logging operations. Different species of trees provide varying amounts of nutrition. The best food is provided by white cedar, hemlock and maple. The poorest are balsam fir, balm of gilead, spruce and alder. White cedar is the only species that will by itself support deer over winter in Northern Michigan. The cutting of 40 acres of cedar at the proper pace will support 400 deer for a winter. In view of its unexcelled nutritive value, the status of white cedar chiefly determines the capability of conifer yards in the eastern Upper Peninsula (Verme 1961).

Most northern white-cedar stands on the Hiawatha are about 100 years old. They are generally even-aged and many have received at least one set of strip clearcuts. Cutting usually consisted of a set of one chain wide strips (running east to west) with residual areas between strips that are at least two chains in width. Under this silvicultural system another set of strips were to be cut ten years after the first harvest. After another ten years the final strips were to be removed at which time the stand would theoretically be regenerated to cedar. Subsequent cutting has been postponed because strips have not consistently regenerated to cedar.

Problems in the regeneration of northern white-cedar have been recognized for quite some time. In a 1956 article of the Journal of Forestry, Philip Thornton summarized problems in managing the type in Upper Michigan. He found that the percentage of cedar is dropping and the percentage of hardwoods and balsam fir is increasing. He also noted heavy accumulation of slash in regenerated areas and that the species composition of the new stands would result in lower future yields. He emphasized that these coniferous swamps are vital to the economic well being of the area. They make up 10% of the acreage and have timber and wildlife values that make them one of the most commercially important segments of the Upper Michigan forest (Thornton 1957).

As previously mentioned stocking surveys in cutover strips show a composition change from the original stand. Northern white-cedar stands must have a majority of cedar stocking to be typed as such. In most cut strips cedar has diminished to less than 10% of stocking while balsam fir, aspen, balm of gilead, spruce and birch have increased markedly. Regeneration characteristics of the species involved explain the composition changes that have occured. Each species has certain traits that affect its ability to compete. Balm, aspen and fir make high and moderate initial growth while cedar may take as long as fifteen years to reach four feet in height. Related to this, balm and aspen sprout profusely when cut producing up to 50 suckers from each adult. Using the adult root system from which they develop allows them to grow up to three feet in the first growing season. Damage caused by browsing animals also varies among these species. Cedar is highly preferred by deer and hare and mortality occurs when 15-20% of the foliage has been removed. Fir and balm are browsed very little if at all. A study by William Johnston (1975) has found that balsam fir will dominate regeneration under cedar-fir mixed stands. Seedlings are established when cutting leaves less than 150 square feet of basal area and the proportion of fir will be greater if deer and hare are present. In Johnston's study 56% of all cedar had been browsed by hare and 9% by deer. Balsam fir becomes more of a component not only because it reproduces and grows in the shade as well or better than its associates, but also because it is not a preferred browse species. If cedar is to be a major component of the next stand then advanced regeneration and natural seeding of other species must be eliminated.

Species composition in cedar stands changes markedly over time. The shorter lived species such as balsam fir and balm are currently dying out of existing stands causing the proportion of cedar, white spruce and paper birch to increase. If succession were allowed to proceed the climax stage would consist of almost pure cedar since it attains ages of 400 years plus and can outlive its associates. As with other climax species, cedar sustains good growth rates over many years. In order for cedar to be maintained it must be managed under longer relations unless short-lived species are removed prior to regeneration of the stand. One hundred and fifty years is the recommended age.

Seedbed requirements also limit cedar regeneration. Often large amounts of slash are encountered in strips. This slash can present a physical barrier to regeneration. Because cedar is rot resistant, slash persists for along time. What seedbed requirements does cedar have then? A review of the literature indicates that the best cedar regeneration occurs where there is a moist organic seedbed, coupled with high germination temperatures and the influence of fire. Seedlings do best in neutral or slightly alkaline soil. They usually develop on rotten wood, decayed litter, peat and moss. Reproduction comes in best on skid roads where moss has been packed down and stays moist throughout the summer. Slash and thick moss layers tend to retard germination. Seedlings which start on heavy moss, the tops of stumps and logs during wet springs often dry out during the summer. In one study, drying caused more than one-third of the mortality of seedlings. (Nelson 1951).

Seed characteristics and germination temperatures also determine cedar regeneration. Work by Dick Godman on the Argonne Experimental Forest has shown the temperature required for good germination of cedar to be quite high, 84 . He has found many similarities among certain light seeded species such as cedar, hemlock and yellow birch, and generalized about them. One such generalization is that with these species optimum germination temperatures do not generally occur until moisture conditions are too dry for germination. In this area adequate temperatures are reached in July and August when seedbeds in the strips have dried. Most high temperature requirement species have small, or light seeds. This characteristic appears to correlate with low vigor, slow growth and very shallow rooting of germinants. This makes them extremely sensitive to surface soil drying (R. Godman 1981). The key point is that cedar regeneration requires both an adequate seed supply and some degree of site preparation to produce its highly specific seedbed requirements.

Cedar seed production is generally reliable. Seed is disseminated from September to November and can carry from 150-200 feet depending on the height of the parent tree. Fire has played a part in the history of most cedar stands and provides the tool needed to prepare desired seedbed conditions. Maissurow, while studying the role of fire in natural stands in northern Wisconsin, found that very few cedar swamps have escaped fire (1941). Experiments at Cusino in the Upper Peninsula and related work in northern Minnesota have shown that cedar and swamp conifer slash on organic soils can be safely and effectively broadcast burned (Johnston 1977). Prescribed burning can achieve four objectives: 1) It removes the physical barrier that results from heavy slash in these stands, 2) Fire removes the advanced regeneration of other species that will outgrow cedar if present, 3) Fire can reduce the heavy moss layer that dries out during the summer and results in seedling mortality, 4) Burning will release phosphorus, potassium and minor elements into plant available forms.

Burning must be accomplished in such a way that the above objectives are met. Strips that are to be burned must be on undrained organic soils in which the upper soil is saturated. Slash must be removed from areas of drained organic soils such as would be found near ditches or where a swamp transitions to upland soil. A mineral soil firebreak is needed near upland areas. Cutting should be planned to create strips three chains wide and perpendicular to the prevailing wind direction. Cutting edges should be straight and avoid sharp angles. Logging should proceed so as to create a slash free alley around the edge of the cutting-burning unit. Slash should be spread evenly over the area and unmerchantable trees should be felled prior to burning. Prescribed burning should occur in July or August of the first season after logging or in May of the second season. The burning objective should be to remove slash less than one inch in diameter (Johnston 1977).

Recommendations:

1. Northern white-cedar is a valuable multiple use forest type that needs to be maintained.

2. Past management has not succesfully regenerated cedar and change is needed.

3. Cedar must be managed under longer rotations unless short-lived species are removed prior to regeneration of the stand. One hundred and fifty years is the recommended age.

4. Cedar must be managed more intensively than in the past. This species is a poor competitor and needs to have competition removed. Cedar also requires specific seedbed conditions that can best be attained by prescribed burning.

5. Deeryards have a definite sustained yield capacity both for wood and deer. The only way to prevent heavy mortality of deer during severe winters and prevent deterioration of yards is to keep the deer population at the proper size.

6. Carrying capacities need to be established for each yard and maintained at that level in cooperation with the Michigan DNR.

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INTERDISCIPLINARY DEVELOPMENT OF CARIBOU HABITAT MANAGEMENT GUIDELINES:

THE ROLE OF THE SILVICULTURIST

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ABSTRACT

The Woodland Caribou (Ranger tarandus caribou) formerly ranged over much of the forested parts of the United States north of 45 degrees latitude. Today, it is a Federally Listed Endangered Species, with only about 50 animals in the lower 48 states (plus one recent transplant in Maine - current status unknown). These animals inhabit the Selkirk Mountains of northern Idaho, northeastern Washington, and southern British Columbia. The majority of identified woodland caribou habitat in the American part of the Selkirks is on two national forests. The management of woodland caribou has been a source of intense controversy between various interest groups, the local community, and several state and federal agencies.

In the winter of 1985/86, an interdisciplinary team of wildlife biologists and foresters representing several government agencies met to develop habitat management guidelines for the Selkirk population of woodland caribou. The caribou data available was far from complete. The team was working in an atmosphere of political scrutiny.

The guidelines produced are in the format of silvicultural prescriptions for the five identified seasonal caribou ranges. For each seasonal range, the guidelines describe the physical site, identify the target stand for that physical site, and prescribe treatment guidelines to produce the target stand on that physical site. Vegetative manipulation is the primary tool to produce the prescribed target stands, and commercial timber management is generally consistent with caribou goals on most of the seasonal ranges. The early winter range prescription is a compromise that reflects data limitations. The long term role of timber harvest on this part of caribou range has not been resolved.

These guidelines have been accepted by all the government agencies involved, are being incorporated into appropriate forest plans, and are being used (with interdisciplinary team guidance) in timber sale preparation in identified caribou habitat. A caribou augmentation

plan has been partially implemented, and 24 new caribou were transplanted from Canada to Northern Idaho in the Spring of 1987. The controversy has not evaporated, but multiple use management is proceeding on these lands.

As a result of changing expectations and more complex demands from the American public, the practice of silviculture within the U.S. Forest Service is in a period of transition. The development of these caribou prescriptions is an example of how silviculturists can meet these changing expectations in a positive manner. In forested ecosystems, silviculturists hold the key to integrated resource management that has a sound biological basis.

INTRODUCTION

This paper is as much about the changing role of silviculture in resource management as it is about caribou. I'm going to start out by making people mad. I'll begin with some gross generalities, that, of course, we all know aren't true. Then, I'll use caribou management as a specific example to prove myself wrong. And then, hopefully, I'll explain how all of this is relevant to the future of silviculture.

Most American silviculturists are probably familiar with the definition of silviculture from David Smith's 1962 text: The Practice of Silviculture. He says that "silviculture is normally directed at the creation and maintenance of the kind of forest that will best fulfill the objectives of the owner." For National Forests, the owner is the American public. Smith goes on to state that "returns from silviculture are generally thought of in terms of timber production, although it is not uncommon for owners to have other goals." Having made the necessary acknowledgement of the legitimacy of non-timber goals, Smith goes on to develop the principles and practice of silviculture in relation to the goal of timber production. Silviculturists have gone on to become known as tree planting and tree thinning experts, and as the people who write timber harvest prescriptions. Meanwhile, fisheries biologists have set guidelines for riparian zones, wildlife biologists have attempted to manipulate plant communities to create wildlife habitat, and landscape architects have tried to maximize visual quality by capturing snapshots of dynamic plant communities.

It's a cliche to say that as demands on the forest have risen and our manageable land base has declined, forest management has become more difficult and controversial. We debate whether the American public wants its National Forests to produce more boards, more wildlife, or more amenities. Of course, the correct answer is: "all of the above." At least part of the reason we are having a hard time with these increasing demands is because we don't have applied forest biologists working to optimize the mix of resources. The history of silviculture had concentrated on timber production. Meanwhile, other resource specialists, lacking an understanding of long-term forest dynamics,have concentrated on preserving those snapshot pieces of the forest that are currently desireable for their resource.

Many resource specialists, frankly, don't trust silviculturists. Their experience in working on interdisciplinary teams has shown that the "silvicultural alternative" is also the maximize timber alternative, that silviculturists always say that any forest 1 year past rotation is going to fall to pieces, and that any objective other than timber production will lead to unmanageable insect and disease problems. Many of these specialists work along on their own, trying, with limited understanding, to manipulate the forest to meet various resource needs, or to "mitigate" the results of what happens following the timber harvest and site preparation prescribed by the silviculturist.

Integrated forest management starts at the beginning of the management effort. It is the applied forest biologist who holds the key to making this management successful. And, it is the silviculturist who has the expertise to be the applied forest biologist. The silviculturist needs to develop the same expertise in creating forested habitat for wildlife species, or in creating a healthy forest environment to recreate in, as he now has in manipulating rotation length to maximize timber production.

The management situation with caribou in 1985 in northern Idaho was a good example of the need for an applied biological approach - an approach that was biologically sound, but also sensitive to the political and social environment.

CARIBOU BACKGROUND SITUATION

The Woodland Caribou (Ranger tarandus caribou) formerly ranged over much of the forested parts of the United States north of 45 degrees latitude, and in to Canada up to 60 degrees latitude. Caribou were found in parts of New England and the Lake States, as well as in the northern Rocky Mountains. Well before 1900 the caribou was gone from most of its New England and Lake States range, although it was 1908 when the last caribou was reported in Maine, and the early 1940's before the last caribou was gone from northern Minnesota (Karns, 1981?). In the very early 1900's, the caribou was still common (although perhaps in somewhat reduced numbers) in the Selkirk, Cabinet, and Purcell Mountains of northern Idaho and northeast

Washington and northwestern Montana (Flinn, 1956; Layser, 1974; and Jerry, 1983). Today, there are still healthy herds of up to several thousand woodland caribou in parts of Canada.

The decline of the caribou in New England and the Lake States was probably due to a combination of habitat destruction, overharvest, and a brain parasite that is spread by white-tail deer (Scott, Audubon Wildlife Report, 1985). In the northern Rockies, the brain parasite is not present. Here, the caribou is primarily a creature of rugged mountainous terrain, where man's access has been somewhat limited, and where forest cover has been largely maintained. However, the caribou is made vulnerable because it has a less wary nature than some other ungulates, matures late, and has a relatively low reproductive rate.

By 1950, the northern Rocky Mountains caribou population appears to have declined significantly from the beginning of the century, although sightings were still somewhat common in isolated parts of the range. Since 1950, human population has been growing in the northern Rockies, road building and timber harvest has accelerated in the mountains, and two catastrophic wildfires in 1967 destroyed over 70,000 acres of caribou habitat in northern Idaho (and possibly resulted in some direct caribou mortality). Spruce beetle epidemics in the 1950's and 60's led to extensive road building and timber harvest in high elevation areas of northern Idaho. Caribou are very susceptible to overhunting, and more access probably meant more hunter mortality. Just north of the international border, in 1963, the Canadians completed a major highway through caribou habitat and caribou began to be killed by motor vehicles. By the early 1970's, the caribou population of the Selkirks was in severe decline (Scott, Audubon Wildlife Report, 1985), and by the early 1980's, there were no longer verified reports of a caribou population in the lower 48 states other than in the Selkirk Mountains of northern Idaho and northeastern Washington.

By the early 1980's the last reamining caribou population was in the Selkirk mountains, and population was estimated at 25-30. Even this small population was spending the majority of its time on the Canadian side of the border. Concern and research about the species began to intensify in the early 1980's. Caribou management became a concern not just to wildlife biologists, but also to national environmental groups. In January 1983 Woodland Caribou were emergency listed as an endangered species, and in February 1984 they received final endangered species listing (Summerfield, 1985; and Jerry, 1983).

By 1985, several forces were coming to focus on northern Idaho, and specifically on the community of Bonners Ferry, in Boundary County, Idaho (population 1,800). Although the timber industry has been significant in Bonners Ferry for many decades, since the 1950's there have been several factors that made timber dominant in that town. Generally accelerating Forest Service road construction and timber harvest since the 1950's, the spruce beetle epidemics & associated salvage logging of the 1950's and 60's, salvage logging after the big fires of 1967, salvage logging of blister rust infected white pine, mountain pine beetle salvage logging in nearby Montana in the 1970's, and the housing booms of the 1960's and 70's all combined to make the timber industry the center piece of the Boundary County economy.

In the late 1970's, forces began to be strongly felt from the other directions. Many of the highest site lands with the easiest access were now gone, and more difficult sites with poor access were making timber less attractive. The extent of timber harvesting had reached a point that concerns for other resources were limiting timber harvest opportunities. The Endangered Species Act of 1973 required all Federal agencies to "utilize their authorities . . . by carrying out programs for the conservation of endangered species . . . " and to not carry out any actions ". . . likely to jeopardize the continued existence of any endangered species or result in the destruction or adverse modification of habitat of such species . . ." Grizzly bear habitat covered much of the federal land in the two northern counties of Idaho, and wolves were thought to be close by. Local and regional groups were lobbying for wilderness in Long Canyon, the last large unroaded drainage with significant commercial timber in Boundary County. The National Forest Management Act of 1976 and its regulations put limits on the size of openings that have a significant effect on potential short term harvest levels. NFMA also brought or expanded limits to timber harvest and road building based on water quality, fisheries needs, visual quality, big game needs, and recreation demand. The Forest Planning effort brought all these timber harvest constraints together and made their cumulative effect visible. While all this was going on, the boom years of the late 1970's turned into the severe recession of the early 1980's, and the local timber economy collapsed. Woods workers were unemployed in large numbers, some mills in northern Idaho closed, and many others cut back workers.

About this time, woodland caribou were listed as an endangered species. In order to comply with its obligations under the Endangered Species Act, the Forest Service instituted management using "Guidelines for Human Activity within the Range of Mountain Caribou, Southern Selkirk Mountains" (Johnson, Miller, and Peek; 1981). These guidelines were state-of-the-art at the time, but were based on very limited research, and were fairly broad brush. The first effect of endangered species listing, and the application of these guidelines, was that several harvest units in an active Forest Service timber sale were deleted from the sale because harvest prescriptions were in conflict with the caribou guidelines. The next effect was that about

110,000 acres of the Idaho Panhandle National Forest were declared caribou habitat in the draft Forest Plan, with about half of these acres removed from the timber base, and the rest of these acres under harvest restrictions.

Caribou were kind of a last straw for many local citizens in northern Idaho. Big trees that had always been available and now were gone, regulations from fuzzy-headed bureaucrats in Washington, demands from urban dickey-bird watchers who didn't care if people had a way to make a living, wilderness, grizzly bear, visual quality, sediment limits, the inexplicable national and international economy -- many small communities in the Inland Northwest were feeling overwhelmed by all these changes. And now there were caribou! People were mad.

Of course, the local timber industry felt threatened by the direction of the national economy, and by what they perceived as declining private and federal timber supplies. In the face of these complex and amorphous forces of social and economic change, some people may also have been searching for a simple solution to their problems. The timber industry industry and allies began lobbying to raise draft Forest Plan timber harvest levels, and to block wilderness designations and other land allocations that limited timber harvest. Some local politicians were also campaigning to eliminate restrictions on timber harvest, and raise the planned harvest levels from local National Forests. Endangered species, and especially caribou, were one focus of all this effort.

On the other side, there were also local groups lobbying for wilderness designations, more recreation opportunities, and protection of endangered species. National interest groups and national politicians became involved in the struggle. Caribou were one highly visible item in this polarized situation.

Since 1971 there had been an International Mountain Caribou Technical Committee composed of representatives from the U.S. Forest Service, the U.S. Fish and Wildlife Service, the British Columbia Forest Service, the British Columbia Wildlife Branch, the Washington State Department of Game, the Idaho Department of Fish and Game, and individuals from industry, academia, and the general public. In 1982, the Idaho Department of Fish and Game instituted a study of the Selkirk caribou herd. In 1983 the Forest Service Intermountain Research Station contracted with the Idaho Department of Fish and Game to obtain data from this research. When the caribou were listed as an endangered species, the U.S. Fish and Wildlife Service was aware that this research was a potential data source for developing a recovery plan. By 1985, preliminary information began to come out of this research effort. Potential caribou habitat was being re-mapped and somewhat expanded. Data was being collected on the physical and biological charcteristics of the Caribou Study Area (Crawfird and Scott; 1985). Both Scott, who did much of the original field work in this research, and Lyon of the Forest Service Intermountain Research Station, were putting out draft publications interpreting the newest data. Bob Summerfield, Bonners Ferry Ranger District wildlife biologist used this preliminary information to prepare a draft Woodland Caribou Cumulative Effects model. This model, and the other information coming available indicated a need for a change in the direction of woodland caribou management.

It was in this environment, in 1985, that the U.S. Forest Service decided to put together an interdisciplinary team to develop new guidelines for caribou habitat management.

THE INTERDISCIPLINARY TEAM

In fall of 1985, the Idaho Panhandle National Forest, in cooperation with the Colville National Forest, and the Idaho Department of Fish and Game, began to assemble the Interdisciplinary Team. The Team included the following people:

Paul Harrington	- wildlife biologist	- Idaho Panhandle National Forest Supervisors Office
Gerry Alcock	- timber planner	- Idaho Panhandle National Forest Supervisors Office
Art Zack	- silviculturist	- Idaho Panhandle National Forest Supervisors Office
Harry Jageman	- wildlife biologist	- Priest Lake Ranger District, IPNF
Bob Summerfield	- wildlife biologist	- Bonners Ferry Ranger District, IPNF
Tom Burke	- wildlife biologist	- Colville National Forest Supervisors Office
Warren Current	- district ranger	- Sullivan Lake Ranger District, Colville NF
Keith Fletcher	- wildlife biologist	- Sullivan Lake Ranger District, Colville NF
Pete Zager	- wildlife biologist	- Idaho Department of Fish and Game
Greg Servheen	- wildlife biologist	- Idaho Department of Fish and Game

Burke and Current only attended the first meeting, leaving a core team composed of six wildlife biologists and two foresters. Both foresters were trained silviculturists, and graduates of Region 1's silvicultural certification program.

Prior to the first official ID Team meeting, the majority of the ID Team went out to the field on the Priest Lake Ranger District, and visited sites representative of different types of seasonal caribou habitat, as identified by the most recent research. There were four meetings of the Interdisciplinary Team, plus several meetings of smaller working groups. Most Team meetings were also attended by two observers: Chuck Roady of W-I Forest Products Company, and Jerry Pavia of the Boundary Backpackers, an environmental group. The Forest Supervisor and the Bonners Ferry District Ranger also attended part of one meeting, and provided some direction. The last ID Team meeting was also attended by Jay Gore of the Boise office of the U.S. Fish and Wildlife Service, and Eric Rominger of their Denver lab (who had recently begun to do some new caribou research as part of a separate federally funded effort). It was obvious that the team was working in an atmosphere of political scrutiny and concern.

At its first meeting, the ID Team recognized that there were two possible approaches. One approach was to begin with normal timber management regimes, and then attempt to mitigate the effects of this management, as required for caribou needs. The second approach was to design a managment regime that was built on caribou needs as a basic and integral part of the whole scheme; timber managment would occur only as an integral part of caribou management. The ID Team chose this latter appraoch of integrated management based on caribou needs. Using this appraoch, the Team would develop new caribou management guidelines, using the data from recent research, primarily the Idaho Department of Fish and Game Study, whose intensive field work was begun by Scott in 1983, and recently continued by Servheen, when Scott left.

The basic thrust of Scott's work was that there were different types of seasonal habitat that the caribou used. In his preliminary report (July 1, 1985) he described these ranges by their season of use, and by elevation, aspect, slope, overstory size class, overstory canopy, and long-range mangement recommendations. However, from here on, life for the ID Team got more complicated. For one thing, Scott had essentially two years worth of data, and was making a professional judgement that one year of the two was partially atypical. However, the "atypical" year had more data observations in some critical areas than did the "typical" year. Scott also was using terminology in a different fashion than most foresters were familiar with. For instance, some of his "partial cuts" appeared to foresters to be clearcuts where relatively small amounts of cull material had not been slashed. Overstory size class turned out to be the visually estimated average diameter of those dominant and co-dominant trees that he felt dominated the stand. Old growth was apparently simply "21 inch plus DBH" stands. The point of these examples is not to criticize Scott, but simply to point out problems in meeting the objectives of establishing guidelines for caribou management. Caribou habitat was primarily forested habitat. Yet, the wildlife biologists had done all the date collection, with very little input from foresters. Foresters and wildlife biologists differed significantly in how they sampled and described forested habitat, and the precision of their terminology.

There were other questions that the ID Team had to work through. There were some differences in interpretation of the data between Scott and Jack Lyon (Intermountain Research Station - U.S. Forest Service). Decisions had to be made on how to use Bob Summerfield's draft Woodland Caribou Cumulative Effects Analysis Model, which was built on a combination of Scott's data and a healthy mix of professional judgement. Greg Servheen, who was continuing Scott's field research, had joined the team, and his observations and interpretations had to be integrated. There were questions about what were the key characteristics of the seasonal ranges the caribou were using. There were big questions about what relative amounts of these various seasonal habitats needed to be mixed together to provide for total caribou needs (e.g. how many acres of early winter range were needed to support the same number of caribou as would live on a given number of acres of late winter range). This last question lead to discussions of carrying capacity for caribou, and pointed out that there was data lacking in terms of understanding caribou needs. To work with limited data, professional judgement was needed. It became obvious that good faith, a willingness to stretch functional perspectives, and a degree of trust would be necessary to make this interdisciplinary team work.

The Interdisciplinary Team meetings involved several processes going on at the same time. The Team was trying to assemble and interpret all the available data - much of it available only in draft or note form. The Team was trying to reach some consensus on how to proceed in those areas that were lacking data. Then, the Team was trying to use all this to agree on caribou seasonal habitat needs, and use those caribou needs to develop prescriptions. Through all of this, there were the human dynamics of developing trust between representatives of different agencies, and between specialists of different disciplines (foresters and wildlife biologists). In terms of producing a successful product, the human dynamics were probably at least as important as the technical items.

The first two meetings of the ID Team were dominated by two items: 1) trying to understand the data available and put together a picture of caribou needs; and 2) going through the mating dances necessary to develop trust and working relationships. In these two meetings, it became obvious that having a clear, systematic and rational approach to the caribou problem would help resolve both the human relations problems and the technical problems.

THE CARIBOU PRESCRIPTIONS

The prescription format ultimately used by the ID Team provided this clear, systematic and rational approach. It was built around four items: 1) a statement of management objectives, 2) a physical and biological description of the site, 3) a description of the target stand for that site (in light of the management objectives), and 4) the treatments necessary to produce that target stand on that site. This approach helped bring all the technical items into focus, highlighted those items where there was substantial agreement, and made clear what needed to be resolved on the more difficult technical items.

At the second ID Team meeting, a rough description of caribou seasonal habitat needs was hammered out by the group. Before the next team meeting, a biologist working group meeting used this rough description to partially resolve questions of how to proceed where there was a lack of data. The two silviculturists took the description of caribou needs, and developed it into a more systematic outline of caribou habitat requirements that included 11 items for each seasonal habitat. These items were habitat type, stand canopy cover percent, average DBH of dominant and codominant portion of the stand, stand size and condition class, basal area, timber type, forage availability, elevation zone, aspect, slope, and slope position. Then, the silviculturists used this outline to develop draft prescriptions. The prescriptions started with a statement of management goals for caribou habitat. Then the management goals and the caribou habitat requirements outline were used to come up with a separate prescription for each of five seasonal habitats. The seasonal habitats were summer, late summer/rut, early winter, late winter, and spring. For each seasonal habitat prescription, there was a description of the physical and biological site to which that prescription applied, a description of a target stand for that site, and prescribed treatments to produce that target stand on that site. The prescribed treatments recognized that forest stands are dynamic, and included a goal for what percent of each site was to be maintained in target stand condition at any one time.

The next meeting of the Interdisciplinary Team was a process of reviewing the outline of caribou habitat requirements and the draft prescriptions, tearing them apart, and then building consensus on caribou habitat requirements, and how this would be applied in the prescriptions. Prior to the last ID Team meeting, both silviculturists and the Idaho Panhandle National Forest Wildlife Biologist met in a working group to revise the prescriptions. These revised prescriptions were the focus of the last ID Team meeting. The prescriptions were gone through line by line by the entire team, and further revisions were made. These revised prescriptions were accepted by all Team members and the U.S. Fish and Wildlife Service representatives as the new "Caribou Habitat Managment Guidelines" for the Selkirk Mountain Caribou. The complete prescriptions are included in Appendix A.

For most of the five seasonal ranges, either the physical site was high elevation, non-commercial timber ground, or caribou needs would best be met by habitat manipulation that was compatible with timber management. However, the most difficult technical questions revolved around the early winter range. Here, the research data allowed for overlap between the physical site of early winter range and spring range. This was significant for two reasons. First, the basic target stand for spring range was a clearcut that would maximize forage production. The basic target stand for early winter range was a multi-level cedar-hemlock old growth stand with high canopy coverage that would maximize snow interception. Obviously, these two physical sites would have to be separated out. The second signifcant factor in this overlap between spring and early winter range was political. Both these sites were defined as cedar-hemlock habitat types, the best timber producing habitat types in the region. Prescriptions that called for maintaining large parts of these habitat types in old growth condition with high canopy closures could have significant impact on timber yields, and impacts on the community of Bonners Ferry.

There was no data for caribou carrying capacity on the different seasonal ranges, and so resolving the overlap between the sites for spring and early winter range ultimately became a question of professional judgement. Approximately 20% of potential early winter range in northerly aspects was in cedar-hemlock old growth condition. Since clearcuts with forage are relatively easy to produce in a short time period, and old growth cedar-hemlock stands take centuries to produce, and since the majority of early winter range was not in old growth condition, the team made a decision to be very conservative about old growth on these sites. Sixty percent of the cedar hemlock zone would be managed as early winter range, with emphasis on northerly aspects. Existing old growth cedar-hemlock stands would not be entered in the first two decades, and management on the rest of the early winter range would be keyed towards developing cedar-hemlock cover types that were moving towards high canopy cover, old growth condition.

If the only condition the caribou needed on early winter range was multi-level, high canopy closure stands that shed lots of snow, old growth was not the only way to meet this need. However, the stands being used by caribou at this time of year were old growth, and the wildlife biologists did not feel their data was complete enough to be sure that snow shed was the only stand attribute the caribou were keying on. With limited data, the biologists felt they had to duplicate the entire stand condition being used. It took some compromise on the part of the foresters on the Team to live with this professional judgement, as well as to be so conservative about the amount of early winter range needed. This compromise was made easier by the fact that the limited amount of old growth currently existing meant that, in the process of converting to cedar-hemlock cover types, or converting to multi-canopied stands, active management could still occur on much of early winter range. Meanwhile, there was an opportunity for further research to clarify exactly what stand characteristics were needed by the caribou on this early winter range, and what were the relative carrying capacities of the various seasonal ranges.

PRESENT SITUATION

The new Caribou Habitat Management Guidelines, in prescription format, have been accepted by all the agencies involved, and are providing basic management direction for the Selkirk Caribou ecosystem. They are incorporated in the revised final version of the Idhao Panhandle National Forest, Forest Plan, and have lead to a single revised Caribou Management Area in that Plan. In line with these guidelines, timber sales are being prepared within caribou management areas. This past winter, part of a Selkirk Mountains Caribou Herd Augmentation Plan was carried out, and 24 Canadian caribou were transplanted to the Bonners Ferry Ranger District. Not everybody in Bonners Ferry is happy with all this, but there appears to be growing acceptance of the fact that this is the way things will proceed, and that caribou probably do not spell doom for the community. The local school children even adopted some of the caribou in the transplant program.

Research is continuing by both the U.S. Fish and Wildlife Service, and the Idaho Department of Fish and Game (in cooperation with the University of Idaho and the U.S. Forest Service). Hopefully, data will be gathered to resolve many of the unknowns about caribou, especially in regards to early winter range needs of caribou.

The ID Team problems with terminology and descriptions of habitat point up the need for silviculturists to be actively invovled in designing sampling systems for all resource objectives, if they are going to help write prescriptions to meet multiple resource objectives. An effort is being made to be involved in developing the study design for ongoing research in caribou habitat needs. This process needs to be formalized.

DISCUSSION

We started out talking about the development of the practice of silviculture. What can this whole story about caribou teach us? Well, the coming buzzword in the Forest Service seems to be "integrated management." The emphasis with integration is that the needs of all the resources are upfront in the management process. Well, this caribou example can show us what problems we still have to overcome, and how we might approach those problems.

It's always easier to criticize the other guy, and since I'm a silviculturist, I'll start by pointing out some problems I've seen with other resource specialists that surfaced at times in working on caribou management. For good historical reasons, some resource specialists feel they have a cause ("save the animals", "save the fish", etc.) and that foresters are the enemy. Because there is a cause, there is often a lot of peer pressure amongst these specialists to present a united front, and not enter into true dialog with foresters. Because uncertainty has been used as a weapon against them in the past, other resource specialists may be defensive when people outside their specialty begin asking too many pointed technical questions. Because they haven't had support in the past, other resource specialists are reluctant to realize the limitations of their specialty. Wildlife biologists may know a lot about animals, but they may need help when it comes to interpreting and manipulating the forest environment.

Now for some self-criticism. If other resource specialists have the short-comings I just outlined, at least in part, it's because of the lack of support they've received in the past. Many silviculturists have not honestly accepted that other resource goals can be every bit as legitimate as timber management. Many silviculturists have been more critical about the technical shortcomings of other disciplines than they have been about their own technical shortcomings. There has been a lack of true interest and involvement in providing as much help to other resources as we provide to timber production. And there has been a lack of an honest dialog with other resource specialist. Again, there are good historical and organizational reasons why all this has gone on. But, if we are serious about integrated management, this must change.

We need to realize that silviculture is not synonymous with intensive timber production. We must truly accept that other resource concerns are as legitimate as timber and we must be willing to accept management schemes that do not maximize timber production. But we must also be able to quantify what potential timber production is lost, and demand that other resource specialists can quantify their losses and gain, so that we can evaluate trade-offs. We should develop the same expertise in producing wildlife habitat as we've got in producing high yielding stands. To be serious about this, we need to devote the same effort in other resource areas as we devote in the timber field, right from the beginning. We must become applied forest biologists capable in a variety of resource fields.

Getting involved in the management of all resources means starting right at the beginning. We all recognize that precision of terminology and good data are necessary to solve biological problems. Once the terminology is clarified, a good inventory or stand exam is necessary to write a good prescription for any resource. As we learned when attempting to write caribou prescriptions, regardless of the ultimate management objective, if a forested ecosystem is going to be managed, a silviculturist should be invovled in the sampling design for that ecosystem. And the caribou example also showed that once it's time to design a management scheme, a good prescription process is an aid in applying that data. Elements of a good prescription process are: 1) management objectives for all resources; 2) a physical and biological description of the site to be managed; 3) a description of the target stand for that site (in relation to the management objectives); and 4) a treatment or alternative treatments necessary to produce that target stand on that site.

We must be willing to enter into honest dialog with other biological specialists. We should be honest about the limits of our expertise (how much do we understand about the interaction of root rots and thinning on future timber yields?), and about the sensitivity of our theory (what is the effect on yield of extending rotations a decade or two past the culmination of mean annual increment?). We should expect critical technical questions from biological experts with other specialties, and we should answer them precisely, not with handwaving about professional judgement. We should also ask serious technical questions of wildlife biologists, soil scientists, etc., and expect precise non-defensive answers. However, for this to come about, we need to develop the attitude that we're all working together for the mutually best solution, rather than probing for each others weaknesses.

Our experience with caribou highlighted some of the changes we need to make, and possible ways to make those changes. With the demands being made on national forests these days, there is a need for "applied forest biologists" who know how to meet a diversity of resource demands in a forest environment. With their understanding of forest ecology, silviculturists are uniquely qualified to move beyond being timber growing specialists, and to become those applied forest biologists. And, in making this professional leap, silviculturists can end the wastful process of doing single resource management with one hand, and then turning around and trying to "mitigate" it with the other hand. Silviculturists can work with other resource specialists to become more knowledgeable about wildlife, fish, recreation, etc, as part of their basic fund of knowledge. They can become invovled with the management of those resources early enough so that data gathered for those resources makes sense in terms of forest ecosystems. And silviculturists can use our prescription process as a tool that over-comes fuzzy thinking, and results in biologically sound multi-resource management.

APPENDIX A

CARIBOU HABITAT MANAGEMENT GUIDELINES
FEBRUARY 1, 1986

Management Goals -
Goal is to produce a proper mix of seasonal habitats needed to support the National Forests' share of a recovered caribou population. Where necessary, this will be done by vegetative manipulation. Growth and production of commercially valuable wood products will occur where consistent with this goal.

SEASONAL HABITATS:

SUMMER -

Physical Site -
- 20%+ slopes
- Lower 2/3 of slope, with valley bottoms and lower 1/3 of slopes preferred; does not include primary and secondary ridgetops
- All aspects
- Subalpine fir habitat type series, with most use in ABLA/CLUN, ABLA/MEFE, ABLA/RHAL, ABLA/STAM habitat types

Target Stand -
- Overstory predominantly spruce/subalpine fir mixture
- Mature stand
- 40-70% crown closure
- 14"+ average dbh of dominant and codominant trees
- Understory includes abundant *Vaccinium*, forbs, grasses, and sedges

Treatments

Even-aged Management:
- A minimum of 25% of these physical sites will be maintained in target stand condition at all times.
- Maintain stocking controls so that canopy closure remains between 40 and 70% when stand is in the sawtimber size classes (precommercial thinning and at least 1 commercial thin will generally be necessary).
- Regeneration harvest:
  - prior to stand becoming overmature (if there is a problem in age class distribution that prevents meeting the 25% minimum in target stand condition at any given time, fill in with overmature stands before initiating regeneration harvest)

- will not generally occur prior to time that average diameter of dominants and codominants has exceeded 14" for at least 1/4 of the rotation;
- rotation will generally be in 120-160 year range.

- Site preparation - light broadcast burn generally preferred to encourage Vaccinium regeneration (spring burns desireable where feasible); avoid dozer piling; protect Vaccinium rhizomes.
- Regeneration will favor spruce/subalpine fir. Planting is an alternative. Consider likelihood of natural subalpine fir regeneration of these sites. Lodgepole is not desireable.

LATE SUMMER / RUT

Physical Site -

- 0-20% slopes
- Valley bottoms, benches, and lower 1/3 slope
- North aspects favored, but all aspects will be used.
- Subalpine fir habitat type series, with most use in ABLA/STAM, ABLA/CACA, ABLA/MEFE, and ABLA/RHAL habitat types.
- Seeps, basins, and riparian areas are key.

Target Stand -

- Overstory predominantly spruce/subalpine fir
- All aged stand
- 40-100% crown closure in trees greater than 30 feet tall
- Overstory dominants and codominants 21"+ DBH
- Understory includes abundant Vaccinium, forbs, sedges, and evergreen forbs and shrubs.

Treatments -

Uneven-aged Management:

- Maintain canopy closure between 40 and 100% in trees over 30' tall.
- Approximate 20 year re-entry cycle.
- set upper diameter cutting limit to maintain a significant component of 21"+ trees in overstory canopy classes.
- Both individual tree and group selections are suitable.
- Use precommercial thinning to avoid developing dense thickets of regeneration (goal is to maximize diameter growth within canopy closure limits).
- Avoid fuels buildups that inhibit free movement of caribou
- Spot site preparation that protects thin-barked spruce/subalpine fir.

- Site preparation and other treatments will favor Vaccinium and development of forbs, sedges, and evergreen forbs and shrubs.
- In stands that are presently even-aged, very light cuts on initial entry may be necessary to initiate this management scheme.

LATE WINTER -

Physical Site -
- 0-40% slopes on south and west aspects; 0-15% slopes on north and east aspects.
- Upper 1/3 of slopes and ridgetops
- Subalpine fir and high elevation habitat type series, with most use in ABLA/XETE, ABLA/LUHI, PIAL-ABLA, LALY-ABLA habitat types.
- Many sites are not capable of producing wood products or are non-forest sites.
- Open stands on primary and secondary ridges are key.

Target Stands -
- Subalpine fir, spruce, and whitebark pine dominate
- Immature to over- mature stands
- 10-50% crown closure
- 8"+ average dbh on dominant and codominant trees
- Lichens necessary

Treatments -
- These sites are calving habitat during June to mid-July; disturbance will be restricted during this time period.
- The majority of these sites are outside of commercial timber production areas, and timber management activities are not anticipated. Natural processes generally produce the target stands desired. A few of these stands may occur of lands that are tentatively suitable for timber managment, and uneven-aged management will take place there.

Uneven-aged management:
- Maintain canopy closure between 30 and 50% in trees over 20' tall.
- 20+ year re-entry cycle.
- Upper diameter cutting limit set to maintain a significant component of 8"+ DBH trees in overstory crown classes.
- Both individual tree and group selections are suitable.

- Use precommercial thinning to avoid developing dense thickets of regeneration (goal is to develop open stand with maximum lichen growth on trees at levels that can be reached by caribou on winter snow pack).

SPRING -

Physical Site -

- All slopes are used, although 0-35% slopes are key.
- Lower 1/3 of slope and valley bottoms used heavily, with minor use on upper slopes.
- South and west aspects are key.
- Hemlock and cedar habitat type series.

Target Stand -

- Tree species composition not important.
- Early successional stages with and without scattered overstory (seedling/sapling stands prior to canopy closure) are key.
- Less than 45% crown closure
- Abundant spring forage available (*Vaccinium*, *Valeriana*, *Streptopus*, *Luzula*, *Lonicera*, *Bromus vulgaris*, etc).
- 0-25 years following major distrubance should provide good spring range.

Treatments -

- 40% of the cedar/hemlock zone in caribou habitat will be managed as spring range, with priority given to south and west aspects.

Even-aged management:

- Site preparation by prescribed burning to maximize early forage response.
- Natural or artificial regeneration both suitable
- Precommercial thin early to maintain good forage production for at least 25 years.
- 80 year rotations
- Area control so that within each caribou management unit, approximately 25% of sites being managed as spring range (emphasis on south and west aspects) meet spring target stand condition at any time.
- In the cedar/hemlock zone, where there is a conflict between meeting spring range and early winter range targets, early winter range needs will have priority.

EARLY WINTER -

Physical Site -

- Slopes less than 80% used; 0-40% slopes preferred.
- Middle and lower 1/3 slopes are key; all are used
- Hemlock and cedar habitat types, including ecotone with subalpine fir zone.
- North and east aspects key (south and west aspects in these habitat types will also be used, with emphasis on those stands that are already approaching target stand condition).

Target Stands -

- Overmature and old growth stands - all-aged stands (climax forest) - - these are key - mature stands may be useable if other attributes are all present.
- More than one canopy layer is desireable.
- Hemlock and cedar overstory in major part of the cedar/hemlock zone; variable amounts of subalpine fir/spruce in overstory at the ecotone.
- Greater than 70% crown closure in trees greater than 30' tall.
- Dominant and codominant trees average greater than 21" dbh minimum, and greater than 30" is desireable.
- Major goal is stand structure that minimizes early winter snow depths.
- Edge effect to provide forage may be beneficial where it does not significantly detract from other attributes.
- Lichen availability beneficial

Treatments -

- Existing old growth all-aged stands that meet target stand conditions will not be entered for at least the first two decades. Target is 60% of cedar hemlock zone in old growth cedar/hemlock cover types (with a subalpine fir/spruce component at the ecotone). Optimum level management for caribou would actively pursue converting seral species to cedar/hemlock cover types through even-aged or uneven-aged management. If cedar hemlock are not on the site, and it is the fastest way to attain target stand conditions, some type conversion may require even-aged harvest systems, and may include planting of desired species. Where uneven-aged management is the most efficient way to reach target stand conditions, the following guidelines will be applied.

Uneven aged Management:

- Over most of the area, maintain greater than 70% crown closure in trees taller than 30 feet.
- Approximately 20 to 30 year re-entry cycle
- Both group and single tree selections are applicable, with groups less than 1 acre in size
- Precommercial thinning in groups will generally be 10x10' or tighter to encourage understory canopy developement and minimize early season snow depths.
- Site preparation generally not necessary
- Slash disposal may be necessary to reduce travel barriers; any burning must protect young cedar and hemlock components.

- Late fall/early winter logging desireable
- Treatments should encourage stand dominated by hemlock and cedar
- Target stand has a significant overstory component in 30"+ trees; set upper diameter cutting limit to meet this goal.

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SILVICULTURE IN GRIZZLY BEAR HABITAT

by

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In recent years, grizzly bears have become a topic of considerable interest and controversy for public land managers, user groups, and environmentalists. For the silviculturist who is expected to provide healthy, productive forests as well as vegetative conditions favorable to the bear, grizzly bear habitat management can be challenging and complex, and at times, frustrating. My purpose in this paper is to discuss these challenges, and examine some of the ways that the silviculturist can respond to them.

I. Endangered Species Act

Since 1975, the grizzly bear (Ursus arctos l.) has been listed as a threatened species under the Endangered Species Act of 1973. The species now occupies portions of Montana, Wyoming, Idaho, and Washington on about 1% of its original range in the lower 48 states. The vast majority of the current range of the grizzly is on federal land, in National Parks and Forests. There are six identified grizzly bear ecosystems in the United States today, excluding Alaska. The Kootenai National Forest contains portions of the Northern Continental Divide ecosystem and the Cabinet/Yaak ecosystem. Most of my comments apply to the Kootenai National Forest and the Cabinet/Yaak ecosystem.

Under the Endangered Species Act, the Federal Agency with jurisdiction on the land, in this case the Kootenai National Forest, is responsible to ensure that all activities which it carries out, provides funding for, or authorizes on the National Forest are done in a manner that doesn't jeopardize grizzly bears or adversely affect their habitat. Planned activities in grizzly habitat are subjected to a biological evaluation in order to assess the potential effect on bears or their habitat. If the evaluation can't clearly determine that there will be no adverse effect, then a process of formal consultation with the U.S. Fish and Wildlife Service is begun. In most cases, mitigation measures are applied so that an adverse effect is avoided. In the case of timber sales, these mitigation measures may be timing of activities outside of periods when bears are known to take advantage of habitat components, road and area closures to vehicle travel, habitat improvement projects, or use of displacement areas which provide secure alternative habitat for bears during the life of the planned project.

II. Cumulative Effects Analysis

Rather than considering the effect of one single timber sale or other government project on the bears, it has become desirable to study the cumulative effects of land management activities in time and space on bears and their habitat. Instead of analyzing the cumulative effects on the whole ecosystem, which in the case of the Cabinet/Yaak ecosystem would be 1300 square miles, these effects are studied on smaller bear management units within the ecosystem. Bear management units are geographically identifiable areas averaging about 100 square miles with known seasonal habitat values or components for grizzlies. The assumed average home range of an adult female grizzly is 100 square miles. The cumulative effects model considers habitat values along with the nature, intensity and duration of disturbances and computes a value for habitat effectiveness. If this value, upon analysis, drops below a threshold level, then habitat effectiveness would be considered to be lower than needed to allow recovery for grizzly bears. Using this analysis process then, activities such as timber sales may be prioritized within bear management units, and scheduled so that too many activities are not taking place concurrently in the same or adjacent areas, and the overall habitat effectiveness of the unit is not reduced below threshold level.

III. Recovery

In addition to this relatively negative, legalistic approach to grizzly bear habitat management, the Forest Service, along with other Federal and State agencies, is committed to recovering viable populations of grizzlies within identified ecosystems. Interagency guidelines for management of grizzly bears and their habitat have been prepared for the concerned National Forests and National Parks, and the States of Idaho, Montana, Washington and Wyoming. The plan for recovery of the grizzly bear includes the following:

1. Direct Habitat Improvement
2. Public Education
3. Law Enforcement
4. Augmentation of bear populations where suitable habitat exists

In the Cabinet/Yaak ecosystem, a viable recovered population is now considered to be 70 to 90 bears. The current population is estimated to be less than 20 bears.

IV. Forest Planning: What is the effect of grizzly bear management on allowable harvest?

In the analysis of timber outputs in the Forest Plan, harvest is limited to 8.3% of area in grizzly habitat per decade. This harvest constraint is applied to about 70% of the regulated timber base on the Kootenai. On areas that are specifically allocated to grizzly bears and timber management in the Forest Plan, thinnings are allowed, but not entered into the FORPLAN runs, because of scheduling problems. Therefore, yields calculated for these areas are somewhat reduced from the maximum attainable under optimum timber management. This reduction applies to about 15% of the regulated timber base.

V. Discussion of Specific Habitat Needs of Grizzly Bears

A. Feeding

Grizzlies are omnivorous animals, but the greatest part of their diet is plant foods. They range widely to areas where food can be found in abundance. Most of their foods are found in areas that are at least seasonally wet or moist. Typically, grizzlies are at low elevations in the spring, where they feed on grasses, sedges, and forbs in floodplains, riparian areas, snowchutes, and revegetated roadsides. In the spring, only a small portion of their total habitat is available to them. With summer season, grizzlies shift to feeding on succulent

SCIENTIFIC AND COMMON NAMES FOR KEY BEAR FOODS in the CABINET/YAAK ECOSYSTEM

SCIENTIFIC NAME	COMMON NAME
Trees	
Pinus albicaulis	Whitebark pine
Shrubs	
Amelanchier alnifolia	Serviceberry
Cornus stolonifera	Red-osier dogwood
Rosa spp.	Wild rose
Shepherdia canadensis	Buffalo-berry
Sorbus scopulina	Mountain ash
Vaccinium globulare	Blue huckleberry
Vaccinium scoparium	Whortleberry
Forbs	
Angelica spp.	Angelica
Athyrium filix-femina	Lady fern
Equisetum spp.	Horsetail
Erythronium grandiflorum	Glacier lilly
Hedysarum spp.	Hedysarum
Ligusticum spp.	Licorice root
Lomatium spp.	Biscuit root
Osmorhiza spp.	Sweet-cicely
Taraxicum spp.	Dandelion
Trifolium spp.	Clover
Veratrum viride	False hellebore
Graminoids	
Carex spp.	Sedges
Graminae spp.	Grasses

forbs in riparian areas, and on berries as they become available. They also seek out high elevation meadows and open, grassy timber stands for grasses and sedges during the summer. Grizzlies tend to move back to lower elevations in the fall, where they feed on remaining berries, roots, forbs, and grasses and sedges in flood plains. There is considerable indication in some areas, including the Kootenai National Forest, that the availability of berries (i.e., vaccinium, shepherdia canadensis, sorbus spp.) is important to winter survival and reproductive success in bears.

Seral plant communities which originate from wildfires provide many of the key grizzly bear foods in northwestern Montana. It is hoped that, in the absence of the large wildfire burns that were present until the last 50 to 60 years, silvicultural methods will provide similar plant communities. On many logged sites, the same bear foods are found in abundance. Habitat improvement projects include prescribed burns in areas not allocated to regulated timber harvest.

B. Security

Grizzly bears, having no natural enemies other than humans, have adapted poorly to human presence in their habitat. Some of the things which have reduced effective grizzly habitat in the recent past are: gas, oil, and mineral exploration, rural subdivisions, summer home development, and timber harvest activities. Timber sales have had a negative impact on grizzlies because of extensive road systems which remain open to the public long after the sales are closed, frequently repeated entries, and in some cases, damage to habitat components.

Important areas to retain security or hiding cover are adjacent to key feeding areas, such as wet meadows, riparian areas, alpine meadows, avalanche chutes, and berry fields, and along travel corridors, such as ridge tops and stream bottoms. Security is also provided by limiting the frequency and duration of human presence near key habitat. In the Kootenai Forest Plan, a goal is to achieve an average of 3/4 of a mile of road that is open to the public for each section of land within grizzly bear management units. In many cases, road closures that are enforced for the public also must be applied to Forest Service activities, such as stand exams or reconnaissance surveys.

VI. Specific Silvicultural Considerations under Grizzly Bear Habitat Management

A. Silvicultural System

In general, silvicultural systems which require less stand tending throughout the rotation are favorable in that there are fewer disturbance creating entries, and roads can stay closed for longer periods of time. Also, systems are preferred in which seral plant communities are developed or maintained, and mosaic patterned forests of interspersed forage and cover are developed. For these reasons, even-aged management systems are preferred over selection systems for uneven-aged management. An exception to this might be in the management of riparian areas, where it may be desired to retain cover over long periods of time. Another exception could be on wet sites, where a change in the water table resulting from complete canopy removal could adversely affect desirable forage plants.

B. Site Preparation Method

The method used to prepare the site for regeneration is usually important in determining how the seral community develops, and what plant species are favored. On moist or wet sites, desirable grizzly bear forage species such as cow-parsnip (Heracleum lanatum), angelica, and wet site grasses and sedges are very sensitive to soil compaction or severe soil disturbance which may be caused by mechanical scarification. On upland sites, many of the berry producing shrubs reproduce well vegetatively and poorly by seed. This is true of blue huckleberry and mountain ash, two important grizzly food producers. These plants are often among the first to resprout after a wildfire. As long as the duff is not so dry that it is consumed to a great extent, the rhizomes of blue huckleberry will resprout quickly after fire. Although the berry producing shrubs are often favored by fire, mechanical scarification, especially if applied uniformly, can be very damaging to these plants. If dozer piling is done, the result often has been that berry producing shrubs are uprooted, and their importance on the site is greatly reduced. Clearcutting or heavy partial cutting without any site preparation, in situations where vaccinium is already established, may actually result in the best shrubfield development.

When choosing site preparation method, there is often a conflict between grizzly bear forage needs and reforestation requirements. If would be easy to say that broadcast burning is always the method of choice, but there are several factors which limit the use of broadcast burning. Some of these are:

- Lack of post logging fuels to carry a successful burn
- Limited number of days when burning can meet the prescribed results
- Lack of personnel to do all the burning when the conditions are right
- Economics - Mechanical scarification is often less expensive, especially if it is a requirement of the timber purchaser.
- Smoke Management - Usually further reduces the number of days when burning can be done.

If tradeoffs are made, usually the sites with the most potential for berry production are scheduled for broadcast burning. Other areas may be planned for mechanical scarification, if soils are not susceptible to compaction, and slopes are not generally over 35 per cent. Dozer scarification can be modified by using a brush blade, and by attempting to reduce the amount of scarification to the minimum necessary to achieve the prescribed stocking level. There are other site preparation tools that may be helpful in reducing the total amount of disturbance in gentle to moderately steep slopes, if there aren't large amounts of logging slash. These include patch scarifiers, such as the Leno scarifier, or other scarifiers mounted to the blade or drawbar of the prime mover. Another tool to be considered is the drag chain scarifier, although its effectiveness in brushfields has not yet been proven.

C. Regeneration Method

In many cases where development of grizzly foods is being encouraged by a light application of site preparation, the choice of natural regeneration is limited. In stands where there is already a developed shrub canopy, attempts to burn to prepare the site for natural seeding are often unsatisfactory. The choice of planting may be necessary in order to meet the stocking objectives for timber management, and to get seedlings established in the developing shrubfield.

D. Harvest Unit Size, Shape, and Placement.
The general objective for timber management in grizzly bear habitat is to have interspersed forage and cover, with at least 30% of the area in hiding and thermal cover. Cover is generally not a problem on the Kootenai, because of the heavily forested nature of the area. Key grizzly use areas, such as avalanche chutes, meadows, and riparian areas need to be avoided, and should have areas of security cover adjacent to them. Shaping of units is used wherever possible to increase the amount of "edge" or boundary, and make forage areas more effective. In order to allow for effective cover, a minimum of 600 feet in uncut corridors between harvest units is the standard on the Kootenai National Forest in grizzly bear habitat. In planning unit placement, travel corridors need to be considered, so that cover may be maintained along them. Cutting along both sides of a main ridge, for example, would be avoided.

VII. Summary

The grizzly bear, under the protection of the Endangered Species Act, offers some unique challenges to the silviculturist. Special requirements for grizzly bear habitat such as feeding and security must be considered when preparing silvicultural prescriptions. Silvicultural activities must be scheduled so as to minimize disturbance to the bears, and access to areas in grizzly bear habitat may be difficult because of road closures. Grizzly bear habitat requirements need to be considered in selection of silvicultural systems, site preparation for reforestation, reforestation method, and harvest unit size, shape, and location. After the loss of effective habitat that the grizzly has endured in the last century, our efforts to retain a viable population in the few remaining grizzly bear ecosystems appear to be worthwhile.

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APPENDIX:

AN EXAMPLE OF A SILVICULTURAL PRESCRIPTION

FOR TIMBER HARVEST IN KEY GRIZZLY BEAR HABITAT

SILVICULTURAL PRESCRIPTION
UNIT 2, HI HARE SALE
PARENT STAND NO. 410-4-10

PREPARED BY: J.C.REICHERT
DATE: 1/14/87

I. EXISTING CONDITIONS

A. SITE DESCRIPTION

MANAGEMENT DIRECTION MA 14 TGRIZ - MAINTAIN OR ENHANCE HABITAT FOR GRIZZLY BEAR, REDUCE HUMAN/BEAR CONFLICT, AND ASSIST IN BEAR RECOVERY, WHILE PROVIDING FOR A PROGRAMMED LEVEL OF TIMBER PRODUCTION.

STAND ACRES 104 TREATED ACRES 12
SLOPE 20-40% HABITAT TYPE WH/CLUN ELEVATION 4800-5000' ASPECT NW
SOILS AND LANDTYPE DEEP GLACIAL TILL, WITH ABOUT 12" LOESS CAP. LANDTYPE GROUP IS 352, GLACIALLY ROUNDED VALLEY SIDESLOPES, ON NORTH ASPECT.

B. PRESENT STAND

DENSITY(BA/A) 220 (TREES/ACRE<7") 346 (TREES/ACRE>7") 89
VOLUME(MBF/ACRE) 40 PAI(CUBIC FT/ACRE/YR) 120

SPECIES COMPOSITION MIXED SPECIES STAND OF 30% WESTERN LARCH, 20% RED CEDAR, 10% WESTERN HEMLOCK, 15% DOUGLAS-FIR, AND REPRESENTATION OF WHITE PINE, SUBALPINE FIR, ENGELMANN SPRUCE, AND GRAND FIR. UNDERSTORY IS PRIMARILY RED CEDAR, WESTERN HEMLOCK, SUBALPINE FIR, AND GRAND FIR.

STRUCTURE SAWLOG SIZE STAND WITH A FAIRLY DENSE OVERSTORY CANOPY.

AGE CLASSES OVERSTORY IN THIS UNEVEN-AGED STAND RANGES IN AGE FROM 100 TO 200+ YEARS.

STAND HISTORY THERE HAVE BEEN NO PREVIOUS HARVEST ENTRIES IN THIS STAND.

CONDITION MATURE STAND, WHICH IS BEGINNING TO BE AFFECTED BY LARCH DWARFMISTLETOE AND INDIAN PAINT FUNGUS IN HEMLOCK AND GRAND FIR. A LIGHT INFECTION LEVELS OF WHITE PINE BLISTERRUST IS ALSO PRESENT.

UNDERSTORY VEGETATION IS PATCHY, DUE TO OVERSTORY CANOPY. PATCHES OF DEVELOPED SHRUB LAYER CONSIST OF BLUE HUCKLEBERRY, MENZIESIA, RIBES, AND MOUNTAIN MAPLE. OVERALL SHRUB COVER IN THE STAND IS ABOUT 20%. HUCKLEBERRY PLANTS ARE GENERALLY SMALL AND UNPRODUCTIVE DUE TO SHADE.

EXISTING FUEL LOADING 16 TONS PER ACRE, WITH DUFF DEPTH OF 2 TO 3 INCHES.

ADJACENT STAND 15 ACRE STAND 410-4-04, TO THE NW, WAS CLEARCUT IN 1962, HAD NO FUEL TREATMENT. STAND IS WELL STOCKED, IS IN HIDING COVER, AND HAS ABOUT 30% COVER IN VACCINIUM, WITH GOOD BERRY PRODUCTION IN MOST YEARS.

II. DIAGNOSIS OF TREATMENT NEED

A. TREATMENT GOAL: AN EVEN-AGED STAND WHICH AT 130 YEARS OF AGE HAS 250 SQUARE FEET OF BASAL AREA AND PROVIDES A MEAN ANNUAL INCREMENT OF 90 TO 100 CUBIC FEET PER ACRE PER YEAR. SPECIES COMPOSITION SHOULD BE APPROXIMATELY 25% WHITE PINE, 25% WESTERN LARCH, AND 25% DOUGLAS FIR, WITH THE REMAINDER IN SHADE TOLERANT SPECIES. STAND SHOULD PROVIDE FORAGE (HUCKLEBERRIES) FOR GRIZZLY BEARS IN EARLY DEVELOPMENTAL STAGES, WITH ABOUT 30% SHRUB COVER IN HUCKLEBERRY. STAND SHOULD BE IN HIDING COVER BY AGE 20

B. ALTERNATIVES CONSIDERED: 1. REGENERATE BY CLEARCUTTING, 2. REGENERATE BY SEED TREE CUTTING.

C. LOGICAL TREATMENT SEQUENCE:

	REGENERATE BY CLEARCUTTING		REGENERATE W/ SEED TREES
YR 0	CLEARCUT, 40MBF/A $60/M	YR 0	SEED CUT, 37MBF/A $60/M
YR 1	BROADCAST BURN, SITE PREP $200/AC	YR 1	UNDERBURN, SITE PREP $200/AC
YR 2	HANDPLANT, 538 TREES/A $240/AC	YR 4	FILL PLANT, 250 TREES/A $200/AC
YR 15	PRECOMMERCIAL THIN TO 400/A $160/AC	YR 15	PRECOMMERCIAL THIN TO 400/A $160/AC
YR 130	CLEARCUT, 40 MBF/A, B/BURN, HANDPLANT	YR 130	SEED CUT, 37 MBF/A, U/BURN, FILL PLANT

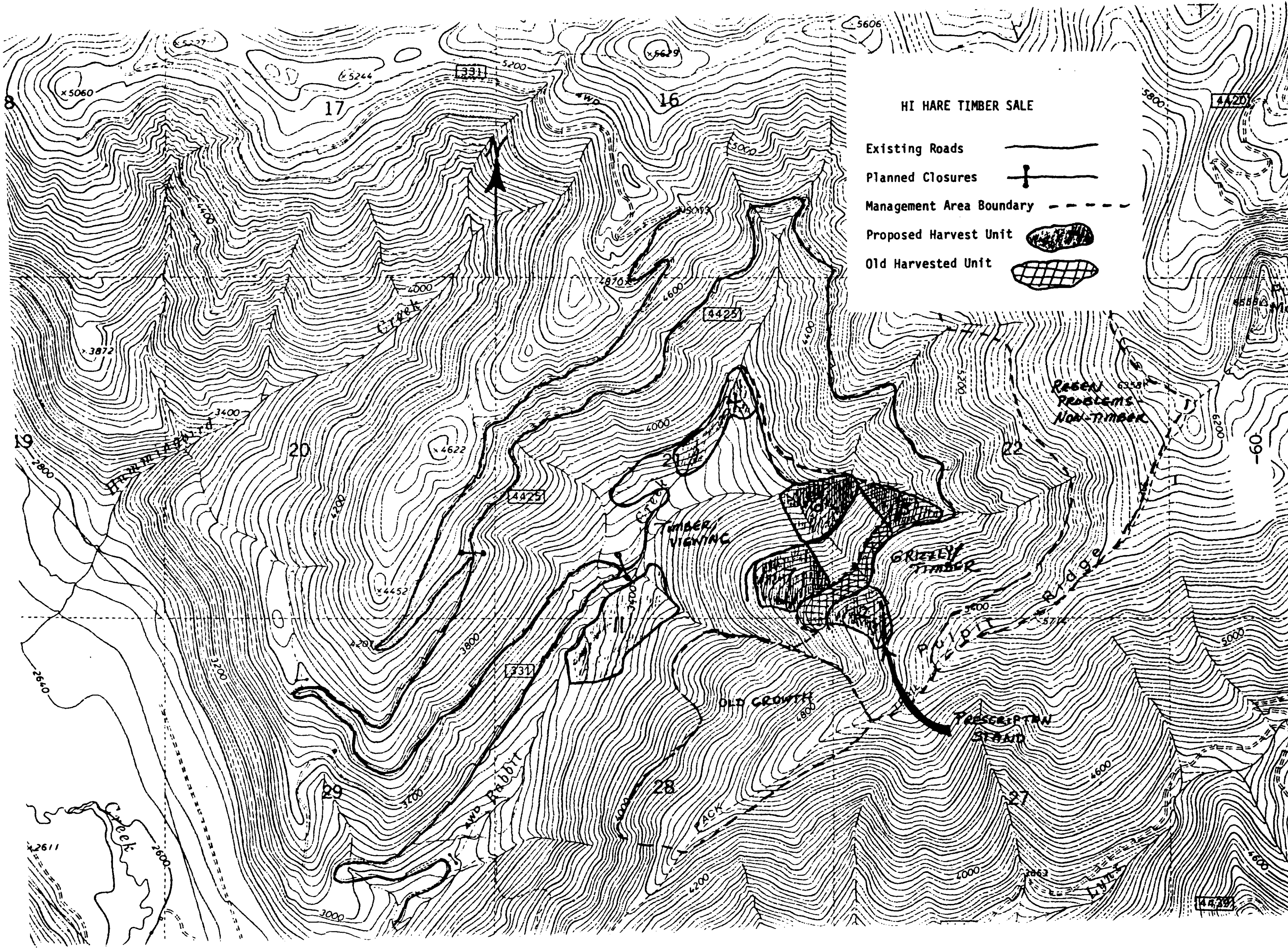
ECONOMIC COMPARISON @ 4% DISCOUNT RATE (ASSUMPTIONS: NO REAL UNIT COST OR VALUE INCREASE OVER TIME)

DISCOUNTED BENEFITS:	$2322	$2148
DISCOUNTED COSTS:	$ 486	$ 436
PNV:	$1836	$1712

D. PREFERRED ALTERNATIVE: ALTERNATIVE 1 IS PREFERRED. FILL PLANTING IS EXPECTED UNDER SEED TREE ALTERNATIVE, BECAUSE OF LIGHT SITE PREP NEEDED TO FAVOR HUCKLEBERRIES. NO SEED TREE REMOVAL PLANNED UNDER MANAGEMENT GUIDANCE (1 COMMERCIAL ENTRY PER ROTATION).

F. DETAILED PRESCRIPTION SUMMARY:

ACTION	TIME	SPECIFICATIONS
HARVEST	YR 0	CLEARCUT, TRACTOR LOG WITH DESIGNATED TRAILS. LEAVE SNAGS AND SNAG CANDIDATES, PER KOOTENAI SNAG GUIDELINES, PREFERABLY NOT HEAVILY MISTLETOED LARCH.
SITE PREP AND FUEL TREATMENT	YR 1	BROADCAST BURN. SITE PREP OBJECTIVES ARE AN AVERAGE DEPTH OF DUFF OF 1" TO 2", UP TO 10% EXPOSED MINERAL SOIL, AND 10 TO 15 TONS PER ACRE OF LARGE RESIDUAL FUELS AFTER BURNING. (LOWER DUFF SHOULD GENERALLY REMAIN INTACT SO THAT HUCKLEBERRY RHIZOMES ARE NOT KILLED BACK)
REFORESTATION	YR 2	PLANT 538 TREES PER ACRE OF WL, DF, AND WP (F2 RUST RESISTANT STOCK) IN EQUAL PROPORTIONS. USE 2-0 BAREROOT STOCK. PLANT WITHIN 1 SEASON OF BURNING SO TREES CAN GET ESTABLISHED ABOVE THE SHRUB LAYER.
EXAMS	YRS 3, 5, 7	DESIRED STOCKING LEVEL IS 400-600 CROP TREES PER ACRE, WITH THE MINIMUM ACCEPTABLE BEING 350, AND WITH 80% OF 100TH ACRE PLOTS BEING STOCKED. ROAD #4425 WILL BE CLOSED TO VEHICULAR TRAFFIC, SO NEED TO PLAN ON COST OF 3 MILE WALK IN.
PRECOMMERCIAL THINNING	YR15-20	MAY BE SCHEDULED DEPENDING ON OTHER SALE ACTIVITY IN THE AREA. THIS MAY NOT BE NECESSARY DUE TO LIMITED NATURAL SEEDING.


HI HARE TIMBER SALE
Existing Roads
Planned Closures
Management Area Boundary
Proposed Harvest Unit
Old Harvested Unit
TIMBER/VIEWING
GRIZZLY TIMBER
OLD GROWTH
PRESCRIPTION STAND
REGEN PROBLEMS NON-TIMBER
Hummingbird
Creek
Rabbit
Pulpit Ridge
331
4425
4420
4429
8
16
17
19
20
22
27
28
29

SILVICULTURAL PRESCRIPTIONS

FOR THE

MANAGEMENT OF BALD EAGLE HABITAT

WITHIN THE

EATON BUTTE BALD EAGLE MANAGEMENT AREA

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Abstract

Habitat management within Bald Eagle Management Areas can be enhanced and improved through the utilization of silvicultural treatments. Existing stand conditions must be assessed prior to determining Management Area treatments. More important, however, is the need to develop guidelines and objectives to utilize during the decisionmaking process for management of the existing stand conditions. Silvicultural treatments which have proven to be very successful are precommercial thinning, commercial thinning, and regeneration systems which include shelterwood. As with many silvicultural treatments, benefits are realized in the long term. When considering the benefits of silvicultural prescriptions within Bald Eagle Management Areas, given the guidelines, objectives, and length of rotations, the term "long-term benefits" acquires a new definition - patience.

Presented at the 1987 National Silvicultural Workshop, Sacramento, California, May 11-14, 1987.

I. INTRODUCTION

The USDA, Forest Service is required to provide for the protection and enhancement of Bald Eagle populations through public awareness programs, cooperation with other agencies, land management planning, and wise resource management. Along with the protection and enhancement of this population comes the management of its habitat - nesting, roosting, and foraging grounds. This management has historically been through avoidance, light salvage or partial cutting, or prohibiting harvesting within the core nesting area. This direction or approach of management may provide for a short-term benefit when dealing with just the existing population, but fails to address the long term enhancement of bald eagle populations through habitat improvement. Due to the disturbance of the natural ecological cycle, harvesting of mature trees, and encroachment of humans it has become apparent to wildlife biologists and silviculturists that the management of Bald Eagle Management Areas must include the manipulation of stands of trees, and not just restricted to preservation.

On the Deschutes National Forest approximately 22,000 acres have been designated for the protection and enhancement of Bald Eagle populations and their habitat. Of these 22,000 acres approximately 75 percent (16,500 acres) are classified as Ponderosa Pine Plant Communities (Volland, 1985).

In addition to having high value from a Bald Eagle management standpoint, these acres presently support and can potentially support another high value resource - timber. These ponderosa pine Bald Eagle Management Areas presently support approximately 15 MBF per acre of high value immature and mature ponderosa pine. This accounts for approximately 246 MMBF of high value immature and mature ponderosa pine. On the Bend Ranger District there are approximately 8,000 acres in 13 Bald Eagle Management Areas which are predominantly composed of immature and mature ponderosa pine (Pinus ponderosa).

II. EATON BUTTE BALD EAGLE MANAGEMENT AREA

This Eaton Butte Bald Eagle Management Area is located on the Deschutes National Forest, Bend Ranger District, in Deschutes County, Oregon. This area lies on Eaton Butte, east of Wickiup Reservoir, which is used for recreational boating, fishing, and water storage for irrigation and domestic water usage. Approximately 844 acres have been designated to be managed for long-term maintenance of Bald Eagle nesting habitat. There are presently 329 acres of mature ponderosa pine and mixed conifer forests that dominate the north half of Eaton Butte. The higher slopes have a mixture of mature white fir (Abies concolor), sugar pine (Pinus lambertiana), Douglas-fir (Pseudotsuga menziesii), and ponderosa pine (Pinus ponderosa). Ponderosa pine density increases as elevation decreases to almost pure pine in the lower third of the slope. Timber harvesting within this area has been limited to removal of high risk and salvage immature and mature ponderosa pine, white fir, sugar pine, and Dougas-fir trees. Other timber harvests have included 59 acres of patch clearcuts in 1979 and a commercial thinning 15-20 years ago on 94 acres of intermediate age ponderosa pine (Milano, 1985).

Two hundred and eleven acres of the management area were recently acquired in a land exchange. This area encompasses the southwestern portion of the management area. It was heavily logged while in private ownership and is in its early successional stages.

This Bald Eagle Management Area was created in 1982 after two Bald Eagle nests were discovered during aerial reconnaissance. In 1983, a third nest was added to this territory. Table 1 depicts these three nests status since 1981.

Table 1
Eaton Butte Nest Status

Nest	Nesting History (Years)					
	1981	1982	1983	1984	1985	1986
62	--	ALT	IN	IN	IN	IN
63	--	OC	IN	IN	OC	IN
66			IN	IN	IN	IN

ALT = Nest is one of two or more used by a nesting eagle pair.

OC = Eagles using nest, no eggs or young present in nest.

IN = Inactive nest, serving as alternate.

-- = Status unknown, but assumed nest present.

III. MANAGEMENT OBJECTIVES AND SILVICULTURAL TREATMENTS

A. Management Objectives

The Deschutes National Forest Draft Land Management Plan proposes Bald Eagle Nesting Habitat Management Areas (BEMA) be managed to provide a continuous supply of available acreage which meets the parameters described for bald eagle nesting habitat. These parameters were adopted from research conducted in northern California of 95 Bald Eagle nest sites (Robert Lehman, 1980).

Deschutes National Forest silviculturists and wildlife biologists developed a management scenario and managed yield table (Figure 1) which would provide for a minimum of 13 percent of the habitat management area being suitable for bald eagle nesting at any point in time. The remainder of the management area would be in equal percentages of various age classes from seedling to mature forest stands. This scenario is based on predicted stand conditions from managed yield tables for ponderosa pine habitat. Management is based on a 345 year stand rotation that requires a progressive series of precommercial and commercial thinnings, shelterwood, and final overstory removal silvicultural treatments. It is this management scenario which guides the proposed silvicultural treatments.

BEMA Objectives: Proposed silvicultural treatments are designed to:

1. Improve tree growth to meet predicted tree diameters (d.b.h.) for each timber age class.

2. Selectively retain and improve vigor of individual trees with structural characteristics preferred by bald eagles for perching and nesting.

3. Favor tree species most desirable for bald eagle nesting.

4. Reduce tree densities where they are currently in excess of those prescribed for in the managed yield table.

These objectives are tied to the silvicultural treatment activity sequence in Bald Eagle Management Areas (BEMA) which are based on Draft Forest Plan Yield Table 15 (Figure 1).

FIGURE 1: DESCHUTES NATIONAL FOREST
MANAGED YIELD TABLE FOR BALD EAGLE MANAGEMENT

Yield Table Description: The prescribed silvicultural activities produce fast growing stands during the first 115 years. Stand vigor will be maintained during the remainder of the rotation by a series of three commercial thinnings. The characteristic tree with large limbs and open crown should be provided by age 305, where 10 trees per acre will be retained until final harvest.

Stand Data at Two Rotations:	(1) CMAI	Extended to Meet (2) Management Emphasis
Age	115	345
Mean Annual Inc. (CF/A/YR)	44.07	30.58
Total Vol. Production (CF/A)	5,068	10,548
Mean d.b.h. (In.)	21.1	40.7

FIELD DATA

AGE	HT	FC	TOP	DBH ALL	DBH CUT	DBH LV	TPA ALL	TPA CUT	TPA LV	MORT	GROWTH
15	13	0	4	2.1	1.7	2.4	350.0	170.0	180.0	10.0	7.6
45	47	69	4	10.0	10.0	10.0	170.0	60.0	110.0	0.0	1.8
55	55	70	4	11.8	0.0	11.8	110.0	0.0	110.0	0.0	1.3
65	61	71	4	13.1	13.1	13.1	110.0	40.0	70.0	0.0	1.7
75	67	72	4	14.8	0.0	14.8	70.0	0.0	70.0	0.0	1.3
85	72	73	4	16.1	16.1	16.1	70.0	30.0	40.0	0.0	2.0
95	76	74	4	18.1	0.0	18.1	40.0	0.0	40.0	0.0	1.6
105	80	75	4	19.7	0.0	19.7	40.0	0.0	40.0	0.0	1.4
115	83	76	4	21.1	0.0	21.1	40.0	0.0	40.0	0.0	1.1
125	85	76	4	22.2	0.0	22.2	40.0	0.0	40.0	0.0	1.1
135	87	76	4	23.3	0.0	23.3	40.0	0.0	40.0	0.0	0.9
145	89	76	4	24.2	0.0	24.2	40.0	0.0	40.0	0.0	0.7
155	91	76	4	24.9	24.9	24.9	40.0	14.0	26.0	0.0	1.1
165	93	77	4	26.0	0.0	26.0	26.0	0.0	26.0	0.0	1.9
185	95	77	4	27.9	0.0	27.9	26.0	0.0	26.0	0.0	1.4
205	97	78	4	29.3	0.0	29.3	26.0	0.0	26.0	0.0	1.0
225	98	78	4	30.3	30.3	30.3	26.0	9.0	17.0	0.0	2.0
245	99	79	4	32.3	0.0	32.3	17.0	0.0	17.0	0.0	1.6
265	100	79	4	33.9	0.0	33.9	17.0	0.0	17.0	0.0	1.3
285	101	80	4	35.2	0.0	35.2	17.0	0.0	17.0	0.0	1.1
305	102	80	4	36.3	36.3	36.3	17.0	7.0	10.0	0.0	2.4
325	103	81	4	38.7	0.0	38.7	10.0	0.0	10.0	0.0	2.0
345	103	81	4	40.7	40.7	0.0	10.0	10.0	0.0	0.0	0.0

Table 2 represents optimum managed stand conditions for BEMA's through a 345 year rotation schedule. This yield table demonstrates BEMA conditions which the Deschutes National Forest will strive for in the management of the Bald Eagle Management Areas. In order to further illustrate these optimum managed stand conditions, Table 2 has been developed to display overstory age, average d.b.h., leave trees per acre, optimum percentage of age classes within BEMA, and silvicultural treatments.

Table 2
Optimum Managed Stand Conditions (345 Year Rotation)

Overstory Average Age (Years)	Overstory Average d.b.h. (Inches)	Overstory Leave Trees/Acre	OPT % In BEMA	Silvicultural Treatment
0-25	3.5"	180	6	Precommercial Thinning (PCT)
25-45	3.5 - 8.5	180	6	
45-65	8.5 -12.5	110	6	Commercial Thinning #1 (CT#1)
65-85	12.5-15.5	70	6	Commercial Thinning #2 (CT#2)
85-155	15.5-24.5	40	20	Commercial Thinning #3 (CT#3)
155-225	24.5-30.0	26	20	Commercial Thinning #4 (CT#4)
225-305	30-36	17	23	Commercial Thinning #5 (CT#5)
305-345	36+	10	13.0	Shelterwood

Overstory final removal at year 345.

B. Silvicultural Prescriptions

As with all silvicultural prescriptions, there are specific land management objectives which must be met. Depending upon these objectives, coordination is mandatory in achieving maximum resource benefits. In the development of prescriptions which will improve and enhance Bald Eagle habitat, both the silviculturist and wildlife biologist must work very closely together to assess the existing and projected habitat needs.

In the assessment of the existing habitat condition, the silviculturist and biologist must delineate the Bald Eagle Management Area into specific stands. This delineation is accomplished through the use of aerial photos, field reconnaissance, and up-to-date stand data.

In 1983, stand delineation and stand data collection occurred within the Eaton Butte Bald Eagle Management Area. The data collected was compiled and analyzed for each individual stand. Once this analysis has occurred, then consolidation of similar stands occurs according to age, average d.b.h., number of trees per acre, and tree species composition. Table 3 displays this consolidation of stands (percentage of total acreage) with the similar characteristics of age and average diameter of overstory trees.

Table 3
Existing Stand Condition

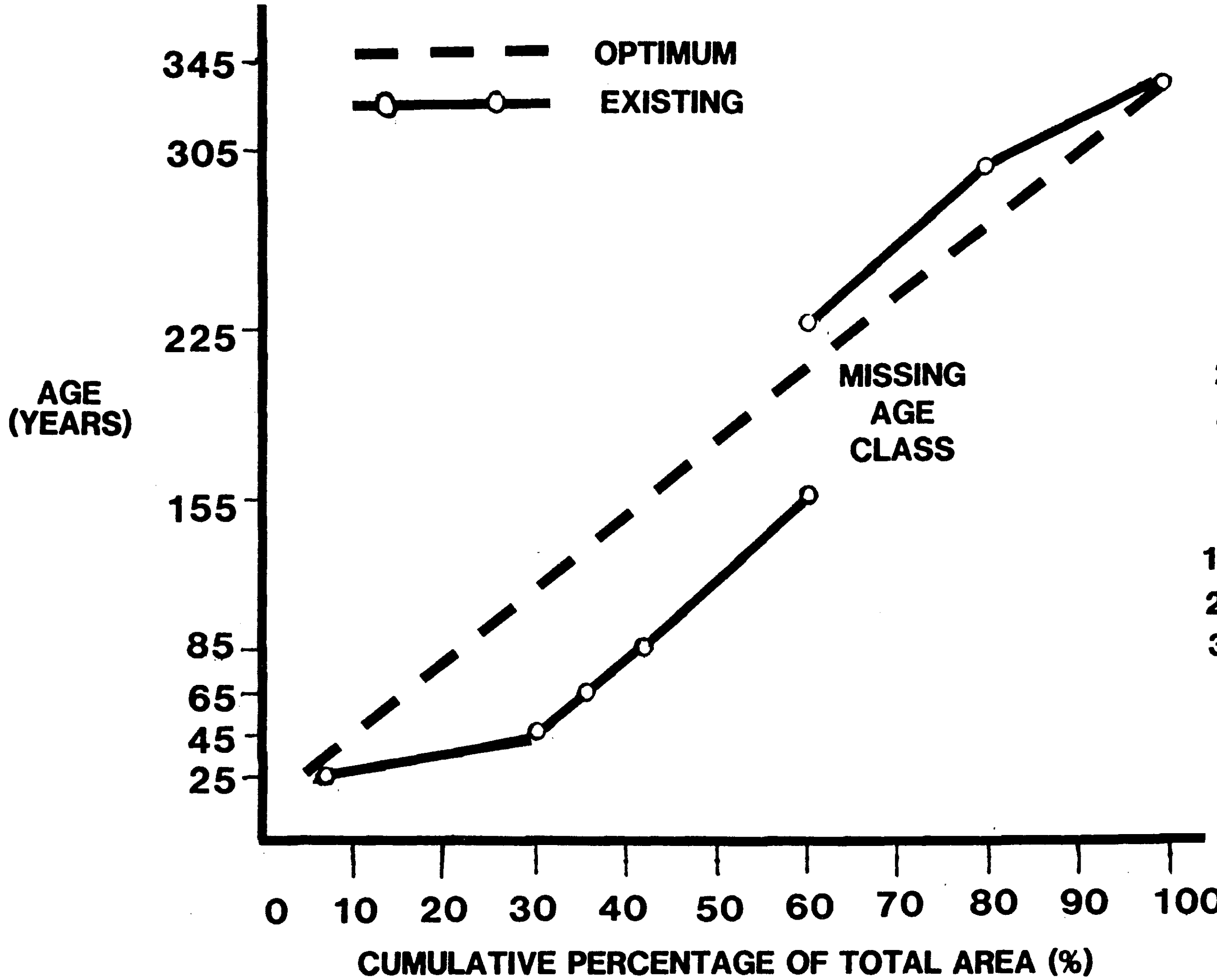
Age Class (Years)	Existing Percent	Acres	Overstory Average d.b.h.
0-25	7	59	3
25-45	25	211	6
45-65	5	42	12
65-85	6	51	14
85-155	18	152	24
155-225	0	0	0
225-305	19	160	26
305-345	20	169	32
TOTAL	100	844	

Existing stand conditions within the management area provide for diversity in age classes, species, diameter, and spatial distribution. Comparison of existing stand conditions (Table 3) to optimum stand conditions (Table 2) for the management area shows there are deficits and surpluses for age classes represented (Figure 2). The surplus percent-of-area representations are in the 25-45 year, and 305-345 year age classes. The deficit situation is occurring in the 155-225 year age class. In all age classes, there exists a surplus of trees per acre when existing and optimum conditions are compared. In order to achieve a movement from existing toward optimum stand conditions, (as described in the Deschutes National Forest Proposed Land and Resource Management Plan), silvicultural treatments must be implemented.

There are three major objectives to be met at this time: (1) Improve tree growth so as to meet predicted tree diameters (d.b.h.) for each age class; (2) Reduce tree densities where they are currently in excess to those prescribed in the yield tables (Figure 1); and (3) Begin regenerating a portion of the 305-345 year age class. This will provide for additional acres from which future nest trees will be produced.

In order to achieve these objectives, three silvicultural treatments will be utilized within the Eaton Butte Bald Eagle Management Area: precommercial thinning, commercial thinning, and shelterwood.

FIGURE 2 : Age Class Distribution At 1983



COMPARISON OF % AREA

Age	Optimum	Existing
0–25	6	7
25–45	6	25
45–65	6	5
65–85	6	6
85–155	20	18
155–225	20	0
225–305	23	19
305–345	13	20

The silvicultural treatment of precommercial thinning will be accomplished within plantations and naturally occurring stands of sapling and pole-size trees. These stands are dominated by ponderosa pine (Pinus ponderosa) with associated species of white fir (Abies concolor), sugar pine (Pinus lambertiana), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii). Three brush species occur throughout these stands, snowbrush (Ceanothus velutina), greenleaf manzanita (Arctostaphylos patula) and bitterbrush (Purshia tridentata). Stocking levels within these stands are excessive with greater than 500 trees per acre with average diameter ranging from 3 to 6 inches. In order to achieve the necessary stocking level control until the first commercial thinning, precommercial thinning will remove all but approximately 180 trees per acre. The average spacing between future crop trees will be 15 by 15 feet. This is based on work by Barrett (1982). The preferred species to be favored throughout the rotation will be ponderosa pine. In order to add diversity, sugar pine and Douglas-fir will be carried through a portion of this 345 year rotation. Any future treatments will be based on stand examination data and bald eagle activity. At this time, the next logical treatment will be commercial thinning in order to continue the movement of these stands toward the optimum stand conditions.

Similar to the precommercial thinning silvicultural prescriptions, commercial thinning will be utilized to achieve stocking level control. The stands to be commercially thinned are those included in age classes 65-85 and 85-155 (Table 3). These stands are predominantly composed of immature (70-120 years) ponderosa pine with average ranges of diameters of 14-24 inches. The canopy is predominantly one-storied with scattered pockets of sapling-sized white fir. As previously mentioned, there are three brush species occurring through these stands, greenleaf manzanita, ceanothus snowbrush, and bitterbrush. In order to achieve stocking level control until the next commercial thinning, these stands will be thinned to approximately 60 to 70 square feet of basal area (Barrett 1979). Again ponderosa pine will be favored throughout the rotation, although sugar pine will be left to provide for species diversity. Slash treatment within these stands will be achieved through the use of prescribed fire. Not only will this reduce the fuel loading, but will also help regenerate the mature brush and make it more palatable as big game browse. These stocking control treatments will increase the vigor and growth of the leave tree resulting in increased average stand diameter, a continued process of moving existing stands to optimum, managed stand conditions, and reduce the susceptibility to mountain pine beetle (Dendroctonus ponderosae) (Larsson, 1983).

The final silvicultural prescription to be described is the implementation of a regeneration system. The method utilized to ensure favorable regeneration and the meeting of the management objectives will be shelterwood. This method will be implemented in mature stands of ponderosa pine, sugar pine, Douglas- fir, and white fir. As described previously in Table 3, these stands are included in the age class of 305-345, which have an average overstory diameter of 32 inches. Associated with this mature canopy component is an immature sapling/pole-size canopy component which occurs throughout the stands. This immature component is predominantly composed of the more shade tolerant species of white fir and Douglas-fir, with scattered sugar, ponderosa, and lodgepole pine. These stands also have the same brush species as previously described. The regeneration system will have many steps involved, with the first being to implement the shelterwood method. Approximately 10 trees per acre will be retained to ensure successful regeneration. These trees will be of the largest diameter (26 plus inches) ponderosa pine with structural characteristics similar to Classes 3A, 3B, and 4A, 4B as described in Keen's tree classification for ponderosa pine (Keen, 1943). This step will be followed by the preparation of the site utilizing mechanical methods to remove the undesirable white fir and lodgepole seedlings, to scarify the soil for adequate seedbed, and to reduce potential competition between the brush and the young seedlings. The final removal of the remaining shelterwood trees will occur only after successful regeneration becomes established and when the stand structure of the Bald Eagle Management Area becomes stabilized. This can be expected to occur within 10 years after the site preparation step. Additional treatments will include precommercial and commercial thinnings as well as regeneration some 345 years into the future.

IV. RESULTS

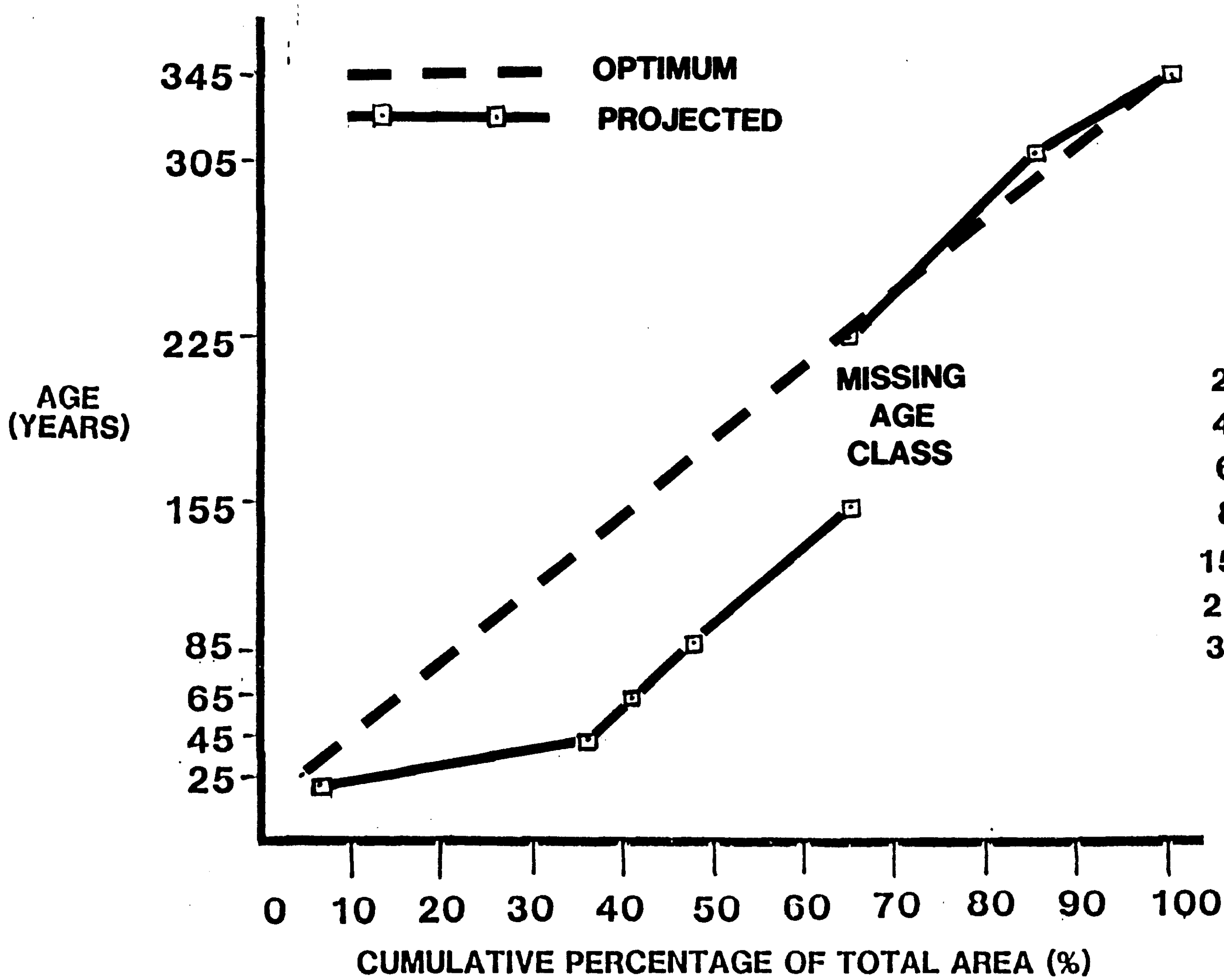
After preparation of the Dorrance Meadow Lodgepole Pine Environmental Assessment, approval was granted in 1984 to implement these previously described silvicultural prescriptions in order to accomplish the objectives for this Bald Eagle Management Area. There were 270 acres of precommercial thinning, 208 acres of commercial thinning, and 41 acres of shelterwood approved to be implemented. Approximately 177 acres of precommercial thinning was accomplished in 1986 with the remainder to be completed in 1987 through the use of service contracts. The commercial thinnings and shelterwoods were included in the Dorrance Meadow Timber Sale and were completed in the fall of 1986. The slash treatment within the commercial thinnings will be accomplished through the use of prescribed fire in 1988. The site preparation within the shelterwoods will also be completed in 1988.

The effects of the implementation of these prescriptions can only be measured in the long-term benefits as they pertain to management of the bald eagle habitat and subsequent increase of their populations. One measure of the effectiveness of these prescriptions is to compare the movement of existing stand conditions toward the optimum, managed stand condition over time. Figure 3: Age Class Distribution at 1993 displays the effects of implementing the described silvicultural prescriptions on the previously mentioned acres. When comparing Figure 2 with Figure 3, the following results have occurred:

A. Stands within age class 0-25 have moved into age class 25-45, while stands within age class 305-345 have moved into 0-25 due to the completion of shelterwood method.

B. Not shown in these figures is the increase in tree vigor and tree diameters within the stands precommercially and commercially thinned.

FIGURE 3 : Age Class Distribution At 1993



COMPARISON OF % AREA

Age	Optimum	Projected
0-25	6	8
25-45	6	29
45-65	6	5
65-85	6	6
85-155	20	18
155-225	20	0
225-305	23	19
305-345	13	15

These effects which have resulted over this period of time are not extremely significant, although when projecting to the Year 2003 (Figure 4), these effects become very significant as they pertain to bald eagle habitat management. Over the next ten year period, the projected stand conditions continue to approach the optimum stand conditions. This approach toward optimum is occurring due to the following:

A. Increasing age of stands causing ingrowth and outgrowth in the age classes.

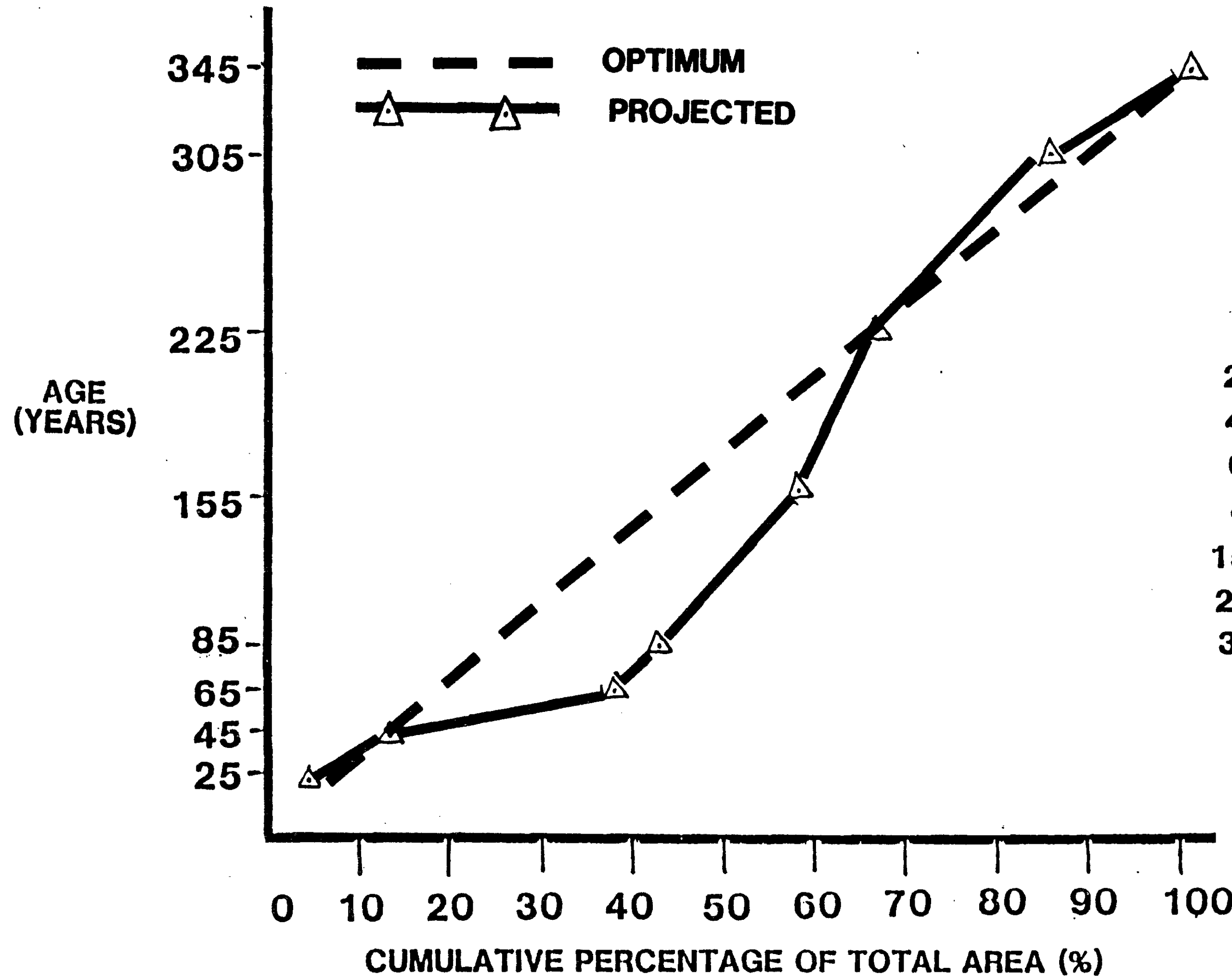
B. The regeneration of stands within the 305-345 age class.

As time goes on this approach toward optimum will continue only if future silvicultural prescriptions such as regeneration systems, precommercial thinning, and commercial thinning are implemented as Figure 4 has indicated.

V. CONCLUSION

Silvicultural treatments can be very effective tools in the protection and improving of Bald Eagle populations and habitat. In order for Wildlife Biologists and Silviculturists to prescribe these silvicultural treatments, they must have existing stand data, management directions and objectives to strive towards, current "state-of-the-art" research information, and information concerning Bald Eagle Management Area status. By utilizing these items, the Deschutes National Forest, Pacific Northwest Region has begun to manage many of these Bald Eagle Management Areas.

FIGURE 4 : Age Class Distribution At 2003



COMPARISON OF
% AREA

Age	Optimum	Projected
0-25	6	3
25-45	6	9
45-65	6	25
65-85	6	5
85-155	20	15
155-225	20	9
225-305	23	19
305-345	13	15

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Old-Growth Wildlife in Second-Growth Forests:

Opportunities for Creative Silviculture

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INTRODUCTION

The last 10 years has witnessed mounting global concern for the accelerating loss of the world's old-growth of primary forests. Much of the concern has centered on the tropics (e.g., Lovejoy 1980) where half of the world's forests are found, human population growth rates are highest, and forest lands are being modified by people seeking a living from the land (Lugo, in press). Concern, however, is not restricted to the tropics. In North America, old-growth forests have become recognized as ecologically unique, vanishing environments, and there is ever-increasing interest in public policies for old-growth preservation (SAF 1984).

Much of the interest in primary or old-growth forests is related to concerns about increasing rates of animal extinctions (Ehrlich and Ehrlich 1981, Lovejoy 1980, Myers 1979). The rate of species loss is highest in those areas of the world with the highest rates of deforestation or forest modification (Ehrlich and Ehrlich 1981, Lovejoy 1980). In North America, concern for wildlife is clearly one of the interests central to the concerns about old-growth (Dawson et al. 1986, Harris 1984, Meehan et al. 1984, Raphael and Barrett 1984, Salwasser 1984, Meslow et al. 1981, Schoen et al. 1981). Old-growth forests are structurally diverse (Franklin and Spies 1984) and they harbor a diverse vertebrate fauna (Norse et al. 1986, Meehan et al. 1984, Raphael and Barrett 1984, Meslow et al. 1981). Most of the species found associated with old-growth forests are not restricted to old-growth habitats, but available information suggests some are. The Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) in western Canada and Alaska (Bunnell and Jones 1984), the northern spotted owl (Strix occidentalis caurina) in the Pacific Northwest (Forsman et al. 1984), and the red-cockaded woodpecker (Picoides borealis) in the Southeast (US FWS 1985) all require old-growth or elements of old-growth for their survival.

There is no doubt that old-growth or primary forests support a diverse assemblage of wildlife. At the same time, the relative value of old-growth as wildlife habitat should be considered an open question. It is probably true that once old-growth is harvested it cannot be reproduced silviculturally (SAF 1984). This need not necessarily imply that loss or reduction of old-growth will be followed by massive animal extinctions and reductions in faunal diversity. A recent paper on reduction of species diversity and forest modification in the tropics (Lugo, in press) concluded that earlier projections of extinction rates (Ehrlich and Ehrlich 1981, Lovejoy 1980, Myers 1979) were probably inadvertently inflated. Projected losses had been magnified by investigators failing to account for the resiliency of forested ecosystems and the importance of secondary forests as "foster ecosystems." In support of his conclusions, Lugo (in press) notes that in Puerto Rico, where primary forests were reduced by 99%, animal extinctions have not approached the magnitude projected based on rates of deforestation.

Evidence suggests that Lugo's (in press) observations and conclusions may be equally relevant to temperate North America. There is no significant acreage of primary or old-growth forests left in the eastern United States. The forests of half a continent have been drastically modified by man, yet the deforestation and modifications have not yet been followed by massive extinctions, at least not among conspicuous vertebrate faunal groups. We make this observation not to engender complacency nor to obscure the sense of exigency that forest managers and policy makers should have for the conservation of old-growth habitats and associated wildlife. Rather, we would like to encourage both researchers and managers to take a broader perspective when considering options for managing wildlife that utilize old-growth habitats. Current emphasis appears to focus on the amount and spatial distribution of old-growth habitats that must be set aside and preserved to protect a particular species or group of species (e.g., Dawson et al. 1986, Harris 1984, SAF 1984). Habitat preservation is a particularly appropriate strategy when the basic habitat relationships of the wildlife species of interest are poorly understood (Carey 1984). Leopold's (1966) first precaution of intelligent tinkering is both intuitively and ethically appropos when the individual elements are so poorly understood. But is habitat preservation the only option for protecting and managing wildlife associated with old-growth? We think not.

Although the prevailing view seems to be that old-growth characteristics cannot be reproduced silviculturally (SAF 1984), this may be true only in terms of reproducing all characters, attributes, and values of old-growth. But if the objective is to manage for old-growth terrestrial wildlife, the evidence would suggest that managers may have additional options available. The Caribbean experience (Lugo, in press) and the faunal record for the eastern United States suggest that second-growth forests, properly managed, can provide habitat for the majority of wildlife species inhabiting primary or old-growth forests. Even in the Northwest, where old-growth preservation policies are being most hotly debated, Franklin and Spies (1984) have noted that it is possible, with appropriate management, to incorporate attributes of old-growth, natural forests into landscapes of more intensively managed second-growth forests.

Our purpose in this paper is to urge both managers and researchers to devote greater energy and imagination to exploring strategies for creating old-growth characteristics and wildlife habitat elements in managed, second-growth forests. Our example is an old-growth wildlife species of the Southeast, the red-cockaded woodpecker. The woodpecker's abundance, distribution, and habitat requirements suggest that at least some "old-growth" species can survive, and perhaps prosper, in properly managed second-growth forests.

In presenting a case for second-growth forests, we feel compelled at the outset to offer a few caveats and points of emphasis. First, we emphasize the need for greater research investments to understand the habitat relationships of old-growth wildlife. Experience with one species cannot be generalized to others. Our current knowledge of which species require what habitat elements is rudimentary (Carey 1984). Much more information and knowledge is needed before we can assess appropriate management strategies for old-growth wildlife (Hanley et al. 1984). Second, our emphasis on second-growth forests is in no way intended to divert attention from efforts to preserve unique, old-growth ecosystems. We view managing for old-growth attributes in second-growth forests as augmenting, rather than replacing, other management options. Third, we echo the admonitions of Lugo (in press) and Franklin and Spies (1984) in noting that professional credibility is at stake when discussing old-growth issues and values. Both researchers and managers should strive for objectivity and precision when assessing the status and needs of old-growth wildlife. Finally, land managers should not anticipate that managing second-growth forests for old-growth wildlife will be easy or cost free. Traditional policies, programs, and goals will have to be modified. This will require additional energy and imagination. It is hoped that the result will be better stewardship of the land and the wildlife resource (Franklin and Spies 1984).

The Red-Cockaded Woodpecker

Nesting Habitat Selection

The red-cockaded woodpecker is endemic to yellow pine forests of the South. They have the unique habit of excavating their cavities almost exclusively in living pines. The woodpeckers are nonmigratory, and an individual cavity tree may be used for several years until the tree dies or the resident woodpecker is evicted by a cavity competitor. Red-cockadeds live in family groups, often termed clans. A clan of woodpeckers can consist of simply a mated pair or a mated pair plus one or two offspring that remain in their natal territory for 1 or 2 years as helpers (Lennartz et al. 1987). The cavity trees used by a clan of woodpeckers are aggregated in groups termed "colonies" (Jackson and Thompson 1971, Lay and Russell 1970). The term "colony" used in reference to red-cockaded woodpeckers should not be confused with an aggregation of breeding birds. Each colony (group of cavity trees) supports one clan (breeding group) of woodpeckers. Colony sites can remain active, supporting a clan, for decades.

Red-cockaded woodpeckers excavate cavities in most species of southern pines, but the largest populations of woodpeckers are found in loblolly (Pinus taeda) and longleaf (P. palustris) forests. There is some evidence that longleaf may be preferred over loblolly (US FWS 1985). Earliest investigators noted that the woodpeckers appeared to select old or mature pines for cavity excavation (Murphey 1939), and dozens of subsequent investigations have supported those early observations (US FWS 1985). Jackson et al. (1979) reported the age of trees with newly started excavations to average approximately 75 years for loblolly pine and 95 years for longleaf pine. The selection of older trees for cavity excavation appears to be correlated with the woodpecker's selection of trees infected by the heartrot fungus Phellinus (=Fomes) pini (Conner and Locke 1982, Jackson 1977).

In addition to selecting old, heartrotted trees for excavating their cavities, the woodpeckers also exhibit a preference for relatively open stands of pine with sparse midstories (US FWS 1985). Active colonies are found in pine stands with a wide range of pine overstory stocking, but the birds do not tolerate high hardwood stocking in the midstory. In the absence of fire, a hardwood midstory gradually develops in southern pine stands. Active colony sites are seldom found or seldom persist where hardwood stocking reaches 35 ft^2/acre (US FWS 1985). The reason for the aversion to hardwoods at nesting sites has not been well studied, but indications are that interspecific competition for cavities (Jackson 1978) and possibly nest predation increase as hardwoods develop in the course of plant succession.

Foraging Habitat Selection

Red-cockaded woodpeckers also exhibit a preference for living pines as a foraging substrate, but the birds are more catholic in their use of foraging habitats. Pine stands are preferred (Hooper and Harlow 1986, Porter and Labisky 1986, Nesbitt et al. 1978), but the birds will also use stands of mixed pine-hardwood (Hooper and Harlow 1986, Ramey 1980) and make occasional use of cypress (DeLotelle et al. 1983, Hooper and Lennartz 1981, Ramey 1980). When foraging in mixed stands, the majority of foraging is done in pines (Ramey 1980).

In addition to selecting pines for foraging substrate, red-cockadeds also exhibit a preference for larger pines over smaller pines (Hooper and Harlow 1986, Porter and Labisky 1986, DeLotelle et al. 1983, Hooper and Lennartz 1981, Skorupa 1979). The observed preference for larger pines as foraging substrate has led some observers (Jackson and Jackson 1986, Ligon et al. 1986) to conclude that the woodpeckers require old or mature pine for foraging habitat. Available data do not support this conclusion. In an area where the woodpeckers selected from a wide range of stand conditions, Hooper and Harlow (1986) found a weak (r^2 = 0.08, $\underline{P} \leq 0.0001$) positive relationship between use of a stand and the density of larger stems. They found no relationship ($r^2 = 0.002$, $\underline{P} > 0.47$) between stand selection and stand age for stands 30 years old and older. The birds made little use of stands < 30 years old but were highly variable in their use of stands > 30 years old.

Population Status and Trends

In 1970 the red-cockaded was federally listed as an endangered species. Active colonies are being lost (Carter et al. 1983, Baker 1982, Thompson 1976) and some small populations have been extirpated (Baker 1983). Old-growth pine is a rare and declining resource in the South. Less than 2.5% of the commercial pine in the South is acceptable red-cockaded nesting habitat, and the acreage is continuing to decline (Lennartz et al. 1983b). The majority of forest lands in the South (90%) is private land, as is the majority of older pine stands (75%). The acreage of older pine is declining most rapidly on private lands where there are no legal requirements to perpetuate habitat for endangered species. Prospects are that in the not too distant future, red-cockaded woodpeckers will be restricted to a relatively few, fragmented habitat reserves on federal forest lands (US FWS 1985, USDA FS 1987).

For an endangered species, the rangewide population of red-cockaded woodpeckers is still relatively large. Lennartz et al. (1983a) reported a total population estimate of approximately 3,000 clans on federal lands. This large number, however, is deceiving. Federal lands in the South are fragmented, widely separated habitat reserves, so the remaining red-cockaded woodpecker populations are isolated from one another. Very few of these remaining populations, probably less than 20%, are large enough to be considered prospectively viable in the distant future (US FWS 1985). Consequently, the fate of the red-cockaded woodpecker is in the hands of the federal forest manager, who has a major challenge to demonstrate whether or not silvicultural art and science can restore the woodpecker to nonendangered status.

Recovery Prospects

The recovery objective for the red-cockaded woodpecker is 15 viable populations (US FWS 1985). Currently, there are only five or six populations large enough to be considered potentially viable in the long run (US FWS 1985). Is the recovery objective overly ambitious? Is there reason to expect that populations will increase with appropriate management? A number of factors would suggest that the red-cockaded's recovery is amenable to management.

First, although Southwide records indicate drastic reductions in habitat and declines in populations, in some areas evidence suggests populations have expanded as habitat conditions improved. The Francis Marion National Forest in the South Carolina Coastal Plain currently supports a population of approximately 400 clans of woodpeckers at a density of about 1 clan per 400 acres of available habitat. The Francis Marion represents one of the largest and most dense extant populations of red-cockaded woodpeckers. But at the time of its establishment, the Francis Marion could hardly have been considered prime red-cockaded woodpecker habitat. The period from 1880 to 1930 has been termed a lumber "bonanza era" in the South (USDA FS 1987). Lumber production reached an all-time high, and many viewed southern forests as croplands to be harvested and then abandoned. The Francis Marion was consolidated from tracts of cutover lumber company lands, and ". . . one could see for miles across lands, barren except for logging remnants" (USDA FS 1987). One has to assume that under those conditions red-cockaded populations were nearly decimated and must have subsequently increased to current levels as land was regenerated to pine, stocking increased, and remnant trees and stands matured.

A second factor facilitating the woodpecker's management and recovery is the bird's flexibility in foraging habitat selection (Hooper and Harlow 1986). With adequate old-growth or mature pine for nesting habitat, the bird's foraging habitat conditions can be met with pine stands of varying age and condition (US FWS 1985). This flexibility in foraging habitat selection makes the woodpecker's requirements quite compatible with multiple use forest management strategies on southern national forests.

A final factor which facilitates integrating management for the woodpecker with other management objectives is that the woodpeckers do not require large stands of mature trees for nesting habitat. Highest red-cockaded densities (1 clan/112 acres) are found in areas with extensive acreage of mature stands (US FWS 1985), but on many forests, if not most, active colonies are frequently old remnant trees or small remnant patches in younger stands. The red-cockaded recovery plan (US FWS 1985) recognizes that a variety of management strategies can be employed to provide nesting habitat.

Alternate Management Strategies

The red-cockaded woodpecker recovery plan emphasizes that providing adequate nesting habitat is the key to the species' survival (US FWS 1985), and that this specific requirement can complicate, and conflict with, timber management plans. The woodpeckers require trees $\geq$ 75 years old in loblolly pine and $\geq$ 95 years old in longleaf pine, but programs to maximize timber yields consider rotations as short as 40 years for both species (USDA FS 1984). Obviously, timber management plans have to be modified to accommodate the woodpecker's needs.

The recovery plan (US FWS 1985) recognizes that active colonies are found in a variety of stand conditions and recommends a variety of methods as appropriate for providing nesting habitat. The recovery plan suggests that nesting habitat can be provided by lengthening rotations, leaving or establishing remnant patches of mature trees, leaving individual remnant trees distributed throughout the general forest area, or some combination of these methods. This gives the forest manager considerable latitude to test different approaches. At the same time, by allowing flexibility, the recovery plan places the responsibility for developing effective management strategies squarely on the shoulders of forest managers. The responsibility is awesome, because the stakes are high. A species' survival is at stake, as well as the forester's professional credibility.

One reason the recovery plan (US FWS 1985) allows flexibility in managing red-cockaded nesting habitat is that active colonies are found in a variety of stand conditions. Another reason is because among the suggested recovery strategies there is no *a priori* reason to objectively judge one approach as obviously better than another. Each has strengths and weaknesses. In attempting to assess the relative merits of the different approaches, at least three basic standards should be considered. Most obvious, the amount of habitat provided must be adequate to meet red-cockaded population objectives. In addition, to provide for population stability, habitat must be continuously available over time. And to provide for both population expansion and stability, habitat should be widely and evenly distributed in space. Each management option will be discussed in relation to these three basic standards.

Lengthened Rotations

Lengthening rotations is the most obvious alternative when considering options for producing older trees. If the goal is older trees, defer the age of harvest. A major advantage of extending rotations relative to the other options, remnant trees and remnant patches, is the amount of habitat provided. Rotation length applies to the entire forest, so ultimately all areas of the forest will provide potential nesting habitat for some period of time. One the surface, extending rotations would appear to offer the most conservative management strategy. This option, however, also has some shortcomings.

One difficulty is deciding on an appropriate or adequate rotation length. The rotation length recommended in the original red-cockaded woodpecker recovery plan (US FWS 1979) was 100 years for longleaf and 80 years for other pines. These ages coincide with the mean age of trees selected for cavity excavation (Jackson et al. 1979) and are generally considered adequate (e.g., Ligon et al. 1986). Conner (1979), however, considered these ages less than optimal and recommended even longer rotations. The longer rotations are extended, the greater the proportion of the forest that will be in older stands at some time, and the greater the proportion of trees that will have heartrot (Hepting 1971). The difficulty is in objectively deciding how long a rotation is long enough.

A second difficulty with simply lengthening rotations involves the age class distribution of the forest, which has been discussed by Seagle et al. (in press). Most public forests in the South have very unbalanced age distributions, the result of exploitive harvesting prior to public acquisition and extensive planting and reforestation in the early years of public administration. Lengthening rotations without provisions for some sort of area regulation results in drastic oscillations in nesting habitat availability. Rather than having a continuous opportunity for population expansion and spread, the woodpeckers would be faced with alternating periods of extremely high and extremely low nesting habitat availability, a situation not conducive to population stability. Perhaps it is unrealistic to discuss rotation length independent of an area regulation provision. However, if an area regulation goal is implied in specifying rotation length, it is not explicitly stated, at least not in the forest plans for the national forests (e.g., USDA FS 1987).

A more difficult situation identified by Seagle et al. (in press) that must be dealt with independent of rotation length is the problem of spatial distribution of habitats. Again, as a result of historic land use, stands in various age classes tend to be clumped rather than evenly distributed across forests. Some areas or compartments are dominated by older stands, but most areas of the forests are dominated by midage stands reforested after federal acquisition. Red-cockaded woodpecker distribution and abundance mimics the habitat distribution. On national forests such as the Francis Marion in South Carolina and the Kisatchie in Louisiana, some areas have very high woodpecker densities while other areas are dominated by stands too young to support woodpeckers (R. Escano, pers. commun.). In the areas of high woodpecker densities, harvest opportunities are restricted to prevent reducing available foraging habitat. Harvest activities, in turn, have to be concentrated in younger stands to meet timber production goals. The result is to perpetuate two forests, one young and one old, within the same area and restrict the opportunities for woodpecker populations to expand and spread. An even or broader distribution of woodpeckers across the forest area would be more desirable to ensure greater protection against disease or catastrophic events. One option, of course, would be to defer harvesting until older stands are more evenly distributed across the landscape. Regardless, the point we wish to make is that merely emphasizing rotation length leaves the problem of spatial distribution of habitats unsolved.

Remnant Patches

Remnant patches are simply stands of trees allowed to mature to decadence. They have no planned harvest schedule, through they may receive intermediate treatments, such as thinning and burning, to create desired habitat conditions. Region 8 of the National Forest Systems is using remnant patches as their primary strategy for providing red-cockaded nesting habitat (USDA FS 1985). Termed recruitment/replacement stands, the number of remnant patches established and managed depends on the red-cockaded population goal and the number of currently active colonies on the forest. One stand is established for each currently active colony to offset natural mortality in the colony stands (replacement), and additional stands are established to support population expansion up to the population goal (recruitment). Recruitment/replacement stands encompass 10 acres and are managed like colony stands (i.e., thinned and burned) to create and maintain desired habitat conditions.

Using remnant patches obviates some of the problems associated with lengthening rotations. First, the manager need not grapple with the problem of an appropriate or best stand age. The oldest stands available are selected for management and allowed to mature to decadence. Because the incidence of heartrot increases with stand age (Hepting 1971), the potential for cavity excavation should steadily increase until natural mortality significantly reduces stand density.

Region 8's recruitment/replacement stand strategy also solves some of the problems of temporal and spatial habitat continuity. By establishing the number of stands needed to meet population objectives, and by providing stands to eventually replace active colonies, a constant habitat base is maintained over time (Seagle et al., in press). Population goals are based on a desired woodpecker density and applied to all available habitat on a compartment-by-compartment basis, so the patches of potential nesting habitat will eventually be distributed rather evenly throughout the entire pine acreage.

A major problem, or perceived problem, with the replacement/ recruitment stand concept relative to lengthened rotations is the amount of potential nesting habitat provided. On a hypothetical forest with 100,000 acres of pine regulated on a 100-year rotation, 20% of the forest (age classes 80-90 and 90-100 years), or 20,000 acres, would eventually represent potential nesting habitat. In contrast, if the same forest had a population goal of one clan of woodpeckers per 400 acres, and each clan were provided a colony site (recruitment stand) and a replacement stand, the amount of habitat provided would be 5,000 acres (250 clans x 10-acre colony or recruitment stand + 250 replacement stands x 10 acres). At this time, the questions of how much nesting habitat is enough and whether providing more habitat would allow the population goal to be reached sooner are subject to debate. The answer can only be provided by monitoring how the woodpeckers respond. In the meantime, as an additional measure of assurance, national forest policy is to manage the general forest area on

70- (loblolly) and 80- (longleaf) year rotations. A small proportion of red-cockaded cavity trees are found in the 60-70 and 70-80 year age classes (Jackson et al. 1979), so some additional nesting habitat will be provided in the general forest area. Even with this additional provision, however, the relative difference in the amount of potential nesting habitat between lengthened rotations and recruitment/replacement stands is the same.

Remnant Trees

The remnant tree option for managing red-cockaded woodpecker nesting habitat involves leaving individual, mature or old-growth trees distributed throughout the general forest area. As with the remnant patch option, the remnant trees are allowed to mature to decadence and are not harvested. We are not aware of any agency having designed and implemented a remnant tree strategy, so we cannot describe a particular operational program. It is possible, however, to envision and discuss the advantages and disadvantages of remnant trees relative to the other two options.

In building a hypothetical example, we will imagine the entire pine acreage of a forest being managed under a remnant tree option. Remnant trees are established at the time of stand regeneration by not harvesting a small proportion of the dominant stand. If natural regeneration is being used, the seed trees, or a portion of the shelterwood, could be left on the site after regeneration is established. If planting is preferred, consideration would be given to leaving the remnant trees in a spatial distribution that would least interfere with planting equipment. If the strategy were implemented in all pine stands, after one harvest/regeneration cycle the entire pine acreage would be potential red-cockaded woodpecker nesting habitat.

In this hypothetical situation, the advantages are obvious. As with remnant patches, the manager is not troubled with a decision about an adequate or best stand age. The trees are left to mature and die, and the proportion of trees suitable for cavity excavation increases with time. Temporal and spatial continuity are no longer problems. With remnants left in all stands at each regeneration cycle, eventually the entire pine acreage provides potential nesting habitat in perpetuity. The one difficulty with the remnant tree option is deciding what density of remnants to leave. As with deciding how long rotations should be, or how large and how many remnant patches to leave, with remnant trees there is no precise, objective answer to the question of how many trees should be left per acre. This would be a function of the needs of the woodpecker and the silvics of southern pines. The question, however, is amenable to investigation and experimentation.

DISCUSSION

The red-cockaded woodpecker illustrates some interesting points related to managing old-growth wildlife. First, reiterating our basic premise, not all old-growth species require extensive areas of undisturbed old-growth stands. Some, such as the red-cockaded woodpecker, may require selected elements or attributes of old-growth to satisfy specific needs.

Total needs may be met if the selected element and need can be identified and integrated with the management of secondary forests. Only accelerated research will provide the necessary information about which habitat elements different species require.

A second point, related to the first, is the question of whether it is legitimate to generalize from the red-cockaded woodpecker to other species. Considering the diversity of ecosystems and the faunal diversity associated with each, generalization would be professionally careless. But the red-cockaded woodpecker may reflect an ecological principal emphasized by Lugo (in press) and pertinent when considering strategies for managing old-growth wildlife. Some primary or old-growth forest ecosystems and associated fauna may be far more resilient than commonly believed. Many habitats and species are adapted to periodic natural perturbation. Lugo (in press) noted the pervasive influence of hurricanes on Caribbean ecosystems. In the South, fire is an integral element of the forest landscapes. Southern pines are fire resistant, and without fire, pine stands succeed to hardwood types (Wahlenberg 1960, 1946). Species associated with ecosystems adapted to natural disturbance might be expected to have a somewhat broader range of habitat tolerances.

Finally, broader habitat tolerances might suggest greater flexibility in designing and implementing management strategies. Flexibility, or having alternatives, is a plus for the manager. As noted earlier, however, having some flexibility does not necessarily make the manager's job easier. As illustrated by our discussion of the various management options for red-cockadeds, different strategies will have different strengths and weaknesses. The manager is left with the difficult task of deciding which strategy will most likely meet the management objectives. When deciding on a management strategy for an endangered species, the risks of failure are high; both the species survival and the manager's professional credibility are at stake.

One way to manage the risk is to exercise the flexibility provided. It is unlikely that one strategy is best for all management situations. Protecting or stabilizing an already large population on a forest with a large habitat base probably requires different tactics than trying to rapidly increase a small population or stabilizing a population where habitats are more restricted or marginal in quality. The only way to determine the most appropriate strategy for particular situations is for the manager to begin implementing natural experiments in the field. With the red-cockaded woodpecker, there are still important questions for research to answer, but the question of the best strategy for providing nesting habitat will ultimately be answered by trying different approaches and monitoring population response. This will require large-scale, long-term natural experiments rather than shorter term sampling or designed experiments. Another way to manage risk is for the manager to experiment with more than one strategy with each management situation. Currently, most management emphasizes one strategy. Of 23 national forests with population goals for red-cockaded woodpeckers, 19 are implementing the remnant patch strategy, 4 have extended rotations, and none is trying remnant trees. It would seem that broader experimentation would benefit both the manager's goals and the woodpeckers.

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WOODPECKERS,RECREATIONISTS AND LUMBERMEN CHEER THE SUCCESS OF ARTIFICIAL REGENERATION OF LONGLEAF PINE

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Abstact--Refinement of longleaf pine (*P. plustrus* Mill.) artificial regeneration techniques over the past twelve years has resulted in up to a two-hundred percent improvement in plantation success rate. Outdoor recreationists, the timber industry and threatened and endangered specie managers applaud this success.

INTRODUCTION

Longleaf Pine has in recent years begun to reclaim its once premier role as a southern pine due to success in artificial regeneration. The open "park-like" stands are home to red-cockaded woodpeckers, a favorite of hikers, hunters and birdwatchers. The high quality poles, pilings and lumber are favored by the timber industry.

LIFE HISTORY

Longleaf pine is found on upland sites in the southeastern U.S.. Soil types vary from deep sands to sandy loams to sandy clay and range from excessively well drained to moderately well drained. It is considered a fire sub-climax species (Laessle 1958). Associated species include scrub oaks (Eyre 1980) such as turkey oak (*Q. laevis*) and blackjack oak (*Q.*

marilandia) on the infertile sites and loblolly pine (P. taeda L.), southern red oak (Q. falcata), and dogwood (Cornus florida) on the better sites.

Longleaf is not a large tree, attaining a height of 100 - 120 feet and a maximum diameter of less than 40 inches. The maximum volume per acre at final cut is in the neighborhood of 15 MBF per acre Scribner.

Reproduction occurs sexually with pollination starting in mid-Feburary (Agriculture Handbook No. 271, 1965) and fertilization about 14 months later. The 6-8 inch long cones mature in October of the second year. Each cone contains 50-60 seeds taking about 4200 of them to make a pound. Seed production begins when trees are about 6 inches in diameter. Good crops occur every 4 to 12 years.

The seed germinates as soon as one week after it reaches the ground, and the early growth is characterized by a stemless grass stage. Height growth begins when the root collar diameter reaches 0.7" to 1.0". This normally takes 1 to 3 years under good conditions, and the "grass stage" may last as long as 20 years (Boyer 1978) if competition or brownspot needle blight (Scirrhia acicola) is severe. Once height growth is intiated it is rapid ranging from 1 to 3 feet per year. Longleaf is intolerant and expresses dominance early. Self-pruning begins as early as age 10.

HISTORY

Longleaf pine once occupied an estimated 60 million acres (Wahlenberg 1946) in the Gulf and Atlantic coastal plains, the Piedmont region and a small area of north Alabama in the Appalachian foothills (fig. 1). This was the dominant upland pine in the southeast when the European settlers arrived. The eastern part of the range and the portions near rivers were utilized by the early settlers for shelter, naval stores and ship construction. Longleaf maintained its dominance until the early part of this century when the railroad loggers arrived and clearcut the south much as they had earlier the lake states .

The "cut-out" and "get-out" timber operators left behind a stump orchard of gigantic portions. These cut over lands had a few small subsistence farms scattered about and were burned quite often for forage production. Longleaf saplings began to appear as grass stage seedlings that were present before the overstory was removed began height growth. Some scattered trees were left by the railroad loggers providing seed in many areas. Many of the resulting stands were not managed as the lands were abandoned. In the late 1920's and early 1930's the Forest Service began purchasing these lands and started fire control programs. The Civilian Conservation Corps intensified fire control efforts, built fences to exclude hogs and planted millions of seedlings, some of which were longleaf.

Intensive harvest of this "second forest" was begun in the 1950's and 1960's and much of the longleaf was replaced with the so called faster growing slash pine (P. elliottii var. elliottii Engelm.). In the late 1960's and early 1970's foresters and managers realized that slash pine wasn't living up to expectations and people began to return to Longleaf.

There was only one problem, no one seemed to be able to regenerate longleaf. Most of the CCCer's were gone. The Forest Service had been planting longleaf for several years but seemed to be wearing the ground out replanting the same stand year after year.

This brings us to the recent past. The Forest Service was beginning to harvest longleaf pine and had recognized the advantages, but was not doing a very good job of artificial regeneration. Before I go into the approaches and the techniques used to successfully regenerate longleaf pine, I would like to expand a little on the advantages.

ADVANTAGES

It is a long-lived tree that is resistant to fire, disease and insects that plague the other southern pines. It is easily managed once established and is forgiving of management mistakes. Response to thinning is good even at ages that other southern pines will not respond.

The thick bark and grass stage growth habit render longleaf very resistant to fire. The long thick tuft of needles nestled around the terminal bud during the grass stage (Agriculture Handbook No. 271, 1965) absorb the heat of fires and protect the bud from damage. The early self pruning reduces the threat of crown fires. The seedlings are vunerable to fire before the first growing season is completed and again when they are less than 3' tall. Large trees can be killed by fire, but an active prescribed burning program can all but eliminate this danger.

The diseases that have damaged millions of acres of loblolly pine and slash pine have little or no effect on longleaf. Since thinning increases the likelihood of an outbreak and intensifies an existing outbreak, F. annous root rot is removing management options on many of the loblolly pine lands. C. fusiform rust is not a problem in longleaf although it costs millions of dollars annually through growth loss, mortality and degrade in the other southern pines.

The southern pine beetle (D. frontalis), which has made news lately does not usually attack longleaf. The thick bark and heavy resin flow prevent an attack from being sucessful if undertaken. The other bark beetles do, from time to time, attack and kill longleaf, but, in general are not a problem. Tip moths are causing problems in some pine plantations but do not feed on longleaf.

Longleaf lumber and building products are valued by many and premium prices are being paid. Several historical restoration projects specify longleaf pine products. The lumber is valued for its density and straight grain. The pole and piling industry in the deep south depends on longleaf pine for its existence. To the manager this means a higher stumpage price for Longleaf than for the other pines. This bid premium has been as much as 40 % for sawtimber and 100 % for small round wood. The product is so highly valued by the pole and piling industry, an intermediate cut can be sold with only 200 to 300 board feet per acre.

The longleaf pine ecosystem is home to many game animals including the bobwhite quail (Colinus virginianus), eastern wild turkey (Megealgris gallopava), fox squirrel (Sciurus niger), and white-tailed deer (Odocoileus virginianus) (Halls and Stransky, 1971). Because of the visibility and the abundance of game, the hunters of these animals prefer to hunt in the open longleaf pine stands. Longleaf plantation canopies don't usually close as as early and can be burned sooner than other pine plantations, thus maintaining their high wildlife values longer.

Picnicking, hiking and auto touring are also popular recreation activities in Longleaf pine stands. The rapid "green-up" after a prescribed burn and the proliferation of wildflowers make these stands favorites. The 68 specie of birds (Wood and Niles 1978) that utilize the longleaf forest year-round make these stands popular with the "birders".

The use of longleaf pine stands by one of the south's most famous Endangered specie, the red-cockaded woodpecker (Picoides borealis), has been well documented. Some other animals that are on State threatened and/or endangered specie lists include; the black pine snake (Pituophis melanoleucus lodingi), the gopher tortoise (Gopherus polyphemus), and the eastern indigo snake (Drymarchon corais couperi).The gopher tortoise is currently under study by the Fish and Wildlife Service for possible inclusion on one of its lists and is listed Mississippi. The black pine snake and the eastern indigo snake are listed as threatened by Mississippi. These specie are directly dependent on the longleaf pine ecosystem and may have become threatened or endangered because of the decimation of the once vast longleaf pine forest. These specie will utilize other forest types but prefer longleaf.

DISADVANTAGES

By now it probably sounds as though longleaf pine is the best thing ever, but there are some diadvantages. The most notable is the difficulty of artificial regeneration. Other disadvantages include the susceptibility of longleaf to brownspot needle blight and the slowness of natural regeneration. Longleaf also has an unearned reputation of being slow growing. Studies have shown that this in not the case. In fact, on some of the harsher sites, longleaf is the only pine that will ever reach merchantable size, and, on less severe sites, longleaf is the only pine that will reach sawlog size.

STEPS TO SUCCESS

In order to improve regeneration success two approaches were taken. One approach was to work toward a natural regeneration system. The other was to improve the artificial system since many longleaf sites were occupied by other pines or sparse stands of longleaf that weren't well suited to natural regeneration.

The natural regeneration system held a lot of promise and many foresters felt that this was the way to go. The system used a modified shelterwood leaving 20-30 feet of basal area per acre (Croker and Boyer 1975) and a seed-bed burn just prior to seed fall. The seed crops for Longleaf proved to be fairly regular but 5 to 7 years apart.

While the shelterwood system was being perfected the artificial program began to come together. In 1978 & 1979 we had identified some of the techniques which had been keeping us from being sucsessful, and we began to move away from the natural system.

METHODS AND MATERIALS

The repeated failures of the 1960's and 1970's resulted in an aggressive approach to artificial regeneration of longleaf pine. This effort led to five key areas where emphasis would be placed. These five areas are: 1. Well prepared sites; 2. Large, healthy, fresh seedlings; 3. Proper care and handling of planting stock; 4. Proper planting procedure; 5. Post planting care and management (Rounsaville 1985).

1. Well Prepared Sites. The site preparation method used was usually shear, rake and disc. Other methods were and are used. The method prescribed for an area was the one that would take control of the site and allow for easy access for the planting machines. The use of one primary method of site prep helped eliminate the site prep as a reason for failure. In other words, if a plantation failed and both of them recieved the same site prep method, it was relatively safe to say the reason for failure was something other than the site prep method.

Topography, soils, cost efficiency, and the amount and kind of vegetation to be controlled were the factors that determined the site prep method chosen.

2. Plant only large, healthy, fresh seedlings. Adequate survival cannot be expected with seedlings less than 0.4" root collar diameter. If there was a "break through" in coming to grips with longleaf pine survival, this was it. John White began an administrative study (White 1978) in 1977 to determine the effect of storage length on survival. This study provided some unexpected results (fig. 2), the most important being that survival of seedlings with a root diameter of 0.3" and less was less than 20 percent and seedlings with root collar diameter of 0.4" would only survive at the rate of 63 percent.

In response to this study and others of a similar nature, we reduced the size of our seedling orders and increased the frequency. Storage was reduced to a maximum of 2 weeks and the storage goal was 1 week.

To maintain the health of the seedlings, Benlate can be used at the nursery reducing the occurrence of brownspot needle blight.

Planting these large seedlings had other advantages over the smaller seedlings planted in the past. They reduced the number of stands that needed brownspot burns which is worth about $ 8.00 per acre and shortened the time spent in the grass stage to as little as one year.

3. Care and Handling of Planting Stock. This proved the hardest aspect of the program to implement. The planting contracts used required that the seedlings would be transported to the planting site in insulated boxes, stored on the site in these boxes and unused seedlings were returned to cold storage each night. Wet mops were required in the planting boxes and boxes not being used were kept covered. Close contract inspection was required and obtained. When the contractor was planting, we had an inspector on the site. Planting quality can be inspected through plots and examination, but care of seedlings can only be inspected while it is occurring.

4. Proper planting procedure. The planting contracts used required the seedlings be planted within 0.5" of the depth grown in the nursery. Seedlings planted deeper may survive but will be much slower in intialing height growth. Seedlings planted shallower will make the seedling more susceptible to fire and drought.

The planting machine used was Reynolds double coulter machine which helps to eliminate the small berm that single coulter machines push up around the seedling. This berm makes it quite difficult to determine whether or not the seedling is planted at the correct depth. Most any planting machine will do an acceptable job if it is in good repair.

The planting rate should be based on past survival and the number of seedlings that achieve height growth. We were planting 990 trees per acre which is a 4 X 11 spacing until 1986. The wide spacing between will allow for mechanical thinning using shears.

5. Post planting care and management. Annual checks should be made to determine survival, amount of brownspot infestation, number of height growth seedlings, and release needs. We used 0.01 acre circular plots installed in grid fashion at the rate of 1 plot per acre. The management prescription for the stand is based on data collected in these annual inventories. Brownspot burns should be carried out in winter using a fast moving head fire 1 to 2 days following frontal passage.

Cattle should be excluded from these stands until 300 trees per acre have begun height growth.

The use of herbicides for site prep and release is showing promise. Oust seems to be a good candidate for the control of grass competition which inhibits height growth. I have used some with an experimental label and the results are very encouraging.

RESULTS

Prior to initiating these measures, survival on the Black Creek Ranger District was poor to fair and the plantation failure rate was 40 to 100 percent. These areas of emphasis or "keys" were gradually phased in starting in the early 1970's as they were developed and have been continously refined. The survival rate (fig. 3) has shown improvement (although not always steady) ever since to a high of 96 % for fiscal year 1984 plantations and more importantly there has not been a plantation failure since fiscal year 1980.

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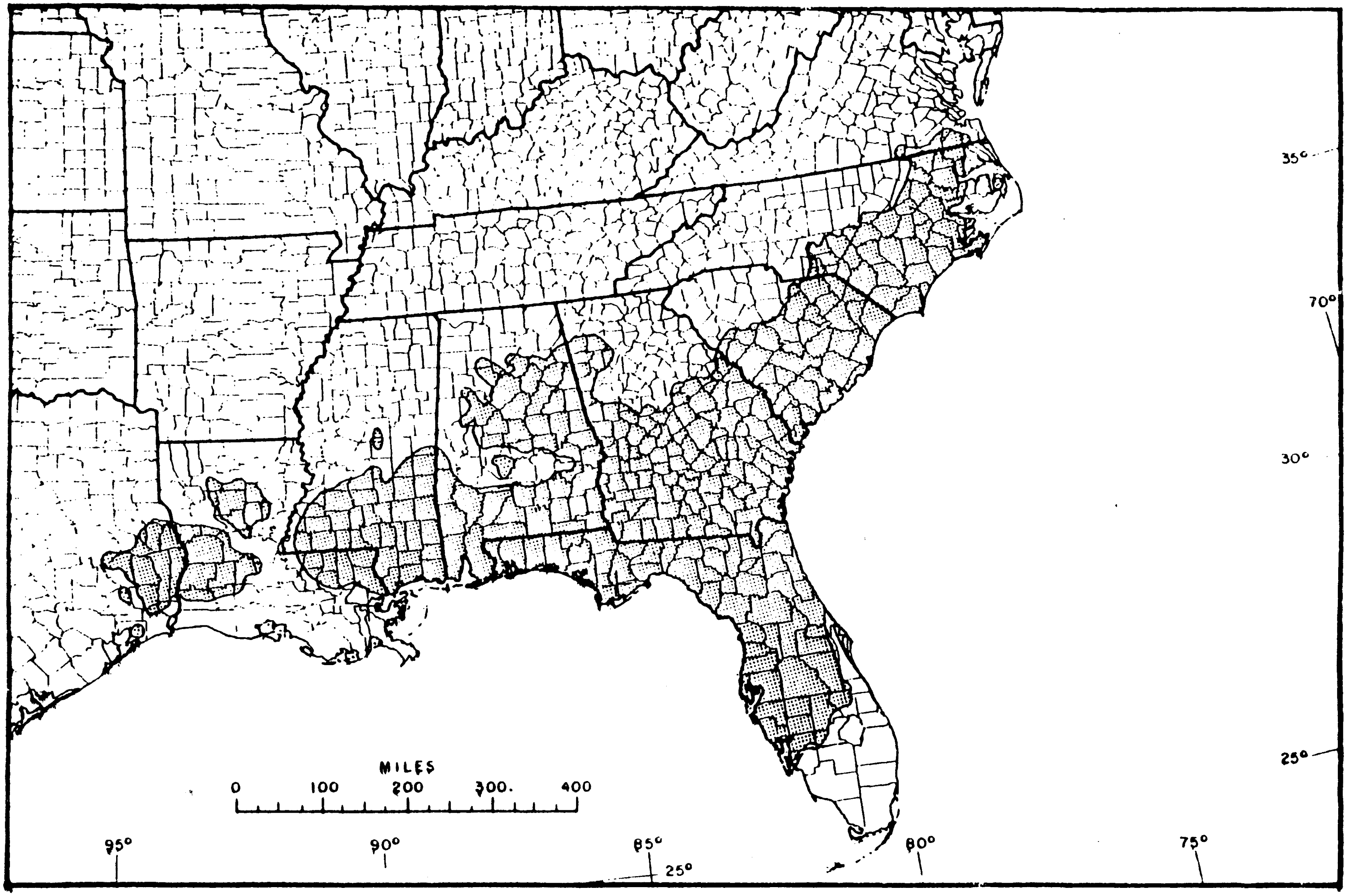

Figure 1: THE RANGE OF LONGLEAF PINE

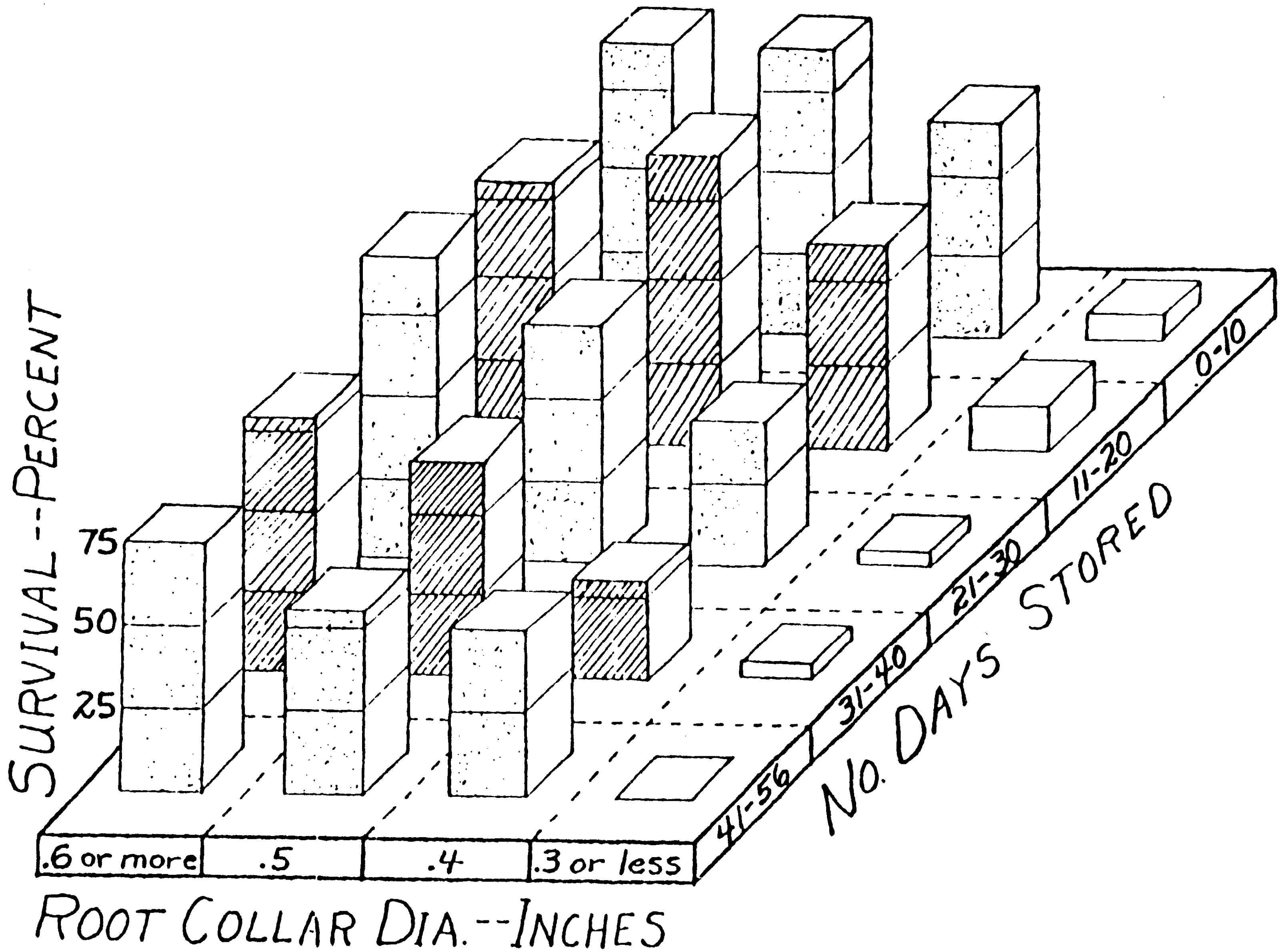

Figure 2: LONGLEAF SURVIVAL BY ROOT COLLAR DIAMETER AND LENGHT OF STORAGE

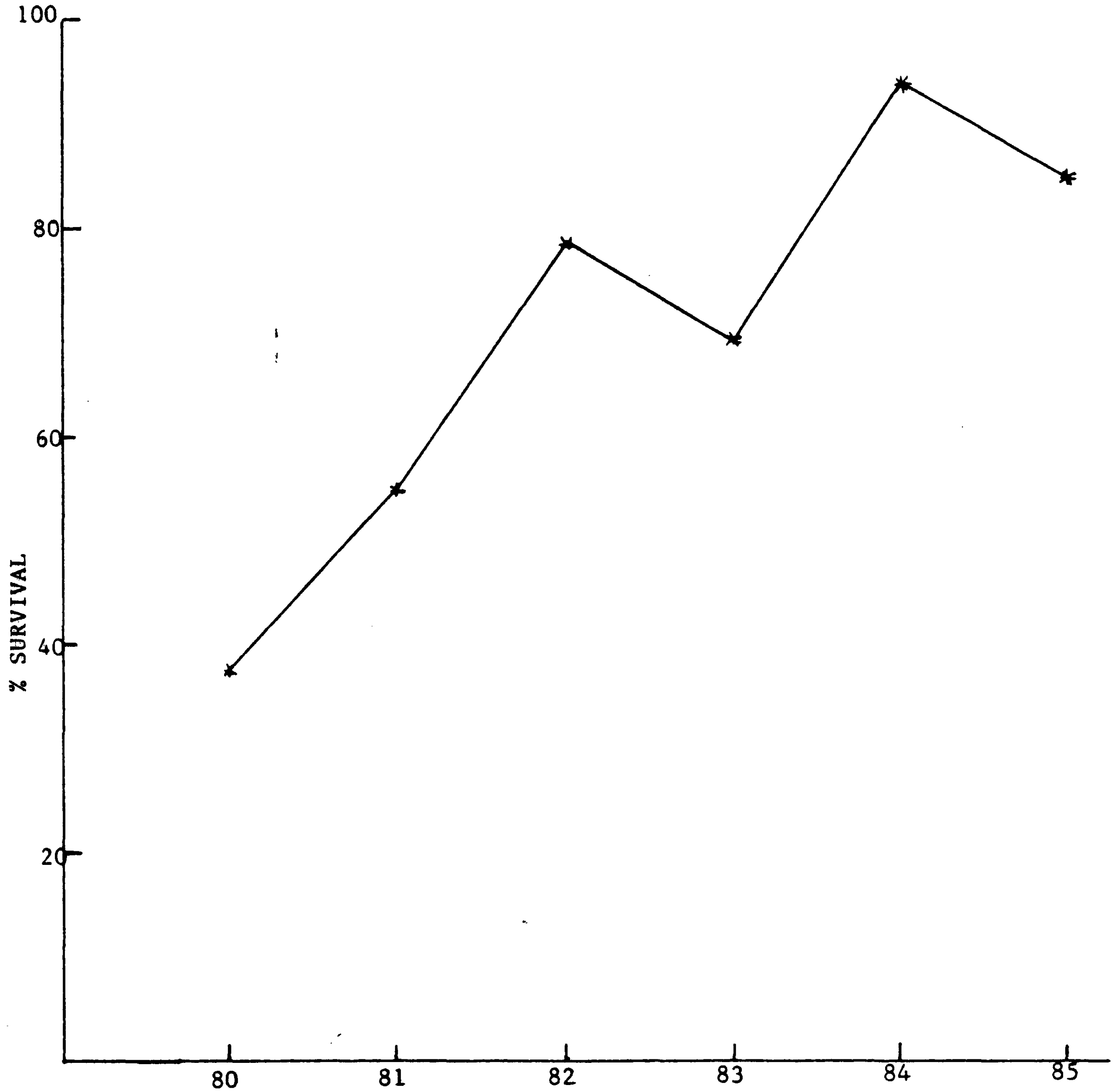

Fig. 3: LONGLEAF SURVIVAL PERCENTAGES BY FISCAL YEAR FOR THE BLACK CREEK RANGER DISTRICT, DESOTO NATIONAL FOREST IN MISSISSIPPI

STREAMSIDE VEGETATION MANAGEMENT FOR AQUATIC HABITAT

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INTRODUCTION

In the last five years the major controversy surrounding fisheries-forestry interactions in Western North America has been the development of criteria for management of streamside forests. Streamside forests are valuable both for commercial wood production and for maintaining the integrity of aquatic ecosystems. The central question of the controversy is what quantity of merchantable timber volume must be left adjacent to fish bearing streams to protect habitat quality and provide adequate future recruitment of large wood to stream channels for maintenance of fish and wildlife habitat. All of the western Forest Service Regions (R-1, 5, 6, and 10), the Bureau of Land Management in Oregon, and the states of Oregon and Washington have specific criteria for management of streamside forests that require leaving a designated number of large conifer trees for fish and wildlife habitat. Standards and prescriptions for these areas are highly variable, but the common theme is to leave a "proper mix" of deciduous and conferous vegetation along streamsides. We contend that active silvicultural management of Riparian Management Areas (RMA's) is the only way long term fisheries habitat needs will be met. Silviculturalists need to develop a deeper understanding of RMA's at both the research and case history study levels, and fisheries biologists need to become more silviculturally oriented and less focused on fish habitat enhancement to assure maintenance of high quality fish habitat.

In this paper we will (1) describe the important components of a riparian management area, (2) discuss some of the management variability between agencies and National Forests along the west coast of North America, (3) examine trends in composition of some streamside forests, and (4) argue that restoration, maintenance, and enhancement of stream habitats must depend primarily on silviculture rather than structural improvement in stream channels.

The term riparian management area is used here because "riparian" relates to any area adjacent to water (not limited to streams), and "management" implies deliberate action to accomplish a predetermined purpose. Other terms such as streamside management zones, riparian management zones, and aquatic habitat management units all refer to similar concepts of multiple resource management adjacent to water. Generally, all of the terms reflect varying degrees of integrated resource management along streams.

The USDA Forest Service recognizes fish habitat as any lake or stream in the National Forest System that supports, or could potentially support, anadromous or resident fish. The National Riparian Policy (FSM 2526.03, 3/86, Amendment 48) addresses the need to delineate riparian areas and manage them for multiple use and sustained yield. Amendment 48 of the National Riparian Policy gives" special attention to land and vegetation for approximately 100 feet from the edges of all perennial streams, lakes, and other bodies of water. The distance should correspond to a least the recognizable area dominated by riparian vegetation (36 CFR 219.27e). Give special attention to adjacent terrestrial areas to assure adequate protection for the riparian dependent resources." This policy recognizes and considers different components of riparian areas and the effect various forest management practices will have upon them.

COMPONENT OF RIPARIAN MANAGEMENT AREAS

Riparian management areas (riparian ecosystems) are generally divided into three fairly distinct segments, (1) aquatic area, (2) riparian area, and (3) riparian areas of influence (Figure 1). Each of these segments contains a variety of components.

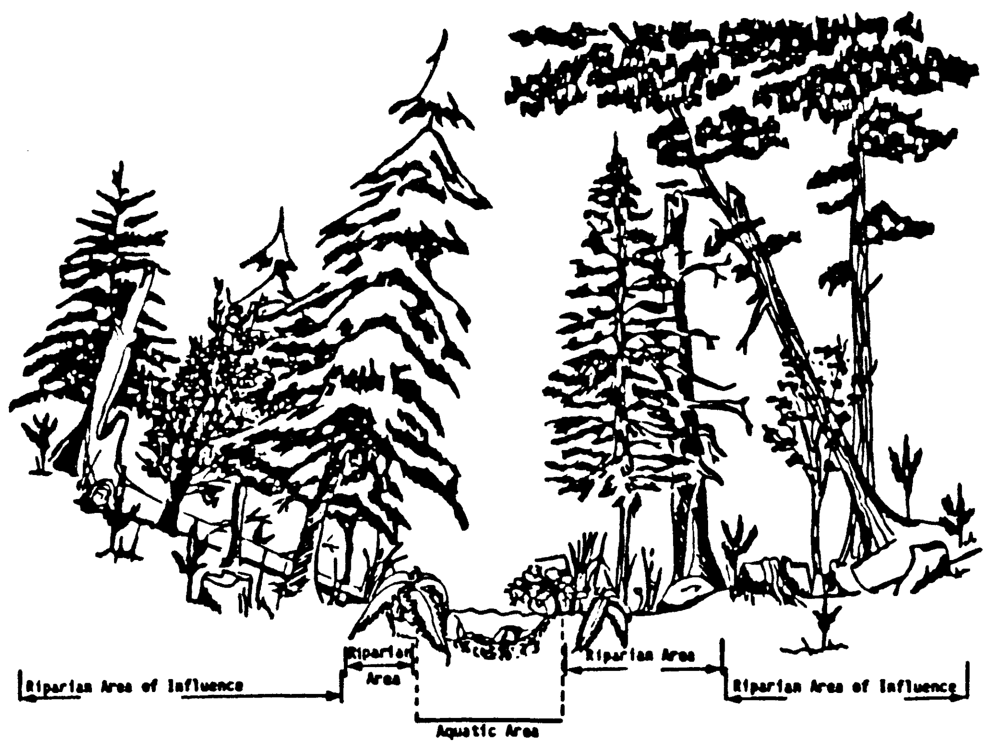

Figure 1. Components of riparian management areas (from Oregon State Department of Forestry, 1987).

Aquatic Area.

The aquatic area is the wetted area of streams, lakes, and wetlands up to the ordinary high water level. Oxbows and side channels are included if they are part of the flow channel or contain fresh water ponds.

Important components of the aquatic area are:

1. Flowing and standing fresh water.

2. Habitat for aquatic life, with the following major parts:

    a. Suitable water temperature for fish life.

    b. Water quality adequate to support aquatic life and other recognized beneficial uses.

    c. Stream channel diversity such as pools and riffles for spawning and rearing of fish.

    d. Large woody debris, boulders, or gravel bars to provide stream structure important for fish rearing and to provide stability to the channel.

    e. Streamside vegetation whose roots help provide bank stability; this vegetation also provides shade and contributes organic matter and insects to the stream nutrient regime.

The character and condition of an aquatic area is primarily influenced by, and dependent upon, the physical, chemical, and biological components of the riparian area.

Riparian Area.

A riparian area is the terrestrial area immediately adjacent to an aquatic area, where the vegetation and microclimate are influenced by both perennial and intermittent high stream flows, high water tables, and moist soils.

Components important to the riparian area are:

1. A mulit-storied forest complex, including mixed species, that provides a variety of wildlife habitat elements including food, cover, and microclimate.

2. Mature trees to provide a variety of present and future snags for birds and arboreal wildlife, dead and down vegetative material for nutrient and ground cover values, and large woody material to provide stream channel structure.

3. Midsummer shading for the aquatic area.

4. Hard and soft snags to provide a variety of habitat niches for a considerable number of birds and arboreal animals.

5. Down woody material also provides habitat niches for small animals.

6. Vegetation adjacent to, and overhanging the aquatic area provides leaves, needles, and other organic material to the water contributing to development of food chains for aquatic life. Vegetation, duff, and litter provides for water filtering important for production of clean water, and root systems help stabilize channel banks.

7. The riparian area generally provides an important growing site for forest tree species having value for timber production.

Generally, the various components diminish in value as the distance from the aquatic area increases. This is particularly true with those components having direct influence on aquatic habitat. The value of the wildlife habitat components remain farily constant throughout the area.

Riparian Area of Influence.

The riparian area of influence is the transition area between the riparian ecosystem and more upland forest ecosystem which is no longer dependent upon, nor has a direct influence upon the riparian management area. Thus, this transition area contains components that may still have direct influence upon the aquatic area.

Important components of the riparian area of influence are:

1. The riparian area of influence is often characterized by deeper soil and a high water table. Some of these areas are particularly important for timber production.

2. Snags, and trees which will become snags, are an important part of this area. Conifer snags exist for a longer time than hardwood snags and are, therefore, more desirable.

3. For fish bearing streams, a system of pools, riffles, and hiding places is important for fish productivity. Large conifer trees within the area of influence provide an important source of long-lasting wood that may influence stream structure in forested areas.

4. Trees within the area of influence may provide a major shade component along some streams which helps to maintain tolerable water temperatures for summertime fish rearing.

5. The riparian area of influence provides a variety of wildlife habitat elements including down logs, stumps, diverse plant species for food, cover, and microclimate influence.

The riparian management area privides both the structural and functional ecosystem diversity necessary for maintenance, protection, and enhancement of riparian dependent fish and wildlife. These ecotones are critical habitat elements in the landscape for fish and many wildlife species. They naturally contain a mix of deciduous and coniferous vegetation of different species, age-classes, and canopy heights.

RMA STANDARDS AND GUIDELINES

Management schemes to maintain structurally and functionally diverse RMA's have been difficult to develop because of conflicting resource demands in riparian areas and the shortage of information on effects of silvicultural management strategies on biological and physical dynamics of streams. We will consider three aspects of RMA management: (1) extended timber rotations or permissable rates of entry into RMA's; (2) organic debris standards; and (3) RMA width and shading requirements.

Extended Timber Rotations.

The 19 National Forests in USDA Forest Service Region 6 have scheduled timber harvest plans that range from 60 to 300+ year rotation age or entrys into RMA's of 3 to 15 percent per decade. There is no consistent geographic pattern in these plans that apply to both coastal and inland forests. Many RMA's within the National Forests have been excluded from scheduled timber harvest. Class I and II streams with high fishery and recreation values most often fall into this category. Most National Forests in Region 6 have planned some form of double rotation scheme for RMA's. The rational for a double rotation comes from the fact that large wood >12 inches in diameter is required in stream channels to provide structural complexity and aid in formation of pools. The diameter and length of wood must increase with increasing stream size to be effective in formation of quality fish habitat. Woody debris at least 24 inches in diameter is required on coastal streams with widths greater than 50 feet. Wood recruitment studies by Grette (1982) and David Heinman, Oregon State University (personal communication) indicate that large coniferous debris does not enter streams in significant amounts until the stand age reaches 120 to 150 years. Planning for the correct mix of age-classes of conifers along streams is rarely done except at the forest planning level.

Studies that integrate riparian silvicultural strategies for fish habitat considerations are rare. A study by Rainville et al. (1985), however, attempted this kind of integration for the Idaho Panhandle National Forest. The investigators linked stream inventory information and silvicultural data and developed a computer simulation model to evaluate the effect of silvicultural practices on the potential recruitment of large wood pieces to stream channels. Forest habitats of western hemlock (*Tsuga heterophylla*), grand fir (*Abies grandis*), abd subalpine fir (*Abies lasiocarpa*) were analyzed. Rainville et al. (1985) assumed that potential recruitment was related to the density of trees >12 inches diameter breast height (dbh), and the number and size of trees affected by mortality. The number and mortality rate of trees >12 inches dbh generally peaked at ages of between 90 and 130 years in western hemlock and grand fir habitat types, but the average size of recruitable trees was greatest in stands older than 200 years. The maximum potential recruitment of wood, and pool frequency, in streams was achieved by thinning the stand to about 890 trees per acre and harvesting the riparian area with small openings (less than 600 feet long along the stream) at a rate of 4 to 5 percent of the streambank length per decade. The standard timber rotation (100 years) and no harvest in the riparian area resulted in much lower rates of potential tree recruitment. Salvaging and commercial thinning in the riparian area also reduced recruitment of large wood to the stream. Active management was clearly essential to maximize stream habitat complexity and fisheries resources in these vegetative habitat types. Alpine fir habitat types did not respond as positively to vegetative manipulation. Rainville et al. (1985) found the density of trees >12 inches dbh peaked at ages between 110 and 150 years. Mortality was greatest between ages 120 to 130 years. Thinning to a density of 890 trees per acre and limiting harvest of the RMA to 3 percent per decade (or no harvest) optimized recruitment of wood to streams. The "postage stamp" entry technique of Rainville et al. (1985) where 600-foot long blocks are clearcut in RMA's is a marked contrast from the forest practice rules of Oregon and Washington, and the general guidelines used in the National Forests of Regions 6 and 10, which generally call for a selective harvest of from 50 to 90 percent of the large trees in RMA's. The selective harvest approach would ideally leave a stream with a canopy of diverse vegetative structure and species along its entire length. The postage stamp approach optimizes fish habitat structure over a broad area (entire basin) and requires a detailed basin harvest and silvicultural plan.

Organic Debris Standards.

All western Regions (1, 5, 6, and 10) of USDA Forest Service have some specific standards for leaving large trees in RMA's for fish and wildlife considerations. Forests in Region 6 specify 9 to 25 trees $\geq$ 16 inches dbh per acre on many Class III streams. Forest guidelines in Region 6 often specify that 60 to 90 percent of the RMA's should be in mature or old-growth timber along Class I and Class II streams. Forest Practice Rules in Oregon require a residual stand of 9 trees per acre >8 inches dbh and a 10-foot^2 basal area along fish bearing streams. Washington requires between 50 and 100 large trees per 1000 lineal feet of stream, not all of which have to be conifers depending on the size and substrate characteristics of the stream. On large Washington streams, leave trees should be representative of the size and species in the pre-harvest RMA stand. On small Washington fish bearing streams 15 to 60 feet wide, up to 30 conifers equal to or >12 inches dbh may be required.

USDA Forest Service Region 10 has the most complete set of standards and guidelines we have seen to date (Region 10 - Aquatic Habitat Management Handbook). The mean number of stems >12 inches dbh per 100 feet of stream is between 13 and 24 for undisturbed habitat conditions. The guidelines require minimum tree sizes for specific stream widths: 1 to 20-foot wide stream require at least 12-inch dbh trees; 21 to 50-foot width requires 20-inch dbh trees; >50-foot width requires 30-inch dbh trees, preferably with root wads attached. The minimum tree length for all channel widths is equal to 1.5 times the channel width.

Region 10 has also predicted smolt yield increases if woody debris is added to aquatic systems (Figure 2). These are preliminary data for Alaska (Mike Murphy, National Marine Fishery Service, Auke Bay, Alaska, personal communication) and can not yet be reasonably extrapolated to other geographic areas. However, we did want to illustrate how such debris loading was related to potential coho salmon smolt yield. In view of the fact that over 85 percent of the anadromous fish bearing streams in Regions 5 and 6 have been cleaned of large woody debris, have no large conifers left in the RMA, or have been scoured by debris torrents, knowledge of such relationships will be useful in the future.

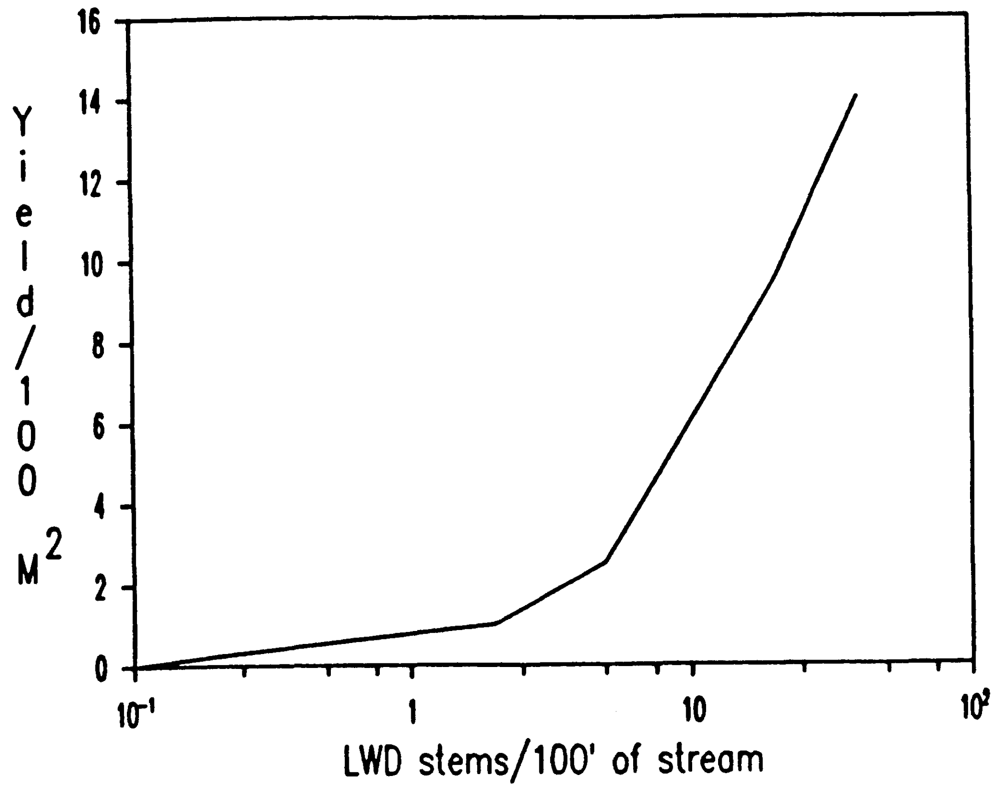

Figure 2. Predicted coho salmon (Oncorhynchus kisutch) smolt yield as related to woody debris in streams of Southeast Alaska.

Width and Shading Requirements.

Virtually all state and federal agencies require 75 percent shade over fish bearing streams. This can be accomplished by any vegetative means. Harvest may be completely disallowed along temperature sensitive streams.

TRENDS IN COMPOSITION OF STREAMSIDE FORESTS

Mature and old-growth forests have historically supplied large trees to stream channels. However, over 85 percent of the streams used by anadromous fish in western Oregon and Washington have RMA's with greatly altered tree size and species composition. Most big cedars and Douglas firs (Pseudotsuga menziesii) along third order and larger streams in the Cascade and Coast Range Mountains have been, or are about to be, removed. Repeated streamside salvage sales on the National Forests have created residual hemlock stands along many streams instead of mixed stands of cedar, fir, and hemlock. About 70 percent of coniferous trees >14 inches dbh are currently harvested within 100 feet of fish bearing streams on privately owned industrial forest land in western Oregon.

Stocking densities of conifers approach 50 thousand (M) board feet per acre along many streams in the Pacific Northwest. This figure is commonly used in Oregon to represent a fully stocked stand of Douglas-fir. However, recent surveys in western Oregon indicate fewer conifers >12 inches dbh than expected in RMA's, with volume ranging from 8 to 25 M board feet per acre (Oregon Dept. of Forestry, 1986; Andrus and Froelich, in press). The reason for the decline in stocking density is twofold. Conifer volumes are naturally low due to competition from salmonberry (Rubus spectabilis), red alder (Alnus rubra), vine maple (Acer circinatum), and big leaf maple (A. macrophyllum) in many terrace areas adjacent to streams where soils remain perennially moist (Andrus and Froelich, in press). There is ample evidence to suggest that a second reason for lower conifer volume in RMA's is successive harvest and salvage operations (Table 1). The reduction of large conifers in RMA's recently examined is a result of no conifer restocking inside the RMA flagging. Progressive reduction in coniferous trees on the Yaquina River and an unnamed Class I tributary (Table 1) is a result of intense competition with hardwoods on moist terraces. In order to maintain the structural and functional ecosystem diversity of RMA's for fish and wildlife, and realize the potential of RMA's for timber production, these areas must be restocked with young conifers. Current research in Oregon and Washington (Grette, 1982; Long, 1987) indicates that total large wood volumes in streams are dominated by pre-harvest or disturbance debris. Long (1987) studied a coastal Oregon basin forested with 50 year-old second growth timber. He found that pre-harvest debris constituted 63 to 70 percent of the total number of pieces found in the fourth order basin. Pre-harvest wood accounted for over 85 percent of the total wood volume within all stream orders. Intensively managed second growth forests are not replacing large woody debris volumes previously supplied by old-growth forest. Wood related fish habitat structure in streams with intensively managed RMA's is currently dependent on wood supplied by the previous stand.

Table 1. Changes in large conifer densities (trees/acre) within riparian management areas.

Location/stream	Pristine Forest (> 70 yr. ago)	Recently Harvested	RMA Stand
CASCADE MOUNTAINS			
Unnamed Class I			
within 50 ft. both sides	31	17	0
COAST RANGE MOUNTAINS			
Yaquina River			
within 50 ft.	16	6	3
within 100 ft.	17	11	1
Siuslaw River			
within 50 ft.	14	17	3
within 100 ft.	16	30	5
Wolf Creek at K-line			
within 50 ft.	33	38	18
within 100 ft.	19	34	11

DEBRIS SUBSTITUTES

Streams in RMA's need a continuous supply of living, dead, and down large woody debris to maintain complexity of aquatic habitats. Silvicultural proposals for assuring that these needs are met have been previously discussed. Debris substitutes that are used as surrogates for large trees in RMA's are conceptually popular with both timber and fisheries managers. Intensive habitat manipulation that relies on introduction of debris substitutes into stream channels for stream rehabilitation or enhancement has broad support throughout the west. The fisheries programs of many agencies emphasize construction of boulder berms, gabion structures of various configurations, boulder clusters, side channels, and off-channel ponds as primary techniques for habitat improvement.

Stream habitat enhancement projects on the west coast have improved spawning and rearing habitat for salmonids and probably increased fish production. Analysis of enhancement projects, however, shows that substituting other structures for large woody debris can be very expensive. The cost of placing individual boulders in the Keogh River, for example, was $22 to $24 per boulder (in 1977 Canadian dollars), depending on whether the boulders were placed with heavy equipment or by helicopter (Ward and Slaney, 1979). Planning estimates of costs for boulder placement in western Oregon streams average $35 per boulder (House and Boehne, 1985). Installing gabions for spawning gravel retention in tributaries of the Coos River, Oregon, cost a total of $225,000 in 1981. Cost per individual gabion ranged from $300 in a fourth-order stream to $1,700 in a sixth-order stream (Anderson, 1982). An average cost of $1,200 for material and labor per gabion does not include engineering design or road access costs (House and Boehne, 1985). To adequately restructure one mile of stream costs between $12,000 and $20,000, with a possible project longevity of 20 to 30 years. Forest managers must weigh the cost of replacing lost debris with enhancement structures against the cost of providing woody debris to streams through management of RMA's. In many instances, after-the-fact substitution of debris may cost much more than allowing debris to be recruited to the channel naturally. Even where structural enhancement is warranted, using native materials, such as logs, to achieve the hydraulic diversity necessary for productive fish habitat may be the most cost-effective means of treating extensive stream reaches (Lisle, 1982).

Another problem with fisheries programs designed around enhancement structures is the general difficulty in finding suitable construction sites. From a logistic standpoint, not all stream miles could be improved with enhancement devices even if unlimited funding was available. For example, one BLM District in Oregon has 528 miles of streams producing anadromous fish, and only 60 miles are feasible for structural rehabilitation. Approximately 90 percent of the stream miles can not be "artifically" rehabilitated because of access problems and other constraints, and must be managed for vegetative diversity in RMA's to maintain acceptable levels of fish production.

CONCLUSIONS

Forest practices over the past few decades have led to long-term declines in woody debris and debris-related fish habitat in small and large streams in the Pacific Northwest, particularly those that have undergone extensive channel cleaning. In some cases a short-term increase in woody debris (slash) has been associated with timber harvest activities, but small unstable debris from this source is often transported downstream within a few years. RMA's presently in young-growth or heavily harvested and salvaged condition are the only potentially significant sources of debris for the future, unless debris is furnished by massive blowdown or debris avalanches. Maintaining RMA complexity for all forest resources is an important stewardship responsibility of land managers.

Managing streamside vegetation is managing fish habitat. Silvicultural prescriptions designed to make RMA's ecologically and biologically diverse are currently lacking. Ecological diversity represents a structural diversity of dead wood and varying canopy heights and a varied vegetative community. Maintaining biological diversity and fish habitat for several salmonid species and other game fish involves much more than set-aside leave strips. Additional research and administrative studies are needed. Knowing how various tree species and debris sizes function through time in channels of different width, gradient, and valley form will aid decisions regarding where, what kind, and how many trees can be selectively removed from RMA's during timber harvest and thinning without interferring with fish habitat considerations and other important RMA resource functions.

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LINKING TIMBER AND WILDLIFE MODELS

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ABSTRACT--The Central States TWIGS tree growth projection model was linked with a habitat suitability index model for gray squirrels. The linked models were used to predict the impact of alternative management strategies on future timber yields, squirrel habitat quality, and financial return. In general, linkages between timber and wildlife models are complicated because timber and wildlife models often 1) operate at different levels of spatial resolution, 2) have different data requirements, 3) are not supported by efficient systems for computation and analysis, and 4) lack sufficient validation and testing. Several existing systems that link timber and wildlife models are making progress in these areas.

The difficult job of managing a forest simultaneously for both timber and wildlife is facilitated by using simulation models that forecast and compare the effects of alternative management strategies on the distribution of these resources. However, combining timber and wildlife models is generally difficult because of the differences in data requirements, modeling techniques, and level of detail used to represent the forest (e.g. individual trees versus stand components versus stands versus compartments). Most forecasting models have been designed to handle single tasks, such as predicting either timber yields or wildlife habitat quality, without consideration of how they might be combined with models for other resources. Linking timber and wildlife models requires new methods for manipulating and analyzing data and new information about how vegetation and wildlife resources interact.

My experience with linking wildlife and timber models comes directly from attempts with two of my colleagues, Gary Brand and Lew Ohmann, to link a Central States tree growth projection system to a habitat suitability model for the gray squirrel (*Sciurus Carolinensis*). Our past experience has been in developing tree and stand growth simulation systems, and in this project we were more interested in the process of linking the timber model to a model for any wildlife species than in the gray squirrel *per se*. The gray squirrel model was chosen because most of the pieces of information needed to evaluate the squirrel model could be obtained from the tree growth projection system we had at our disposal.

This paper describes the tree growth projection system, the gray squirrel habitat suitability index model, their linkage, and results of some applications. A final section discusses some of the general problems that must be confronted in the large-scale linkage of timber and wildlife models.

Presented at the USDA Forest Service National Silviculture Workshop, Sacramento, California, May 11-14, 1987.

The TWIGS Tree Growth Projection System

The timber model we used in this study was the TWIGS tree growth projection system for the Central States (Miner and Walters in preparation, Shifley in press, USDA Forest Service 1983). TWIGS is an individual-tree model that has been calibrated for the major species and forest types in Indiana, Illinois, and Missouri (A Lake States version for Minnesota, Michigan, and Wisconsin is also available). The individual-tree descriptor means that the models operate on a list of trees, similar to Figure 1, that results from a stand inventory. The inventory must include one or more sample plots on which species, dbh, and per acre expansion factor for each tree were recorded. Stands can be sampled using fixed-sized plots or horizontal point samples, and several sample plots can be combined to create an aggregate tree list representing a stand. The models in TWIGS are distance-independent, meaning that model users do not need to know the distance and direction from a tree to its competitors.

PROPERTY "My woods", STAND "Oak-hick"
Year = 1985, Age = 50, Site index for Red Oak = 75.0, Plantation code = 0

Seq no.	Spp group code	USFS Spp code	Species group name	DBH	Crown ratio code	Trees/ ac	Status code	Tree class
1	21	833	Red oak	12.1	4.0	9.0	1	20
2	21	833	Red oak	11.7	4.0	10.0	1	20
3	21	833	Red oak	10.3	4.0	12.0	1	20
4	21	833	Red oak	8.4	3.0	18.0	1	20
5	20	802	White oak	11.0	4.0	11.0	1	20
6	20	802	White oak	10.7	3.0	11.0	1	20
7	20	802	White oak	9.2	4.0	15.0	1	20
8	20	802	White oak	8.7	3.0	17.0	1	20
9	8	407	Select hickory	11.1	3.0	11.0	1	20
10	8	407	Select hickory	8.5	3.0	17.0	1	20
11	8	407	Select hickory	7.7	2.0	22.0	1	20
12	8	407	Select hickory	6.3	2.0	32.0	1	20
13	29	931	Othr up.hard	7.0	3.0	27.0	1	20
14	29	931	Othr up.hard	5.2	3.0	48.0	1	20
15	18	318	Hard maple	2.0	5.0	25.0	1	20
16	18	318	Hard maple	2.5	5.0	25.0	1	20
17	18	318	Hard maple	3.0	5.0	25.0	1	20
18	18	318	Hard maple	3.0	4.0	25.0	1	20
19	18	318	Hard maple	3.5	5.0	25.0	1	20

Figure 1. A typical TWIGS tree list with headings added for clarity. Users supply the property name, stand name, year of measurement, age (optional), site index, site index species, plantation designator (if applicable), species code, dbh, trees/acre, status, and tree class. Tree lists can be created using a word processor or by using a special companion program to TWIGS called TREEGEN.

The TWIGS projection system works directly with the tree list, annually updating the dbh and number of trees per acre for each entry on the tree list. A system of mathematical models estimates annual dbh growth and annual probability of mortality for each tree on the list from information on the tree's species, dbh, site quality, and the number and size of competitors. The projected tree list has exactly the same format as the initial tree list; the only difference is that through time the trees become larger and fewer in number. At any point in the projection, the tree list can be summarized to get densities or volumes by species, size class, or both. Internally, the individual tree modeling approach retains much more information than yield tables or whole stand mathematical models that operate using only the per acre characteristics of the stand. As will be evident in the next section, the capacity to provide detailed information on the characteristics of certain portions of the stand was essential to linking the TWIGS model with the gray squirrel model.

The TWIGS projection system analyzes one stand at a time. Users control the length of the projection and the frequency and detail of the output. The TWIGS management options allow users to simulate many thinnings or harvest strategies for the stand. Users can set and change stumpage rates by species for three product classes, and the value of harvested trees is automatically recorded in a financial ledger for analysis. Revenues from activities other than timber harvesting can also be added to the financial ledger, as can annual costs or one-time costs. The economic analysis options in TWIGS calculate the internal rate of return, present net value, and other economic parameters for each simulated management scenario. Multiple TWIGS runs can be used to compare several alternatives for the same stand. Figure 2 provides a simplified flowchart of TWIGS's operation.

No model gives perfectly accurate predictions of forest change. However, documents by USDA Forest Service (1983), Shifley (in press), and Kowalski and Gertner (in press) report the accuracy of Central States TWIGS under a wide range of conditions. Generally, TWIGS performs best when predictions are initiated from a sapling or larger size stand and do not exceed 30 years in length.

TWIGS is operational on the Data General, IBM-compatible microcomputers (with at least 256K RAM) running MS-DOS, and Apple IIe microcomputers with Apple Pascal. New versions of TWIGS for the DG and IBM-compatible machines (512K RAM) will be available later this year and offer improved economic analysis capabilities, automatic plotting of past and current stand conditions on stocking guides, and an improved user interface.

The Gray Squirrel Habitat Suitability Index Model

There are many different methods of modeling wildlife populations. For example, some models forecast wildlife population dynamics directly,

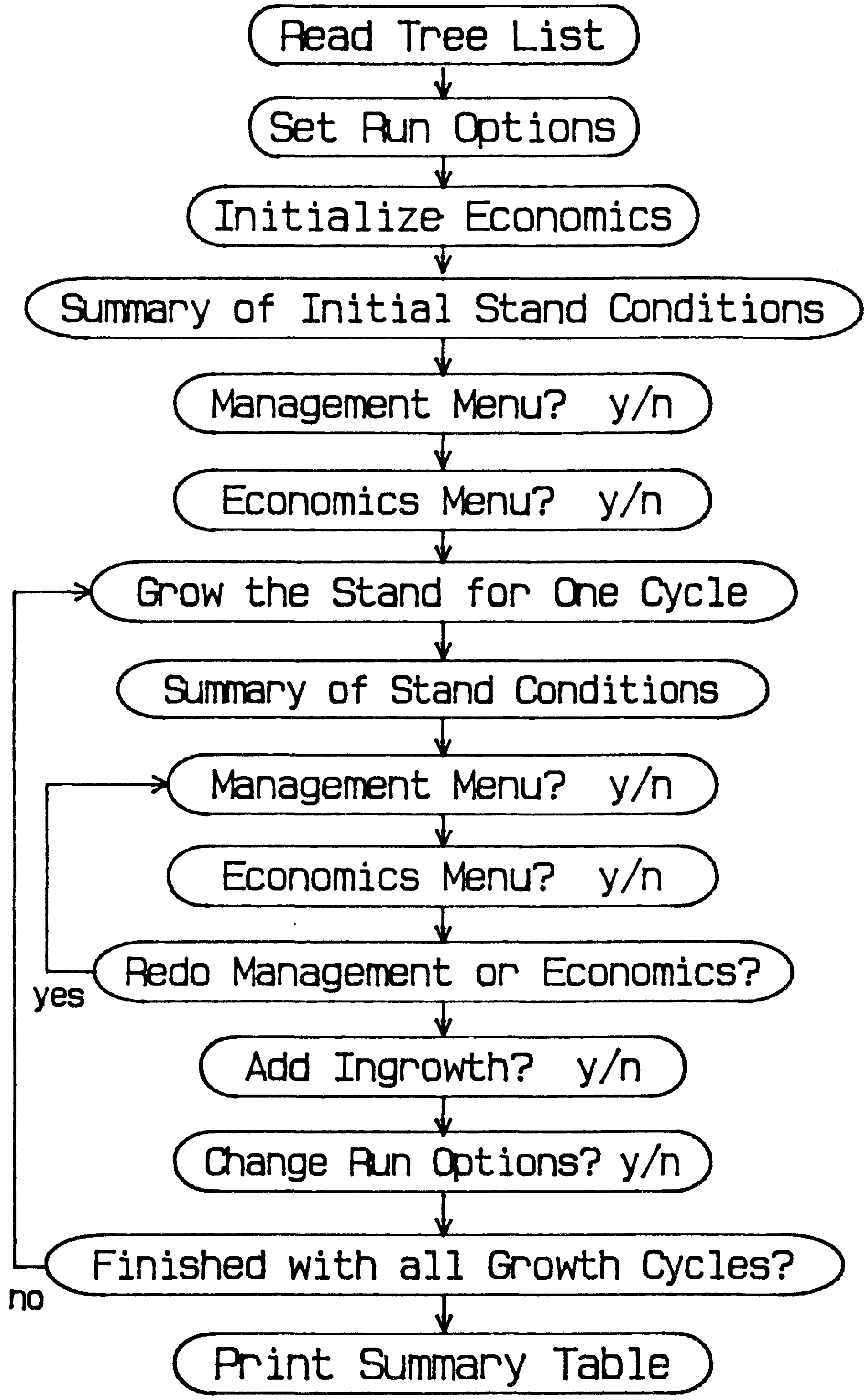

Figure 2. TWIGS flowchart showing basic steps in the program's operation.

predicting the future number of animals per unit area. The class of wildlife models known as habitat suitability index (HSI) models evaluate the relative quality of the physical and vegetative characteristics of a site. A site with a high HSI value can support a relatively large wildlife population even though it may or may not presently have a large population. Because they focus strictly on the physical and vegetative site characteristics, HSI models are generally easier to apply than are models that forecast the dynamics of animal populations from information about current population levels, birth rates and death rates.

Allen's (1982b) habitat suitability index (HSI) for gray squirrel was chosen for use with TWIGS. Squirrels are an important wildlife species, and populations are often monitored to evaluate progress toward wildlife management goals (e.g. USDA Forest Service 1986). However, the decision to link TWIGS with this squirrel model was pragmatic; most of the information required to evaluate this squirrel HSI model could be projected and evaluated from the TWIGS tree list. A survey of available HSI models revealed few that could be evaluated with only the information provided by a tree growth projection system.

HSI models are designed for field use. They are based on easily measured variables describing habitat characteristics to which the species responds, that have values that can be predicted, and that change or can be changed through management (Schamberger and O'Neil 1986). HSI models are built around quantitative and subject evaluations by experts and are designed to meet immediate needs for forest management information.

It is important to recognize that HSI models are not models of animal populations or of carrying capacity. HSI models do not make any statement about the number of animals; rather, they assess the vegetative and physical characteristics of the habitat and give the site a numerical rating between zero and one to indicate the relative habitat quality. Although the habitat quality is presumably related to the number of animals, HSI models make no attempt to quantify these relations. Due to a variety of factors outside the scope of the HSI model, these relations may not be constant across the geographic range of the HSI model's applicability. From an operational standpoint, it would be prudent to assess the relation among HSI models and wildlife populations in one's analysis area. Previous attempts to develop such relations (e.g. Laymon and Barrett 1986) have met with varying degrees of success. A good summary of HSI model testing considerations is given by Schamberger and O'Neil (1986).

The gray squirrel HSI model has two components. The first component evaluates the winter food supply and the second evaluates the quality of cover for over-wintering and rearing young. Specifically, winter food availability is estimated from the percent canopy closure of hard-mast producing trees 10 inches dbh or larger and from the number of different mast producing species (Figure 3). The cover and reproduction needs are estimated from the percent canopy closure of trees taller than 16.5 feet, from the mean dbh of trees at least 80 percent as tall as the tallest tree in the stand, and the percent crown cover of woody vegetation

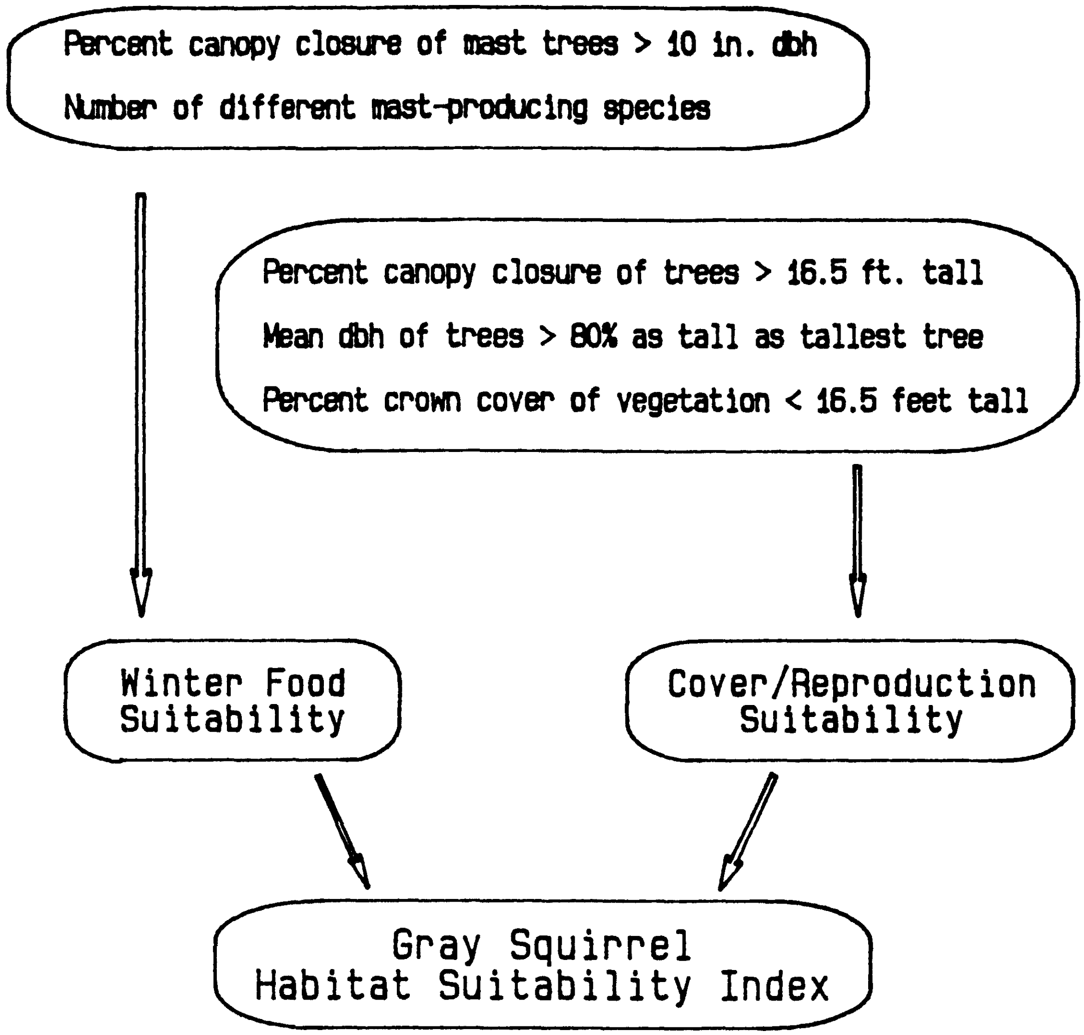

Figure 3. Elements of Allen's (1982b) model of gray squirrel habitat suitability index. Five characteristics of the forest stand are combined to provide separate indices of suitability for winter food and cover/reproduction needs. The overall suitability rating is the lesser of these two values.

shorter than 16.5 feet. Per acre estimates for these five variables are combined to form separate index values for winter food and cover/reproduction needs. The overall HSI is the lesser of the cover/reproduction and the winter food indices. The overall HSI is always a number between zero and one, zero indicating unsuitable habitat and one indicating optimal habitat.

As mentioned previously, HSI models were developed for field use. Consequently, the variables used to estimate HSI are those that can be readily measured from a field inventory. Often, however, it is impractical to conduct an extensive inventory solely to evaluate of squirrel habitat quality. Moreover, some of the most important considerations in making a management decision are the possible effects of management alternatives on future habitat suitability. The latter concern requires linking the habitat models and a model that forecasts changes in the variables used to evaluate habitat suitability.

Linking TWIGS with the Gray Squirrel Model

Linking the timber and squirrel models requires that the information processed by TWIGS be translated into the five variables needed to evaluate gray squirrel HSI. For one variable, the number of different mast producing species, the linkage was **direct**. TWIGS tracks the growth and survival of individual trees on the tree list; we simply counted the number of different hard-mast-producing species.

Calculating three other variables used to evaluate HSI required computations in addition to the normal TWIGS output. These variables were the percent canopy closure of hard-mast-producing species, the mean dbh of trees at least 80 percent as tall as the tallest tree, and percent canopy closure of trees at least 16.5 feet tall. These are examples of an **indirect** linkage. By adding equations to estimate tree height as a function of tree diameter (Ek 1974) and equations to estimate crown diameter as a function of tree diameter (Minckler and Gingrich 1970, Ek 1974), it was possible to compute these three additional values needed to evaluate the HSI.

The linkage for the remaining variable, percent crown cover of vegetation less than 16.5 feet tall, proved more difficult. There were no local equations relating the shrub crown cover to the forest overstory information projected by TWIGS. Consequently, we relied on the help of two experts, John Probst of the North Central Forest Experiment Station and Richard Burt of the Hoosier National Forest, to provide a **subjective** link for this variable. Based on their experience and supporting data provided by Probst, we estimated that shrub crown cover would be approximately 15 percent for fully stocked oak-hickory stands and approximately 60 percent for stands where the overstory was maintained at 60 to 70 percent of full stocking.

We developed a special version of TWIGS to compute the variables needed to make the linkage and evaluate the gray squirrel HSI for simulated future stand conditions. The same result could have been achieved without modifying TWIGS if we had wanted to save the projected TWIGS tree lists representing future stand conditions and manually summarize HSI.

Applications

Use of the linked models has been demonstrated in two applications involving stands from the Hoosier National Forest in Indiana. The first application compares three management alternatives for a single stand, the second compares two management alternatives for nine contiguous stands.

Table 1.--Initial conditions of the 45-year-old oak-hickory stand used to compare effects of three management alternatives on timber yields, gray squirrel habitat suitability, and financial return

	Live trees (no./ac)	Basal area (sq.ft./ac)	Mean dbh (inches)	Sawtimber (mbf/ac)
Pignut hickory	204	6	1.6	0.5
White oak	362	58	5.0	1.0
N. red oak	9	5	10.2	0
Black oak	50	21	8.4	1.1
Scarlet oak	66	18	7.1	0
TOTAL	691	108	—	2.6
Mean	—	—	4.5	—

The first application, described in detail in Brand et al. (1986), centers on a 45-year-old oak-hickory stand measured during a 1977 forest inventory. White oak site index was 70 feet. The stand included five species and 691 trees per acre with a basal area of 108 square feet per acre (Table 1). The plot had previously been measured in 1967, and the 1967 stand conditions were projected to 1977 using TWIGS. The 1977 conditions predicted by TWIGS were similar to the observed 1977 conditions, increasing our confidence in the accuracy of TWIGS for this location.

Three management alternatives were evaluated: 1) no action, 2) periodic diameter-limit cutting of all trees 14 inches dbh and larger, and 3) intensive management for high-quality sawtimber as per Sander (1981). The third option included periodic thinnings to regulate stocking and to favor faster growth of higher quality trees held to rotation age. The evaluation period was the 35 years from the 1977 measurement through

2012, when the stand reached its rotation age of 80 years. The diameter-limit cut produced the greatest volume of sawtimber over the period, 6.2 mbf/ac versus 5.9 mbf/ac and 4.9 mbf/ac for the intensive management and no action options, respectively (Table 2). Gray squirrel habitat suitability index was highest with the no action option and lowest under intensive management (Figure 4). Brand et al. (1986) used the economic analysis option in TWIGS to compute internal rates of return for each alternative. Using the mean stumpage rates for each species from Hoover and Park (1983), assuming a market for pulpwood or firewood at about $12/cord and incorporating no cost other than a $2/ac annual administration cost for the period, we estimated internal rates of return at 3.9 percent, 3.4 percent, and 2.3 percent for the intensive management, diameter-limit, and no action alternatives, respectively. Product quality should be highest under intensive management. If, under this option, average stumpage value increased an equivalent of about one quality class per log at rotation, the internal rate of return for this option could be as high as 5.6 percent.

It is important to note that the linked TWIGS-HSI model did not decide which alternative was best. But it did help to put the tradeoffs in squirrel habitat quality, yield of timber, timing of timber yields, and financial return into perspective.

The second example from Shifley et al. (1986) used the same linked TWIGS-HSI model to compare two management alternatives for a contiguous group of nine stands covering 258 acres on the Hoosier National Forest. One alternative was to treat each stand according to the recommendations in silvicultural guides of Sander (1981) and Roach and Gingrich (1968) without considering activities in surrounding stands. The silvicultural guides indicated that three stands should be thinned and the remaining six stands clearcut.

Although this prescription was appropriate for the stands considered individually, there were potential problems in implementing this plan. One was a policy of limiting clearcut size to approximately 30 acres. A management team from the forest had recommended another option: thin three of the stands to about 60 percent stocking to release crop trees, clearcut two other mature stands, and do nothing with the remaining four stands.

A comparison of the two alternatives for the nine stands showed that at the end of 20 years the total value of the standing crop and intermediate harvests was higher for the management team's option (Table 3) than for the alternative of strictly following the silvicultural guides. The team's option also produced significantly higher gray squirrel HSI values (Figure 5). However, the silvicultural guide option, which included clearcutting six stands, produced greater income in the early years of the analysis period. If the alternative rate of return (i.e. the interest rate at which the income could be invested elsewhere) were higher than 1.4 percent, the guide-based option was financially more attractive. Note, however, that this financial analysis excludes the detrimental impact on squirrel HSI, visual quality, and other goods and amenities that are difficult to evaluate monetarily.

Table 2.—Comparison of three management alternatives for a 45-year-old oak hickory stand[1]

Year and treatment	No Action		Diameter Limit Cut		Intensive Management	
	Sawtimber (MBF/ac)	Pulpwood (CCF/ac)	Sawtimber (MBF/ac)	Pulpwood CCF/ac	Sawtimber MBF/ac	Pulpwood CCF/ac
1977 Thinning	—	—	—	—	1.0	3
1987 Thinning	—	—	—	—	—	4
1997 Thinning	—	—	2.8	3	—	—
2012 Final Harvest	4.9	18	3.4	13	4.9	7
TOTAL	4.9	18	6.2	16	5.9	14

[1] Also see Figure 4.

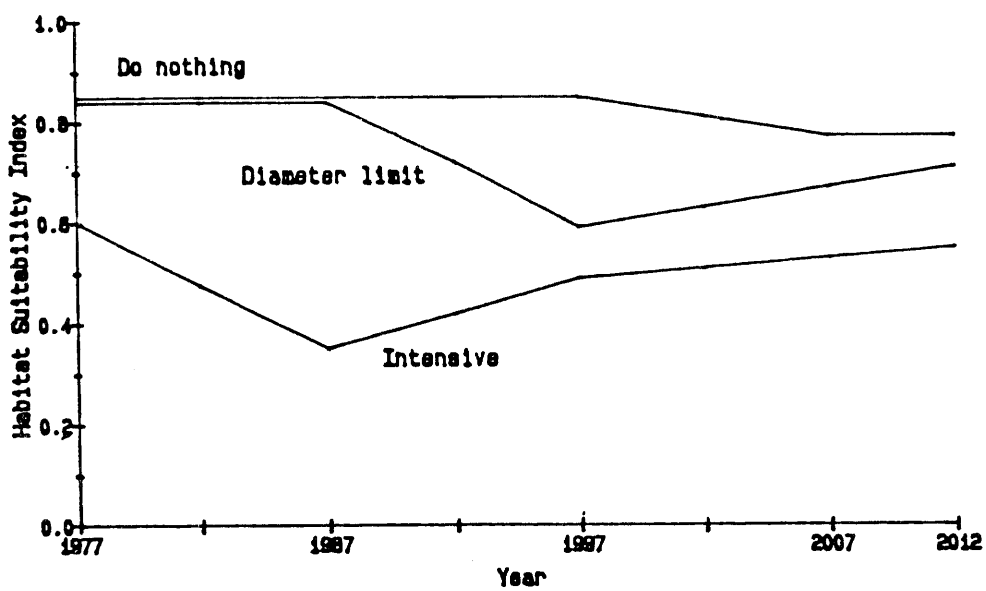

Figure 4. Gray Squirrel HSI values for three management alternatives in a southern Indiana mixed-oak stand.

Table 3.--Comparison of two management alternatives on a 258-acre tract of the Hoosier National Forest[1]

Year	Silviculture Guide-Based Option					Interdisciplinary Team Management Recommendation				
	Acres Thinned	Acres Clearcut	Sawtimber (MBF)	Pulpwood (CCF)	Value ($1000)	Acres Thinned	Acres Clearcut	Sawtimber (MBF)	Pulpwood (CCF)	Value ($1000)
1983	98	160	928	18	93	98	36	274	7	25
1993	38	0	23	1	1	38	0	23	1	1
2003 standing crop (all stands)	-	-	471	19	55	-	-	1419	20	145
TOTAL (1983-2003)	136	160	1422	38	149	136	36	1716	28	171

[1] Also see Figure 5.

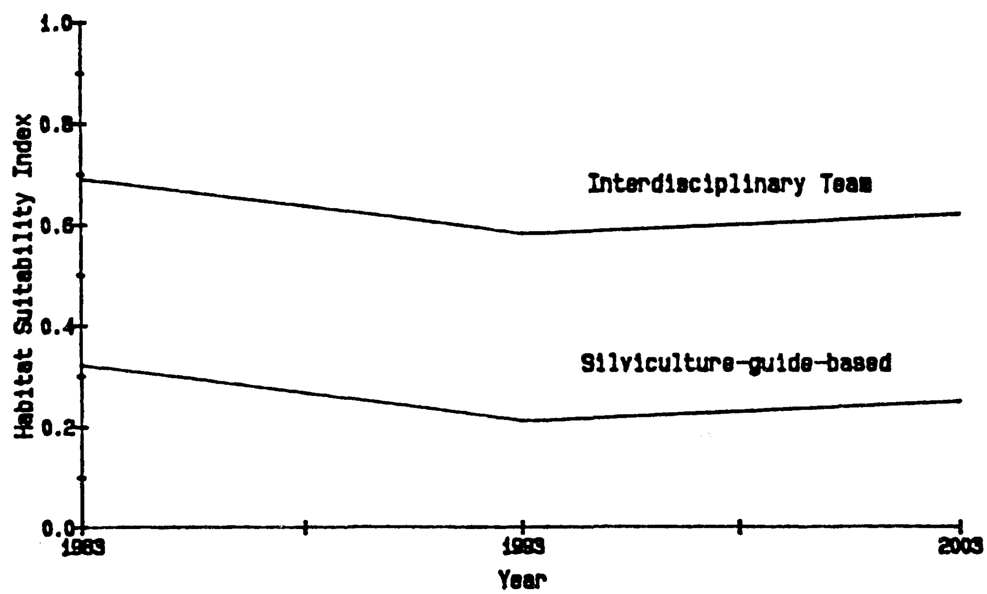

Figure 5. Mean gray Squirrel HSI values for two management alternatives for a 256-acre tract in southern Indiana.

As before, there are no simple answers and the model does not specify a "best" alternative. Modeling helps bring the alternatives into a quantitative framework that can provide some of the pieces of information necessary to support decisionmaking.

Barriers to Linking Models for Large-Scale Applications

Linking vegetation and wildlife models can be a powerful procedure to assist in evaluating management alternatives. The examples in the preceding section provided a reasonable level of detail on timber yields and squirrel HSI for specific stands. Information on other wildlife species is also important, but several barriers stand in the way of expanding the TWIGS-squirrel model to include other wildlife species. These barriers are not unique to the TWIGS-squirrel model, they are problems characteristic of any timber-wildlife model linkage. Nor are the barriers insurmountable; the conclusion of this section identifies some modeling systems that have made progress in linking wildlife and timber information for many species.

Barrier 1.--Multiple levels of spatial resolution.

One reason we were able to easily link the squirrel model with TWIGS is that the gray squirrel habitat evaluation procedures fit within the definition of a forest stand used by TWIGS. Squirrel habitat can be evaluated on a stand-by-stand basis without knowing stand area or adjacent vegetation types, even though these factors may, at times, be important. Most other wildlife models, including HSI models for other species, require information that is not readily available from a forest inventory projection system (e.g., distance to water or spatial juxtaposition of stands). The HSI model for the fox squirrel (Allen 1982b), for example, requires information on access to grain supplies. Information of this kind requires one to look beyond the boundaries of a single forest stand.

Barrier 2.--Different data requirements for timber versus wildlife models.

Most timber models have been designed to estimate change in the commercially valuable overstory trees; the input requirements and output produced by timber models are designed to accomplish this task efficiently with as little data as possible. However, the typical timber model information on the number and volume of merchantable trees is often not relevant in evaluating habitat suitability for wildlife species. Often the vegetative components with no commercial value (e.g., snags, den trees, shrubs, and ground cover) determine wildlife habitat suitability. Fortunately, there is a growing tendency toward developing individual-tree based models that can accommodate growth and management simulation of any species or class of tree, regardless of its value as stumpage. Models of the dynamics of understory vegetation are becoming available. The work described by Mouer in this proceedings and in previous publications (Mouer 1986) has demonstrated that models predicting understory vegetation as a function of the characteristics of the overstory and the site can be used to complete some of linkages needed to evaluate habitat suitability. If models for low vegetation had been available for the Central States, the canopy closure of the low vegetation in the TWIGS HSI models could have been a direct linkage rather than a subjective one. Research focused on creating mathematical models for all layers of forest vegetation can provide many of the linkages between timber and wildlife models that are currently missing.

Barrier 3.--Computational and analysis tools.

Even when appropriate models of vegetation and habitat suitability or wildlife population dynamics are available, the logistics of linking models and applying them to evaluate alternatives for a given geographic region can be overwhelming. Computational and graphical tools must be developed to manipulate the data, simulate management options, and present the results. In the past, timber data has been maintained separately as stand records. Wildlife data have been maintained in formats appropriate to the species being considered, but rarely in a format corresponding directly to a stand. Wildlife habitat evaluations require some pieces of information outside the traditional concept of forest stand. Spatial arrangements of vegetation, water, and other features of the landscape must be considered to evaluate habitat characteristics or to predict wildlife population dynamics. Software is needed to 1) maintain and link timber and wildlife data bases, 2) simulate future conditions of forest vegetation and habitat suitability for different management alternatives, and 3) analyze and display spatial information that affects management decisions. Several systems that have been developed to begin addressing this need are mentioned in a later section.

Barrier 4.--Model validation.

All models are simplified representations of reality. As such, they necessarily omit many of the details of the real system they represent, focusing only on the measurable characteristics of the system that can be used to identify its current state and to project its future state. Timber and wildlife models must be evaluated, singly and in combination, to determine their correspondence to observed changes in timber and wildlife populations at specific locations. Vegetation models must be evaluated to determine the extent to which they accurately predict actual changes in vegetation. Accuracy in prediction is not the only consideration in model evaluation and validation; factors such as ease of use, access, data requirements, and design can all be important. Two general references on evaluating timber models are those by Buchman and Shifley (1983) and Hepp (in press).

Wildlife models are even more difficult to evaluate than vegetation models. Part of the difficulty in evaluating HSI models lies in the fact that HSI is an abstract quantity with no direct correspondence to local animal populations. Local differences in predation, disease, and previous management activities may lead to significant differences in population sizes for locations with similar habitat suitability indices. Animal populations are more difficult to census than are vegetative populations, making HSI models all the more difficult to validate. But practical application of a habitat suitability index model necessitates relating the suitability index (a number between zero and one) to the number of animals, recognizing that this relation may be different for different locations. An alternative to HSI models are models that directly predict numbers of animals, but these models are more complex than HSI models and linkages to vegetation models may be even more difficult.

Some Existing Timber and Wildlife Modeling Systems

Despite the barriers listed in the previous section, much progress has been made in developing systems that link wildlife and timber models. Some examples are listed below.

ECOSIM--Ecosystem Component Simulation Models

Calibrated for use in forests of the southwestern United States, ECOSIM includes tree-based forest growth models patterned after those used in TWIGS (Rogers et al. 1984). ECOSIM incorporates models to estimate herbage production, water yield, forest floor characteristics, soil loss, scenic beauty, and habitat suitability for squirrels and non-game birds. ECOSIM forecasts future quantities of these goods and amenities for simulated management alternatives with different levels of harvest, regeneration, prescribed burning, and range improvement.

DYNAST--Dynamically Analytic Silviculture Technique

DYNAST is a general framework used to combine projected information on yield and forest size structure with habitat suitability models to provide a method of comparing management alternatives (Boyce 1977, 1980). DYNAST operates with large acreages, using yield tables to forecast shifts through time in the number of acres by forest type and size class. The number of acres by type/size class defines the vegetative structure of the forest, which is in turn related to habitat quality for species of interest. Although originally developed for use in Appalachian forest types, the techniques used in DYNAST are quite general, and the methodology has been adapted for other regions (e.g. Benson and Laudenslayser 1986, Kirkman et al. 1986). For wildlife species whose populations are related to stand age gradients, the DYNAST approach can be quite powerful, particularly when tied to National Forest data bases. This model requires users to provide appropriate yield tables, and it is currently restricted to even-aged management.

Mark Twain National Forest Simulation System

This system was developed specifically to evaluate alternatives for large management areas on a national forest (Kirkman et al. 1986). The DYNAST model forecasts the future size/age structure of a management area (i.e. number of acres by mean stand dbh, stand age, and forest type). This information can be converted into estimates of timber yield; and by using PATREC models (Williams et al. 1978), it can also be converted to wildlife population potentials. In combination with the

TMIS and WMIS data bases and the Missouri Fish and Wildlife Information System (a data base of wildlife habitat requirements, species' life histories, and other pertinent facts), this simulation system is a powerful tool for quantifying many of the factors that influence the selection of a preferred management alternative.

CHAMPS--Computerized Habitat Analysis and Multiple-Use Prescription System

CHAMPS combines a stand inventory data base and a geographic information system with an expert system that accesses timber and wildlife knowledge bases (Rauscher 1986). When complete, CHAMPS will provide users with methods to interactively examine stands for treatments, graphically display the spatial arrangement of selected stands, and link vegetative and spatial information to knowledge bases that assist in selecting prescriptions that meet goals for production of timber and wildlife habitat. CHAMPS is the only system listed here that uses a geographic information system to assist in the decision process.

TIMPRO/FOREMAN

TIMPRO/FORMAN, an extension of the YIELD program (Hepp 1982), simulates the results of management alternatives in terms of timber yields, financial return, and habitat suitability for deer, squirrel, and quail (Cooney 1987). TIMPRO/FORMAN operates simultaneously on several stands to produce summaries of wood flows, financial returns, and habitat suitability indices through time. User preferences for timber, economic return, or habitat quality can be formulated as constraints that can be interactively modified to develop a preferred management option.

This is not an exhaustive list of systems linking wildlife and vegetation models; other excellent examples can be found elsewhere in this proceedings. Verner et al. (1986) is an excellent general reference on current research in this field. Existing systems linking vegetation and wildlife resource simulation models represent advances in research and technology directed at solving complex resource management problems. But far more effort devoted to modeling, systems development, and validation is necessary to develop these into the comprehensive simulation systems required to evaluate resource management alternatives.

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PREDICTING CANOPY AND SHRUB COVER, AND RELATIONSHIPS BETWEEN STANDS FOR EVALUATING MULTIRESOURCE SILVICULTURE

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ABSTRACT

Decision-support models such as the Stand Prognosis System are valuable tools for evaluating tradeoffs among multiple resources. Essential features of such models are the ability to forecast vegetation changes, simulate management effects on vegetation, and relate the objectives of vegetation management to objectives for managing other resources. Components of the Prognosis Model that relate to wildlife habitat are discussed. These are projection of stand canopy structure and understory development, and simultaneous projection of groups of stands in a logical planning unit, with spatial and temporal interactions between them. Examples and potential applications of relating Prognosis Model projections to wildlife habitat are presented.

INTRODUCTION

This meeting has been convened to discuss how silviculture can be the tool to help accomplish management objectives for many resources. The majority of the workshop participants are primarily silviculturists, timber managers, or researchers in timber management; yet every one of us is obligated by law and profession to consider multiple-use benefits of our research and management activities. The very obligation to produce multiple goods and services has led to a Catch-22 situation reflected by the continuing controversy over "below-cost" timber sales. Critics question whether the objectives of timber management can be compatible with the objectives for managing other resources. Can the costs and benefits of managing timber be compared with the costs and benefits of managing other resources? How can we be confident that multiple-resource objectives can be achieved in the future, when management plans are based only on existing vegetation conditions?

One essayist has recently addressed the issue of whether the multiple-resource results of timber management and harvest will compensate for the difference between timber sale receipts and costs (Krutilla 1987). He suggests that it may not be possible to supply the required data and systematic investigation in the current level of planning and analysis (within the context of National Forest planning) to resolve this question. An alternative is to develop and make use of the best planning and analytic models available, and to use these models to explore alternative management prescriptions for multiple resources in reasonably sized planning areas.

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Sophisticated models continue to be developed by researchers and applied by planners. Models may be helpful tools for designing silviculture to benefit other resources. They may be designed to represent interactions between resources. For example, much work has been done on the biology of Rocky Mountain elk and possible management implications for their habitat (see Thomas 1979, Lyon 1984). Also, habitat suitability index models have been developed for many wildlife species to assess management effects on habitat, although much work is needed to test their validity. New models are incorporating methods to include spatial resolution in the planning process. With the use of planning models such as FORPLAN II, we are moving toward an ability to represent spatial effects among planning units. It is also imperative to make sure we have the right information in the inventory phase to link the effects of vegetation management to other resources. Integrating this information into analytic models is an ongoing research task.

The models required for multiresource analysis should include a number of integrated components. The first is a reliable method for forecasting vegetation changes through time. After all, we are primarily vegetation managers. Second, models should realistically represent management activities and their effects on vegetation. Third, we should be able to relate the objectives of vegetation management to the objectives for managing other resources (Christensen and Davis 1986). And finally, procedures are required for comparing different management prescriptions on an area large enough to encompass multiple-use interactions, including timber management.

OVERVIEW OF THE STAND PROGNOSIS SYSTEM

The Prognosis Model (Stage 1973, Wykoff and others 1982) was designed to be the central component in an integrated decision-support system for evaluating tradeoffs among multiple resources. It has been used to predict future patterns of stand growth and the probable consequences of management on stand development in the Northern Rocky Mountains and elsewhere. Its primary application has been to evaluate silvicultural investments in growth and yield. But the same components of the Prognosis System that represent timber management applications-- vegetation growth, mortality, and simulation of management activities--make it useful for examining the effects of silvicultural options on other resources, such as wildlife habitat. Recent additions to the Prognosis Model have enhanced its potential application to other resources.

The Prognosis Model simulates stand development by predicting growth, mortality, and regeneration of individual trees sampled from an inventory. Growth predictions depend on the combination of site, stand, and tree characteristics of the existing inventory. Originally formulated to simulate the diverse forest conditions of northern Idaho, the Prognosis Model has been extended to represent the growth characteristics of other conifer ecosystems in the Northern, Intermountain, Pacific Northwest, and Pacific Southwest Regions (Johnson and Dixon 1985).

For each growth projection cycle (normally 10 years), the model predicts diameter and height growth, change in crown ratio, and survival for each tree in the inventory (Wykoff and others 1982, Wykoff 1986). In the Inland Empire version of the model, growth relationships are included for 11 commercial conifer species. Projection results are written in a yield table format summarizing density, volume, growth, and mortality for the residual stand, and for the amount of material removed by harvest.

Crown dimensions and foliage production are predicted for each tree by the COVER Model (Moeur 1985). If harvest and site preparation activities are simulated, then the Regeneration Establishment Model predicts the regeneration of new seedlings following site disturbance (Ferguson and Crookston 1984). Also following a disturbance, the COVER Model predicts the occurrence, height, and cover of shrubs, forbs, and grasses in the understory. Virtually any silvicultural prescription that can be applied to individual trees can be simulated. Thinning activities can be specified by date, or they may be scheduled contingent upon stand characteristics reached within a projection (Crookston 1985). The base Prognosis Model may be linked to models that simulate the dynamics of pest populations and their impact on the stand (see Monserud and Crookston 1982). Prognosis stand projections can be linked also to an economic analysis program (Horn and others 1986).

The base model and any combination of related component models may be used to project the development of individual forest stands through time. Additionally, a new Prognosis procedure called the Parallel Processing Extension links groups of stands in a simultaneous projection, enabling the simulation to consider spatial and temporal interactions among stands (Crookston and others, in preparation). The remainder of this paper will focus on two of the most recently developed Prognosis System models, COVER and the Parallel Processor, and how they can be used to link projections to other resources. While the example applications deal with wildlife habitat, the Prognosis System is well suited to evaluation of other ecosystem components requiring quantification of forest vegetation, response to management, and dynamics among stands. Among these are insect pest analysis, visual impacts, and hydrologic impacts.

INDIVIDUAL STAND VEGETATION VALUES RELATED TO WILDLIFE HABITAT

The COVER Model extends Prognosis by modeling the structure of tree crowns and understory vegetation (Moeur 1985). It provides three types of information: (1) a description of the amount of cover and foliage in the tree canopy by height class (for all conifer species); (2) the probability of occurrence, height, and cover of shrubs and other nonconifer species in the understory following stand disturbance; and (3) a summary of overstory and understory cover and biomass in the stand. These stand structure predictions can be used to examine the probable effects of silvicultural treatments on wildlife habitat components, such as thermal cover and hiding cover, forage production, and the interactions of shrubs and trees that determine vertical and horizontal stand diversity.

Summary values for the tree canopy include stand height (height of the largest 40 trees per acre by d.b.h.), canopy closure, foliage biomass, and the density of stems, their basal area, and the sum of their diameters (the lineal feet in stems at breast height). The tree canopy is also partitioned by 10-foot height classes for displaying canopy closure (percentage of ground area covered by the projections of crowns of trees whose total heights fall within a given height class), crown volume (volume in cubic feet of crown frustums within a height class, computed from predicted crown shape, diameter, and length for individual trees), crown profile area (area in square feet occupied by crown profiles, as if the stand were flattened in a vertical plane), foliage biomass, and number of trees.

Understory development is projected by the COVER Model for the first 40 years following stand treatment. Probability of occurrence, height, and percent cover are projected individually for each of 31 species or species groups common to Inland Empire forests. The projections are summarized as the weighted average cover and height of understory vegetation for the stand. The understory models are sensitive to time since disturbance, type of site preparation, degree to which the canopy has been opened, and physiographic site characteristics.

Many of the shrub and tree cover values projected by Prognosis can be related to wildlife habitat. For example, thermal cover for elk in the Northern Rockies is defined as a stand of coniferous trees 40 feet or more tall, with an average canopy closure exceeding 70 percent (Thomas and others 1979a). Prognosis Model canopy closure and stand height projections are directly interpretable to show when, or if, adequate thermal cover is provided in the course of stand development. For example, Winn (1985) applied Prognosis to evaluate elk thermal cover in Utah's Uinta Mountains by projecting lodgepole pine stands on three different sites under three silvicultural prescriptions.

Hiding cover for elk (defined by Thomas and others [1979b] to be vegetation capable of hiding 90 percent of an adult animal from view at a distance of 200 feet) can be obtained from the projection by summing the diameters of tree trunks, foliage in the lower canopy, and shrub height and cover. Certain assumptions need to be made to interpret the vegetation values as hiding cover. These include assumptions about the spatial distribution of trees and shrubs in the stand, the contribution of tree foliage near the ground to hiding cover, and a translation of shrub height and vertical cover to horizontal cover. Hiding cover may be evaluated for individual stands using Prognosis values as input to Lyon's HIDE2 program (Lyon 1987). HIDE2 evaluates hiding cover by computing visual blockage within a stand, given tree densities and diameters and canopy diameters of shrubs and trees with lower level foliage. In another example, specialists in the Gallatin National Forest in the Northern Region used predicted stem and foliage values from Prognosis to project changes in hiding cover in stands affected by defoliation and mortality due to western spruce budworm (USDA FS 1986). Their model was developed to predict changes in hunter or visitor days from the response of big game hiding cover to different budworm outbreak and treatment scenarios.

Other wildlife habitat applications of Prognosis output are possible. For example, foliage-height profiles and crown volumes by height class in the tree canopy are useful statistics in evaluating bird habitat relationships (for example, Swift and others 1984). Both the regeneration model and shrub models are sensitive to type of site preparation and could be used to examine the effects of prescribed fire on conifer establishment and forage production.

STAND INTERACTIONS

It is now possible within Prognosis to project the development of groups of up to 200 stands, with dynamic interactions among them, as a logical planning unit. Simultaneous projection of stands is controlled by the Parallel Processing Extension (PPE) (Crookston and others, in preparation). The PPE is being designed to run concurrently with a geographic information system so that spatial effects may be mapped and displayed within a simulation.

The PPE allows formulation of harvest policies that incorporate the dynamic development and management of groups of stands, spatially and temporally, in a simulation. These dynamic interactions can represent effects of naturally occurring biological agents that cross stand boundaries (such as insect pests) or policy constraints on the proximity and timing of treatments.

Harvest simulation for a group of stands projected in parallel specifies activities to be scheduled for individual stands, conditional upon the development and management planned for other stands in the analysis unit. This precludes the model user from having to foretell when, or if, the events that lead to scheduling of activities actually occur. Harvest targets and individual stand harvest priorities are subject to variables that are continually monitored throughout the projection. Some variables operate for the entire analysis area, such as time, weighted average growth, mortality, volume, basal area, and density of trees. Additionally, most of the state variables for individual stands in the projection can be used to key simulated activities (table 1). Thus, it is possible to create a simulation in which activities are "automatically" carried out when the right mix of conditions is met. As an example, a policy might be to intensively manage an area. Intensive management could be defined as thinning stands that are overstocked, and harvesting stands when they reach some specific standards of size and maturity. Harvested stands would be regenerated by preparing the site and planting areas that do not reach full stocking naturally within a few years. A schematic diagram of this harvest simulation is presented in table 2.

The policy description, definitions of stand conditions, and silvicultural activities are controlled by explicit keywords that guide the projection. This makes the system extremely flexible in the kinds of activities and constraints that can be represented. The PPE can also be used to generate decision trees to answer "what if" questions. These may involve different timing choices for management actions, comparing different silvicultural prescriptions, simulating random events such as mountain pine beetle infestation, or contrasting policies. Projection results may be displayed by individual stands, or as composite yields over the entire analysis area.

Another important development in the PPE, which previously has been unavailable in most simulation or optimization procedures, is the ability to represent spatial relationships among stands. The spatial variables, like the other stand variables in table 1, can be used to monitor and control activities in the simulation. These spatial variables include (1) stand area and location; (2) adjacent stand locations and length of their common boundaries; and (3) distance from the stand to roads. The spatial attributes may be used in the projection to define decision variables for individual stands, such as proximity to a clearcut (where "clearcut" is defined by the model user in terms of stand top height and number of trees), sum of adjacent areas clearcut, distribution of edge, and distance to roads.

Table 1--State variables that can key simulated management activities in the the Parallel Processing Extension of the Stand Prognosis Model.

Year or growth cycle
Stand age
Crown competition factor[1] (by species)
Volume[1] (cubic or board feet)
Basal area[1]
Top height[1]
Quadratic mean dbh[1]
Number of trees[1]
Removals (trees or volume)
Accretion
Mortality
Periodic annual increment
Mean annual increment
Change in number of trees
Change in basal area
Change in crown competition factor
Defoliation level due to tussock moth
Defoliation level due to western spruce budworm
Mortality due to mountain pine beetle

[1]Before and after thinning.

Table 2--A schematic Prognosis Model diagram for harvest simulation.

```
BEGIN HARVEST SIMULATION for group of stands
POLICY LABEL: Intensive management
TARGET:       Harvest net growth in planning area
PRIORITY:     Select stands with greatest volume,
              closest to roads,
              not adjacent to clearcuts
    CONDITIONAL ACTIVITIES for first stand in projection
    IF    Density > x
    THEN  Thin the stand
    IF    C.a.i. < m.a.i.
    THEN  Harvest AND regenerate
    IF    Time since regeneration > y AND density < z
    THEN  Plant
    END
    •
    •
    •
    CONDITIONAL ACTIVITIES for other stands
    •
    •
    •
END HARVEST SIMULATION
```

With these features, it is possible to use the Prognosis System to formulate and explore realistic management scenarios representing diverse resources. For example, it could be used to test a long-term, multiobjective plan for sustaining habitat for an elk herd whose home range encompasses an entire watershed. The silviculturist and wildlife biologist would work together to develop a mix of habitat components that should be maintained over time to provide the opportunity for a specified level of use by the elk. These might include a proper temporal and spatial mix of thermal cover, hiding cover, shrub production, edge distribution, distance to roads, arrangement of cover areas and forage areas, and travel corridors. The system could be used to explore questions of the type: Is maintenance of elk habitat compatible with the harvest target over the area in the long run? Without an integrated decision-support model, plans would be based on current conditions, and future effects could only be estimated with educated guesses. With the Prognosis System, the interdisciplinary team could compare a number of alternative prescriptions specifying harvest targets subject to wildlife habitat constraints.

CONCLUSIONS

Assuming that a vegetation model can provide a reasonable prediction of change through time, the challenge to the wildlife specialist is to interpret the change in terms of habitat suitability (Christensen and Davis 1986). At another level, models must do more than just reflect the immediate habitat requirements of a species. They must also consider the spatial and temporal arrangement of fragments of essential habitat components (Temple and Wilcox 1986).

The National Forest Management Act of 1976 contained explicit direction to manage for habitat diversity, but provided no guidelines for defining habitat diversity or distribution. A recent RPA update recommends increased funding for additional research initiatives dealing with critical wildlife and fish habitat issues (USDA FS 1986a). A statement from the Forest Service's Wildlife-Timber Management Initiative invokes the need for high-priority research dealing with multiresource effects:

> Integration of species conservation with the production of forest products is seriously impeded by our inadequate knowledge about wildlife and fish habitat requirements and how they relate to timber management.

Multiresource research and planning must assure compatibility between vegetation and wildlife habitat models in the inventory, modeling, application, and monitoring phases. Several integrated stand projection models presently in use may provide reasonable links to wildlife habitat models. The Prognosis System has several unique components for linking vegetation projections to other resource models. Among the most useful for representing effects on wildlife habitat are predictions of canopy structure and understory development, and consideration of biological and management dynamics among stands.

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SILVICULTURE OF MIXED HARDWOODS IN THE ALLEGHENIES FOR TIMBER, WILDLIFE, AND OTHER RESOURCES

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INTRODUCTION

Both timber yields and forest wildlife populations are regulated primarily by the organization of forest vegetation on an area; i.e., its species composition, density, and age or size arrangement over time and space. Thus, forest cutting or any other manipulation of the vegetation to benefit one resource will also affect the other.

In view of this interrelationship, it would seem apparent that silvicultural decision-making should provide for simultaneous consideration of both resources. Unfortunately, this is often not the case. Too often, timber and wildlife plans are drawn up independently, frequently using inventory data collected separately for each resource. Too often timber cuts are planned with little thought about how they will impact on wildlife or on how they might be modified to maintain critical habitat without significant loss of timber yield. Too often wildlife improvement practices are conducted with little thought about how the same benefit might have been obtained through timber cutting, or without evaluation of the cost of the improvement relative to wildlife population gain.

Part of the problem stems from the fact that our knowledge on management of these two resources has developed independently for the most part, with scientists in each discipline developing separate techniques of assessing vegetative condition and separate systems for manipulation of that vegetation to achieve their particular goals. Coordination often consists of attempts to mesh independently prepared plans, rather than integration of the decision-making process throughout all of its phases.

In this paper, I will describe a silvicultural decision-making system that ensures consideration of both timber and wildlife needs at all planning levels, provides analytical tools to evaluate the effects of any treatment on both resources, and ensures that state-of-the-art knowledge in both timber and wildlife disciplines is utilized in the selection of management practices.

THE SILVAH PRESCRIPTION SYSTEM

System Overview

The decision-making system that I shall describe is the result of nearly 15 years of research at the Northeastern Forest Experiment Station at Warren, Pennsylvania. A major share of that research has been aimed at identifying the important biological factors affecting Allegheny hardwood forests, to learn how these factors affect tree regeneration, stand growth, and wildlife habitat. As part of this research, we have attempted to develop objective management guidelines on how much is enough or too much, and what treatments can be used to achieve best results, in particular circumstances.

For example, we quickly learned that successful tree regeneration following harvest cutting is highly dependent upon the abundance of advance seedlings. But how many are needed? How does the number vary with size of seedlings, with site conditions, with deer browsing pressure, with cutting treatment? How does the amount of food for deer and other wildlife that utilize regeneration cuts vary with these same factors? Answers to these questions have been incorporated into the guidelines mentioned above.

Second, we have integrated the guidelines developed through this research into a complete stand analysis and prescription procedure that provides a systematic way of measuring and evaluating critical conditions, and of using that data to arrive at a recommended treatment (Marquis et al. 1985). This system involves an inventory of basic vegetation and site factors that are then summarized in specific ways to evaluate a stand's potential for tree growth and regeneration, and its suitability as habitat for a variety of wildlife species. The heart of the decision-making process is a set of decision tables that are utilized to determine an appropriate management prescription, based upon critical levels of the various vegetation and site variables in combination with specific landowner objectives.

Since all steps in this process are based upon measured site and vegetation variables, the entire process can easily be adapted to computers. Thus, the data analysis, report generation, and even the decision-making can be automated to a considerable degree. We call our program SILVAH, which stands for SILViculture of Allegheny Hardwoods.

SILVAH operates on an individual stand basis, providing data analysis and management recommendations that are specific to each stand. But summaries of each stand are also output to a computer file so that individual stands can be combined into a forest-wide data base that provides a powerful tool for management planning as well.

Inventory

In the SILVAH system, all analysis and decision-making is based upon inventory data collected in the basic management unit--the stand. A single inventory is conducted for all resource uses, and data is collected so as to permit a complete evaluation of the present vegetative conditions and site capabilities or limitations.

Inventories of the overstory trees are done with either variable-radius (prism) or fixed-radius plots, located so as to provide a statistically adequate sample of the stand. Each sample tree is recorded by species, diameter breast height, merchantable height, and quality. Tree quality is assessed on several bases. One incorporates a timber product classification (sawtimber by grade, bulk products, cull) and a quality of growing stock classification (acceptable, unacceptable). Another assessment concerns tree vigor and susceptibility to attack by damaging agents such as the gypsy moth. The third quality assessment is for wildlife habitat utility (cavity trees, den trees, snags, etc.).

Understory vegetation is also inventoried, with the amount of detail collected optional depending upon the owner's objectives. At the minimum, understory data includes a record of the amount of advance regeneration present and the presence of limiting amounts of interfering understory plants. For more complete analysis of both tree regeneration potential and wildlife habitat, understory data collection includes a tally of numbers of stems of trees and shrubs, by species and height class, plus a tally of percent cover of nonwoody vegetation by species groups.

Site factors include the determination of site classification and soil type (from existing soils maps) and a tally of specific conditions known to influence either tree regeneration and growth or wildlife habitat. These include the presence of poor soil drainage, extreme surface rockiness, spring seeps, marshes, streams, and other water courses. Included also are estimates of the area in forest openings and agricultural land adjacent to but outside of the stand itself, plus a record of the ease of access to the stand (type of road and distance to paved road) for evaluations of both timber operability and likelihood of human disturbance to wildlife.

Stand Analysis

Data from the inventory is analyzed in numerous specific ways to provide estimates of the stand's stage of maturity, its potential for tree regeneration, the status of tree growth and mortality in relation to the need for thinning, and the food and cover characteristics of the habitat and their suitability for particular wildlife species. In the wildlife habitat analysis, we include the major game species individually, plus a selection of indicator nongame species that are representative of different wildlife guilds or habitat types.

The analysis includes all of the usual tables one expects from a forest inventory. There is a complete summary of existing timber volumes and values by species, size, product type, and quality. The stand is categorized into a standard forest type, size class, and density.

Overstory data is analyzed to determine diameter distribution (stand structure). For even-aged stands, effective stand age and the number of years of additional growth needed to reach maturity are estimated. The need to consider timber stand improvement in the understory trees is also assessed. For all-age stands, the ease of applying selection management is assessed on the basis of diameter distribution, amounts of sawtimber, and presence of shade-tolerant species.

Stand density is analyzed in relation to growth and mortality, and the need for thinning and volumes available from such cuttings are assessed. Stand density is also evaluated in terms of canopy density as it affects cover and nesting or foraging sites for wildlife.

The number of existing den and cavity trees is calculated and compared to desired levels. Potential for increasing the number of such trees is estimated from species and size distributions, and information on the tendency of various species to form cavities or decay.

The quantity of seeds produced for tree regeneration are estimated from data on species and size of overstory trees. The same data, along with data on understory vegetation, are used to estimate the quantities of hard and soft mast available for wildlife.

Data on understory vegetation is compared to critical levels established from tree regeneration research to assess the adequacy of advance seedlings and the abundance of plants that may interfere with seedling establishment and growth. These are used, along with estimates of deer populations, site limitations, and seed supply, to assess the potential ease with which the stand may be regenerated if harvest cut. Understory and overstory data is also used together to estimate the presence of food, cover, and nesting sites for wildlife within the several layers of vegetation from ground level to canopy.

The end results of these and other analyses is an assessment of the combined timber and wildlife potential of each individual stand. The computer program SILVAH presents the results of these analyses both in tabular and narrative form. We have found the narrative to be especially useful, to professional managers and to lay persons as well.

For example, data on stand density and tree volume may be interpreted in the narrative as "this stand is well above the density for optimum tree growth, and mortality among the smaller stems is probably high. A thinning to provide some intermediate yield is highly desirable at this time." And the same data on overstory density combined with understory information may produce the message: "dense canopy conditions and lack of understory vegetation in the zone 0-2 meters above the ground provide poor habitat for ground-nesting birds such as veeries, ovenbirds, rufous-sided towhees, and northern juncos." Such evaluations, routinely printed in each stand, ensure that the user's attention is systematically focused on all of the resources of the stand.

Prescription

The third stage in the decision-making process is the determination of a management prescription. This determination is based both on the goals of the landowner, and on the characteristics of the site and present vegetation. So owner objectives must be clearly identified.

A series of decision tables, with a list of critical biological factors and landowner goals on one axis, and a list of management prescriptions on the other axis, is then used to find a recommended treatment for the present stand. The decision tables are constructed in such a way that there is only one possible treatment for each combination of goals and stand conditions. One scans through the tables either manually or via computer, using the data from the stand analysis and the owner's goals to find a column in the decision table that matches in all respects. That column is the recommended treatment, which will provide the best management scheme, based upon current knowledge.

Obviously, no system of this sort can substitute for professional judgment, nor is it intended to do so. The decision tables are based on average situations. Circumstances not evaluated or other considerations may dictate that the recommendations be modified. So the procedure provides a starting point or standard which must be verified by professional judgment. Nevertheless, it removes much of the subjectivity formerly associated with silvicultural decision-making and ensures that a wide range of factors are systematically considered in the process. It also provides for uniformity in prescriptions among stands and among individual prescribers.

Obviously, it is impossible to manage a single parcel of land for maximum timber yields and optimum habitat for all wildlife species. Manipulation of the vegetation to favor one will simultaneously affect all others--some adversely. Some goals cannot be achieved in some stands because of biological constraints. For example, one cannot expect to grow high quality hardwood sawtimber on a very poor site, or use selection cutting in a stand that lacks suitable shade-tolerant species, or maximize squirrel populations in young stands that lack mast-producing trees. Likewise, some goals are incompatible with others. Maintenance of extremely high deer populations may preclude tree regeneration under all-age management, or short rotation timber production may preclude wildlife dependent upon old-growth vegetation, for example. In these situations, the decision tables will provide no recommended prescription, but will indicate the source of the conflict and suggest a re-evaluation of landowner goals.

If the recommended treatment includes a partial cutting of any type, a set of marking instructions is then generated. Desired residual stands are calculated using a stand structure model suitable for either even-age or all-age management, as appropriate. Then trees to be removed to achieve that objective are calculated. The narrative indicates the residual density desired, and provides a series of ratios for each major size and quality class, indicating the proportion of trees to be cut from each class.

The context in which SILVAH treats the various landowner goals is currently limited. SILVAH was originally conceived as a timber management tool, and it considered other resources only in a minor way. Several options based on visual (aesthetic) goals were included, but wildlife and water resource options were not.

Wildlife goals are now incorporated more formally, but timber cutting is still assumed to be the major tool available to manipulate the vegetation for wildlife and other resources. Thus, prescriptions take the form of a recommended treatment within the context of one of the traditional forest management systems. However, an analysis of how that prescription will alter the habitat for each of the game and indicator nongame species is included in the narrative. And if the user identifies specific wildlife species to be featured, the timber prescription will be modified to accommodate the wildlife goal. At present, this accommodation is limited to ones that can be achieved without major modifications to timber management practices.

In the future, we hope to provide more complete accommodation of other resource uses, including situations where timber management is a secondary rather than a primary goal. But analyses of trade-offs among conflicting resources cannot be made on an individual stand basis. Rather, such analyses must be made at the forest or management unit level, as discussed later.

Additional Features

The computer program SILVAH does all of the analyses and prescription-writing described above automatically, once provided with inventory data and management goals. In day-to-day use, it provides for data processing and decision-making to occur on large numbers of individual stands without time-consuming and costly testing of possible alternatives.

But SILVAH provides the opportunity for alternative testing if that is desired. The user can choose to ignore the recommended treatment and specify any other treatment desired. The effect of that treatment on vegetation, timber potential, and wildlife habitat will be assessed in the same way as for a SILVAH-recommended treatment. Thus, one can compare the effect on the residual stand of as many alternative treatments as desired.

In addition, SILVAH contains a stand growth simulator, so that one can project the stand into the future after any treatment. Stand analyses like those produced on the actual inventory data can be produced for any future date, permitting detailed comparisons of impacts of any number of possible treatments on future timber and wildlife yields.

Forest-wide Considerations

The system I have described is primarily a stand-level tool, using inventory data from a single stand to determine an appropriate prescription for that stand. Some of the data collected for wildlife habitat evaluation provides for a crude estimation of habitat types surrounding the stand in question, but this information is very limited in scope and detail. Thus, the primary wildlife function of the SILVAH program is assessment of habitat conditions within each stand, and of the change in those conditions resulting from any treatment that may be prescribed.

Prescriptions that balance timber and wildlife goals can be determined only over a group of stands--a management unit or forest-wide area. It is only over such larger units that the organization of vegetation--the arrangement of size and age classes--can be adequately determined, and that this vegetation can be managed to produce sustained yield over a long period of time. Forest-wide considerations can affect timber prescriptions as well.

Whether or not a particular stand should be harvested and a new one regenerated depends not only upon the conditions within that stand, but upon the number of other stands in that management unit that are also ready for harvest. Whether or not the additional browse that will be created by such a harvest is needed to sustain the desired deer or hare population (or to minimize damage from these animals to seedling regeneration) depends upon how much additional browse will be available in that management unit. Whether or not the loss of mast resulting from harvest of this stand will be important for squirrel populations depends upon the amount of mast produced in other parts of the management unit. And so forth.

Our SILVAH system does not currently deal with these forest-wide decisions directly. But SILVAH does output a computer file containing a summary of the conditions in each stand both before and after recommended treatments. This file can easily be incorporated into a data base for forest-wide management planning.

This multi-stand data base will be the input to a second level of the SILVAH prescription system. A supplementary program will calculate the optimum arrangement of forest age and size classes for any user-specified combination of timber and wildlife goals. The amount of area that should be treated in various ways (harvest cuttings, partial cuttings, etc.) to achieve that vegetation pattern throughout the unit will be estimated.

Then, the information in the SILVAH data base will be scanned to match up individual stand prescriptions with the desired management unit totals. Where necessary, the original SILVAH prescriptions on selected stands will be modified to ensure that the desired vegetative structure is achieved.

Any modifications to the original SILVAH prescriptions will be based on an evaluation and ranking of each stand's suitability for the alternate prescription. This will ensure that stands selected for modified prescription are the most appropriate ones for that purpose in the management unit.

Thus, the completed SILVAH prescription system will provide decision-making assistance at two levels. At the stand level, SILVAH will provide a complete analysis of present conditions for both timber and wildlife uses, recommend a treatment based primarily on the timber management needs of that stand alone, and provide an assessment of the immediate effect of that treatment on wildlife habitat suitability for a variety of wildlife species.

At the forest or management unit level, SILVAH will balance the separate needs of landowner goals to estimate the overall vegetative structure needed to achieve those goals. And then it will recommend modifications to the original stand-level prescriptions to meet the specified multiple use goals for the property.

SUMMARY

A stand-level procedure for analyzing site and vegetation variables, and using that data to determine the best silvicultural prescription is described. The procedure provides for a single inventory of existing conditions, and analyses of that data in ways that permit evaluations of current conditions for both timber and wildlife resources. The analysis of stand conditions in combination with specific landowner objectives are then utilized to select a silvicultural prescription that represents the best current knowledge in that forest type and resource area. The system is computerized in a program called SILVAH, which writes narrative descriptions of stand conditions in terms of timber and wildlife goals, and selects a recommended treatment, which is complete with instructions for its proper application.

The SILVAH program also provides the facility to test alternative treatments selected by the user, and provides information needed to evaluate the impacts of these treatments on various timber and wildlife goals. These alternatives can be tested both for immediate impact on the residual stand, and on future impacts via an incorporated stand growth simulator.

Development of a multi-stand data base for forest-wide planning is also provided, and use of these data for modification of the original stand-level prescriptions is discussed. This second-level of prescription provides the means of optimizing multiple resource needs and ensuring that the forest vegetation is organized so as to provide sustained outputs of the desired products and values.

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STOCKING CHARTS AND THEIR USE FOR NON-TIMBER MANAGEMENT OBJECTIVES

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ABSTRACT

Stocking charts can be used as a communication tool to display the different management regimes that meet various resource objectives in addition to timber management. A standardized format helps to display the different management objectives.

NEED FOR COMMUNICATION

Forest managers need to communicate with different resource specialists concerning what levels of growing stock are needed to meet the management objectives of a Forest Plan. At the same time the resource specialists need a tool to display over time the results of silvicultural treatments. In addition, many people who are interested in the management of the National Forests need an easily understood reference of how decisions are made concerning the desirable density level for a stand of trees. Stocking charts are one tool that can be used to communicate this information.

The Forest Service adopted a standardized format to express stocking to compare current conditions to some desired or standard condition. When one uses stand attributes like the number of trees per acre (or hectare), the basal area per acre (or hectare), and the quadratic mean diameter (QMD), other vegetative characteristics can be described. This allows the opportunity to determine if the desired vegetation will fulfill the management objectives for the resources to be managed on the specific piece of land. Stocking level charts are not meant to replace growth and yield prediction models, computer simulations, or

field evaluations but to be another tool to display management options. Often a stocking chart can be used to display a simulator model run.

As a quick review, the need for the Forest Service to standardize terminology and format for displaying stocking levels came from a Chief's 1978 Report "Evaluation of Reforestation and Timber Stand Improvement on the National Forests" (USDA FS 1978a). Subsequently, based upon the Chief's Action Plan (USDA FS 1978b) and the recommendations of a National task force, the format described by Gingrich in 1967 was determined to be the most appropriate background chart for National Forest stocking guides.

The format graphically illustrates the mathematical relationships among basal area, number of trees, and quadratic mean diameter. Basal area and number of trees are easily available from stand examination data.

STANDARDIZED FORMAT AND REFERENCE LEVELS

Figure 1 graphically displays the relationships of basal area, trees per acre, and quadratic mean diameter. As noted early, the basal area and trees per acre are available from stand exam data. The quadratic mean diameter can be calculated from these two variables (Ernst and Knapp 1985).

As the plotted relationships serve little purpose alone, specific information by species or forest type must be placed on the chart for its use in the stand management decision making process. The establishment of reference levels for measuring relative density is a critical step in the development of a stocking guide. The most commonly used techniques for establishing levels include stand density index (Reinke 1933), tree area ratio (Chrisman and Schumacher 1940), and crown competition factor (Krajicek and others 1961). As a reference for full stocking, normal yield tables, stand density index (SDI), or tree area ration is used. This is generally referred to as the average maximum density or AMD.

The Forest Service standardized format (fig. 2) shows the AMD line which represents 100 percent stocking based upon SDI or normal yield tables. A second reference level noted as 100 CCF represents the condition where the crowns of open-grown trees are just beginning to touch. This means that the cumulative crown area of all open-grown trees is equal to 100 percent of the ground surface area. Generally, the area within these bounds of growing space gives the range of densities to meet most timber management objectives. However, as pointed out by Puuri and others (1987), these boundaries for other resource management objectives or for conifers on more xeric sites may not always coincide with the AMD and 100 CCF lines.

MANAGEMENT ZONES AND EXAMPLES OF USE

Usually, a management zone is displayed on the chart to show the area within which we wish to manage a stand (fig. 3). This zone is based upon some stated management objectives and biological situation. At this time specific examples of management situations can be portrayed on the chart. Some examples of specific management situations follow.

Prioritization for Treatment--Often questions are asked as to why a certain stand has been selected for treatment. The stocking chart can show prioritization for treatments. In figure 4 stand A has greater density than stand B and will soon grow to the AMD at which time one might expect increased mortality. Thus, stand A generally would be treated prior to stand B.

Thinning Prescriptions--Figure 5 demonstrates a stand that qualifies for precommercial thinning treatment. The number of trees per acre at point A are thinned to point B. As the smaller less desirable trees are cut, the QMD of the residual stand is increased. This stand will now be able to grow without inter-tree competition for a period of time.

Computer Simulation--Stocking charts can display management regimes developed by computer simulation such as Prognosis (fig. 6). Here many aspects of stand management can be noted including the precommercial thinning, the commercial thinnings, the changes in the QMD, the basal area, and trees per acre over time, and other items including the natural mortality that occurs in the stand which effects stocking levels.

Multiresource Management--One might compare different management emphasis such as big game habitat and Douglas-fir in western Oregon and Washington on the same stocking chart. In figure 7 different stocking levels and different timing of thinnings are shown. The individual specialist then can discuss and relate what is happening to stand structure, the individual tree characteristics such as diameter and crown, and can from other information project how the rest of the vegetation on the area might respond to the stand treatments.

Pest Management--Many biological factors can effect trees in a given area. Stocking charts can show some of the concerns a manager must face in managing a forest. Figure 8 reflects the relative risk ratings for the southern pine beetle which can cause extensive damage to pine. Knowing this, one can risk rate forest stands and try to manage within areas of the least risk. This is also a good tool to demonstrate to the public why specific stands are selected for silvicultural treatments.

SUMMARY

Stocking charts can be an effective communication tool to display management opportunities and silvicultural treatments. Managers and members of the public with different resource backgrounds or resource use objectives can utilize stocking chart.

The standardized Forest Service format is based upon the relationships of quadratic mean diameter, number of trees per acre, and the basal area of the stand. A standardized format allows easy communication between specialists and between interested people in different locals.

Stocking charts can display different management regimes that reflect various resource emphasis, effects of silvicultural treatments, and management considerations such as insect risks and wildlife habitat needs. Comparisons

between different harvesting schedules readily show the effects on number of trees per acre and diameter of the residual stand.

Stocking charts are not meant to replace other more precise tools like yield prediction models or treatment response computer simulations but are a tool to be used to display what is happening over a period of time.

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Figure 8-- Stocking chart to guide pest management decisions.

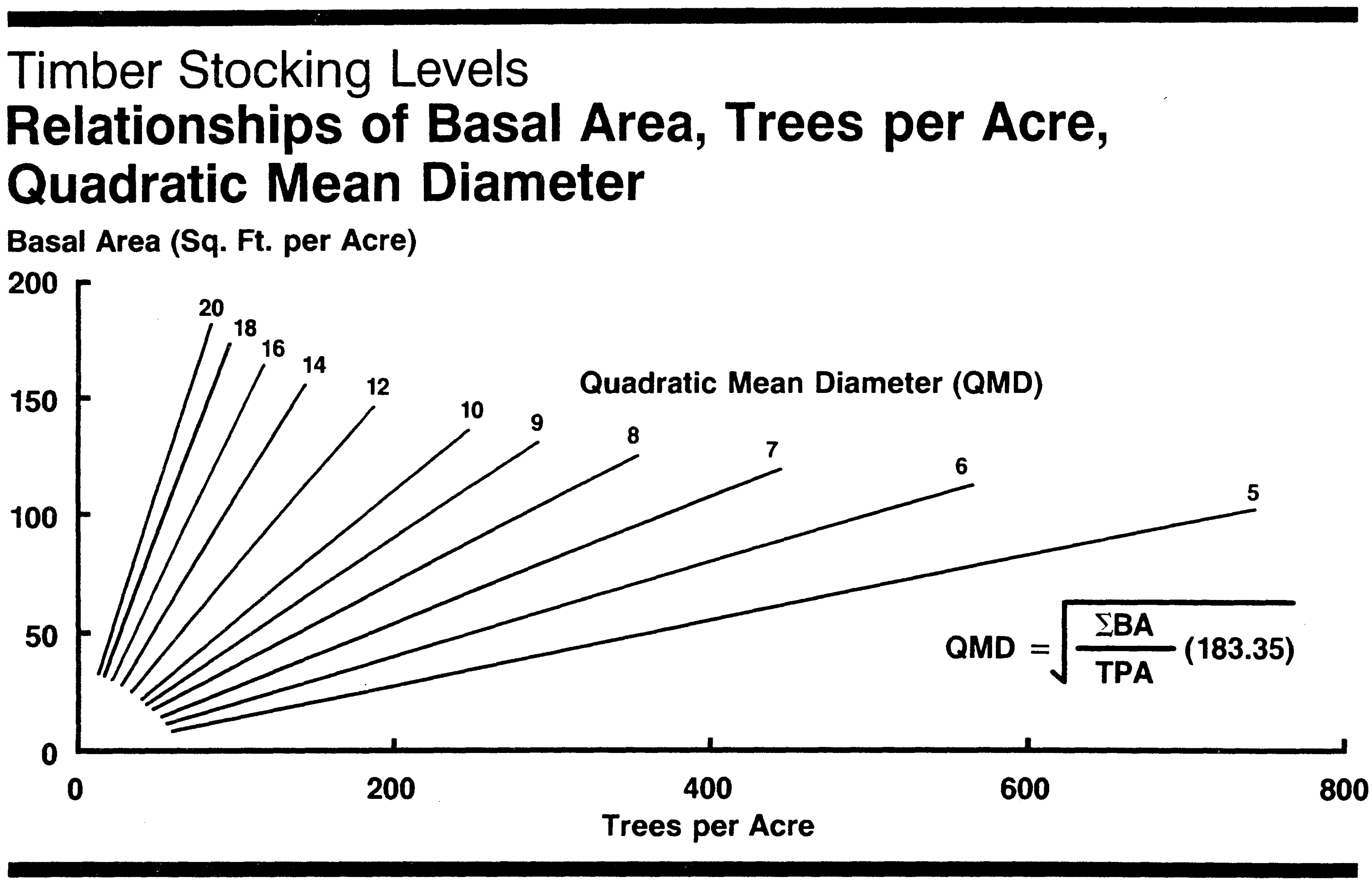

Figure 1 -- Relationships of basal area, trees per acre, and quadratic mean diameter.

Timber Stocking Levels
Reference Levels for Average Maximum Density and 100 CCF

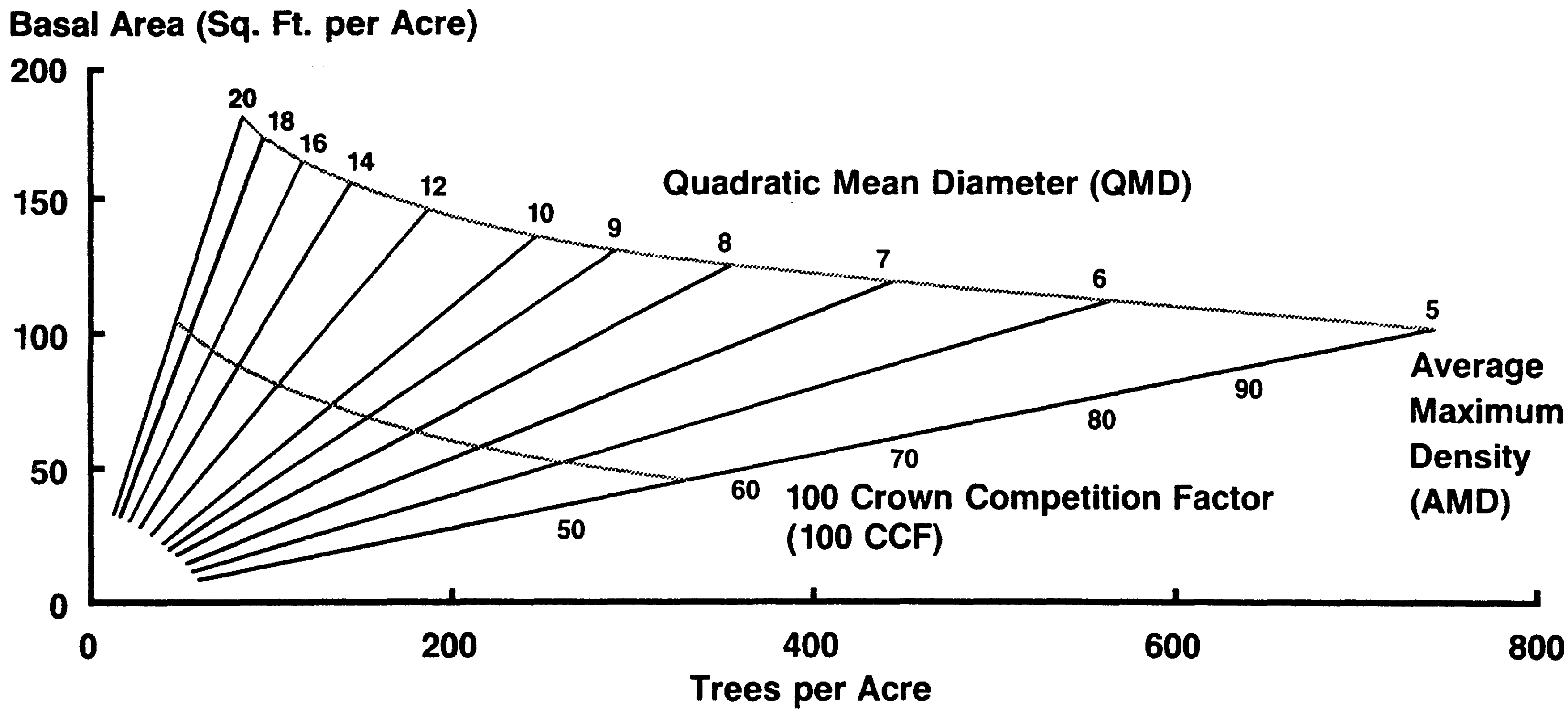

Figure 2 -- Reference levels for average maximum density (AMD) and 100 CCF.

Timber Stocking Levels

Forest Service Standardized Format with Reference Levels (AMD and 100 CCF) and Management Zone

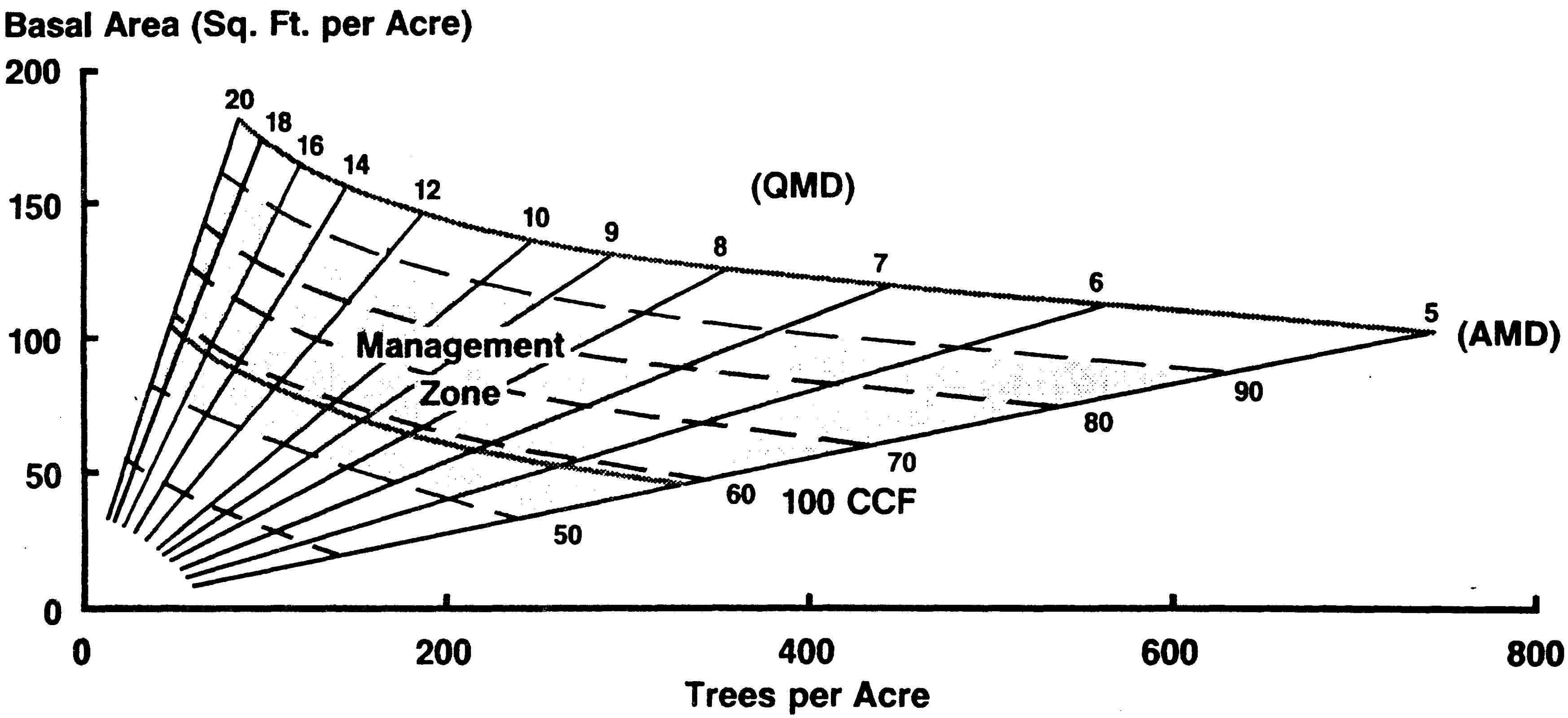

Figure 3 -- Forest Service Standardized format for development of stocking level charts.

Timber Stocking Levels
Reference to Prioritize Stands for Treatment

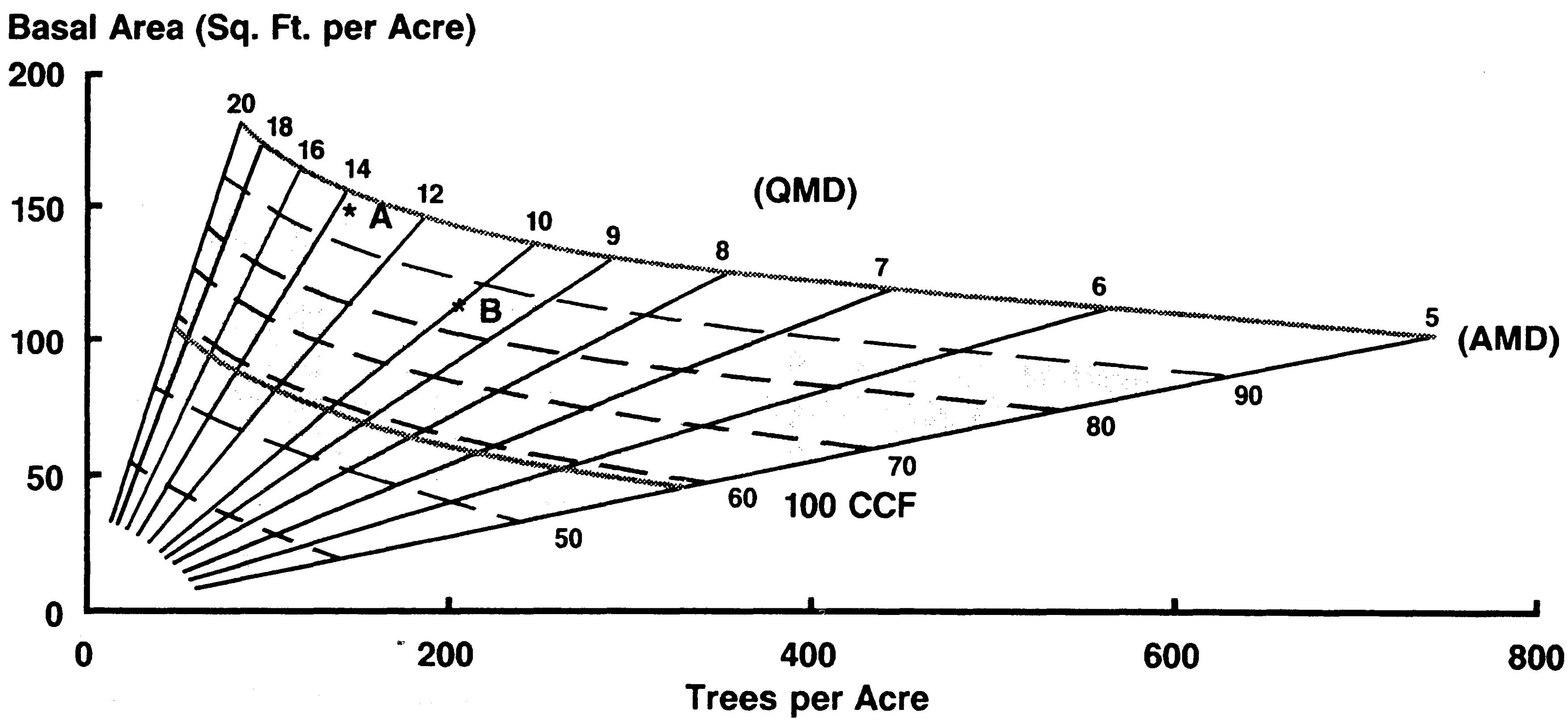

Figure 4 -- Stocking chart as a reference for treatment prioritize stands for treatment.

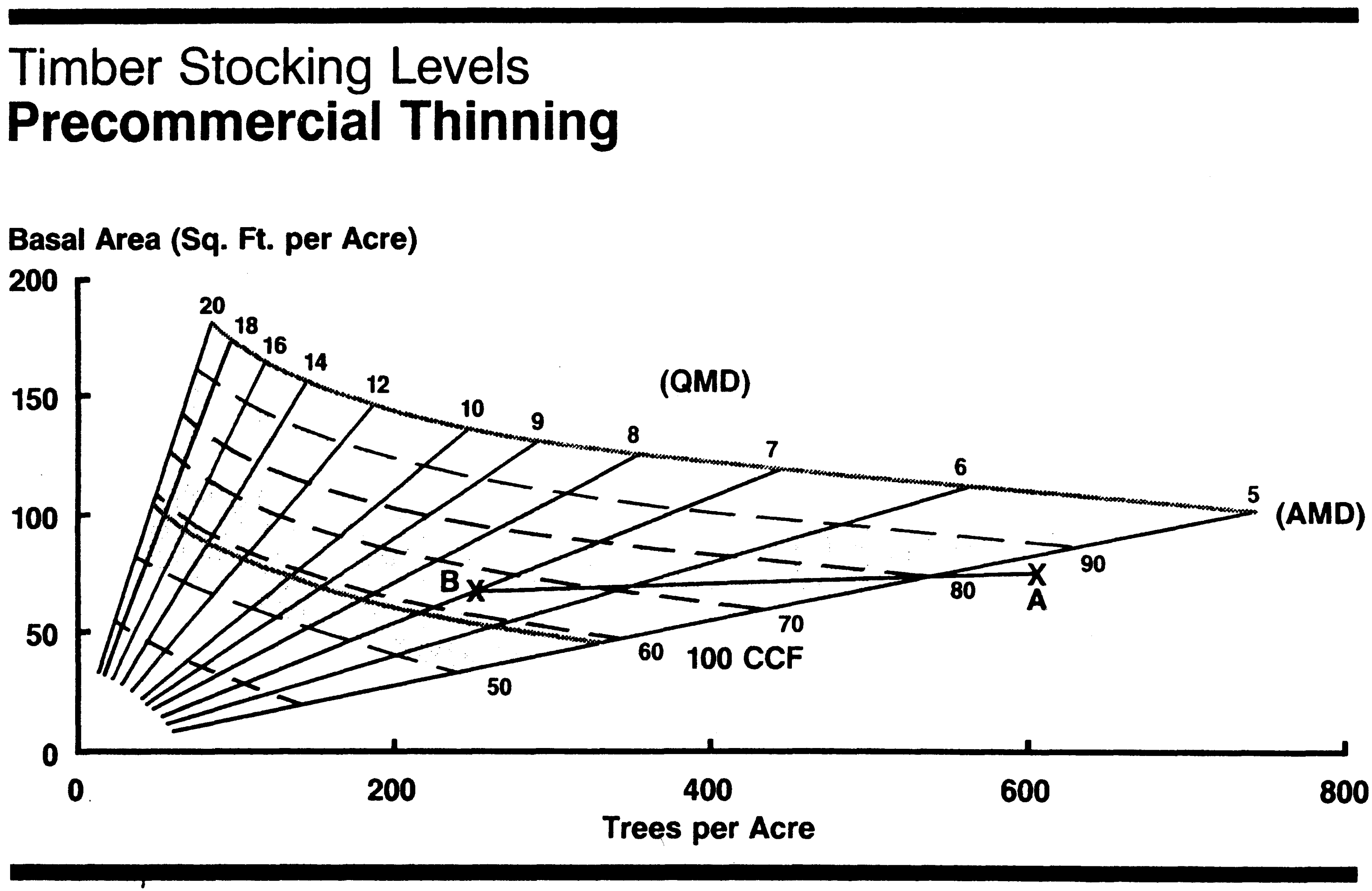

Figure 5 -- Stocking chart to guide precommercial thinning.

Timber Stocking Levels
Management Regime Developed by Computer Simulation

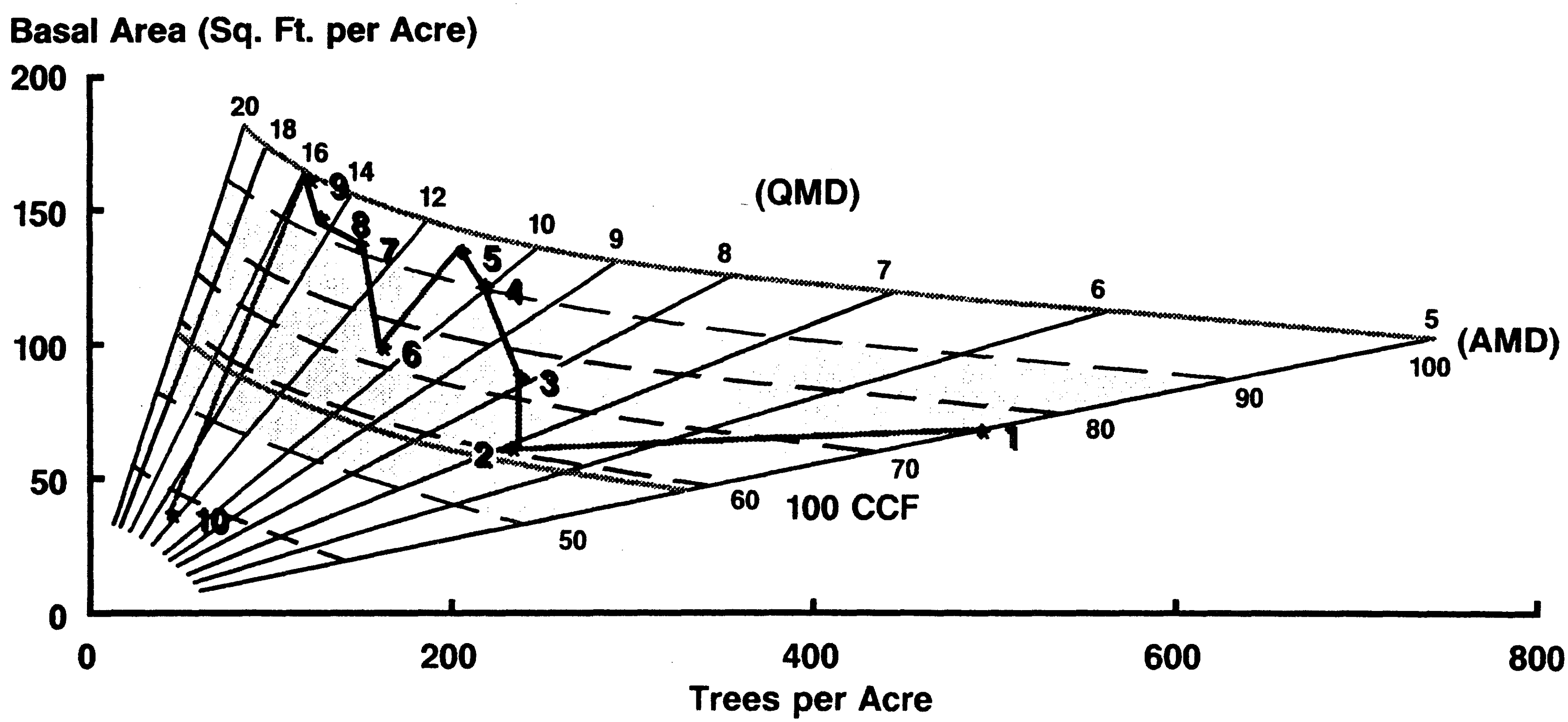

Figure 6 -- Stocking chart to compare computer developed management regimes.

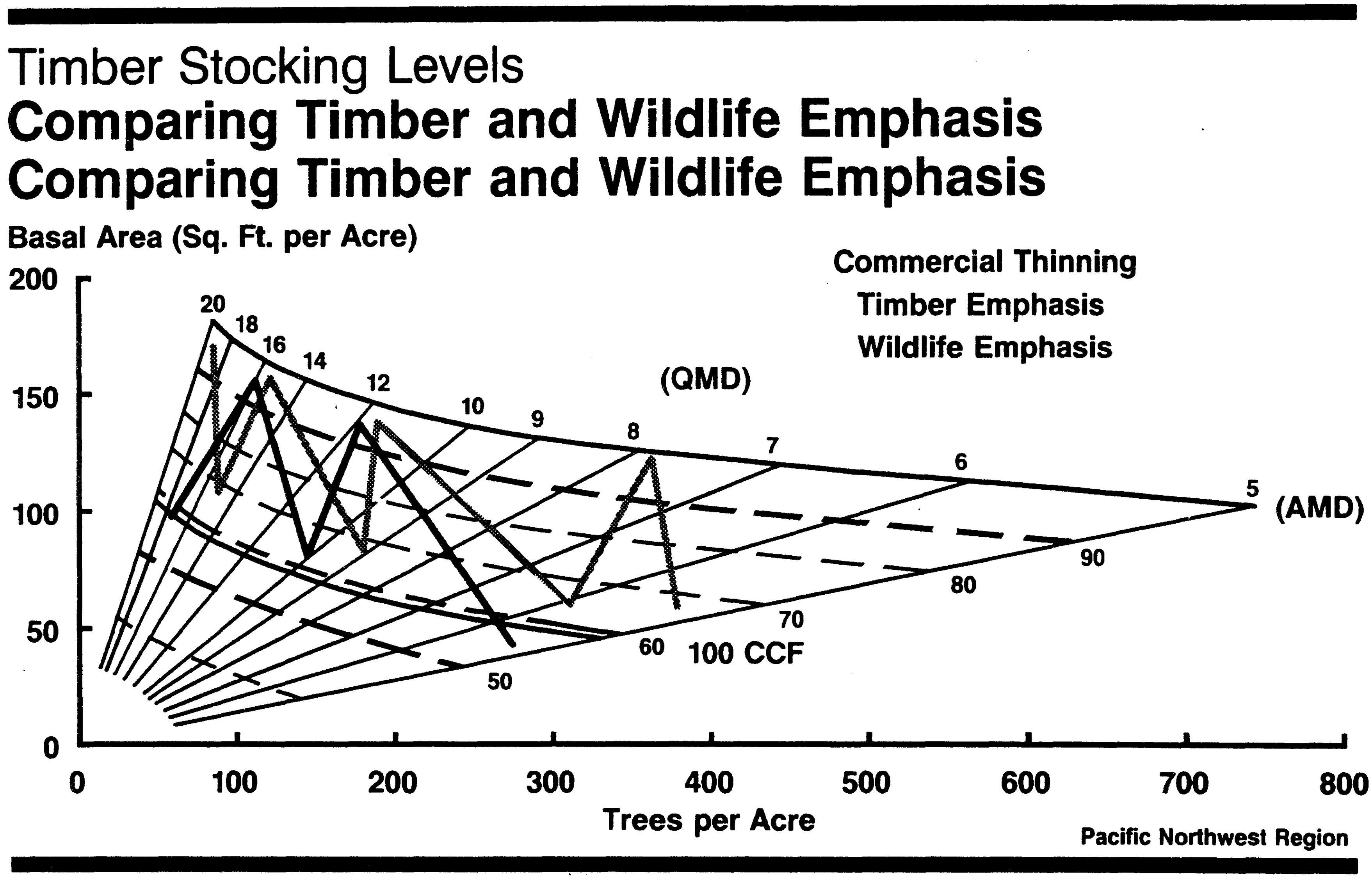

Figure 7 -- Stocking chart to compare timber and wildlife emphasis.

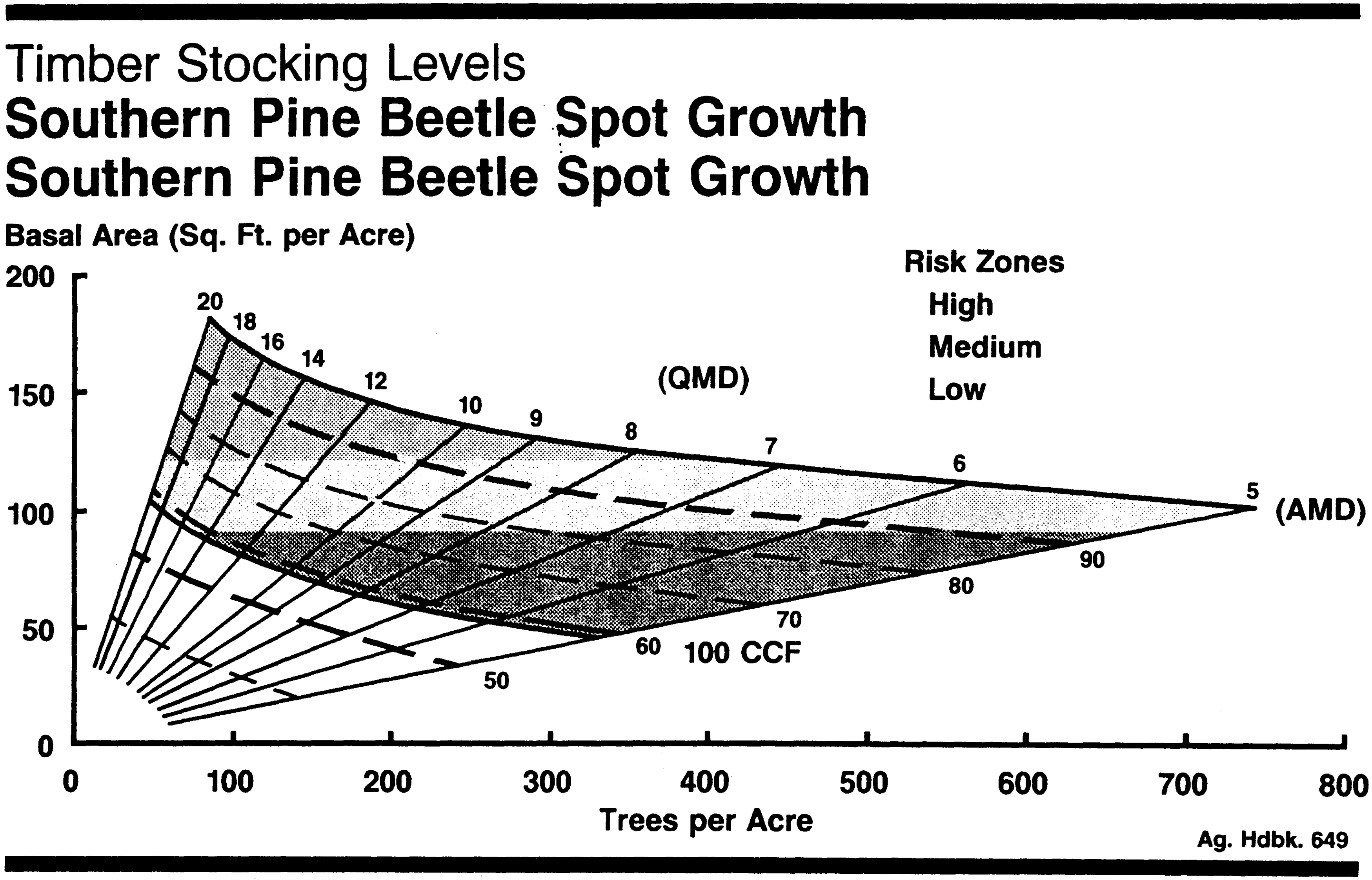

Figure 8 -- Stocking chart to guide pest management decisions.

SUCCESSFUL SILVICULTURAL OPERATIONS WITHOUT HERBICIDES

IN A MULTIPLE USE ENVIRONMENT

by

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LOCATION AND SETTING

The Siuslaw National Forest is located in the central portion of the Oregon Coast Range. The general crest of the Coast Range is 1,500 feet above sea level; some peaks are higher, with a few over 2,000 feet. The topography consists of a complex ridge system characterized by short, steep slopes.

The Forest has a maritime climate. Average annual precipitation varies from 80 inches at the coast to 120 inches at higher elevations. Although some snow falls, it is usually limited to elevations greater that 2,000 feet.

I would like to give you a brief glimpse of the Siuslaw, for those of you who have not been there:

The Forest provides habitat for more than 330 species of wildlife including 5 T&E species, and 3 sensitive species, including the Spotted Owl.

The Forest offers a wide diversity of recreational experiences, with the Oregon Coast as the principal attraction locally, nationally, and internationally. In addition, the three Wildernesses, the Cascade Head Scenic-Research Area, and the Oregon Dunes National Recreation Area provide something for everyone.

Five of the seven most important fish-producing river systems in coastal Oregon flow from the Siuslaw. The 1,200 miles of stream are key spawning and rearing habitat for anadromous fish. Another 7,000 miles of stream influence those habitats.

On a per-acre basis, the Siuslaw is the most productive National Forest in the country. The Forest burned over in the mid 1800's. Less than 34 thousand acres of old-growth trees are present in the Forest today. In 1986, 316 million board feet of timber were harvested, which brought in $60 million of receipts. There was nearly 1 billion board feet of buyback volume and 33 defaulted sales totaled 225 million board feet in the last year or so.

MANAGEMENT SITUATION

The Forest contains some of the most productive lands for conifer production in the world. The average Douglas-fir (Pseudotsuga menzeisii (Mirb.)) site index (100-year base) is 161. This site index is generally uniform throughout the Forest. The Siuslaw falls within the Tsuga heterophylla (western hemlock) Zone as described by Franklin and Dyrness (1973). The major tree species is Douglas-fir; however, the Forest also supports major volumes of Sitka spruce (Picea sitchensis) and western hemlock. The principal hardwood species is red alder (Alnus ruba), with some component of bigleaf maple (Acer macrophyllum).

The principal silvicultural objective is to establish new plantations, commensurate with other resources, following harvest with 250-300 uniformly spaced stems (conifer and or conifer/hardwoods) per acre at a stand age of 10 years. We normally plant between 350-400 seedlings per acre. With proper animal protection, vegetative management, and allowance for seedling mortality, we are able to meet this objective.

During stand establishment, vegetative competition occurs during two distinct periods: (1) During plantation age 2-4 years, salmonberry (Rubus spectabilis) is the major competitor. (2) Red alder becomes a major competitor when it overtops Douglas-fir seedlings, usually at a stand age of 5-8 years.

Salmonberry and red alder are major competitors on approximately 60 percent of the Forest; these vegetation species can develop everywhere on the forest, however.

HERBICIDE INJUNCTION

Until 1984, the primary method for controlling vegetation during the plantation development period was herbicides. At that time, as a result of a lawsuit, the Forest Service and Bureau of Land Management were enjoined from using herbicides, pending the completion of a satisfactory Worst Case Analysis. Since that judgment, silvicultural needs on the Siuslaw National Forest have, of necessity, been met with non-chemical alternatives. The last use of herbicides on the Forest occurred in fiscal year 1983. (See attachment 1 for greater detail.)

Before the judgment, the Siuslaw National Forest had chemically treated an average of 5,600 acres each year. Treatments were primarily for site preparation and stand release. In addition, herbicides were used for facility maintenance, road rights-of-way, and noxious weed control.

CURRENT PRACTICES

Since 1983, all site preparation and release has been done by manual means. Yet the number of acres receiving treatment yearly have basically remained the same. Some operations (especially site preparation) are more expensive now than when treatment was accomplished by herbicides. The cost of some treatments has increased because of retreatment needs. But to date, the

Forest has not lost any plantations to vegetative competition. Although costs have sometimes increased and some decreases in growth may be occurring, no reforestation or release backlog has developed on the Forest.

The best way to examine how the job is accomplished now is to look first at site preparation and then at stand release. These treatments are substantially different, not only because they occur at different plantation ages, but also because the target vegetation is usually different.

1. Site preparation--During this phase the usual target vegetation is salmonberry. Salmonberry is generally established in the existing stand before harvest. Following harvest, salmonberry releases and generally increases in vigor. To obtain adequate site preparation, the following treatments are used:

a. An increased reliance on burning.

b. Hand slashing ahead of burning. This must be done far enough in advance of burning to allow proper drying, but not so far ahead as to allow resprouting of the slashed vegetation. Hand slashing is conducted for silvicultural purposes on about 20 percent of our burn units. No mechanical site preparation is done on the Forest because of the steep topography and soil conditions.

A successful burn for site preparation affords the plantation a 1-to 2-year head start on the competing salmonberry and associated vegetation.

2. Release--About half of the acreage planted on the forest each year will need some kind of release treatment before age 10. Release occurs at two different time periods depending upon whether the competing vegetation is brush or hardwood.

a. Brush release--The principal brush species requiring release treatment is salmonberry. Release from salmonberry occurs on roughly 20 percent of the acres needing release. Release is accomplished by cutting the vegetation to ground level in a 3-foot radius around each tree. This cutting is done by chainsaw or other cutting tools. Treatment needs can occur anytime between 1 and 4 years. From one to three treatments are required before the young conifers gain dominance over salmonberry.

The success of these treatments is often affected by browsing big game--notably black-tailed deer (<u>Odocoileus hemionus columbianus</u>) and Roosevelt elk (<u>Cervus canadensis roosevelti</u>). When big game populations are high, severe browsing has sometimes occurred on released trees. Where this has happened, both animal control treatments and additional release treatments have been necessary. Additional release treatments have been needed in this situation because the browsing has placed the trees at a disadvantage to the brush, and additional time is necessary before the trees can recover and gain dominance over to the brush.

b. Hardwood release--On the Siuslaw, red alder can overtop a plantation and severely decrease its annual growth. If overtopping alder is left too long, conifer mortality will occur. To prevent this situation from developing, it is frequently necessary to conduct a hardwood release, sometime between plantation age 5 and 7 years. Release is accomplished by cutting all red alder to a stump height of 6 inches or less. This treatment, if properly timed, is needed only once. Release from red alder constitutes about 80 percent of the release activity on the forest.

NEW METHODOLOGY AND INFORMATION

The absence of herbicides has been overcome by the application of new methodology and new information.

1. The development and use of better quality seedlings, along with improved animal control techniques, have minimized replants and given plantations a fast start. In fiscal year 1986, the Forest's replant percentage was 1 percent. This is down from a 20 percent replant rate just 5 years ago. The use of better quality seedlings is largely responsible for this decrease in replanting needs.

2. The target stocking levels have been reduced as a result of better yield models and economic analyses. Now the target is 250-300 trees per acre at age 10 instead of 430 trees per acre at age 10. This has not reduced the number of acres needing release, but the reduction in the stems per acre will produce a marketable product (12 inches DBH) in 35 years. The 430 stems per acre produced a 7 1/2 inch product at the same age. This product was not readily marketable.

3. Research conducted on the Siuslaw has determined the "Window of Success" for hand release of red alder. This research was done cooperatively with the Pacific Northwest Range and Experiment Station (Olympia Lab) and the Forest. Basically, this research indicates that successful hand release can be conducted on red alder between the ages of 6 and 10 years, when it is cut between June 1 and August 1. Following this prescription has given the forest a success rate of up to 96 percent for hand release.1/

1/"Control of Red Alder by Cutting", by Thomas C. Turpin, Forest Silviculturist, Siuslaw National Forest, Corvallis, Oregon, and Dean S. DeBell, Principal Silviculturist, Pacific Northwest Range and Experiement Station, Olympia, Washington. Paper presented at State Convention, S.A.F., Salem, Oregon, May 1986. Paper is available at the Siuslaw National Forest, Corvallis, Oregon.

4. Treatment needs have also been reduced because manual treatments can be confined to only those acres or fractions of acres that actually need treatment. Aerial herbicide application has to be on a broader scale, so some
acres not in need of treatment were being treated.

COSTS

The absence of herbicides has increased the cost of plantation establishment on the Siuslaw National Forest. Increased treatment costs have ranged from a low of $30/acre to a high of $300/acre. This difference depends upon site conditions, weather variables, timing of treatments, and air-quality conditions.

OTHER RESOURCES

The discontinued use of herbicides has provided some beneficial values to wildlife and has had a favorable impact on the social acceptance of vegetation management. These benefits are as follows:

1. Wildlife

a. The vegetation on harvested areas is recovering much faster, thus the areas are providing cover and forage sooner. When herbicides were used, the regrowth of vegetation was delayed for 2 to 3 years, and in some cases the target species never resprouted. This was often the case when glyphosate was used on salmonberry.

b. A greater diversity of plant species are available to wildlife. After harvest and site preparation, nearly all of the species on the site resprout, providing more habitat and forage for all kinds of wildlife.

c. More vegetative protection for tree-eating rodents is available. Habitat for brush rabbits (Silvilagus bachmani), snowshoe hare (Lepus americanus) and mountain beaver (Aplodontia rufa) has improved to a great extent. The increased populations of these animals have and will necessitate more animal control treatments at the time of planting.

d. Plantations will probably close in (crown closure of conifers) 2 or 3 years later. This will provide a longer period of time for usable forage for big game species.

e. Browsing is occurring over entire plantations, not just along plantation edges, more hiding cover is available.

2. Social

Certain social impacts have been favorable. Contracts for both site preparation and release treatments have increased significantly. These contracts have created a significant number of new jobs for the unskilled labor force. Needless to say, a wider distribution of money is expended from our contracts. There also may be a wider acceptance and understanding of our plantation treatments than there was just 3 or 4 years ago.

CONCLUSION

In conclusion, the necessary site preparation, reforestation and release treatments are being accomplished on the Siuslaw National Forest. No backlog of work is accumulating. The work is being accomplished through the site-specific application of a number of silvicultural techniques. District silviculturists have had to hone their remaining tools and learn to treat only the areas that need treatment. During the last 4 years we have learned much about our vegetation treatments. With the assistance of research, we have identified the proper time to cut red alder. With more time and assistance from research, we will identify the proper timing for similar treatment of salmonberry.2/ The use of herbicides would make our job more efficient in many areas, but the silviculturists have found alternate means to get the job done to acceptable standards.

Plantation establishment is costing more per acre without herbicides. However, this provides us a real challenge to find cheaper, more efficient treatments to accomplish the job.

Without the use of herbicides, more contracts and jobs are being created, which provides a social benefit. From these jobs, the dollars expended tend to go into more hands and more communities.

The impact on other resources, specifically wildlife, has been beneficial. The major benefit to wildlife has been the more rapid recovery of vegetation, which in turn provides more cover and forage.

2/Cooperative study between Siuslaw National Forest and Pacific Northwest Research Station, Forestry Sciences Laboratory, Corvallis, Oregon. Study is titled "The Effected OF Season OF Mechanical Treatment ON THE Development OF Salmonberry Competition--a Study Plan," by John C. Zasada. The study will be established in fiscal year 1987.

ATTACHMENT 1

In 1983, a suit was filed in U.S. District Court for the District of Oregon on July 13. (Civil 83-6273-E). The plaintiffs were Northwest Coalition for Alternatives to Pesticides, Oregon Environmental Council, and Audubon Society of Portland. The defendants were J. R. Block, Secretary, United States Department of Agriculture; James Watt, Secretary, United States Department of the Interior; and William Ruckelshaus, Administrator, Environmental Protection Agency. The Oregonians for Food and Shelter, Incorporated, were interveners.

A judgment was entered March 14, 1984, finding that, "The defendants have not prepared an adequate Worst Case Analysis, pursuant to their NEPA [National Environmental Policy Act] obligations under 40 CFR 1502.22." The defendants were enjoined from all spraying of herbicides with the United States Department of Agriculture, Forest Service, Region 6, and within the United States Department of Interior, Bureau of Land Management (BLM) Districts, within the State of Oregon until completion of obligations under 40 CFR 1502.22 (Incomplete or Unavailable Information).

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COORDINATING REFORESTATION AND LIVESTOCK GRAZING ON THE TONASKET RANGER DISTRICT IN NORTH CENTRAL WASHINGTON [1]

WILLIAM R. TERRILL [2]

Abstract

Several actions were taken to improve the coordination between the Range and Silviculture operations on the Tonasket Ranger District. The actions include: A.) The development of a grass seeding guide that meets acceptable Range/Silviculture resource objectives. B.) A strategy that provides for range forage utilization in young tree plantations. C.) A strategy that protects young tree plantations from unacceptable livestock damage. D.) A vegetation management program that allows for long-term transitory range and adequate control of competing vegetation after tree establishment. E.) A plantation grazing program that is supported by all parties involved (including the Ranger, Range, Silviculture, and Livestock Permittees).

[1] Presented at the National Silviculture Workshop, Sacramento, California, May 11-14, 1987.

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INTRODUCTION

The 401,300 acre Tonasket Ranger District lies in North Central Washington along the Canadian border. Continental glaciation influenced the characteristic undulating terrain and glacial-till soil. Moisture ranges between 15-40 inches of precipitation (mostly in the form of snow). Temperatures vary between -25 degrees to 100 degrees F. Summer drought is common. Fire and xeric conditions have influenced the type and distribution of vegetation. Douglas-fir, ponderosa pine, western larch and lodgepole pine are the principle conifer species. Huckleberry, snowberry and ninebark are the brush species. Pinegrass, wheatgrass and fescue are the native grass species.

Temperate, semi arid forest and forest grasslands support a 40 million board foot timber sale program and an 8,000 cattle, 1200 sheep livestock program. There are 43 allotments, 53 permittees and 38,500 AUM'S under permit on the district. Grazing generally occurs between June 1 and Sept. 30. Livestock grazing has been historically an important activity on the district. Large ranching operations depend on the summer forage. Presently there are 3500 acres of tree plantations on 184 individual plantations. Most of these clearcuts were created since the early 1970's. The district has had an aggressive planting program for the past 8 years.

THE PROBLEM

Many planted tree plantations have not performed satisfactorily. Of the existing 3500 acres of plantations, an estimated 1032 acres will fall below desirable tree stocking if damaging agents continue. We are beginning to reschedule planting on many of these failures. The majority of clearcuts were not planted immediately after harvest, resulting in pocket gopher buildup and established livestock use.

Intense competition from natural and domestic grass seeding is a problem. Frequently, post-harvest activities have included the seeding of over 20 pounds to the acre of rhizomatous grasses. In addition to pre-existing pinegrass, this seeding resulted in dense grass sod mats. Timothy, orchard grass, burnet, pubescent wheatgrass, hard fescue and white clover have been influential in stimulating gophers, attracting livestock and causing vegetative competition problems.

Data compiled since 1979 indicates that we are receiving 4 percent mortality on first year seedlings and 7 percent by the third year due to cattle. Trampling damage is showing up on 15 percent of our first year seedlings and 25 percent by the third year. Presently this damage can not be differentiated by livestock or deer. Unknown mortality is substantial. Grass competition and stem bruising are two of the many suspect problems. We have recently taken steps to improve our site preparation by using fire, require auger planting of bareroot stock and are treating for pocket gophers. We have built a high humidity cooler and are paying close attention to seedling care and handling.

Silviculture was continuing to clearcut and plant without regard for the grazing situation within the allotment. Range was continuing to sow grass in these clearcuts for erosion control, noxious weed control and forage production. Permittees were confused about the grazing status of plantations within their allotments. Cattle and grass were cursed and the seedlings continued to suffer from trampling damage and grass competition.

The problems caused by livestock and grass do not exist to any significance in natural plantations on this district.

THE PROPOSED SOLUTION

Grass Seeding;

In the spring of 1986 several Range Conservationists, Silviculturists and Ecologists from the Forest met and assessed the present grass seeding situation on the Okanogan N.F. We came to some common agreements on the solution and Clint Williams (Zone Ecologist) put together a grass seeding quideline. Several categories had to be established in order for a grass seeding recommendation to be made. Land management objectives needed to be determined first: a.) Erosion/weed control. b.) Tree regeneration (artificial and natural). c.) Forage production. d.) Stabilization of roads and primary skid trails and e.) Tree stocking control.

The ecological sites had to be classified on the ground. The plant associations were separated into dry and wet environments. It is felt the dry environments are where tree growth and survival suffers from moisture stress caused by dense grass.

Several recommendations were also made within the guideline. Seeding rates would be determined from pure live seed instead of pounds per acre. The presence of pinegrass in addition to the ecological classification would restrict grass seeding. Bulbous grasses would be avoided where timber management is the objective in order to reduce pocket gopher enhancement. Recommended grass species and rates shall be followed unless documented in an E.A. or Silvicultural Prescription. Grass seeding should not be limited in non-regeneration timber harvests. Seeding rates shall be monitored.

Grazing Management;

During Spring 1985 I met with the district permittees and explained the problems we were having with our young planted tree plantations and admitted the confusion we were promoting by not informing them of their grazing status. They were informed about the need for a workable solution of Plantation Grazing Management. Their input was collected and used in the process.

We then had a meeting with Silviculturists and Range people from the forest and developed plantation grazing criteria. Based on available research and local observations, the following grazing strategies and plantation conditions were developed:

I. NO GRAZE (would be allowed):

a.) on a planted plantation with less than 180 well-distributed crop trees per acre that average less that 5 feet tall or

b.) with average crop tree height of less than 3 feet tall and where replanting is not planned or

c.) plantations that are being treated for other damaging influences (i.e. gophers).

II. RESTRICTED GRAZE (involves no more than 20-40% grass forage utilization, short duration grazing, no salting, water troughs and springs fenced to restrict livestock). This would be allowed:

a.) on planted plantations where replanting is scheduled or

b.) on plantations that have more than 180 well-distributed crop trees per acre that average between 3 and 5 feet tall.

III. FULL GRAZE (involves normal "good grazing" management meeting soil management and forage condition goals. This would be allowed:

a.) on natural plantations or

b.) on planted plantations with at least 180 well distributed crop trees per acre averaging at least 5 feet tall.

During the 1986 field season we collected data within those tree plantations; crop tree stocking, height and distribution. Plantation Management cards were built for each plantation and a grazability status was recorded.

During the following winter a photo-masaic of 1:24000 scale, 14"X22" size photographs were prepared with magnetic backing. A sheet metal wall was assembled and the photographs were placed on the board, demonstrating the entire district. The district boundary was traced along with labeled allotments, pastures, fence locations, water troughs and springs. We then colored in the previously determined grazing strategies;
NO GRAZE - Red (Stop)
RESTRICTED GRAZE - Yellow (Caution)
FULL GRAZE - Green (Go)
YET TO BE DETERMINED - Black.

We went into the permittee meetings with our stand grazing criteria, grazability status of each plantation, and a photograph of their allotment showing the improvements and plantation locations. We then got down to the task of developing an allotment management plan to achieve the goals of plantation management. Using the criteria and strategy as a baseline, we then looked at each plantation within the allotment.

Risk is essential to make such a program work. Deviations from the guide were made on a case by case (plantation by plantation) basis. We agreed to graze some plantations for an assortment of reasons including low risk, confidence in the permittees abilities and their commitment to plantation protection. We went into the meetings with the following acres of grazability status:

FULL GRAZE	=	222 acres
RESTRICTED	=	682 "
NO	=	2354 "
UNDETERMINED	=	242 "

We came out of the permittee meetings with the following grazing status:

FULL GRAZE	=	265 acres
RESTRICTED	=	721 "
NO	=	2272 "
UNDETERMINED	=	242 "

The following action items were agreed to:

a.) three miles of fence to be constructed.
b.) three miles of fence to be reconstructed.
c.) one water development installed.
d.) eight allotments with changed and designated salting locations.
e.) all allotments in need of improved herding.
f.) one allotment put in NON-USE category due to acreage and distribution of NO GRAZE plantations. Livestock were moved to other allotments taking non-use.
g.) two pastures taking NON-USE due to extent of NO GRAZE plantations within the allotment.
h.) three changes made in turn-on locations.
i.) three changes made in turn-on dates.
j.) three scheduled fieldtrips with permittees to clarify objectives and locate plantations.

We reached a mutual understanding of what we would do to implement the desired grazing strategy for each plantation. Our program was well-received and an excellent spirit of cooperation exists.

Using a volunteer to report locations of cattle in relation to tree plantations and disperse cattle congregating within plantations was discussed with permittees. The support for this was overwhelmingly favorable as long as the person understands cattle and ranching. Our range people are supportive. We have a qualified volunteer. The Ranger is to make a decision on this before field season.

Tree planting provides many advantages over natural regeneration. But, our timber sites do regenerate naturally and we do not have timber/grazing conflicts in such natural plantations. For those reasons, I am using natural regeneration when possible on future timber harvests.

IN SUMMARY

Much research and experience has demonstrated that cattle and trees can be compatible resources. Work done in southwest Oregon, in the Blue Mountains, and in southern British Columbia are examples of livestock/timber management successes. An operational guide or system is paramount in dealing with many individual plantations, pastures, allotments and permittees. This guide was developed to meet local conditions. Some basic concepts and graphics were used from a system developed on the Payette National Forest to coordinate grazing and plantation protection within sheep allotments.

Several Key points are worthy of mention in making this program a success. It is important that the permittees be introduced to the problem before any solutions are proposed. This program is a joint effort between Range and Silviculture. The photo-mosiac board is essential to the program for the visual value of planning and to promote ownership with the permittees. Besides informing and listening to the permittee, a sense of ownership can be promoted by some aesthetic and psychological aids. It is suggested the photo-mosiac board be placed in the Range department to foster familiarity. The board can be labeled with grazing/timber management terminology. Their brands, some tree plantation visuals, and range improvements can be displayed on the board. Visit with the permittees in the woods and show them some of your reforestation efforts. One must be willing to take some risks, especially if you stand to gain more than you lose. We need to sell the program like McDonald's sell hamburgers; promote it, talk it up, be positive, foster a "can-do" attitude. We must manage the program on a site specific level, plantation by plantation. A full-time plantation manager is essential. If nothing else, I have learned that these livestock permittees are a good bunch of people who have a strong resource management and land ethic. Good management makes sense to these people. They have many of the solutions. Their vested interest in the grazing permit fosters more ownership than many of our other forest users. Cooperation is inexpensive and hopefully leads to damage prevention.

INFORMATION AVAILABLE THAT COULD BE USEFUL IN IMPLEMENTING A PLANTATION GRAZING PROGRAM

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Establishing a Research Base for Multifunctional Management of Aspen in the Central Rocky Mountains

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Abstract

Studies of Rocky Mountain aspen date from the early 1900s and have covered a wide range of topics. Today, aspen stands are increasingly important sources of fiber for manufacturing, prime producers of forage for large and small herbivores, and habitat for many other wildlife species. Current studies of aspen at the Rocky Mountain Station are providing a research base for management of the highly prized aspen resource.

Introduction

Aspen (Populus tremuloides) is the most widely distributed and abundant deciduous tree in the Rocky Mountains. But no where in the West is the species more highly prized than in Colorado, where television and radio regularly report the progress of its color changes during the fall senescence to thousands of people who flock to the best viewing areas each year.

According to Daubenmire (1943), aspen is one of the few species that grows from the alpine vegetation zone to the basal plains. In Colorado, commercial stands generally occur between 7,500 and 10,500 feet in elevation, dominating a large number of plant communities and occurring as a subordinate component in many others (Hoffman and Alexander 1980, 1983; Mueggler 1985a).

Although generally considered to be seral, there is considerable evidence that climax, or at least long-lived, stable aspen communities occur throughout the Rocky Mountains (Mueggler 1985a). Among various criteria used to support this observation is the presence of widely distributed, uneven-aged stands, which strongly suggests that aspen clones and stands can, without conifer competition, successfully regenerate repeatedly without major disturbances, such as wildfire (Mueggler 1985a).

According to Green and Van Hooser (1983), commercial aspen sites occupy about 4.4 million acres in the West. Of this, more than one-half (2.9 million acres) are located in Colorado. If poletimber, which currently is marketable in some locations, is included, the area of standing commercial aspen in Colorado totals about 2.1 million acres or about 2% of the total area of that state. Certainly, all of these acres are not physically or administratively available for harvest, but the net acreage obviously is substantial. In addition, thousands more acres are occupied by noncommercial aspen that presently is without monetary value, except perhaps as firewood.

Current Utilization of Aspen in Colorado

Fiber

Over the short run, aspen can produce wood as fast as any other commercial species in the Rockies. However, in Colorado, with no pulp industry, there traditionally has been little sustained market for aspen wood or fiber. Periodically, aspen has been used for mine props, pallets, paneling, shakes, rough boards, box and crating lumber, and other minor products (U.S. Department of Agriculture 1976). But the only steady market is on the San Juan National Forest in southwestern Colorado, where about 400 acres of mature aspen have been clearcut annually for almost 40 years to supply a matchstick factory and an excelsior plant.(1)

In the mid-1980s, the wood products industry established two waferwood mills that utilize aspen for part of their raw material. It is estimated that each mill requires about 2,200 acres of raw material per year, of which 800 to 900 acres are aspen. To date, much of this aspen has come from private land. However, the public land contribution is expected to increase from the current average of about 200 acres per year, as the easily accessible supply from private land declines.(2,3,)

During the past 10 years, most National Forests in Colorado have been assigned clearcutting targets for noncommercial aspen designed to maintain the species on site, or to change its age-class distribution, as benefits to wildlife habitat. Most of these targets are being met through firewood sales. The Arapaho-Roosevelt, a Colorado Front Range forest, clearcut about 230 acres annually for this purpose between 1981 and 1985.(1)

Although these acreages may seem miniscule to those from the major timber-producing regions, they have not been trivial to interest groups that have protested harvesting for any purpose and particularly for industrial use. Fortunately, conflicts to date have been resolved without court action by committees made up of Forest Service personnel and representatives of the concerned organizations (The Aspen Panel 1985).

Forage

It is certain that virtually all aspen stands in the central Rockies are grazed to some degree by wild herbivores. In addition, most accessible stands have been used by livestock since the late 1800s.

Aspen stands probably are the best producers of understory vegetation among the forested communities in Colorado. With some exceptions, commercial aspen acreage produces many forbs, fewer grasses and sedges, and still fewer woody plants. Unpublished data from five of our study areas indicate that uncut stands of commercial aspen can produce 1,000 to 2,000 pounds per acre of air-dried understory vegetation and two to three times that much in the earlier years after clearcutting. Part of the increase on clearcuts consists of aspen regeneration, which, in some places, is fed upon by wild herbivores and livestock.

Long-term impacts of grazing on the composition of understory vegetation can be substantial, especially where wild and domestic animals feed on the same sites. Understory communities commonly observed today may be much different in proportions of species or growth forms now than before livestock was introduced. Preferred species have undoubtedly declined, and those of lower preference increased over the past 100 years (Mueggler 1985b).

Aspen stands on big game winter ranges generally are of noncommercial quality, and usually are managed for forage and protected as habitat for wildlife.

Wildlife Habitat

Aspen and aspen-conifer plant communities provide habitat for a wide variety of wildlife species and individuals within species (DeByle 1985). In the subalpine zone where conifers often dominate, aspen offers the only upland deciduous habitats. Also, our unpublished data suggest that aspen-conifer habitats may be more productive for some wildlife species than pure stands of either form.

Much has been written about the value of western aspen as habitat for many wildlife species. Few long-term definitive studies have been conducted to document these observations, however, or to determine effects of various management practices on changes in habitat characteristics, or responses of individual wildlife species or groups of species. Potential changes in numbers of individuals or species usually have been inferred rather than documented from periodic inventories in treated and untreated stands over periods of time.

For example, few statistically valid inventories have been made of species or individuals within species before or after the harvest of commercial quality aspen in the Rockies.

Research in Aspen in the West

Historical Research

Documented studies of aspen in the West began early in the present century. These were primarily in Utah, were mostly observational, and focused on the ecological status of the species--whether aspen was a permanent or successional species (Mueggler 1985a). Baker (1925) published a major bulletin summarizing findings on western aspen during the first quarter of this century.

Numbers of literature citations on western aspen increased slowly from about 1930 to the mid-1960s, and have been continuous and substantial since then. DeByle and Winokur (1985a) list over 1,000 citations directly or indirectly involving western aspen.

Studies in the Intermountain area have continued to dominate aspen research for many years (DeByle and Winokur 1985a). From 1974 to 1985, a major aspen research effort was conducted by the Intermountain Station at Logan, Utah. This program strongly emphasized vegetation classification and other ecological topics, as well as physiological aspects of aspen ecology.

Research on aspen in Colorado also began early but progressed slowly until the late 1960s. In 1976, a symposium conducted by the Rocky Mountain Station in Fort Collins, Colo. summarized the state of the art in aspen management and utilization (U.S. Department of Agriculture 1976).

Other recent western aspen conferences have been held in Utah in 1981, and in Colorado Springs, Colo. in 1984. In 1985, a major book on western aspen was published by the Rocky Mountain Station (DeByle and Winokur 1985b). This effort compiled virtually all of the available literature reporting on studies conducted on or related to aspen in the western states.

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Current Research

Current research at the Rocky Mountain Station was begun primarily in response to concern expressed in 1977 by then Regional Forester Craig Rupp. He knew that most of the aspen in Region 2 was mature or overmature and was concerned that much might be lost without renewal treatments.

This concern prompted formation of a Region-Station Aspen Task Force in early 1977. Except perhaps for pathological aspects, the lack of a satisfactory data base from which to satisfactorily formulate plans for aspen management became evident as the report by this group was being prepared.

Our present aspen research program, begun in 1977, is directed primarily at mature or currently harvestable stands, and includes subjects ranging from nongame birds to stand classification and growth and yield modeling (table 1). The main emphasis, however, has been directed toward determining effects of harvesting and other cultural treatments on (1) aspen regeneration and early growth, (2) related understory components, including forage production, habitat use, and impacts of big game and livestock, and (3) through cooperators, responses of selected nongame wildlife species and groups of species.

In addition to our work, the Station's Wildlife Research Work Unit at Laramie, Wyo. currently is implementing a major investigation to determine the role of aspen and aspen-conifer mixes as habitat for a wide array of nongame birds and mammals.

Results from this new program and research currently underway should add measurably to the data base required to adequately assess responses to treatments, and to plan orderly programs for multiresource management in the central Rockies.

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Table 1.--Current aspen studies by Multifunctional Research Work Unit 4151 at the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo. (1987).

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1. SMALL BLOCK CLEARCUTTING OF ASPEN TO IMPROVE WILDLIFE HABITAT: A hypothesis that habitats offering a variety of age classes are preferable to existing large expanses of mature aspen prompted the clearcutting that is being evaluated in this study. Responses of understory vegetation, aspen regeneration, and growth and use by big game, sheep, small mammals, and selected bird species are being monitored.

   Investigator: Glenn L. Crouch
   Location: Routt National Forest, northwestern Colorado

2. EFFECTS OF COMMERCIAL CLEARCUTTING ON WILDLIFE HABITAT AND BIG GAME USE IN A PURE-ASPEN STAND IN SOUTHWESTERN COLORADO: This commercial timber sale included a large number of variable-sized blocks clearcut over a 5-year period. Understory responses, regeneration, and large herbivore use are being evaluated in various sizes and ages of clearcuts. Nongame bird responses are being monitored by the cooperator.

   Investigators: Glenn L. Crouch and Virgil E. Scott (U.S. Fish and Wildlife Service)
   Location: San Juan National Forest

3. COMPARISON OF CUTTING, BURNING, AND HERBICIDE TO REGENERATE MATURE ASPEN FOR WILDLIFE ON THE WHITE RIVER NATIONAL FOREST, COLORADO: Responses of over- and understory components, big game, and cattle to various stand regeneration treatments are being evaluated in small stands of mature to overmature aspen.

   Investigator: Glenn L. Crouch
   Location: White River National Forest, west-central Colorado

4. COMPARISON OF SOME WILDLIFE POPULATIONS IN ASPEN, ASPEN CONIFER, AND CONIFER FORESTS: Numbers of nongame birds and small mammals are being compared across five levels of aspen and spruce-fir stands ranging from pure aspen to pure conifer. Vegetative habitat components also are being compared across the same gradient.

Investigators: Virgil E. Scott (U.S. Fish and Wildlife Service) and Glenn L. Crouch
Location: White River National Forest, west-central Colorado

5. IMPORTANCE OF SMALL STANDS OF ASPEN IN LODGEPOLE PINE TO BIRD AND SMALL MAMMAL DENSITIES AND DIVERSITY: Numbers of nongame birds and mammals using small inclusions of aspen are being compared with those in the surrounding 900-acre, 65-year-old stand of lodgepole pine.

Investigators: Virgil E. Scott (U.S. Fish and Wildlife Service) and Glenn L. Crouch
Location: Fraser Experimental Forest, central Colorado

6. AN EVALUATION OF DOZER-SHEARING TO REGENERATE ROCKY MOUNTAIN ASPEN: Effects of dozer-shearing or pushing are being compared with chainsaw felling as methods to regenerate aspen stands. Comparative effects of the two methods of understory vegetation and large herbivore use also are being evaluated using differential fencing and slash removal.

Investigators: Wayne D. Shepperd and Glenn L. Crouch
Location: Routt National Forest, west-central Colorado

7. THINNING IN POLE-SIZED ROCKY MOUNTAIN ASPEN: The case-history investigation is evaluating effects of a simulated commercial thinning in pole-sized, mid-age aspen. Five levels of treatment removed various percentages of the original basal area from adjoining areas of the same clone. Fencing of one-half of each block allows comparisons of treatment effects on understories with and without grazing by cattle, elk, and deer.

Investigators: Wayne D. Shepperd and Glenn L. Crouch
Location: Fraser Experimental Forest, west-central Colorado

8. INITIAL THINNING IN YOUNG ROCKY MOUNTAIN ASPEN: Designed to investigate long-term effects of early precommercial thinning, this study also will provide growth information for yield model updates.

Investigator: Wayne D. Shepperd
Location: Three sites in western Colorado

9. A COOPERATIVE SURVEY OF THE CONDITION AND VIGOR OF REGENERATING ROCKY MOUNTAIN ASPEN: Reported and observed regeneration failures after clearcutting prompted this regionwide survey of selected areas that had been clearcut for at least 5 years. Pathological and physical mortality factors are being assessed.

Investigators: Wayne D. Shepperd, Thomas E. Hinds, and Glenn L. Crouch
Location: Various sites in Colorado

10. RELATIONSHIPS OF ELK, DEER, AND PERMITTED CATTLE TO SUCCESSFUL REGENERATION AFTER COMMERCIAL CLEARCUTTING OF ASPEN IN SOUTHWESTERN COLORADO: Aspen regeneration, and big game and cattle activity are being monitored in- and outside cattle exclosures to determine relative effects of the animals on regeneration responses.

    Investigator: Glenn L. Crouch
    Location: San Juan National Forest

11. CLASSIFICATION OF ASPEN FORESTS BY STAND CHARACTERISTICS: Data from this study will establish the range of aspen stand and growth conditions in the central and southern Rockies, and be used to develop a classification system for existing stands based on information available from Stage II inventories.

    Investigator: Wayne D. Shepperd
    Location: Colorado and southern Wyoming

12. RATES OF CLONAL EXPANSION IN ROCKY MOUNTAIN ASPEN: Persistence and expansion of isolated aspen clones are being examined at various locations in Colorado. By determining age and size-class structure, spatial distribution of ages within clones, and reconstructing clonal history, an understanding of clonal dynamics should be achieved.

    Investigators: Frederick W. Smith (Colorado State University) and Wayne D. Shepperd
    Location: Various sites in Colorado

13. VOLUME TABLES AND GROWTH AND YIELD PREDICTION TOOLS FOR EVEN-AGED AND TWO-AGED STANDS OF ASPEN IN THE CENTRAL ROCKY MOUNTAINS: This study is developing volume tables and point-sampling factors for aspen. Also, stand growth and yield relationships for variable density yield tables for even-aged and two-aged stands are being developed and incorporated into a species-specific subroutine for program RMYLD2 for computing yield tables needed to examine alternative management strategies in aspen stands.

    Investigators: Carleton B. Edminster and H. Todd Mowrer
    Location: Colorado, southern Wyoming, and Utah

Footnotes

[1] Personal communication, San Juan National Forest, February 1987.

[2] Personal communication, Colorado State Forest Service, February 1987.

[3] Personal communication, Routt National Forest, February 1987.

[4] Personal communication, Arapaho Roosevelt National Forest, February 1987.

CONTROLLING TITI ENCROACHMENT ON THE NATIONAL FORESTS IN FLORIDA

by

Edith W. Petrick[1] and John J. Petrick[2]

Abstract.--An estimated 125,000 acres of formerly productive pinelands of the Apalachicola NF in Florida have been invaded by a noncommercial shrub/tree species association known locally as "titi". The primary species are swamp cyrilla, (Cyrilla racemiflora), buckwheat-tree, (Cliftonia monophylla), and little-leaf cyrilla (Cyrilla parvifoli). The encroachment is due largely to the introduction of fire protection activities and discontinuation of annual burning during the 1930's. Following approximately ten years of fire exclusion, a prescribed burning program emphasizing winter backfiring was initiated on the Apalachicola NF during the 1940's. These relatively cool burns did little to prevent titi encroachment. The National Forests in Florida has initiated a program to reclaim a portion of these lands for commercial pine production. Through a combination of mechanical site preparation and planting followed by band fertilization during the first year of establishment, well-stocked stands of vigorous seedlings have been established. To date, 2000 acres have been successfully reforested. The work is costly, time-consuming and must be balanced with a variety of other resource concerns, such as wildlife habitat needs, watershed protection, and recreation and visual resource management objectives.

INTRODUCTION

The Apalachicola National Forest, established in 1936 by President Franklin D. Roosevelt, covers 558,735 acres in the northwest Florida panhandle. The terrain is flat to gently rolling with soils ranging from excessively drained to very poorly drained. Natural fertility is generally low with most of the poorly drained soils being phosphorous deficient. Vegetation of the Apalachicola National Forest is typical of southern coastal plain pine forests with pine-palmetto flatwoods predominating. Slash pine (Pinus elliottii) and longleaf pine (Pinus palustris) are the primary management species occupying sites suitable for timber production. The ecosystem is fire-adapted and dependent, having developed under the influence of natural lightning fires which occur frequently as a result of summer thunderstorms. Prescribed burning has historically simulated the role of natural fire and is needed to maintain forest vegetative conditions to meet management objectives for fire protection, wildlife, recreation, visual quality, forage and timber production.

Bay systems form in poorly drained depressions and drains intermingled with the pinelands. Although bay systems may contain mixtures of cypress, blackgum, sweetbay, and other bottomland hardwoods, they are primarily occupied by a brush species locally known as "titi". "Titi" refers to three related species which are buckwheat-tree (Cliftonia monophylla), swamp cyrilla (Cyrilla racemiflora) and little-leaf cyrilla (Cyrilla parvifolia). These species are multi-stemmed, evergreen shrubs that grow in dense stands typically on wet sites. The buckwheat-tree, which is most abundant, may obtain heights of 30 to 40 feet and diameters of 6 to 12 inches. The leaves are thick and wax-coated with a high oil content which makes titi a volatile fuel. The tree is a prolific seeder and sprouter. Titi swamps will burn during prolonged droughts on windy summer days with low humidity. When ignition occurs, the fires are hot and difficult to control, often resulting in crown fires and extensive spotting. The only foreseeable commercial value for this species is fuelwood, for which there is no demand at present.

An estimated 125,000 acres of formerly productive pineland on the National Forests in Florida, which were occupied by longleaf and slash pine during the turn of the century, have been invaded by the titi species, predominantly buckwheat-tree and swamp cyrilla.

It is important to understand how the encroachment of titi occurred. In the early 1900's the old-growth timber was removed from the lands which are now the Apalachicola National Forest. Prior to harvest the lands were characterized by extensive stands of pine timber with understories of native grasses. During these years, the land was managed as open range. Cattlemen burned annually during the growing season using headfires, burning the bays whenever they became dry enough to burn. The intensity and frequency of these fires confined the titi species to the wettest sites.

After acquiring these lands in 1936, the U. S. Forest Service initiated a fire prevention and protection program which drastically reduced the number and intensity of fires which had historically occurred on the these sites. Coupled with the cutover condition of the land, the reduction in number and intensity of fires allowed the titi to leave the wet areas and perimeter zones of pinelands and to partially or fully encroach on the dry pine ridges. As titi increased in size and density it became impossible for pine seedlings to become established in its dense, competitive understory. During the last fifty years, the land area occupied by titi species has increased significantly. When compared to photographs taken in 1937, current photographs show large increases in the widths of bay swamps and large decreases in the amount of land which appears to be suitable for pine. In some cases, ridgetop stands have been totally occupied by titi species.

Under the guidelines of the last Timber Management Plan, the lands invaded by titi were classified as "unproductive" with the qualifying statement: "which may contain areas of productivity". There are an estimated 125,000 acres of land with potential productivity based on evidence of previous stand conditions. Typical signs of previous productivity are presence of scattered cull pine trees, large lightwood stumps and understory vegetation such as saw-palmetto. Other methods of site identification are photo analysis and use of soil maps.

During a Forest Resource Management Review (FY-81), actions were taken to initiate a pine reclamation program for sites identified as suitable. Guidelines and targets were established and funds became available in FY 83 when work began to reclaim the first 500 acres of "unproductive" land. The majority of lands considered feasible for reclamation, a total of 90,000 acres, occur on the Apalachicola Ranger District. The remainder, a total of 35,000 acres, occurs on the Wakulla Ranger District. The work was initiated and remains predominantly on the Apalachicola Ranger District. Since initial identification of the 125,000 acres for reclamation, a new Forest Land and Resource Management Plan has gone into effect. Through analysis of this project from a multiple resource stand-point, it has been determined that only 35,000 acres should be reclaimed.

Issues related to the reclamation work included protection of wetlands, potential reduction of wildlife habitat and honey production area, and visual quality effects. Analysis of the issues indicated that reclamation of the titi areas would have no significant detrimental effect and in most cases would enhance the resource concerned.

The extensive stands of titi lack diversity. By selecting scattered stands and using natural boundaries which give a pleasing curvilinear shape, visual quality will be improved.

The titi stands are currently unproductive wildlife habitat. One indicator species, eastern black bear, uses the swamps for escape cover. Analysis of bear escape cover needs determined that dispersed reclamation of the 35,000 acres would allow adequate retention of habitat. Additionally, the regeneration areas would greatly diversify existing vegetation, improve habitat for deer and other browsing species and provide future foraging area for the red-cockaded woodpecker, a federally endangered species.

A local industry unique to the area is honey production. Special use permits are issued for apiaries placed in the forest on small plots the permittees maintain. Titi honey is a specialty and many producers prefer locations near large stands of titi. There was initial concern that there would be an unacceptable loss of honey production area. The decision to reclaim 35,000 acres is acceptable relative to this issue.

Watershed protection has been the major concern involving the reclamation project. Care must be taken to correctly identify sites which are operable and are not wetland/titi swamps. Use of aerial photography and soil data helps in area selection. Reclamation has been restricted to sites with soil types of the poorly drained or drier classifications. This prevents reclamation of wetlands, which are classified as very poorly drained.

Since FY 83, over 2000 acres have been successfully reclaimed using mechanical site preparation and machine planting. A discussion of the trials of different methods, current results, and future plans follows.

METHODS

A variety of methods were tried during the first two years of reclamation efforts. These included different combinations of mechanical treatments and use of fire following the initial chop. Four years of evaluation have resulted in knowledge of what works well on these sites.

The site prep was predominantly accomplished in two phases. The first year an initial chop was done to get the massive amount of material on the ground. This was done with a D-8 dozer pulling a single drum chopper having a minimum width of 7 feet and minimum weight of 13000 pounds. Significant top kill was accomplished with the initial chop, but the main benefit was getting the material on the ground where it can begin decomposition and facilitate further treatment. The first chop cost approximately $45.00 per acre and was contracted locally.

The second phase was the follow-up treatment to the first chop and occurred a year later. Treatments tried during the second phase were: 1) follow-up with a double-drum chopper 2) shear, rake, windrow, chop, and bed 3) double chop and bed 4) single chop and double bed 5) rake, windrow, double bed 6) bed with fire plow 7) mound with Bracke seeder. Costs per acre for the above treatments ranged from $45 to $175 per acre.

During FY 83, fire was used in combination with the initial chop as a means of reducing the slash and controlling sprouting competition on the areas. This was discontinued due to the extreme hazard of the burning operation and because results did not meet the slash reduction and competition control objectives.

Both mechanical and hand planting of slash pine, the management species, were tried. There is sufficient equipment and labor in the local area to contract either method and they are equal in cost at approximately $25.00 per acre. Hand planting was done on areas with minimum site preparation while machine planting followed intensive site preparation.

Beginning FY 84, when survival of the first planted stands was assured, the stands were band fertilized. This was done under contract with farm tractors and skidders. Diammonium phosphate (18-46-0) was applied at a rate of 250 pounds per acre over the tops of the seedlings in bands three feet wide along the rows. The total cost of this operation was approximately $32.00 per acre including materials and labor. The soils of the Apalachicola NF are characteristically low in phosphate. This is particularly true for the titi areas being reclaimed. The early fertilization was done to boost the seedlings over the tremendous competition that reoccurs on the sites following site prep. The fertilization has been continued.

RESULTS

For pine reclamation, the initial chop is necessary in order to knock down the massive amount of material on these sites so that further treatments can be accomplished. Following chopping, the average fuel was 23 tons/acre (Fuel Model 4 - Anderson 1982). It takes tremendous horsepower and weight to make the initial pass through the dense stands. Forward momentum is required of the dozer in order to push over the dense stands where stems can be as large as 12 inches dbh. A double-drum chopper is places too much weight and drag on the dozer to be effective.

First-year results led to the decision that burning following the initial chop was not a necessary or beneficial treatment. The first sites chopped were burned during the month of August three weeks after the chop. The semi-cured fuel load of approximately 23 tons/acre with leaves containing a high oil content proved to be more than was desired in a prescribed burn. Flame lengths were in excess of 50 feet and spotting potential was extreme with ignition possible to one-half mile. This was too great a risk to established commercial pine stands and plantations which were adjacent to the reclamation areas. In addition, the results of the burn did not meet the objectives. Although fine fuels and leaves were consumed, the problem material, i.e. three inches diameter and above was not. The larger fuels at ground level maintained a high fuel moisture content since the titi is found on wet sites. In addition, the fire did not consume the root mat found in association with titi. Instead, root sprouting increased to two to four times that of unburned stands. Therefore, the objectives of reducing slash and controlling competition were not met. Based on this and the high risk of escaped fire, it was determined that prescribed burning is undesirable in combination with mechanical site preparation.

Results from the second phase of site preparation showed that a second chop is detrimental to the site. Too many passes with heavy equipment break down the capacity of these sites to support weight. The second chop was done using a double-drum chopper and D-8 dozer for a combined weight of 103,000 pounds. Further degradation of slash without increased competition control resulted from a second chop.

Shearing was done the first year on sites with dense titi with large diameters. This proved to be impractical because the D-8 could not maintain enough forward momemtum to shear material on the wet sites. Due to low traction the equipment was often mired.

Raking and windrowing was the most useful and essential part of the entire site preparation operation. It was done to clear the area of loose debris and to displace the thick root mat associated with titi. The root mat averaged 8 inches in thickness and ranged up to 14 inches thick. It is a peat moss type material that contains organic matter bound by thousands of fibrous titi roots. If not properly disturbed this root mat will sprout back intensively and result in insurmountable competition to the newly planted seedlings. Seedlings do not survive well in the root mat because it is not tightly packed. Seedlings die due to air pockets or drought when the root mat becomes dry periodically during the year. Raking can remove this mat to the degree necessary for seedling establishment. There is adequate organic matter left on site after removal of the root mat. A site can be raked more effectively than sheared because the rake requires a D-6 dozer which is 50,000 pounds lighter than the D-8 required for shearing or chopping.

Bedding is the final operation necessary for successful preparation of these sites. A bedding plow with an hour glass packer is the most successful unit. It has eight disks in front of the plow which rip up the residual root mat and mix mineral soil with organic matter. This material is then formed into a bed which is packed by the packing wheel with a shape designed to maintain the bed height while eliminating air pockets within the bed. Two beds gave better results than one bed. One bed was not high enough to get the seedling root systems out of the water zone. The water zone can be at or near surface level three to six months out of the year. The second bed further displaces the roots of competition, further mixes mineral soil and organic matter, and results in a well-packed bed approximately six inches higher than the first.

The bedding plow works well because it can negotiate wet sites. This equipment weighs less than any other implement associated with the site preparation process. A D-6, rather than a D-8, is needed to pull the bedding plow. It does not cover the entire area. There are untreated strips approximately 3 feet wide between beds. This untreated area provides support for the planting equipment since the soil crust has not been destroyed by repeated passes with heavy equipment.

Based on survival, mechanical planting was the most successful method of reforestation. Twenty percent better survival was obtained by mechanical planting than by hand planting. This was attributed to less handling and exposure of the seedlings.

Fertilization has proven cost effective. Differences in height are apparent between fertilized and non-fertilized rows of seedlings.

During the initial years of this work, the 80-acre stand size limitation, which is the standard for slash pine management on the forest, proved an unfavorable restriction. Areas suitable for reclamation greater than 80 acres were often found. Following regeneration of an 80-acre portion there were sometimes small isolated areas left in an unproductive state due to the infeasibility of managing them separately. An Environmental Assessment was prepared to increase the maximum allowable individual stand size from 80 to 160 acres and approved. This increase produced the most desirable combination of net public benefits and was determined to be visually and environmentally acceptable.

In addition to the site specific reclamation program, many acres of national forest land are being reclaimed each year as a result of the aggressive prescribed burning program. The Apalachicola National Forest is targeted approximately 60,000 acres annually in an effort to maintain the forest on a three year burning cycle. Much of the burning is done using aerial ignition and spot fires. This method gives the advantage of relatively hot prescribed fire and the ability to burn isolated areas which are inaccessible by ground crews. Results of the burning program are that titi species encroaching on the perimeter of general forest area stands are now being slowly pushed back into the swamps.

FUTURE PLANS

Herbicide use has been considered as a method of site preparation that would reduce costs and vegetative competition. Titi has proven to be difficult to kill due to its waxy leaf surfaces. Glyphosate and Triclopyr have been used with some success. The most effective method has been using Triclopyr following a single chop with a light weight chopper which skinned up the bark of the stems. This allowed the herbicide to enter the plant in the same manner as an injection procedure.

This FY (1987), in an effort to further control competition, the double bedding will be done as a delayed operation. The second bedding operation will be postponed for 6 weeks following the first bedding to allow sprouting. The second bedding will occur when the titi is young and vulnerable and when root reserves are being depleted. This should reduce the amount of sprouting that reoccurs during the first year of growth.

Because there is a limited window of time each year due to rainy periods when the sites are operable for pine reclamation, the method of contracting may be revised. We are presently allowing a set number of days for contract time during which the work can be accomplished. Because weather conditions are so variable, the estimate of days can be insufficient. We are considering having the contract run a full year beginning October 1 with the contractor to have the work accomplished by the following September 30th. This would result in the work being completed during the FY that funds are allocated and allow the contractor to use dry spells that occur throughout the year.

FY 1987 is the first year that we have attempted to complete the entire site preparation job within one FY. The initial chop was done in October and the second phase is scheduled for the summer months. This would have the benefit of adding a year of productivity to the life of the stand. It appears that the 6-month delay between the two phases of site preparation will be adequate for the material to decompose following the initial chop.

Mechanical planting and band fertilization will be continued in most cases. Also, containerized seedlings will be tried as an additional means of increasing initial growth needed to overcome competition.

CONCLUSIONS

The pine site reclamation work being done on the Apalachicola National Forest is an important regeneration effort. It has been done with careful consideration for other resource concerns including wildlife, watershed, and visual quality objectives. Public opinions have been solicited and considered during the decision-making process for determining acceptable methods and the amount of acres to reclaim. Analysis shows that this silvicultural treatment is beneficial in many ways due to the diversity it introduces to a non-diverse vegetative type.

An economic analysis prepared by Glenn Parham[3], Forest Silviculturist of the National Forests in Florida, determines the work to be cost effective from a timber management viewpoint (Table 1.).

Credit goes to the Apalachicola Ranger District staff who have been innovative and aggressive in finding successful ways to accomplish the work. Their efforts show that through a combination of mechanical site preparation and planting followed by band fertilization during the first year of establishment, well-stocked stands of vigorously growing pine seedlings can be established. The sites are predicted to be some of the most productive on the forest (Site Index 70 to 90 for slash pine) due to the adequate moisture and high organic content of the soil.

Table 1. Economic analysis of pine reclamation in titi areas.

Year	Management Activity	Cost	Revenue	Present Value Costs	Present Value Revenues
0	Site Preparation	54		54	
1	Site Preparation	120		115	
2	Plant, Fertilize	114		105	
3	Survival Exam	3		3	
18	Prescribe Burn & Commercial Thin*	30	234	15	116
23	Prescribe Burn	12		5	
28	Prescribe Burn & Commercial Thin*	45	400	15	133
33	Prescribe Burn	18		5	
37	Prescribe Burn	21		5	
40	Prescribe Burn & Commercial Thin*	72	500	15	188
45	Prescribe Burn	29		5	
50	Prescribe Burn	36		5	
55	Prescribe Burn & Clearcut*	216	4666	25	540
	Totals:			372	893

Net Present Value: $521

Benefit/Cost Ratio: 2.40

Assumptions:

1) Pine stumpage will increase at an annual rate of 2.5 percent through year 2030. (See page 205 of Forest Resource Report No. 23, An Analysis the Timber Situation of the United States 1952-2030). The increase will be net of inflation.
2) Labor and other costs will increase at an annual rate of 4 percent.
3) The discount rate used is 4 percent.
4) Catastrophic fires, insect and disease outbreaks will not occur.
* 5) Thinnings will occur at ages 15, 25, and 38 with yields of 6 and 8 cords of pulpwood and 1.5 MBF sawtimber consecutively. Clearcutting will yield 8.0 MBF sawtimber. (Best estimates used due to inavailability of volume tables on these sites.)
6) Overhead costs are estimated at 20 percent of direct costs.

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Management of the Nonindustrial Private Forestlands in the South[1]

Roger W. Dennington[2]

INTRODUCTION

Over 30 percent of the nation's commercial forest land is owned by nonindustrial private forest (NIPF) landowners in the South (Figure 1). It is important to the national as well as state and local economies that these properties produce their share of consumptive and nonconsumptive forest products. Failure to meet their share will likely put more pressure on public lands and create an increased demand for foreign or substitute products.

COMMERCIAL FORESTLAND - U.S. & S.E.

	U.S.	(%)	S.E.	(%)
	1,000 Acres			
National Forest	88,718	(18)	11,544	(6)
Other Federal	10,692	(2)	3,575	(2)
State	23,415	(5)	2,595	(1)
Local Public	12,896	(3)	912	(71)
Forest Industry	68,782	(14)	36,500	(18)
Nonindustrial Private	277,982	(58)	144,822	(72)
	482,485	(100)	199,948	(100)

Figure 1

Over 50 percent of forest industry's land is located in the South. This fee land supports a competitive and thriving industry that has become the number one manufacturing business in many of the southern states. Because the stockholders of several southern located forest industries desire to make their assets more liquid, over seven million acres of industry land has been for sale in recent months. As industry reduces its landbase, even more demand is expected to be put on the NIPF properties to supply an increasing percentage of the forest outputs.

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1 Presented at the 1987 National Silviculture Workshop, Sacramento, CA May 11-14, 1987.

2 Silviculturist, Cooperative Forestry, Region 8, Atlanta, GA.

REASON FOR CONCERN

The South, with leadership from the USDA-Forest Service, is completing a comprehensive study of the total forest resource in this region. Titled, "The South's Fourth Forest," the study has determined that for the first time in several decades, the softwood net annual growth has begun to decline (Figure 2). The major cause for the change in softwood growth is the lack of adequate regeneration in pine stands after harvest on the NIPF lands (Figure 3).

NET ANNUAL SOFTWOOD ROUNDWOOD GROWTH IN THE SOUTHEAST

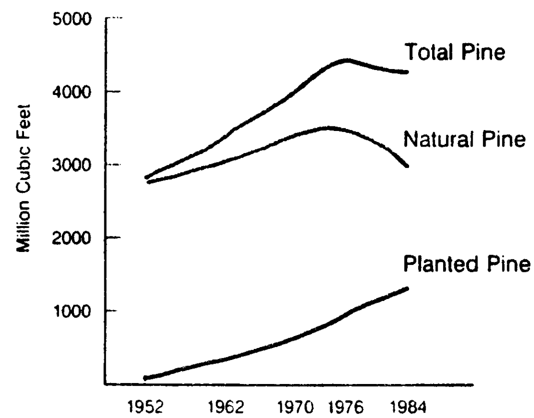

Figure 2

REFORESTATION ACTIVITIES ON SOUTHEASTERN NIPF PINE STANDS AFTER HARVEST

Reforestation Activity	Percent of Total Acres Harvested
Planted Pine	36
Seeded Pine	1
Left Seedtrees	9
No Active Reforestation	54

Figure 3

Over 50 percent of the acres in pine_stands on NIPF properties do not have any reforestation action taken after harvest. But as distressing as these figures may be, just a few years ago it was worse--only one out of four were being reforested after harvest. The cumulative consequences from the failure to reforest such a high part of such a large block of productive forest land is apparent.

UNDERSTANDING THE LANDOWNERS

Through the years, many studies and surveys have been conducted to provide a better understanding of who these landowners are and what motivates them. The more they are "studied," the more we understand how diverse a group they really are. Most foresters are strongly oriented toward timber production and assume that most landowners are too. Such is not the case. Many landowners have management objectives more centered in wildlife, aesthetics, and pride of ownership.

A high percentage of the southern NIPF landowners are over 55 years of age with relatively short planning horizons. They are reluctant to make large per acre reforestation investments that will have payoffs in 20-25 years. Surprisingly, at least for many foresters, the main reason reforestation investments are not occurring is the landowners' belief that the site will reforest itself without the intervention of man (Figure 4). The study that produced these results also found that landowners perceived that the costs were too high and that returns were too distant and too low.

REASONS WHY SE - NIPF LANDOWNERS DO NOT INVEST IN PINE REFORESTATION

Reasons	Acres Not Reforested
Felt Site Would Reforest Itself	4 of 5
Reforestation Cost Too Much	1 of 2
Other Uses for Harvest Revenues	2 of 5
Return on Investments to Low	1 of 3
Return on Investment to Distant	2 of 5

Figure 4

After the near liquidation of the southern forest during the late 1800's and early 1900's, the forest for the most part regenerated itself naturally. As late as the 1950's, over 90% of the forest was of natural seed or sprout origin. The old timer landowners believe if it happened once it can happen again. They are not completely wrong. Many southern foresters have become so plantation oriented that they seem to overlook or have forgotten the fact that given a little help under the right circumstances, the forces of nature can recreate a forest. Naturally regenerated southern pine stands generally require considerably less initial reforestation investments and have rates of return comparable to planted stands.

TECHNICAL ASSISTANCE

To have managed forest, nonindustrial private forest landowners need technical or professional assistance just like any other forest landowner. Marketing timber products, making and executing silviculture prescriptions, and providing adequate forest protection are tasks that require more time, skill, and knowledge than most NIPF landowners have. Consequently, many are "ripe" for a timber buyer that approaches them with what appears to be a lucrative offer to purchase their timber. Many purchasers offer to cut to a minimum diameter and leave manageable stands after the cut, when in fact, all that is left afterward is a scattered and sparce population of suppressed trees that lack the capability to grow into a profitable stand.

Studies have shown that on the average, landowners who use the assistance of a forester when selling timber receive stumpage prices nearly twice as much as those who did not. In addition, residual stands after harvest have on the average, one-third more volume per acre when a forester is used. Clearly the technical assistance provided by a forester makes a difference.

In the South, there are approximately 2000 foresters who provide professional services to the 3.5 million NIPF landowners (Figure 5). Consulting foresters comprise the largest group followed by state service foresters. Consultants generally prefer to work with larger landowners and prefer to engage in timber sales rather than other cultural work. Most states restrict the amount of total time their public foresters can work with any one landowner so as to avoid conflicts with the consultants and spread their services among more landowners. In most states, the consultants and the state have a good working relationship. As a result, the state serves as a motivating influence with passive landowners and refers them to consultants for more complete services.

FORESTERS AVAILABLE FOR TECHNICAL ASSISTANCE ON SOUTHEASTERN NIPF LANDS

	FT	PT
State	350	250
Consultants	610	600
Industrial Management Assistance	100	–
Extension Service	60	10
Soil Conservation Service	15	–
	1135	860

(1565)

Figure 5

With an average of only one forester for every 92,000 acres of NIPF property, it is no wonder management is often non-existent or less intense than on other forest properties (Figure 6). Further complicating this situation is the fact that the property lines are often poorly defined, the ownership is quite often broken up into many parcels, it often has no previous history of sound management, and it does not enjoy the established operating budgets common to public and industrial forest land operations.

FORESTERS PER ACRE

$$\text{SE - NIPF}: \frac{144{,}822{,}000 \text{ Ac.}}{1565 \text{ Foresters}} = 92{,}538 \text{ Ac./For.}$$

$$\text{N.F. - R8}: \frac{11{,}544{,}000 \text{ Ac.}}{511 \text{ Foresters}} = 22{,}591 \text{ Ac./For.}$$

Figure 6

Surveys have shown that the nearly 3.5 NIPF landowners have ownerships that average about 42 acres each (Figure 7). Almost 80 percent of the acres are in ownerships of 100 acres or larger and are owned by only 9 percent of the property owners. This suggest that much of the limited amount of technical assistance should be targeted toward these larger ownerships.

OWNERSHIP SIZE - NIPF IN S.E.

Ownership Size (Acres)	Number of Owners	(%)	Total Acreage in Size Class	(%)
	Thousands			
1 - 99	3,203	(92)	30,428	(21)
100 - 999	263	(8)	55,239	(38)
1000 +	13	(>1)	59,155	(41)
	3.479	(100)	144.822	(100)

Figure 7

REASONS FOR OPTIMISM

To close this paper having only looked at the dismal side of this story would discredit the many good things that are occurring on NIPF lands in the South. Progress is being made and the results of years of hard work by many dedicated people is beginning to become apparent. Examples of some very positive things include:

--A tree planting program that reforested over three fourths of a million acres in FY '86 (Figure 8).

--By 1990 almost all of the southern pine seedlings planted on NIPF lands will be of genetically superior origin.

--The Conservation Reserve Program in FY '87 resulted in 500,000 acres of margin crop lands being converted to forest plantations. An additional 2-3 million acres are expected to be planted by this program within the next 3-5 years.

--The levels of professional expertise in both the state and consulting foresters ranks has substantially improved over the past decade.

--Reforestation after harvest ratios have been improved from 1:4 ten years ago to 1:2 today.

--The southern forestry community is recognizing the need to sell forestry on a regional and mass media basis.

TREE PLANTING - FY86

NIPF	753,138 Acres
N.F. (R8)	71,085 Acres
N.F. (All Regions)	240,894 Acres

Figure 8

In summary, management of the NIPF lands in the South is, (1) important to the national and local economies, (2) is difficult because of the shortage of foresters, landowner motivation, and available capital, and (3) is showing signs of substantial improvement in recent years. Foresters who manage southern NIPF lands face a challenging future. They appear to be meeting the challenge.

SILVICULTURE TO ENHANCE RECREATIONAL VALUES IN THE SAWTOOTH NATIONAL RECREATION AREA

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Kenneth A. Britton
Sawtooth National Recreation Area
Sawtooth National Forest
Ketchum, Idaho

Located in the mountainous part of south-central Idaho, the Sawtooth National Recreation Area is a land of sparkling lakes and streams, rugged peaks, and pastoral valleys. Created in 1972, the 754,000 acre Sawtooth NRA has the responsibility of managing the resource to "assure the preservation and protection of the natural, scenic, pastoral, and fish and wildlife values and to provide for the enhancement of recreational values". The "management, utilization, and disposal of natural resources on federally owned lands such as timber, grazing, and mineral resources is authorized as long as their utilization will not substantially impair the purposes for which the recreation area was established".

Trees are an intricate part of the total NRA resource. Their role as a visual medium between the open valleys and rocky peaks is immediately apparent. In developed recreation sites their great value is for screening and shade.

Lodgepole pine is the predominant species of the valley bottoms and morainal foothills. It grows throughout the majority of our developed recreation sites. Douglas-fir, subalpine fir, and whitebark pine occupy the steep slopes. Englemann spruce is found along creek bottoms. Scattered stands of quaking aspen are found throughout the Sawtooth NRA below 8000 feet. Subalpine fir and Douglas-fir habitat types predominate; however, some stands of lodgepole pine and aspen habitat types have been identified.

Utilization of the timber resource has been occurring for the past one hundred years. The earliest white man cut mine timbers and railroad ties from the Sawtooth country. Later, houselogs, lumber, firewood, and charcoal were important products of the forest. Today the forests of the Sawtooth provide landscaping transplants, Christmas trees, posts, poles, houselogs, firewood, and a limited amount of sawtimber to small, local sawmill and post and pole yard owners for commercial use as well as to individuals for personal use. Approximately one million board feet of timber is sold annually within the Sawtooth NRA. In addition, one-and-one-half million board feet of personal use firewood is also removed each year.

Forest management is "used to maintain vegetative and ecosystem diversity, to maintain or enhance NRA values, to maintain healthy forest stands, and to provide forest products for personal and commercial uses. Silvicultural needs will not override visual, recreational, and fish and wildlife needs". The General Management Plan for the Sawtooth NRA states that "forestry practices will be directed to enhancement of the scenic and recreational values of the NRA". Our timber planning objectives "strive for long -term maintenance of the general forested appearance with emphasis on maintenance of a variety of habitat types in various stages of development".

With these objectives in mind, we have initiated a small, but intensive timber management program to ensure that future NRA visitors will experience a diverse and pleasing forest environment.

Some of our earliest attempts at uniting timber management and recreation occurred in the late 1970's near Galena Lodge, a cross-country ski touring center in the upper Big Wood River valley. Many of Galena's ski trails wound through stagnant stands of lodgepole pine and provided little visual variety to skiers. Some of the low, ridge-top trails would afford spectacular vistas to the nearby Boulder and Smokey Mountains if limited tree harvest occurred. Sales were planned and laid out with a specific objective of improving the visual quality of the ski trails. The Galena Lodge permittee was regularly involved during the planning and layout phases.

During a five year period approximatly one million feet of post, poles and firewood was removed from the area. Spectacular vistas to the mountains did appear along portions of the ski trails, creating much-needed visual diversity for Galena's skiing visitors.

With this positive experience behind us, we decided to expand our attempts at visual management to include the major travel corridors within the Sawtooth NRA. After all, if we could improve visuals along ski trails, it seemed logical that roadside visuals could similarly be improved. In the process of improving visuals, we felt that our efforts would also improve the long-term health and vigor of these heavily-viewed stands.

With the assistance of our landscape architect, who had previously inventoried all NRA lands to determine specific visual quality objectives, stands that would most benefit from treatments were identified. Most of these stands were small areas that could easily be manipulated with little impact to the visitor. Patch cuts of less than five acres were laid out and sold. There were no restrictions imposed on the purchaser regarding periods of cutting. We received very few comments from the general public despite the fact that trees were being removed immediately adjacent to State Highway 75, the main travel corridor through the Sawtooth NRA.

Our first conservative attempts along the highway proved less successful. This commercial pole thinning experienced significant blowdown within three years of treatment.

Patch cutting has been the most successful method of treating our stagnant lodgepole pine stands to most successfully realize our long-term objectives. Natural regeneration in our lodgepole has simplified re-establishing tree cover in cutover areas.

In order to insure the best possible results, we do impose some additional requirements on our purchasers as well as on our own crews. We require a four-inch stump height on all roadside sales. This requirement is two inches less than our normal stump height requirement in lodgepole sales and is imposed to reduce visual impacts caused by cutting along major travel routes. All sales are marked with paint marks facing away from heavily-traveled roads. It is imperative that extra slash disposal efforts be made, if necessary, to guarantee the least possible visual impact to our visitors.

In an attempt to reduce dwarf mistletoe infections in lodgepole regeneration we are strip cutting one-hundred to one-hundred-fifty foot corridors around regenerating patch cuts. Several of the strip cuts have been incorporated into ski trail layout to heighten the ski experience or have been incorporated into roadside sales to enhance scenic values. Although we do not intend to eradicate mistletoe from the lodgepole, we do hope to retard it's spread into regeneration so that overall vigor can be maintained for a longer period.

Treatments in dwarf-mistletoe infected Douglas-fir sawtimber have been used to enhance snowmobile and ski opportunities as well as to create wildlife openings and improved summer range for elk and deer. Since our primary objective is not necessarily to produce high-value timber in an optimum period, we sometimes seed cutover openings with grasses and forbes to increase big-game browse availability.

Since the advent of fire control, many of the aspen stands within the Sawtooth NRA have declined in health and vigor. Regeneration is limited within these stands. Conifer encroachment has also reduced the size of many of the stands. We have always recognized the high scenic value of our aspen stands, but only more recently have become aware of the long-term prognosis if we do nothing to alter the current trends.

During the summer of 1983, in an attempt to reduce conifer encroachment and to increase the number of stems of aspen in a given area, we laid out an experimental lodgepole strip cut approximately twenty-five to one hundred feet wide, around a one-quarter acre aspen patch. All conifers were removed from the site; the wood left for personal use firewood cutters.

Aspen suckering was widespread during the first season following cutting. After two seasons we concluded that our treatment had nearly doubled the size of the original stand. The autumn landscape could indeed be enhanced through aspen treatments. With this background, we began to investigate other possibilities for managing aspen.

Our wildlife biologist is in the process of inventorying aspen stands that could be stimulated by silvicultural treatment. We are also inventorying stands that are located within view of State Highway 75 and have sold one commercial firewood sale adjacent to the highway with the objective of regenerating this declining stand. Personal use firewood and wildlife dollars have been used to fall aspen in accessible areas and in wildlife migration areas.

Two year monitorings of three cutover areas revealed a range of between 400 and 1200 suckers per acre ranging in height from 3 to 60 inches.

We are presently exploring the use of prescribed fire to stimulate inaccessible, declining clones and are confident that our efforts in aspen management will insure future, healthy stands that will increase available forage for wildlife as well as increase visual diversity within the Sawtooth NRA.

In 1986, reforestation - timber stand improvement dollars were used to improve visuals within non-commercial stands along heavily-traveled, developed site access roads into the Redfish, Pettit, and Alturas Lake recreation complexes.

Accomplishing TSI work that would most enhance the scenic values of the three popular access routes was the primary objective in selecting stands for treatment. In addition, fuels reduction dollars have been used in the past to create shaded fuelbreaks around developed recreation sites in the Redfish and Alturas Lake complexes. Working predominantly in even-aged lodgepole pine, Forest Sevice crews have opened vistas onto streams and meadows and have created more open, park-like stands adjacent to popular recreation sites. Continued periodic maintenance of these regularly-viewed, non-commercial stands will not only reduce the fire hazard within heavily-used recreation sites, but will increase species diversity, improve the health and vigor of targeted stands, and will maintain the scenic quality that we want to provide our visitors.

The Wood River Campground Vegetation Management Plan, completed in 1983 with the assistance of volunteer labor, was our first concerted effort to manage vegetation within a developed recreation site. Increased annual losses to mountain pine beetle within the campground made us realize that trees were going out quicker than they were coming in. Inventory of the vegetation within the campground revealed a serious lack of trees in the one to three inch diameter class. All other size classes appeared to be well represented in the stand makeup. It became apparent that in order to maintain our investment for future generations we would have to artificially build up stocking in the one to three inch size class.

During the past three years we have transplanted over 200 sapling-sized trees into Wood River Campground. We have expanded our planting program to other campgrounds within the NRA and more recently have encouraged our special-use resort, recreation residence, and organization camp permittees to begin underplanting trees within their permitted areas. During the past two years over two thousand seedlings have been purchased by the permittees and planted in special-use areas of the NRA.

* * * *   * * * *

Following the creation of the Sawtooth NRA in 1972, timber management practices became extremely conservative. No patch cutting was permitted and treatments were to be located away from travel corridors and major viewsheds. Impacts to recreational visitors were to be non-existant. It took less than ten years to realize what the long-term impacts to vegetation would be, particularly in lodgepole pine, if cutting was to be constrained to single tree selection and small group harvest.

We have since reversed our philosophy to a more direct approach to timber management. If we are indeed most concerned about maintaining healthy, diverse stands within travel corridors and viewsheds so that the majority of our recreation visitors will view an aesthetically-pleasing forest environment, then our primary emphasis should be to treat stands within these areas to ensure that future visitors will have this same opportunity.

The result is a pro-active, rather than reactive, approach to vegetation management. A planned cooperative effort with the Intermountain Forest and Range Experiment Station and the Region Four Forest Pest Management office will attempt to further this pro-active approach by implementing several techniques to test the effectiveness of an integrated mountain pine beetle management program in reducing losses to recreational values in Sawtooth Valley during the next several years.

By combining cooperative efforts with our normal commercial and non-commercial vegetation management program and by continually exploring a variety of applicable silvicultural practices, we hope to successfully increase the diversity, health, and vigor of the forest environment, maintain a forested appearance within existing developed recreation sites, and enhance the scenic beauty that is so much a part of the Sawtooth NRA.

Silvicultural Prescriptions for Visual Resource Management

Hubertus J. Mittmann
Regional Landscape Architect, R-2

From past reactions to our management activities it is quite evident that the American public is very much concerned with the appearance of their landscapes, especially those which are managed by public agencies. Many research projects prove that enjoyment of scenic quality is the main objective when people are skiing, fishing, hunting, or participating in other recreational activities.

Since most landscape alterations are either soils manipulation, structure introduction, or most importantly vegetation alteration, it is pertinent that we discuss visual resource management at this workshop with the theme of "Silviculture for All Resources," because everything can be seen from somewhere.

I am assuming that you are all familiar with the National Forest Landscape Management System and the visual resource management program. Basically what we have done is establish visual quality objectives on all National Forest acres based on variety class of the landscape, distance zones and sensitivity levels. These visual quality objectives were adopted in the Forest Plans and now we have to design our management activities in such a way that they will meet these objectives.

This is where the challenge for the silviculturists comes in because the appearance of vegetation management activities will pretty well determine how the public perceives us, not by how scientifically correct it is but by what it looks like.

How then can we best design these vegetation management activities so that they achieve our management goals and look good at the same time? Since we have the best technology available to us and outstanding professionals of all disciplines in our ranks it will take team work, the interdisciplinary approach to planning and design, that is the only way. We all will have to understand the basics of the different resource areas to achieve the different management objectives. For example, as a landscape architect, I have to understand what the wildlife, recreation or timber management basic concepts are before I can apply landscape architectural design concepts to also meet the visual quality objectives. The silviculturist will have to do the same thing and learn what the recreation, wildlife or visual resource objectives are and what basic concepts are involved before a prescription can be written. For that reason alone we need to attend each others training sessions and learn from each other.

Lets investigate the basic concepts of visual resource management in more detail. We must realize that this is a very dynamic, ever changing process because as we establish new viewing platforms for people, such as roads and recreation areas the sensitivity levels and distance zones from which a landscape area can be seen will usually change and new visual quality objectives will have to be established based on these new conditions.

We can not write a cookbook on how visual quality objectives can be met because the measure if we or if we don't meet a visual quality objective depends on the characteristic landscape which is described in terms of line, form, color and texture. The more we vary from the natural line, form, color and texture the more contrast we create and the less likely we are to meet any visual quality objective.

The key is to inventory the characteristic landscape, not at the micro project scale but rather at the macro viewshed or fourth order watershed scale, to determine what the landscape character has to offer to help us meet the visual quality objectives.

For example, in a foreground or middle ground area which now has 5 to 10 acre natural openings we can meet the retention or partial retention visual quality objectives with similar openings in size and shape. If we had a solid stand of timber without openings we could probably only meet modification or maximum modification visual quality objectives with the 5 to 10 acre openings. On the other hand, if a landscape has 70 to 100 acre openings we should work with similar size and shape of openings to retain that character.

If we have a landscape which doesn't have much identifiable character which would help us in our management, we may have to design a desired character which we can establish for management purposes over time.

We should never deal with just a project or one entry but rather we must deal with a continuous landscape unit such as a viewshed or a fourth order watershed and design all entries over time in this area to achieve our long term visual goals.

A tremendous tool in checking our designs out over time are the Perspective Plot and the New Perspectives software computer programs. You must try them to see what they can do for you.

In R-2 we have simulated many vegetation management projects showing up to five entries over time. We have found that the public can relate much easier to a perspective printout showing the effects of the proposed management than to plan view proposals. The computer printouts of the visual effects on the landscape have clearly eliminated many misunderstandings and have reduced necessary public hearings and legal actions with their associated costs. We don't use this tool enough and I recommend that we emphasize the benefits of these computer programs more.

Over the past years I had considerable involvement on silvicultural projects, the R-2 certification board and the "Trees" course. I have found that most silviculturists are eager to learn about applying their skills to other than just timber management projects and they are very willing to learn about the basic concepts of other resource areas. This is very encouraging and the benefits will be reflected in future projects. I also learned that had these individuals been exposed to the basic concepts of other resource areas in school it would have been a lot easier to recognize the needs of these resource areas and incorporate them into the prescriptions.

I propose that we discuss this with the Forestry Schools urging them to incorporate exposure to these real world situations in their curriculum to assure that the students have an understanding of the interdisciplinary approach and the variety of projects they will be facing once they are employed.

This brings me to some of the real world situations we are facing in the Forest Service for which we need solutions. In all these situations we need to make certain that the resource, vegetation and visual needs are met. This is not always easy and the interdisciplinary planning team will have to work hard to assure the best solution for all.

Ski Areas - The visual impact of ski areas is far reaching. We have to make sure that the visual impact is within the adopted visual quality objectives but we also need to make certain that our main objective of good skiing is met. Vegetation treatments will play a major role on how a ski area meets its objective. The ski runs should be designed to simulate a natural appearance with irregular edges and healthy, wind firm trees along the edge to assure good snow deposition and protection of the multimillion dollar investments. Since most ski areas are located in mature and overmature vegetation the challenge is to develop a vegetation management plan which will rejuvenate this vegetation and prescribe treatment over time to enhance the skiing potential, protect the area from major insect and disease infestations, enhance the visual appearance and protect the investment of the ski area. Since we usually deal with all timber types in these areas the solution will stretch the imagination of any silviculturist.

Developed Recreation Areas - The vegetation in these areas has been trampled, bruised and abused and in most instances is mature and overmature with no revegetation coming in. How do we rejuvenate a stand like this and make it acceptable from the recreation and visual stand point? What measures do we take? Do we plant, protect, clearcut, selectively cut, introduce new species, treat the soil, fertilize, and irrigate to protect our investment? In many situations we may have to do all of these things. It may surprise you to know that we have done a lot of clearcutting in different recreation areas with excellent public acceptance. Naturally the cleanup of these areas had to be almost complete for appearance sake but the overall results were excellent.

Viewshed corridor plans along major highways and scenic roads. To manage the vegetation in full view of the traveling public gives us an opportunity to show what we can do. We need to open views, expose natural features along the road, assure the safety of the traveler yet provide a variety of species, age classes and types of vegetation which will make any drive an experience to remember. To do this right we need to prepare a plan which will in an orderly manner show what needs to be done, when to assure the percentages of age classes and different species in this dynamic vegetation environment.

Timber Management Patterns - Buffer zones, square or rectangular clearcuts and wind rows of debris must be a thing of the past. We don't need to hide anything if we do it right and as I mentioned before with all the talent and technology available to us there is no excuse for bad vegetation management especially as it affects the visual environment.

Chris Marvel, Forest Landscape Architect on the Medicine Bow National Forest in Wyoming, had developed a checklist which if followed will help in designing visually acceptable harvest patterns:

1. Using aerial photographs, measure several natural openings which are within, or just adjacent to, the perimeter of the sale area. This is the approximate range of size of openings which your sale should use in its harvest design to help create natural appearance. This is a feature in the area which should be synonymous with this area's landscape character type.

2. Lay out the harvest blocks so they do not violate any of the following principles:

    A. Units should be irregular in shape--avoid straight lines. Follow natural type lines. Avoid having a shape with an edge which has too much variation. Compare the natural opening produced by Nature in the sale area to determine the edge a shape should have.

    B. Axis of the shape should be parallel to slope contours or parallel to minor ridges running down slopes.

    C. All harvest units should have visual linkage. This means that the harvest unit axis should link smoothly together so that the eye easily follows them.

    D. Avoid regular spacing of harvest units. Avoid same size harvest units. Spacing should be irregular and size of units should vary for good diversity and natural appearance.

    E. Choose a size of harvest unit that is compatible with existing openings or which correspond to natural stand boundaries if no opening exist. (See A.) Avoid unit sizes which are either too small or too large by comparing them to natural openings or natural stand boundaries within or adjacent to the sale area.

    F. Avoid leaving a small strip in between two treated stands. The area left should be of sufficient size to be considered a manageable stand.

I would like to add one more principle to this list. When a harvest pattern incorporates a road don't use the road as an edge, but rather bring the pattern, clearcut or shelterwood cut, across the road to make it part of the traveling experience. If you use the road as an edge the opening along it will create a contrast from the other side and draw the travelers attention and make this a focal area which we really don't want to do.

To the contrary of may peoples thinking, a landscape architect involved in a timber sale will usually be more aggressive than a silviculturist and enlarge units and increase volume by working with the large scale the landscapes offer us. I cannot see any conflict in working together to meet our goals.

Although this presentation only focused on a few things we all can see that visual resource management and silvicultural prescriptions have to go hand in hand to assure an aesthetically pleasing landscape. The best way we can do this is by working together to solve the management problems we face and provide the public for which we manage these National Forests with an environment we can all be proud of. I hope we can have more of these workshops in the future to further the interdisciplinary approach in the Forest Service.

VISUAL RESOURCE MANAGEMENT ON NATIONAL FOREST LANDS

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Abstract: This study attempts to record the interdisciplinary process involved in the creation of a long term comprehensive plan between visual resources and silvicultural prescriptions. Other resources integrated into the plan were wildlife, soils, recreation, etc.

INTRODUCTION

The project area under consideration is located on the Mariposa Ranger District on the Sierra National Forest. It is located 30 miles south of Yosemite National Park. It is approximately 1 1/2 hours driving time from Fresno, California or 4 to 5 hours driving time from San Francisco or Los Angeles areas. It involves the viewshed around Bass Lake Recreation Area. Bass Lake has about 750,000 RVD's yearly. A large percentage of the shoreline is under private ownership, mostly owned by Pacific Gas and Electric. The heavy recreation use season is from Memorial Day to Labor Day weekend. The predominant timber type is mixed conifer heavy to Ponderosa Pine. The topography is typically flat near the lakes edge then becomes steeper towards the upper edges of the viewshed.

PROCESS

The first step in developing this plan was to delineate the viewshed. This was done by identifying viewpoints around the area from resorts, campgrounds, and housing tracts. The forest's Draft Land Management Plan designated this viewshed to have Retention managed in the foreground views and Partial Retention managed in the middleground views. These areas were then identified and the lines placed on a map.

The next step assessed the current timber conditions and visual character of the basin. The direction for the basin was to establish a desired mix of size classes featuring the old, mature look of Ponderosa Pine. FORPLAN was used to schedule the cutting by size class to achieve the desired condition and to optimize the mix during the conversion period. This harvest schedule was then compared to the forest wide harvest schedule to make sure it was feasible.

After an acceptable harvest schedule was developed, the process to check the ability to actually implement the harvest schedule began. A paper logging plan for the entire viewshed was developed. This plan was overlaid with the timber type maps to generate polygons or "stands." The priority strata identified by FORPLAN was used to develop three decades for harvest strategies. These harvest strategies were simulated using the HP 9000 and Perspective Plot program to assess if the visual quality objectives were being met.

The next step was to design a timber sale to implement the first decade of harvest in the viewshed. The Salter Timber Sale was planned and has since been harvested. The logging engineer, silviculturalist, and landscape architect took the paper logging plan with tentative harvest units to the field and flagged the roads and units with some field modifications to fit the terrain. The stands have been harvested, prepped, and most of the units have been planted. The first decade of harvest has occurred and has met the visual quality objectives. The next timber sale is being planned now. Its primary goal will be to continue the process of regeneration in the Retention areas.

CONCLUSION

This plan is one of many alternatives in creating a planning process to maintain or enhance the qualities of a viewshed. It should be stressed that this plan is not intended to be all conclusive. It is merely one of a series of complex and continually developing planning process leading to the creation of a responsive viewshed management plan.

ONE SILVICULTURIST'S ROLE IN PLANNING

FOR WINTER SPORTS

or

"Trees Ain't The Thing"

Authors:

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Abstract:

The authors present a concept which departs from the historical idea that the technical skills of a silviculturist are focused on growth and maintenance of trees for timber production. In the authors' view, the land manager must first determine the primary use to which land is to be dedicated. The silviculturist must become thoroughly familiar with that use objective and provide options to the manager which will help achieve the stated goal. The silviculturist thus becomes one of several technical experts providing advice to the manager in achieving a non-timber oriented goal.

ONE SILVICULTURIST'S ROLE IN PLANNING FOR WINTER SPORTS

Background and History

In the late 1970's, planning was completed for the Beaver Creek Ski Area on the White River National Forest, Region 2. The total area to be made available for the development was identified as an early step in the planning process. Part of this total planning concept included the first "Vegetation Management Plan" written as an integral part of the Master Development Plan for a downhill ski area. This first Vegetation Management Plan was written by Ranger District and Forest staff specialists. No satisfactory precedent could be found, and the skiing industry was not familiar with it, so the Forest personnel had to develop the concept, integrate it into the master planning process, and write the plan. Application and use of the Beaver Creek Vegetation Management Plan have revealed the value and significance of such planning, together with some opportunities for improving similar documents.

In the years following the planning for Beaver Creek, the Land and Resource Development Plan for the White River National Forest was written and implemented, and the Forest Service Manual was supplemented to include specific requirements for recreation master planning. The Forest Plan includes standards and guidelines to control development and use in areas designated for winter sports; the new Manual supplements provide the process by which the Forest Plan is to be implemented, and mandate the use of other component plans as part of master planning. One of the component plans is the Vegetation Management Plan.

Early in 1985 the Forest received proposals from the Vail Ski Area planners which were beyond the scope of the Master Development Plan then in effect for that ski area. In the District Ranger's opinion, the new development proposals clearly indicated a new Master Development Plan was needed because the objectives of the old Plan had been achieved, or had reached "build-out". The new development proposals were beyond the scope of the original Master Development Plan. Management personnel at the Vail Ski Area were told that a new Master Development Plan must be written and approved before the White River National Forest would approve expansion, new developments, or other changes. The original Master Development Plan did not include a Vegetation Management Plan, as it had been written under guidelines that were approximately 20 years old.

When Vail Associates, Inc. began to assemble their technical staff and consultants to produce a new Master Development Plan, they had difficulty locating a silviculturist acceptable to the Forest Service, one who was familiar with local forest cover types and Forest Service data collection and recording procedures. The District Ranger suggested the use of a silviculturist from within the ranks of the Forest Service, with all costs to be borne by Vail Associates. This was done, initially requiring approximately six weeks of field and office time, with an additional two weeks of followup.

This effort brought the original concept of vegetation management to maturity. At the Beaver Creek Ski Area the concept was applied to land having no developments whatsoever. At the Vail Ski Area, intensively developed lands were included in vegetation planning, as well.

Need for Vegetation Management Planning

The potential exists for development and use of 12,700 acres of National Forest lands under the proposed Vail Master Development Plan. Currently there are 7,700 acres within the Vail Ski Area permit boundary, all of which would be part of the expanded ski area permit. In addition to ski runs and lifts, there are rest areas, sanitation facilities, waste treatment plants, water transportation, treatment, and storage facilities, snow making lines, restaurants, access roads, power lines, and other improvements scattered throughout the permit area.

Current stand conditions are not good. Many stands are decadent, resulting from the impacts of insects, disease, age, and overstocking, and mortality is increasing. These conditions, together with the large acreage over which they occur, and the significant contributions trees make to the success of a ski area, made it clear that planning for active management of trees was necessary.

Private land owners and the Town of Vail reap some spin-off benefits by having healthy stands adjacent to their holdings. Land values and the ambiance of the community are enhanced by having healthy trees scattered throughout the municipal area, and these trees can contribute only as long as they are not affected by insects or disease from adjacent National Forest timber stands.

Concepts for Vegetation Management Planning

When faced with the need for in-depth, site specific planning, the land manager must have a reasonably complete picture of the final product, thus ensuring that all planning efforts are focused and productive. This picture may change or evolve as dictated by the results of the planning process, but the ultimate goal should remain fairly constant. In the design of the master development planning process for the Vail Ski Area, the study plan and end product for each technical specialist was proposed by Vail Associates, reviewed and modified as necessary, and approved by the Forest Service.

For the Forest Service silviculturist this process was relatively straightforward, for obvious reasons. There was a minimum of confusion over terminology; he was experienced in the required data collection, format, and storage; and there was minimal loss of time due to training needs. However, he found it necessary to shift his traditional job "mind set" from providing leadership and support for a timber management goal to one of providing technical input for operation and management of a ski area. This new role was that of a technical expert, comparable to a ski lift engineer, soils scientist, wildlife biologist, landscape architect, and many others required to create a complete and workable Master Development Plan.

A secondary feature of this concept, but one important to implementation, is that the Vegetation Management Plan and stand prescriptions must be written in non-technical language. This encourages the ski area Mountain Manager and District Ranger to make decisions for timber stand managment without feeling the need for further intensive participation by a silviculturist.

The Vegetation Management Planning Process

The "Vail Mountain Master Plan" submitted by Vail Associates sets the tone for the component Vegetation Management Plan. The seventh goal of the Master Plan is to "Preserve and enhance the environment as a key element of this Master Plan. Vegetation management, erosion control, prevention of geological problems, air, water, and visual quality are all areas of concern." Further on the Master Plan states "In addition to its winter operations Vail Associates conducts extensive summer maintenance programs to mitigate erosion and stream sedimentation problems and to manage the health of forested areas within Vail's permit area. This in turn contributes to the safety of the visitor while maintaining the health and beauty of the area's natural systems."

In response to these broadly stated goals, it was necessary to determine what value trees have for the Vail Ski Area. These "values" have little to do with the intrinsic value of the trees themselves, but rather the other benefits they provide as essential elements in the utility of the land base for downhill skiing. The primary values are:

1. Snow retention, or the snow fence effect.
2. Solar protection, or shading, to reduce icing and snow loss.
3. Visual quality, the vegetative diversity between ski runs and throughout the permit area.
4. Wind protection, the reduction of snow loss from scour.
5. Snow stability, or the anchoring of snow to prevent slides.
6. Traffic control, safety, and dispersal of skiers.

It is arguable that there are numerous other values provided by trees on a ski area. However, those were identified as secondary by the District Ranger and the ski area manager, and therefore were not given principal emphasis by the silviculturist in the development of the Vegetation Management Plan.

The silviculturist then began to identify ways to manage trees for these purposes. First, past activities on the ski area having effects on the natural vegetation were reviewed. Also reviewed were the terrain analyses done by ski area personnel to determine the location and extent of future development proposals. It was also necessary to understand the options and constraints of the Land and Resource Management Plan for the Forest, and all other management direction established to control and direct Forest land uses related to ski area development. Data collection was then begun, keeping in mind the identified values of tree stands and the purposes they serve. The data collection included a determination of the biological limitations of the species found relative to the sites on which they are found. Other physical and biological opportunities and constraints were also noted during data collection, including information on soil erosion (existing or potential), wildlife considerations, off-season recreation possibilities, and others.

From this wealth of information, the silviculturist wrote the initial timber stand prescriptions. These prescriptions include all options meeting the stated objectives for the management of trees on the ski area. They are designated as "initial" to make it clear that the prescriptions are not approved for implementation at this stage of their development. The prescriptions become final upon the land manager's choice among the options and any refinements he deems necessary. This is done at the time the ski area permittee (Vail Associates, Inc.) proposes to implement any part of the Vegetation Management Plan. The choice of the silvicultural option to be used is one of several decisions to be made by the District Ranger to maximize achievement of the overall goal of a winter sports land use. This decision is verified or validated by an on-the-ground review prior to implementing the treatment of the stand.

Implementation and Monitoring of the Vegetation Management Plan

The creation of master development plans and their component plans, such as vegetation management plans, is the primary responsibility of the proponent or permittee. The implementation of a Vegetation Management Plan is a cooperative responsibility and activity between the Forest Service and the permittee, directing the development and managment of timber stands to achieve the goals and objectives of both parties. This shared responsibility is implied by the terms and conditions of the special use permit, broad goals and objectives of the Forest Plan, and the partnership status of the Forest Service and permittee in this long term private capital investment in public land use. The establishment and maintenance of healthy trees is mutually beneficial by providing values specific to winter sports needs and by implementation of the Forest Plan.

To initiate the implementation process, the permittee includes sites to be considered for vegetation management as part of the summer operating plan and schedule. This is submitted to the Forest Service for review and approval. Procedures for achieving the treatment program can range from a pure capital investment by the permittee to conventional timber sale activities by the Forest Service, including use of KV monies when appropriate. The permittee and the Forest Service should cooperatively develop commitments for both parties which will provide for the accomplishment of the proposed and approved activities. When these commitments have been decided, they become a part of the summer operating plan.

Annual program monitoring is needed to assure compliance with the commitments described in the summer operating plan. This activity measures not only the units of activity committed to, but also assures compliance with the silviculture prescriptions and associated management decisions. An integral part of this monitoring is to maintain and/or update stand data records to reflect the changes in vegetation resulting from site development and use. The information relating to treatment activities and subsequent biological responses should be maintained in an appropriate Forest Service data base.

Many of the silviculture prescriptions require multiple entries in order to achieve the desired stand condition. The monitoring system should also provide for stand review and subsequent treatment scheduling, by stand, to assure long term compliance with the approved silviculture prescription.

Long term monitoring is needed to record vegetation responses resulting from the stand treatments applied and to determine if these activities achieve the objectives of the silviculture prescription and its intent to fulfill the overall goals of the Master Development Plan. Biological responses resulting from vegetation management activities and other activities related to site development and use may require adjustments to the Master Development Plan. Through an effective and well maintained monitoring system, the Forest Service and permittee are provided with the opportunity to make adjustments with minimum impact to the permittee's activities, and thus allow for increased achievement of Forest Service goals as set forth in the Forest Plan.

Summary and Conclusions

The concepts and processes for developing the Master Development Plan and its component Vegetation Management Plan must be driven by a predetermined decision for land use. To paraphrase the Cheshire Cat in "Alice in Wonderland", if we don't know where we're going, how can we tell if we ever get there? Making the land use decision and describing the desired result as completely as possible is a difficult and time-consuming task. Active participation is needed from everyone affected by the decision. This means that not only the Forest Service and the proponent must work together, but a whole host of local, state, and federal agencies, plus other individual and group concerns must be incorporated into the process. This is the heart of the "scoping process" required by the National Environmental Policy Act.

Vegetation management is one of the many tools available to the land manager in achieving long term goals. The concept extends far beyond producing raw material for the wood products industry. It's importance may vary from one decision to the next, but should never be overlooked.

The concept is also applicable to nearly all plant associations, not just timber types. By substituting a range conservationist or botanist for the silviculturist in the process previously described, the concept is immediately adapted to many other plant communities. Decision makers may also find it useful to meld all of these disciplines in the analysis and evaluation processes.

In the case of a vegetation management plan for a ski area, most of the timber stand characteristics desired for enhancement of skiing are identical to those desired for a healthy forest. However, achieving those characteristics on a ski area means adjusting traditional tactics designed primarily for timber production.

The vegetation management plan must be written in a clear, straightforward manner. Future land managers and their staffs may not have immediate access to a silviculturist for interpretation of complex, jargon-laden prescriptions. If permittees have a level of responsibility for implementation of the plan, they too must be able to understand and execute the prescriptions effectively.

The process described herein has been shown to be effective. No doubt there are many ways to improve it, limited only by the imagination and initiative of those who are looking for better ways to make decisions now and for future generations.

COORDINATION OF FOREST PEST ACTIONS ON FOREST LANDS
Allan J. West, Deputy Chief, State and Private Forestry
National Silviculture Workshop
Sacramento, California
May 14, 1987

I am pleased to be here this morning to spend a few minutes to discuss what I am trying to do in State and Private Forestry and especially with Forest Pest Management. My only regret is that I could not spend more time with you and learn more about the issues facing you as the national leaders in silviculture. Moreover, I would have appreciated participating in yesterday's field trip for a couple of reasons. First, it would have taken me back 30 years when I had several classes at Blodgett while I was at the University of California at Berkeley. Then, it has been almost 8 years since I left a field assignment on the Los Padres National Forest. People in positions like mine need to see first hand what is happening in the field.

Fortunately, I was recently in the field at the working level. Late last Saturday, I returned home after 2 weeks in Micronesia. I was looking at tropical forestry on several islands to get a better understanding of agroforestry. It is very obvious to me that the natives on those islands are very dependent on their own natural resources for subsistance living. It may be a different type of forestry than you have been discussing this week, but the basic principles of planning for and implementing a program to provide a continuous supply of quality forest products are essentially the same.

Well let's get to the reasons why I am here. I know some of you may ask, "Why would the Deputy Chief for State and Private Forestry come and talk to us? That's a part of the Forest Service separate from the National Forest System and our primary interest is in the National Forests."

When I was preparing my remarks, I was going to say that "our primary interest is in timber management on the National Forests." However, after looking at your agenda, I believe it's obvious you are not functionally oriented but are concerned about the total quality multiple use management of the Nation's forests. Many of our critics frequently accuse us of being concerned only about timber production. Your agenda for this meeting dispels this criticism and I applaud you for providing such a diversified workshop.

I still haven't told you why I wanted to talk to you in place of, say, Lamar Beasley, Deputy Chief for National Forest System. There are many reasons, and I hope to bring them out during my brief remarks this morning. You need to know I specifically asked to be on the program when I first learned about the workshop last fall.

The most important thought I want to share with you is that we are one Forest Service; just because we have three program areas, we are not three separate organizations. We must all work together and communicate thoroughly to accomplish our mission. Lamar and I completely agree on these points and will emphasize coordination between the two Deputy areas. In the Chief's office, the recent merger of Fire and Aviation Management with Cooperative Fire Protection under State and Private Forestry is an example of this coordination. Lamar and I want to emphasize coordination between other programs as well such as Timber Management and Forest Pest Management. I don't want to leave the impression that this hasn't happened, but I know coordination can be strengthened and improved in a number of areas such as budgeting, technology transfer, land management planning, etc., at all levels of the organization. I want to provide a positive climate to ensure this starts at the Chief's office and continues to the District level.

The second reason is that the public is more concerned today than ever before about the state of health of the Nation's forests. This has recently been demonstrated in the questioning by members of both the Senate and House Appropriations Committees. The oral questions were followed by many written questions and a request for a major report on gypsy moth in the East. In our responses, we came across as tackling one small part of the problem and as not being fully concerned about the state of health of the Nation's forests. That was not our intent, but our answers were interpreted that way. In fact, Senator Byrd, Chairman of the Appropriations Committee, said flatly that he wanted us to outline a program that would rid the Northeast of gypsy moth. He did not want to let the gypsy moth get established in West Virginia. Professionally, we all know the impossibility of accomplishing what he wants but as good bureaucrats we cannot ignore the request of the Chairman of our Appropriations Committee. We received similar signals from Senator Hatfield of Oregon regarding western spruce budworm and gypsy moth in one part of Oregon. We also heard from congressional delegations in Texas, Louisiana and Mississippi in regard to southern pine beetle.

We know that recent trends in environmental concerns and funding personnel are partially responsible for our responses to Congress and the general public. However, the mood we sense is that we need to express what we need, to do the professional land management job. People are concerned about forest health. Chief Robertson is committed to doing something about this issue and has personally directed me to begin preparing a program to meet this end. It will be a key item during the July RF&D meeting. I am pleased with the challenge, and hope you are too. The long-term solution will largely depend on your leadership and the results of your partnership with Forest Pest Management.

My vision, which I sincerely hope you share, is that forest pest impacts can best be mitigated through proper forest management. Prevention of serious forest pest-related damage should be our goal. The best insurance, as well as the least costly approach to pest management, is to reach and to maintain forest health through your prescriptions. You are the key players in this equation to better forest management; you have the expertise, the talent, responsibility and, I hope the desire to realize this vision. It will be through your efforts that stands are manipulated to achieve management objectives. Decisions reached under your guidance will, to a large degree determine whether stand entries and treatments create situations that lessen susceptibility, leave conditions unchanged, or increase susceptibility to forest pests. I believe it is imperative that we manage our forests to minimize the impacts of forest pests. We must make the right decisions long before epidemic populations limit our options. We simply must utilize the lead time we have to mitigate the potential impacts of future pest outbreaks, so we can create conditions which will lessen or even eliminate that next infestation.

Some of you have recently experienced outbreaks or are currently in the throes of an outbreak. Ask a certified silviculturist on the Targhee National Forest in eastern Idaho what a mountain pine beetle outbreak can do to lodgepole pine. Mountain pine beetle has recently or is currently significantly impacting the pine resource on the Bitterroot, Flathead, Helena, and Lolo National Forests in Region 1 and on several National Forests in Regions 4 and 6. In all, approximately 9 percent of the 39+ million acres of lodgepole and ponderosa host types in the United States is infested with mountain pine beetle.

In the last 5 years another bark beetle, the southern pine beetle, has caused even greater damage than the mountain pine beetle. The southern pine forests occupy 50 million acres and approximately 53 percent of that area is infested. Hardest hit have been Alabama, Texas, Mississippi, South Carolina, and Louisiana. In addition, populations are building on several National Forests. This is the second year of record levels of activity: over 83,000 beetle spots reported in 1986. Although population levels subsided in late 1986 and early 1987, the hot dry summers over the past 2 years could result in an intensified outbreak again this summer.

In FY 1987 we will spend $8 million to treat outbreaks of defoliators. In 1986, western spruce budworm caused visible defoliation on 13.2 million acres and gypsy moth defoliated 2.4 million acres. These two lepidopteran species are currently the most serious forest defoliators.

Funding appropriated for suppression of forest pests on Federal lands has been only about half of that requested. Suppression dollars available for cooperative projects on State and Private lands have been slightly more than needed in recent years. This extra amount has been reprogrammed for suppression projects on Federal lands. This year, approximately $2.3 million was reprogrammed from cooperative suppression to treat western spruce budworm in eastern Oregon. Silviculturists can play a key role in determining how suppression funds are allocated. As pest models are combined with growth and yield models, silviculturists will use these models to set priorities for treating outbreaks.

Now I want to cover some of those areas there you and the pest management specialists should maintain close working relationships. When is the last time you talked with your Forest Pest Management specialist? We don't have many Forest Pest Management specialists, but please consider them as a part of your staff. They are usually centrally located but available, generally on short notice when contacted in person, by phone, DG, or mail. Of course, I also expect Forest Pest Management specialists to initiate contact with you when appropriate. And I can assure you that I will share my message to you with all regional Forest Pest Management Staff Directors/Group Leaders.

Training is one of the first items that comes to mind when requesting help from Forest Pest Management. The sessions can be tailored to meet specific needs and may include such topics as pest identification, management considerations, modeling, hazard tree recognition, integrated pest management, and proper use and storage of pesticides. To fully utilize our Forest Pest Management specialists, it is essential they provide training on a systematic and continuous basis, and that you attend the training sessions. As you know, some Forest Pest Management training sessions count toward recertification.

To emphasize prevention and the healthy forest concept, we must make wise use of our available time before the next outbreak. This rationale requires excellent planning and literally affects every area in which Forest Pest Management may be involved. Let's use the types of vegetation management programs/projects you get involved in as examples of planning areas where Forest Pest Management specialists may be helpful. Assume you are looking at several stands in a particular drainage. An early consideration in this examination should be the relative susceptibility of those stands to the forest pests which could cause siginficant impacts. A system that rates risk or hazard to those stands from forest pests can serve as an excellent tool to use when setting treatment priorities. Risk rating is a tool you should not overlook whether you manage loblolly pine stands on the Kisatchie, lodgepole stands on the Gallatin, or mixed conifer stands on the Umatilla National Forest. Risk rating for many important pests has now progressed to the point that much can be done by computer even at the Forest or District level.

In project planning, it is preferable that you be adequately trained in pest management but still involve the Forest Pest Management specialist. That way, both stay informed and in communication. Visit some of those proposed treatment sites with the Forest Pest Management specialist to discuss specific site factors, pest conditions, and management options tailored to the site. Sometimes this situation lends itself to one-on-one discussions with the Forest Pest Management specialist; at other times additional staff should accompany you. Involvement of your Forest Pest Management specialist in interdisciplinary team discussions and field visits is an excellent means of technology transfer. This benefits both you and your pest management specialist, but perhaps even more important, it can be of considerable value to those individuals representing other disciplies who may have had little exposure to pest management. If you have not involved Forest Pest Management in your interdisciplinary team, I strongly recommend that you do so.

Another area of cooperation is the Incident Command System. This system is designed to handle emergencies like fires and floods. Fire staffs also have specialized crews that can help Forest Pest Management in suppression projects. Fire managers should also be concerned about the aftermath of pest outbreaks. At this year's National Fire Directors meeting, I told them I wanted them to be more involved with Forest Pest Management. Timber Management also has areas that overlap with Forest Pest Management. For example, both groups may be asked to make recommendations on Forest Plans relating to site preparation, rights-of-way treatment, aquatic pest control, and seed orchard and nursery management. These are additional examples of areas where we can work closely and thereby avoid duplication of effort while maintaining similar standards of management. I might say, however, I am disappointed in the lack of Forest Pest Management input in the majority of Forest Plans.

Some of you may not realize that your Forest Pest Management specialist provides expertise and services not only to Forest Service personnel but also to other Federal, State and corporate personnel as well as to private individuals. No staff in the Forest Service has a broader scope of responsibility for their discipline than Forest Pest Management. Your Forest Pest Management specialist may work with National Forest System personnel one day, National Park Service or military the next day, and State, corporate, or private individuals the following day. Excellent communication is required to keep your counterparts outside the Forest Service informed of your plans to control pests. Most pest infestations can only be successfully treated by a well-planned and coordinated effort involving most if not all landowners. Stand treatments prior to infestations can and often should involve adjacent landowners to offer projects of sufficient size and to help treat high risk stands. The pests will certainly cross ownership boundaries and effective treatment will require coordination on your part. Practicing good forest management will minimize pest impacts to the National Forests. Excellent communication and coordination of stand treatments with your counterparts outside the Forest Service will minimize pest impacts to other forested lands as well as the National Forests.

In closing, let me restate an earlier portion of the presentation:

My vision, which I sincerely hope you share, is that forest pest impacts can best be mitigated through proper forest management. Prevention of serious pest-caused damage should be our goal. The best insurance and least costly approach to pest management is to reach and maintain forest health through your prescriptions and resultant actions. You are the key players in this equation to better forest management; you have the expertise, the talent, responsibility, and, I hope, desire to realize this vision.

I can assure you that at the national level there will be improved communication and cooperation between Forest Pest Management and Timber Management and indeed expect such at all levels of our organization.

USING THE HP71B

FOR

STAND EXAMINATION

U.S.D.A. Forest Service

Southwestern Region

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STAND1
USER DOCUMENTATION

Instructions for
version 2.0

STAND1 is a self-prompting field data entry program for stand exams using the HP71B computer. The program has been designed to include as many data edits as possible to ensure data is clean and accurate at the time of data collection. The program will only ask for the information needed for each tree based on EXHIBIT 1 (page 22.21--2), FSH 2409.26d. When the data has been downloaded from the HP71B to the DG, the data should be ready for a final edit in the STAGE2 data entry program.

COMPONENTS

The field data entry program for stand exams consists of five parts:

1) STAND1 - the data entry program.

2) SPRNT - a program to use if a hard copy of the data is desired. This program is designed to print the data on a HP Think Jet printer (80 columns).

3) SCOM - a program to use to download the data from the HP71B to the DG. This is essentially the same program the cruise routine will use.

4) DIR - a program to keep track of programs and data files in memory and/or on tape. A wide printer is needed to run this program. It is not necessary to know how to run this program to use the other stand exam programs.

5) Data Files - the data entry program will automatically create a data file for data storage. The name will be composed of the letters 'STD' plus the 4 digit stand number.

MEMORY NEEDED

1) STAND1 - 15297 bytes

2) SPRNT - 936 bytes

3) SCOM - 4362 bytes

4) DIR - 557 bytes

5) Data Files - an average 6 point stand exam should take approximately 4000 to 5000 bytes.

To use the program in the field, only the programs STAND1 and SPRNT need to be present in memory. This gives a total requirement of 16233 bytes, leaving apporximately 15000 bytes of memory (on a 32K computer) for the data files. However, for data protection, it is recommended that at the end of each day all data files be copied to tape.

When the data is ready to be downloaded to the DG, STAND1 and SPRNT can be purged from memory and program SCOM loaded to memory from tape. Data files for downloading can either be located in memory or stored on tape.

LOADING THE PROGRAM TO THE HP71B

Attach the HP71B through the IL Interface cables to the HP Cassette Drive. Place the tape containing the stand exam programs into the cassette drive compartment. All programs and data files not needed should be purged from the HP71B's memory (backing to tape first if necessary). Type 'COPY STAND1:TAPE TO STAND1'. This will cause some movement on the cassette drive. Finally the cursor will appear again on the screen. Repeat this command for programs SPRNT and SCOM (if needed right away).

STORING DATA ON THE CASSETTE TAPE

If the tape is being used for the first time, type the command 'INITIALIZE :TAPE'. This command will erase any files from the tape and then format the tape for use. Do this ONLY if the tape is new or the data on the tape is no longer needed.

To copy data files from memory to tape, enter the command 'COPY STD0000 TO STD0000:TAPE', where 0000 would be replaced with the proper stand number. Again the cassette drive will move. When the cursor again appears on the screen the data has been stored on tape. The cassette tape can hold numerous stand data files at one time.

EXECUTING STAND1

To run the stand exam field data entry program, enter 'RUN STAND1' (type the word 'RUN', do not use the key labeled 'RUN'). Press the 'END LINE' key. The program will display the current version of the program. The first question it prompts for is if growth trees will be timber species or other species. Respond by entering either 'T' or 'O'.

The program has been set to accept only the legal codes or ranges as specified in FSH 2409.26d

The 'END LINE' key is pressed after each entry. The 'END LINE' key is also used to zero fill or blank fill when zero or blank are legal codes.

The program now proceeds to ask for the stand header information as shown on form R3-FS-2400-106. The program will ask for the following data items in the order given:

1) COMPARTMENT #

2) STAND # - at this point the program will automatically create the data file for storage. If the program finds that a file already exists with the given stand number, the program will ask the user if the data should be appended to the existing file or if a new file should be created. If the user specifies that the data should be appended, all the data entered will be added to the end of the existing data file and the program tells the user that the data will be appended to the existing file. If the user specifies that a new file should be created, the program will add an alpha character onto the end of the standard name so that a unique file name is created. The program will display to the user what this file name is for later reference.

When the file name exists and the user specifies that the new data should be appended to the end of the existing data file, the program will only ask for the forest number, BAF, and GP.

3) FOREST #

4) DISTRICT #

5) SURVEY DATE - The program has been set to get the date of survey from the system date. The user should make sure the system date is set correctly before executing the program. (See the HP71 Reference Manual for directions on setting the system date.)

6) ACRES

7) BAF

8) FPS

9) GP - if a GP of 99 is specified, the program will ask for tree positions for all trees. A code less than 99 will be the OVERSTORY/UNDERSTORY break for live trees and the program will only ask for tree position for DEAD/MORTALITY trees.

10) POINTS

After the header information has been entered, the program will then begin to ask for the POINT/TREE information. The program first displays the current point number. If this number is correct, enter an 'END LINE'; if the point number is incorrect, enter the proper number and an 'END LINE'. If all the points for the stand have been entered, type 'QQ' to terminate the program (see Final Remarks section).

The program has been developed so that the point numbers can be entered in any order. Also a point number can be repeated as often as required in case the user needs to revisit the point. If a point is revisited during the course of the exam, the user will need to move the data lines into proper order once the data has been downloaded to the DG.

The program will now ask for a tree number or a valid option. If more tree information is to be entered, enter a TREE NUMBER. The valid options available at this point include:

1) XX - end of tree information for the current point. The program then writes all the tree information for the point to the data file. The program continues by displaying the next point number in sequence. (Also see the Traveling Between Points section to see how XX puts the STAND1 program in suspension)

2) ? - display the last tree number entered. This can be used if the user has contacted a momentary case of amnesia and can't remember what the last tree number used was.

3) ED - edit the tree information for any tree for the current point. This allows the user to view and/or edit the entries for each tree on the point. Once the user has seen or changed the value in question, entering an 'X' will return the user to the tree number prompt. Entering 'ED' will prompt you for the TREE(XX=END) number. Enter the tree number you want to edit.

4) LD - obtain a limiting distance calculation. The program will continue by asking for the DBH/DRC, SLOPE PERCENT, and DISTANCE to the TREE FACE. The program then calculates the limiting distance, displays the calculated value, and shows whether the tree was in or out.

After the tree number has been entered, the program will continue by asking for the tree history and the remainder of the tree items. The program will ask for only the tree information required based on the tree history, species, and stem diameter entered. Leading zeros are not required as the program will fill the answer to obtain the proper data length. Again 'END LINE' will zero fill or blank fill any field where zero or blank is a legal code. 'END LINE' will blank fill the number of stems (item 9) and the VARGEN program will interpret the blank as one stem. Only legal codes as specified in FSH 2409.26d will be accepted. Anytime an invalid response is entered the program will
display what was entered along with the prompt 'INVALID' and will then display the question again.

SITE TREES

For site trees (tree history 99), the program will ask the user if the site tree is on or off the point. If the site tree is on the point, the program will ask for the tree number of the tally tree to use. The program will then copy all the tree information for this tree to the new tree number and only ask for information that was missing on the tally tree (ie., AGE). If the site tree is off point, the program will ask for all the information needed including azimuth and distance. In either case the program will record in the remarks column a reference as to whether the tree is on or off point.

Azimuth is recorded to the nearest degree; distance to the nearest chain.

GROWTH TREES

The HP71B has been programmed to ask the user after each tree if the tree will be used for a growth tree. If the user answers with a 'Y' the program will continue to ask the user for the tree age and growth information based on the tree diameter. The user can enter as many (or none) growth trees for each point as needed.

REMARKS

An option for entering remarks for each tree has been made available for the HP71B. However, the remarks are limited to 5 characters in length. The program will automatically record 'OFFPT' or 'TR#01' site tree information in the remarks column indication if the tree was off point or the tally tree number if on point.

For other trees, the remarks can be any combination of characters. Following is a suggested list of remarks:

1. ABD55 - abnormal DBH, height at which the diameter was taken was 5.5 feet.

2. EHT30 - estimated top length of a broken portion of a tree with a broken top.

3. EAGE - estimated age when the age is estimated.

4. OD58 - other damage, when a tree has more than one damaging agent.

5. SSCUT - seedlings and saplings cut to determine age.

6. SKROT - skipped growth tree because of rot.

7. EDIAM - estimated stem diameter on other tree species when difficult to measure.

Any other five character codes may be entered to fit the situation.

EDITING DATA

When the program displays the prompt 'TREE(XX=END) =', the user can either type in the next tree number or the letters 'ED' to execute an edit of the data for any tree on the current point. After entering 'ED', the program prompts for the tree number to edit. After entering the tree number, the program then displays each item descriptor and the current value for the item for that tree. If the item is correct, continue by entering an 'END LINE'. If the item is incorrect, type in the new value and an 'END LINE'. The value just entered will replace the previous value.

The edit routine will display all the items from form R3-FS-2400-106 for each tree starting at point number, even if no value was initially entered. Once the edit routine is called, the user must either enter an 'END LINE' for each item until the last item (REMKS) has been displayed, at which time the next 'END LINE' will end the edit routine and cause the prompt 'TREE(XX=END) =' to be redisplayed, or else enter the letter 'X' at any item prompt, which will again end the edit routine and cause the program to display the prompt for tree number.

FINAL REMARKS

The program allows for entering final remarks for the stand in order to document any changes made since the information was entered for the header card. After the user enters 'QQ' after the last point number, the program displays the prompt 'REFER CHANGES(Y/N)?'. If the user would like to make note of something about the stand, enter 'Y' and the program will continue by displaying a message stating that the user may enter as many lines of comments (each up to 80 characters long) as needed, with a NEW LINE after each line. To end the input, enter a NEW LINE. If the user wants to end the program, enter 'N' and the STAND1 program is ended.

If the user enters any comments, the comments must be removed from the end of the file before the data is run through the edit routine on the Data General.

TRAVELING BETWEEN POINTS

After all the trees have been entered for a point and 'XX' for the tree number has been entered to write the data to the data file, the program can be suspended and the computer turned off during travel to the next point. This will keep erroneous data from being entered into the computer during transit.

To put the computer in suspension, depress the gold 'f' key and the 'OFF' key. To resume the program, depress the 'ON' key and then the gold 'f' key and the 'CONT' key (the '+' key). The display will now show a '?' from the last prompt before the computer was turned off. This '?' is requesting the point number. Either enter an 'END LINE', the number of the new point, or a '?'. If the '?' is entered the program will redisplay the last prompt which will be the new point number.

NUMBER OF TREES ON A POINT

Only 25 trees may be entered on a point. If there are more than 25 trees on a point, end the point by entering 'XX' and 'END LINE' after data for the 25th tree has been recorded. The display will show 'PNT(QQ=END) = __?' displaying the next point number. Change the point number back by entering the point number for the point with more than 25 trees, then 'END LINE'. Continue entering the tree numbers 26, 27, 28, etc. until all tree data are entered for the point. Be sure you have completed the edit on the first 25 trees before moving since the first 25 trees cannot be edited after you move to the next **so called point**.

TERMINATION OF THE PROGRAM

After all the tree information for the last point in the stand has been entered, the data written to the data file, and any final comments added to the data file, the program will terminate. The display will now show the normal prompt ('>'). The computer is now ready to accept any HP command.

PRINT PROGRAM

Once all the tree information for the stand exam has been entered, and the field program terminated, the data file can be printed to an HP 80 column printer. Hook the HP71B to the HP THINK JET printer with the IL Interface cables. Enter 'RUN SPRNT'. This program then prompts the user for the data file name to print. Again, the stand exam data files are named with the letters 'STD' followed by the four digit stand number (followed by the unique alpha character if needed). The program will now print the data out on the printer.

DOWNLOADING DATA TO THE DG

To download the data files from the HP71B to the DG, the following procedure will be used:

1) Load the program 'SCOM' from tape to memory using the command 'COPY SCOM:TAPE TO SCOM'. (Any other programs in memory can be purged at this time if more memory is needed.)

2) If the data files are stored on tape, this tape should be inserted into the cassette drive at this time. (SCOM will download files located either in memory or on tape.)

3) Connect the HP71B to the RS-232 Interface and the cassette drive (if the data is stored on tape) with the IL Interface cables.

4) Type 'RUN SCOM' on the HP71B.

5) At the prompt 'DG(D) OR TELENET(T)', enter a D for Data General. Do not need to press 'END LINE'.

6) The program will now display various BAUD settings. Enter a '48' as the Data General is set up for 4800 BAUD. Press 'END LINE'.

7) The HP71B will now display the message 'READY TO TALK TO HOST'.

8) At this time sign on to the Data General and enter the necessary information to get down to the command line. At the command line enter 'CLI' (this will put you into IS-CLI).

9) At the 'IS-CLI)' prompt, enter the CLI command 'CHAR/CRT4' (this will ready the Data General for input from a terminal other than the standard DG terminal).

10) The Data General is now ready. Hook the HP71B RS-232 Interface to the DG either through a switch box (switch from A to B) or by disconnecting the RS-232 cable from the back of the DG terminal and connecting the cable to the HP71B RS-232 Interface.

11) On the HP71B, enter an 'END LINE'.

12) On the HP71B,the display should show the prompt 'IS-CLI)'. This is the DG command now coming over the HP71B. Enter the command 'CR/I FILENAME' where FILENAME will be the name of the file you wish to create on the Data General. After entering the 'END LINE' on the HP71B, the display should show the prompt 'IS-CLI))'.

13) At this time anything the HP71B sends will be stored in the file just created. On the HP71B depress the 'WHITE UP ARROW' key. The HP71B will respond with the question 'ALL FILES(Y/N)?'. If all the data files on tape are to be downloaded to the DG, enter 'Y'. If you wish to download only one file either in memory or on tape enter 'N'. If 'Y' was entered the HP71B will start downloading all the files beginning with the letters 'STD' from tape. If 'N' was entered, the HP71B will ask for the name of the file to download (enter ':TAPE' after the FILENAME if you want to download from the tape). In either case during the downloading the HP71B will display the line number being send. More than one set of files can be sent by depressing the 'WHITE UP ARROW' key again at the 'FILE SEND' prompt.

14) After the file or files have been send, the HP71B will display 'FILE SEND'. On the HP71B enter a 'END LINE'. On the HP71B display the prompt 'IS-CLI))' will again appear. On the HP71B enter a ')'. Press 'END LINE'. This will end the input of data into the file named on the Data General.

15) At this time all the data has been downloaded from the HP71B to the Data General. The switch box can now be set back for the Data General terminal or else disconnect the DG cable from the HP71B RS-232 Interface and connect it to the DG terminal.

16) On the DG enter the command 'CHAR/6130'.

17) The data file on the Data General is now ready to be edited.
You may want to first SED the data file and remove the blank line at the end of the file that the HP71B adds. Also if any references were added to the end of the data on the HP71B, these should also be deleted. After this the Stage2 Data Entry program can be executed on the DG and the data edited.

Exhibit 1

Tree Tally Guide

TREE OR COVER CLASS	TREE IDENTIF.				TREE MEASUREMENT						TREE CLASSIFICATION						OTHER				
	1	2	5	6	7	8	9	10	11	12	14	15	16	17	18	19	20	21	22	23	
	POINT NUMBER	TREE NUMBER	TREE HISTORY	SPECIES	DBH/DRC	TOTAL HEIGHT	NUMBER STEMS	HEIGHT GROWTH	RADIAL GROWTH	TREE AGE	INJURY DEFECT	TOTAL DEFECT	CROWN RATIO	CROWN CLASS	DAMAGE/DEATH	COVER CLASS	TREE POSITION	MISTLETOE	SNAG BARK	SITE TREE CLASS	REMARKS
TIMBER SPECIES																					
1. 5.0"+ DBH																					
Live	S	X	01	X	X	X			G	G	X	X	X	X	X		X	S			S
Dead, Mortality	S	X	05	X	X	X					X	X			X		X		S		S
Dead, Salvable	S	X	08	X	X	X					X	X					X		S		S
Dead, Nonsound	S	X	06	X	X	X											X		S		S
2. LT 5.0" DBH																					
Live	S	X	01	X	X	X	X	G	G	G	X	X	X	X	X		X	S			S
OTHER SPECIES																					
3. 3.0"+ DRC																					
Live	S	X	01	X	X	X	X		G	G	X	X	X	X	X		X	S			S
Dead, Mortality	S	X	05	X	X	X	X				X	X			X		X		S		S
Dead, Salvable	S	X	08	X	X	X	X				X	X					X		S		S
Dead, Nonsound	S	X	06	X	X	X	X										X		S		S
4. LT 3.0" DRC																					
Live	S	X	01	X	X	X	X	G	G	G	X	X	X	X	X		X	S			S
5. COVER CLASS	X	X	00													X					
6. SITE TREE	S	X	99	X	X	X				X	X	X	X	X	X			S		X	X

Items to be coded on the Forest/Stand Tree Record Sheet, Form R3-FS-2400-106, are specified in this chart.

The "X" indicates that information for the item shall always be determined and recorded.

The "S" indicates that information for the item shall sometimes not be determined and recorded according to specifications.

The "G" indicates that information shall always be determined and recorded for growth trees according to specifications.

A code number indicates specific codes which shall always be entered for a certain type of tree. For example, the tree history code for a Mortality Tree shall always be entered as 05. Azimuth, Distance, Available, and Ongrowth columns are not shown on this chart.

USDA FOREST SERVICE

FOREST / STAND TREE RECORD SHEET

—Stage I/II—

(Ref: R3 FSH 2409.26d)

PLACE NAME ______													PAGE ____ OF ____											DO NOT PUNCH
COMPARTMENT ______ 1-6						STAND ____ 7-10				FOREST __ 11-12			CARD TYPE 9/13											PUNCH FOR EACH TREE 1–13
DISTRICT __ 65-66			SURVEY DATE ____ 67-70				ACRES ___ 71-73			BAF __ 74-75		FPS _ 76		GP __ 77-78					PTS __ 79-80					PUNCH FOR FIRST TREE 65–80
TREE IDENTICATION						TREE MEASUREMENTS						TREE CLASSIFICATION							OTHER					REMARKS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
POINT NUMBER	TREE NUMBER	AZIMUTH	DISTANCE	TREE HISTORY	SPECIES	DBH/DRC	TOTAL HEIGHT	NUMBER STEMS	HEIGHT GROWTH	RADIAL GROWTH	TREE AGE	AVAILABLE	INTERNAL DEFECT	TOTAL DEFECT	CROWN RATIO	CROWN CLASS	DAMAGE/DEATH	COVER CLASS	TREE POSITION	MISTLETOE	SNAG-%BARK	SITE TREE CLASS	ONGROWTH	
XXX	XX	XXX	XX	XX	XXX	XXX	XXX	XX	XXX	XX	XXX	XX	X	X	X	X	XX	XX	X	X	X	X	X	PUNCH (14-59)
14-16	17-18	19-21	22-23	24-25	26-28	29-31	32-34	35-36	37-39	40-41	42-44	45-46	47	48	49	50	51-52	53-54	55	56	57	58	59	

MAKING SILVICULTURE EXPERTISE AVAILABLE

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Abstract -- Forested lands allocated to resources other than timber management or mixtures of which timber management is only one of the goals still must have treatments designed to be biologically sound and capable of meeting the land management objectives.

With reduced budgets and the resulting changes in organizations, generally fewer silviculturist positions, how do we ensure the silvicultural expertise is available to prescribe for and manage stands that have a variety of resource objectives?

Region 1 has initiated the utilization of "Expert System" technology to "capture" and "make available" silviculture expertise. A brief introduction to the technology is given and a review of current uses in natural resource management is covered. The action taken by Region 1 in the development of an Expert System for a portion of the silvicultural prescription process is presented.

In designing and implementing vegetative treatments to meet a variety of management objectives, a common element needed is silvicultural expertise -- silvicultural expertise applied to site specific problems. Regardless of what the management objectives are, our treatments will always have to be ecologically sound, technically correct, defensible, and visibly successful under public scrutiny.

Having silvicultural expertise available to be applied is being accomplished in a variety of ways, but most commonly through people. We have captured and packaged this expertise in silviculturists. This knowledge, available from the cumulation of research and from years of observation and experience, has been brought together in certified silviculturists. Most of our capturing and packaging has been through continuing education programs such as CEFES, TREES, Silviculture Institute and others.

In addition to these continuing education programs, other traditional means have been guidelines, handbooks, policy, etc. What is needed is something more than just making the knowledge available. We have to make sure it is used in a fashion that is consistent and repeatable. Relying upon people as our primary source of expertise and the means to make it available may not always be viable. Many of us are experiencing changes in our organizations; reductions in positions and positions assuming more responsibilities. We have often gone from the district silviculturist who had prescription development and coordination of all silvicultural activities as his/her sole responsibility to positions where prescription development is only a portion of his/her total responsibilities.

There is a relatively new technology that has considerable promise in helping us meet the need of maintaining silvicultural expertise within changing organizations. This is a technology we believe has application within the silvicultural prescription process.

The technology is referred to as expert systems or knowledge systems, a subarea of Artificial Intelligence (AI). Definitions of AI can vary significantly, covering two major extremes that range from: the study of how to make computer do things that people can currently do better, to the study of mental facilities through the use of computers (Charniak and McDermott, 1985). The first really represents not worrying about exactly how the computers do it. The second focuses on the process, how to duplicate human mental processes. Artificial intelligence covers a number of areas: natural language comprehension, both written and spoken; machine learning; vision; game playing; theorem proving; intelligent tutoring systems; cognitive psychology; robotics; and expert systems.

Expert systems is the one area which has had commerical success. Systems have changed from being only within the University environment in the 1960's and early 1970's, to actual working sytems in the mid 1970's and early 1980's. Within the last 2 years, there has been a significant increase of the systems within the business world.

Examples of application of this technology has been made in medical diagnosis systems, a geological site evaluation system for locating ore deposits, systems for helping to configure computer systems and a system for helping oil rig supervisors solve problems. Applications have only begun to be made for the area of natural resource management.

As with AI, one can also find many different definitions of expert systems. What one person considers an expert system may not qualify as one to other people. In the rush to "capture the market", many products are being produced that claim to utilize AI technology.

The following is a general definition for expert systems taken from W. L. Mills, professor of forest management at Purdue University:

"In general they are computer programs capable of solving problems in a narrow-well-defined knowledge domain using artificial intelligence techniques to store and retrieve knowledge which is composed of both data and relationship among data."

To get more specific a number of common features can be used as defining dimensions for expert systems (Hayes-Roth, et al., 1983). These dimensions should be thought of as continuums along which systems can vary continuously.

Expertise:

An expert system should attain the high level of performance that a human expert achieves in some task. This means producing high quality results in minimal time.

Symbol manipulation:

An expert system should use symbolic, representational reasoning and have symbolic representation of the information in its domain of concern. Its important to be able distinguish work on expert systems from simple high-quality special-purpose programming.

General Problem-solving ability:

An expert system has to have knowledge that supports inferential procedures. Having all of the knowledge in the world is worthless if one cannot apply it effectively.

Complexity and difficulty:

Problems have to be complicated enough to require an expert. Some people working within the field believe that certain domains do not qualify as potential arenas for expertise because they are somehow not complex enough.

Reformulation:

An expert system must be able to take a problem stated in some initial form and convert it into the form appropiate for processing by expert rules.

Abilities requiring reasoning about self:

Expert systems need the ability to rationalize about their own decisions. This is usually associated with some form of tracing of the rules fired; this is about as close to real explanation that today's system can come.

Task:

The final defining dimension is the generic task that the system is built to do. The type of task influences the architecture. Expert systems will be specific to a single domain. Tasks are defined in terms of interpretation, diagnosis, monitoring, prediction, instruction, planning and design.

The distinicton between an expert system and a knowledge system is generally whether one thinks the system captures the knowledge of an "expert."

For us to be able to utilize expert systems in our areas of resource management it is important we have some exposure to basic concepts that are fundamental to the technology. Just being able to follow instructions for a given software package is not sufficient. Harmon and King, 1985, provide an excellent source for an initial exposure to expert systems.

Significant attributes of expert systems include a knowledge base and an inference engine. The knowledge base is the aggregate of the AI techniques for storing "knowledge." The inference engine is the AI techniques used to make inferences with the knowledge. The fact that they are separate is important. It makes possible easy changing of the knowledge base.

Artificial Intelligence techniques for storing and capturing knowledge are sematic nets, object-attribute-values, frames, and rules (Harmon and King, 1985). Semantic networks are the most general representational scheme. They consist of a collection of "nodes" connected by "links." Nodes can be object or events. Links are often relationships between nodes. Object-attribute-value triplets are a specialized case of the semantic network in which the links are only two types of relationships; "has a" and "is a." Frames are also a specialized case of semantic networks. A frame consists of a collection of "slots", values, that describe an object. There are no restrictions on the types of relationships that links can represent and the slots can include additional features such as pointers to other frames, or rules and procedures. Rules are the most commonly used technique of representation. They consist of a number of premises, "if clauses", connected by "and" and "or," and conclusions in a "then clause."

The inference engine is that portion of the expert system that contains the strategies to draw inferences and control the reasoning process. Drawing inferences involves rules of logic and means to handle uncertainty. The control of the reasoning process addressed how to start. Rules and facts reside in a static knowledge base. There must be a way for the reasoning process to begin. When alternative lines of reasoning emerge, means for resolution of the conflict must exist. The most common strategies for control of the reasoning are search techniques: backward and forward chaining. Backward chaining is considered goal-directed. Forward chaining is considered data-driven. With both chaining techniques two methods of execution must be addressed: depth-first and breath-first. In depth-first, searching for detail is made first. With breath-first, sweeps across all premises in a rule are made before digging for greater detail.

These techniques in terms of knowledge representation and inference account for significant differences from conventional programming. The previous features listed as identifying dimensions included "symbol manipulation." This is commonly accomplished through using a symbolic language such as Lisp or Prolog. A comparison of the type of programming with symbolic languages done for expert systems to conventional programming is:

conventional programming	symbolic programming
algorithms	heuristics
numerically addressed data base	symbolically structured knowledge base
oriented toward numerical processing	oriented toward symbolic processing
sequential, batch processing	highly interactive processing
mid-run explantation impossible	mid-run explanation easy

The application of these AI techniques can be accomplished by a variety of "tools." The selection of a "tool" is a very important step. Having some understanding of what is meant by AI techniques is essential in making a selection of a tool to use. These tools exist in a gradient that ranges from programming in symbolic languages to the use of commerical "shells." With the languages one essentially has to program all of the AI techniques. With a shell one simply uses what techniques have been preprogrammed. Within this gradient of tools, at the end with shells, one loses flexibility in techniques. At the other extreme with symbolic languages, a great deal of expertise in the technology is required. For our proposed application, we are trying to acquire what is called a "hybrid" tool. It contains the capability to function with a progammed "shell," but also has the flexibility to utilize programming with Lisp.

Our silvicultural prescription process in which we plan on using this technology can be described as consisting of three distinct steps: the collection of stand data; the comparison of the existing stand to the target stand, which is the diagnosis of treatment needs; and the development of the detailed prescription. The entire process may take a relatively short time or it may extend over a period of years from the time stand examinations are made to time final prescriptions are written.

The portion of our process that we are developing an expert system for is the diagnosis step. The decision to apply this technology to this particular step can be reflected in "clues" (Harmon and King, 1985) that can be used in helping identify places where expert systems can be utilized:

- tasks that are performed by a few individuals. These individuals spend a substantial amount of their time on this task.

-task requires an analysis of a complex set of conditions and the typical performer may often forget to consider everything.

-there can be a large discrepancy between the best and worst performer.

The diagnosis step not only accounts for the greatest amount of time for a silviculturist in the process, but also represents that portion with the greatest impact as a result of wrong decisions. Our greatest impacts usually do not come from the detail involved in implementation of the final prescriptions, but from the choice of the wrong basic treatment needs: to clearcut when it should be a shelterwood, to try to commercially thin when the initial stocking cannot support a thinning, or to accept existing understories when we should regenerate.

By having the option of using an expert system for the diagnosis step, probably 80 percent of the stands needing diagnosis could be delegated by the silviculturist. This would ensure the silviculturist would have the time to do the diagnosis on the stands that represent unique situations that may not be adequately handled by an expert system. In addition to using the system in a demand mode for individual stands, the expert system would allow "batch" processing for the diagnosis of treatment needs for a number of stands as is needed when doing area analysis.

The diagnosis portion of the prescription process when handled by an expert system would not function as a conventional program designed to produce the correct answer every time. It would behave like an expert, usually producing correct answers, but sometimes producing incorrect ones. However, it would insure consistency in the treatment needs identified for similar combinations of stand, site, and management objectives.

It would not display bad judgement; jump to conclusions and then seek to maintain those conclusions even in light of conflicting evidence; nor would it have bad days.

We have evaluated a range of "tools," and built a prototype of an expert system for the diagnosis step. Currently we have been working with our Management System people and the Washington Office to obtain software that can be used to construct the total system-- a system that can be implemented in a Data General environment.

Our prototype was developed on micros using a software package INSIGHT 2+. Further work with this software is not planned because it does not offer flexibility in terms of knowledge representation other than rules and implementation is limited to micros.

Some features of our prototype have been very useful in communicating how this technology can be utilized with our diagnosis step of the prescription process. Figure 1 displays a simple logic diagram developed for a single-story, even-aged stand. This logic was captured in terms of rules within our prototype. Figure 2 shows a given rule that covers the shaded portion of the logic chart. Rule #35 contains a premise concerning condition. The knowledge used to satisfy that premise can be found in another rule, rule #424, Figure #3. This determination of "condition" is very simple. It is tied to live crown ratio. It can later be made as complex as desired by involving items such as growth rates, insect and disease indicators. Another premise dealing with acceptable species ties to rules #405 and 406, Figure #4.

We have used the rules concluding whether species are acceptable or not to display how knowledge of a variety of types can be captured. Both the Northern Regional Guide and handbook material stress the use of seral species to develop and maintain stands that are least affected by insects, disease, fire and wind damage. This is especially true for areas allocated to an objective of maximum timber production. For the specified habitat type, information from Forest Habitat Types of North Idaho identified which species occur in seral roles. The Forest Plan for the Clearwater Forest identifies management intensity of high to include commercial thinnings. Information from stand attributes can identify whether the slope is less than or greater than 35 percent. Slope percent generally determines harvest methods for the commercial thinnings. Applying some knowledge from local experience, we know that on ground over 35 percent we would utilize cable systems for the thinning. Our experience has been that the stand will experience some damage to the residual trees. Grand fir cannot tolerate damage from cable systems used in a thinning operation. Thus, our choice of acceptable species drops from three to two if slope is over 35 percent and all other factors are the same.

Other features such as assigning variable confidence values to the rules, mid-run explanations, and tracing the decision logic are difficult to display without having an actual demonstration of the prototype.

To summarize, a comparison between human expertise and artifical expertise is useful:

Human expertise	Artifical expertise
perishable	permanent
difficult to transfer	easy to transfer
difficult to document	easy to document
unpredictable	consistent
expensive	affordable

Expert System technology is a unique opportunity to accommodate in one interactive system:

laws, policies, regulations

research finding

regional guidelines

experience and local knowledge

Expert systems provide an opportunity to make silvicultural expertise available in a climate of reduced organizations and make expertise available to ensure that our treatments for the variety of resource objectives are ecologically sound, technically correct, defensible and successful.

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ASPENEX: AN EXPERT SYSTEM INTERFACE TO A GEOGRAPHIC INFORMATION SYSTEM FOR ASPEN MANAGEMENT

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BIOGRAPHICAL SKETCH

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ABSTRACT

ASPENEX is a software package developed to demonstrate the potential of an expert system to integrate new computer technologies for streamlining decisionmaking processes in various areas of forest resource management. A user friendly shell on a microcomputer integrates several advanced technology tools including; geographic information system and communication software to assist resource managers on the Nicolet National Forest, Wisconsin, with aspen management. ASPENEX offers the natural resource community the first useable link between a micro based expert system and the Data General; thus offering the user the power of a minicomputer and the advantages of a microcomputer.

INTRODUCTION

Intelligent decisions concerning management of national forests require expertise from several disciplines. Much of the information used by forest management experts is spatial in nature (e.g., tree stand size, proximity of stands to roads, slope, and underlying soil type). A geographic information system (GIS), facilitates analysis of spatial data. To take advantage of the spatial analysis capabilities that a GIS offers, GIS-derived information must be effectively integrated with forest management expertise. Obtaining and interpreting spatial information requires skill in manipulating and extracting information from a GIS, a skill possessed by few forest management experts.

Introduction and use of automated information systems has also had a major impact on natural resource management. Today, more and more resource managers are being assisted in their decisionmaking process by database management systems (DBMS) which handle textual and numeric data, GIS which handles spatial data, and simulation models which provide predictions. More recently, expert systems have emerged as another tool for offering solutions to complex problems by mimicking human reasoning processes (heuristics) and employing a knowledge base of information extracted from domain experts.

Analysis of text/numeric/spatial data is routinely and traditionally accomplished through the interaction of experts familiar with the resource management decision at hand. The introduction and use of expert system technologies not only automates the storage and manipulation of knowledge, or expertise, it also permits integration of the analysis of text/numeric/spatial data using the expertise embedded in the expert system (Burrogh 1986).

One disadvantage of employing new high technology tools (such as DBMS, GIS, and simulation models) is lack of true integration. As a result, some of the potential advantages of these technologies, such as speed and comprehensiveness in decisionmaking, may be lost.

This paper describes ASPENEX, a system that links an expert system residing in a microcomputer with a GIS (Map Overlay and Statistical System, MOSS) on a Data General minicomputer. EXSYS[1/] the microcomputer or PC-based expert system shell was used to build the program that interfaces with the GIS via a commercial communications software package (XTALK) and to supervise the system's reasoning process. ASPENEX thus employs an expert system to provide easy access to the GIS by both trained and non-proficient users.

The type of activities resource managers undertake in managing a specific species of trees can be illustrated by the aspen management program on the Nicolet National Forest, located in northern Wisconsin. This program provided the rational for interfacing a PC-based expert system to a DG-based GIS to obtain insights into aspen management activities and to assess the feasibility and usefulness of the ASPENEX approach.

[1/] Mention of commercial products is for convenience only and should not be considered an endorsement by USDA Forest Service.

Management of the Nicolet National Forest's aspen resources is important to resource managers because of aspen's susceptibility to white trunk rot (Phellinus tremulae) (Basham 1985) and its high value for timber production and for wildlife (deer and grouse) habitat (Perala 1977). Resource experts from various disciplines (e.g., silviculturists, soil scientists, pest management specialists, and wildlife biologists) all contribute their knowledge toward decisions as to whether to manage an aspen stand for timber, wildlife, or even to manage it at all. Traditionally, these professionals evaluate the site characteristics of an aspen stand and recommend a particular management action based on their intimate knowledge of the relationship between site characteristics and subsequent stand production in conjunction with their knowledge of numerous factors external to the aspen stands (e.g., economics, forest plan direction, and harvest quotas).

Most aspen management decisions on the Nicolet National Forest are based on spatial data obtained with conventional analytical techniques using the public domain GIS, MOSS, currently operating on the Nicolet National Forest (Anonymous 1984). However, access to this spatial data requires proficiency with GIS or assistance. Resource managers use the maps and related analytical data in decisionmaking. Management of aspen resources at other locations would require the same level of access to data and help with the decisionmaking process via expert involvement.

ASPENEX COMPONENTS

ASPENEX is a prototype system that automates analysis of aspen stand site characteristics by integrating a knowledge base developed from resource managers housed in an expert system with the analytical capabilities of a GIS. The expert system provides the rules required to manage aspen, while the GIS provides spatial information relative to the aspen stand. ASPENEX was designed so that the spatial site characteristics are automatically passed to the expert system where data are analyzed using a rule base created from domain experts. ASPENEX consists of four major software components: GIS, the expert system, the control program, and communications.

Geographic Information System (GIS)

In 1982, the public domain GIS known as MOSS was installed on the Nicolet National Forest's Data General (DG) computer. Since then, over 20 different themes of spatial information have been digitized for spatial analysis using MOSS. These themes comprise the spatial information required for day-to-day management and long-term forest planning. Some of the themes in the MOSS database are timber stand maps, soil types, transportation, hydrology, wildlife and pest information, and land ownership. Currently MOSS is being used on the Nicolet National Forest to assist in pest management, grouse habitat identification, and forest planning (Anonymous 1984).

ASPENEX uses both the database features (digital and spatial) and the spatial analysis capabilities offered by MOSS. Map features can be selected based on specific search criteria provided by the expert system. Analyses can be performed on these features using specific MOSS functions such as area calculations and proximity determinations. For example, MOSS can identify all mature aspen stands larger than 40 acres growing on good soil, yet within half a mile of a road.

Expert System

The expert system of ASPENEX was developed using an expert system shell known as EXSYS. EXSYS operates on most microcomputers and requires minimal training to program (EXSYS 1985). ASPENEX employs EXSYS interprogram communication capability, whereby results from MOSS analysis are passed back to EXSYS where they are evaluated by the rule base. EXSYS then allows the system to build and store ASCII data files containing the results of a particular run. These files can be further scrutinized with other data analysis packages such as a spreadsheet or a statistical package.

Communication

The hardware/software configuration placed the GIS functions and related spatial data on the DG and the expert system on a microcomputer. For ASPENEX to transfer data between MOSS and EXSYS, communication software was developed using XTALK, a commercial communication package. The communication software handled all intermachine transfer of data as well as initiation of program execution on the different computers. Eventually we hope to conduct all communications using public domain software (Autometric, Inc. 1986).

Control Program

The execution and control of the various components of ASPENEX are orchestrated by a control program running on the microcomputer. This program performs a number of different functions to assure proper operation of ASPENEX. These functions include:

User Interface - Prompts the user for the geographic area (7.5 minute USGS quadrangle) of interest.

Formatting of Data - Formats data into a standard exchange format for use in MOSS and EXSYS.

Execution of ASPENEX Components - Provides the proper sequencing of ASPENEX operations (Figure 1).

Error Checking - Prohibits operations using faulty or illogical information.

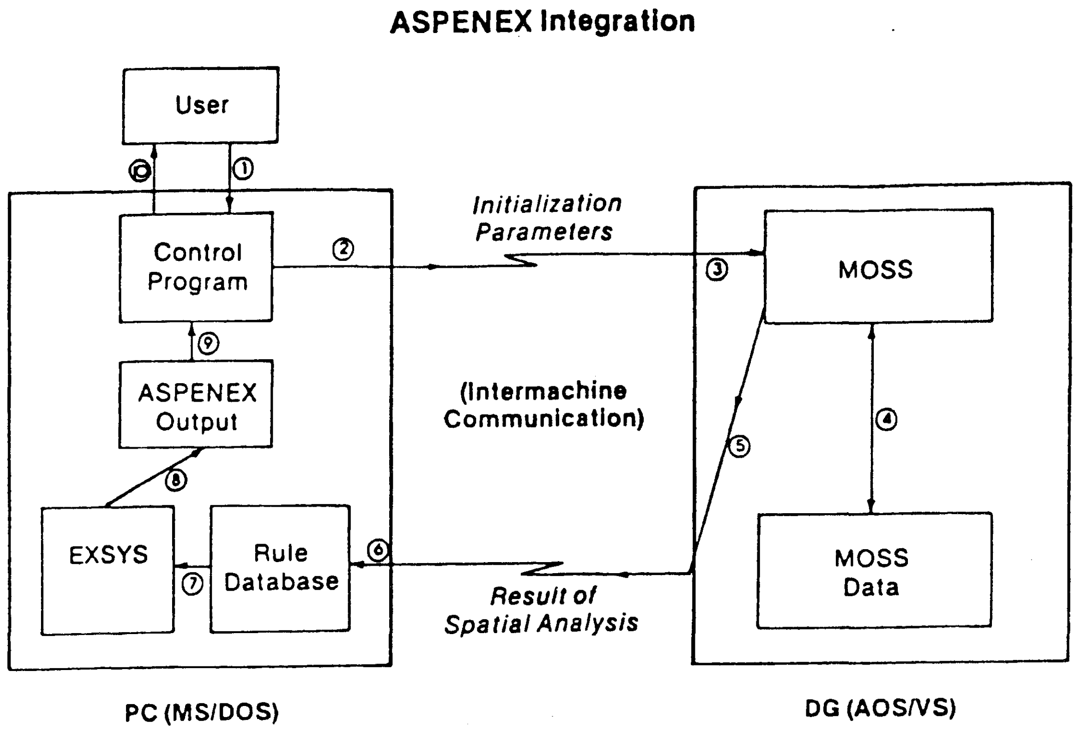

Figure 1. Operation and integration of ASPENEX. The hardware used by ASPENEX is a personal computer running the MS/DOS operating system and a Data General running the AOS/VS operating system. The user activates ASPENEX from the PC while communication software transfers necessary information between the computers. The numbers in circles indicate the sequence of ASPENEX operations.

ASPENEX OPERATION

ASPENEX Integration

A conceptual model of the overall operation of ASPENEX is shown in Figure 1. The user interface or control program, intermachine communication program, expert system functions and ASPENEX rule base reside on the personal computer. MOSS analysis programs and database are resident on the Data General minicomputer. The user activates ASPENEX by executing the control program on the personal computer. The control program, in turn, prompts the user for the geographic area to be analyzed. The user responds by typing in the name or menu number of the quad sheet of interest. The control program uses this information to set up a file to be used by the communication program. It then logs onto the DG and checks whether the necessary MOSS maps for the specified area are available from the geographic information system database. If maps are available, MOSS functions are executed and results are transferred back to the PC-computer. Once the result data file is received by the PC-computer, the control program logs itself off the DG. It then reformats the MOSS derived data file for entry into EXSYS where the rules are fired against these data. Results from EXSYS analysis are written to a file for printing or subsequent analysis.

Rule Base Creation

The final recommendation for aspen management can be one of three actions: (1) manage the stand for wildlife; (2) manage the stand for timber; or (3) do not manage the stand at all. Choice of the appropriate action depends on site characteristic information for the tree stand in question, as well as that of nearby stands. Typically, site characteristics include information on stand age, density, stand size, species type, underlying soil, distance to access roads, and spatial distribution of related stands. Management action for a stand is evaluated individually, based on the stand's site characteristics.

The rules determining the appropriate management action for a given stand are derived by assigning scores for each management action in relation to values for each site characteristic or variable. Scores for each management action range from 0 to 100. The functional relationship between site characteristic and management action is a quantitative representation of knowledge found in published sources (Basham 1958; Graklandoff 1985; Perala 1977; Shields and Bockheim 1981; Walters 1982) and from interviews with aspen experts. The final score for a recommended management action is the average of scores for all site characteristics.

Spatial Analysis

ASPENEX determines site characteristics through the execution of MOSS functions, using the Nicolet National Forest spatial database. Information pertaining to stand type, stand size, soil type, and distance to roads were all necessary before recommending a management action.

Table 1. Example of report generated by ASPENEX.

Stand ID[a]	Area	Soil Code	Proximity to Road
02219016913	35.35	2	No
02221003913	24.75	2	Yes
02220002122	121.44	5	Yes

	Possibility for Management[b]		
Stand ID[a]	Timber	Wildlife	No Management
02219016913	64	82	35
02221003913	71	73	21
02220002122	64	57	30

[a] Stand ID contains, within the 11 digits, information on tree species, size class, and density.
[b] "Possibility for Management" values calculated by expert system using spatial information provided by geographic information system.

ASPENEX Output

Final output from ASPENEX is a report summarizing stand characteristics derived from MOSS and a final composite score calculated by EXSYS using the stand information (Table 1). Three scores between 0 and 100 are associated with each stand. These scores correspond to the management action: timber production, wildlife habitat, or no management. The type of management favored is based on the highest score from EXSYS. The composite score is calculated using the average of all individual values when the rules are found to be true. ASPENEX is sufficiently flexible to sort the composite scores in any manner desired. The report can be further evaluated and summarized in a database management system statistical package. The data can also be transferred back into MOSS for creation of a map to locate and identify those stands recommended for a particular management action.

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DISCUSSION

ASPENEX offers significant advantages to resource managers several of which can be directly ascribed to expert systems in general. For example, users will not need extensive training, consequently, domain experts will be freed from conducting repetitive types of analyses. In addition, administrative units utilizing ASPENEX will be able to achieve resident domain expert knowledge.

The real significant contribution to the resource managers in the Forest Service is the dynamic link between the PC-based expert system and the DG minicomputer. This configuration offers the user the power of a minicomputer and the advantages of a microcomputer. Thus, ASPENEX allows resource managers an opportunity to compare a more significant number of aspen management options than by previous methods while realizing manpower and dollar savings. In addition, a majority of the computing process is executed in the dedicated environment of the microcomputer, thus freeing users from the frustrations of competing with CEO operations on the DG which take priority over any application programs.

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UNEVEN-AGED MANAGEMENT ON THE DESCHUTES NATIONAL FOREST

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ABSTRACT. During 1986 the Deschutes National Forest issued a draft Forest Plan and requested public comment. Sixty percent of the public who responded by letter opposed the practice of clearcutting as endorsed by the plan. As a result, the Forest chose to analyze the implications of uneven-aged management on timber yield and economic return. This analysis required development of uneven-aged yield tables which described the flow of timber yields during the 150 year planning horizon. The Prognosis growth and yield model was used to develop these yield tables. This exercise using actual stand data represented a new and untested application of Prognosis. After calibration and testing, the model performed satisfactorily and produced uneven-aged yield tables which were incorporated into the Forplan model. When constrained to use these yield tables on 153,000 acres of ponderosa pine and mixed conifer, the long run sustained yield and the present net value of the Forest dropped by four percent. This reduction was deemed acceptable by the Forest Management Team. As a result of this analysis, uneven-aged management will be strongly considered as a part of the management strategy in the final Forest Plan.

THE PUBLIC ISSUE

The Draft Forest Plan for the Deschutes National Forest was issued early in 1986. Over 1640 letters were received in reaction to the proposed plan. Of those responding, more than 60 percent expressed strong opposition to clearcutting. Few, if any comments were received in support of current timber harvest activities or those proposed in the Draft Plan. Activities on the Forest had focused largely on even-aged management. Clearcutting and shelterwood cutting had been the favored silvicultural systems applied. Less than five percent of the total harvestable acres were scheduled for uneven-aged management.

Comments in opposition to clearcutting came from both timber industry and the environmental community. Most industry representatives advocated a return to selective cutting on the National Forest. Behind this response was a desire to harvest predominately high value large diameter trees. Other industry comments related to the undesirable practice of harvesting fast growing immature trees in multi-aged ponderosa pine stands. Here, industry representatives suggested management of individual trees for optimum growth rather than the broad brushed stand management approach commonly used on the Forest.

Many people within the environmental community recommended the selection system or uneven-aged management as an alternative. Maintaining biological diversity was the overwhelming justification. Concern was registered about the destruction of wildlife habitat and the conversion of our National Forest into a tree farm or monoculture. Some respondents claimed our clearcutting practices were a violation of the National Forest Management Act (NFMA). Shelterwood cutting was judged as nothing more than a two stage clearcut. Many environmentally oriented respondents felt that clearcuting was wasteful and uneconomical.

Criticism had been directed toward our harvest activities in General Forest management areas in both the ponderosa pine and mixed conifer forest types. Harvest activities in ponderosa pine are often viewed as foreground scenes from roads adjacent to harvest units. Here, the characteristics of individual trees as well as the ground disturbance associated with logging and fuels treatment are clearly visible. Activities in the mixed conifer forest types are more often viewed as background scenes from highways or distant viewpoints within the National Forest. Here the harvest units appear in sharp contrast to the characteristic landscape, especially during the five or six months each year when they are snow covered.

Management practices associated with the lodgepole pine forest type were well accepted by those responding to the Draft Plan. Here the mountain pine beetle provided acceptable justification for even-aged management using clearcutting or the seed tree system and natural regeneration. No comments were received which specifically opposed the Forest's planned management of Retention or Partial Retention management areas.

Based on an analysis and review of these comments, a commitment was made by the Forest Management Team to analyze the feasibility of adopting a new silvicultural strategy which addressed these concerns. As a basis for this analysis, the Management Team first described the characteristics of a forest stand which would be responsive to the public's notion of appropriate forest management.

THE CHARACTERISTIC STAND

This characteristic stand contains a variety of size classes, either represented as single trees or as small even-aged groups. As a minimum, the stand structure would include at least a few old growth trees on most acres, poles or small sawtimber, and seedling or sapling sized regeneration. Alexander (1986) describes this structure as an irregular, multi-storied stand. Schubert (1974) describes this structure as an irregular, uneven-aged stand. Regardless of definition, the public apparently expects ponderosa pine and mixed conifer forests on the Deschutes to be kept green, contain a variety of tree sizes and at least a few old growth trees on most acres.

This structure is represented on many acres of the Forest which have been partially cut using Keen's (1943) risk rating system, Hallin's (1951) concept of Unit Area Control or any one of a number of other cutting schemes. These strategies often produced small openings, usually no wider than the height of the trees harvested. Following the necessary sequence of events, these openings filled in with natural regeneration and produced the characteristic structure which now serves as a model of publicly acceptable forest management.

Unfortunately, as these strategies were implemented, little attention was paid to the establishment of regeneration in non-stocked openings or stocking level control necessary for the growth and development of saplings, poles and small saw-logs. Although these strategies met objectives which were important at the time, they generally ignored another important objective of producing a sustained yield from a more or less regulated forest.

The proposed analysis of new management strategies required the development of managed yield tables which outlined a prescription to both maintain this characteristic landscape for ponderosa pine and mixed conifer forest types and provide for a predictable sustained yield. Along with yield tables, new cost and value data for economic analysis needed to be generated. Descriptions of suitable stand and site condition were needed, and finally, the total number of acres on which this new strategy could be applied. With this information in place, testing could be done within the Draft Plan's preferred alternative using the Forplan model (Johnson et al., 1980). The effects of a new management strategy on the Forest's present net value (PNV), allowable sale quantity (ASQ) and long term sustained yield capacity (LTSYC) would need to be evaluated. Based on this evaluation, a decision could be made to accept or reject the notion of applying new silvicultural prescriptions on the Forest.

UNEVEN-AGED STRATEGIES DEFINED

As a first step in the development of new yield tables, three different silvicultural prescriptions were outlined which appeared to maintain the characteristic forest stand as described by the Management Team. These prescriptions were developed without strong consideration for the classic principles of uneven-aged management. Uneven-aged management per se was not seen as the real issue. The first strategy employed the usual shelterwood seed cut, reserved vigorous immature saplings and poles, and either planted or naturally regenerated a fully stocked seedling-sized stand. The shelterwood overstory was retained until the seedling-sized stand grew to a height of 15 feet. At that time, the majority of the shelterwood trees were harvested, reserving two or three large trees per acre. The understory was precommercially thinned and managed through the remainder of the rotation as an even-aged stand. Stand density was maintained at acceptable levels through a series of commercial thinnings, always cutting from below.

The second strategy was identical to the first until the point of overstory removal. In the second strategy, the shelterwood overstory was never removed and the new stand was allowed to develop beneath the canopy of shelterwood trees and the reserved saplings and poles. The stand was precommercially thinned and stand density was later managed through a series of commercial thinnings, always cutting from below.

The third strategy borrowed in part from past strategies used to manage ponderosa pine on public lands in the West and from current strategies used by private landowners including Gilchrist Timber Company. This prescription employed a series of three partial removal entries, each separated by a 20 year period. At each harvest entry, approximately one third of the trees greater than 16 inches and 20 percent of the trees between 9 and 16 inches were randomly removed as well as a portion of the smaller trees, representative of logging damage to the understory. The initial stand structure is maintained through this series of harvest entries, although the representation by trees greater than 16 inches was reduced dramatically over time and replaced by more vigorous trees of smaller size. Between three and six trees greater than 16 inches were retained following the final partial removal entry. Following these three entries, stand density was managed through a precommercial thinning and a series of commercial thinnings, always cutting from below. Natural regeneration was periodically introduced into the stand following harvest entries.

A fourth strategy, the standard clearcut, was also modeled. In this case, a few green trees per acre were retained for cavity dependent wildlife species and a portion of the trees less than 9 inches DBH were randomly removed, representative of logging damage to the understory. The stand was planted, precommercially thinned, and later stand density was managed through a series of commercial thinnings, always cutting from below. The clearcut strategy was introduced as a baseline against which the three uneven-aged strategies were compared.

In all four strategies, commercial thinning was scheduled when the stand density reached a predetermined upper limit. In addition, a minimum harvest of 2000 board feet was necessary. When these two criteria were met, stand density was reduced to a predetermined lower limit. Because these thinnings always cut from below, smaller slower growing trees were eliminated and stands moved toward a more even-aged structure.

Actual stands were modeled using Prognosis keyword files which represented each of the four strategies. Each strategy was allowed to operate for 150 years, the planning horizon used in the Forplan model. For all strategies, 150 years also became the default rotation age. The default rotation age was used only to compare yields for each strategy outside the Forplan model. In Forplan, 150 years became the rotation age for uneven-aged management prescriptions whereas the other management prescriptions retained their original shorter rotations. The Region 6 Timber Stand Exam Program was the source of individual tree data for these stands. Forty six actual stands were selected which represented a broad range of conditions and structures across the Forest. All stands which were modeled displayed multiple canopy levels which suggested opportunities for uneven-aged management. Stands which were essentially even-aged, dwarf mistletoe infected or otherwise did not suggest opportunities for uneven-aged management were not modeled.

THE PROGNOSIS MODEL

The Prognosis Model (Stage, 1973) was selected for use in developing uneven aged yield tables. Prognosis is an individual tree, distance independent growth and yield model which was first developed for use in northern Idaho and western Montana. The Prognosis model uses a list of sample trees and a set of specially formatted instructions, called keywords, which indicate the user options selected and control the program execution and output. A geographic variant of Prognosis, The South Central Oregon/ Northeastern California Prognosis (Johnson et al.,1986) was used for the analysis. This variant, known by the acronym SORNEC, was recently calibrated for the Forest and this exercise represented its first practical use.

Since Prognosis is an individual tree model, a wide variety of forest types can be accommodated, as can any structure ranging from even-aged to uneven-aged (Johnson et al., 1986). Tree data used for calibration, however, were generated from even-aged stands. The substantially different interrelationships between trees in uneven-aged stands were not incorporated into the calibration. Although Prognosis can accommodate an uneven-aged structure, the model's ability to predict the growth and development of uneven-aged stands over time was relatively untested.

CALIBRATION AND TESTING

Before the Prognosis model could be used with confidence on the Forest, calibration and testing was necessary. First, a series of runs were made which tested the precalibrated height and diameter growth funtions. For these tests, seedlings were planted on site prepared ground, precommercially thinned and later commercially thinned, mimicing the existing managed yield tables. The intent was to determine if the diameter and height growth funtions used in the calibration produced trees of the predicted size at the appropriate time. Managed yield tables were used as the benchmark. Only the diameter growth of grand and white fir appeared unrealistically slow. Height growth for all species were adjusted upward by as much as 50 percent. These diameter and height growth adjustments were made using keywords which were later incorporated into keyword files. While these adjustments were developed from a bare ground simulation, they are appropriately used to adjust diameter and height growth in the actual stands used to produce uneven-aged yield tables. At first it seemed appropriate to test Prognosis by developing new even-aged managed yield tables which could be compared with the existing yield tables used in the Draft Plan. This idea proved impractical since Prognosis used different individual tree volume equations and standards of merchantibility than the more primitive model used to develop the earlier managed yield tables. Although volume equations and standards of merchantibility could be changed in Prognosis, this exercise was beyond the scope of the uneven-aged analysis.

Mortality functions were checked by allowing the 46 stands to grow without treatment for 5 decades using only the keywords which adjusted growth. Percent change in net growth per decade for these stands, segregated into the appropriate stratum and averaged, was compared with empirical stand projections developed from Forest inventory data for the same period. Based on this test, adjustments to the basic mortality functions were unnecessary.

The sensitivity of Prognosis to the interrelationship between trees of different sizes was tested next. A downward yield adjustment had been made in the existing managed yield tables to accommodate the competitive effect of retaining a few large diameter green wildlife trees above a managed stand. The adjustment had been made based on a rather simplistic procedure using the ecological concept of maximum biological potential. This analysis was repeated again using Prognosis and the 46 stands used to develop uneven-aged yield tables. The comparison between Prognosis and the earlier effort were remarkable close. In addition, the diameter growth of individual trees representing most size classes and competitive situations were tracked over the 150 year period. Diameter growth seemed reasonable for the stands evaluated.

STRATEGIES COMPARED

Comparisons were made between the net cubic foot volume produced by the three alternative silvicultural strategies and the standard clearcut. To develop this comparison of strategies for each stand, net cubic foot volume was accumulated from each harvest entry and added to the residual stand volume at the end of the 150 year planning period. These stand specific comparisons were summarized for the two productivity strata in ponderosa pine and three productivity stratum in mixed conifer. These same strata were used in the development of both emperical and managed yield tables used in the Forest Plan. The comparison results are displayed in Table 1. This method was chosen rather than the use of mean annual increment (MAI) since MAI was not entirely appropriate for comparison purposes due to the overlapping rotations using this uneven-aged strategy.

TABLE 1. Strata average yield comparison (net cubic foot volume per acre, sum of all harvest entries and residual volume projected for 150 year planning period) for clearcut and three alternative strategies and percent change compared to the clearcut strategy (1/ Meyer ponderosa pine site index, McArdle Douglas-fir site index for mixed conifer)

productivity stratum 1/	standard clearcut	Silvicultural Strategies: Strategy 1 shelterwood, age 15 remove overstory	Strategy 2 shelterwood, never remove overstory	Strategy 3 3 partial removal entries
ponderosa pine 83	12.58 2/	11.61 (-8%) 3/	9.58 (-24%)	12.32 (-2%)
ponderosa pine 78	8.59	8.18 (-5%)	6.62 (-23%)	8.59 (0%)
mixed conifer 99	15.50	15.95 (+3%)	11.95 (-23%)	14.61 (-6%)
mixed conifer 74	11.78	12.15 (+3%)	11.00 (-7%)	11.48 (-3%)
mixed conifer 68	9.36	9.04 (-3%)	8.12 (-13%)	8.53 (-9%)

2/net cubic foot volume per acre
3/net cubic foot volume per acre and percent change in yield relative to the clearcut strategy

Stategies 1 and 2, which are displayed in Table 1, include planted rather than natural regeneration. Additional strategies which included natural regeneration and a 10 year regeneration time lag were developed but have not been included in Table 1. The natural regeneration prescriptions tend to accumulate more volume growth on existing shelterwood trees and delay the emergence of a new managed stand. Yields for natural regeneration generally drop by an additional two or three percent. This is due in part to the ten year delay in establishment of a new naturally regenerated stand. In some cases, yields actually increase, apparently because of additional growth allowed to accumulate on residual trees.

Essentially the only difference between the standard clearcut and Strategy 1 is the influence of a shelterwood overstory of between 8 and 15 trees per acre for a 15 year period. Table 1 suggests this influence can be either positive or negative, apparently as a function of site quality and the characteristics of the individual stands modeled. Stands on better sites with vigorous and full crowned shelterwood trees actually produce more net cubic foot volume than the standard clearcut, even when shelterwood trees are retained for as long as 15 years.

The difference between Strategy 1 and Strategy 2 is more dramatic. Here the shelterwood overstory influences stand growth and development during the entire 150 year planning period. In addition, Strategy 2 maintains a greater density until stands are commercially thinned. In this case, good stocking level control is not achieved until late in the rotation. Rarely is more than one commercial thinning attainable. Strategy 1 typically achieves two and on better sites three commercial thinnings during a rotation.

Table 1 suggests that Strategy 3 compares favorable with the standard clearcut prescription in ponderosa pine. In the mixed conifer stratum, the comparison is slightly less favorable. Because of concerns about the insect and disease impacts associated with uneven-aged management in the mixed conifer forests, an additional adjustment was made outside the Prognosis model to account for volume loss associated with root and stem decays as well as western spruce budworm and Douglas-fir tussock moth outbreaks beyond those predicted for the clearcut strategy. This external adjustment reduced the mixed conifer yields for the shelterwood strategies by an additional 4 percent and the partial removal strategies by an additional 12 percent. These adjustments were made based on analysis and recommendations provided by the Region 6 Forest Pest Management group in Portland. No adjustment was made for dwarf mistletoe. This analysis assumes the alternative strategies are not applied to stands where dwarf mistletoe will reduce predicted harvest volumes.

Individual stands within each productivity strata performed with great variability when compared with the strata average. Within the ponderosa pine stratum, yields for individual stands using Strategy 3 ranged from a 20 percent increase to a 26 percent decrease compared to the clearcutting strategy. For Strategy 3, stands with multiple canopies layers and a well stocked sapling and pole-sized stand component performed best. Because Strategy 3 harvests approximately 90 percent of the trees greater than 16 inches within a 40 year period, stands perform best when the bulk of the growing stock is concentrated in sapling and pole-sized trees which will grow vigorously and move into the large sawtimber size class by the end of the 150 year planning period. Here, the prescription functions roughly as an overstory removal, executed in three entries over 40 years. On plots which are nonstocked, natural regeneration introduced following initial harvest entries grows to large sawtimber size by the end of the 150 year planning period.

Even-aged old growth stands with poorly developed canopy layers and poor stocking in the saplings and pole-sized stand component performed poorly. Stands with the bulk of the growing stock in trees greater than 16 inches are understocked following the three partial removal entries and the natural regeneration does not gain full site occupancy until later in the rotation. Even stands with three or more distinct size classes performed poorly if crown ratios and past diameter increment were only fair and saplings were poorly represented. Had prescriptions been written and modeled individually for each stand, their growth and yield could have faired somewhat differently than with the standard prescription written to process all 46 stands.

A PREFERRED STRATEGY EMERGES

Based on the analysis of these three alternative strategies, the Forest Management Team recommended that Strategy 3, the strategy with 3 partial removal entries should be developed into a set of free form managed yield tables and incorporated into the Draft Forest Plan's preferred alternative for further testing. Yield tables were developed for each of the five strata based on the strategy outlined in the Prognosis keyword files and on the yield stream produced by the series of Prognosis runs. Yield results for individual stands within the stratum were summarized to produce an average yield. These yield tables were adjusted to depict the same initial net cubic foot volume as the existing empirical yield tables. Over the 150 year planning period, the uneven-aged yield tables for ponderosa pine were adjusted so that they produced the same total volume as the sum of the initial empirical volume harvested by clearcutting and the managed yield volume produced using the existing managed yield tables. In mixed conifer, the uneven-aged yield tables were adjusted so that they produced between 15 and 20 percent less than the clearcutting strategy to reflect the additional volume falldown associated with insect and disease problems.

New management costs were also developed for the uneven-aged yield tables. Costs for timber sale planning, layout and sale administration were 15 percent greater than those used for commercial thinning in the Draft Plan. Fuel treatment costs were reduced for each partial removal entry but in summary equaled the fuel treatment costs for the standard clearcut strategy. Fuel treatment costs for subsequent entries would equal those for commercial thinning in the clearcut strategy. Strategy 3 also includes site preparation, planting, chemical or mechanical release and animal damage control on 20 percent of the acres planned for uneven-aged management. This cost will account for areas which cannot be successfully regenerated naturally. A portion of this cost will accrue following each partial removal entry. Values for timber harvested were adjusted upward for partial removal entries occuring in the future to account for the increase in average diameter and value of harvested trees.

PERFORMANCE IN FORPLAN

The Forplan model was first given free will to select the uneven-aged stategy from among the other available management strategies, including overstory removal and clearcutting. The uneven-aged strategy was never selected by the model. Although uneven-aged investment costs were lower than the clearcut strategy, deferring the harvest of much of the available stand volume for 20 years or more had a dramatic effect on the stand's present net value.

The Forplan model was next constrained to apply the uneven-aged prescriptions on 125,000 acres of ponderosa pine and 28,000 acres of mixed conifer across the Forest. With this constraint in place, the PNV of the Forest dropped by 4 percent, from 737 to 704 million dollars when compared to the preferred alternative in the Draft Plan. The first decade allowable sale quantity measured in net cubic feet dropped by 4 percent from 466 to 448 million cubic feet.

The Forest Management Team felt that these changes in PNV and ASQ were reasonable. Other proposed changes in the conversion period for mountain pine beetle infested lodgepole pine, the question of a departure from the long run sustained yield and the long term availability of quality ponderosa pine sawtimber further complicate the forest planning issue. After presenting this analysis to the Regional Forester and his Staff, they concured that these changes seemed reasonable, particularly in response to the public reaction to clearcutting.

THE UNEVEN-AGED STRATEGY REFINED

When the concept of this new strategy was first introduced, the term multi-age management was coined to describe an as yet unrefined and purely theoretical concept applied to maintain a characteristic stand structure. Discussion relating to this new strategy inevitably raised the question "is this new strategy even-aged or uneven-aged?" From one point of view, this new multi-age management prescription could be described as a small group or in some cases a single tree selection, an uneven-aged system. From another point of view, multi-age management could be described as a three stage group shelterwood, with improvement cuttings in the smaller size classes, an even-aged system. With either system, the characteristic stand structure could be maintained. The critical difference which defines the uneven-aged system is the identification of a desired distribution of tree sizes, and management toward that end. As the strategy was modeled in Prognosis, stand structures are simplified over time and progress toward an even age. This trend toward an even age was developed by the contraints imposed by the Prognosis model and the analysis process rather than a deliberate management intent. Because of the complexity and time involved in individually modeling uneven-aged prescriptions in Prognosis, commercial thinning from below was chosen for the second half of the rotation. Modeled either way, the results would have been the same. As the multi-aged strategy is implemented on the ground, consideration should be given to the eventual development of an uneven-aged diameter distribution. Based on performance of actual stands in the Prognosis model, volume growth in the short run is heavily dependent on the existing growing stock and the existing distribution of tree sizes. Using this strategy, the stand's initial distribution of diameters strongly regulates the cutting strategy. Corrective cutting to minimize disparities in the diameter distribution are not readily employed. Instead, each individual tree or even-aged group of trees is managed to maximize its potential growth and volume production. In the long run, cutting strategies will move the stands toward an uneven-aged structure, but never at the sake of the growing stock. After considerable debate, this new multi-aged strategy was called uneven-aged management.

A sample keyword file used to model the uneven-aged prescription in Prognosis is illustrated in Figure 1. This prescription, applied in the Forplan model to 153,000 acres of mature and overmature ponderosa pine and mixed conifer, can be applied in the field to more or less fully stocked stands where the stand structure includes trees of crop tree quality in several size classes. Most important is the presence of crop trees in the sapling and pole sizes. The strategy begins with an initial harvest entry which removes approximately one third of the trees over 16.0 inches DBH. Trees removed are of the poorest quality and highest risk. Emphasis is placed on retaining trees of highest quality and best grade. In many stands, 20.0 or 24.0 inches DBH may be a more appropriate lower diameter limit for partial removal. Depending on stand structure and condition, removing one third of the large trees may not meet the objectives of increasing stand vigor and opening up sites for natural regeneration. Here, 16.0 inches DBH and 33 percent are simply modeling parameters applied against average stand conditions. Within the 9-15 inch DBH class 20 percent of the trees are harvested in the model. These are the old small trees with poor crowns as well as intermediate-aged trees which are commercially thinned. Forty percent of the trees less than 9.0 inches DBH are destroyed to represent logging damage to the understory. Actual stand conditions should determine the percent of trees in the 9-15 inch class which should be removed and the projected extent of damage to the understory. In the management strategy outlined in Figure 1, precommercial thinning was not applied following the first partial removal entry. In this case, thinning was roughly simulated through the logging damage. In reality, precommercial thinning may be necessary at this point in the rotation to achieve desired growth objectives. Ten years following this harvest entry it is assumed that 75 trees per acre will naturally regenerate into the openings created by the logging.

The second harvest occurs twenty years after the first harvest is executed. At this time 50 percent of the trees greater than 16.0 inches DBH are harvested (including trees which have grown into this size class during the previous 20 years). Here, 16.0 inches DBH and 50 percent are modeling parameters applied against average stand conditions. Again, 20 percent of the trees within the 9-15 inch DBH class are harvested. Within all sizes, the emphasis is placed on retaining the trees of best quality. Ten percent of the trees less than 9.0 inches are destroyed to simulate logging damage. Ten years following the second harvest entry, 75 trees per acre naturally regenerate in the openings created by the logging.

The third entry occurs forty years after the first harvest entry is executed. At this time 90 percent of the trees greater than 16.0 inches and 20 percent of the trees within the 9-15 inch class are harvested (including trees which have grown into these size classes). At this time the emphasis is placed on retaining

Figure 1. Example of Prognosis keyword file used to model Strategy 3 (3 partial removal entries) in the ponderosa pine 83 (Meyer site index) productivity strata. Refer to the Prognosis user's guide (Johnson et al., 1986) for the definition of Prognosis keyword codes.

```
MGMTID
HPR
INVYEAR      1982.
TIMEINT         1.       3.0
TIMEINT         7.      15.0
NUMCYCLE       15.
SPECPREF     1983.      10.0      -2.0
BAMAX                                                 445.0
NOTRIPLE
MINHARV         8.              2000.0
THINDBH      1982.      16.0     999.9       .33
THINDBH      1983.       9.0      15.9       .2
THINDBH      1984.      0.         8.9       .4
ESTAB        1994.
PLANT        1995.      10.0      75.0      90.0
RESETAGE     1995.
TALLYONE     1997.
END
THINDBH      2005.      16.0     999.9       .5
THINDBH      2006.       9.0      15.9       .2
THINDBH      2007.      0.         8.9       .3
ESTAB        2014.
PLANT        2015.      10.0      75.0      90.0
TALLYTWO     2017.
END
THINDBH      2025.      16.0     999.9       .9
THINDBH      2026.       9.0      15.9       .2
THINDBH      2027.      0.         8.9       .2
ESTAB        2034.
PLANT        2035.      10.0      75.0      90.0
TALLYTWO     2037.
END
THINBTA      2050.     200.0                            8.9
IF
(BBA GT 150)AND(YEAR GT 2045)
THEN
THINBBA                100.0                 9.0
ENDIF
REGDMULT                 4.0       1.3
READCORD
     1.0       1.0       1.0       1.0       1.0       1.0
     1.0       1.0       1.0       1.0       1.0
REGHMULT        1.0      4.0       1.5
HTGMULT         1.0      4.0       1.4
REGHMULT        1.0      7.0       1.5
HTGMULT         1.0      7.0       1.4
REGHMULT        1.0     10.0       1.5
HTGMULT         1.0     10.0       1.2
```

three to six trees per acre 16.0 inches and larger which best meet the needs for cavity dependent wildlife. Within the smaller sizes, emphasis is again placed on retaining the best trees. Five percent of the trees less than 9.0 inches are destroyed to represent logging damage. Ten years following this entry, 75 trees per acre naturally regenerate into the openings created by logging. After an additional 15 years, the stand is precommercially thinned and the residual trees are grown until the stand reaches a target basal area per acre and at least 2000 board feet per acre can be harvested. The stand is then thinned from below to a predetermined residual basal area per acre. Each time the the stand's basal area and board foot volume satisfy the criteria, another commercial thinning is executed. In reality, these commercial thinnings could harvest from a variety of size classes and begin to recreate the characteristic stand structure. Although not portrayed in the model, natural regeneration may occur following each commercial thinning. As the target diameter is reached, the stand can again be harvested using a series of partial cuts similar to those carried out during the first 40 years of management.

The strategy portrayed in the keyword file in Figure 1. only applies to ponderosa pine stands which are more or less fully stocked. In reality, stand structure is strongly influenced by past management practices, wildfire, and bark beetles. Within a given stand, an array of stand structures will be encountered, usually in small groups typical of the irregular uneven-aged stands. In many cases the first or second partial removal entry have already been made. In other cases, a precommercial or commercial thinning within a small group would be the appropriate prescription. The age and condition of these small even-aged groups dictate the cutting prescription rather than a predetermined diameter distribution. In some cases, individual trees rather than small groups will be managed. Here, they should be managed with respect to their potential for growth and with a thought to the desired diameter distribution.

WHAT'S IN THE FUTURE?

Based on public concerns about clearcutting and the results of the analysis, the Final EIS for the Deschutes will likely incorporate direction for uneven-aged management of ponderosa pine and mixed conifers. Management direction will place emphasis on the use of uneven-aged systems where individual stand and site conditions are appropriate. The implementation of uneven-aged management will be controlled by standards and guidelines incorporated into the Final EIS.

These standards and guidelines were developed through the cooperative efforts of Forest and District silviculturists, scientists from the Bend Silviculture Lab, the Forest ecologist, soil scientist, wildlife biologist, landscape architect and others. They will set the framework for implementation of uneven-aged management through definition of acceptable uneven-aged systems, identification of appropriate forest types, stand structures and conditions, as well as site conditions, and will include a set of standards for the development of silvicultural prescriptions.

With these guidelines in hand, the Forest will proceed cautiously with the implementation of uneven-aged management. Initial prescriptions will be applied in ponderosa pine stands where conditions appear ideal. Prognosis will be used in the development of silvicultural prescriptions. District keyword files will be developed to quickly model both clearcut and uneven-aged prescriptions for stands within proposed timber sale areas. From these computer simulations, comparisons of growth and yield can be made and presented to the interdisciplinary teams responsible for timber sale environmental assessments. These tradeoffs in growth and yield can be weighed against the other positive or negative impacts associated with uneven-aged management. Prognosis can be further used to fine tune silvicultural prescriptions for timber stands where uneven-aged management is the selected alternative. Using Prognosis and an iterative process, marking guidelines can be developed to take advantage of the existing growing stock while slowly moving the stand toward a more uneven-aged structure.

There are still many important concerns about the feasibility of uneven-aged management on the Forest. Of most importance are our concerns about natural regeneration, soil compaction, forest diseases and the increased complexity associated with uneven-aged management. Natural regeneration is a critical component necessary for the success of uneven-aged systems. Meyer (1934), Hallin (1959), Mowat (1961), Schubert (1974) and Barrett (1979) discuss the unpredictable nature of ponderosa pine natural regeneration. Based on many lifetimes of collective experience working with ponderosa pine, these scientists suggest a critical sequence of events is necessary for the establishment of natural regeneration. This sequence of events includes an abundant seed crop, a seedbed of bare mineral soil free from competing vegetation, prolonged moisture for germination and growth during the critical heat of July and August, and a low population of seed eating rodents. Unfortunately, foresters have little control over several of the factors which influence success or failure. Fortunately there are a number of opportunities for natural regeneration following planned harvest entries. In some cases, planting will be necessary to aid in the establishment of new age classes essential for full site occupancy in the future and the maintenance of a sustained yield.

A new emphasis on the long term site productivity of forest stands strengthens concern about increased soil compaction. Concerns are generated because of the potentially more frequent harvest entries associated with uneven-aged management and the uncontrolled nature of skidding as individual trees are managed. When viewed in the perspective of a rotation or more, the entry schedule associated with uneven-aged management produces about as many opportunities for compaction to occur as with even-aged management. With uneven-aged management, however, there is never a good opportunity to perform restorative soil treatments such as tilling or cultivation over entire stand areas as there would be after stands are clearcut. Because of this, more emphasis must be placed on prevention of detrimental compaction or soil displacement. Standards and guidelines have been developed to control season of logging, allowing skidding on appropriate sites only when soils are dry or frozen. On more sensitive sites which are poorly drained or highly compactable, skidders will be restricted to designated skid trails and logs will be yarded using drum line and winches. Fortunately, soils on the Deschutes are predominately coarse textured sands and the potential for detrimental compaction is far less than soils which are poorer drained and with higher clay content. Still, care must be taken to prevent damage, even on these forgiving soils.

There is also widespread concern about the propensity of uneven-aged management to increase the extent and severity of disease, particularly in mixed conifer stands. Dwarf mistletoes and root or stem rots are of particular concern. Although an agreement can be reached about the amount of yield falldown the Forest is willing to accept while applying uneven-aged management to diseased stands, determining the extent of infection which will produce that accepted falldown is another problem. The issue is further compounded since many of the sites with high recreational value, where uneven-aged management could produce the greatest public benefit, are those sites in the mixed conifer type carrying an overstory of overmature ponderosa pine and an overstocked understory of white fir and associated species. These stands have been selectively harvested in the past and now exhibit a broad array of disease problems. Initially, uneven-aged management should be applied here with extreme caution. Ultimately, monitoring and reevaluation will move the Forest toward the best use of uneven-aged managaement in these stand types.

Still another concern is the management complexity associated with uneven-aged management. No doubt the application of uneven-aged management will require greater skill levels at all points in the timber management process. Many more acres will need to be treated to maintain current harvest levels. Prescriptions will become more complicated and timber marking will be on an individual tree basis. Both timber harvesting and fuels treatment will be restricted by the presence of a residual stand. Stand record keeping may become more complex. This increased complexity and the associated needs for increased personnel comes at a time when Forest Service budgets and staffing continue to shrink. Fortunately, uneven-aged management may also produce some reductions in the District work load. Sale design and layout may be simplified. Programs in reforestation and animal damage control may be reduced. Timber management should become more cost effective as front end costs to establish new plantations are reduced.

The Forest is currently working in cooperation with the Ochoco National Forest and the Bend Silviculture Lab to develop a long term study of uneven-aged management on the two Forest area. This work will involve the installation of at least eight replications of a study designed to evaluate the long term consequences of uneven-aged management in ponderosa pine. The objectives will be to determine the effects of uneven management practices on tree growth and yield over time, soil compaction, and natural regeneration. This work will answer some but not all of our concerns. Further monitoring and evaluation will be necessary.

Despite these concerns, there may still be a place for uneven-aged management on the Deschutes National Forest. After all, it is just another silvicultural tool available for use to meet management objectives. The greatest fear comes in the misapplication of uneven-aged management as a panacea thought to cure all the ills of intensive management. This is no more rational than to disallow the use of uneven-aged management altogether. The one great blessing of uneven-aged management which may in the final analysis outweigh all the concerns is the options which it retains. If, in a decade or two, the overwelming weaknesses of uneven-aged management come to light, partially cut stands can still be clearcut and managed with even-aged systems as long as the system is not allowed to deteriorate into selective harvesting.. This is a particularly important advantage. Once stands are clearcut, few options remain in the short run.

Our changing management philosophy and our movement toward uneven-aged silvicultural systems comes in response to a public who places increased emphasis on the forest's recreational and aesthetic values and on a common sense, cost effective approach to forestry. Although the forest products industries remain a strong element in our local communities, new and important industries have grown in response to the public's desire to live near and recreate in our National Forests. These publics place competing and sometimes conflicting demands on the Forest. Uneven-aged management has the potential to resolve these conflicts in some cases. Uneven-aged management of ponderosa pine is not new. Since the turn of the century foresters have looked at alternatives for managing ponderosa pine to meet the management objectives important at the time. What is new is that only now have we been able to demonstrate what we think are the growth and yield consequences of these strategies. Using Prognosis, we can show to our publics what we think the tradeoffs really are. We've been able to demonstrate that as a result of their overwhelming responses to our Draft EIS, we have the ability to make important changes in the shape of forest management on the Deschutes. Hopefully, these changes will be able to meet the needs of all.

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UNEVEN-AGED MANAGEMENT IN NORTHERN ROCKY MOUNTAINS

by

Russell T. Graham[1]

ABSTRACT

Selection silvicultural systems uneven-aged management can be applied in the Northern Rocky Mountains. Use is limited to the management of shade-tolerant species, which are often less valuable, slower growing, and more disease prone than shade-intolerant species. Selection systems are particularly valuable in special use or sensitive areas throughout the region and on sites where even-aged systems are unsuitable. Research is being conducted on the consequences of using selection systems in the Northern Rocky Mountains.

INTRODUCTION

Uneven-aged management is appropriate for use in all major forest types of the Northern Rocky Mountains, with the exception of western larch (Larix occidentalis Nutt.) (Burns 1983). Selection systems are useful on sites where continuous forest cover is required, for example, to maintain habitat for the spotted owl. A managed stand with an optimum diameter distribution may be healthier, more fire resistant, and more stable than an even-aged stand.

A stand or watershed with a primary use other than timber can be managed, with a selection system, to maintain forest cover and produce a timber crop. In addition, selection systems may be appropriate on sites where even-aged reforestation methods fail to provide adequate regeneration.

CHARACTERISTICS OF UNEVEN-AGED MANAGEMENT

Uneven-aged management two traditional silvicultural systems; recently an additional variant has been proposed. These are:

- Individual tree selection
- Group selection
- Free selection[2]

The traditional methods have their origins in European silviculture (Knuchel 1953). They most often rely on natural regeneration, but artificial regeneration can be used. They appear to work well in many parts of the world but are said to have resulted in destruction and loss of productivity on some sites (Mustian 1978). In the Northern Rocky Mountains, the most successful applications of uneven-aged silviculture are on small land holdings that can be intensively managed.

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The individual tree selection system concentrates on management of single trees, developing managed stands with balanced diameter (age) distributions. In contrast, the group selection system concentrates on groups of trees within a stand. This system creates a multitude of small, even-aged groups within a larger stand. Most definitions restrict the size of harvest openings to less than 2 acres for a stand to be considered uneven-aged.

The group and individual tree selection systems require stand goals for basal area, maximum tree size, and diameter distributions. The lack of goals and concomitant lack of regulation caused failure of many early attempts at selection cutting (Marquis 1978).

Free selection is an uneven-aged system with no mathematically defined goals. It is used most often for sanitation, salvage, or vigor cuttings, and usually in stands along travel-ways or stream courses where the goal is to maintain considerable forest cover. Silviculturists select trees for removal by instinct and observations of vigor more than from a precise marking plan--the art form of silviculture! How successful such stand treatments are depends not only on the skill and knowledge of the individual forester, but on his or her intuition about how the stand will develop. This system is difficult to integrate into forest planning. It requires a high level of expertise at the site, something often not available.

Many species in the Northern Rocky Mountains are not well suited for uneven-aged systems. Western white pine (*Pinus monticola* Dougl.), western larch, and lodgepole pine (*Pinus contorta* Dougl.) are examples. These species do not occur as climax vegetation. Other species, such as grand fir (*Abies grandis* Lindl.), subalpine fir (*Abies lasiocarpa* [Hook.] Nutt.), western hemlock (*Tsuga heterophylla* [Raf.] Sarg.), western redcedar (*Thuja plicata* Donn), and Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco), are climax tree species over much of the area. They are well suited for selection silviculture. On the driest sites, where ponderosa pine (*Pinus ponderosa* Laws.) is climax, uneven-aged silviculture could be successfully used.

Many stands are not readily converted to all-aged structures. Most stands can be converted, but it may be both difficult and time consuming. Therefore, in northern Idaho we have applied selection prescriptions only to relatively balanced, all-aged stands (Graham and Smith 1983).

APPLICATION IN THE NORTHERN ROCKY MOUNTAINS

Uneven-aged silviculture can be applied in the Northern Rocky Mountains, but it promotes the regeneration of shade-tolerant species. On some sites this will not be a disadvantage because ponderosa pine and Douglas-fir have excellent growth rates and command good prices. But, on highly productive sites, the species featured with selection systems are less valuable than western white pine and western larch. Western redcedar is an exception.

Four main objectives are used to describe the target stand when preparing uneven-aged prescriptions:

- Largest desired tree
- Residual basal area
- Desired diameter distribution
- Length of cutting cycle

Defining these objectives is the most difficult part of preparing selection prescriptions. Yield tables, habitat classifications, and computer models can help. Once the objectives are defined, several methods can be used to determine the proper balanced diameter distribution (Alexander and Edminster 1977; Tubbs and Oberg 1978).

The largest tree in the stand, the target tree, can be defined as a commercial-sized tree or one that fulfills a multiple-use goal. In selecting this tree, size, species, growth rate, and tree value must be considered. Management plans for forests or compartments can help guide this decision.

The classic work in describing diameter distributions in uneven-aged stands can be attributed to de Liocourt (Meyer 1943, 1952; Meyer and others 1961). He devised the "q" value as a factor for defining diameter distributions. The "q" value describes the well-known reversed "J" shaped curve. Several researchers have refined these techniques, but no better method or description of diameter distributions for uneven-aged stands has been devised. However, the reversed "J" shaped diameter distribution may not be the most productive nor the most desired for many sites and species (Hann and Bare 1979).

Length of cutting cycle can be estimated from yield tables or computer models. An operational amount of volume should be produced between each cutting cycle. Depending on species, and product value, this volume can vary.

PROBLEMS

Uneven-aged silviculture is difficult to apply; it takes much more care and diligence than most even-aged systems. Past attempts to apply these systems in our area were often disguised "high-grade" operations. The largest, most vigorous trees in the stand were cut, and the residual stand was not developed through neglect or because of inadequate funding for continuous management. When this happened, the stands would remain even-aged with a dense stand of poor-quality trees slowly increasing in size. This practice has led to a generally held conclusion that selection systems cannot be applied in the Northern Rocky Mountains.

Regulation of volume from working circles or forests is difficult to schedule using uneven-aged systems. This is a another major reason for not applying selection systems on many areas.

Because there are more steps in preparing uneven-aged prescriptions, they tend to be much more time consuming and complex than even-aged prescriptions. Because of this complexity, proper training of marking personnel is important. Often, foresters are unable to grasp the concept of marking stands to basal area levels, the first, and most important, control in a selection prescription.

Multistoried stands can be severely damaged if care is not taken when harvesting. This is especially true on steep slopes where skyline equipment is required. During falling, care must be exercised to prevent damage to crop trees of all sizes. Western hemlock and grand fir are very sensitive to bark wounds, important entry points for bole-rotting organisms. Western redcedar is more resistant than other species to bole-rotting fungi that enter through wounds. Root damage from yarding operations is also a problem if yarding systems are not properly applied. Therefore, contract enforcement, through proper sale administration, is critical for the success of selection prescriptions.

Stand condition is important. Selection systems are more likely to fail in stands with few crop trees than in stands with many crop trees representing all diameter classes.

Reduction of hazardous fuels and site preparation are difficult to achieve when using selection systems. There is little opportunity for economical slash disposal in stands with few or no openings. The only option for fuel abatement is lopping and scattering logging debris, or some type of whole tree yarding. All of these factors have the potential to make selection silviculture expensive, difficult to apply, and possibly damaging to resources.

RESEARCH IN PROGRESS

Because uneven-aged silviculture systems are not used extensively in the Northern Rocky Mountains and Forest Plans now being prepared or just finished list only a minor portion of the acreage where uneven-aged silviculture is preferred, our Research Work Unit has a relatively minor emphasis on uneven-aged silviculture.

PRESCRIPTION PREPARATION

Our first efforts began in 1976 with two stands in the Priest River Experimental Forest in northern Idaho. I will use one of these to illustrate our procedures. The stand was inventoried, resulting in the following description:

- Species mix: western white pine (3 percent), Douglas-fir (2 percent), western larch (2 percent), grand fir (32 percent), western redcedar (50 percent), western hemlock (11 percent), and an occasional lodgepole pine.

- Stand age: 110 yr
- Trees per acre: 1,136
- Basal area: 190 ft^2/acre
- Volume: 16 MBF/acre (3,712 ft^3/acre)
- Habitat type: western hemlock/clintonia uniflora
- Natural "q": 1.8

The goals of the prescriptions were:
- Residual basal area: 150 ft^2/acre
- Largest Tree: 24 inches diameter
- Diameter Distribution "q": 1.3
- Cutting cycle: 10 yr

Applying the stand characteristics to the the desired diameter distribution resulted in an excess of trees in diameter classes less than 14 inches and a shortage of trees in diameter classes over 14 inches (Figure 1).

The prescription devised was to remove excess trees without cutting below the desired basal area of 150 ft^2/acre. We have been criticized for not marking based on tree vigor alone, but if vigor was the primary criterion, we could easily destroy stand structure. We instructed markers to stay within desired guidelines and mark low-vigor trees of all species in the excess size classes. We marked an occasional tree in size classes that were deficient, but only if the tree would not live until the next entry.

HARVESTING

The stand was part of a larger sale that included shelterwood, clearcut, and seed-tree units. Roads were constructed as part of the sale, so the selection units did not support the entire road costs. Likewise, a skyline yarder was used in the clearcuts and in shelterwood units, so selection units alone did not support move-in and move-out costs of the yarder. Each yarding corridor was specified to maintain optimum spacing, with directional felling required. The unit was harvested using a skyline with 150-ft lateral capability with an external yarding distance of 600 ft.

Tree tops were lopped and scattered; debris at landings was piled and burned. Logging damage was minimal. Some openings were created where large trees were removed and the skyline trails created openings approximately 12 ft wide and up to 600 ft long. In 1978, a small amount of additional cutting was completed in the diameter classes less than 4 inches.

Harvesting had little impact on stand attributes. The "q" of the diameter distribution remained 1.8 (Figure 1). We reduced the number of trees in the 8- to 14-inch diameter classes, but we also removed trees in the 14- to 18-inch diameter classes. We reduced the trees per acre to 1,129 and basal area to 165 ft^2/acre. Three MBF/acre in high-value trees were harvested, resulting in a residual volume of 13 MBF/acre.

TEN YEARS LATER

Ten years after harvesting, the stand was scheduled for another entry. The stand characteristics at that time were:

- Stand age: 120 years
- Trees per acre: 961
- Basal area: 163 ft^2/acre
- Volume: 15.5 MBF/acre (3,484 ft^3/acre)
- Habitat type: western hemlock/clintonia uniflora
- Natural "q": 1.7

The stand condition is good. There were no changes in species composition, with some western redcedar and western hemlock regenerating. We plan the second entry this summer (1987), following a prescription similar to the first. The majority of trees removed will be in diameter classes less than 12 inches, with only extremely low-vigor trees removed in the classes exceeding 12 inches (Figure 1).

Approximately 3 MBF/acre will be harvested, a yield similar to that from the first entry, but the value of the volume may be reduced because of the smaller tree size. Also, fewer high-valued western white pine, western larch, and Douglas-fir will be removed.

FUTURE DIRECTION

The stands in the Priest River Experimental Forest were not typical of stands most likely to be considered for uneven-aged silviculture. They were on north-facing slopes, which regenerate well, and are highly productive. The usual prescription for these stands is to clearcut, broadcast burn, and plant a mixture of rust-resistant western white pine and western larch, and allow the remaining species to regenerate naturally.

The sites where uneven-aged silviculture seems more desirable and is most likely to be applied are on south-facing slopes, along stream courses, in scenic areas, or in habitat types difficult to regenerate. Sites in the Douglas-fir and grand fir habitat series are good examples. To provide information on how such sites would respond to a selection prescription, we designed a timber sale in the Deception Creek Experimental Forest near Coeur d'Alene, ID.

This sale consists of 270 acres of single-tree selection compared to 30 acres of clearcuts and 30 acres of shelterwood cuts. The 270 acres where uneven-aged systems will be used consist of:

- Diameter distributions: "q's": 1.1, 1.3, 1.5
- Residual basal areas: 100, 125, 150 ft^2
- Replicates: three: one on a south-, one on an east-, and one on a west-facing slope
- Shelterwood and clearcut units are on east- and west-facing slopes only.

The entire area was harvested in the 1940's and 1950's by removing small volumes of poor-vigor western white pine. These vigor cuttings had already created stands with uneven-aged characteristics. As in our first attempt at marking uneven-aged stands, we had difficulty in achieving our objectives.

The sale area has all roads in place, with spacings near 500 ft. Only maintenance road work had to be completed with the sale. The timber has been sold and harvesting started.

We plan to inventory these stands as they develop, to establish regeneration trends, tree growth, and disease development. In addition, we have an opportunity to compare the development of the stands to the more normally prescribed treatments (shelterwood and clearcut). Also, the sale area betterment and slash disposal plans allow for burning and planting in the selection units.

CONCLUSIONS

Based on our limited experience, uneven-aged silviculture can be applied in the Northern Rocky Mountains. Problems do occur, but they are no more limiting than those with even-aged systems. Some uncertainties in using selection systems can be mitigated by careful planning and execution. The problem of forest regulation can be handled by present growth models and mensurational techniques. Whether for production of nontraditional resources (caribou and spotted owl), or where regeneration is difficult to achieve with conventional (even-aged) systems, uneven-aged silviculture should be applicable and useful to many situations in the Northern Rocky Mountains.

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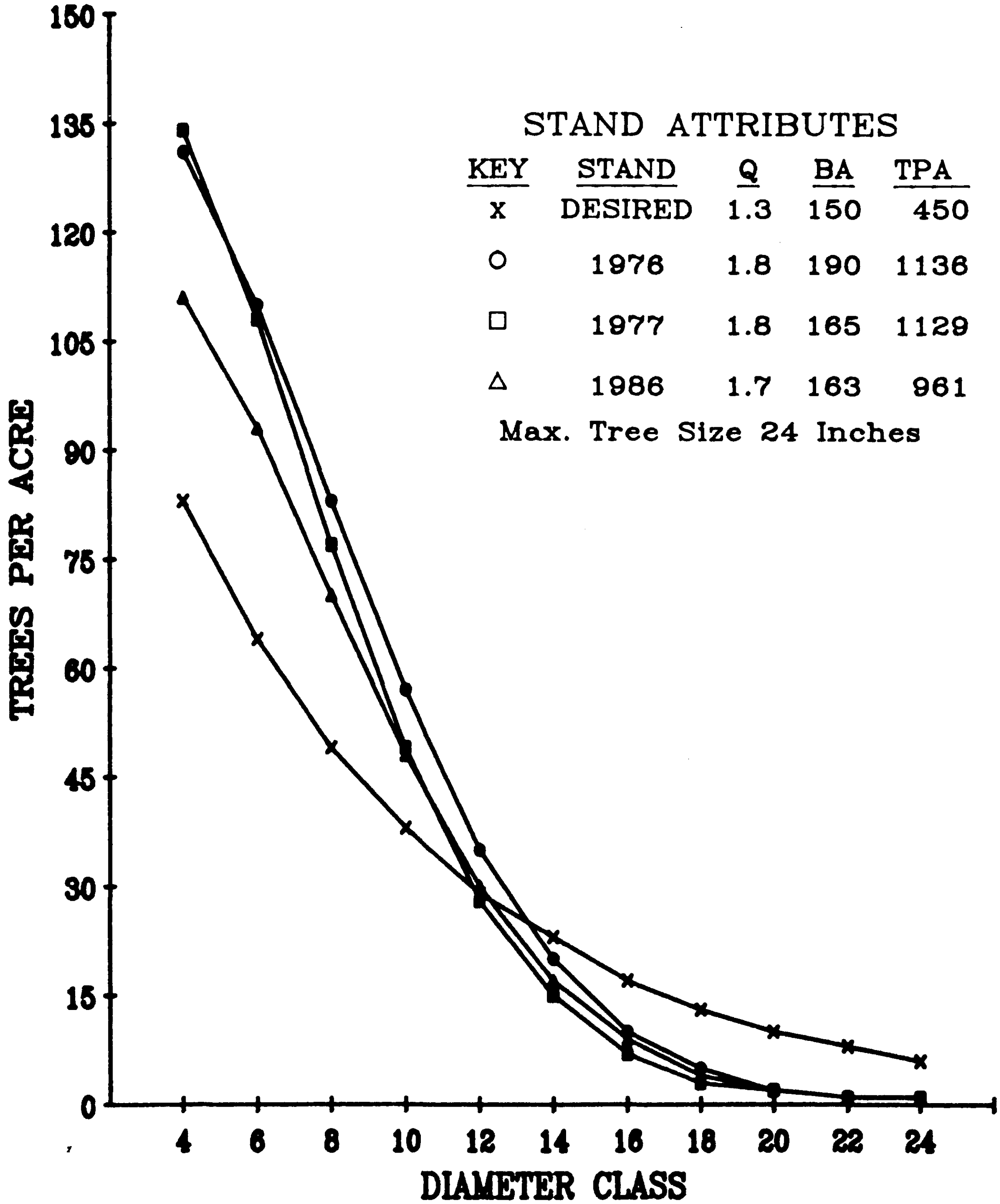

Figure 1. Actual and desired diameter distributions for a 110-year-old mixed conifer stand in northern Idaho.

THE REFORESTATION IMPROVEMENT PROGRAM HISTORY AND PROGRESS[1]

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ABSTRACT

The Reforestation Improvement Program (RIP) is a cooperative Forest Service venture that involves all three branches--National Forest System, Research, and State and Private Forestry. Using high-tech data logging and computer equipment, a minimum of two seedlots from each Forest Service nursery and the environmental conditions acting on them will be studied carefully from the time of sowing until 5 years after outplanting. The objectives are to improve nursery practices, develop a quality control program for continuous use by the nurseries, and identify factors that require additional research.

INTRODUCTION

The Reforestation Improvement Program (RIP) is a National Forest System (NFS), Research, and State and Private Forestry (S&PF) effort to improve nursery seedling quality and plantation survival and growth. The concept is to use state-of-the-art data logging and computer technology to carefully monitor selected seedlots to determine the relationships between environmental conditions, nursery culture, seedling handling, seedling characteristics, and performance after outplanting. This information will be used to sharpen nursery practices, develop a continuing quality control system, and identify knowledge gaps that require research.

The idea was first discussed at the Forest Regeneration Committee meeting in 1980. Then, following the Seedling Quality Workshop at Oregon State University in 1984, NFS, Research, and S&PF representatives discussed the Forest Service nursery program and the research needed to improve the production of quality bareroot stock. In January 1985, a team of nursery managers and research scientists developed a draft proposal to implement RIP. All Regions had the opportunity to review and comment on the draft. The final proposal was approved by the Directors of Timber Management (TM) and Timber Management Research (TMR) and the Deputy Chiefs for NFS and Research, and all Regions with bareroot nurseries agreed to participate. Plot establishment got underway in 1986. This paper describes the objectives, procedures, and current status of the program.

JUSTIFICATION

As a result of the National Forest Management Act of 1976, successes and failures in our reforestation program are clearly documented and reported to Congress. Criteria to measure reforestation quality have also been included in line officer's performance standards. Silviculturists are making more detailed evaluations of plantation survival and growth, and the results of these evaluations have dramatically increased the visibility of our reforestation program. The "Productivity Improvement Analysis of Reforestation" report published in 1983 states that a 10 percent reduction in reforestation failures would save $2,624,000 annually and that a 50 percent reduction would save over $13,000,000 annually.

Many plantation failures are difficult if not impossible to explain with the data presently collected. We simply do not know whether the problems are occurring at the nurseries, during shipping and handling, during planting, or are due to site factors or lack of seedling adaptation.

Advances in tree improvement and availability of genetically improved seed provide another important stimulus to improve nursery and reforestation practices--this valuable seed should be used as efficiently as possible.

Research by Jim Jenkinson, Pacific Southwest Research Station, has shown the importance of incorporating new information about seedling physiology into nursery practices. He has developed time windows for lifting several major timber species and specific seed sources at individual nurseries. Lifting seedlings outside of these windows results in reduced survival and growth and, in the worst case, plantation failure.

Weyerhaeuser Company has led the way in growing seedlings by family (seed collected from a clone in a seed orchard), observing growth response to cultural treatments, and grouping families with similar growth into "response groups." Cultural treatments are then tailored to each "response group" in order to grow seedlings to desired specifications.

GOAL

Make reforestation a highly predictable process leading to reliable establishment of fast growing plantations, and learn more about basic tree seedling ecophysiology.

EXPECTED BENEFITS

Benefits will increase each year as we monitor new seedlots, encounter different weather conditions, modify cultural practices, and accumulate information on field performance. Expected short-term and long-term benefits are as follows:

SHORT-TERM (1 to 5 years):

1. Development of a standardized system for collecting and analyzing nursery data will facilitate interchange of information and technology among nurseries, research units, and National Forests.

2. Increased awareness of seedling biology on the part of growers and users through personal and detailed testing and tracking of seedling performance from "seed to site" will sharpen the skills of the dedicated professionals who are charged with conducting nursery and reforestation programs.

3. Improved nursery practices will reduce the costs of stock production and the amount of seed required, and they will increase the likelihood of consistently producing stock having high potential for survival and early growth in the field.

4. Seedling production will gradually shift from an art to a science, enabling nurseries to consistently grow seedlings to target specifications.

LONG-TERM (5 years and longer):

1. Tree survival and growth after outplanting should be significantly increased, with fewer failures and replants and lower reforestation costs.

2. The ability to predict tree survival and growth in relation to nursery cultural practices, stock handling, and site conditions will be improved.

3. A standardized quality control program for nurseries to use on a continuing basis will be developed and, as the years and data accumulate, we should see further improvement in nursery efficiency and in the entire reforestation program.

4. A greater knowledge of nursery environments and an understanding of seedling physiology in relation to environment and genotype will enhance research efforts, and knowledge gaps requiring research will be identified.

5. As nursery and field practices are refined and standardized, the nursery and reforestation handbooks will be revised.

PARTICIPANTS

Each Region was asked if its nursery(ies) wanted to participate in the program--all 11 nurseries volunteered to take part. Four weather stations were purchased for each nursery--two to be used in the nursery and two to be set up on the planting sites. The nurseries agreed to execute a standard data collection and analysis procedure, although they can use the data to generate any additional information they desire. Forest Pest Management (FPM) pathologists from the participating Regions agreed to conduct pathogen and mycorrhizae analyses. With the help of Regional Office silviculturists, National Forests and Ranger Districts interested in participating in the outplanting phase were identified prior to selection of specific seed sources.

A national program coordinator was appointed to facilitate installation of the monitoring system and implementation of data collection. The first coordinator was Russ Ryker, Intermountain Station, Boise, Idaho, who served until his retirement in January 1986. He was replaced by Pete Owston, Pacific Northwest Station, Corvallis, Oregon, who is the current coordinator.

A statistical analysis team (SAT) was created to help develop data collection and analysis procedures. They will evaluate the data from a research perspective and identify specific problem areas that need additional research emphasis. Members of this team include: Bill Rietveld, North Central Station (NC), Rhinelander, Wisconsin; Dick Tinus and Rudy King, Rocky Mountain Station (RM), Flagstaff, Arizona, and Fort Collins, Colorado, respectively; and Jim Barnett, Southern Station (SO), Pineville, Louisiana.

The original proposal also made provision for a national steering committee to monitor the overall program and make modifications as necessary. Members of this committee are the coordinator, representatives from TM and TMR, and three advisors--one scientist from Research, a nursery manager, and one silviculturist from a participating National Forest.

ESTABLISHMENT OF NURSERY PLOTS

Each nursery was assigned to study two different seedlots of at least one of the major species that it produces: Ponderosa pine is being monitored at Albuquerque, Bend, Bessey, Lucky Peak, and Placerville; Douglas-fir was assigned to Coeur d'Alene, Humboldt, Stone, and Wind River; red pine is being studied at Toumey; and Ashe is doing both loblolly and longleaf pines. Ten nurseries made the initial sowings in 1986. Placerville, which is producing 1-0 stock, has begun in 1987.

The same lots of each species are to be sown in each of three consecutive years so that they will be grown under a variety of weather conditions. Standard cultural practices are to be used in the 100 feet of seedbed that are to be sown for each lot and year. All of the sowings are to be as close together as possible so that they are in similar soil and subject to similar weather.

ENVIRONMENTAL MEASUREMENTS

High-tech, automatically recording weather stations are the heart of the environmental monitoring phase of RIP. One station has been installed on a permanent site at each nursery to collect baseline weather data. A second station has been erected near the test seedbeds so that sensors can monitor the weather and soil conditions to which the seedlings are actually exposed. Conditions measured are: air temperature at 1.5 meters above ground and at the seedling canopy level (20 cm), relative humidity, precipitation and irrigation, wind speed and direction, incoming radiant energy and photosynthetically active radiation, soil surface temperature, and soil temperature and moisture in the seedling rooting zone. The recorder scans the sensors every 5 minutes around the clock and records maximum, minimum, and average temperature; average humidity, radiation, and wind direction; average and maximum wind speed; and total precipitation or irrigation for each hour. The data are stored magnetically in a removable pack that holds 32,000 bits of information. The packs are changed once a month, data from the full pack are transferred electronically to the microcomputer, and the pack is erased for future use.

The data are moved to a spreadsheet for summation and graphing. Indexes such as growing degree days, chilling hours, and potential evapotranspiration are also calculated.

One-time measurements of soil physical characteristics will be made in the test beds, and periodic measurements will be made of soil fertility, pathogen levels, and quality of irrigation and runoff water.

Environmental conditions that the seedlings are subjected to during lifting, processing, shipping, and planting will be carefully monitored. This will include details such as root exposure time; temperatures during grading, storage, and shipping; and number of times the seedlings are handled. Temperatures during storage and shipping will be measured by using another recording device, a datapod, that will be placed inside packing bags and be set to record temperatures at hourly intervals for several months at a time.

Weather data and factors such as soil characteristics, competing vegetation, animal damage, insect and disease damage, and stand history will be measured or observed and used in the correlations or interpretations of results.

CULTURAL PRACTICES

The whole range of cultural activities performed on the test lots will be documented by date and specific treatment. Unusual occurrences associated with application or results will be noted. Treatments include seed stratification, sowing, thinning, weeding, fertilization, pesticide application, and pruning of roots and tops. No experimental treatments will be applied to the monitored seedbeds; but if any practice is changed nursery-wide during the Program, the modified practice will also be instituted in the RIP seedbeds. This information will be used primarily to aid in interpretation of results rather than for making specific correlations with growth and performance.

SEEDLING MEASUREMENTS

Despite all of the high-tech gadgetry, seedlings remain the main focus of the program. We will examine them inside and out--i.e., morphologically and physiologically--and correlate their development, growth, and condition with the environment that acted on them.

Monitoring will begin with establishment of history plots at time of sowing to determine germination rates and plantable seedlings as a percent of seeds sown. In addition, a sample of randomly chosen seedlings in the seedbeds will be measured periodically for height and diameter growth, and detailed observations will be made of seedling color and bud activity. As lifting time approaches, root activity and plant moisture stress will be measured periodically. Growth measurements will be graphed for easier interpretation.

A flurry of measurements and analyses will occur when seedlings are lifted: Final external characteristics will be measured or observed--height, stem diameter, bud length, and foliage color; and internal (physiological) conditions will be assessed by a variety of measurements and tests--mineral nutrient status, carbohydrate reserves, root growth capacity (RGC), cold hardiness, and resistance to moisture stress.

Some of the physiological measures require sophisticated equipment and will be done by private or university laboratories. The RGC, cold hardiness, and stress tests, however, will be done at the nurseries. This will be more economical, and the seedlings will not be subjected to storage and shipping that might alter their physiology. The main reason for doing the tests on-site, however, is to give nursery personnel more of a "feel" for the organism they are growing.

The RGC test is an excellent example of development and cooperation within the Forest Service. This greenhouse method of assessing root growth capacity of tree seedlings, conceived by Professor Ed Stone at the University of California-Berkeley, was refined and used by Jim Jenkinson, PSW, over a period of years with the cooperation of Jim Nelson and others at the Humboldt Nursery. Recently, Dick Tinus, RM, and Bill Rietveld, NC, have developed a mist-chamber technique that simplifies and shortens the test; and the Missoula Equipment Development Center (MEDC) refined the mist-chamber apparatus and built a unit for each of the nurseries. These are in place and are being tested in preparation for full-scale use during the next lifting season.

ESTABLISHMENT OF FOREST PLOTS

The "Proof of the Pudding" is, of course, field performance of the seedlings. It makes no sense to grow beautiful seedlings if they are going to "fizzle" after outplanting. Therefore, we have asked various Ranger Districts to volunteer to establish and monitor forest plots--we call them "forest" plots rather than "field" plots to avoid confusion with nursery fields.

Two forest weather stations are available per nursery, and two sites must be established for their use. The sites must be ones that can be partially planted in each of three consecutive years. Depending on the seed sources, some units will put two sources on each of the two sites, and some will have only one source per site. Only 200 seedlings of each source will be carefully tracked, so it will not be a heavy workload. Site preparation will be the biggest problem on many sites, because we are asking that approximately one-third of each site be planted in three different years but with as similar conditions of competing vegetation as possible. We will be working individually with each Forest unit to develop a planting plan that is operationally feasible, statistically valid, and consistent with RIP plans and objectives.

As with the nursery phase, environmental conditions, handling, treatments, and seedling performance will be carefully recorded for analyses and correlations.

DATA HANDLING AND ANALYSIS

Obviously, data collection and handling are critical parts of RIP. Each nursery was provided with a microcomputer, an electronic data logger, and software to make them work in as simple, standardized, and accurate a manner as possible. Data are transmitted electronically from the weather stations and hand-operated data loggers, or manually through the computer keyboard, to spreadsheet files in the computer. Data summaries and graphs have been standardized; however, nursery managers can manipulate the data to generate other summaries and graphs as they wish. This information will be useful in planning and evaluating day-to-day nursery operations as well as for building a strong data base for continuing quality control. The data will also be used for scientific analysis by the members of the SAT. The weather and seedling data from the nurseries and forest sites will be archived at Fort Collins Computer Center for use in the future.

THE MISSISSIPPI EXPERIENCE

The W. W. Ashe Nursery, as a grower of 1-0 stock, served as a good shakedown test for the growing, testing, and planting phases of RIP. Nursery personnel from the managers to the technicians exhibited high interest in the Program and did a good job in conducting the necessary tasks. In cooperation with the Region 8 Office, the DeSoto National Forest, and the Southern Station, forest plots were established in Mississippi and Louisiana this past February. We found a few places where some minor procedural changes will be beneficial for the future, but the basic plan worked well.

THE COMING YEAR

Much needs to be done between now and next spring: The second crop is now being planted at the nurseries; coordination with Forest units is needed to ensure that site preparation and other preliminary tasks are accomplished; weather stations need to be installed on the forest sites; and the process of lifting, packing, testing, and outplanting must be accomplished for about 25 seedlots!

In terms of data handling, Russ Ryker, as a rehired annuitant, has been working on developing the format for the complete database as well as standardized programs for the electronic data loggers. The SAT has planned a fall meeting at which a complete set of weather and seedling growth data will be examined to ensure that the information is flowing as needed.

This is an ambitious program that requires the help of many people from throughout the Forest Service. Personnel at the nurseries have done a terrific job in spite of already heavy workloads; reforestation scientists, with the support of TMR, have given considerable time and thought to RIP even though it is not part of their regular research programs; FPM pathologists have met several times to standardize procedures, and they have conducted soil analyses on schedule; now, silviculturists and other Ranger District personnel will be asked to contribute their time and talents in the critical field performance phase of the program.

RISK TAKING IN SILVICULTURE

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Risk taking is not new to the practitioners of silviculture. By virtue of our being alive and being human, we are called on to take risks. Everyday we use our professional judgment in forecasting, we take risks. As a matter-of-fact, our profession is an art because our decisions dwell beyond the realm of the known in the world of speculation, maybes, I thinks, best guesses, and past experiences

Much has been said recently in the media, in our organization, in books, and in training sessions about risk management. The Chief told a subcommittee of congress on February 26th of this year, "Within the requirements of existing law and policy, I plan to emphasize innovative management that will give Forest Service employees more freedom to be creative and responsive as they go about their day-to-day work." The Washington Post quoted the director of the Office of Personnel Management, according to the February 27th Daily News Digest, as saying "Many federal officials are prone to avoid risk and dodge responsibility, instead of exercising independent judgment" and "--forward motion (of government) is threatened by managers who dodge this newly granted discretion (of flexibility and vitality)"

The January 26th edition of U.S. News and World Report had a lengthy article on risk takers. I am going to quote some statements from that article. "The railroads and steel mills of the 19th century were the products of their (risk takers) derring-do. Now, their (risk takers) billion-dollar takeovers, artificial-heart implants and aviation feats in experimental planes have made them heroic fiqures." University of Wisconsin psychologist Frank Farley says about risk takers, "They are the great experimenters of life, they break the rules." Economist George Gilder: "(they infuse) America with an entrepreneurial culture and spirit that are a key to America's ability to compete with Japan and other nations." Test pilot Dick Rutan said, "There are only two types of flying worth a damn-test pilots and combat. The rest is repetitive and boring and should be left to bus drivers." "Experts point out that the highly competitive nations such as Japan excel in applying technology but do not have as much creative capital as the United States. Some U.S. companies have gone so far as to make risk taking part of their corporate cultures." Psychologist Charles Garfield says of achievers, "We almost never hear the word failure, they don't see mistakes as failures but describe them as setbacks, a glitch, or course corrections."

I have two more quotes from this article. One is by Daniel Boorstin, Librarian of Congress; he said "Historically, risk takers are people who shatter the illusion of knowledge, they are willing to try something that everyone thinks is outrageous or stupid." And the article closes with another quote from Frank Farley, "We're on the verge of a quantum leap into exploration." It then goes on to say, "Why will people take these leaps into the unknown? It may be as simple as the thrill that Fast Eddie Felson found in the smoky pool halls of The Hustler: 'You make shots that nobody's ever made before. And you play the game the way nobody's ever played it before'."

Carefully analyzed, risk management takes two directions. One direction is to minimize risk taken. This is done by buying insurance, increasing inspections, adding quality checks, writing more detailed plans, prescribing more steps in a procedure, putting on protective equipment, increasing training, hiring better qualified people, etc. etc., etc. Don't we all wish risk had been reduced prior to the last Challenger flight? I watched an early morning T.V. show aimed at YUPPIES, that discuseed this kind of risk management. The Forest Service's safety programs, accident investigation, and recently, wellness program, is triggered by this type of risk management. Our natural resource management gives strong consideration to this type of conservative risk management, especially with regard to threatened and endangered species, unstable soils, visuals, old growth, spotted owls, and cavity nesters.

The other side of risk management is purposely taking risks. Perhaps we knowingly take risks for the thrill of it. We sky dive, downhill ski, rock climb, race cars, fly planes, hurl our bodies off cliffs into the ocean, walk through downtown New York or Washington alone at night or tell our spouse we don't like what they are wearing.

We also take risks for gain such as: gaming in Reno, or supporting our state's lottery, or buying stocks and bonds, presenting a new idea to the boss, running for public office, or planting a garden in April, in Lakeview, Oregon.

It is this latter type of risk management I will cover today. I will be discussing taking risks to gain a profit. Of course in the case of the Forest Service, the profit we gain is usually in the form of cost savings, not added benefits. But, if we become more cost efficient by spending less, rather than receiving more, we are just as far ahead.

First of all, let me state that the atmosphere on the Fremont National Forest is conducive to taking risks. The Forest Supervisor encourages us to take "smart" risks when we can save money, people, or time. Secondly, all the district silviculturists on the forest are willing to be innovative and look for new, and perhaps, risky ways to do business. Thirdly, there are other staff specialists, both in the Supervisor's Office and the Districts that are eager to be creative. And last, the people that aren't willing to take risks, or be innovative, don't create impediments to the process.

I will describe seven areas where we have successfully taken risks on the Fremont National Forest. All of these affect silviculture, to some degree, and four of them were coordinated efforts with other disciplines. This latter point fits nicely with the overall theme of this conference.

The first area is stewardship contracting for reforestation. Gaston Porterie will cover this topic much, so I defer to his experience and expertise. I just want to mention that the Fremont has let two years' worth of these contracts and has a solicitation into contracting for a stewardship contract for animal damage. This asks the contractor to protect previously planted units, for a certain period of time, from whatever animal happens along.

The second program is called the Fuel Appraisal Process. This was the subject of my talk to this body in Rapid City two years ago. Briefly, the system determines the probability of an area catching on fire, and what the dollar loss of that fire will be. We then determine how much we can afford to treat activity fuels. The question that generated this process came from silviculturists who felt they were spending too much money cleaning up precommercial thinning fuels. This is now a national system. This process was primarily driven by our fire people, with help from silviculture.

The next area I'll mention is our underburning program. The credit for this also must go to our fire people. But the silviculturists are generally supportive and think the underburning will save substantial amounts of money, when integrated with the above fuel appraisal process. This underburning program is not news to the south, but it is innovative in the northwest. The purpose is to return the stands to the low fuel hazard levels that natural fires produced prior to aggressive fire suppression. We have our ponderosa pine habitat types on a 20 year frequency of underburning.

The fourth area is contractor self inspection for all silviculture contracts. I think this one is quite humorous because we thought it was the law of the land. So, we went into it like lambs to the market. Then we found we were the only ones around and were catching a lot of heat for doing it in planting contracts. Since we had convinced ourselves that we could save money, not give away the farm, and save FTE's by doing the contractor self-inspection, we bowed our neck and finished the season. Then we found ourselves as regional and national leaders in self-inspection. It shows that sometimes being head-strong pays off. But again, I emphasize, that we didn't know at the time we had an option to do otherwise. If I were to summarize one good thing about contractor self inspection, it is to say, that it keeps us from playing supervisor to the contractor's employees.

The district silviculturist of our Paisley Ranger District, Bill Wolertz, developed our fifth venture. This is a process to predict animal damage on a plantation and also determines volume loss over a rotation and the subsequent value loss of the animal damage. This gives us the ability to do a marginal analysis to determine when it would pay to protect seedlings from predicted animal damage. Animal damage predictors are not new, but the marginal analysis ability was new to us. This will push us to increase our risk taking by not protecting from animals and to grit our teeth when we see some damage. What Bill discovered is that we can live with a lot of damage that visually looks bad.

The sixth action we adopted was grazing plantations to release them from grass and forb competition. This was a joint effort with the range conservationists of the forest and was initiated to reduce damage from cattle. We found by initiating the timing and duration of the grazing, we not only controlled damage, but got release. The idea was borrowed from Weyerhaeuser Co. who had been doing it for three or four years at that time. The secret was to turn lots of cattle on early for a short period of time, and then get them off. This year we are going to graze our first and most famous seed orchard. Think of letting cattle within five miles of a seed orchard a few years ago. This is a risk for no other reason than dealing with those silviculturists who think the only place you should see a cow is smothered with onions and mushrooms.

The last bit of risk taking I'll share with you is known by the generic name "reforestation risk taking". It actually can encompass other areas such as planting units that have not been burned or site prepared in any other way. Reforestation risk taking is a process to quantify the risk and monitor the results. The silviculturists were told by management to take risks, but not how much or where or given any relief from targets or survival and growth. After an S.A.I. plan and K.V. collection activity review pointed out this problem, we were given the charge of quantifying risk. "We" means the district silviculturists and yours truly.

What we developed was an agreement between us and the forest leadership team that set an agreed upon limit on reforestation costs for a fiscal year. This cost per acre included all overhead, computers, building maintenance, and other items. In return, we were allowed to measure our success by having 2/3rds of our units meeting the first year survival goal minus 10%. This 10% was the risk we were taking. What this did was have us look at each unit rather than an overall average survival which had total failures mixed in with tremendous successes. The process in a nut shell says the prescriber visits each unit and determines what he/she can eliminate in the normal process of reforestation to get the cost down to the agreed upon average cost, and estimate the risk of not meeting the survival goal. So, let's say the survival goal is 85% and the agreed direct project reforestation cost is $450/acre. At each unit, the prescriber would make a prescription that would aim at 85% survival and not cost more than $450/acre. Any money saved more than the $450 could be used on the difficult units, where savings can't be made. We don't keep books on each unit, however, we just look at the bottom line in costs, and we spread the first year survival out for all the units on the forest to see if 2/3rds meet 75%. So far this process has driven down costs and not affected survival. The value of the system is the dialogue with management, the process a prescriber uses to force him/her to look at alternatives, and to understand the limits of the risk taking. In effect, management has joined the risk wagon with the silviculturists.

The Fremont National Forest has recently been designated a pilot forest. I anticipate that the need to take risks in order to increase efficiency will be highlighted with this designation. We have tried many other items and found the risks too high for the pay offs, or the benefits were vastly over estimated. Carefully calculated risk taking makes the job interesting and the return can be great. But even with failure, progress will be made, because we know not to do that a second time the exact same way. But perhaps if we tried it just a little to the left..............?

Overview of Forest Stewardship

Gaston Porterie
Tiller Ranger District
Umpqua National Forest
Pacific Northwest Region

I. What is Forest Stewardship?

As applied to contracting for forestry services, forest stewardship is a system for achieving a result on-the-ground, giving the contractor more incentive and risk. Forest stewardship also is an opportunity to combine whatever different types of resource work you want into one contract, stretched over several years. The different types of work being tried so far include reforestation, timber stand improvement, fuels treatment, timber harvest and resources. Resource work under consideration includes clover seeding for deer/elk habitat enhancement, streamside vegetation management, and stewardship for the Sierra Summit Ski Area in California.

(overhead projection of overlay "Nature of Stewardship Contracts")
(attached)

II. How does stewardship work?

A contracting Request for Proposals is advertised with criteria for evaluation of the proposed work, and contractor proposals are evaluated by a "Board of Contract Review". Award is based on a rating scale and negotiation concerning proposal specifics and cost. Inspections are for intermediate completion payment and an end result.

The criteria can include a wide variety of specifications. The main silvicultural criteria for reforestation and timber stand improvement is the criteria for target crop trees.

(overhead projection of overlay "Sample Crop Tree Standards")
(attached)

The need for performance bonding is eliminated because of the payments held in reserve over time, and the tighter selection criteria with regard to contractor experience and management.

III. Innovative Contract Activity across the Regions

As of April, 1987 these are at least some of the National Forests with stewardship-style contracts (including end results, multi-year or other negotiated planting contracts) working, being prepared, or considered:

Region	Forests
1	Flathead and Idaho Panhandle

2	Routt and Pike-San Isabel
3	two planned for next year
4	?
5	Klamath, Eldorado, Sierra
6	Fremont, Gifford Pinchot, Ochoco, Rogue River, Siskiyou, Siuslaw, Umpqua, Wallowa-Whitman, Willamette, and Winema
8	Kisatchie
9	Superior, Chippewa
10	?

(handout available, Journal of Forestry article; November, 1986)

(attached)

NATURE OF STEWARDSHIP CONTRACTS

MAY INCLUDE WHATEVER YOU WANT:

- Reforestation
- Timber Stand Improvement
- Timber Harvest (End Results Contract)
- Fuels Treatment

PROPOSALS ARE REQUESTED FOR PROCUREMENT

PROPOSALS ARE RATED BY YOUR GROUP ON:

- General operational prescription
- Specific unit treatments & methods
- Contractor's qualifications & experience
- Contractor's organization & management

PRICE & TREATMENTS ARE NEGOTIATED

ACTUAL PAYMENTS ARE BASED ON SUCCESS OVER TIME, INSTEAD OF TECHNIQUES

CONTRACTOR SHARES OUR RISK, AND WE TRUST CONTRACTOR MORE

STEWARDSHIP CONTRACT

SAMPLE CROP TREE STANDARDS

- SURVIVED AT LEAST ONE SEASON
- ACCEPTABLE SPECIES
- NON-CHLOROTIC
- TWICE THE HEIGHT OF SURROUNDING BRUSH OR HARDWOODS
- AT LEAST 250 TREES PER ACRE
- TREES SPACED AT LEAST 7.5 FEET APART
- UNDAMAGED, UNBROWSED, FREE TO GROW
- LEADER GROWTH AT LEAST:
    - 4" FOR SEEDLINGS
    - 12" FOR RESIDUAL SAPLINGS

Stewardship Contracts

Could privatization ultimately encompass the entire regeneration cycle on public lands?

By Gaston L. Porterie, Norman B. Gartley, and Alan J. Horton

Stewardship, the concept of responsibility for the total well-being of a piece of land, is evolving as a land-management tool. Range conservationists in the West have experimented with stewardship contracts on large blocks of rangeland with intermingled ownership (Oregon State University 1984). The Public Rangeland Improvement Act of 1978 authorized such contracts. As a result, in 1980, the secretaries of agriculture and the interior cosponsored model programs in Montana, Idaho, and California. National forests, public domain, and private rangelands are all part of this ongoing conservation effort (Cleary 1984).

Stewardship contracts are also developing as a silvicultural tool by which forestry contractors perform work over several years. Such contracts commonly include site preparation, tree planting, quality control, release from competing vegetation, and animal damage control. Other possibilities are timber harvests, fuel treatments, cone collection, growing seedlings in nurseries, and monitoring. Stocking control at the precommercial thinning stage could be added to multiyear contracts. The political popularity of privatization could lead government land managers to contract out the entire regeneration cycle, retaining only direction and general control of prescriptions and operations.

Reforestation contractors would benefit from the long-term security of stewardship contracts compared to the continued hassle of entering low bids, while still running a business. With a better idea of long-term workload, the reforestation industry could help stabilize local work forces.

Shared care for seedlings would be an improvement over the adversarial relationship that sometimes occurs in conventional contracts. Better care and greater seedling survival result from better communications and the sharing of incentives and risk by land managers and contractors. Cooperation between government agencies jointly involved in stewardship contracts is another plus

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The Dorena Experience

Administrative costs are down, but treatment costs are up.

In 1980, the USDI Bureau of Land Management (BLM) explored the potential benefits of contracting for reforestation using a "stewardship" concept. The agency was encouraged to do so by the Northwest Forest Workers Association, a consortium of silvicultural contractors located in Eugene, OR. Using a favorable feasibility study, staff of the Oregon state office of the BLM developed the first stewardship contract.

In November 1982 the contract was awarded, providing for reforestation of 540 acres at a cost of $437 per acre on the Eugene District, Dorena Resource Area. The BLM furnished the seedlings and prepared the units for planting. The contractor was responsible for reforesting the units within 3 years. Incentive payments were dependent on quality of tree planting and vegetation control.

First-year results—In 1983, planting quality was superior on all but one unit. A first-year survival survey showed that all but one unit had acceptable stocking. The contractors replanted the marginally stocked unit at their own expense. Treatments conducted the first year included planting, mulching, seedling protection, and brush and hardwood control. Vegetation control included both chemical and manual treatments. Overall, the contractor accomplished the treatments in a timely manner and with high quality.

Second-year results—In 1984, the contractor continued to monitor the units and perform necessary seedling protection and control of competing vegetation. Stocking levels remained satisfactory despite a long dry period in late summer.

Third-year results—In 1985, the contract was completed with about 80 percent survival.

A second stewardship contract was prepared and awarded in December 1984 for 590 acres. The Pacific Northwest had a record drought in 1985, and first-year reforestation survival was generally poor on difficult sites. Stewardship contracts will occasionally need replanting.

The BLM is tracking the costs of stewardship versus the low-bid method of reforestation contracting. Evidence indicates savings in administrative costs, because of fewer procurement actions and because of reductions in contract inspection, but higher treatment costs. The results of trial contracts will provide the background material for decisions on the future use of stewardship contracts.

in this era of land-interchange proposals.

The Process

Stewardship contracts are negotiated in a manner similar to other contracts for professional services, such as archeological surveys. The contracts are based on how well the proposals of contractors meet silvicultural prescriptions. Stewardship contracts often differ from other professional service contracts by having a longer time span, with payment made for end results rather than work performed. The end result is a specified stocking of healthy, vigorous crop seedlings on each acre at the end of a three-year period. The USDA Forest Service (1985, 1986) and the USDI Bureau of Land Management (1982) have prepared sample stewardship contracts.

Competing proposals are evaluated by criteria such as general prescriptions, site-specific prescriptions, personnel qualifications/experience, and organization/management. Criteria may include the participation of a qualified forestry advisor. Proposal prices are weighed in the context of the evaluation rating and a preset price cap. The contracting land manager may negotiate changes in prescriptions or price to accomplish objectives and then select the best qualified contractor, who may or may not be the lowest bidder.

Negotiations are crucial. A contractor's proposal may contain a practice that will be inefficient in accomplishing the prescription. Then again, a contractor may offer "a better idea." Utilizing the skills and knowledge of forestry contractors could lead not only to efficient treatments, but also to increased commitment of the contractor to the job.

Bonding may not be needed, because graduated payments to the contractor depend on satisfactory intermediate and final products. With bonding eliminated, smaller contractors no longer have a bidding disadvantage. Incentive payments may be made for quality work, such as planting without "J" roots or extra release from competing vegetation. Typically, first-year payment is 40 percent after planting and 20 percent after first-season survival. Second- and third-year payments of 20 percent each are made if crop survival and growth are satisfactory. The schedule can be extended in long-term contracts.

Because of multiyear contracts, funds for the entire term may have to be available up front. Although contracting agencies are thus required to commit funds in advance, compensating long-term savings are projected.

Attractive Alternative

By combining several types of contracts into one, stewardship requires less administrative paperwork, especially when several districts, areas, or tree farms are joined together in a single contract. Administrative savings can be considerable, because the more restrictive contracting procedures, such as small business set-aside, wage determinations, hiring requirements, and other requirements become fixed costs in a government contract. For example, a single stewardship contract for a national forest could spread a fixed cost over several districts and several years, thus reducing cost per acre.

Operational savings can also be achieved by reducing the need for inspections and by providing motivation for quality work. Dollar savings accrue operationally along with savings in the number of personnel needed in times of organizational attrition. Contractors may also save costs by using the same machinery for both logging and site preparation if called for in the same contract.

Despite high startup costs ($400 to $600 per acre in the Northwest), costs for stewardship work are comparable to the sum of a series of conventional contracts for site preparation, tree planting, seedling protection, and release. In the early 1980s the first stewardship contracts were new and different, and not many bids were received. As the stewardship market becomes established, bid prices should decrease as forestry contractors discover the advantages of these contracts.

Stewardship contractors prepare operational prescriptions for on-the-ground treatments to carry out the land manager's prescription. The expertise required and the cost to the contractor of preparing operational prescriptions for a proposal ($2,000 or more) will limit the market to serious bidders. *Table 1* provides a sampling of stewardship endeavors now under way. Reports on the Dorena, Umpqua, and Winema contracts are presented in boxes on pages 30, 32, and 33.

Not all the stewardship action is in

Table 1. Representative multiyear stewardship contracts of the USDI Bureau of Land Management (BLM) and the USDA Forest Service (FS) in Oregon, 1983–86.

Agency	Location	Tree planting	Area	Work*
		yr.	*ac.*	
BLM	Eugene District			
	Dorena Resour. Area	1983	541	PR, PL, QC, RL, AN
		1985	594	PR, PL, QC, RL, AN
FS	Umpqua Natl. For.			
	Tiller Ranger Dist.	1984	183	PR, PL, QC, RL, AN
		1985	813	PR, PL, QC, RL, AN
		1986	414	PR, PL, QC, RL, AN
FS	Winema Natl. For.			
	Chemult Ranger Dist.	1986	1,888	CC, TH, FT, PR, SE, PL, QC, IN, RL, AN
FS	Ochoco Natl. For.			
	Prineville	1987	800	PR, PL, QC, RL, AN
FS	Willamette Natl. For.			
	Blue River Ranger Dist.	1985	165	PR, PL, QC, RL, AN
FS	Wallowa-Whitman Natl. For.			
	Baker/Unity Ranger Dist.	1987	±500	PR, PL, QC, AN
FS	Siuslaw Natl. For.			
	Hebo Ranger Dist.	1986	592	PL, AN, RL

**Codes:*
PR = site preparation
PL = tree planting
QC = quality control
RL = release
AN = animal damage control
TH = timber harvest
FT = fuels treatment
CC = cone collection
SE = seedling production
IN = self-inspection

The Umpqua Experience

Survival rates are up.

Based on the experiences of the BLM silviculturists, the staff of the Umpqua National Forest in Roseburg, OR, decided to explore the stewardship concept. A task group, working together as a board of contract review, provided opportunities for the kind of hands-on, value-driven action described by Peters and Waterman (1982) in their best-selling book on management. Such involvement usually occurs in environmental analysis and planning rather than in project operations. The agreement of the task group that all decisions would be reached by unanimous vote facilitated implementation.

A forest-stewardship contract was modeled after the BLM boilerplate. With the assistance of foresters and contracting officers from the regional office, the first stewardship contract of the USDA Forest Service was awarded in 1984. Following negotiations, a silvicultural contractor agreed to reforest 183 acres on the Tiller Ranger District.

Tree planting began in the winter of 1984. An immediate, positive change was apparent in the attitudes of the tree planters toward quality control. Special care was taken in handling seedlings, selecting planting spots, digging holes in deep logging slash, placing roots, and protecting microsites. A rapport developed between the contractor and Forest Service personnel, and productivity improved.

After the dry summer of 1984, planted tree survival was 93 percent for the stewardship units, while planted tree survival on conventional-contract units averaged 85 percent. This was despite the

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On the Umpqua National Forest, stewardship contracts encourage planting in deep logging slash.

fact that stewardship units occupied more severe sites than conventional planting. Area plantation exams made of stewardship units in November 1984 showed 95 to 100 percent of the plots satisfactorily stocked. Second-year plantation exams showed these stewardship units to be 95 to 123 percent stocked, demonstrating that good initial survival tends to continue over time.

In January 1985 a stewardship contract was awarded for 813 acres on the Umpqua National Forest at a price significantly below the cost of doing the work by separate contracts. After the severe summer drought of 1985, average stewardship seedling survival was 78 percent versus 70 percent on conventional reforestation contracts. The stewardship contractor spot-replanted to bring stocking levels up to prescribed objectives.

the West. Negotiated contracts for tree planting are being used by National Forest System personnel in the South and North Central regions as well. The Kisatchie National Forest (LA) and the Superior and Chippewa national forests (MN) are requiring that planting contractors submit technical proposals similar to stewardship contracts in the West.

Proposals are evaluated with criteria such as local planting experience with certain methods or equipment, qualifications of supervisors and crew, past contract success, equipment, techniques, quality control, and business-administration skills. Though the reforestation environment and the economic climate may differ, foresters throughout the country seek the same quality and cost-effectiveness demonstrated by stewardship contracts. With current demands for reforestation success on smaller budgets, the low-bid and sometimes low-success contract is becoming less desirable.

James L. Barrett, a timber, range, and wildlife staff officer with the Kisatchie National Forest, reports that stewardship-style contracts have been performed for the planting of 6,000 acres over the last 3 years. Seedling survival for these Southern pines is up, whether hand- or machine-planted. The average cost for 1984–85 was $57/acre, which should make Western foresters envious.

East and West, stewardship contracts are off to a good start. Land managers are becoming more aware of stewardship as an attractive alternative to low-bid contracts in achieving sound forest management. Increasing expectations and the rapidly changing values of public landowners demand just such innovation and efficiency from natural-resource managers. ■

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The Winema Experience

Can stewardship contractors reforest beetle-damaged lodgepole pine stands?

Stewardship contracts are being tested on the Winema National Forest in southern Oregon to bring 160,000 acres of mountain pine beetle infested lodgepole pine stands under management, without increasing the federal workforce. The stewardship concept is being applied through an end-results contract.

In a recent value analysis (a method for evaluating projects to achieve required functions at optimum cost), personnel compared conventional forestry contracts with the stewardship approach. Improved efficiencies associated with the integrated nature of stewardship surfaced as the most likely area of improvement. New federal acquisition regulations, a mountain pine beetle epidemic, a shrinking federal workforce, and the desire of land managers to foster a partnership between government and forestry contractors have influenced the decision to explore end-results contracts.

The total reforestation of decadent lodgepole pine stands has been integrated into one contract. Biomass removal, seed collection, seedling production, fuels treatment, site preparation, planting, natural seeding, and stand tending have been included in a 5-year package. The first end-results contract was awarded for 1,888 acres. Dead and decadent lodgepole pine trees are currently being sheared and stacked on site to dry before removal. Winema personnel recently awarded several more end-results contracts, featuring natural-regeneration strategies in the beetle epidemic area and totalling 5,004 acres. Road construction on the Winema is also being handled by end-results contracts.

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STEWARDSHIP REFORESTATION IN REGION 5

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The Scott River District of the Klamath National Forest has implemented a three-year Stewardship Reforestation contract involving three backlog brushfield units for 105 acres. The essence of the project is that the Steward is reponsible for establishing conifer plantations and meeting specific goals for the plantations through the third growing season. All three units were planted and baited for pocket gophers by the Steward in April 1986, and baited again in September-October 1986.

Realized and perceived benefits of Stewardship include:

1. Saving on contract administration time. To date, 11 person-days have been spent on administering the project. Under comparable service contracts, 34 person-days would have been required to administer the work accomplished to date.

2. Saving on preparation, solicitation and administration of separate contracts to accomplish prescribed treatments. For this project, one contract replaced six separate contracts (planting; vegetation management - 2 treatments in 2 years; gopher damage control - 3 treatments in 3 years)

3. Relieving available personnel from intensive inspection duties to accomplish beneficial project work (TSI, RCA, stand monitoring, etc.).

4. Project funding. Funds for multi-year contracts may be set aside, essentially guaranteeing all treatments necessary for reforestation

success will be implemented. (This project required appropriated (RI) funds.)

5. Encouraging professionalism among service contractors by allowing them to develop a vested interest.

A snowballing of stewardship could conceivably save 15-25 percent of costs associated with forest regeneration.

Solicitation of the project was through a Request for Proposals. Prospective stewards were asked to prepare a prescription for each unit, and to supply information on qualifications and experience of key personnel, as well as information on their organization and management structure. A price proposal was also required.

Bonding was not available to prospective stewards because of risks of multi-year contracts perceived by bonding companies.

A Board of Contract Awards was established to review and rank proposals against established criteria. Following this procedure, price proposals were opened and a cost/quality ratio was established.

Award was made to the offeror whose technical proposal was acceptable, and whose cost/quality relationship was most advantageous to the Government.

The technical proposal of the successful offeror has become part of the contract, as will any environmental documents prepared by the District. The Steward shall assess treatment needs during the life of the contract and, as required, submit modifications to the original proposal for consideration by the District.

Quality of work accomplished by the Steward is being measured against project standards for tree root placement, stocking at the end of each of the first three growing seasons, and control of competing vegetation.

Progress payments will be made as each objective is met. Incentive payments for superior work in tree root placement and control of competing vegetation can be earned.

As written, this contract can be applied on any District with very minor modification. The document is on DG for easy transfer and utilization by another unit.

A principal goal of this project is to control competing vegetation to directly promote conifer survival and growth, and to indirectly reduce losses to pocket gophers by controlling their habitat. The Steward prescribed ground application of herbicides to meet this goal. The District is seeking an exception to the herbicide moratorium which will allow the Steward to proceed with his prescription as planned.

Allowing the Steward to proceed as planned will allow the continuity and integrity of his proposal to be retained. It will show that Forest Service policy can be consistent enough to allow engagement in multi-year reforestation contracts, encouraging future participation by the private sector. And the probability of successfully reforesting these old brushfields will be greatly enhanced.

*U.S. GOVERNMENT PRINTING OFFICE:1989-241-854:00123/FS