WISCONSIN FOREST MANAGEMENT GUIDELINES

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Wisconsin Department of Natural Resources
Division of Forestry
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For additional information, call **608-267-7494** or visit our web site at:
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FOREWORD

Dear Wisconsin Woodland Owner, Forest Enthusiast or Resource Professional:

Wisconsin is fortunate to have more than 15,000,000 acres of forestland. During the last century, we learned the phenomenal value of our forests after nearly losing them to land use conversion and fires. Future social, economic and environmental pressures will be different, but we have a duty as a society to find ways to meet our needs without imperiling the productivity of forests for future generations. That is the goal of sustainable forestry, outlined in the chapters to follow.

Agreeing on measures to protect forest ecosystems while addressing our many values and needs is complex. The Department of Natural Resources (DNR) welcomes broad discussion of the principles of sustainable forestry. To that end, a draft edition of *Wisconsin's Forest Management Guidelines (FMG)* was distributed for public review between October 2002 and March 2003.

Hundreds of comments received in the course of five open house meetings and from letters were considered in developing this updated edition. Not every suggestion could be incorporated (some being in conflict, depending on the perspectives of the respondents), but the DNR made a sincere effort to craft a practical reference within time and budget constraints. I hesitate to call it a "final version," recognizing that more opportunities for improvement will be discovered as we use the FMG. Future editions will be released as changes are accumulated.

Keep in mind that the FMG is not meant to be an exhaustive textbook. Our goal is to establish basic, sensible concepts that outline responsible resource management at the site-level. Other technical publications should be used to learn details or explore additional landscape scale considerations. Although application of the FMG is voluntary, the document does refer to statutes, administrative rules and programs that could involve mandatory procedures or prohibitions. In those situations, users are encouraged to review original source regulations for specifications that may not be covered here.

The FMG is written for resource managers and enthusiasts. Our hope is that it is straightforward and appealing enough to be understood with little effort. A companion version designed for woodland owners and others looking for a simpler presentation is being developed and will be made available in 2004.

The Wisconsin DNR owes a debt of gratitude to the Minnesota Forest Resources Council, who granted permission to base this manual on a similar project completed in Minnesota a few years ago. We are pleased to be able to build on Minnesota's process, which was an Herculean effort involving more than 80 partner organizations, hundreds of meetings, and more than three years worth of time. Perhaps they will find something new in our efforts that will be useful for them.

In whatever way you are involved in the forests of Wisconsin, I hope you find this guide helpful. Your commitment to protect and sustainably-manage Wisconsin's forests is greatly appreciated.

Sincerely,

Paul Delong
Chief State Forester

MASTER INDEX

FOREWORD

MASTER INDEX C
THE PURPOSE OF INTEGRATED GUIDELINES ..... N
How this Guidebook is Organized ..... N
THE CONCEPT OF INTEGRATED GUIDELINES ..... O
Who Will Use the Guidelines? ..... O
FACTORS THAT MAY AFFECT IMPLEMENTATION ..... P
WHAT THE GUIDELINES ARE ..... Q
WHAT THE GUIDELINES ARE NOT ..... R

CHAPTER 1 — WISCONSIN'S FORESTS: A QUICK OVERVIEW

A STATEWIDE SNAPSHOT OF WISCONSIN'S FORESTS 2
Wisconsin's Forests 2
Forest Area 2
Forest Types 3
Number of Trees 4
Timber Volume 4
Growth and Removals 5
Economic Importance 5
Biodiversity 5
Ownership 6
Urban Forests 6
A BRIEF HISTORY OF WISCONSIN'S FORESTS 7
Forests Before European/American Settlement 7
Forests Since European/American Settlement 9

CHAPTER 2 — GENERALLY ACCEPTED SILVICULTURAL PRINCIPLES

SUSTAINABLE FORESTRY 15
LANDOWNER GOALS AND OBJECTIVES 16
SITE EVALUATION AND STAND DELINEATION 17
Forest Cover Types and Silvicultural Alternatives 19
SILVICULTURAL SYSTEMS OVERVIEW 21
EVEN-AGED SILVICULTURAL SYSTEMS 25
Even-aged Harvest and Regeneration Methods 25
Even-aged Tending Methods 33
Even-aged Harvest Considerations 34
UNEVEN-AGED SILVICULTURAL SYSTEMS 35
Uneven-aged Harvest and Regeneration Methods 35
Uneven-aged Tending Methods 37
Uneven-aged Harvest Considerations 38
PASSIVE OR NON-MANAGEMENT OPTIONS 39
SILVICULTURAL SYSTEMS SUMMARY 40
Table 2-1: Generally Accepted Regeneration Harvest Methods By Forest Cover Type 41
SALVAGE HARVESTS 42
UNSUSTAINABLE CUTTING METHODS 43
MANAGEMENT PRESCRIPTIONS 44
RESOURCES FOR ADDITIONAL INFORMATION 46

CHAPTER 3 — WILDLIFE HABITAT

SPECIFIC WILDLIFE HABITAT GUIDELINES 49
Leave Trees and Snags 49
Coarse Woody Debris and Slash 51
Conifer Retention and Regeneration 52
Mast 55
Patterns of Cutting 56
Endangered, Threatened and Special Concern Species 58
State Natural Areas and Rare Natural Community Types 61
Affected Natural Communities 62
Field Survey Consultants and Other Resources 64
Wetland Inclusions and Seasonal Ponds 65
Riparian Wildlife Habitat 66
RESOURCES FOR ADDITIONAL INFORMATION 69

CHAPTER 4 — VISUAL QUALITY

THE VALUE OF VISUAL QUALITY 72
A Concern for Aesthetic Quality 72
Benefits of Visual Quality Management 73
VISUAL SENSITIVITY LEVELS 75
Recognizing Different Levels of Visual Sensitivity 75
Visual Sensitivity Levels 75
The Value of Recognizing Different Levels of Visual Sensitivity 76

CHAPTER 5 — RIPARIAN AREAS AND WETLANDS

THE VALUE OF RIPARIAN AREAS 78
A Transition from Aquatic to Terrestrial Ecosystems 78
Potential Threats to Riparian Areas: Pollutants and Impacts 79
Protecting Riparian Functions and Values 81
RIPARIAN MANAGEMENT ZONES 84
What Exactly is a Riparian Management Zone? 84
Agricultural and Urban Areas 84
Existing Regulations 85
BMPS FOR RIPARIAN MANAGEMENT ZONES 86
BMPs: Riparian Management Zones 86
BMPs: Lakes and Navigable Perennial Streams 87
BMPs: Navigable Intermittent Streams 87
BMP: Non-navigable Streams 87
WETLANDS 88
BMPs: General 88

CHAPTER 6 — CULTURAL RESOURCES

CULTURAL RESOURCES 90
Forest Management for the Protection of Cultural Resources 90
What Cultural Resources Are 91
Economics of Cultural Resource Management (CRM) 91
Potential Impacts 92
Cultural Resource Management (CRM) and the Law 92
Cultural Resource Inventories 93
Assessing Cultural Resources 93
Field Identification of Cultural Resources 94
Assessing Management Alternatives 94
When Accidental Discovery Occurs 94

CHAPTER 7 — FOREST SOIL PRODUCTIVITY

THE VALUE OF FOREST SOIL PRODUCTIVITY 96
Sustainable Soil Productivity 96
SOIL CHARACTERISTICS AND POTENTIAL IMPACTS 97
Three Related Groups of Soil Characteristics 97
Characteristic 1: Physical Characteristics of Soil and Potential Impacts 97
Characteristic 2: Chemical Characteristics of Soil and Potential Impacts 101
Characteristic 3: Biological Characteristics of Soil and Potential Impacts 103
APPLYING GUIDELINES TO VARYING SITE CONDITIONS 104

CHAPTER 8 — ECONOMICS

BALANCING ECONOMIC CONSIDERATIONS AND OTHER FOREST VALUES 107
BASIC FOREST MANAGEMENT AND ECONOMICS: THREE THINGS EVERY FOREST LANDOWNER SHOULD KNOW 108
1. How to Increase the Returns from Forestry Investments 108
2. How Forest Products Are Sold 111
3. How to Get Fair Market Value for Your Timber 111
ADVANCED FOREST ECONOMICS: AN INVESTMENT ANALYSIS PRIMER 115
TAX AND RECORD-KEEPING CONSIDERATIONS 120
The Original Basis: A Key Tax Consideration 120
Forestry-related Tax Deductions 123
RESOURCES FOR ADDITIONAL INFORMATION 124

CHAPTER 9 — FOREST MANAGEMENT PLANNING

FOREST MANAGEMENT PLANNING 126
Incorporating Sustainability Into Forest Management Plans 126
Forest Management Plan Elements 130

CHAPTER 10 — GENERAL OPERATIONAL GUIDELINES

OPERATIONAL CONSIDERATIONS 134
Timing and Coordination of Activities 134
Designing Operations to Fit Site Conditions 135
Managing and Minimizing Infrastructure 135
PROTECTING CULTURAL RESOURCES 136
FUELS, LUBRICANTS, WASTE, AND SPILLS 137
Fuels, Lubricants and Waste 137
Spills 137
BMPs: Spills 137
POST-OPERATIONAL ACTIVITIES 138
BMPs: Nonpoint Source Pollution Prevention 138

CHAPTER 11 — FOREST ROAD CONSTRUCTION AND MAINTENANCE

Integrated Resource Management Considerations 140
UPLAND FOREST ROADS 142
BMPs: Planning, Location and Design 142
STREAM CROSSING DESIGN AND CONSTRUCTION 143
BMPs: Fords 143
BMPs: Stream Crossings 144
BMPs: Pipe Culverts for Stream Crossings 145
ROAD CONSTRUCTION AND DRAINAGE 147
BMPs: Road Construction and Drainage 147
DRAINAGE STRUCTURES 149
BMPs: Drainage Structures 149
BMPs: Pipe Culverts for Cross-drains 150
BMPs: Open-top Culverts 150
BMPs: Broad-based Dips 151
BMP: Waterbars 151
SOIL STABILIZATION 152
Mulch and Seeding 152
BMP: Mulch and Seeding 152
BMP: Diversion Structures 152
BMP: Sediment-control Structures 153
WETLAND FOREST ROADS 154
BMPs: Wetland Roads, Skid Trails and Landings 154
15 FEDERAL REQUIREMENTS 155
BMPs: Forest Roads in Wetlands 155
ROAD MAINTENANCE 156
BMPs: Road Maintenance 156

CHAPTER 12 — TIMBER HARVESTING

Integrated Resource Management Considerations 158

PLANNING AND DESIGN CONSIDERATIONS 159

Soil Productivity 159
Water Quality and Wetlands 159
BMP: Planning and Design 159
Visual Quality 159
Cultural Resources 166
Slash Management and Landings 166
Leave (Reserve) Trees, Coarse Woody Debris, and Snags 167

OPERATIONAL CONSIDERATIONS 168

Protecting Soil Productivity 168
Protecting Water Quality and Wetlands 168
BMPs: Protecting Sensitive Areas 168
Protecting Cultural Resources 169
Skid Trails 169
BMPs: Skid Trails 169
BMPs: Stream Crossings for Skidding 169
Landings 170
BMPs: Landings 170
Minimizing Rutting 170
BMP: Rutting 170
Managing Slash 170
BMP: Slash 170
Snags (Standing Dead Trees) 171
Leave (Reserve) Trees 171
Providing Coarse Woody Debris 172
Managing the Harvesting Process 172
The Timber Sale Contract 172
Five Steps in a Careful and Successful Timber Sale 173
Understanding the Sample Timber Sale Contract 174
Contract Breach: A Very Serious Decision 174
What is Reasonable? 174

POST-OPERATIONAL ACTIVITIES 176

CHAPTER 13 — MECHANICAL SITE PREPARATION

Integrated Resource Management Considerations 178

PLANNING AND DESIGN 180

Layout and Design Considerations 180
Timing and Intensity of Activities 180
Selecting Application Methods 181
BMP: Selecting Application Methods 181

OPERATIONAL CONSIDERATIONS 183

Managing Slash and Windrows 183
Protecting Resources 183
BMPs: Protecting Resources 183

POST-OPERATIONAL ACTIVITIES 184

CHAPTER 14 — PESTICIDE USE

Integrated Resource Management Considerations 186

PLANNING 187

Considering All Your Options: Integrated Pest Management 187
Pesticide Characteristics Affecting Ground and Surfacewater Contamination Potential 187
Selecting Pesticides 188
Selecting Application Methods 188
Spill Response 189
BMP: Spill Response 189

OPERATIONAL CONSIDERATIONS 190

Transportation of Pesticides 190
Storage of Pesticides 191
Emergency Planning and Community Right-To-Know 191
Mixing and Loading Operations 192
BMP: Mixing and Loading Operations 192
Pre-Application Activities 192
Timing and Weather Considerations 193
BMP: Timing and Weather Conditions 193
Applying Pesticides 193
BMPs: Applying Pesticides 193
Protecting Water Resources 194
BMPs: Protecting Water Resources 194

POST-OPERATIONAL ACTIVITIES 195

Equipment Clean-up and Container and Waste Disposal 195
BMP: Equipment Clean-up 195
BMP: Container and Waste Disposal 195

RESOURCES FOR ADDITIONAL INFORMATION 196

CHAPTER 15 — REFORESTATION

Integrated Resource Management Considerations 198

PLANNING AND DESIGN 199
Setting Goals 199
Site Evaluation 199
Planting Design 201
Species Selection 202
Spacing 202
Planting Arrangement 203
Direct Seeding vs. Seedlings 204
Seed Source Selection 205
Stock Type Selection 206

OPERATIONAL CONSIDERATIONS 207
Site Preparation 207
Planting 208

POST-OPERATIONAL ACTIVITIES 211
Monitoring Program 211
Vegetation Control 211
Animal Control 212
Insect and Disease Control 212
Weather and Environmental Damage 213

RESOURCES FOR ADDITIONAL INFORMATION 214

CHAPTER 16 — INTERMEDIATE SILVICULTURAL TREATMENTS

Integrated Resource Management Considerations 216

PLANNING 217

OPERATIONAL CONSIDERATIONS 218
Release 218
Thinning 220
Improvement Cutting 225
Salvage and Sanitation Cutting 225
Pruning 226

POST-OPERATIONAL ACTIVITIES 227

RESOURCES FOR ADDITIONAL INFORMATION 228

CHAPTER 17 — FIRE MANAGEMENT

PART I: WILDFIRE MANAGEMENT

Protection of Resources from Wildfire 231
Protection of Property from Wildfire 231

PART II: PRESCRIBED FIRE MANAGEMENT

Integrated Resource Management Considerations 232

PLANNING AND DESIGN 233
Burn Plan Management 233
BMP: Burn Plan Management 233
Land Management Objectives 234
Factors Influencing Fire Behavior 234

OPERATIONAL CONSIDERATIONS 236
Fire Spread Patterns 236
Ignition patterns 236
Firebreaks 240
Managing Fuelbreaks and Accesses 241
BMP: Managing Fuelbreaks and Accesses 241
Protecting Water Quality and Wetlands 242
BMPs: Protecting Water Quality and Wetlands 242
Smoke Management Considerations 242
Safety Considerations 243
Pre-burn Briefing 244

POST-OPERATIONAL ACTIVITIES 245
Post-burn Monitoring 245
Fire Effects Evaluation 245
BMPs: Post-operational Activities 245

RESOURCES FOR ADDITIONAL INFORMATION 246

CHAPTER 18 — FOREST RECREATION MANAGEMENT

Integrated Resource Management Considerations 248

PLANNING AND DESIGN 249

OPERATIONAL CONSIDERATIONS 251
Construction 251
Operations 251

RESOURCES FOR ADDITIONAL INFORMATION 252

GLOSSARY

Glossary....253

APPENDICES

APPENDIX A: MARKING AND CROP TREE SELECTION GUIDELINES....264
Marking Priority Guide....264
APPENDIX B: SAMPLE TIMBER SALE CONTRACT....267
Contract Performance, Period, Extensions, and Termination....267
Downpayment, Bond, Remedies, and Damages....268
Products To Be Removed....269
Sale Type, Scaling, Hauling, and Payments....269
Utilization and Operations....271
Notice of Intent To Cut and Compliance With Laws....273
Title, Boundary Lines, and Access....273
Liability and Insurance....273
General....274
APPENDIX C: MFL ENTRY REVIEW CHECKLIST....275
APPENDIX D: PESTICIDE LAWS AND RULES....277
APPENDIX E: REGULATIONS RELATING TO FOREST MANAGEMENT AND WATER QUALITY....279
Federal Laws....279
State Laws....279
APPENDIX F: PERMITS....284
Permits for Water Quality....284
Other Permits....284
APPENDIX G: CITED REFERENCES....285

RESOURCE DIRECTORY

FOREST MANAGEMENT ASSISTANCE AND EDUCATION 288
Wisconsin Department of Natural Resources 288
University of Wisconsin Extension (UWEX) 289
Forest Industry Safety Training Alliance (FISTA) 290
Wisconsin Family Forests (WFF) 290
Community Forestry Resource Center (CFRC) 290
Gathering Waters 291
Wisconsin Forest Productivity Council (WFPC) 291
USDA Forest Service Northeast Area 291
Wisconsin Woodland Owners Association (WWOA) 292
American Tree Farm® System (ATFS) 292
Wisconsin Walnut Council 292
CULTURAL RESOURCE ASSISTANCE 293
NON-TIMBER PRODUCTS 293
PETROLEUM SPILLS 293
SOURCES OF MAPS AND PLANNING TOOLS 294
Aerial Photography 294
Digital Mapping Resources 294
Wisconsin Wetland Inventory Maps 294
Topographic Maps 295
Soil Surveys, Soil Interpretations, and Erosion Control 295
FINANCIAL INCENTIVE PROGRAMS 296
Forest Tax Programs 296
Cost-sharing Programs 296
FISH AND WILDLIFE HABITAT, WETLAND PROTECTION 297
FOREST HEALTH 298
WATER CROSSINGS 298
PRESCRIBED BURNING 299
ENDANGERED, THREATENED OR SPECIAL CONCERN SPECIES 299
PESTICIDE USE 299
ADDITIONAL RESOURCES I HAVE FOUND 300

CREDITS AND ACKNOWLEDGEMENTS

Credits and Acknowledgements 301

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Purpose

THE PURPOSE OF INTEGRATED GUIDELINES

Figure A: Autumn in northern Wisconsin shows the diversity found in a mixed conifer and hardwood forested landscape.

How this Guidebook is Organized

Because this guidebook has been designed for a variety of audiences, some landowners may find it to be more technical than they need, while some resource managers may find it to be more basic than they might prefer. Some readers will be more interested in an overall understanding of "why" a particular resource (forests, wildlife, water, soils, visual quality, or cultural resources) is important relative to overall sustainability, and "why" particular strategies are employed in their management. Other readers will be more interested in "how to" implement a particular activity or practice needed to carry out a management strategy. They would like to know, for example, "how to" construct a forest road, or develop a forest management plan, or design and administer a timber harvest.

Part one of the guide – Chapters 1 through 8 – is designed to address the "whys" of each of a number of important resource components. Why do the forests of Wisconsin look like they do – how are they changing? Why are various timber stands harvested differently? What are the key issues related to wildlife management and the protection of water resources, riparian areas, soils, and cultural resources? Why is visual quality an important resource consideration, and what trade-offs need to be considered? Why are economic considerations an important component of the forest management decision-making process?

Part two of the guide – Chapters 9 through 18 – focuses on the "how" of specific activities that are normally carried out in the management of a forest. It begins with the development of a well-considered, ecologically-based forest management plan, and then presents integrated guidelines related to a number of "on-the-ground" activities necessary to carry out such a plan.

Obviously there is linkage between "why" and "how" a resource is managed. The management of any one resource also impacts others. The implementation of any one specific management activity must be considered from many perspectives. Readers are encouraged to explore the entire guide in order to gain a more complete understanding of any particular plan of action before proceeding.

Part three of the guide contains additional resources, ranging from a glossary of terms to a list of additional resources and sources of assistance.

• IMPORTANT NOTE •

The ***WISCONSIN'S FORESTRY BEST MANAGEMENT PRACTICES (BMPs) FOR WATER QUALITY FIELD MANUAL*** has been incorporated into and is found throughout this guide. BMPs are identified by the "✓" symbol.

THE CONCEPT OF INTEGRATED GUIDELINES

Sustainability means meeting the needs of the present without compromising the ability of future generations to meet their own needs. **Sustainable forestry** is a proactive form of management that provides for the multiple uses of the forest by balancing a diversity of both present and future needs. It is a process of informed decision-making that takes into account resource needs, landowner objectives, site capabilities, existing regulations, economics, and the best information available at any given time.

Those concerned about forest management have long recognized the challenge of balancing social, economic, and environmental objectives and implications. They also recognize the complex relationship between forest management practices and the long-term sustainability of our forests.

Integrated resource management approaches, comprehensive planning, and recommended practices and guidelines are not new ideas. So what is new? Three things:

- The concept of one set of integrated guidelines to support the sustainability of many different resources within forest communities.
- The recognition that guidelines should be designed to accommodate a wide range of resource needs, landowner objectives, and site conditions.
- The idea of a broad-based, collaborative approach to developing user-friendly guidelines applicable to forests throughout Wisconsin.

This concept of integrated guidelines recognizes the forest as a community of related resources, rather than a collection of separate resources. Integrated guidelines reflect the forest ecosystem that they are designed to help sustain.

Who Will Use the Guidelines?

These forest management guidelines have been developed for use by forest landowners, resource managers, loggers, contractors, and equipment operators, who share a concern for balancing forest management activities and the long-term sustainability of forest resources. Although many individuals may participate in managing a particular site, final decisions regarding guideline implementation lie with the landowner.

These guidelines were designed to help landowners, resource managers, and loggers determine how to protect the functions and values of forest resources during forest management activities. They do not provide advice on whether to manage or which management activities are needed.

Figures B and C: Sustaining forest resources for future generations depends on balancing a diversity of social, economic and environmental objectives, including production of timber for wood and paper products.

FACTORS THAT MAY AFFECT IMPLEMENTATION

Generally speaking, these guidelines are informational and voluntary. They are designed to help landowners and resource managers meet today's needs while also maintaining ecosystem integrity and productivity for future generations. Any federal, state and local regulations, however, whether or not referenced by these guidelines (such as endangered species laws, pesticide rules, permitting requirements, zoning ordinances, etc.), take precedence and must be observed. Landowners voluntarily participating in formal incentive programs such as Wisconsin Forest Landowner Grant Program or the Managed Forest Law are obliged to comply with the statutes and rules that apply, some of which may be reflected in these guidelines.

Parts of these guidelines also have special significance to private consulting foresters, and industrial forest products companies that voluntarily participate in Wisconsin's Cooperating Forester Program. Section NR 1.213 (3)b, Wisconsin Administrative Code, provides that a cooperating forester "shall manage private lands where the cooperator provides service in a manner which maintains the long-term capacity of the land to provide forest products, uses and values desired by landowners in accordance with the silvicultural guidelines in department handbooks and directives or a written, science-based forest management commitment submitted to and approved by the department in advance." For purposes of administering the Cooperating Forester Program, compliance with the following sections of these guidelines is considered mandatory:

- **Generally Accepted Regeneration Methods by Cover Type found in Table 2-1,** Chapter 2, page 41, unless the DNR has approved an exception described in a science-based forest management commitment submitted by the cooperator. The regeneration methods designated in the table have been substantiated by forestry research, and have been found to be reliable techniques for manipulating forest vegetation with predictable results. Since our understanding of forest ecology and silvics is constantly evolving, the management commitment option allows the adoption of new techniques as they are proven.
- **Wisconsin's Forestry Best Management Practices for Water Quality (BMPs),** designated by the symbol "✓" found throughout these guidelines. Wisconsin BMPs identify and explain guidelines for landowners, loggers and land managers to protect water quality. They were prepared in response to federal legislation. Section 208 of the 1977 Clean Water Act requires each state to develop plans and procedures to control "silviculturally related nonpoint sources of pollution ... to the extent feasible." Section 319 of the 1987 Water Quality Act requires each state to develop and implement a program to reduce nonpoint source pollution to the "maximum extent practicable." Compliance with Wisconsin BMPs will help meet our federal obligations.

Cooperating foresters must also abide by federal, state and local regulations, including those related to forest incentive programs administered by the DNR. Implementation of other information presented in these guidelines is encouraged, but not mandatory.

Figure D: Harvesting timber stands can contribute to the long-term health, productivity and sustainability of valuable forest resources.

WHAT THE GUIDELINES ARE

Figure E: Integrated guidelines recognize the forest as a community of related resources, rather than a collection of separate resources.

- The guidelines are designed to be flexible, recognizing that both site conditions and landowner objectives vary. Determining the most appropriate guidelines for implementation on a particular site depends on the informed judgment of the landowner, resource manager, or logger responsible for that site.
- It may be possible to implement several guidelines simultaneously in some instances. For example, trees left to protect cultural resources may also satisfy mast guidelines for wildlife, as well as apparent harvest size guidelines for visual quality.
- Implementation of the guidelines is voluntary, except as noted previously.
- The guidelines are designed to help forest landowners, resource managers and loggers meet two goals:
  - Conduct forest management activities while addressing continued long-term sustainability of diverse forest resources.
  - Promote or enhance the functions and values of water and soil resources, riparian areas, wildlife habitat, visual quality, and cultural resources.
- The guidelines represent practical, sound, and generally-accepted practices based on the best available scientific information.
- The guidelines are designed to assist with site-level forest management. They are not designed to provide broad-based landscape direction.

WHAT THE GUIDELINES ARE NOT

- The guidelines are not a substitute for a resource management plan. They are intended to support implementation of a plan once it is in place.
- The guidelines are not intended to replace any existing rules or regulations.
- The guidelines are not intended as a substitute for obtaining professional assistance as needed to achieve management objectives, or meet appropriate engineering standards. They are guidelines – not construction standards or engineering specifications.
- The guidelines are not designed to help determine whether a particular forest management activity should or should not occur. They are designed, instead, to provide guidance in how to implement a particular forest management activity.
- The guidelines are not intended to address all forest management activities and all forest resources. They address major forest management activities as they relate to selected components of a healthy forest.
- The guidelines do not address landscape scale considerations and issues. Landscape-level assessment, planning, and management issues are complex, and beyond the scope of these guidelines.

Figure F: Professional natural resource managers and educators like these are available across the state to assist landowners in the sustainable management of their forests. Contact your local Wisconsin DNR office for a copy of the Directory of Foresters, and see the Resource Directory in this manual for additional sources of information.

WISCONSIN FOREST MANAGEMENT GUIDELINES

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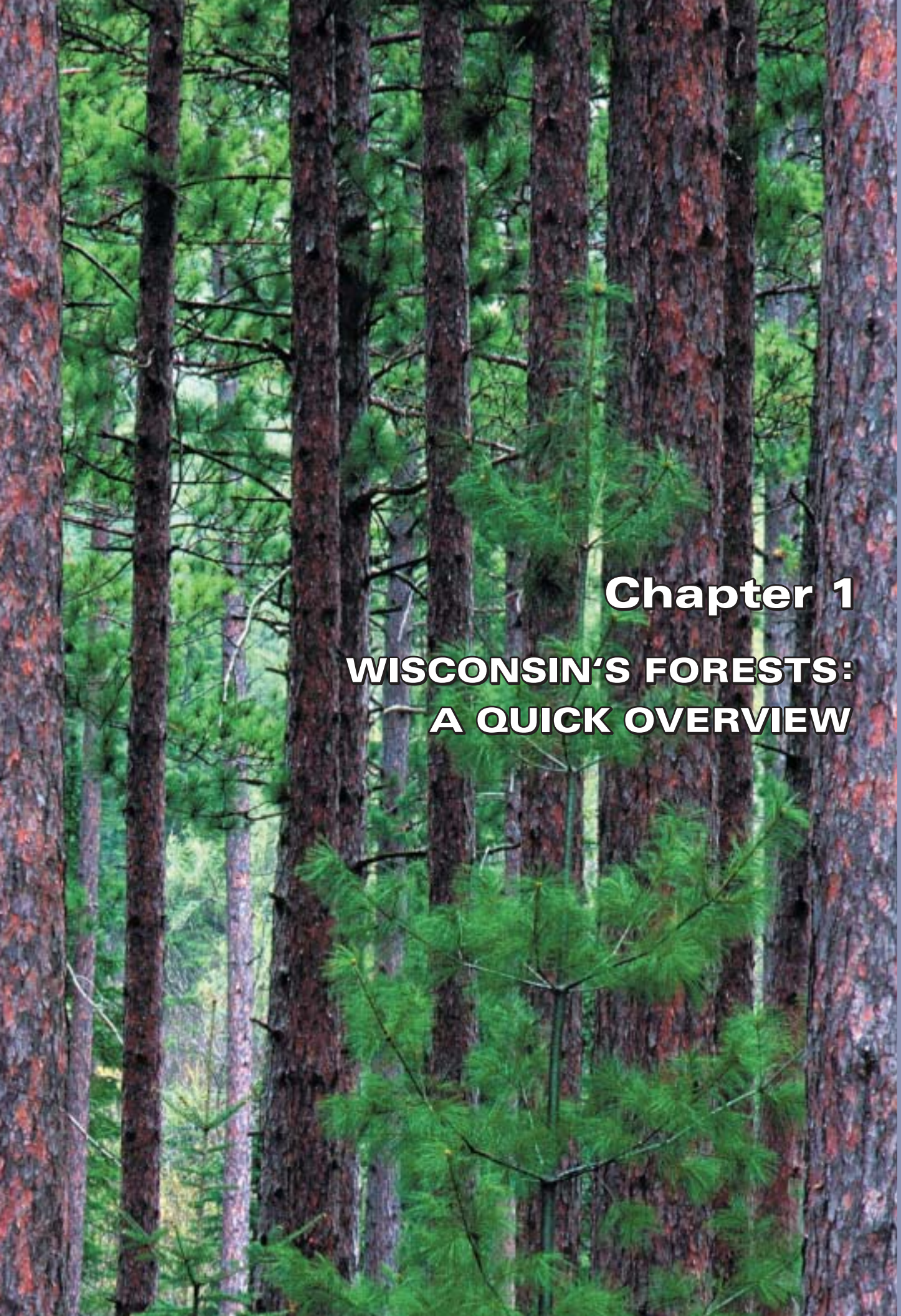

Chapter 1

WISCONSIN'S FORESTS: A QUICK OVERVIEW

CHAPTER 1 — WISCONSIN'S FORESTS: A QUICK OVERVIEW

A STATEWIDE SNAPSHOT OF WISCONSIN'S FORESTS 2

Wisconsin's Forests 2
Forest Area 2
Forest Types 3
Number of Trees 4
Timber Volume 4
Growth and Removals 5
Economic Importance 5
Biodiversity 5
Ownership 6
Urban Forests 6

A BRIEF HISTORY OF WISCONSIN'S FORESTS 7

Forests Before European/American Settlement 7
Forests Since European/American Settlement 9

A STATEWIDE SNAPSHOT OF WISCONSIN'S FORESTS*

Wisconsin's Forests

Wisconsin's forest resources can be divided into two broad categories, the Northern Mixed Forest and the Southern Broadleaf Forest. These two forest types exist in Wisconsin because they have adapted to the different soil types and climates that have supported them over thousands of years.

These two regions meet in an area called the tension zone. The tension zone stretches across Wisconsin from northwest to southeast in an S-shape. The tension zone forms the northern boundary of many species' ranges, both plant and animal. From Polk and St. Croix counties southeast to Milwaukee, the tension zone divides the state into the two major ecological regions. The northern region, the Northern Mixed Forest, is more closely related to the forest of northeastern Minnesota, northern Michigan, southern Ontario, and New England. The southern region, the Southern Broadleaf Forest, is warmer and generally considered closer, ecologically, to the forests of Ohio and Indiana. The tension zone is a diverse area, where representative plant and animal species from both the Northern Mixed Forest and the Southern Broadleaf Forest types can be found, as well as a significant shift in vegetation.

Forest Area

Of Wisconsin's 35 million acres of land, about 16 million acres are forested. Forest area in Wisconsin has been steadily increasing since 1968, mostly due to the conversion of marginal agricultural land back into forests. Currently, forest covers about 46 percent of the total land area of the state. Since 1983, forestland has increased about four percent, or 640,000 acres. Most of this accounted for in the northern area of the state. Forests from 20 to 80 years of age experienced the largest increase in acreage.

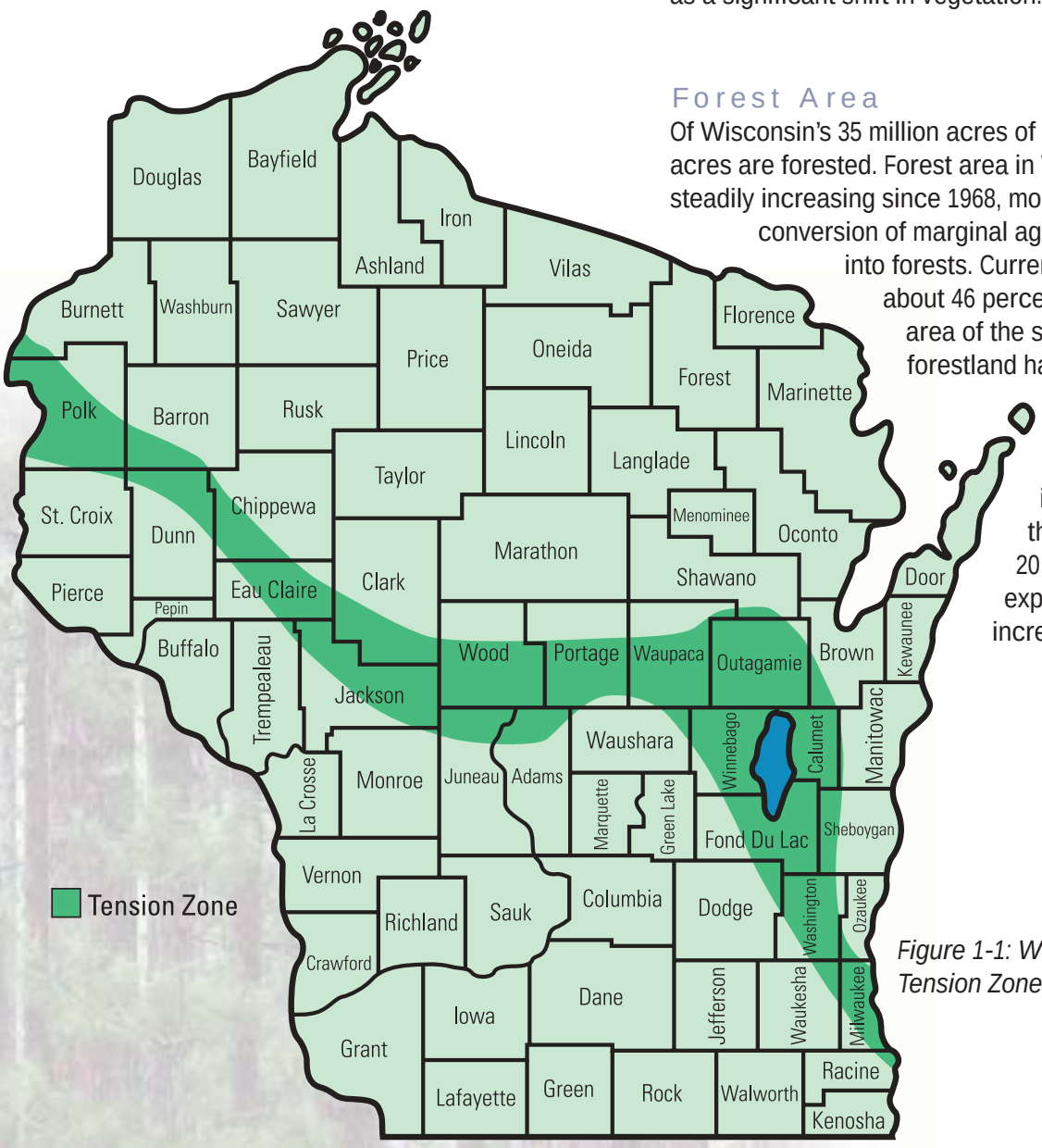

Figure 1-1: Wisconsin's Tension Zone

* *Note: The information in this chapter was taken from Wisconsin Forests at the Millennium: An Assessment. November 2000. Wisconsin Department of Natural Resources Division of Forestry, publication PUB-FR-161 2000.*

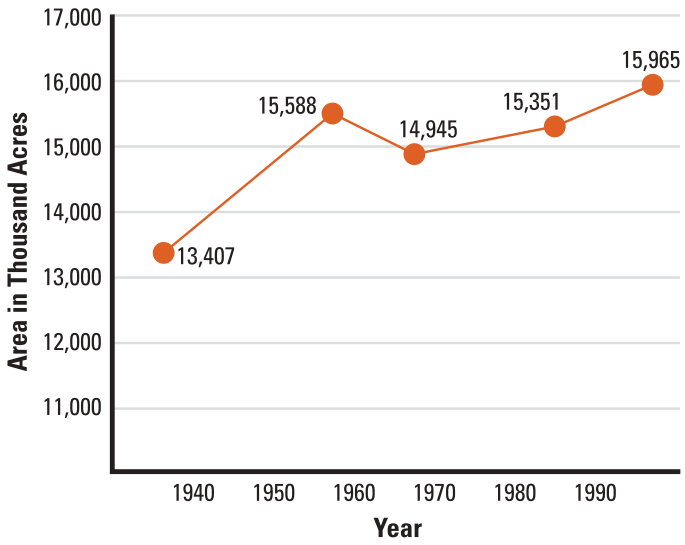

Figure 1-2: Wisconsin forest acreage over time.

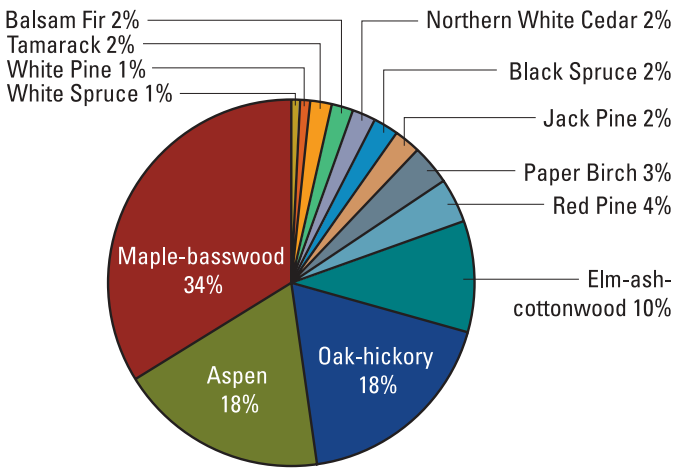

Figure 1-3: Wisconsin forest types, 1996.

Forest Types

The most abundant forest types in Wisconsin are hardwood forest types. Maple-basswood, aspen-birch and oak-hickory are the most common. Maple-basswood accounts for 5.3 million acres, followed by aspen-birch forest type with almost 3.4 million acres, and oak-hickory with about 2.9 million acres. While 84 percent of Wisconsin's forests are hardwood types, there are also significant softwood types occupying large areas, especially in the north. Red pine, jack pine, black spruce, northern white cedar, and tamarack are the most common types.

Areas and relative proportion of various forest types have changed significantly over the last 70 years. Hardwood succession is very apparent. Since the first official statewide forest inventory in 1936, aspen-birch forest area has decreased steadily, although it is still much more common than at the beginning of the Cutover. The Cutover was the period of intense timber harvest in the Lake States, lasting about 40 years, from 1880 to 1920. Since 1936, maple-basswood, soft maple-ash, and oak-hickory forests have increased just as steadily. Conifer forest area has remained roughly constant over the last 70 years.

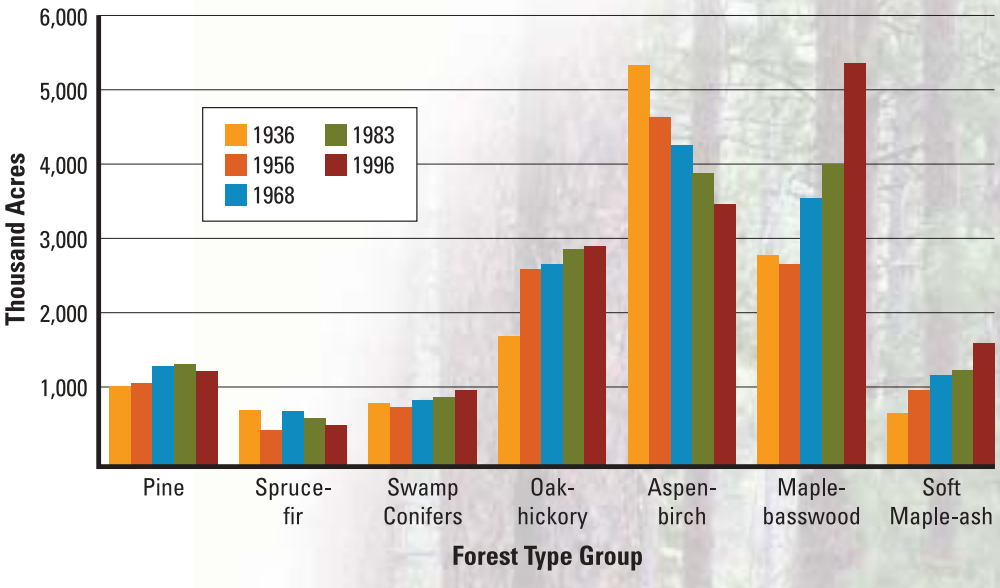

Figure 1-4: Wisconsin forest types over time.

Figure 1-5: The area of aspen-birch and other "pioneer types" has declined over the last 70 years. These sun-loving species require the open conditions created by a windstorm, fire or an even-aged harvest to regenerate and grow.

Number of Trees

Predictably, along with an increase in forest area, there has been a corresponding increase in the number of trees. Between 1983 and 1996, trees more than 10 feet tall increased by 1.4 billion individual trees. In 1996, there were 9.8 billion trees in Wisconsin.

Timber Volume

Between the 1983 forest inventory and the 1996 forest inventory, overall growing stock volume in Wisconsin's forests has increased by almost 12 percent – about two billion cubic feet. In 1996, there were 18.5 billion cubic feet of growing stock volume, of which 4.4 billion were conifer, and 14.1 billion were hardwood. Along with this overall increase, the state's maples, oaks, basswood, ashes, white and red pines, white and black spruces, and balsam fir are some of the commercially important species whose growing stock volume increased. Aspen, paper birch, and jack pine volumes decreased between inventories.

During the same period, sawtimber volume increased dramatically – by more than 30 percent or 11 billion board feet. Sawtimber is the largest timber size class. These trees tend to be older, more economically valuable, mature seed-producers, and are important to the forest's structure. As Wisconsin's forests age, continued growth of sawtimber volume is likely.

PLANTATIONS

More than 95 percent of Wisconsin's standing forests are a result of natural regeneration. The remaining 4.5 percent of Wisconsin's forests are plantations. In this context, plantations refer to areas established through planting that are sufficiently productive to qualify as timberland. The planted species is not necessarily dominant. The majority of plantations are conifer types and located in the central and northern parts of the state.

Figure 1-6: Most of Wisconsin's plantations are pine, however, they constitute only 4.5 percent of the state's total forestland.

Growth and Removals

In Wisconsin, our forests are growing at a rate that significantly exceeds harvest. Between 1983 and 1996, average net annual growth exceeded harvests and other removals by almost 158 million cubic feet. During the period between inventories, average net annual growth was 490 million cubic feet. Average annual removals were 332 million cubic feet, about 68 percent of average net annual growth. Between 1968 and 1983, average annual removals were 45 percent of average net annual growth. Average net annual growth of sawtimber in particular also exceeded average annual removals, resulting in a net increase in sawtimber volume between 1983 and 1996. Each year, on average, sawtimber volume increased 1.68 billion board feet. About 59 percent of that growth was offset by removals – 986 million board feet each year. One important measure of sustainability is that the Wisconsin timber net growth versus removals ratio is greater than one, statewide.

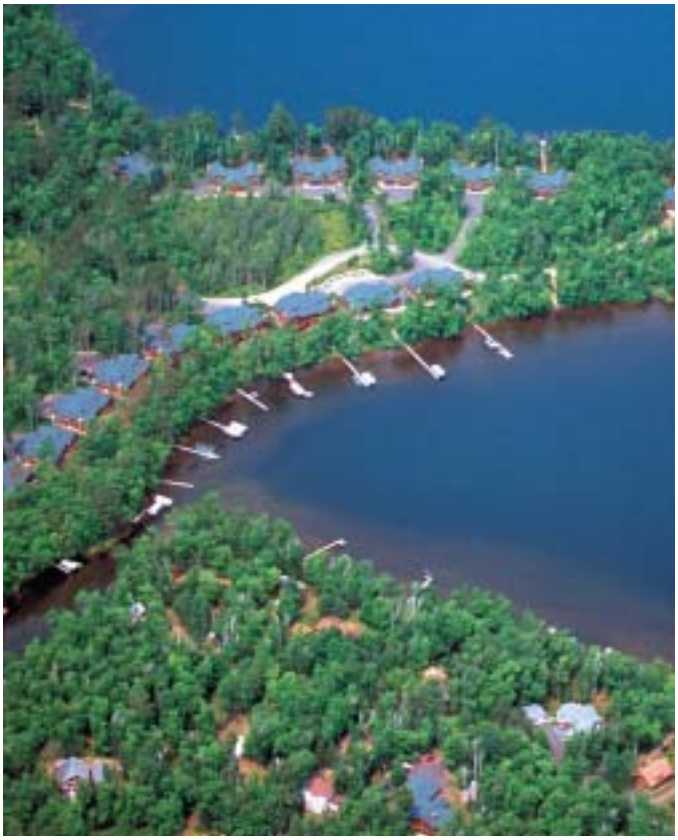

Figure 1-7: Continued lakeshore development is influencing Wisconsin forests.

Economic Importance

Wisconsin's forests provide the raw materials for homes, offices, furniture, paper, medicines, paints, plastics, and many products people may not realize come from trees. In Wisconsin, more than 1,850 wood-using companies produce nearly 20 billion dollars of forest products every year. More than 300,000 Wisconsin jobs rely on the forest products industry.

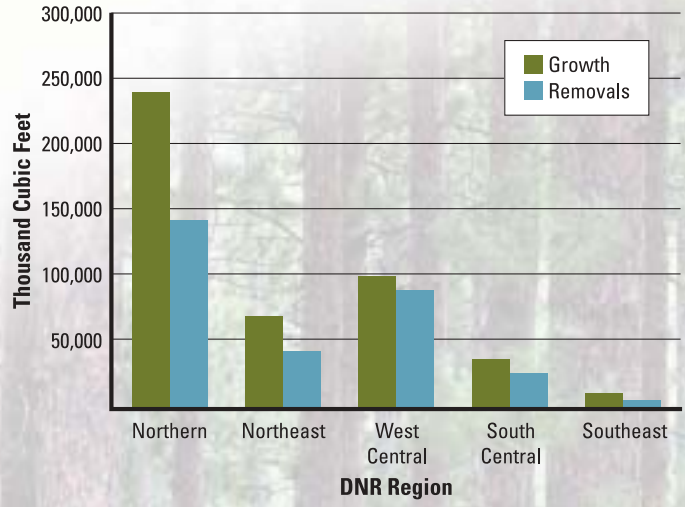

Figure 1-8: Bar graph showing growth and removal by DNR regions.

Biodiversity

Wisconsin is blessed with abundant biodiversity. Located at the junction of three of North America's six biotic provinces – the eastern deciduous forest, the northern boreal forest and the temperate grasslands – we have a wealth of species and natural communities. 2,652 species of native plants and 681 species of native vertebrates have been identified in Wisconsin. In addition, there are thousands of species of nonvascular plants and invertebrates. The challenge is to manage this diversity to conserve Wisconsin's heritage and preserve future management options (*Wisconsin DNR Biodiversity as a Management Issue 3*).

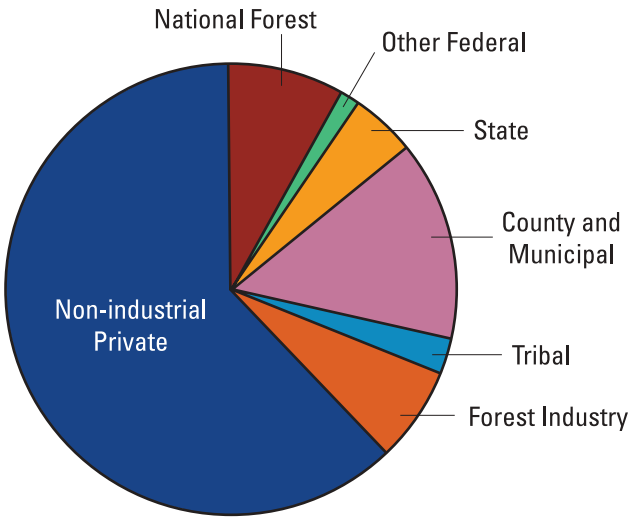

Figure 1-9: Forest acres by ownership category.

Figure 1-10: A lot for sale in Wisconsin's forestland.

Ownership

Individual, private owners own the majority of Wisconsin forests – 57 percent. The state owns just five percent, and the federal government, 10 percent. In the public sector, counties and municipalities own the largest – 15 percent, followed by the forest industry (seven percent), private corporations (four percent), and tribal lands (two percent).

Ownership is increasingly important to Wisconsin forests. The demographics of Wisconsin forestland owners are changing, as are their values and goals for their land. The increase in second homes and non-resident landowners has resulted in more forest owners of smaller parcels. Lakeshore development is another trend related to this phenomenon.

This increase in second homes and non-resident landowners results in a significant increase in the number of individual private owners. Increased human presence in the forest has significant impact on the integrity of forest communities. Between 1984 and 1997, the number of Wisconsin's non-industrial private owners increased 20 percent to 262,000. Every year, an average of 3,385 new parcels are carved from Wisconsin's forestlands. As a result, ownership size is decreasing and development is increasing.

Urban Forests

Many Wisconsin residents associate with urban forests. Urban forests surround people every day. The trees, lawns, landscape plantings, gardens, urban wildlife, and people of the cities compose the urban forest ecosystem. Wisconsin has about 1.7 million acres of urban forest, about 4.7 percent of the state's total land area. Statewide, the average urban canopy cover is 29 percent of the urban area. In the northern region, urban canopy cover is closer to 38 percent, in the south it is about 26 percent.

Figure 1-11: A home on lakeshore development.

A BRIEF HISTORY OF WISCONSIN'S FORESTS

Wisconsin's forests are reservoirs of vast ecological, economic and social wealth. Throughout Wisconsin's history, forests have played a primary role in supporting the people who have lived here. The forests of Wisconsin are dynamic, living systems that change with the human demands placed on them as well as through natural occurrences such as succession, severe weather events, fire, insect infestations, and disease.

Forests Before European/American Settlement

When the last glaciers receded from northern Wisconsin between 10,000 and 12,000 years ago, a complex array of habitats supported the colonization of plants, wildlife and humans. At the time of European/American settlement (1825 to 1880), forests stretched over most of the area that would become the state of Wisconsin. Between 22 and 30 million acres – 63 to 86 percent of the total land area of the state – were covered with forests. Two major forest divisions became apparent – the Northern Mixed Forest and the Southern Broadleaf Forest, each representing several ecosystems.

The native vegetation of the northern region is more cold-tolerant. Pine, spruce and tamarack are more abundant. Before European settlement, sugar maple, hemlock and yellow birch dominated the mesic forests of northern Wisconsin. Various pine species were also important. Aspen and white birch were important successional species that followed natural disturbance across northern Wisconsin. Acid bogs were a significant ecosystem in the northern Wisconsin forest. Pine forests and barrens were important on the sandy soils of central and northwestern Wisconsin. In the southern part of the state, oak-hickory and maple-basswood forests were especially prevalent. The southern and western parts of the state also supported oak savanna and prairie habitats. Forested and non-forested wetlands were found throughout the state (see Figure 1-13, page 8).

EARLY HUMAN INFLUENCE

There is evidence of human presence in Wisconsin as early as 11,000 years ago. The post-glacial ecology of Wisconsin was influenced by humans from its very beginning. The extent of that influence in times before European settlement is remarkable.

Figure 1-12: This old growth forest of pine, hemlock and northern hardwoods west of Minocqua is typical of the native vegetation that was found in northern Wisconsin before European/American settlement.

New research indicates that before European contact beginning in 1492, there were about two million people living in North America. In Wisconsin, 15th-century population is estimated between 60,000 and 70,000. From 1492 to 1634, the population was reduced to as few as 4,000 individuals, primarily as a result of introduced European diseases and war.

Especially prior to this population collapse, native people profoundly influenced the land and ecology of Wisconsin in areas where they lived. Perhaps most significant was their use of fire. It is thought that native people used fire throughout the state in varying degrees to encourage the establishment of favored plant and animal communities. Prairie and savanna were likely maintained by these fires.

Hunting and trapping also influenced the ecological communities of the area that later became Wisconsin. Native people hunted a broad spectrum of animals. Deer, fish and black bear were the cornerstone of the Woodland Indians' diet, but mussels, birds, fish, and more than 25 other mammal species were utilized as well. Many animal populations may have been limited by human hunting rather than by other carnivores or food supply.

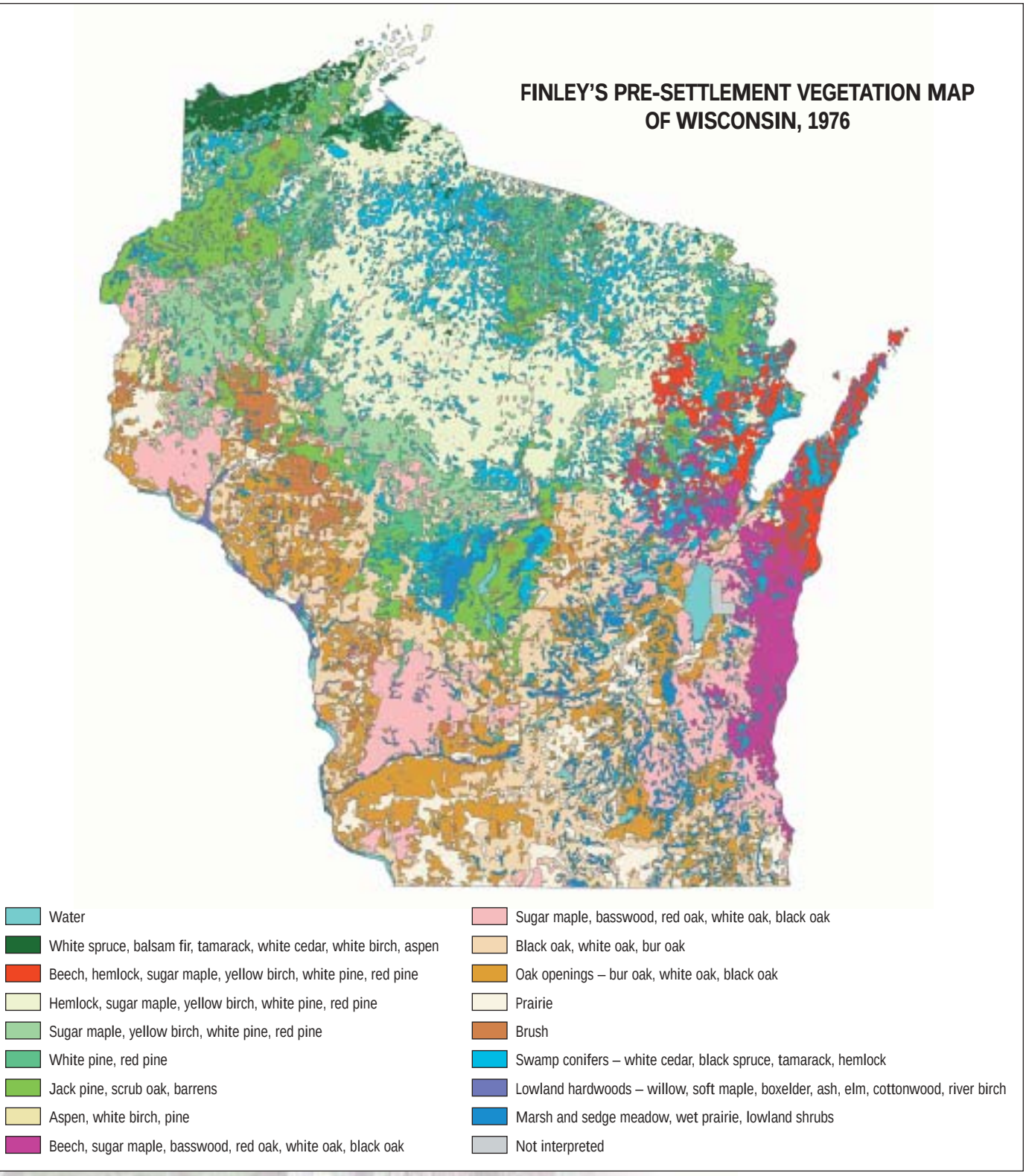

Figure 1-13: Original Vegetation Cover of Wisconsin by R. W. Finley (1976). Compiled from U.S. General Land Office Public Land Survey records. In Wisconsin, the majority of the survey was conducted between 1832 and 1866. It was the first statewide survey to collect quantitative and spatially-explicit vegetation data. This map represents very generalized vegetation cover at the time of survey, and just prior to major settlement by peoples of European/American descent.

Nuts and fruits were also important to native people, and there is evidence that they planted orchards to ensure a supply. There are accounts from early European explorers describing the "planted tree groves" of chestnuts, locusts, oaks, ashes, basswoods, beeches, cottonwoods, maples, pecans, medlars, mulberries, and plums. These "orchards" may have resulted in the forest islands seen on the prairies by early European explorers.

Foraging also influenced the ecology of Wisconsin. Collected plants may have become over-represented in biotic communities because of Indian dispersal. It was said of wild rice by the Menominee, "Whenever the Menomini enter a region, the wild rice spreads ahead; whenever they leave it, the wild rice passes." Mining, trails, agriculture, and placement of settlements in pre-contact times had a large impact on the landscape. Many of our major highways began as roads between native people's settlements hundreds of years ago.

When early explorers arrived in Wisconsin in the 1630s, they found a greatly reduced population. Because of this, until recent archeological research contested the belief, it was assumed that there were very few people living in Wisconsin before European settlement. The forests early European explorers saw likely changed as a result of the decrease in human population. Because there was no longer the need or capacity to burn or clear the land, many areas maintained by fire as grassland or early successional forest soon became mature forests.

Figure 1-14: Prairies and savannahs were common native habitat in the southern and western parts of Wisconsin, and often maintained by the Native Americans use of fire.

The tribes living in Wisconsin in the mid-1600s included the Winnebago, Ojibwe, Menominee, Dakota, Potawatomi, Heron, Sauk, and Fox. However, some of these groups have stories of migrating from other areas to Wisconsin. For example, the Ojibwe tell of their migration from the eastern ocean in the 1400s. This era corresponds to the "Little Ice Age," a period of significant cooling of the North American continent. Temperatures between 1450 and 1850 averaged 1.5ºF cooler than today.

Forests Since European/American Settlement

Today, Wisconsin's forests are significantly different than those before European/American settlement. A variety of historical reasons can account for this.

EXPLORATION AND SETTLEMENT

In 1634, Frenchman Jean Nicolet landed on the southern shore of Green Bay to arrange a truce between the Winnebago and their enemies so that the French fur trade would be protected, a task at which he succeeded. This was the first direct European influence felt on the land that would become the state of Wisconsin. However, for two hundred years, the forests remained sparsely settled while providing for the lucrative fur trade and continuing to support native people.

Various treaties in the early 1800s, which either removed or confined native populations, opened up Wisconsin to intensive European/American settlement. With the dramatic increase in human population came increasing demands on resources. Much of the southern part of the state was converted to agriculture. The fertile soil in this area, including much that was previously forested, became the base for some of the most productive farms in the growing nation. During this process, southern forests were cut and burned to aid in clearing the land and create nutrient-rich ash to fertilize crops. Timber was not a major economic contributor until the 1870s.

THE CUTOVER

In the late 1860s following the Civil War, logging became an important component of Wisconsin's economy. By 1893, Wisconsin had reached its logging zenith and was a world leader in lumber production with more than 3.5 billion board feet produced annually. Pulpwood consumption was about 211,000 cords. Sawmills sprang up everywhere along Wisconsin's many rivers, which transported logs to the mill and finished products to burgeoning cities to the south and west.

In 1898, the federal government conducted and published a survey of Wisconsin's northern forests. By this time, a first wave of cutting was well underway, and a second wave beginning. In the survey's introduction, B. E. Fernow estimates the 1850s pine (red and white pine) volume at 130 billion board feet. By 1898, all but 17 billion had been removed, and cutting was continuing at a rate of two billion board feet per year. Fernow wrote, "In almost every town in this region, logging has been carried on, and 8,000,000 of the 17,000,000 acres of forest are 'cutover' lands, largely burned-over and waste-brush lands, and one-half of it as nearly desert as it can become in the climate of Wisconsin."

By the 1930s, most of the valuable timber in the northern area of the state had been removed or destroyed by fire. The harvest occurred in two waves; the pines were harvested first and floated down the rivers to cities to the south. When railroad shipping became available, valuable hardwoods were cut and taken by train to the south. Then the other, less economically-desirable trees were cut.

Harvest techniques varied in cutover lands. Some lands were clearcut, but most were high graded. The largest and most valuable trees were removed, often leaving species and individuals less dominant to re-seed an area. At the time of the first statewide inventory in 1936, the approximately 16 million acres of forestland in the state was primarily young, early succession second growth.

The Cutover led to a variety of problems for contemporary and future residents. Not least among the challenges was the wave of forest fires that cinched the destruction of millions of acres of trees, and took thousands of human lives. Slash (wood residue from logging operations) burned easily and quickly. Fires spread over large areas, leaving ashes in their path.

Another result of the Cutover was the land boom of the early 1900s. In northern Wisconsin, logging companies sold sizable tracts of cutover land to speculators who then sold smaller farms to the immigrant population arriving in Wisconsin, enticed by the promise of land. Farmers diligently removed stumps left from the Cutover, sometimes disposing of them through fire, which further contributed to frequent and intense forest fires of the era.

Figure 1-15: Eight million acres of forest were cut by 1898, the height of the Wisconsin Cutover.

CONSERVATION

This degradation of Wisconsin's forests did not go unnoticed. An era of forest conservation was about to begin. One of the most persistent advocates of conservation was E. M. Griffith, appointed the first state forester in 1904. With the help of people as disparate as Senator Robert LaFollette, Sr., lumber baron Frederick Weyerhaeuser, and University of Wisconsin President Charles R. Van Hise, Griffith pieced together land into state-owned forest preserves. He also oversaw construction of the first state nursery at Trout Lake near Minoqua, implemented new fire control strategies, and was influential in locating the U.S. Forest Products Laboratory in Madison.

Unfortunately, neither the public nor the Wisconsin Supreme Court was ready for such innovations. County governments were concerned about the loss of land from the tax rolls, and contended that Griffith and his cohorts were trying to turn northern Wisconsin into a "playground for the rich" at the expense of the farmers becoming established in the area.

The Supreme Court found that the land was purchased for the forest preserves under the authority of an improper amendment to the state constitution. Griffith resigned in 1915, and the reforms that he tried to promote were not implemented for another decade.

Finally, in the late 1920s and 1930s, some of Griffith's goals were realized. A new concern for conservation and an understanding that the forest resource is indeed finite formed new decisions regarding Wisconsin's forests. Farmers in the north realized the land and climate were not well-suited to agriculture. Many of them abandoned the land, bankrupt. This land reverted to forest.

The State Constitution was amended in 1924 to allow state funds to go to the acquisition, development and preservation of forest resources. The Northern Highland State Forest, still the largest state forest, was the first created under the new amendment. The Forest

Figure 1-16: Logjam on a river. Rivers transported much of the timber cut from Wisconsin forests in the late 1800s.

Crop Law, a precursor to the current Managed Forest Law, was passed in 1927, making it easier for private landowners and counties to conserve forest resources for future use. County forests were created from much of the tax delinquent land of failed farms. In 1928, the first national forest land was purchased in Wisconsin, creating what is now known as the Chequamegon-Nicolet National Forest.

After 50 years of pervasive forest fires, made worse because of the ready availability of fast-burning slash from the extensive harvesting, the public began to value fire control. Human life, farms, buildings, and forests were protected with new fire prevention and control measures. With the invention of Smokey Bear in 1944, the public embraced a commitment to fire prevention and forest conservation in Wisconsin.

Figure 1-17: The Civilian Conservation Corps fought fires, planted trees and contributed in substantial ways to Wisconsin's growing conservation ethic.

In the 1930s and early 1940s, a notable influence on Wisconsin's forests was the Civilian Conservation Corps (CCC). As in other areas, the "CCC boys" fought fires, planted trees, built park buildings, and worked on other conservation projects. Reforestation efforts commenced across the state, with the goal to renew the forests. Many of Wisconsin's older pine plantations originated with CCC efforts.

The Cutover era dramatically changed the composition, structure and function of Wisconsin's forests. The extensive logging and large fires allowed species like quaking aspen and paper birch to become prevalent, encouraging large populations of whitetail deer and other wildlife that thrive in early successional habitat.

A forest inventory of Wisconsin was conducted in 1936. It revealed a very young forest, with aspen-birch by far the most prevalent forest type. Many years passed before the cutover forests recovered sufficiently for harvest. Fortunately, by this time there was a better understanding of the need to conserve forest resources and employ sound forest management. In many instances, professional foresters from forest products companies and government agencies worked together to bolster the growing forests.

Since the Cutover era, Wisconsin's forests have recovered dramatically. The state now supports a wide array of healthy forest ecosystems. Ecological, economic and social benefits have grown with the growing forest. There are also challenges that face Wisconsin's forests including environmental issues, economic demands, and changing expectations among people who use and own the forests.

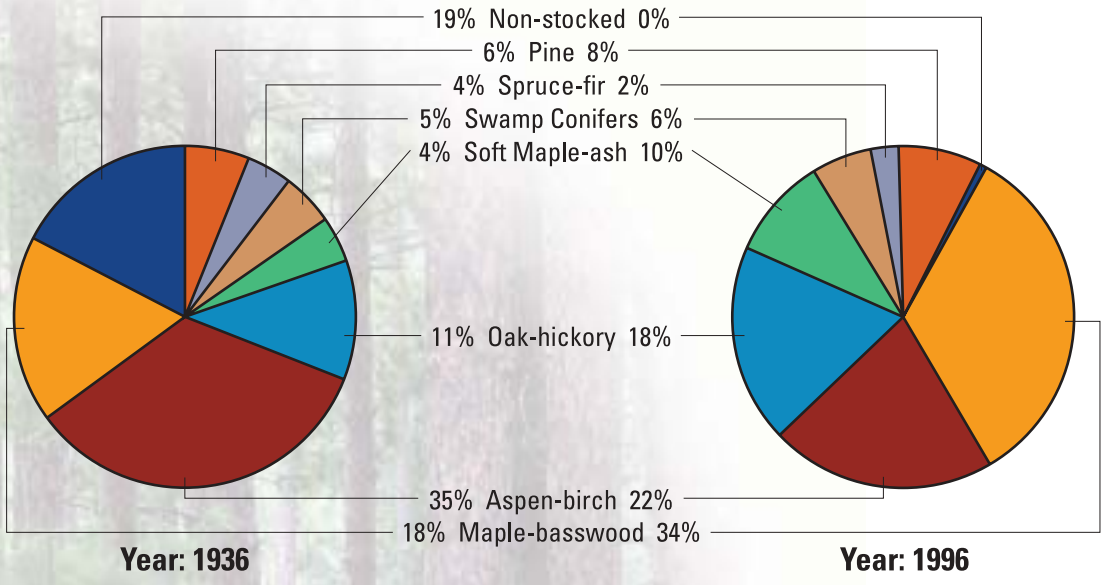

Figure 1-18: Wisconsin forest area by type in 1936 and 1996.

WISCONSIN FOREST MANAGEMENT GUIDELINES

PUB-FR-226 2003

Wisconsin Department of Natural Resources
Division of Forestry
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Madison, Wisconsin 53707

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October, 2003

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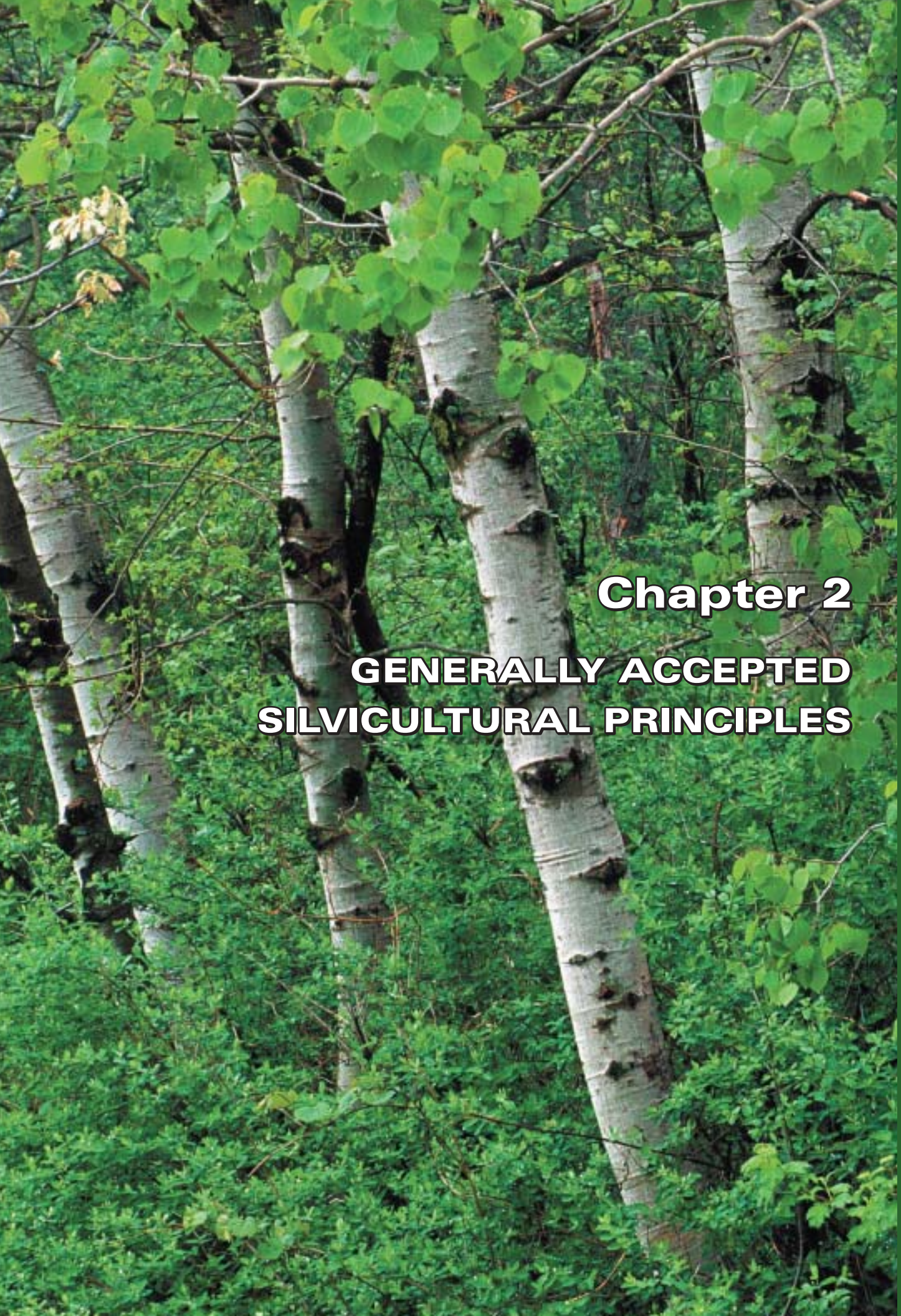

Chapter 2

GENERALLY ACCEPTED SILVICULTURAL PRINCIPLES

CHAPTER 2 — GENERALLY ACCEPTED SILVICULTURAL PRINCIPLES

SUSTAINABLE FORESTRY 15

LANDOWNER GOALS AND OBJECTIVES 16

SITE EVALUATION AND STAND DELINEATION 17

Forest Cover Types and Silvicultural Alternatives 19

SILVICULTURAL SYSTEMS OVERVIEW 21

EVEN-AGED SILVICULTURAL SYSTEMS 25

Even-aged Harvest and Regeneration Methods 25

Even-aged Tending Methods 33

Even-aged Harvest Considerations 34

UNEVEN-AGED SILVICULTURAL SYSTEMS 35

Uneven-aged Harvest and Regeneration Methods 35

Uneven-aged Tending Methods 37

Uneven-aged Harvest Considerations 38

PASSIVE OR NON-MANAGEMENT OPTIONS 39

SILVICULTURAL SYSTEMS SUMMARY 40

Table 2-1: Generally Accepted Regeneration Harvest Methods By Forest Cover Type 41

SALVAGE HARVESTS 42

UNSUSTAINABLE CUTTING METHODS 43

MANAGEMENT PRESCRIPTIONS 44

RESOURCES FOR ADDITIONAL INFORMATION 46

The purpose of this chapter is to focus on growing stands of trees and the generally accepted silvicultural practices used in Wisconsin.

This chapter will:

- Provide an overview on the interdependence of compatible landowner objectives, a careful evaluation of site capability, and the selection of an appropriate silvicultural system – the three essential elements of sustainable forestry practices.
- Expand upon each of the preceding three essential elements of sustainable forestry practices.
- Identify, define and explain various silvicultural systems and their application to the common forest cover types in Wisconsin.
- Address other types of harvesting, unsustainable cutting methods, and passive management strategies.
- Provide examples of how to distill all the sustainable forestry considerations into an effective management prescription at the stand level.

For more detailed silvicultural information related to a specific forest cover type or forest management treatment, readers are referred to the Wisconsin DNR *Silviculture and Forest Aesthetics Handbook, 2431.5*.

Figure 2-1: Integrated guidelines recognize the forest as a community of related resources, rather than a collection of separate resources, as shown in this photo of the Baraboo Bluffs and Devil's Lake in Sauk County.

SUSTAINABLE FORESTRY

FOREST ECOLOGY
The science concerned with 1) the forest as a biological community dominated by trees and other woody vegetation; 2) the interrelationships between various trees and other organisms constituting the community; and 3) the interrelationships between organisms and the physical environment in which they exist.

SUSTAINABLE FORESTRY
The practice of managing dynamic forest ecosystems to provide ecological, economic, social, and cultural benefits for present and future generations (from Ch.28.04(1)e, Wisconsin Statutes).

SILVICS
The study of the life history, characteristics and ecology of forest trees. It involves understanding how trees grow, reproduce and respond to environmental variations. The silvics of a particular tree species would describe the climatic range, temperature and light requirements, moisture needs, thermoperiodicity, soil conditions and topography, life history and development, commonly associated trees and shrubs, and any environmental, insect and/or disease factors that affect its growth and survival.

SILVICULTURE
The practice of controlling forest composition, structure and growth to maintain and enhance the forest's utility for any purpose.

Sustainable forestry practices must be based on compatible landowner objectives, the capabilities of each particular site and sound silviculture. Each of these factors is equally important.

Landowners' goals and objectives might encompass a wide range of values and benefits such as commercial products, recreation, aesthetics, wildlife habitat, endangered and threatened resources, and clean water. Understanding landowners' goals and objectives is essential to ensure that prescribed forestry practices are relevant and will endure over time. Landowners' goals and objectives must also be compatible with sustainable forestry defined as the management of dynamic forest ecosystems to provide ecological, economic, social, and cultural benefits for present and future generations. The silvicultural principles discussed in this guide assume that landowners are committed to sustainable forestry.

Site capabilities help define sustainable forestry practices. Each particular growing space has its own set of environmental conditions affecting tree growth. Factors like soil type, aspect and climate influence the moisture and nutrients available to individual trees and must be considered to ensure long-term forest health and vigor (see "Site Evaluation and Stand Delineation," page 17).

Silviculture is based on both forest ecology (relations between organisms) and the silvics (behavior or response) of individual tree species. Silvicultural systems are applied to stands of trees (rather than to individual trees) composed of species that commonly grow together. By definition, silviculture is the practice of controlling forest composition, structure and growth to maintain and enhance the forest's utility for any purpose. Silviculture is applied to accomplish specific landowner objectives.

The following sections of this guide will cover a number of silvicultural systems and harvest methods separately to facilitate the discussion of sound silviculture. These systems, however, are often most effective when used in combination to best accommodate differences between and even within stands. The ability to adapt silvicultural systems to address multiple objectives is limited only by one's imagination and creativity, making the practice of sustainable forestry both an art and a science. Table 2-1 (see page 41) summarizes the array of regeneration harvest methods generally considered acceptable for the forest cover types in Wisconsin.

LANDOWNER GOALS AND OBJECTIVES

Silviculture and forestry practices are not ends within themselves, but rather a means of achieving specific objectives in a landowner's overall goal to manage a forest on a sustainable basis. The test of a silvicultural prescription or recommended forestry practice is how well it meets the landowner's sustainable forestry goals and objectives.

As noted previously, landowner goals may be varied, reflecting a variety of forest values and benefits. Some goals may have a higher priority than others, but it is important to remember they are often interrelated, and generally depend on sound forestry practices to be realized.

Goals can be achieved by accomplishing specific objectives. For example, a goal of periodic income or maintenance of wild turkey habitat might be achieved through an objective to regenerate an oak timber type through small shelterwood harvests spread over time. Think of a silvicultural prescription as a site-specific "action plan" to accomplish objectives.

In developing goals, landowners should realize that although specific site characteristics of their land could make some objectives unsustainable, there might be other viable courses of action to choose from. It is up to the forester and other resource professionals to identify all options open to the landowner, and to use as much flexibility as possible in designing a silvicultural prescription that best addresses the full range of landowner goals (see Chapter 9: Forest Management Planning for more information).

Figure 2-2: Landowners and resource managers should meet on-site prior to preparing a plan or conducting operations. Such meetings can help assure common understanding of landowner objectives, forestry prescriptions and site characteristics.

GOAL
A concise statement that describes a future desired condition normally expressed in broad, general terms that are timeless with no specific date by which the goal is to be achieved.

OBJECTIVE
Concise, time-specific statements of measurable, planned results that relate to overall goals.

Note: Generally, "goals" apply to an entire property and "objectives" to individual stands.

SITE EVALUATION AND STAND DELINEATION

Site capability determines what types of forestry practices are sustainable. A **site** is defined by the sum total of environmental conditions surrounding and available to the plants. A site is also a portion of land characterized by specific physical properties that affect ecosystem functions and differ from other portions of the land (Kotar, 1997).

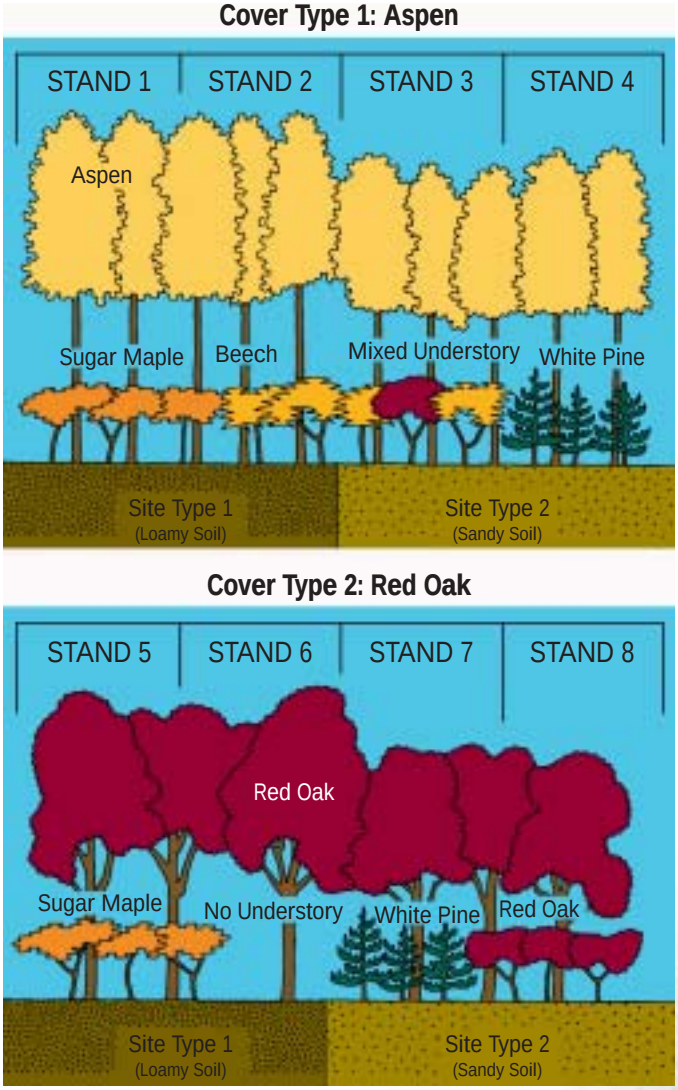

Figure 2-3: A schematic representation of two site types (loamy soil and sandy soil), two forest cover types (aspen and red oak), and eight stands. Each stand has unique composition and is defined by a specific combination of overstory and understory species. Each stand also can be considered as a unique ecological or silvicultural opportunity unit.

Forestry practices are carried out on a stand basis which determines where practices will occur. A **stand** may loosely be defined as a contiguous group of trees sufficiently uniform in species composition, arrangement of age classes, and general condition to be considered a homogeneous and distinguishable unit.

A stand is usually treated as a basic silvicultural unit. Stands are normally identified by the forest cover type involved (e.g., an “aspen stand,” a “northern hardwood stand,” or a “jack pine stand”). Cover types are discussed in more detail later in this chapter.

Forest stands are delineated through the use of aerial photographs, forest reconnaissance, inventory, and cruising. Sites are generally delineated based on soils, topography, landforms, geology, vegetation associations, and site index.

It is important to note that forest stands and sites often overlap each other. As illustrated in Figure 2-3, a single stand may occupy more than one site and a single site may support more than one stand.

Since a stand is the basic unit of silvicultural planning, care should be taken to ensure that it represents a uniform ecological opportunity unit. In other words, each specific site and stand combination has a unique set of silvicultural opportunities and constraints, which can be used to increase the number of outcomes available to the landowner. As shown in Figure 2-4 and Figure 2-5, defining stands by cover type and site type will facilitate the determination of management objectives.

Forest **site quality** is the sum total of all factors affecting the capacity to produce forests or other vegetation. Biotic and abiotic factors impact moisture, nutrient, and energy (light and heat) gradients, which determine vegetation growth and dynamics. Site quality affects tree growth, species composition and succession (plant community development). As site quality varies, so do forest management potentials and alternatives.

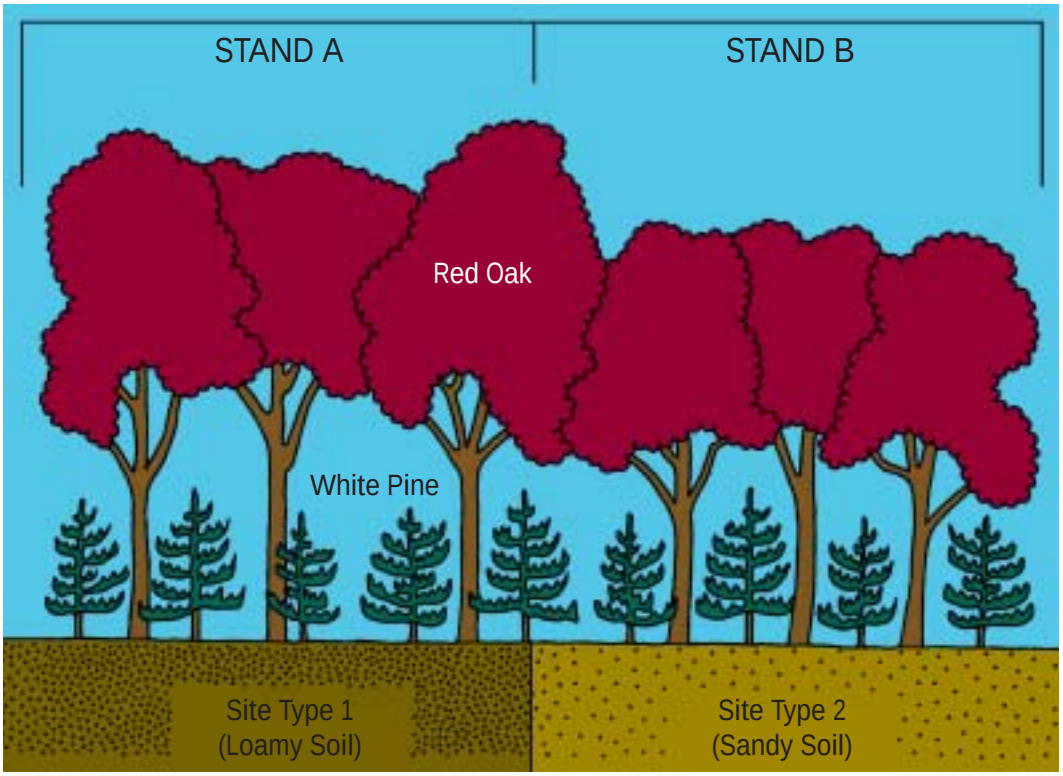

Figure 2-4: A single stand (red oak overstory with white pine regeneration) "straddles" two significantly different site types. Because ecological and silvicultural potentials differ for the two site types, the stand was split (A and B) to identify two ecological and silvicultural opportunity units.

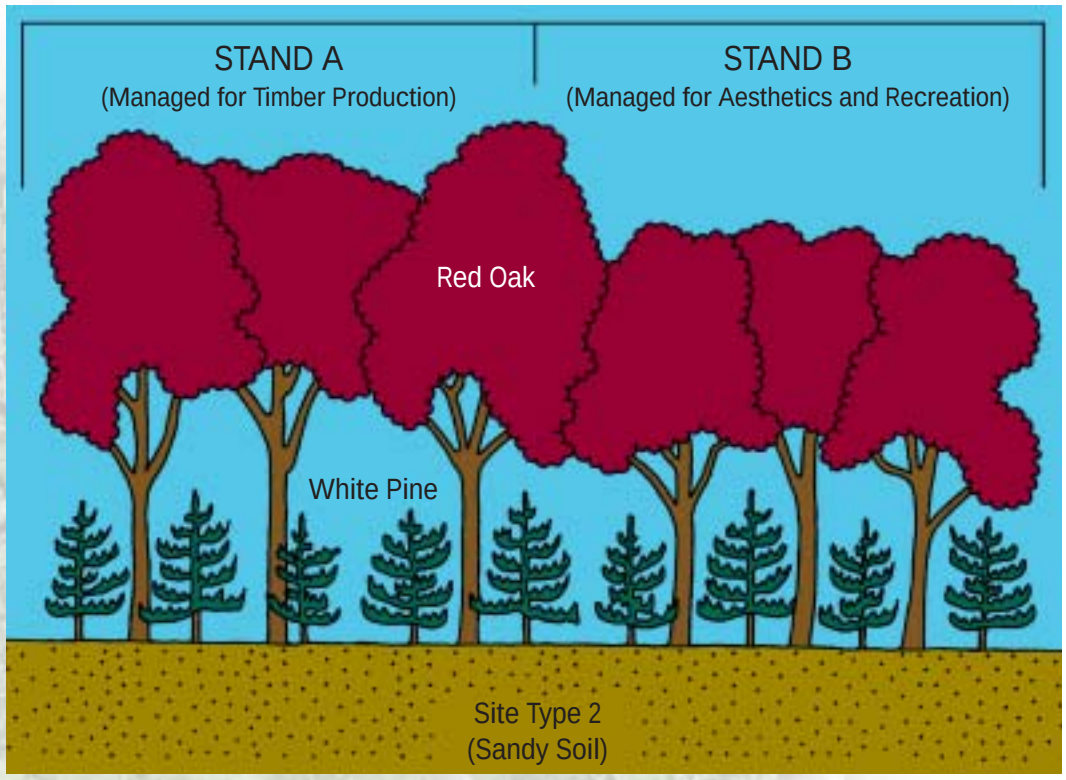

Figure 2-5: This stand is divided into two management units on the basis of different management objectives. E.g., in Stand A, oak will be harvested and white pine released to form a new crop, while in Stand B, oak overstory will be retained to provide a food source for wildlife and conditions for future old growth.

Forest site productivity is a measure of the rate of tree growth and overall wood volumes that can be expected on a given site. Productivity for a given species will generally vary between different sites as will productivity for different species on the same site.

There are direct and indirect ways to evaluate forest site quality and productivity:

- **Direct measures** of forest productivity such as historical yields and mean annual increment. These measurements are influenced by stand characteristics and may not be available.
- **Indirect measures** that relate environmental characteristics to tree growth and productivity are more commonly used. Indirect measures can be applied individually or in combination.
  - **Site Index:** Growth rates are measured and compared to tables that predict the height a particular species will attain at a given age.
  - **Vegetation Associations:** The number and relative density of key characteristic ground plants are measured, and a vegetative habitat type is identified. A great deal of inventory and other productivity date is available for each habitat type in Wisconsin.
  - **Physical Site Characteristics:** Examples include geology, landform, aspect, topography, and soil. These characteristics can be used to differentiate among types of sites that are significantly different with respect to their capabilities to support or produce different cover types or rate of tree growth. It is important to remember, however, that different combinations of individual site factors can result in functionally similar sites.

Regional site classification systems can provide tools to understand local site variability, impacts on site quality and productivity, and potential management alternatives.

Forest Cover Types and Silvicultural Alternatives

In a forested situation, tree species tend to occur in associations known as forest cover types. They range from a single tree species to several different species that commonly grow together on a specific site. The Department of Natural Resources recognizes 19 forest cover types statewide. It is important to understand that only a subset of these cover types will naturally occur on any given site, and, as a result, the range of sustainable management alternatives available are usually limited.

COMMON FOREST COVER TYPES FOUND IN WISCONSIN

Oak	Scrub oak	Northern hardwood
Aspen	White birch	Hemlock hardwood
Red pine	White pine	Central hardwoods
Jack pine	Red maple	Swamp hardwood
Cedar	Black spruce	Bottomland hardwoods
Walnut	Fir-spruce	Tamarack
Swamp conifer-balsam fir		

The forest cover type existing at a given point in time on a particular site will tend to change over time through the natural process of forest succession. Following a major disturbance such as fire or windstorm (or a silvicultural treatment designed to create similar conditions), a **pioneer community** normally invades a site. These communities (or forest cover types) are made up of sun-loving species able to rapidly establish themselves on an open, relatively competition-free, highly-disturbed site. Over time, the canopy begins to close and limit available sunlight, which results in other more shade-tolerant species becoming established.

As the original pioneer species are no longer able to compete, other **successional communities** better adapted to the changing microenvironment gradually replace them. A gradual transition to a number of different successional communities may occur as each gains a reproductive edge on the continually changing site conditions. At some point, after a long period free of disturbance, sites will transition to a potential **climax community** that is self-regenerating. This climax community will occupy the site until another disturbance creates conditions favoring re-establishment of a pioneer community (a major disturbance) or one of the earlier successional communities (a lesser disturbance).

In Wisconsin, these successional trends are fairly well understood for each ecological habitat type (site type). The pathways on some sites involve only a few stages; on others there may be several. Figure 2-6 is an example of the successional stages and trends on one particular site type.

An understanding of forest succession on a particular site can provide a great deal of useful information to a landowner evaluating potential management goals, and a forester developing the silvicultural prescriptions needed to achieve those goals. Referring to Figure 2-6, for example, one might reason:

- Only seven successional stages occur naturally on this site. Long-term management for quality northern hardwood or black walnut sawtimber, for example, would not be practical.
- Of the naturally occurring successional stages, some are currently more common at a landscape scale (as identified by the circles).
- Since a climax association is normally self-sustaining, maintaining an existing red maple, red oak, white pine, white spruce, and balsam fir type on this site would minimize regeneration costs.
- Based on the successional paths identified for this habitat type, the changes resulting from various levels of disturbance can be predicted. A partial removal of red pine overstory trees to release invading white pine, for example, would hasten the conversion from a red pine to a white pine timber type. On the other hand, a severe windstorm in a red oak-red maple stand might re-establish an aspen-white birch association for a period of time.
- Maintaining a pioneer or mid-successional stage would require a disturbance, such as active management, to overcome the natural tendency to convert to the next stage. Increasing light levels by maintaining a lower canopy density is needed to allow reseeding of the more light-demanding, earlier successional stages. Marking criteria would have to focus on releasing preferred species from more shade-tolerant species to ensure survival.
- Reversing the trend and going back to a previous successional stage would generally require a significant disturbance. Even-aged management would normally be needed to create conditions favorable for re-invasion by pioneer successional stages like aspen and white birch. Prescribed fire or mechanical scarification may be required to favor jack pine. Site preparation and planting would probably be needed to re-establish red pine. In general, the further succession is set back, the more disturbance and effort will be required.

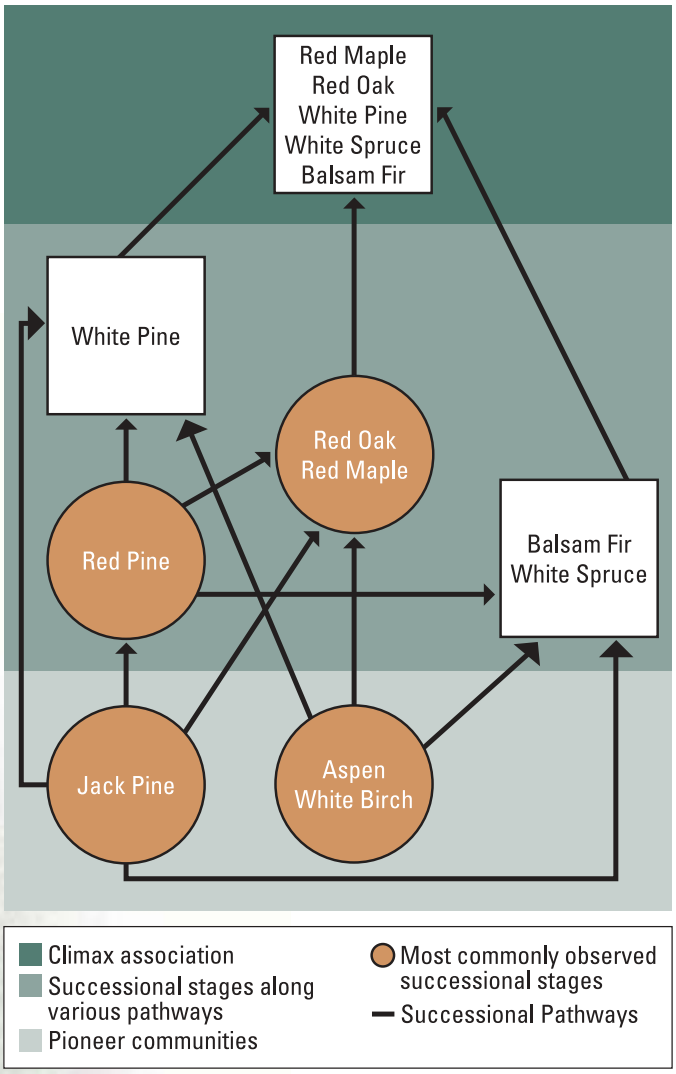

Figure 2-6: A generic example of the information available relative to the most commonly observed successional stages and probability of succession for a particular site type.

SILVICULTURAL SYSTEMS OVERVIEW

A **silvicultural system** is a planned program of vegetative manipulation carried out over the entire life of a stand. All silvicultural systems include three basic components: **harvest, regeneration and tending**. These components are designed to mimic natural processes and conditions fostering healthy, vigorous stands of trees. Typically, silvicultural systems are named after the regeneration method employed to create the conditions favorable for the establishment of a new stand.

A **harvest method** differs from a simple harvest cut in that it is specifically designed to accomplish two objectives – removal of trees from the existing stand, and the creation of conditions necessary to favor regeneration and establishment of a new stand. The method selected depends on the species to be regenerated or established in the new stand. Harvest methods vary from the complete removal of a stand in a single cut or in stages over several years, to the selection of individual trees or groups of trees on a periodic basis.

A **regeneration method** is a process by which a stand is established or renewed. The various methods include: 1) removal of the old stand; 2) establishment of a new one; and 3) any supplementary treatments of vegetation, logging residue, or soil applied to create conditions favorable for the establishment of reproduction. There are two general regeneration techniques:

- **Natural regeneration systems** rely on natural seeding or root/stump sprouts and are generally carried on concurrently with the harvest process. In some cases, additional follow-up activities (e.g., scarification, understory competition control, slash treatment, or prescribed fire) may be necessary.
- **Artificial regeneration systems** depend on the planting of tree seedlings or seeds. Generally, planting occurs on non-forested land or following complete removal and harvest of a forest overstory and results in an even-aged stand. Examples of artificial regeneration systems are:
  - **Afforestation:** Establishing a new forest on non-forested land.
  - **Reforestation and Conversion:** Forest type conversion when the desired species is not present or is inadequately represented to provide sufficient seed or vegetative reproduction.
  - **Reforestation and Re-establishment:** Forest type re-establishment when the desired species are difficult to regenerate, and it appears to be more efficient to utilize artificial regeneration than to depend on natural regeneration.

Table 2-1 (see page 41) shows the regeneration harvest methods described in this chapter as generally accepted for application to Wisconsin forest cover types.

Tending includes a variety of intermediate treatments that begin after regeneration is established and are implemented as needed throughout the rotation of a forest stand. These treatments include pruning, release, thinning/improvement, and salvage/sanitation. They are done to improve stand composition, structure, growth, quality and health, and to produce specific benefits desired by the landowner. Some tending operations are non-commercial (e.g., pruning, early release of crop trees, precommercial thinning), requiring outright investment by the landowner, and can be collectively referred to as timber stand improvement (TSI). Other tending operations, such as commercial thinning, can generate revenue for a landowner. Intermediate silvicultural treatments are discussed in detail in Chapter 16: Intermediate Silvicultural Treatments.

Several different silvicultural systems are discussed in detail in the next section of this chapter, emphasizing the particular rationale and goals of each. Although each system is discussed separately to aid in understanding, **it should be understood they are commonly used in combination to best accommodate site differences between and within stands.** Flexibility and imagination are key in tailoring silvicultural systems to address the host of values inherent in sustainable forest management.

SILVICS, THE BASIC BUILDING BLOCKS OF A SILVICULTURAL SYSTEM

EXAMPLES OF SELECTED SILVICAL CHARACTERISTICS FOR THREE COMMON WISCONSIN TREE SPECIES

	Aspen	Northern Red Oak	Sugar Maple
Pollination	March - April	April - May	March - May
Seeds Mature	May - June	September - October of the next year	Fall
Seed Dispersal	Immediately after ripening. Wind and water long distance dissemination.	September - December Gravity and animal dissemination.	Fall Wind dissemination up to 330 feet.
Good Seed Years	Every 4 - 5 years	Every 2 - 5 years	Every 1 - 5 years
Germination	Immediately following dissemination. No dormancy. 32 - 95ºF. Bare soil required.	Spring, 2 years following pollination. Mixed mineral/ humus soil preferred.	Spring, 1 year following pollination. Best at 34ºF. Bare soil not required.
Seedling Development	6 - 24" height and 8 - 10" taproot development in the first year in full sunlight.	Moderate height growth. Dieback common. Rapid taproot development.	Best growth in 30 - 90% full sunlight. Sensitive to moisture stress.
Vegetative Reproduction	Vigorous root suckers following fire or cutting. 4 - 6' height growth in first year.	Stumps sprout readily and can average 24" of height growth per year.	Stumps sprouting decreases with increasing tree size.
Shade Tolerance	Intolerant. Pioneer species.	Mid-tolerant. Maximum photosynthesis occurs at 70% shade.	Very tolerant.
Typical Rotation Age	45 - 70 years	60 - 150 years	80 - 175 years
Max. Life Expectancy	100 - 150 years	300 - 400 years	300 - 400 years

For a complete listing of all Silvical Characteristics for all Wisconsin trees, see the following web site:
http://na.fs.fed.us/spfo/pubs/silvics_manual/table_of_contents.htm

Another key factor to keep in mind is that all harvests are not necessarily part of a regeneration system. In some cases, a harvest is specifically designed to capture the value of trees that might otherwise be lost. An example would be a situation where past cutting practices or natural events have left many mature trees scattered over an otherwise immature stand. Waiting for the scheduled regeneration harvest of the younger stand would likely result in loss of valuable forest products. As a result, a harvest might be carried out as part of an intermediate or salvage operation specifically to remove all or a portion of the older trees. Even though such harvests are not part of the overall regeneration system being applied to the primary stand, they should be compatible with overall long-term silvicultural objectives.

Remember, too, that silvicultural systems are developed based on the characteristics of forest cover types and a consideration of site factors. Specific treatments within a system should be modified to accommodate any special requirements.

Some of the key considerations in the selection of a silvicultural system include:

- **Shade Tolerance:** The ability of a given tree species to survive and grow in low light conditions under a forest canopy is referred to as its shade tolerance. This silvicultural characteristic is one of the most important considerations in the selection of a silvicultural system. Once established, most trees will maximize vigor and growth in near full sunlight. However, the amount of sunlight required for regeneration, early survival and different growth rates varies between tree species. Some species require full sunlight for their entire life cycle while others benefit from some protection in the regeneration and early establishment phases, only requiring full sunlight later to maintain growth and vigor. Still other species are able to regenerate and develop under very shady conditions, and use that ability to effectively compete with more sun-loving species.

SHADE TOLERANCE OF WISCONSIN TREE SPECIES

Shade-tolerant

Able to reproduce and grow under a dense canopy.

Sugar maple[1]	Beech[1]	Basswood
Red maple	Boxelder	Ironwood
Musclewood	Hemlock[1]	Balsam fir[1]
Black spruce	White spruce	White cedar

Mid-tolerant or Intermediate

Reproduce best under a partial canopy which admits limited sunlight.

Red oak	White oak	Bur oak
Black oak	Hickories	Swamp white oak
Elms	Hackberry	Silver maple
Yellow birch	Ashes	White pine

Shade-intolerant

Light demanding species that reproduces best in full sunlight.

Aspen[2]	White birch	Balsam poplar
Black cherry	Butternut	Northern pin oak
Black walnut	River birch	Jack pine[2]
Red pine	Tamarack	Eastern cottonwood

1 Most tolerant species *2 Least tolerant species*

Note: Tolerance levels for a given species may vary during its life cycle.

- **Age Distribution and Stand Structure:** The age difference between individual trees within a particular stand varies. Some cover types typically regenerate all at once following a major disturbance (e.g., fire, wind events, insect and disease activity, past cutting, etc.). Others regenerate as groups following smaller disturbances, while still others regenerate almost continuously as individual trees die and create openings. As a result, the trees in some stands are essentially all the same age, while in others age varies widely. These age differences within a stand are often reflected by differences in tree heights and diameters. Trees in an even-aged stand tend to mature at the same time, while trees in an uneven-aged stand tend to mature as groups at distinct intervals or as individual trees on a relatively continuous basis.

- **Stand Condition:** A species composition, age, structure, quality, health and vigor, and spatial distribution of the trees (and other plants) within a stand must be carefully considered. Silvicultural guidelines and standard management systems generally are developed for typical or average conditions.

  In some cases, however, stands may exhibit a combination of low vigor, poor health, excessive logging damage, low stocking, inappropriate age or stand structure, low tree quality, compacted or eroded soils and/or other abnormal characteristics. These stand conditions typically result from abuse, neglect or improper management practices such as high grading or diameter limit cutting. Such **degraded stands** may require modification of a standard silvicultural system to address specific stand and site conditions. Sometimes, intermediate treatments such as a series of improvement cuttings and free thinnings, can restore degraded stands to acceptable and productive conditions. Other times, when degradation is extreme, regeneration methods may be needed to initiate development of an entirely new stand. The appropriate rehabilitative treatments may not be those generally recommended for the cover type, or may be applied at unusual times or in an unusual sequence.

Figure 2-7: Pulling garlic mustard before seeds set, as demonstrated by a Wisconsin Conservation Corps crew member, is an effective method to control this non-native invasive plant.

- **Understory Competition:** The relative competitive abilities of desired species, other species, and undesirable species (trees, shrubs, and herbs that are present or could invade) should be considered. Key species-specific considerations include regeneration strategies, shade tolerance, response to release, and growth rates across variable site and stand conditions. Different silvicultural methods and systems can be utilized to encourage or discourage a particular species.

  The presence of **non-native invasive plant and animal species** can limit the success of potential silvicultural systems. The aggressive competitive abilities of some plants can interfere with desired regeneration and development. Some non-native invasive species can directly attack and damage desired species. Specific silvicultural methods and systems must be designed to discourage the growth and spread or ameliorate the impacts of such species.

- **Seed Production, Dissemination and Predation:** If regeneration is dependent on seed from the existing stand, a harvest may have to be timed to coincide with periodic seed years. Tree selection, sale shape, and follow-up seedbed preparation treatments must enhance seed dissemination, and discourage seed predation.

- **Seedbed Characteristics, Germination Requirements and Early Survival:** Some species require a mineral seedbed for germination while others are able to penetrate the litter on the forest floor and germinate in undisturbed areas. Still other species germinate best on seedbeds composed of a combination of mineral soil and humus. The germination temperature and the sunlight requirements for early survival may also be more specific for some species than others.

- **Seedling Establishment and Competition Control:** In some cases, overstory shade is needed to protect desired seedlings from excessive heating and drying during the establishment phase and/or retard the development of competing species. In others, full sun is required to maximize growth and the ability of the desired species to outperform competing species.

- **Quality Considerations:** In stands managed for high-quality sawtimber, overstory shade levels must be carefully controlled to minimize sunscald and epicormic branching and forking, while at the same time maximizing tree form and merchantable height.

EVEN-AGED SILVICULTURAL SYSTEMS

Even-aged management systems are normally used to harvest, regenerate and tend sun-loving forest cover types that grow poorly or will not regenerate in their own shade. The cover types adapted to these systems are generally those accustomed to regeneration and rapid domination of a site following a catastrophic disturbance, such as a fire or major windstorm. Stands normally consist of trees at or near the same age. Even-aged systems are also applied to cover types dominated by shade-tolerant species when the intent is to focus on the less-tolerant component of the stand. Portions of even-aged management systems, specifically the intermediate thinning regimes, may also be used in the early stages of young northern hardwood stands to facilitate a long-term conversion to the uneven-aged system.

Even-aged Harvest and Regeneration Methods

Light requirements, growth rates and reproductive characteristics of the species to be regenerated govern the degree of overstory removal at the time of harvest. Competing vegetation and site characteristics are additional factors. The following are the generally accepted even-aged regeneration methods used in Wisconsin.

EVEN-AGED REGENERATION METHODS USED TO PARTIALLY SIMULATE THE DEGREE OF STAND MORTALITY THAT WOULD NORMALLY FOLLOW A MAJOR NATURAL DISTURBANCE SUCH AS A FIRE OR MAJOR WINDSTORM

These methods are primarily used with intolerant species such as aspen, red pine or jack pine that require full sunlight to ensure complete regeneration and optimum development.

- **Coppice:** (Figures 2-8 through 2-11) A method designed to naturally regenerate a stand using vegetative reproduction. The overstory is completely removed.

  Generally, there is no residual stand left as the residual can interfere with the regeneration, and is not necessary to shelter the regenerated stand. This method differs from the other even-aged regeneration systems (clearcut, seed-tree and shelterwood) in that the regenerated stand is derived from vegetative reproduction rather than a seed source.

Figure 2-8: This aspen stand was harvested one year ago using the coppice regeneration method. Red pine "standards" were retained to enhance visual diversity. Abundant aspen from vegetative reproduction is now established.

Figure 2-9 (Coppice A): A 50-year-old aspen stand with smaller numbers of northern red oak, red maple and white pines mixed in (the understory has been reduced for image clarity).

Figure 2-10 (Coppice B): An aspen stand immediately following a clearcut/coppice regeneration harvest showing tree stumps, coarse woody debris and scattered advanced natural regeneration.

Figure 2-11 (Coppice C): A stand of dense coppice-origin aspen sprouts 10 to 15 years after the initial harvest.

Figure 2-12: This central Wisconsin stand of mixed jack pine and "scrub" oak was clearcut within the past year.

- **Clearcut:** (Figure 2-12) A method used to regenerate a stand by the removal of most or all woody vegetation during the harvest creating a completely open area leading to the establishment of an even-aged stand. Regeneration can be from natural seed produced by adjacent stands, trees cut in the harvesting operation, direct seeding, or replanting.

  This method differs from the seed-tree and shelterwood methods in that no trees are left in the cut area for seeding purposes. Rather, the seed source is from outside the cut area or from felled tops of harvested trees.

- **Seed-tree:** (Figures 2-13 and 2-14) A method designed to bring about natural reproduction on clearcut harvest areas by leaving enough trees singly or in groups to naturally seed the area with adequate stocking of desired species in a reasonable period of time before the site is captured by undesirable vegetation. In this method, only a few trees (typically three to 10 per acre) are left and the residual stocking is not enough to sufficiently protect, modify or shelter the site in any significant way. Seed-trees may be removed after establishment or left indefinitely.

  This method differs from the coppice method in that regeneration comes primarily from seed rather than sprouts. It differs from a clearcut in that the seed source for regeneration is from residual trees within the harvest area rather than outside the cut area, or relying on seed existing on or in the ground. It differs from a shelterwood in that the residual stocking is too sparse to modify the understory environment for seedling protection.

Figure 2-13 (Seed-tree A): A mature forest of mostly white pines mixed with smaller amounts of northern red oak and red maple. Seed-tree harvesting is one method used with even-aged species that require full sunlight for regeneration. All trees in such stands are generally ready for harvest at the same time, but sufficient advanced regeneration is not usually present.

Figure 2-14 (Seed-tree B): White pine residual following a seed-tree regeneration harvest leaving about three to 10 trees per acre as a seed source to renew the stand.

EVEN-AGED REGENERATION METHODS USED TO PARTIALLY MIMIC NATURAL DETERIORATION OF THE OVERSTORY OVER TIME

These methods are tailored to more tolerant species that require partial shade and/or a seed source for optimum regeneration, but once established need full sunlight for survival and full development (such as white pine and oak).

- **Shelterwood:** (Figures 2-15 through 2-20) A method used to regenerate a stand by manipulating the overstory and understory to create conditions favorable for the establishment and survival of desirable tree species. This method normally involves gradual removal (usually in two or three cuts) of the overstory. The overstory serves to modify understory conditions to create a favorable environment for reproduction and provide a seed source. A secondary function of the overstory is to allow further development of quality overstory stems during seedling establishment. The most vigorous trees are normally left as the overstory, and the less vigorous trees removed.

A successful shelterwood harvest often requires the removal of intermediate or suppressed saplings and poles (often of less desirable species such as elm, ironwood or red maple) because the smaller understory trees will suppress development of vigorous seedlings of the preferred species.

Initial shelterwood cuttings resemble heavy thinnings. Natural reproduction starts under the protection of the older stand, and is finally released when it becomes desirable to give the new stand full use of the growing space. At that point, the remaining overstory is completely removed.

This method differs from clearcutting and coppice methods in that the next stand is established on the site before overstory removal. It differs from a seed-tree cutting in that the overstory serves to protect the understory as well as distribute seed. Finally, an even-aged shelterwood harvest differs from uneven-aged selection methods in that it promotes an even-aged stand structure.

Figure 2-15: May apples and other ground vegetation have begun to resprout following the first shelterwood cut (seed cut) in this red oak stand. Logging slash was removed and the ground scarified to provide improved conditions for light-demanding oak acorns to germinate.

Figure 2-16 (Shelterwood A): A dense stand of mature oak sawtimber and associated hardwoods before harvest. Notice the uniformity in size and age in the overstory, and the lack of regeneration.

Figure 2-17 (Shelterwood B): An oak forest soon after the first stage of a shelterwood harvest. The overstory has been opened up to allow sufficient light penetration for seed germination. Enough shade has been retained to prevent excessive drying of the seedbed and enhance early survival and establishment of the new seedlings. (Note: In some situations, post-harvest treatment of the understory with herbicides or mechanical scarification may be needed to control competition or prepare the seedbed.)

Figure 2-18 (Shelterwood C): The same stand after five years. Notice the regeneration developing as a result of the increased light penetration.

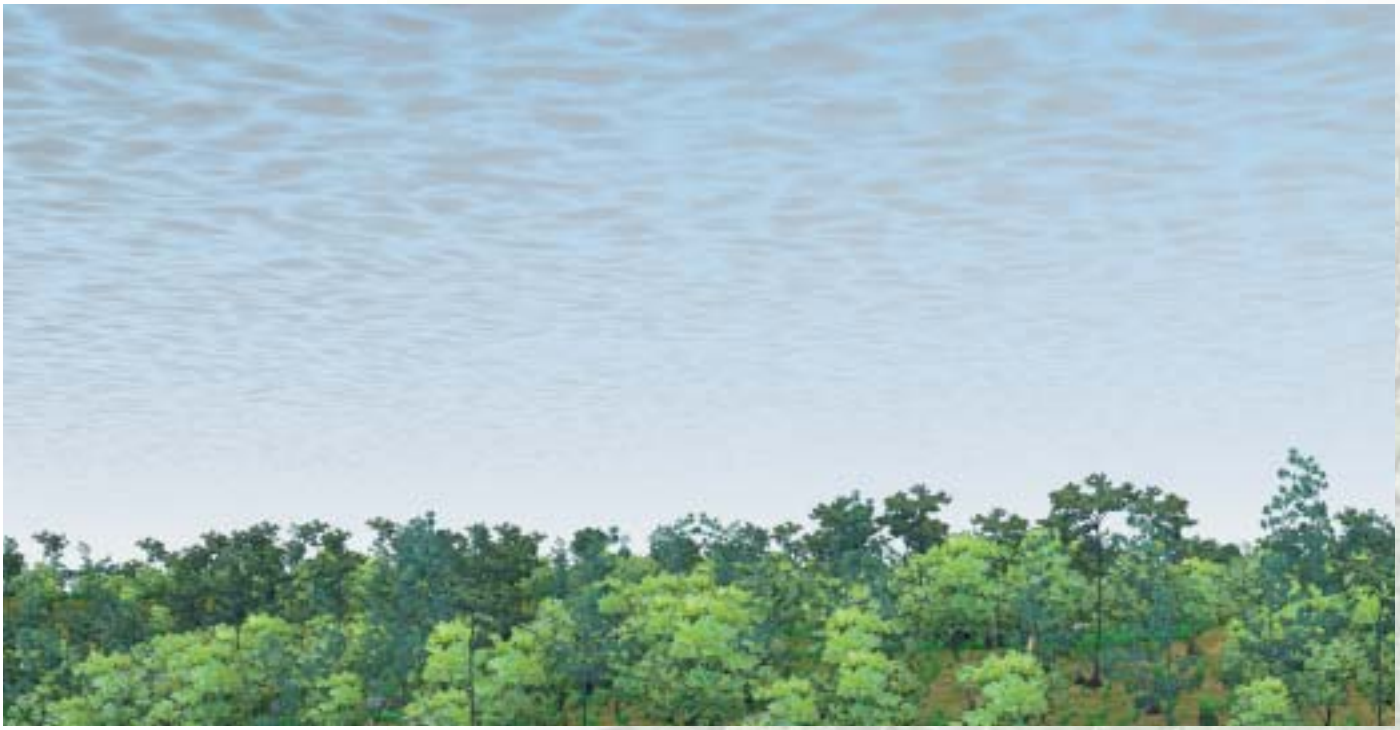

Figure 2-19 (Shelterwood D): An oak stand after the second stage (overstory removal) of a shelterwood harvest. After approximately 10 years, adequate regeneration is fully established, and the overstory has been removed to provide the added sunlight needed to maximize growth and development.

Figure 2-20: Natural regeneration after a shelterwood harvest has developed into an excellent stand of red oak poletimber, 30 years later, on the Hardies Creek Stewardship Forest in Trempealeau County.

- **Overstory Removal:** A method used to mimic the natural deterioration of the overstory but at an accelerated rate in situations where adequate regeneration is already established. The entire stand overstory is removed in one cut to provide the release of established seedlings and saplings. This method has been referred to as a natural shelterwood or a one-cut shelterwood.

  Overstory removal results in an even-aged stand structure as opposed to uneven-aged structure. It differs from the clearcut and the coppice regeneration methods in that seedling and sapling regeneration is established prior to the overstory removal. It differs from the shelterwood and seed-tree methods in that no manipulation of the overstory is needed to establish regeneration.

  Overstory removal can be applied to all forest stands being managed on an even-aged basis if desirable advance regeneration is well-established. Cover type specifics and applicability of overstory removal are addressed in appropriate cover type chapters of the Wisconsin DNR *Silviculture and Forest Aesthetics Handbook, 2341.5*. General considerations in the application of the overstory removal method are:
  - Overstory health, condition and composition
  - Potential risk of raising the water table on wet sites
  - Adequate stocking, distribution, vigor and desirability of established, advanced regeneration
  - Site capability
  - Existing and potential competition, including exotic species

All the even-aged methods have **variants with reserves** involving scattered trees left throughout the harvest area or in groups or clumps. Individual trees or groups of trees left uncut on a long-term basis will hamper the growth of seedlings adjacent to them, but regeneration should be adequate as long as the reserves do not exceed approximately 20 percent crown density. With such reserves, even-aged systems can be managed as two-aged systems on a long-term basis.

In most cases, the goal of an even-aged silvicultural system is to naturally regenerate a species already present in the stand. Depending on the species involved, additional activities may be required to ensure that its germination and growth requirements are met. These may involve the use of prescribed fire, disking and other forms of scarification to expose a mineral soil seedbed to enhance seed germination and survival. Where natural regeneration is insufficient or in cases where the desired species was not present in the harvested stand, tree planting or direct seeding may be required.

Even-aged Tending Methods

Tending operations implemented in young stands usually are non-commercial. **Timber stand improvement (TSI)** generally includes the **intermediate treatments** pruning and release. **Pruning** is usually applied to improve timber quality and value, although it can also be utilized to control disease, improve aesthetics, or improve stand accessibility. **Release** treatments are designed to free young trees from undesirable competing vegetation to improve stand composition, growth and quality.

Thinning and improvement are intermediate treatments implemented in older stands with larger trees that often offer commercial opportunities. **Thinning** entails the removal of trees to temporarily reduce stocking and concentrate growth on the more desirable trees. Thinnings are applied primarily to improve diameter growth, manipulate structure, enhance forest health, recover potential mortality, and increase economic yields. **Improvement cutting** is the removal of less desirable trees of any species primarily to improve composition and quality. Typically, improvement is applied coincidentally with thinning.

Specific applications of intermediate treatments depend on landowner goals and objectives, economic constraints and opportunities, site capability, stand development, and the silvics/ecology of the desired species and their competitors. Intermediate silvicultural treatments are discussed in detail in Chapter 16: Intermediate Silvicultural Treatments.

In most even-aged stands, intermediate treatments are generally applied relatively consistently across the stand. These thinning practices can be modified (spatially) and temporarily applied in even-aged stands where the long-term management objective is conversion to uneven-aged management. For example, in even-aged small sawtimber-sized northern hardwood stands, even-aged thinning guides can be applied to most of the stand, however, some regeneration gaps can be created to initiate the development of an uneven-aged structure. Following one or more of these modified even-aged thinnings with canopy gaps, later operations are then based on uneven-aged selection management guidelines (simultaneous thinning, harvest and regeneration).

Figure 2-21 and 2-22: The importance of tending an even-aged stand is illustrated by comparing these two plots in the famous Star Lake thinning experiment started by Fred Wilson with red pine planted in 1913. Figure 2-21 (left) shows the poor growth and mortality in the plot that was never thinned. The adjoining plot, Figure 2-22 (right), shows the impact that periodic thinnings (every five to 10 years starting in 1943) can have on red pine growth and quality.

Even-aged Harvest Considerations

Under even-aged silvicultural systems, entire stands are harvested all at once or over a relatively short period when they reach a given age. The term rotation is used for the period of years required to grow timber stands to a specified condition of maturity. The age of the stand at the end of the rotation period when it is normally harvested is called the **rotation age**.

Traditional rotation ages are set at a point in time when average annual growth reaches its maximum. Beyond that age, stands grow more slowly. Decay and tree mortality may begin to increase. This rotation age varies by species and site, and is normally established for each individual species reflecting prevailing regional or local conditions. Eventually a stand will reach its pathological rotation age, at which time insect and disease activity result in such extensive decay and mortality that harvesting of the stand is no longer economically viable. At the stand level, natural mortality of the overstory becomes significant. Regeneration of the current overstory may also become difficult due to natural succession and loss of seed sources.

Rotation length will vary with a number of factors:

- **The average growth rate and life span of the species involved.** A typical rotation age for a stand of aspen, for example, is 45 to 60 years. A typical rotation age for an oak stand may be two to three times as long.
- **The type and quality of product desired.** Pulpwood takes a shorter time to produce than sawlogs, which must be larger in diameter. High quality sawlogs and veneer logs require more time since they are typically grown to still larger diameters and at higher density levels.
- **Economic considerations.** Changes in supply and demand in general, specific customer requirements, market values, and internal infrastructure demands can all result in modified rotation ages.
- **Site productivity.** More productive sites support increased growth rates for a longer period of time. As a result, the period of positive mean annual growth is also extended, increasing the optimum rotation age. Different rotation lengths are typically employed across the range of site productivity.

Figure 2-23: Red pine is a good example of a species amenable to modification of rotation age to reflect site productivity, product goals, and landowner non-timber objectives.

- **Insect and disease concerns.** The level of mortality and decay caused by insects and disease is a prime factor in net growth. Insect and disease outbreaks can significantly reduce stand growth, and in extreme cases, cause such extensive mortality that they determine rotations. As stands age, the risk of sudden, extensive mortality increases.
- **Landowner goals.** Rotation ages can be extended to enhance non-timber resources if a landowner is willing to accept reduced growth rates and potentially forgo some timber revenues. In some cases, these extended rotations can enhance the supply and value of some high quality timber products such as sawtimber and veneer. Just as stands can be held for some time after the normal rotation age, they can also be harvested for a period prior to the normal rotation age. This harvest period can be used to space harvests over time, divide or combine stands to meet other landowner goals, manage the flow of timber income, or deal with other supply and demand economic constraints.

UNEVEN-AGED SILVICULTURAL SYSTEMS

Uneven-aged management systems are normally used to harvest, regenerate and tend forest cover types that will regenerate and grow under their own shade. Stands managed under uneven-aged systems are normally comprised of three or more age classes. These cover types are adapted to regenerate under partial canopies following minor disturbances like individual tree mortality, or a moderate disturbance such as a wind storm that would damage up to one third of the stand. Uneven-aged systems are designed to mimic such disturbances.

Even shade-tolerant species grow most vigorously in relatively free-to-grow conditions with full sunlight, assuming other growth requirements like soil moisture, are met. As a result, regeneration and most vigorous growth typically occur in small- to medium-sized gaps (small openings). The number and size of gaps created through uneven-aged management are dependent upon species composition, acreage regulation, and tree rotation age or size. Normally, these systems are used to manage stands containing mixed trees of all ages, from seedlings to mature trees. They are also used to convert even-aged stands into an uneven-aged structure.

Figure 2-25: Species Desirability

Uneven-aged Harvest and Regeneration Methods

Stand regeneration is achieved by periodically manipulating the overstory and understory to create conditions favorable for the establishment and survival of desirable tree species. Thinning, regeneration and harvesting usually occurs simultaneously. The harvested trees are essentially replaced by growth on the younger trees left in the stand. These silvicultural systems are designed to maintain an uneven-aged stand condition, while manipulating the multi-age and multi-size structure of the overstory to facilitate continual recruitment and development of quality growing stock.

With the uneven-aged silvicultural system, the tree selection decision (to cut or leave) considers a number of factors as illustrated in Figures 2-24 through 2-26.

Figure 2-24: Tree Quality

Figure 2-26: Desired Age and Size Class Distribution

The following are generally accepted uneven-aged natural regeneration systems used in Wisconsin:

- **Single-tree Selection:** (Figures 2-27 and 2-28) Individual trees of various size and age classes are periodically removed to provide space for regeneration, and promote the growth of remaining trees. Each regeneration opening (gap) covers an area equivalent to the crown spread of a single large tree that has been removed. Individual trees are selected for removal from all size classes (to achieve desired residual density levels) following recognized order of removal criteria based on tree risk, vigor, quality, and spacing.

The goal, particularly in the northern hardwood cover type, is to achieve an optimum distribution of size and age classes so each contains a sufficient number of quality trees to replace those harvested in the next larger size class. Specific selection criteria vary slightly with the particular species makeup of the stand involved (see the Wisconsin DNR *Silviculture and Forest Aesthetics Handbook, 2431.5* or an appropriate management guide).

Figure 2-27 (Single-tree Selection A): An uneven-aged northern hardwood stand which has not been harvested in 15 years. The basal area is approximately 120 square feet per acre.

Figure 2-28 (Single-tree Selection B): The same stand following a single-tree selection harvest. Trees have been removed from across the range of age and size classes to maintain an uneven-aged structure. The residual basal area is about 84 square feet per acre.

- **Group Selection:** Trees are periodically removed in small groups to create conditions favorable for the regeneration and establishment of new age classes. In general, the openings created may range in size from fairly small 0.02 acre (30' diameter circle) up to one-half acre (166' diameter circle or approximately two tree lengths). In northern hardwood management, gaps are generally less than one-tenth acre. Smaller openings favor regeneration of more-tolerant species, while larger openings favor mid-tolerant species.

  In general, stands dominated by large crowned tolerant species (such as sugar maple, beech and hemlock) do not require the creation of large openings to provide sunlight for regeneration, and individual trees are harvested as they mature using the single-tree selection method. However, some of the less-tolerant species commonly associated with sugar maple (such as basswood, yellow birch and ash) benefit from the use of the group selection method to enhance recruitment and growth of new seedlings. One-quarter to one-half acre gaps may also have potential application in the management of uneven-aged stands of mid-tolerants like red oak and white pine on some sites. Potentially, most-tolerant to mid-tolerant species can be managed by applying variations of the selection regeneration method, if appropriate steps are taken to control competition.

  In general, stands managed under uneven-aged systems regenerate as a result of manipulation of light levels during the harvest process. In some cases, non-commercial removal of additional cull trees or poorly formed saplings may be needed to further enhance regeneration in specific areas which are not opened up through the normal selection process.

Uneven-Aged Tending Methods

In uneven-aged silvicultural systems, tending operations are not as clearly distinguished from harvest and regeneration operations as in even-aged systems. Harvest and regeneration are perpetual operations, rather than occurring once during a stand's rotation, so tending must also be integrated and not temporally separated. In addition, uneven-aged stands often have a spatially patchy age structure that may require patchy applications or variations of intermediate treatments.

Release treatments are designed to free young trees from undesirable competing vegetation to improve stand composition, growth and quality. These **timber stand improvement (TSI)** treatments can be applied to regeneration openings created by single-tree or group selection systems, although costs associated with the location and treatment of scattered regeneration patches may be prohibitive. They are probably most needed and feasible where the objective is to facilitate the survival, growth, and development of seedlings and saplings of mid-tolerant species growing in larger openings created through application of the group selection system. In addition, as canopy crowns expand over time, previously created regeneration gaps may need to be re-opened or expanded to maintain the vigorous growth of young trees; this release operation can be conducted concurrently with other periodic cutting operations.

Thinning is an intermediate treatment that entails the removal of trees to temporarily reduce stocking to concentrate growth on the more desirable trees. Thinnings are applied primarily to improve diameter growth, manipulate structure, enhance forest health, recover potential mortality, and increase economic yields. **Under the uneven-aged silvicultural system, thinnings are implemented concurrently with periodic harvest and regeneration operations.** Stands are normally re-entered on an eight- to 20-year cutting cycle depending on landowner objectives, economic constraints and opportunities, site quality, tree growth rates, stand development, and the silvics of the desired species. Specific target stand stocking levels (density management) by size and age class are very important to tree growth and quality development. Often, small groups or patches of essentially even-aged trees can be recognized and treated. Tree selection is based on a recognized order of removal that considers tree risk, tree vigor, crop tree release, species composition, and spacing. Additional criteria can also be employed to enhance wildlife habitat, biodiversity, water quality, and aesthetic values. Temporary **improvement cutting** may be needed to improve composition or quality in stands that have been previously unmanaged, neglected or poorly managed.

Figure 2-29: When the uneven-aged system is used, an optimum maximum tree diameter class (the target diameter) is determined for each stand.

Uneven-aged Harvest Considerations

Harvests in uneven-aged stands occur regularly. The normal cutting cycles range from eight to 20 years. The interval is based on site quality, growth rates, removable volumes, and landowner goals relative to each stand.

Individual trees are removed from each size (or age) class as needed to achieve the desired level of stocking. When selecting which trees to remove within each diameter class, the primary factors considered are risk, vigor, quality, and spacing. In addition, an optimum maximum diameter class is determined for each stand based on the following considerations:

- **Site Productivity:** Higher quality sites normally allow trees to be carried to a larger diameter before growth rates decline significantly and degrade/decay becomes a major factor in tree value.
- **Average Growth Rates and Life Spans of the Species Involved:** Stands managed under uneven-aged silvicultural systems normally contain a variety of different species, each having a different optimum maximum diameter class.
- **Type and Quality of Products Desired:** A decision to focus on sawtimber, veneer or both will influence the selection of an optimum maximum diameter class.
- **Balancing Risk and Economic Value:** As a particular high quality crop tree gets larger, it becomes more economically valuable. The value increase is due to more than just the additional volume accumulated as the tree grows. As a tree passes though a number of threshold diameters, it increases in grade and value dramatically. The values of sawlogs depend more on grade than volume. Larger diameters are required for the higher grades, which can bring two to three times the value of lower grade logs. Attaining veneer size can result in another major increase in tree value. The decision to leave a particular large valuable tree uncut must be weighed against the uncertainty of it still being alive and healthy 10 to 15 years later, when the next periodic harvest will be done. If it survives, it may increase significantly in timber value; if it is damaged or dies, that value could be lost. The evaluation of tree risk and vigor is critical to the determination of individual tree rotation.
- **Landowner Goals:** Maximum diameter classes can be increased/decreased depending on specific landowner goals. They can be extended to enhance non-timber resources (e.g., aesthetics, wildlife food and shelter, and old growth characteristics) if the landowner is willing to accept reduced growth rates and forgo some timber revenues. In the case of low risk, vigorous, high quality trees, the extended rotations can increase the supply of sawtimber and veneer, therefore, the total value. Just as trees can be held longer, they can also be harvested earlier to respond to variable market conditions (supply and demand economics), manage the flow of certain timber products or income, or divide/combine stands to meet other goals.

Reaching the optimum maximum diameter class is not the only criterion for tree selection. Other marking criteria (risk, vigor, spacing, quality, and basal area stocking levels) take precedence, and may result in a specific tree being retained longer. Vigorous, low risk, high quality trees may be retained well beyond the target diameter, for example, if stocking in the maximum diameter class is too low or other poorer quality trees are removed instead.

Flexibility exists in the selection of an optimum maximum diameter class. The diameter class chosen, however, is a key factor in the determination of the optimum number of trees needed in each of the other various diameter classes – from the smallest to the largest – to ensure that quality trees are available to replace those harvested.

PASSIVE OR NON-MANAGEMENT OPTIONS

Figure 2-30: Passive management is the most appropriate approach with fragile plant communities such as this relic white pine stand on cliffs in a stream-side riparian zone.

Some landowners and resource managers choose to "let nature take its course" on some forestland. In such cases, they make a conscious management decision to not actively manipulate the vegetation. This passive management is not considered a silvicultural system since it does not involve manipulation of vegetation.

Landowners and managers have different reasons for choosing to not actively manipulate vegetation. They may wish to protect and preserve fragile or special sites or communities (e.g., cliff communities, springs, groves of large old trees, and cultural sites). They may wish to develop habitat for specific wildlife that prefers relatively undisturbed forests. They may enjoy the appearance (aesthetics) and the recreational opportunities. Philosophical reasons may include the desire to allow nature to develop free of human impacts. Wilderness areas and some research control sites may be passively managed.

The concepts of "preservation" and "natural dynamics free of human impacts" are relative. Forests are dynamic communities that are continuously changing and adapting to external inputs and internal disturbances. Natural processes like forest succession, plant competition, wildlife and insect activity, tree aging and decay, windstorms, fires, and climate change will cause changes in forest composition, structure, and function over time. Forests cannot be maintained in a static, unchanging condition. Also, there are no forest ecosystems undisturbed by human activities. Disturbance has occurred through impacts on climate, atmospheric composition and inputs, fire control, management of wildlife populations (intentional and unintentional), introduction of exotics, recreational use, other human uses, etc. Passively managed forests will continue to change and will be subjected to human impacts, however, these changes and impacts often will be different than in actively managed forests.

Passive management does require monitoring, and certain events may necessitate the implementation of some short-term active practices. Examples include control of exotics, fire management, disease and insect management, wildlife management, recreation management, removal of diseased or weakened trees that pose safety hazards, and loss of attributes desired by the landowner. Passive management requires an understanding of the effects of natural processes and the impacts of other human activities (internal and external to the forest) on the development of the forest. This knowledge will facilitate the achievement of landowner objectives, and minimize the chances of counterproductive results or unintended consequences. In some situations, a blend of passive management and active silvicultural treatment may most effectively achieve landowner goals.

SILVICULTURAL SYSTEMS SUMMARY

As discussed in previous sections of this chapter, each of the silvicultural systems and regeneration harvest methods have a number of variations that can be employed to tailor them to the specific species and sites involved. The choices can be confusing, but hopefully this summary will help sort things out.

EVEN-AGED SILVICULTURAL SYSTEMS (NORMALLY USED FOR SUN-LOVING SPECIES)

Clearcut
A complete overstory removal designed to facilitate regeneration by natural seeding, direct seeding or planting.

Coppice
A complete overstory removal (clearcut) designed to promote regeneration through sprouts and suckers.

Overstory Removal
A complete removal of the overstory in a single harvest, applied to any even-aged cover type if adequate regeneration is already established (used to accelerate release of a new stand).

Seed-tree
All overstory trees, except for about three to 10 seed trees per acre are removed to facilitate regeneration by natural seeding.

Shelterwood
A complete overstory removal in two to three harvests spaced over a period of years. The residual trees from the first cut serve to modify understory conditions to create a more favorable environment for reproduction and provide a seed source. They are removed when the regeneration is established.

UNEVEN-AGED SILVICULTURAL SYSTEMS (NORMALLY USED FOR SHADE-TOLERANT SPECIES)

Single-tree Selection
Individual trees are harvested from all size classes on a recurring cycle. Regeneration occurs naturally in the openings created (favors species that are more shade-tolerant).

Group Selection
Trees are removed in small groups on a recurring cycle. Regeneration occurs naturally in the openings created (favors species that require more light for regeneration).

SIGNIFICANCE OF TABLE 2-1 TO THE WISCONSIN COOPERATING FORESTER PROGRAM

Table 2-1 (page 41) summarizes the regeneration harvest systems that are generally recognized as acceptable and widely applied in Wisconsin. The designations are substantiated in forestry research literature and further elaborated in the Wisconsin DNR *Silviculture and Forest Aesthetics Handbook, 2431.5*. Under the framework established by NR 1.213(3) b, Wisconsin Administrative Code, all forest management and timber harvesting assistance provided by the DNR and Cooperating Foresters must be consistent with the sideboards established in Table 2-1. Exceptions will be granted only if a science-based management commitment describing an alternative method is submitted to and approved by the Department of Natural Resources in advance. Procedures regarding management commitments can be found in Chapter 21 of the Wisconsin DNR *Private Forestry Handbook, 24705.21*.

GENERALLY ACCEPTED REGENERATION HARVEST METHODS BY FOREST COVER TYPE

	Natural Regeneration Harvest Method						Artificial Regeneration Method[5]
	Even-aged Systems[6]				Uneven-aged Systems		Planting/Direct Seeding
Forest Cover Types[1]	Coppice	Clearcut	Seed-tree	Shelterwood	Single-tree Selection	Group Selection	
Jack pine		X	X				X
Red pine							X
White pine			X	X			X
Aspen	X						
White birch		X[2]		X			
Scrub oak	X	X		X			
Oak		X		X			X
Black walnut							X
Red maple	X			X		X	
Central hardwoods				X		X	
Northern hardwoods				X	X	X	
Hemlock hardwoods[4]				X	X		
Fir-spruce		X[2]		X			X
Swamp conifer-fir		X[2]		X			
Black spruce		X[2]		X			
Tamarack		X[2]					
Cedar[4]		X[2]		X			
Swamp hardwoods				X			
Bottomland hardwoods	X[3]			X		X	

1 Harvest methods apply to the **cover type to be regenerated**, not necessarily the currently existing cover type.

2 Strip clearcutting generally recommended.

3 When silver maple predominates.

4 Regeneration may be hampered due to animal browsing (herbivory).

5 Refers to reforestation, not afforestation.

6 Overstory removal is acceptable for any timber type managed on an even-aged basis if desirable regeneration is well-established.

Table 2-1: Generally Accepted Regeneration Harvest Methods by Forest Cover Type

SALVAGE HARVESTS

Figure 2-31: Forest management plans are often modified by natural disturbances like this major wind storm in a northern Wisconsin hemlock stand.

In addition to regeneration harvests employed as part of a silvicultural system, salvage harvests are carried out as part of an overall forest management program. Unlike regeneration harvests, which are also designed to facilitate regeneration of the new stand, salvage harvests are geared only to the recovery and use of dead or dying trees that would otherwise go unharvested. Wind events, fire, flooding, insect and disease activity, and weather extremes can all wreak havoc on the best of forest management plans. High quality trees can have significant economic value and often justify a salvage effort. Removal of infected trees is often necessary to prevent additional mortality.

It should also be remembered, however, that dead and dying trees are part of the overall forest system, and provide a number of benefits to wildlife and other ecological processes. Decisions to conduct or not conduct a particular salvage operation are often a balance between potential economic return, impact on stand silviculture, risk of wildfire, cost of salvage, and the ecological value of leaving the trees in place. When mortality is significant, a regeneration strategy should be developed to facilitate regeneration, based on current conditions and landowner goals.

UNSUSTAINABLE CUTTING METHODS

A silvicultural system is a planned program of treatments over the life of a stand. Other cutting methods exist primarily to maximize short-term economic gain, and are not part of a long-term plan to ensure regeneration of a healthy, vigorous stand on a sustainable basis.

The following examples of unsustainable cutting methods are not an all-inclusive list. These methods may result in a new stand of trees, but due to the lack of consideration of specific species requirements, they often lead to stand degradation and are not considered generally accepted silvicultural practices that result in sustainable forestry:

- **Diameter limit cutting** is cutting all trees above a set diameter regardless of the impact on stand structure, stand quality, tree quality, species composition, or regeneration needs. At times referred to as a "selective cut," the only consideration is diameter as opposed to specific criteria employed in a true single-tree selection harvest under the uneven-aged silvicultural system.
- **Economic clearcutting**, where any tree of economic value is cut with no consideration for site, silvics of the species involved or regeneration needs. This practice differs from a clearcut in the even-aged silvicultural system where all trees are harvested, regardless of value, in order to ensure residual shade and competition does not hamper the regeneration and development of a new stand.
- **High grading** (Figures 2-32 and 2-33), also referred to as "selective logging," is the practice of cutting only the largest, most valuable trees in a stand and leaving low value and poor quality trees to dominate. This practice is NOT the same as a single-tree selection regeneration harvest described in the silvicultural systems section (see page 36). High grading is not designed to enhance the quality and reproductive potential of the residual stand, but maximize immediate revenue. The term "selective logging" is sometimes used intentionally by unscrupulous loggers to create false expectations on the part of landowners.

It is emphasized that economic gain and sustainability ARE compatible. Using creativity and imagination in the application of sound silviculture will best achieve both goals in the long-run.

Figure 2-32: Before

Figure 2-33: After

Figures 2-32 and 2-33: The figures above depict the results of a typical "high grade." All the larger trees with the greatest economic value have been removed leaving only poor quality trees behind. No consideration was given to size and age distribution, residual stocking levels or regeneration needs.

MANAGEMENT PRESCRIPTIONS

As the previous sections of this chapter describe, the basic question of "what to grow and how to grow it" is not as simple as it may first appear. Indeed, the answer can involve the collection and evaluation of a great deal of information, and the consideration of a number of alternative strategies. **In the end, the question – "what to grow and how to grow it" – must be answered clearly, logically and completely.** This final step in the decision-making process can be compared to the last phase of designing a new home – the development of a blueprint which spells out in detail exactly how your vision transfers to clear, specific action. The silvicultural counterpart to that blueprint is a management prescription.

A **management prescription** or recommendation is a detailed description of a specific treatment or cutting scheme designed to implement a specific stand management objective. Prescriptions describe the individual activities necessary to implement the overall silvicultural system in a given stand.

A **forest management plan** is written for entire properties and identifies general landowner goals as well as other property and landscape information. The more detailed plans also identify specific stand management objectives, and the series of management prescriptions describing specific actions needed for all stands for an entire operational period (see Chapter 9: Forest Management Planning).

It is important a management prescription reflect all relevant factors and be written in a clear, logical fashion. Less complex prescriptions are normally written in a narrative format. More complex prescriptions involving a number of interdependent activities with the outcomes of each leading to different pathways may include a decision tree or diagram (see Figure 2-34).

The development of a detailed management prescription for a given stand is a complex process. It requires a thorough understanding of the landowner's objectives, silviculture, silvics, capabilities and limitations of the resource, and collection and evaluation of considerable vegetative and site data. Since each stand is unique, a forester and possibly other resource professionals should be involved to provide technical assistance.

MANAGEMENT PRESCRIPTIONS: FACTORS TO CONSIDER

1. Landowner's Objective
- Is it sustainable?
- Were all opportunities considered?

2. Assess Biological Characteristics
- Site capabilities
- Past disturbances
- Current vegetative condition and potentials (growth and succession)
- Forest health and protection

3. Consider Other Relevant Environmental, Cultural, Social, and Economic Factors Such As:
- Aesthetics
- Recreation
- Wildlife
- Presence of endangered species
- Invasive species
- Landscape scale issues (critical habitat, percentage of land in a cover type, etc.)
- Regulations (statutes, rules or local ordinances)
- Traditions (possibly related to ethnic heritage)
- Markets
- Community viability
- Watershed protection and erosion control

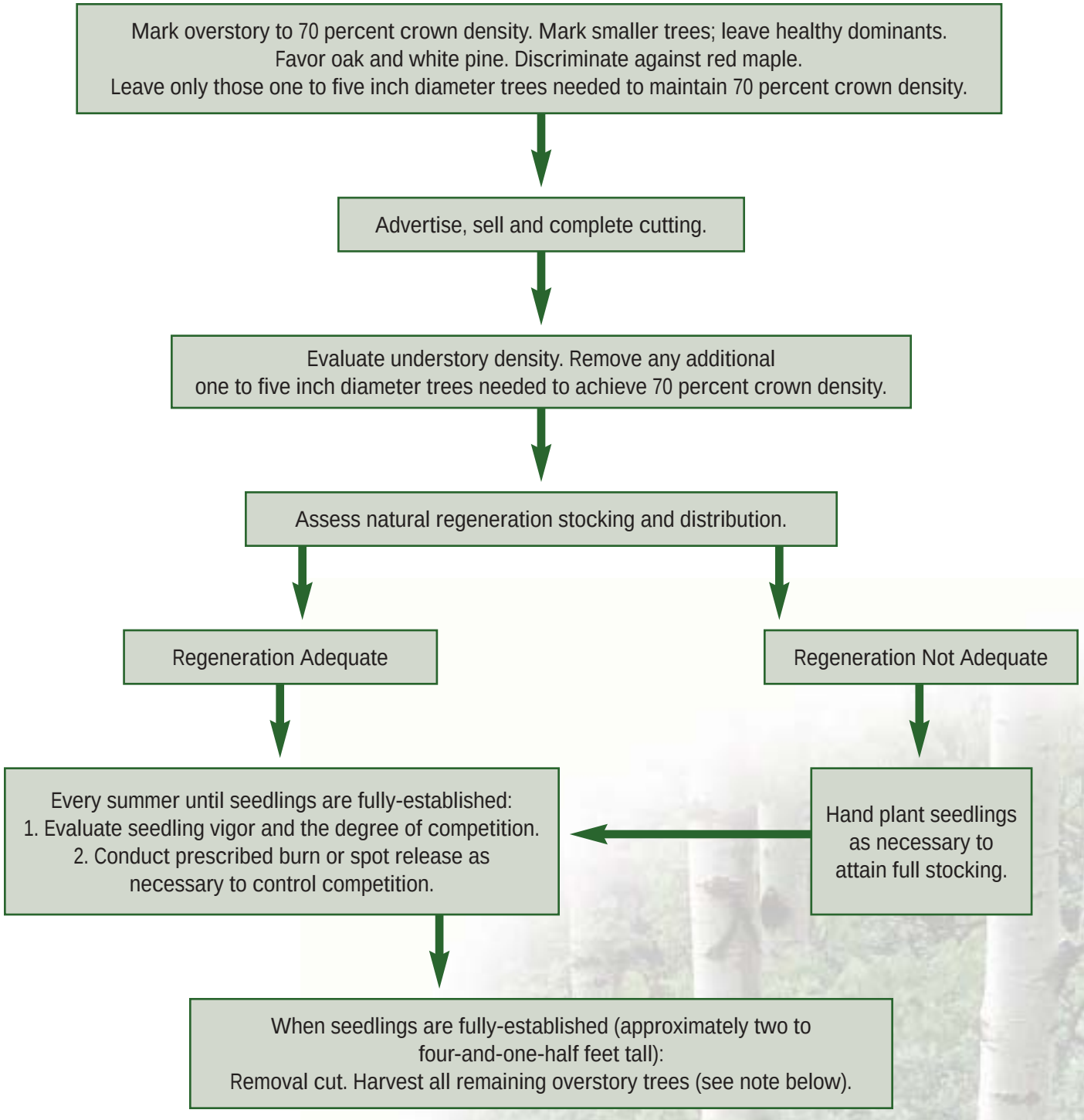

Figure 2-34: An example of a management prescription designed to implement a shelterwood regeneration harvest in a mature red oak stand. (Note: While this particular management prescription has a timber management focus, it could easily be modified to incorporate other objectives. To enhance wildlife habitat, for example, a portion of the residual overstory (20 to 30 percent) could be retained during the final removal cut to provide for a continuous supply of mast. The shade from the scattered residual large canopy red oak would somewhat hamper seedling growth and distribution, but the stand would still regenerate and the red oak cover type would be perpetuated long-term.) There is a significant amount of flexibility available to tailor a silvicultural system to meet various needs as long as the primary objective to regenerate the stand is not compromised.

RESOURCES FOR ADDITIONAL INFORMATION

APPROACHES TO ECOLOGICALLY BASED FOREST MANAGEMENT ON PRIVATE LANDS

Kotar, J. (1997). *Approaches to ecologically based forest management on private lands*. University of Minnesota Extension Service, Publication NR-604.

THE DICTIONARY OF FORESTRY

Helms, J. A. (Ed.). (1998). *The dictionary of forestry*. Society of American Foresters.

THE PRACTICE OF SILVICULTURE (7TH ED.)

Smith, D. M. (1962). *The practice of silviculture (7th ed.)*. New York: Wiley.

SILVICULTURE: CONCEPTS AND APPLICATIONS

Nyland, R. D. (1996). *Silviculture: Concepts and applications*. New York: McGraw-Hill.

SILVICULTURE AND FOREST AESTHETICS HANDBOOK, PUBL. NO. 2431.5

Wisconsin Department of Natural Resources. (2002). *Silviculture and forest aesthetics handbook*. Madison: Wisconsin Department of Natural Resources.

These resources are specific to the information in this chapter only. Refer to the Resource Directory for additional resources related to this chapter.

NOTE: Figures 2-9, 2-10, 2-11, 2-13, 2-14, 2-16, 2-17, 2-18, 2-19, 2-27, 2-28, 2-32 and 2-33 use computer-generated simulations to depict various harvest methods listed in Table 2-1 (see page 41). The images were produced by Andrew M. Stoltman as part of the *Forest Visualization at Multiple Scales for Management* project at the University of Wisconsin-Madison, Department of Forest Ecology and Management.

WISCONSIN FOREST MANAGEMENT GUIDELINES

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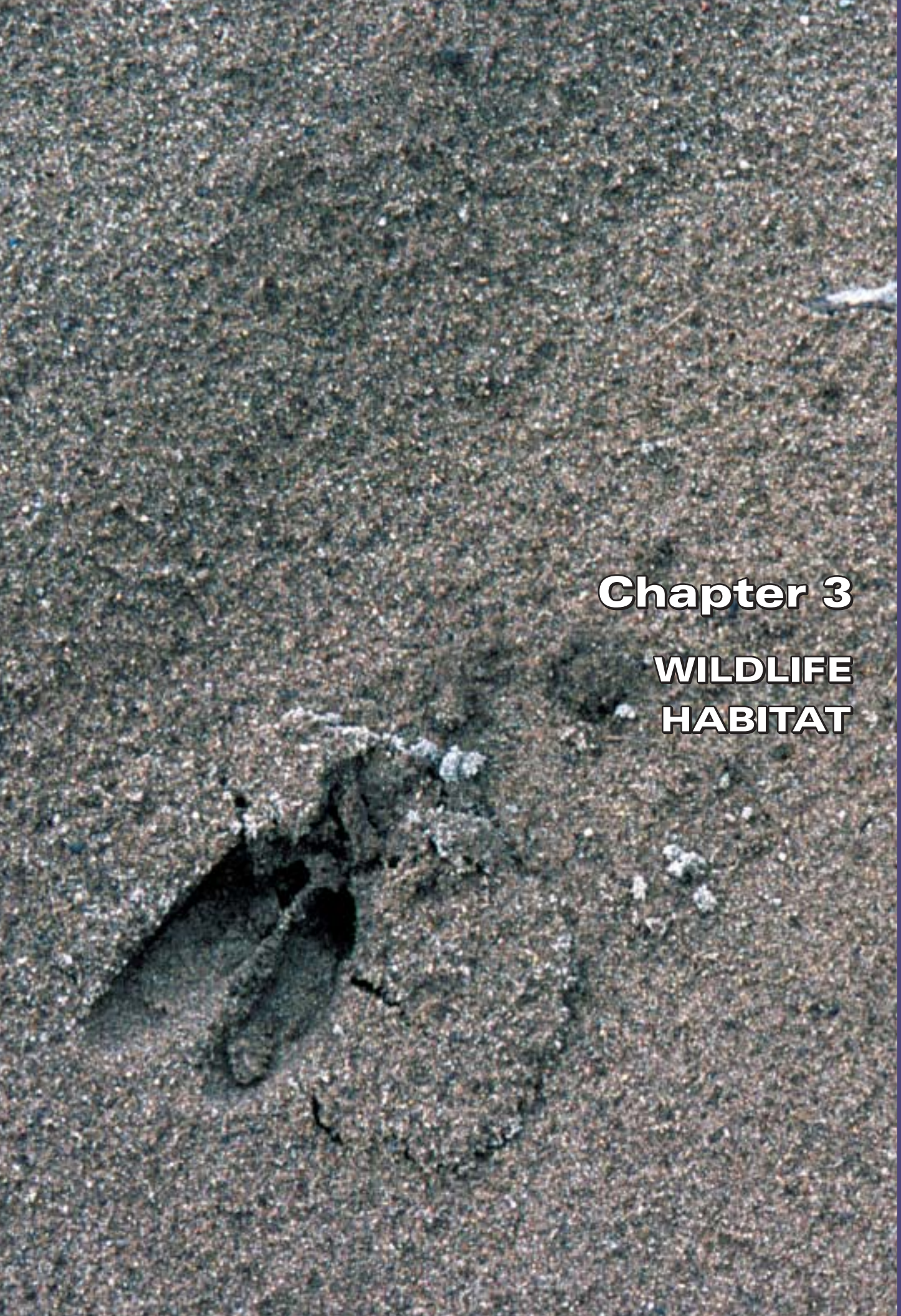

3

Chapter 3

WILDLIFE HABITAT

CHAPTER 3 — WILDLIFE HABITAT

SPECIFIC WILDLIFE HABITAT GUIDELINES 49
Leave Trees and Snags 49
Coarse Woody Debris and Slash 51
Conifer Retention and Regeneration 52
Mast 55
Patterns of Cutting 56
Endangered, Threatened and Special Concern Species 58
State Natural Areas and Rare Natural Community Types 61
Affected Natural Communities 62
Field Survey Consultants and Other Resources 64
Wetland Inclusions and Seasonal Ponds 65
Riparian Wildlife Habitat 66

RESOURCES FOR ADDITIONAL INFORMATION 69

Wisconsin contains a diverse natural heritage with more than 2,652 plant species and 681 vertebrate species identified to date (Wisconsin Department of Natural Resources, 2003). In addition, thousands of fungi, invertebrates, and non-vascular plant species also contribute to healthy ecosystem functioning. Wisconsin is located at the junction of three of North America's six biotic provinces, thus generating a number of different habitats and niches for species to occupy. Wisconsin's forests lie within all three of these provinces and therefore are also quite diverse. The Society of American Foresters (SAF) lists 19 forest types that occur within the state. Each forest type occurs along a gradient of moisture, temperature, soil type, and climate, creating the different habitats and niches for species. All told a significant percentage of Wisconsin's native flora and fauna is associated with forested habitats.

Each species associated with a forested habitat or niche contributes to ecosystem functioning and, in turn, larger ecosystem processes. For example, studies have shown that insect-eating birds reduce overall levels of foliage loss from insect populations. As a result, bird populations can affect larger ecosystem processes such as carbon storage or primary productivity. Therefore, loss of organisms or groups of organisms from an ecosystem can have much larger consequences on forest health and larger ecological processes. The challenge is to conserve all the working parts within a particular ecosystem in order to maintain ecosystem resilience when disturbances occur. Simplified forest ecosystems suffer more damage from forest pests and are more likely to have problems regenerating effectively.

The primary focus of this chapter is on forest-dependent terrestrial and amphibious forms of wildlife. The intent is to provide practical, science-based guidelines to address a number of specific issues and projected impacts relating to forestry and wildlife. The resource directory contains DNR and non-DNR contacts that can provide additional information on management of all wildlife species.

Certainly, much more can be done to enhance wildlife habitat or individual species than the steps recommended in these guidelines. Furthermore, each management practice, including the option to do nothing, will favor some species and hinder other species. As a result, it is not practical to provide a comprehensive set of guidelines covering all possibilities for improving habitat in Wisconsin forests. Instead, these guidelines cover the essentials for addressing site-level issues related to forestry practices. Those interested in pursuing objectives that focus primarily on wildlife management are encouraged to consult a professional wildlife manager for more information.

It should be remembered that it is difficult to separate site-level and landscape-level issues. For wildlife, more than for other forest resources, what occurs on a site influences the surrounding landscape and vice versa. While the guidelines focus on the site level as much as possible, some of the more important "landscape implications" will also be discussed. Landscape-level wildlife needs can best be addressed through professional planning for individual properties and cooperation among landowners and agencies within a landscape.

Finally, many wildlife habitat guidelines can be applied simultaneously. For example, leave tree clumps in clearcuts might also serve as rare species buffers, provide mast production, and enhance vertical structure. These overlapping benefits may extend to other forest resources as well, such as for cultural resource protection and visual quality. In other cases, retention of various structural habitat components may create safety issues like the reduction of visual quality or increase the potential for pest damage. Other chapters of the guide will address some of the trade-offs that need to be considered relative to other resources.

SPECIFIC WILDLIFE HABITAT GUIDELINES

Leave Trees and Snags

PURPOSE

The purpose of this habitat aspect is to provide for wildlife requiring perches, tree cavities, and bark-foraging sites through retention of suitable leave trees and snags on a site during forest harvesting and timber stand improvement. This guideline will also contribute to the continued presence of coarse woody debris on a site.

RATIONALE, BACKGROUND AND BENEFITS

In Wisconsin, up to 30 breeding birds, nearly 30 mammals, and several reptiles and amphibians use snags as breeding sites. Different species have adapted to different ecological conditions. Saw-whet Owls utilize cavities in and around lowland conifer swamps, while Red-headed Woodpeckers nest in cavities in open or semi-forested conditions. The major issue for timber harvesting and cavity-dependent wildlife is whether suitable trees and nest cavities remain for these species following logging or timber stand improvement.

Retention of leave trees and snags during timber harvesting provides habitat for wildlife that require perches, tree cavities, or bark-foraging sites as the surrounding forest regenerates. Leave trees can be left scattered throughout a harvest area or in clumps as illustrated in Figure 3-9 (see page 63). The distribution and density of leave trees and snags will affect which wildlife species benefit from the practice. Leave trees can also impact regeneration after harvest. Snags and leave trees may also provide unique niches and microsites for a variety of plants, especially within retained clumps. Leave trees or snags that fall over and decay will also benefit soil conditions as well as wildlife that utilize coarse woody debris.

The fundamental idea is to retain some structure for snag- and cavity-dependent species on a site, or maintain the potential to produce such structure as a stand grows and develops (see Chapter 12: Timber Harvesting, for specific recommendations on leave tree and snag selection and distribution).

ECO-REGION APPLICABILITY

Cavity and snag trees are important statewide. Wildlife species that use cavities range in size from small mammals such as bats and mice, up to black bears. A range of tree sizes is necessary on a landscape scale to provide for the full use of this habitat feature.

Figure 3-1: Snags provide ideal conditions for wildlife requiring perches, tree cavities, and bark-foraging sites.

Openland or brushland management may require felling of all stems to reproduce open conditions needed in these habitats. Additionally, some forest types, such as aspen, require full sunlight for best regeneration and may require similar treatment. These forest types can function as openland during early stages of establishment. However, some openland wildlife species require cavities. For example, Eastern Bluebirds will nest in single, scattered snags in an open landscape. Generally, dead standing stems do not detract from the establishment or maintenance of openland/brushland habitat. However, they may provide structure for some undesirable wildlife species in some situations. European Starlings will nest in cavity trees in open or semi-forested landscapes if the site is adjacent or near an agricultural or urban/suburban setting. Starlings will out-compete other cavity nesting birds for this limited resource. In addition, if managing for openland species that are under severe predation pressure from raptors, consider removing all standing stems.

Figure 3-2: This strip of uncut pine provides a wildlife travel corridor through a clearcut area.

Cavity/snag trees are equally important in forested stands. There are a number of cavity-dependent species that require a larger forested acreage with sufficient canopy cover. Small mammals, bats and breeding birds that live in heavily forested areas also nest in cavities and use snags for foraging sites. Black-capped Chickadees and Tufted Titmice are only two of a number of charismatic forest bird species that nest in cavities. When conducting a single-tree selection harvest consider leaving snag and cavity trees of varying diameters. Barred Owls and Pileated Woodpeckers utilize large cavities and snag trees, while Downy Woodpeckers and Chickadees utilize smaller trees. In addition, these trees will also eventually topple and contribute to coarse woody debris on the forest floor.

LANDSCAPE IMPLICATIONS

Although these guidelines address site-level recommendations for snags and leave trees, the contribution of an individual site should be considered in the context of the surrounding landscape. Many of the cavity-dependent species being addressed have home ranges larger than the typical harvest unit, so planning for their needs requires a broader look, both spatially and temporally, at the larger forest community. Many other species have smaller home ranges than the typical harvest unit.

If suitable habitat exists surrounding a given harvest site, then leave trees may not be as critical on that site. However, if harvests are likely in the adjacent habitats, then the trees left on the initially harvested sites become more important as the surrounding forest regenerates. Consideration must be given to the time it takes for a regenerating stand to produce trees of adequate size and degree of decay to provide suitable structure.

Coordination among neighboring landowners may result in varying numbers of leave trees on a site if adjacent lands exceed or fall short of the recommendations. Managers of larger land-holdings may be able to plan for sufficient cavity-dependent wildlife habitat on portions of their property (such as riparian reserves) and reduce leave tree/snag requirements on other portions.

Coarse Woody Debris and Slash

PURPOSE

The purpose of coarse woody debris and slash is to provide cover, food or growing sites for a diverse group of organisms through the retention or creation of coarse woody debris and slash during forest management.

RATIONALE, BACKGROUND AND BENEFITS

A wide variety of organisms benefit directly or indirectly from presence of coarse woody debris and slash. Small mammals dependent on slash and coarse woody debris in turn provide food for mammalian carnivores and forest raptors (such as the pine marten and the Broad-winged Hawk). Amphibians such as Wood Frogs, Four-toed Salamanders, and Red-backed Salamanders utilize the cool, moist microsites created by coarse woody debris as resting/feeding areas.

Woody detritus reduces erosion and affects soil development, stores nutrients and water, is a major source of energy and nutrients, serves as a seedbed for plants, and is a major habitat for microbes, invertebrates and vertebrates. For example, yellow birch, white cedar and eastern hemlock regeneration is enhanced by coarse woody debris. These tree species are important components of a diverse northern forest, and provide habitat for an untold number of vertebrate and invertebrate species. Bird researchers in northern Wisconsin found that hemlock dominated natural areas contained higher species diversity and richness than the even-aged managed hardwood sites that dominate this landscape.

The fundamental idea is to retain or enhance the amount of coarse woody debris in a stand in order to benefit the organisms associated with coarse woody debris, and to support nutrient cycles that benefit healthy forests (see Chapter 12: Timber Harvesting, for specific recommendations on coarse woody debris).

Figure 3-3: Coarse woody debris provides cover, food, habitat structure, and growing sites for many different animals and plants.

ECO-REGION APPLICABILITY

Coarse woody debris is important to forests and forest organisms statewide. Each eco-region has a number of species that utilize slash and coarse woody debris. In the north, birds such as Winter Wrens and Ruffed Grouse utilize downed logs for nesting/feeding sites and for territorial displays. Blue-spotted or Northern Red-backed Salamanders enjoy the moist, cool microsites provided by rotting logs on the forest floor. In the south, birds such as Hooded Warblers or Kentucky Warblers may be taking advantage of the arthropods that live in and around coarse woody debris. Regardless of the location, coarse woody debris and slash is an important component of the forest ecosystem.

LANDSCAPE IMPLICATIONS

Although these guidelines address site-level recommendations for snags and leave trees, the contribution of an individual site should be considered in the context of the surrounding landscape. Coarse woody debris left on a specific site may be benefiting reptiles and amphibians living there but breeding elsewhere. Thus, coarse woody debris placement might be influenced by off-site factors. For example, when managing a pine plantation, coarse woody debris may be important as a salamander migratory corridor between an adjacent hardwood forest and a wetland breeding site. However, if the pine plantation is bordered by other dry or arid cover types, and lacks wetlands of any type, coarse woody debris may not be important to salamanders at this site.

The size and position of intensive timber management may also determine the importance of coarse woody debris to associated organisms. For example, if a clearcut takes place surrounding a temporary wetland, coarse woody debris left in the clearcut and in the wetland would be essential habitat for breeding salamanders. Increased sunlight in the pond and harvested stand makes desiccation a problem for salamanders. More downed logs would provide cool, moist microsites in order to avoid direct sunlight during the heat of the day. In addition, leaving downed logs would also provide drumming sites for Ruffed Grouse. If however, the clearcut was smaller and the wetland was bordered by older forest, coarse woody debris left in the clearcut would not be as important for salamanders. However, it still may perform other ecological functions important to the forested stand.

Conifer Retention and Regeneration

PURPOSE

The purpose of this aspect of habitat is to ensure diversity of wildlife habitat through the retention and regeneration of conifers for food, nesting and cover in mixed deciduous/coniferous stands. Conifers should continue to be a significant structural component in appropriate habitats and landscapes.

RATIONALE, BACKGROUND AND BENEFITS

Many wildlife species benefit from a mixture of conifer and deciduous trees and shrubs. Retaining young conifers, including isolated trees and scattered clumps, can provide habitat and food needed for many wildlife species, and can increase the probability that conifers will later regenerate on harvested areas.

Various animal species, including the Great Gray Owl, Bald Eagle, Pine Warbler, white-tailed deer, elk, pine marten, lynx, snowshoe hare, and red-backed vole, depend on coniferous stands for structural attributes. Others – including Spruce Grouse, Red-breasted Nuthatch, red squirrel, porcupine, and elk – depend on food that coniferous stands provide. Deer and elk will often winter in conifer forests due to the reduced snow depths and thermal cover that these stands provide. Many species associated with the boreal forests of Canada reach the southern limits of their range in the coniferous and mixed coniferous forests of northern Wisconsin. Examples of these include pine marten, fisher, gray wolf, Cape May Warbler, Boreal Chickadee, Great Gray Owl, Gray Jay and Palm Warbler.

Historically, conifers often existed as scattered trees or clumps within hardwood stands. Many of these conifers have been lost due to poor regeneration following early logging. A number of species are adapted to these scattered overstory conifers or patches of conifer within a hardwood stand. Pine Warblers are often heard singing from scattered overstory white pines that have persisted or regenerated within an oak or maple forest. Bald Eagles or Osprey often use these scattered superstory trees as nesting or roosting sites. Often aspen/birch stands in northern Wisconsin contain patches of regenerating or mature white spruce or balsam fir. Birds such as Cape May Warbler, Magnolia Warbler and Canada Warbler will locate territories in and around these coniferous patches. These dense areas of conifer also provide thermal cover for grouse, deer and other northern species during cold winters and warm summers.

When retaining conifers, clumps are preferable to scattered trees. Clumped conifers are more windfirm, are better potential seed sources because of improved pollination, can withstand snow and ice loads more successfully, and can provide better cover (see Table 3-1, page 54).

Figure 3-4: A deer trail meanders through a frost-covered opening. The retention of openings, created as log landings during harvesting, or as the result of other forest operations, can help provide a mix of habitat conditions for many wildlife species.

ECO-REGION APPLICABILITY

These guidelines are most applicable to the northern part of the state. Certain areas in west-central and central Wisconsin that do contain areas dominated or co-dominated by white and jack pine may also benefit from these recommendations.

It is important to match existing site conditions and silvicultural objectives to plans for conifer retention and regeneration. Consult the silvicultural handbook or DNR staff for distributions of different conifer species within different ecological landscapes. Conifer regeneration and retention will work best if done in appropriate conditions and site locations. For example, retention and regeneration of fir and spruce in aspen/birch stands would be most appropriate on the Superior Coastal Plain and other areas of northern Wisconsin that historically supported a mixed aspen/spruce forest type. Retention and regeneration of white or red pines might be most effective in the Northern Highland landscape, where white and red pines once dominated forest canopies.

LANDSCAPE IMPLICATIONS

Although these guidelines address site-level recommendations for conifer retention and regeneration, the contribution of an individual site should be considered in the context of the surrounding landscape. When discussing conifer retention and its importance to wildlife, landscape scale management can be very important. Many species that utilize coniferous or mixed/coniferous woods have much larger home ranges than the particular stand being considered for management, therefore, it is important to take into account neighboring properties. In other situations, scattered leave trees or clumps of conifer regeneration will provide wildlife benefits, even when isolated from similar conditions.

If the stand being considered for management is bordered by coniferous forest, or if the region contains a large percentage of coniferous/mixed coniferous forest, then conifer retention or regeneration will have a greater likelihood of benefiting those species with larger home range needs or area requirements. Species such as Blackburnian Warblers, Connecticut Warblers or Cape May Warblers will use conifer retained in managed areas if these landscape conditions are met. Often, small songbirds such as these will nest in loose colonies where extra-pair matings are an important part of the breeding strategy. Larger patches of habitat will increase the chances that this mating system will work.

If the stand being considered for management is isolated from appropriate coniferous or mixed coniferous habitat, it will be of lesser value to those species needing large areas of this habitat. However, other species may utilize smaller patches of coniferous regeneration. For example, small patches of thick fir or spruce may harbor wintering Ruffed Grouse or Saw-whet Owls. Scattered white pine canopy trees can be important nesting areas for Pine Warblers or Bald Eagles.

CONIFER SPECIES	EXAMPLES OF USES BY WILDLIFE
Red Pine	Mature trees may be used by raptors for perches or nest trees. Seeds are important mast for winter songbirds and red squirrels. Larger stands of mature trees provide breeding habitat for Red Crossbills, Pine Warblers, Blackburnian Warblers, and Pine Siskins. Mature stands with dense deciduous or coniferous understories can contain diverse breeding bird assemblages, including some rare species.
White Pine	When young, provides good escape and severe winter cover for many species. High calorie, large seeds eaten by many small mammals and winter songbirds. Mature trees are important for cavity-dependent wildlife, preferred Bald Eagle nest trees, and escape trees for bears. Roosting trees for Wild Turkeys where present in central and southern Wisconsin.
Jack Pine	Very good cover for a number of species when trees are young and stands are well-stocked. Used as browse, most notably by Spruce Grouse. Seeds eaten by red squirrels and Red Crossbills. Persistent cones provide a year-round food source. Mature stands in north-western Wisconsin home to rare Connecticut Warbler.
Balsam Fir	Important winter and summer cover for deer, elk and many species of birds. Birds eat seeds and use trees for nesting. When allowed to persist in hardwood understory, is important nesting cover for Black-throated Blue Warblers and other bird species. Thermal cover for grouse and owls.
Black Spruce	Important escape and severe winter cover. Birds such as White-winged Crossbills eat seeds and use trees for nesting. Buds and needles are important Spruce Grouse food. Often have diverse and abundant small mammal populations, which are important food sources for owls and other forest raptors. Black spruce wetlands contain many vertebrates and invertebrate species not commonly found in Wisconsin. Dead or dying trees often provide insects and snags for Black-backed Woodpeckers.
Tamarack	Mature stands provide excellent habitat for owls and other birds. Snags are used as hunting/singing perches. Seeds are eaten by small mammals, Pine Siskins and Crossbills.
White Cedar	Mast is important food source for winter songbirds. Very important winter cover for deer. Important for browse during severe winters. Provides cover and cooling effect near water.
White Spruce	Important seed source for winter finches. Summer nest cover for rare songbirds such as Cape May Warbler and Evening Grosbeaks. Thermal cover for owls and grouse.
Eastern Red Cedar	Important winter cover in southern Wisconsin. Fleshy berry-like cones used by birds for food.
Hemlock	Hemlock-dominated forests or mixed stands contain distinct breeding bird assemblages not found in hardwood forests. Mature trees provide important owl roosting sites. Mast important to red squirrels and winter finches.

Table 3-1: Conifer Species and Examples of Use by Wildlife

Mast

PURPOSE

The purpose of this habitat aspect is to provide for wildlife that utilize mast production from trees and shrubs.

RATIONALE, BACKGROUND AND BENEFITS

Many species of trees and shrubs have developed a seed dispersal system that benefits many species of wildlife. Producing mast in the form of nuts or berries encourages mammals such as squirrels or birds to eat or transport the seeds to other areas. Oaks may produce thousands of acorns in the hope that a Blue Jay or Turkey will accidentally scratch one into the forest soil. Dogwoods and juneberries will produce fruit attractive to migrating birds, which will pass the seeds to neighboring areas during migration. This complex reproductive strategy is essential to the inner workings of many ecological systems in Wisconsin.

High levels of fat, protein and carbohydrates in mast contribute to energy stores critical for migration or hibernation, and for survival of newly-independent young. Many birds that eat insects on breeding grounds will consume berries during fall migration. Yearly variations in mast production may impact subsequent reproductive success of many species. Often, plentiful mast production will lead to abundant small mammal populations, which in turn benefits forest carnivores that prey on small mammals. During winter, some sources of mast remain available to forest wildlife on trees and shrubs, under snow or stored in caches (see Table 3-2, page 56).

Mast production is generally favored by increased crown exposure to light, crown size, maturity of trees or shrubs, increased soil nutrients, tempered microclimates (especially during flowering), and adequate soil moisture. Production on a site tends to vary considerably from year to year.

Other considerations with respect to mast include:

- Mast-producing species often depend on animals for their dispersal and reproduction.
- Riparian edges often contain a higher concentration and richness of mast-producing species.
- Most shrub species will regenerate well and produce mast after cutting, burning or soil disturbance.

Although concerns for oak and other dominant tree species are particularly important, especially in relation to game species (such as deer or gray squirrels), other mast species also provide important benefits.

ECO-REGION APPLICABILITY

Retention of mast and other key food-producing tree types should be prioritized in accordance with the local abundance of each tree species. In areas of least abundance, greatest attention should be applied to retention. Planning silvicultural treatments to increase mast-producing trees should be performed in accordance with silvicultural guidelines laid out in the DNR silvicultural handbook.

LANDSCAPE IMPLICATIONS

Although these guidelines address site-level recommendations for mast production, the contribution of an individual site should be considered in the context of the surrounding landscape. Land managers in regions with low mast availability have opportunities to enhance wildlife habitat characteristics by careful management of mast species on their land. Some wildlife species may travel significant distances to obtain mast. The black bear, for example, may travel 10 miles to obtain mast. Breeding birds will often relocate family groups to wetland edges, or areas with increased levels of berries during late summer before migration. In areas with sufficient mast production, mast production may not be as important.

MAST SPECIES	EXAMPLES OF USES BY WILDLIFE
Oaks (acorns), beech and hazel nuts	Deer, bear, Wild Turkey, Woodpeckers, Blue Jay, Wood Duck, squirrels
Maple and ash seeds	Small mammals, Evening and Pine Grosbeaks
Aspen, birch and hazel buds	Ruffed Grouse
Yellow and white birch seeds	Common Redpoll, Pine Siskin, American Goldfinch
Conifer cones and seeds (such as white cedar, balsam fir, black spruce, white pine, common juniper, red cedar, Canada yew)	Red squirrels, White-winged and Red Crossbills, Pine Siskins, Red-breasted Nuthatch, Pine Grosbeak
Late summer soft mast (such as juneberries, blueberries, cherries, dogwoods, and elderberries	Important to a number of birds and mammals as they prepare for migration and winter
Soft mast retained in fall and through winter (such as mountain ash, cranberry and nannyberry, winterberry)	Waxwings, Pine Grosbeaks and other bird and mammal species
Vines (such as wild grape)	Numerous bird and mammal species

Table 3-2: Examples of Mast-producing Plants that Will Benefit Wildlife in Wisconsin

Patterns of Cutting

PURPOSE

The purpose of this habitat aspect is to provide site- and landscape-level wildlife habitat requirements by using a variety of sizes and shapes of harvest areas. Understanding the impact from site-level management on the larger forested area will help land managers make better wildlife decisions.

RATIONALE, BACKGROUND AND BENEFITS

This management objective will involve making silvicultural decisions on a landscape basis. Ideally, the management regime should range from the very fine-scale management represented by selection cutting to the coarse-scale management affected by sizable clearcuts. The size of clearcuts and other treatments should be determined by considering issues such as size of the management unit, the home range requirements of large animals, aesthetics, and natural disturbance regimes.

Although ownership considerations may preclude this, size and shape of both cut and uncut areas should mimic natural disturbance regimes that historically impacted the forest type to be managed. This will then benefit the native species of plants and animals adapted to this forest type and disturbance regime. Larger patch sizes historically occurred under natural disturbance regimes on even-aged, fire-dependent types, such as jack pine. Large clearcuts in such types can function for a short time as habitat for some area sensitive openland species such as Sharp-tailed Grouse and Upland Sandpipers.

These managed areas will be of even greater benefit to openland species if they are placed adjacent to more permanent open barrens. Colonization of new openland habitat created by forest management is much more likely to occur if it is adjacent to existing populations of openland species. As the managed area ages, it will become less attractive to openland species, but other early successional species such as Eastern Towhees and Brown Thrashers will colonize the site.

Smaller patches are appropriate in more heterogeneous forest types, such as deciduous forests on moraines. For example, northern mesic forests dominated by sugar maple, hemlock or beech were much more likely to undergo disturbance from wind than from large fires. Most wind events created smaller patchy canopy gaps within a larger forested matrix. Species like Black-throated Blue Warblers nest within the thick regeneration generated by these disturbance events, and thus could benefit from a silvicultural treatment that mimics this process.

The shape and size of the cutting area determines the total amount of edge habitat created through management. An **edge** is defined as the transition area between two different forest types or successional stages. This transition zone can be "hard" (between a forested habitat and a field) or "soft" (between two age classes of forest habitat). "Hard" edges tend to be permanent, and may have more impact on wildlife than "soft" edges. "Soft" edges can also form as forest expands into open habitats. These "soft" edges differ from the regeneration found in canopy gaps by virtue of the amount and distribution of the regenerating age class. The amount and type of edge in a landscape will create conditions favorable for some species and detrimental to others. Many game species such as white-tailed deer and Ruffed Grouse, along with Indigo Buntings and Chesnut-sided Warblers, prefer the wide variety of cover and food resources found along forest edges, and tend to be very good competitors for those resources. Landscapes with high amounts of natural or man-made edges tend to favor these edge species. However, many species of birds, some mammals and herps prefer the interior of larger (greater than 100 acres) blocks of forest. Cerulean Warblers, Acadian Flycatchers, Hooded Warblers, Black-throated Blue Warblers, and many other interior species are listed as endangered, threatened or species of special concern by the Bureau of Endangered Resources due to loss of appropriate habitat. A large increase in the amount of edge, through forest management activities or a natural disturbance in large blocks of forest, will increase edge species which will replace many interior species.

Figure 3-5: Two age classes of aspen, managed for grouse by clearcutting, illustrate the "edge" where two stands meet.

ECO-REGION APPLICABILITY

The soils, climate and geology of different eco-regions across the state favor different types of forests. Each forest type and its associated wildlife are adapted to a particular disturbance regime. Ideally, forest management activities should take these disturbance regimes into account.

In general, more diverse and larger patch sizes are possible in northern Wisconsin than in the forest fragments of southernmost Wisconsin. Since many of our southern forests have been converted to other uses, special consideration should be given to conserving large patch sizes of existing forests.

LANDSCAPE IMPLICATIONS

When employing large clearcuts, consider harvesting in segments over several years. This will provide both early successional diversity and, over the long-term, a large mature forest stand. Coordinate with adjacent landowners when natural stand boundaries cross property lines.

Endangered, Threatened and Special Concern Species

PURPOSE

The purpose of this section is to increase awareness of endangered, threatened and special concern species (ETS species), and the need to maintain or enhance populations of these species. In addition, this section will help to increase awareness of statewide forest policies to consider endangered and threatened species in the forest management decision-making process.

Frequently Asked Questions

WHAT DOES IT MEAN WHEN RARE SPECIES ARE FOUND ON MY LAND?

It means you have land that is quite different than most properties in the state. Native species that have been eliminated elsewhere still find a home on your land. This may have some legal obligations, but it may also yield some benefits.

WHAT IS THE DIFFERENCE BETWEEN ENDANGERED AND THREATENED SPECIES?

Endangered means the species is in danger of becoming extinct. Threatened means the species is less vulnerable, but a chance exists that they will soon be endangered.

WHAT IF THE SPECIES ARE PLANTS?

The plants that are found on private property belong to the landowner. What becomes of them is the decision of the landowner. Of course, the Department of Natural Resources wants to encourage and help the landowner protect and manage these valuable plants.

WHAT IF THE RARE SPECIES TURN OUT TO BE BIRDS OR OTHER ANIMALS?

Because animals usually travel freely from one property to another, they belong to everyone. Laws determine what anyone can do with these species. For example, it is illegal to shoot a timber wolf in Wisconsin, although it is not illegal to shoot a white-tailed deer in season. Laws also protect nesting birds or turtles from being disturbed during the nesting season. For example, it is illegal to disturb an active Bald Eagle nest. Sometimes habitats are protected. Many of our State Natural Areas protect large pieces of rare habitats such as beach dunes, sedge meadows, or old growth forest. These rare habitats often host a number of rare plants and animals. Chiwaukee Prairie State Natural Area in Kenosha County hosts 40 rare plants, birds, butterflies, insects, turtles, and natural communities.

IF AN ENDANGERED SPECIES IS FOUND, WHO WILL GET THIS INFORMATION?

The information is shared with the landowner or land manager, of course. Otherwise, it is confidential. It is not dispensed to the media, and is exempt from the open records law.

HOW DOES A LANDOWNER BENEFIT FROM THE KNOWLEDGE THAT AN ETS SPECIES OCCURS ON THEIR PROPERTY?

You learn from biologists what makes your property special. You may get help with managing the natural resources on your land. Several programs are in place that can provide tax advantages or cost-sharing for management. Knowledge of the occurrence of rare plants and animals is increasing every year. The best information on occurrences of rare species is the Endangered Resources Program's Natural Heritage Inventory. Information on publicly-owned land is relatively good, however, private land is inventoried only with permission of the landowner, and coverage is very patchy.

RATIONALE, BACKGROUND AND BENEFITS

By definition, ETS species are rare. Wisconsin is home to more than 12,700 fungi, 2,652 plant species, 37,000 invertebrate species, and 681 vertebrate species. The Wisconsin Department of Natural Resources lists 859 of these plants and animals as endangered, threatened or special concern, with more than 28 percent – 245 species – further identified as species that may be affected by forest management activities. Five of these are also listed as federally endangered or threatened.

All species found in a natural forest ecosystem contribute to its healthy functioning. Humans tend to place values on the species found in these ecosystems, however, for the plants and animals living in the forest, no value judgment is given. They are there because that's where they live. Only we can make decisions affecting their habitats. Management decisions should occur with the best information available. Reasons for considering all species in the decision include the following:

- Conservation of species because of their innate values.
- Conservation of rare species that play a critical role in ecosystem function.
- Conservation of nutrient recycling and soil enhancing animals and fungi.
- Conservation of natural disturbance regimes.
- Deter invasion by aggressive, non-native invasive species.
- Conservation of genetic strains that are adapted to local climate and site conditions.
- Conservation of aesthetic and recreational values.
- Conservation of species that may produce economically-valuable products or provide eco-tourism benefits.
- Scientific and educational benefits.

PROTECTION AND MANAGEMENT

Most forest management activities will not involve ETS species. Even when they are found, the laws seldom totally prohibit activities. The landowner owns the plants found on the property. On public land, endangered and threatened plant species are considered when developing a management plan or conducting a timber sale. Endangered and threatened animal species are protected by law, but many can be incidentally taken, if certain restrictions are followed. Special concern species have no legal protection, but that does not abdicate the responsibility to consider them in planning actions.

When found, most ETS species tend to be found in specialized habitats. Seeps, ephemeral ponds, cliffs, extensive bog areas, old-growth forest, and large blocks of southern Wisconsin forest harbor a vast majority of the 245 forested ETS species. Many species are also localized in their distribution. Several species are found in only a few locations in the state with the rarest species almost exclusively found on publicly-protected land.

Many studies on the relationship between timber harvest and vertebrates provide a basis for making decisions regarding those rare species. Relatively little is known about the impacts of timber harvest on rare plants and especially invertebrates. Long-lived and slow-dispersing understory plants and invertebrates, especially those that have their optimum habitat in late-successional or old-growth forest, may be particularly affected by timber harvest.

The Managed Forest Law (MFL) applies sound forest practices of timber cutting for effective propagation, or improvement of various timber types. Sound forest practices also include, where consistent with landowner objectives, management of forest resources for endangered and threatened plants and animals. MFL applications are screened for occurrences of endangered and threatened species through the Natural Heritage Inventory (NHI) On-line Database maintained by the Bureau of Endangered Resources (BER).

Figure 3-6: Cavity trees enhance the quality of wildlife habitat.

Figure 3-7: Eagle nest in the top of a white pine tree. Leaving trees like this provide ideal sites for nesting.

LEGAL PROTECTION

Endangered and threatened species are protected in Wisconsin by one or more of the following laws: the Federal Endangered Species Act of 1973 (Public Law 100-478), Lacey Act, Migratory Bird Treaty Act, Bald Eagle Protection Act, Wisconsin Endangered and Threatened Species Law (State Statute 29.604 and Administrative Rule NR27), and the Wisconsin Non-game Species regulations (State Statute 29.039).

Other laws, both state and federal, may apply to the protection of plants and animals in the state. Specific information may be obtained from your local DNR office, or the BER Endangered Resources Program (see the Resource Directory).

Other sources of information include:

- Local DNR biologists, conservation wardens, foresters, park managers, or naturalists.
- Nature centers, colleges and universities, and University of Wisconsin-Extension offices.
- NHI On-line Database, **www.dnr.state.wi.us/org/land/er/nhi/NHI_ims/onlinedb.htm**
- NatureServe Web Site, **www.abi.org**
- Wisconsin Vascular Plant Web Page, University of Wisconsin Herbarium, **wiscinfo.doit.wisc.edu/herbarium/**
- Breeding Bird Atlas Maps for Listed Species, **www.uwgb.edu/birds/wbba/**
- Wisconsin Herpetological Atlas Web Site, **www.mpm.edu/collect/vertzo/herp/atlas/atlas.html**

State Natural Areas and Rare Natural Community Types

PURPOSE

The purpose of this habitat aspect is to increase awareness of protected state natural areas and rare (including geographically restricted) natural community types. Generally, natural areas are tracts of land or water-harboring natural features, which have experienced the least intrusive degrees of human disturbance, and which represent the diversity of Wisconsin's native landscape. They contain outstanding examples of native biotic communities, and are often the last refuges in the state for ETS species. Natural areas may also include exceptional geological features. State Natural Areas are officially recognized parcels that can be visited to better understand the ecology of forests with little past disturbance. Rare natural community types are either scarcely found on the landscape or harbor a seral stage that is rarely found in today's forested ecosystem (see pages 62-64 for descriptions).

RATIONALE, BACKGROUND AND BENEFITS

Natural areas and rare natural community types represent only a small portion of the total forested area of the state. A statewide, county by county, inventory for the presence of natural areas was completed by the State Natural Areas Program in the period of 1969 through 1983. Each site was evaluated for landscape characteristics, natural community site values and species viability.

Since 1985, this data and subsequent natural areas data is housed in the Natural Heritage Inventory (NHI) database. This program tracks rare natural communities plus many others that are geographically restricted, contain older seral stages, or harbor diverse concentrations of species. Among the rare natural communities such as oak openings, mesic prairies and algific talus slopes nearly all occurrences are tracked. For relatively common natural communities, such as northern mesic forests, the tracked occurrences represent those examples least disturbed by human activities (e.g., older successional stages) as well as areas that support exceptional biotic diversity. The significance of a given natural community occurrence is therefore related to not only its quality and condition, but also its size, context, and relative condition to more degraded examples.

The presence of natural areas or sensitive natural communities can provide many benefits for the landowner and citizens of the state:

- Protect habitat for ETS species.
- Provide reference areas to compare the effects of more intensively managed areas. Best used in an adaptive management situation and often times can accommodate some active management.
- Provide opportunities for scientific research where natural processes are allowed to proceed essentially unimpeded.
- Provide opportunities for formal and informal education to gain an appreciation and understanding of biotic communities and their component species.
- Apply the principles of ecosystem management to the forest.
- Provide areas which are managed more intensively (barrens and savanna) or less intensively (late succession to old-growth forest) than normal sustainable forest practices.
- Protect significant geological features.
- Provide a reservoir of genetic and biological diversity.

Natural areas and rare natural community types are often managed by avoidance, while other sites can be maintained by fire, or appropriate silvicultural techniques.

The best information on natural areas and sensitive natural communities is provided by the DNR State Natural Areas Program in the Bureau of Endangered Resources (BER). A compilation of known occurrences of sensitive natural communities can be found at the BER web site listed under information sources. The extensive statewide inventory covered only a fraction of the forested land in the state. Many sites remain unknown. Identifying natural areas and sensitive natural communities can be challenging, and may require expert evaluation.

Affected Natural Communities

The following natural communities may possibly be affected by activities. The database of communities is based on State Statute 23.27 to identify natural areas meeting a critical level of importance in the state. The Endangered Resources Program manages the list of these forest communities:

- **Black Spruce Swamp:** Characterized as a conifer swamp with high canopy closure dominated by closed canopy black spruce. Significant examples have old trees greater than 100 years and large size greater than 40 acres, or are found with a diverse array of other forested wetland types.
- **Bog Relict:** This geographically limited community is found in south of the tension zone in Wisconsin, and contains many of the more widespread bog species from the north. These relicts are often isolated from similar northern communities and many times contain rare species.
- **Boreal Forest:** A forest community dominated by white spruce, white cedar, white pine, balsam fir, and paper birch is limited to areas near the Great Lakes. Mature forests are rare in Wisconsin, and old-growth examples are virtually non-existent.
- **Central Sands Pine-oak Forest:** This recently described and geographically limited natural community is found in Central Sands eco-region, and characterized by a diverse canopy of red pine, white pine, several oak species, and red maple. The ground layer is sparse, mostly penn sedge and blueberries. Virtually no sites have been identified for ecological study.
- **Floodplain Forest:** Also known as bottomland hardwoods is found along most of our large rivers. Characteristic trees include silver maple, river birch, green ash, hackberry, cottonwood, swamp white oak, and formerly elms. These forests are very diverse and larger patches can provide habitat for several rare species. Ecologically important sites contain trees greater than 100 years, and have unrestricted flood pulse events.
- **Forested Ridge and Swale:** This rare forested community complex is limited to a narrow fringe along the Great Lakes, and formed on old dunes and beach ridges created during past high water events.

Figure 3-8: A bald eagle resting on a white pine branch in northern Wisconsin.

- **Hemlock Relict:** These are isolated hemlock stands occurring in deep moist ravines or on cool, north and east-facing slopes in southwestern Wisconsin. These relicts are very rare with extremely small opportunities for enhancement or expansion. They should be treated with a very, light hand, if at all.
- **Mesic Cedar Forest:** This is a rare upland forest community of mesic sites in northern Wisconsin, characterized by white cedar as a co-dominant tree. Associates include hemlock, white spruce, yellow birch, and white pine. All stands of this type are rare and should be considered for alternative management.
- **Mesic Floodplain Forest:** A very rare natural forest community found on alluvial terraces of streams flowing into Lake Superior. This forest is characterized by typical northern hardwood in the canopy, but the ground layer has an exceptionally diverse spring ephemeral flora with many southern species reaching their range limit. These rare isolated terraces should be managed with a very, light hand, if at all.

- **Northern Dry Forest:** This relatively common forest community is characterized by the presence of jack pine, Hill's oak and occasional red pine. Stands of special ecological interest were generated after a catastrophic fire, have older age classes with many openings, and are planned for regeneration using prescribed fire.
- **Northern Dry-mesic Forest:** A forest community dominated by various combinations of white pine, red pine, red oak, and red maple, this type is very common in the state. Stands of special ecological interest are greater than 100 years of natural origin with a special emphasis on those stands with continued fire management.
- **Northern Hardwood Swamp:** This natural forest community is found along lakes, rivers and isolated basins with the predominant species being black ash. Sites of special ecological interest are those greater than 100 years found along rivers or lakes having intact hydrology with little chances of being killed by beaver activity, and those found in extensive tracts or large basins.

Figure 3-9: Numerous "islands" of uncut trees in this clearcut stand, along with scalloped edges, provide good wildlife habitat and improved visual impact after timber harvesting.

- **Northern Mesic Forest:** A combination of forester's northern hardwood and hemlock/hardwood cover types, this natural forest community is our most common. Stands of special ecological significance are those containing trees greater than 100 years old, numerous tip-up mounds, abundant coarse woody debris, embedded vernal pools, and extensive tracts covering numerous landforms.
- **Northern Wet Forest:** Roughly equivalent to the swamp conifer cover type, this forest is dominated by black spruce, tamarack and occasionally jack pine. Stands of special ecological significance are greater than 120 years old, have nearly continuous canopy, and are relatively free of dramatic water level fluctuations.
- **Northern Wet-mesic Forest:** Roughly equivalent to the white cedar cover type, this natural forest community is dominated by white cedar, but also has significant balsam fir, black ash and spruces in the canopy. Most stands have a special ecological significance due to the confounding effect of deer on cedar regeneration. Until effective cedar replacement can be assured, most stands should be considered for alternative management.
- **Oak Woodland:** Once relatively common on Wisconsin's landscape, this natural forest community roughly intermediate in structure between oak opening and southern dry forest, is now virtually non-existent. Ecologically significant sites lie entirely in the realm of restoration. Sites should be evaluated for canopy structure, remnant oak woodland ground layer species, and availability for long-term fire management. Assistance for evaluations may be provided by BER.
- **Pine Relict:** Similar to hemlock relict, these conifer dominated communities are found in isolated locations in the driftless area of southwestern Wisconsin. This natural community has red pine, white pine and occasionally jack pine as the dominants, and is found on sandstone outcrops. Regeneration is often problematic and should be attempted only with great care.

Figure 3-10: Course woody debris in riparian and upland forests provide great habitat for nesting and foraging salamanders, small mammals, and birds such as this Cape May Warbler.

- **Southern Dry Forest:** This natural forest community represents the oak cover type found on dry, especially sandy, sites. White oak and black oak are the dominants, and often red oak and black cherry are associates. Shrubs are well-developed and diverse. Sites with special ecological significance are those greater than 100 years old with numerous standing and fallen dead trees.

- **Southern Dry-mesic Forest:** Most closely associated with the red oak or central hardwoods cover types, this natural community is dominated by red oak with significant inclusions of white oak, basswood, sugar maple, red maple, and white ash. Sites with special ecological significance are those greater than 100 years containing numerous tip-up mounds, coarse woody debris, vernal pools, seeps, and crossing different landforms.

- **Southern Hardwood Swamp:** This natural community is associated with isolated basins in glaciated southeastern Wisconsin. Common dominants are red maple, green ash, and formerly American elm. This natural community is rarely found in an unmanipulated condition. Sites with special ecological significance are any without or very few invasive exotics, such as buckthorns, honeysuckle and reed canary grass.

- **Southern Mesic Forest:** This natural forest community can be confusing, because it is analogous to the northern hardwood cover types. However, it's found primarily south of the tension zone and usually has much different ground layer species than northern hardwoods north of the tension zone. Stands of special ecological significance are those greater than 100 years, larger than 120 acres, abundant coarse woody debris, embedded vernal pools, and seeps.

- **Tamarack (Poor) Swamp:** This natural community is a broken or closed canopy tamarack swamp growing under limited influence of mineral enriched water. A common associate is alder in the shrub layer. This community has only recently been described, and stands for ecological study have not been established.

- **Tamarack (Rich) Swamp:** This geographically limited forested wetland community is found south of the tension zone. The relicts have many northern species and have sustained severe alteration due to water level manipulation. This rare community type should be considered for alternative management.

- **White Pine/Red Maple Swamp:** This geographically limited swamp community is restricted to the margins of the bed of extinct glacial Lake Wisconsin. It often occurs along headwater streams and seepage areas on gentle slopes. White pine and red maple are the dominants. This very rare natural community should be considered for alternative management.

Field Survey Consultants and Other Resources

The following resources can assist in a field survey to identify state natural areas and rare natural communities:

- DNR Natural Areas staff, heritage ecologists, heritage zoologists, heritage botanists, non-game specialists, forest ecologists, or wildlife managers (see the Resource Directory).

- Local wildlife biologists, foresters, park managers or naturalists.

- Endangered Resources Web Site, **dnr.state.wi.us/org/land/er/nhi/NHI_ims/onlineb.htm**

Wetland Inclusions and Seasonal Ponds

PURPOSE

The purpose of wetland inclusions and seasonal ponds is to provide site-level wildlife habitat features for terrestrial species associated with wetland inclusions and seasonal ponds within forests.

RATIONALE, BACKGROUND AND BENEFITS

Wisconsin has an abundant variety of wetland inclusions and seasonal ponds. The mixture of land and water features across the landscape provides an important dimension to the habitats of many wildlife species.

Wetland inclusions and seasonal ponds are different from puddles. Wetland inclusions and seasonal ponds retain water for longer periods, and support populations of invertebrates that consume forest litter that falls into the depressions. These invertebrates provide food for birds, mammals, amphibians, and other species. Red-shouldered Hawks, a threatened species in Wisconsin, often choose forested areas that contain a number of wetland inclusions to ensure an adequate supply of prey for rearing young. Seasonal ponds are also important spring food sources for breeding waterfowl and migrating birds.

Seasonal ponds are best identified in spring when they are full of melt-water from the spring runoff. Frogs calling in spring, vegetation type or topography might provide additional clues to their location.

One important component of many forest ecosystems are amphibians, and many depend on seasonal wetlands for breeding habitat. These temporary or seasonal wetlands are important to amphibians because they do not contain fish populations, which prey on salamander eggs. Blue-spotted and spotted salamanders will enter these ephemeral wetlands as soon as they lose their ice cover in spring. Pay attention to roadsides during the first warm rain of spring, and you will literally see the forest floor crawling with salamanders traveling to breeding sites. Five species of frogs are also heavy users of wetland inclusions. Anyone who has walked along a forest road at night can recall the croaking of wood frogs, the peeping of spring peepers, and the distinctive notes of chorus frogs. Frog songs can be so loud in these wetland inclusions that they block out all other sounds. Later in the spring and early summer, Cope's and Eastern Gray treefrogs use these wetland inclusions for breeding.

WETLAND INCLUSIONS AND SEASONAL PONDS

- **Wetland inclusions** are wetland basins within an upland site.
- **Seasonal Ponds:** Sometimes called vernal pools, seasonal ponds are depressions in the soil surface where water pools during wet periods of the year, typically in the spring and fall.
  - A seasonal pond will have an identifiable edge caused by annual flooding and local topography.
  - The edge is best identified during the spring or fall, but it may be identified during dry periods by the lack of forest litter in the depression. Such depressions typically are fishless, and retain water for longer periods than puddles.

Note: Replenished annually, leaf litter is consumed during inundated periods, and noticeably depleted thereafter. Deciduous litter will likely be consumed faster and more thoroughly than conifer litter.

Because of the high biomass of amphibians in forested habitats, they are extremely important both as predators of invertebrates, and as prey for other forest wildlife species.

Applying guidelines for water quality, leave trees and snags, coarse woody debris, and slash during forest management activities can retain and create key habitat features (including woody debris, litter depth and plant cover) in these areas, while preventing siltation, excessive warming, or premature drying-up of wetland inclusions and seasonal ponds.

THE NEED FOR RESEARCH AND MONITORING

Even though the ecological importance of wetland inclusions and seasonal ponds is recognized, the total number and location of all such water bodies in Wisconsin's forests is unknown. Existing inventories, such as the National Wetland Inventory, are incomplete with regard to wetland inclusions. Furthermore, seasonal ponds are sometimes difficult to recognize in the field. Uncertainty regarding the abundance and location of wetland inclusions and seasonal ponds indicates the need to document their occurrence, and further research their role in forest ecology in Wisconsin.

Figure 3-11: Wild lupine in central Wisconsin; the Karner Blue Butterfly's only known larval food plant. The Karner Blue is listed as an endangered species, even though they are relatively abundant in parts of Wisconsin.

Riparian Wildlife Habitat

PURPOSE

The purpose of riparian wildlife habitat is to provide site-level wildlife habitat features for species that utilize riparian ecosystems.

RATIONALE, BACKGROUND AND BENEFITS

Riparian areas are among the most important parts of forest ecosystems. These areas have high plant diversity, both horizontally and vertically from the water's edge, which contributes to the high diversity of animals that live in these areas. Up to 134 vertebrate species occur in riparian forests in this region, but many of these species will also use non-riparian forest habitat. The species that are of most concern in riparian areas are "obligate" species, which require both the water and surrounding forests as habitat. In Wisconsin, obligate riparian species include amphibians, reptiles, birds, and mammals. Numerous plant and invertebrate species are also strongly associated with these habitats. Different animals are associated with different stream sizes. In general, larger animals are associated with larger streams and smaller species with smaller streams. A reverse pattern is found in some salamanders.

Although some degree of mature forest cover is desirable along many riparian areas, all habitat conditions are valid, given long-term disturbance regimes. Some wildlife species, such as woodcock, require dense woody cover that can be provided by young forest or shrub cover in riparian areas. The greatest concern for riparian habitats is in those areas of the state where uplands have been converted to agriculture, resulting in little additional forest of any kind in the region. This situation occurs more in the southeastern and western portions of the state rather than in the north, which affords more flexibility in age classes, structures and cover type (see Chapter 5: Riparian Areas and Wetlands, for specific BMPs and harvesting criteria for riparian zones).

Forest streams come in many sizes, growing from spring-fed trickles to large rivers as they move downhill, and converge with one another to drain larger and larger watersheds. Along this gradient, the ecological characteristics of a riparian area change in a gradual continuum. Because of these characteristics, management guidelines for riparian areas in general should be considered on a landscape level.

It is important to keep in mind the following wildlife-related concerns for riparian habitats:

- **Leave Trees and Snags**
  - Prothonotary Warblers, Tufted Titmice, Wood Ducks, and a number of other species are dependent on existing cavities in riparian forests. Woodpeckers and chickadees select dying or diseased trees in which to excavate cavities. It is important to leave existing cavity trees and potential snags for use by the many cavity nesters that utilize riparian forests.
  - Some riparian species require large super-canopy trees (trees above the existing canopy) for hunting perches and nesting sites. On larger rivers, Osprey will often perch in a large, dead white pine above a river to look for prey.
  - Shade is essential for maintaining microhabitat conditions for some riparian animals. Winter Wrens, Northern Waterthrushes and many salamanders like the cool, moist conditions created by a closed canopy riparian forest. Yellow Warblers, Willow Flycatchers and some herps need more open riparian conditions. Providing a range of seral stages where appropriate will benefit a number of riparian species.

- **Coarse Woody Debris and Slash**
  - Many riparian animal species require downed logs for cover. Downed logs and slash in riparian areas provides additional microsites for insects and the species that prey on these insects. Salamanders, frogs and small mammals utilize these large logs as travel routes to avoid predation.

- **Mast**
  - Riparian edges often contain a higher concentration and richness of unique mast species, especially shrubs, than adjacent upland areas. It is well-documented that riparian areas are critical migratory stopover locations for birds that winter in the Neotropics. These areas often have more insect life in the spring before leafout than associated uplands. In the fall, dogwoods, nannyberry, wahoo, honeysuckle, elderberry, and other mast-producing shrubs and trees provide nourishment to birds migrating south and other species preparing for winter.

- **ETS Species (see page 68)**
  - Many ETS species are found in riparian areas.
  - Many of the bigger blocks of forest in the southern half of Wisconsin occur in riparian zones along the larger rivers. These are important areas for forest interior species such as Red-shouldered Hawks, Cerulean Warblers, Acadian Flycatchers, Yellow-throated Warblers, Yellow-crowned Night Heron, and a host of other species found in the southern half of the state.
  - High quality streams and rivers are important habitat for many rare dragonflies, fish, mussels and clams, and other invertebrates. Often the presence of these species is used to evaluate stream health. The middle St. Croix, middle and lower Chippewa, and lower Wisconsin are good examples of riparian systems that host many rare species.

- **Natural Communities and Sensitive Sites**
  - Many natural communities are associated with riparian ecosystems. Some, like floodplain forests, are always associated with riparian areas. Others, such as northern edge meadow, emergent aquatic, and alder thicket are often associated with riparian areas, but can also be found in other situations. For a complete listing and description of natural community types in Wisconsin, see the BER web site.

ECO-REGION APPLICABILITY

These guidelines are applicable statewide.

LANDSCAPE IMPLICATIONS

In areas dominated by agricultural landuse practices (in southern and east-central regions), where riparian forests represent the majority of the forests in the area, consider using uneven-aged management. Most rare species associated with these forests require high-canopy closure and large blocks of forest.

Figure 3-12: This stand of red pine has been thinned three times, and the shrub layer resulting from increased sunlight reaching the forest floor now provides good wildlife habitat.

ETS SPECIES ASSOCIATED WITH RIPARIAN ECOSYSTEMS

- Red-shouldered Hawk[1]
- Yellow-crowned Night Heron[1]
- Acadian Flycatcher[1]
- Western Ribbon Snake
- Yellow-throated Warbler[2]
- Blanchard's Cricket Frog
- Prothonotary Warbler[3]
- Midland Smooth Softshell Turtle
- Louisiana Waterthrush[3]
- Many rare mussels and clams
- Cerulean Warbler[1]
- Osprey[1]
- Wood Turtle
- Great Egret[1]
- Snowy Egret[2]
- Bullfrog
- Bald Eagle
- Massassauga Rattlesnake
- Many rare fish species
- St. Croix snaketail, splendid clubtail and a host of other rare dragonflies
- Numerous other plants, snails and invertebrates

1 Threatened Species
2 Endangered Species
3 Special Concern Species

Figure 3-13: Large blocks of older forest are important to forest interior species such as this Cerulean Warbler.

RESOURCES FOR ADDITIONAL INFORMATION

AMPHIBIANS OF WISCONSIN

Amphibians of Wisconsin (2001), Bureau of Endangered Resources (BER) Publ. No. ER-105 2001, Department of Natural Resources, Madison, Wisconsin. BER publication that gives an overview of amphibian biology and conservation in Wisconsin. Provides a detailed life history and management information for each species in Wisconsin.

BUREAU OF ENDANGERED RESOURCES WEB SITE

This web site provides a wealth of information on rare species and natural communities, the State Natural Areas Program, Invasive Species, program information, and news and events regarding the Bureau, **www.dnr.state.wi.us/org/land/er/**

THE ENDANGERED AND THREATENED INVERTEBRATES OF WISCONSIN

The Endangered and Threatened Invertebrates of Wisconsin (1999), Bureau of Endangered Resources (BER) Publ. No. ER-085-99, Wisconsin Department of Natural Resources, Madison, Wisconsin. BER publication details life histories and general conservation issues of each listed invertebrate species in Wisconsin. Also includes a county by county listing of occurrences of these species at the end of the document.

THE ENDANGERED AND THREATENED PLANT SPECIES OF WISCONSIN

The Endangered and Threatened Plant Species of Wisconsin (1993), Bureau of Endangered Resources (BER) Publ. No. ER-067, Wisconsin Department of Natural Resources, Madison, Wisconsin. BER publication gives basic occurrence and habitat information for the listed plant species in Wisconsin. Species descriptions are separated by general habitat type. Unfortunately, this document has not been updated since 1993, so not all information is current.

THE ENDANGERED AND THREATENED VERTEBRATES SPECIES OF WISCONSIN

The Endangered and Threatened Vertebrates Species of Wisconsin (1997), Bureau of Endangered Resources Publ. No. ER-091, Department of Natural Resources, Madison, Wisconsin. BER publication that gives life history, distribution and management information for all threatened and endangered vertebrates in Wisconsin. A county by county listing of species occurrences is included, but is not up-to-date.

NATURAL HERITAGE INVENTORY ON-LINE DATABASE

This application provides users an opportunity to search the Wisconsin Natural Heritage Inventory (NHI) Program's database for the status and distribution of endangered resources, or to learn what species or natural communities are known to exist within a particular area of interest. The On-line Database is intended for information and general planning purposes rather than regulatory decision-making, **www.dnr.state.wi.us/org/land/er/nhi/NHI_ims/onlinedb.htm**

NATURAL HISTORY OF AMPHIBIANS AND REPTILES OF WISCONSIN

Vogt, Richard C. (1981). *Natural history of amphibians and reptiles of Wisconsin.* Milwaukee Public Museum and Friends of the Museum, Inc.. This publication is a good source of general information on the natural history of herps in Wisconsin.

RUFFED GROUSE SOCIETY

For information on the management of forest habitats for ruffed grouse and other wildlife species, contact:

The Ruffed Grouse Society
451 McCormick Road
Coraopolis, PA, 15108
Phone 412-564-6747
www.ruffedgrousesociety.org

SNAKES OF WISCONSIN

Snakes of Wisconsin (2000), Bureau of Endangered Resources (BER) Publ. No. ER-100-00, Department of Natural Resources, Madison, Wisconsin. BER publication that gives an overview of snake biology and conservation in Wisconsin. Provides a detailed life history and management information for each species in Wisconsin.

THREATENED AND ENDANGERED SPECIES OF FORESTS IN WISCONSIN: A GUIDE TO ASSIST WITH FORESTRY ACTIVITIES

*Threatened and Endangered Species of Forests in Wisconsin: A Guide to Assist with Forestry Activities (*2000). A joint publication of International Paper Company, U.S. Fish and Wildlife Service and the Wisconsin Department of Natural Resources is available from any of the sponsors. Gives a description, life history information and forestry considerations for endangered and threatened species that utilize forested habitats.

WILD TURKEY: ECOLOGY AND MANAGEMENT IN WISCONSIN

Wild Turkey: Ecology and Management in Wisconsin (2001). Bureau of Integrated Science Services, Department of Natural Resources, Madison, Wisconsin. This publication gives a complete account of Wild Turkey re-introduction, management, and ecology in Wisconsin. Landowners interested in managing their land for Wild Turkeys should consider this source as a definitive guide to Turkey biology in Wisconsin.

WILDLIFE AND YOUR LAND: A SERIES ABOUT MANAGING YOUR LAND FOR WILDLIFE

Wildlife and Your Land: A Series About Managing Your Land for Wildlife. Bureau of Wildlife Management, Department of Natural Resources, Madison, Wisconsin. This source served as the foundation for many of the wildlife issues covered in this chapter of the *Forest Management Guidelines*. This collaborative effort focuses on different management issues land managers and owners should consider when managing their property. This series is available in hardcopy form or on the web at **www.dnr.state.wi.us/org/land/wildlife/publ/wildland.htm**

WISCONSIN BREEDING BIRD ATLAS WEB SITE

2002. University of Wisconsin-Green Bay, **www.uwgb.edu/birds/wbba/**. This web site displays the results of the Wisconsin Breeding Bird Atlas performed from 1995 to 2000 on private and public lands across the state. It is a good source of information for the range and distribution of bird species within the state. The web site will generate a species list by quad or county, and also contains pictures of the species that could be used in identification.

WISCONSIN STATE HERBARIUM: UNIVERSITY OF WISCONSIN-MADISON WEB SITE

This web site **(www.botany.wisc.edu/herbarium/)** contains on-line herbarium records for all plants found within Wisconsin. You can search the herbarium by species, genus or common name. Each species description contains information on location, habitat, photos, and a floristic rating. Locations are only given to the county level.

WISCONSIN'S BIODIVERSITY AS A MANAGEMENT ISSUE

Wisconsin's Biodiversity as a Management Issue (1995). Department of Natural Resources, Madison, Wisconsin. This report was written for Department of Natural Resources managers to provide them with a context for their work. This report gives an overview on the issues and implications of Wisconsin's rich biotic heritage. It also gives an overview of the ecological, social and economic issues tied to each major community type in Wisconsin. This is a good general source for information on the landscape surrounding a given property.

These resources are specific to the information in this chapter only. Refer to the Resource Directory for additional resources related to this chapter.

WISCONSIN FOREST MANAGEMENT GUIDELINES

PUB-FR-226 2003

Wisconsin Department of Natural Resources
Division of Forestry
PO Box 7921
Madison, Wisconsin 53707

For additional information, call **608-267-7494** or visit our web site at:
www.dnr.state.wi.us/org/land/forestry/

October, 2003

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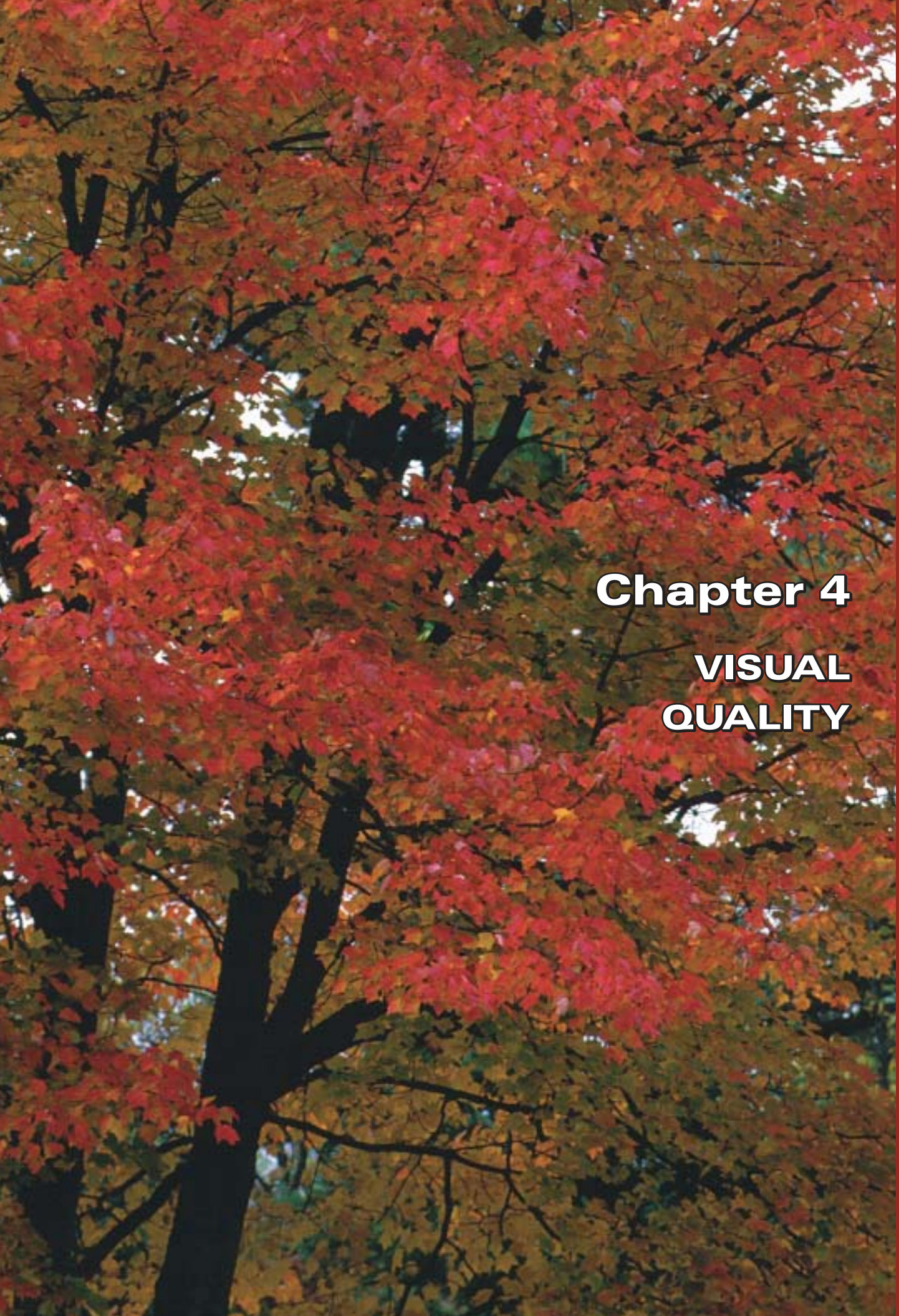

4

Chapter 4

VISUAL QUALITY

CHAPTER 4 — VISUAL QUALITY

THE VALUE OF VISUAL QUALITY 72
A Concern for Aesthetic Quality 72
Benefits of Visual Quality Management 73

VISUAL SENSITIVITY LEVELS 75
Recognizing Different Levels of Visual Sensitivity 75
Visual Sensitivity Levels 75
The Value of Recognizing Different Levels of Visual Sensitivity 76

THE VALUE OF VISUAL QUALITY

Figure 4-1: The "most sensitive" level applies to those travel routes where significant public use occurs, and where the visual quality is of high concern to all typical users.

A Concern for Aesthetic Quality

Concern about the aesthetic quality of forested lands throughout the state is a great source of pride for Wisconsin citizens. Scenic beauty – or "visual quality" – is one of the primary reasons people choose to spend their recreation and vacation time in or near forested areas. They are also attracted by the peace and quiet of the outdoors – the serenity, the solitude, and a host of other emotional, spiritual and sensory responses that make up the richly aesthetic and deeply personal experience that is so closely tied to time spent in or near our forests.

Wisconsin forests are particularly vital to the health of two industries: tourism and forest products. Many of the demands on the forests from these two industries are compatible and even complementary. Recognition of the importance of scenic values to recreational users has led to the development of a set of forest aesthetic management guidelines which have been incorporated in the Wisconsin DNR *Silviculture and Forest Aesthetics Handbook, 2431.5*. See Chapter 12: Timber Harvesting for specific techniques to balance timber harvesting and visual quality.

Figure 4-2: Scenic quality is one of the primary reasons people choose to spend their recreation time in or near forested areas.

Figure 4-3: Trilliums in Oneida County.

Benefits of Visual Quality Management

Visual quality is one important aspect of the broad, multi-faceted concept of integrated forest resource management. Visual quality management can:

- Enhance visual quality of forested lands for recreational users which results in a healthy tourism economy.
- Enhance public acceptance of forest management and timber harvesting, therefore, helping to sustain a healthy forest products industry.
- Minimize the visual and audible impacts of forest management activities on tourists and other recreational users.
- Minimize visibility of harvest areas by limiting apparent size of harvest.
- Minimize visual impact of slash.

Figure 4-4: Slash from pine harvests is much smaller in size than hardwood tops and limbs. Slash from mechanical harvesting, commonly used in pine, aspen and birch, is usually compacted by the processing machine.

Figure 4-5: Careful planning and control of the logging operation can have a major impact on the visual quality following a timber harvest.

- Minimize the impact of landing operations on recreational viewers and users.
- Minimize visual contrast created by snags and broken or leaning trees.
- Reduce visual impacts associated with the design and use of forest access roads.
- Reduce the visual impact of site preparation practices, and reduce the time that the effects of these practices are visible.
- Promote more natural-appearing stands.
- Enhance the aesthetics of visual management areas by minimizing visual impacts of timber stand improvement activities.
- Reduce visual impacts of treated vegetation.
- Reduce noise and unsightliness related to gravel pits.

Figure 4-6: Untreated logging slash, such as these oak tops, takes longer to decay and is often objectionable to landowners. Lopping of tops or harvesting firewood may provide a solution.

Figure 4-7: Large, unbroken clearcuts along well-traveled roads are often viewed by the public as unsightly, at least until the new regeneration becomes established on the site.

Figure 4-8: This aerial view shows a mosaic of pine and aspen stands with scalloped boundaries in a portion of the Northern Highland State Forest that is managed to enhance aesthetic quality.

Figure 4-9: This ground-level photo was taken in the center of the aerial view shown in Figure 4-8 while looking toward the lower left. This area, managed for aesthetic quality, shows oak sprouts and young aspen in the foreground, young jack pine and older aspen in the middle, and mature red and jack pine in the background.

VISUAL SENSITIVITY LEVELS

Recognizing Different Levels of Visual Sensitivity

Some of the factors important in the determination of visual sensitivity include:

- The perceived degree of sensitivity of users of that travel route or recreation area concerning landscape aesthetics.
- The volume and type of use the travel route or recreation area receives.
- The speed of travel within the route or area.

Figure 4-10: This major highway, a "most sensitive" example, carries a high traffic load through scenic hill country in Wisconsin.

Figure 4-11: An example of a "moderately sensitive" area, this narrow blacktop road winds alongside scenic Otter Creek in the Baraboo Hills.

Visual Sensitivity Levels

MOST SENSITIVE

Applies to travel routes and areas where significant public use occurs, and where visual quality is of high concern to typical users. Examples of such routes may include public highways, local roads, recreational lakes and rivers, and designated recreational trails and areas that provide a high level of scenic quality.

MODERATELY SENSITIVE

Applies to travel routes or recreation areas, not identified as "most sensitive," where visual quality is of moderate concern to typical users. Examples of these routes and areas may include public highways and local roads, recreational lakes and rivers, and designated recreational trails that provide moderate to high scenic quality but less significant public use.

LESS SENSITIVE

Applies to travel routes or recreation areas, not identified as "most sensitive" or "moderately sensitive," where visual quality is of less concern to typical users. Examples of these routes may include public highways and low-volume local forest roads, non-designated trails, and non-recreational lakes and rivers.

Figure 4-12: Example of a "less sensitive" area along this back road that receives very little traffic.

The Value of Recognizing Different Levels of Visual Sensitivity

Recognizing the level of visual sensitivity helps the landowner, resource manager and logger to choose the visual quality guidelines that help fulfill the landowner's expectations.

Timber sale contracts should reflect differences in visual sensitivity. An area classified as "most sensitive" would normally have different contract specifications than those used in an area classified as "less sensitive." Landings, for example should be avoided within view of travel routes or recreation areas classified as "most sensitive," while they might be visible in areas classified as "less sensitive," but located outside the travel route right-of-way.

Figure 4-13: The selective thinning in this red pine stand was designed to mimic natural changes that occur over time. Trees were removed from all size classes, so that the remaining stand has a mix of sizes, quality, and tree spacing, therefore, providing a more "natural" and less "plantation" look.

Figure 4-14: A buffer strip of uncut trees has been retained between this clearcut and the highway in the lower left of the photo to improve visual impact. A riparian management zone between the harvested area and the wetland on the right-hand side has been left uncut as well.

Figure 4-15: Autumn in the Baraboo Hills showcases the diversity found in a mixed pine and hardwood forested landscape.

WISCONSIN FOREST MANAGEMENT GUIDELINES

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Wisconsin Department of Natural Resources
Division of Forestry
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Madison, Wisconsin 53707

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October, 2003

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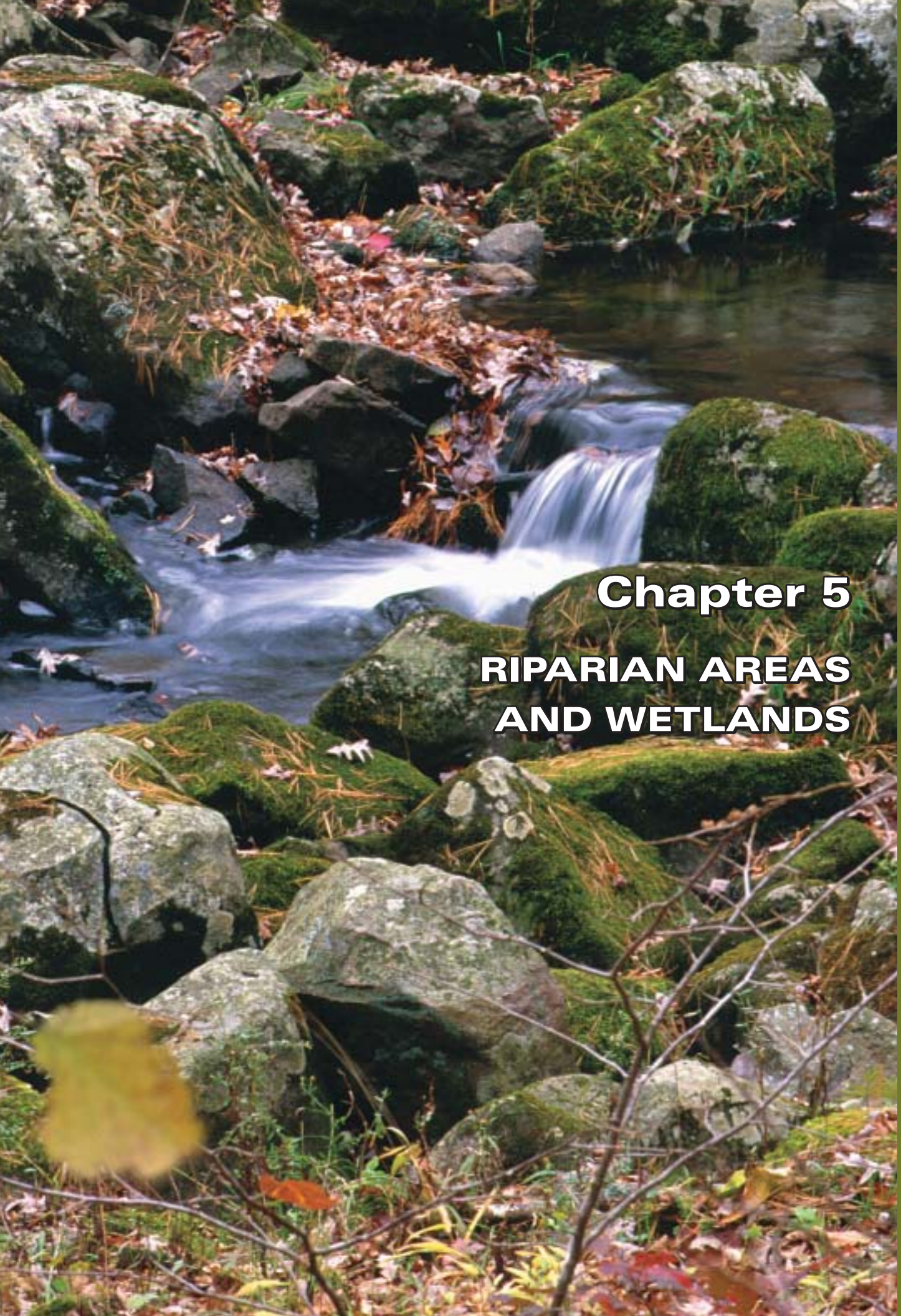

5

Chapter 5

RIPARIAN AREAS AND WETLANDS

CHAPTER 5 — RIPARIAN AREAS AND WETLANDS

THE VALUE OF RIPARIAN AREAS 78

A Transition from Aquatic to Terrestrial Ecosystems 78

Potential Threats to Riparian Areas: Pollutants and Impacts 79

Protecting Riparian Functions and Values 81

RIPARIAN MANAGEMENT ZONES 84

What Exactly is a Riparian Management Zone? 84

Agricultural and Urban Areas 84

Existing Regulations 85

BMPs FOR RIPARIAN MANAGEMENT ZONES 86

BMPs: Riparian Management Zones 86

BMPs: Lakes and Navigable Perennial Streams 87

BMPs: Navigable Intermittent Streams 87

BMP: Non-navigable Streams 87

WETLANDS 88

BMPs: General 88

THE VALUE OF RIPARIAN AREAS

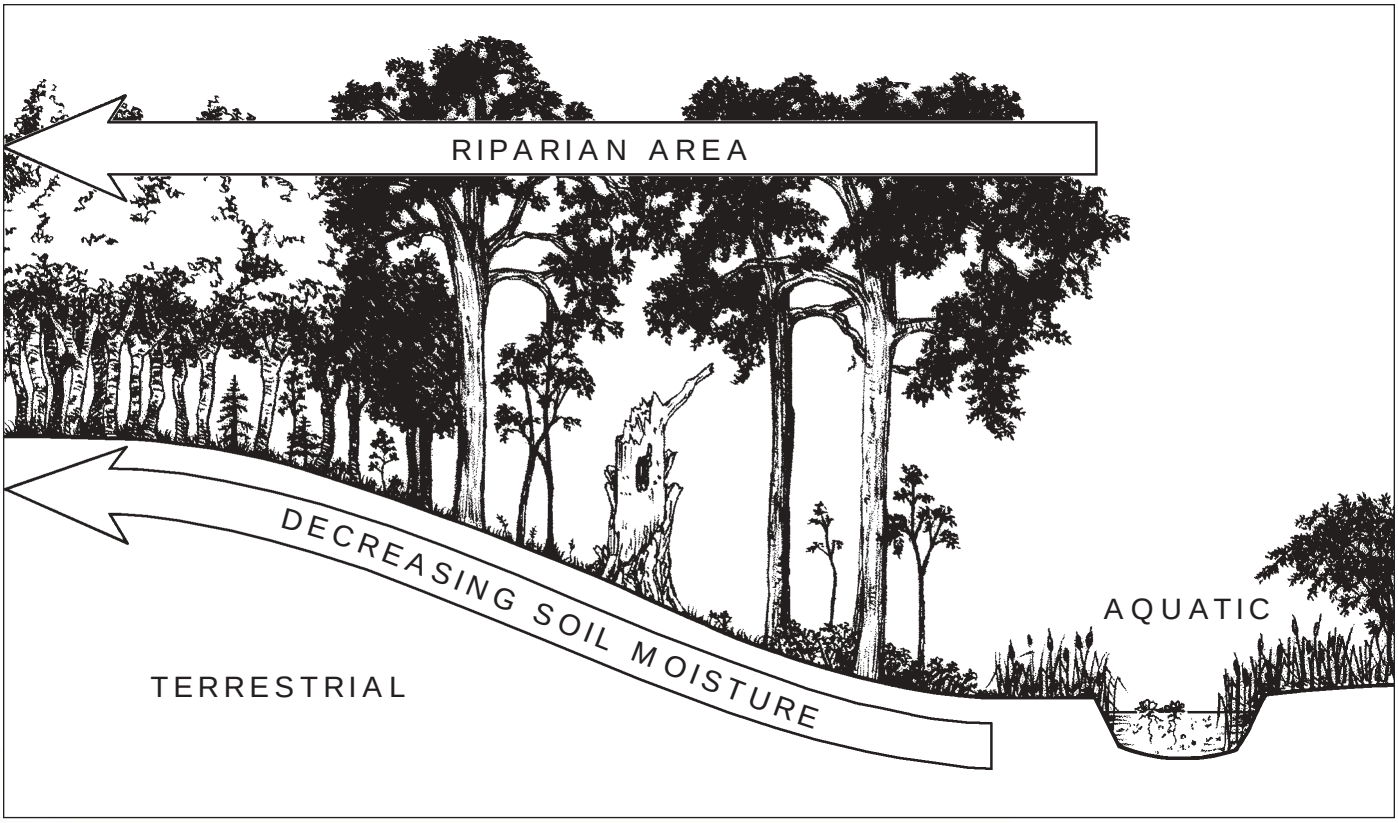

Figure 5-1: Transition from aquatic to terrestrial habitat in a riparian area.

A Transition from Aquatic to Terrestrial Ecosystems

A riparian area is the area of land and water forming a transition from aquatic to terrestrial ecosystems along streams, lakes and open water wetlands (see Figure 5-1).

Riparian areas are among the most important and diverse parts of forest ecosystems. They support high soil moisture and a diversity of associated vegetation and wildlife, and they perform important ecological functions that link aquatic and terrestrial ecosystems.

- Riparian areas maintain streambank, channel and shoreline stability as well as stream temperature and water quality.
- Riparian areas provide conservation and water storage, nutrient and food input to the aquatic system, in-stream structure of coarse woody debris, and a moderated microclimate.
- Riparian areas provide important habitat for many species of fish, mammals, birds, reptiles, amphibians, and insects.
- Riparian areas are also important for recreation, tourism, forest products, hunting, fishing, biological diversity, and provide many other values to humans.

To protect the functions and values of riparian areas, management practices are modified within **riparian management zones (RMZs)** for streams and lakes to protect water quality, fish, and other aquatic and terrestrial resources. These RMZs are applied adjacent to lakes and navigable perennial streams, navigable intermittent streams and non-navigable streams.

Potential Threats to Riparian Areas: Pollutant Types and Impacts

One of the biggest threats to water quality in the United States is **nonpoint source pollution**. Nonpoint source pollution occurs when surfacewater runoff from rainfall or snowmelt moves across or into the ground, picking up or carrying pollutants into streams, lakes, wetlands, or groundwater. Soil becomes a nonpoint source pollutant when water runoff carries large amounts of soil into a waterbody.

Nonpoint source pollution is the source for about half of all pollutants entering our nation's waters. Nationally, three to nine percent of all nonpoint source pollution comes from forestry practices. Because Wisconsin is relatively flat, only about three percent of the state's nonpoint source pollution comes from forestry practices. While three percent sounds small, localized nonpoint source pollution can be significant, and the cumulative effects of all sources can seriously degrade water quality in a drainage system.

Forest management activities can generate the following forms of nonpoint source pollution:

SEDIMENT

Forest floor vegetation and organic debris protect the soil from the erosive actions of falling raindrops and runoff. Forestry management activities such as road building can remove this protection, and lead to erosion of the soil creating sediment. When sediment is carried away in runoff and deposited elsewhere, sedimentation occurs. Without using appropriate BMPs on exposed and sloping land, the soil will likely erode and may wash into a body of water. **Sediment is the primary pollutant associated with forestry activities, especially at stream crossings for forest roads and skid trails.**

In the world of nature, sedimentation is a slow, naturally occurring process – however, human activities often speed it up. The result can be large amounts of sediment accumulating in lakes, streams and wetlands that speed up the aging of lakes, and bury fish spawning grounds and aquatic plants. These plants are a source of food and habitat for fish and other aquatic organisms.

Accumulating sediment also constricts naturally flowing channels, leading to increased stream bank erosion and possible flooding. Suspended sediment can cloud the water, reducing the hunting success of sight-feeding fish, and can also damage the gills of some fish species, causing them to suffocate.

Figure 5-2: Large woody debris that falls naturally into streams can greatly benefit aquatic ecosystems.

ORGANIC DEBRIS

Leaves and **large woody debris** (usually large fallen logs, at least 12 inches in diameter, with an attached root ball) that naturally fall into streams can greatly benefit aquatic ecosystems. However, too much organic debris deposited in a short time can harm water quality. This can occur during logging when treetops and branches fall or wash into streams. Too much decomposing matter in streams can decrease dissolved oxygen in the water, which fish need to thrive and reproduce.

Figure 5-3: A small intermittent stream tumbles over the rocks down a southern Wisconsin hillside.

Figure 5-4: The invasion of reed canary grass in this bottomland hardwood stand has eliminated herbaceous plants and tree regeneration.

Figure 5-5: Vernal pools, or casual water, provide habitat for certain wildlife species. Forestry operations should be conducted at the proper time to avoid disruptions to these small ecosystems.

INVASIVE PLANTS

A number of non-native invasive species are impacting forested riparian areas and wetlands. Reed canary grass can rapidly overtake a site where the forest canopy is opened up by harvesting or wind damage. It is extremely difficult to regenerate bottomland forests once reed canary grass is established. Another non-native invasive species, glossy buckthorn, can form a dense shrub layer that also limits regeneration.

CHEMICALS

Pesticides (herbicides, insecticides and fungicides) help control forest pests and undesirable plant species. But when applied improperly, pesticides can be toxic to aquatic organisms. Fuel, oil and coolants used in harvesting and road-building equipment must also be handled carefully to avoid water pollution.

TEMPERATURE

Some sunlight filtering through trees is healthy for many streams. It can promote plant growth (food) in the water, and foster healthy ground vegetation along shorelines. However, when trees and the shade they provide are removed along most small streams, peak mid-summer water temperatures climb as a result of increased solar radiation. This can eliminate cold water fish, reduce dissolved oxygen, and affect the metabolism and development of fish.

NUTRIENTS

Nutrients such as nitrogen and phosphorus exist naturally in forest soil, and can enter waterbodies if the soil erodes into water. Also, if fertilizers are used in forest management, they can wash into waterbodies in runoff. Excessive amounts of nutrients may cause algal blooms in lakes and streams, which can reduce levels of dissolved oxygen in the water to below what fish and other aquatic species need to survive.

STREAMFLOW

Timber harvesting can increase peak streamflow which increases chances for flooding, streambank erosion, and sedimentation. If timber harvesting equipment compacts a large area of the forest soil, water infiltration into the soil is reduced, and surface runoff into streams increases. This also reduces water percolation through the soil to recharge groundwater which provides cool, clean water to lakes and streams – helping to maintain steady streamflows and lake levels throughout the summer.

Harvesting can also contribute to an increase in peak streamflow. In basins where 60 percent or more of the trees are less than 15 years old, snow can melt several times faster than in older stands.

Figure 5-6: This headwater segment of a small southern Wisconsin perennial stream is designated Category 5 trout water. Forestry operations near such waters must be consistent with various regulations, and BMPs should be used within the riparian management zone.

Protecting Riparian Functions and Values

Clean water is essential to Wisconsin's economy and rich quality of life. Lakes and streams provide habitat for wildlife, fish and other aquatic species. Our forests play a vital role in purifying and maintaining clean water for streams, lakes and groundwater.

The most practical and cost-effective method to assure that forestry operations do not adversely affect water quality in Wisconsin is through the use of the voluntary **best management practices (BMPs)**. These BMPs are voluntary in the sense that they are not legally mandated. However, the Wisconsin Department of Natural Resources (DNR) strongly encourages their use by all Wisconsin forest landowners, land managers and forestry professionals. **BMPs are identified by a "✓"** to help separate them from other recommendations in the guide.

Several categories of public and private landowners in Wisconsin already use forestry water quality BMPs to guide their management activities. For example, compliance is required on DNR properties such as State Forests, and lands enrolled in the Managed Forest Law Program since 1995. In addition, the forestry water quality BMPs have been adopted by all 29 counties enrolled in Wisconsin's County Forest Law program. The majority of Wisconsin's industrial forestland is enrolled in the American Forest and Paper Association's Sustainable Forestry Initiative, which requires water quality BMP compliance and logger training as a condition of membership.

It is the policy of the U.S. Department of Agriculture Forest Service to promote and apply approved BMPs for the control of nonpoint sources of water pollution. Currently, BMPs developed by the Wisconsin DNR for nonpoint sources of water pollution support the Chequamegon and Nicolet National Forests.

In addition to the BMPs described in this manual, you should be aware of existing municipal, county, state, and federal regulations relating to forest management and water quality (see Appendices E and F for information on permits and regulations).

This guide can help you when making decisions about management activities on your land. **Applications of BMPs may be modified for specific site conditions with guidance from a natural resource professional, if modifications provide equal or greater water quality protection, or if the modification has no impact on water quality.** Seek professional advice on BMPs and all forest management activities from natural resource professionals such as:

- Consulting foresters
- Industrial foresters
- Wisconsin DNR foresters, fish managers, and water quality staff
- USDA Natural Resources and Conservation Service staff
- County Land Conservation Department staff

Figure 5-7: Too much decomposing debris, such as treetops and limbs from logging, can decrease the oxygen in streams which fish need to thrive and reproduce.

Careful planning for forest management activities, such as road construction, timber harvesting and site preparation will minimize nonpoint source pollution. A well thought-out plan will lead to harvest operations that use BMPs, remove forest products efficiently and profitably, and promote sustainable forest growth and water quality protection.

A comprehensive forest management plan should include forestry BMPs for water quality. The level of formality and detail should be appropriate to the project size, cost and environmental risk. The plan should also be flexible and adaptable to changing conditions.

Landowners and land managers should select the best forest management strategy to protect water quality specific to the site. A contractor (e.g., logger or road developer) working with the landowner and land manager, is usually responsible for implementing forestry BMPs.

Wisconsin DNR foresters and consulting or industrial foresters can work with you to develop a list of BMPs to include in your forest management plan. Cost-sharing assistance may be available for plans written by a consulting forester.

Figure 5-8: Wetland with scattered black spruce and tamarack surround a small northern Wisconsin lake.

Figure 5-9: Trees and other vegetation along the shoreline of this undeveloped northern Wisconsin lake help reduce soil erosion.

Use the following to plan forest management activities:

- Plan forest management activities to avoid operations in wetlands, including building landings, skid trails and roads. Where avoidance is not practical, minimize impacts by limiting the extent of wetland activities.
- Make a list of site-specific forestry BMPs you need to protect water quality in all timber sale contracts, timber harvest plans, and forest management plans.
- Develop a forest management plan that states the management objectives for the site. Plan operations to protect water quality by considering site conditions. Identify on a map the following site conditions:
  - Harvest unit boundary
  - Property boundaries
  - Existing forest road system (roads, skid trails and landings)
  - Sensitive areas which include streams, lakes, wetlands, flood plains, habitat areas for threatened or endangered aquatic, animal and terrestrial plant species, steep slopes, and erodible soils
  - Riparian management zones
  - Stream crossings
  - Equipment maintenance and fueling areas
- Locations of non-native invasive species that should be kept from spreading.
- The following resources can be used to identify site conditions:
  - **United States Geological Survey (USGS) Topographic Maps (7.5 minutes):** Available from the Wisconsin Geological and Natural History Survey, and some outdoor/sporting goods suppliers.
  - **Aerial Photographs:** Available from the Wisconsin DNR, the USDA Farm Services Agency, or the USDA Natural Resources and Conservation Service.
  - **County Soil Surveys:** Available from county land conservation departments and the USDA Natural Resources and Conservation Service.
  - **Floodplain Maps:** Available from your local county zoning administrators.
  - **Wisconsin Wetland Inventory Maps:** May be reviewed at DNR service centers and local county or municipal zoning offices, or can be purchased from the Wisconsin DNR, Bureau of Fisheries Management and Habitat Protection, PO Box 7921, Madison, WI 53707-7921.
- Conduct on-site evaluations.
- Obtain necessary permits and licenses before beginning management activities. For existing regulations pertaining to forest management activities, see Appendix E.
- Plan to stabilize bare soil as soon as possible after exposing it to prevent erosion into streams, lakes, wetlands, and riparian zones. This is especially important on steep slopes and erodible soils, in riparian management zones, and at stream crossings (see Chapter 11: Forest Roads).
- Maintain a spill containment and clean-up kit appropriate for the materials on the operation (see Chapter 10: General Operational Guidelines).

RIPARIAN MANAGEMENT ZONES

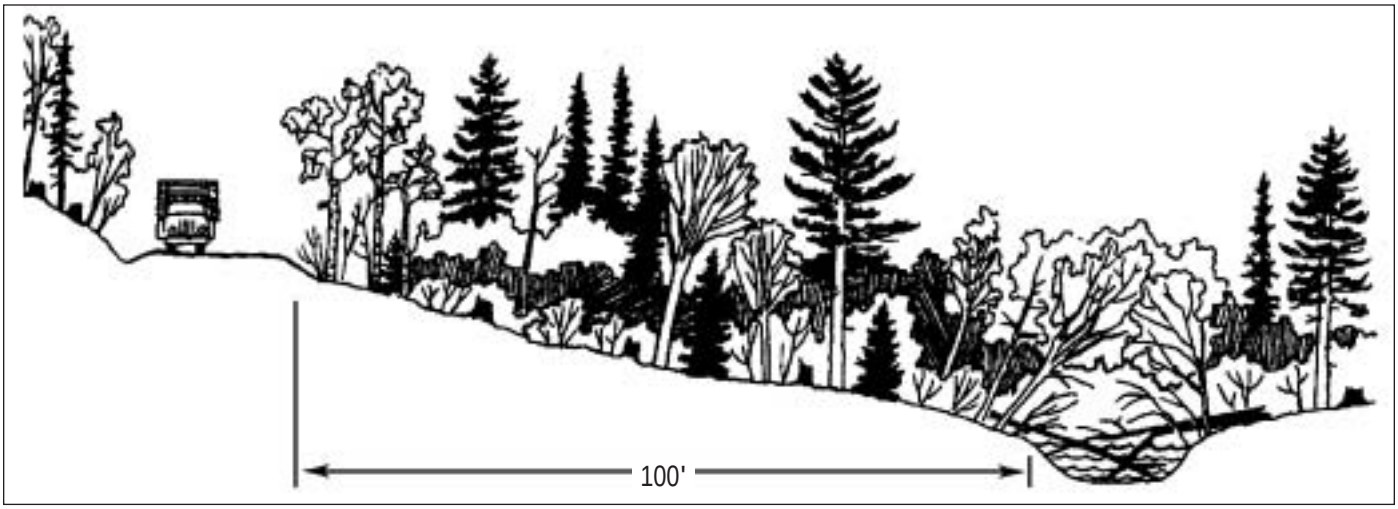

Figure 5-10: Cross-sectional depiction of a riparian area.

What Exactly is a Riparian Management Zone?

Riparian management zones (RMZs) are land and vegetation areas next to lakes and streams where management practices are modified to protect water quality, fish and other aquatic resources. These areas are complex ecosystems that provide food, habitat and movement corridors for both aquatic (water) and terrestrial (land) communities. Also, because these areas are next to water, RMZs help minimize nonpoint source pollution impacts to surfacewaters.

Riparian management zones help to:

- **Filter sediment and nutrients from runoff.** As runoff water moves through plants and the duff layer (needles, leaves and decaying matter), it slows and drops sediment that has been carried along. This settling process keeps sediment and nutrients from flowing into streams and lakes. It also allows plant roots to take up the nutrients that have dissolved in the runoff and soaked into the soil, further reducing the amount of pollution flowing into lakes and streams.
- **Allow water to soak into the ground.** Trees, plants, leaves, and twigs slow surface runoff, allowing water to soak into the soil. This helps reduce peak flow levels in streams, and replenishes the groundwater that helps maintain lake levels and stream flows.
- **Shade streams.** In most cases, plants and trees along streambanks are necessary for shade, keeping water from becoming too warm for aquatic life in the summer.
- **Stabilize streambanks and lakeshores.** Trees and plants along streambanks and lakeshores reduce soil erosion because they 1) reduce the impact of raindrops on exposed soil, and 2) provide roots that hold the soil together which makes it more difficult for waves, currents and runoff to wash the soil away.
- **Provide food and habitat for aquatic organisms.** Fallen leaves and other organic debris from trees are the base of the food chain for aquatic organisms in small forest streams. Large woody debris creates riffle areas and plunge pools, critical habitat for fish and other aquatic organisms. The pools trap leaves and twigs long enough for microorganisms to decompose them. These microorganisms become food for insects and other invertebrates, which in turn become food for fish.

Agricultural and Urban Areas

Riparian zones are very valuable to agricultural, urban and forested areas. Runoff from cultivated fields, as well as city streets and lawns, can contain sediment, pesticides and fertilizer. Plants in riparian zones filter out these contaminants, reducing the amount of pollutants entering waterbodies. Riparian zone landowners in all agricultural and urban areas should maintain or restore riparian management zones. Do not allow livestock to graze in forested RMZs (contact the USDA Natural Resources and Conservation Service, or your local land conservation department to establish a grazing plan).

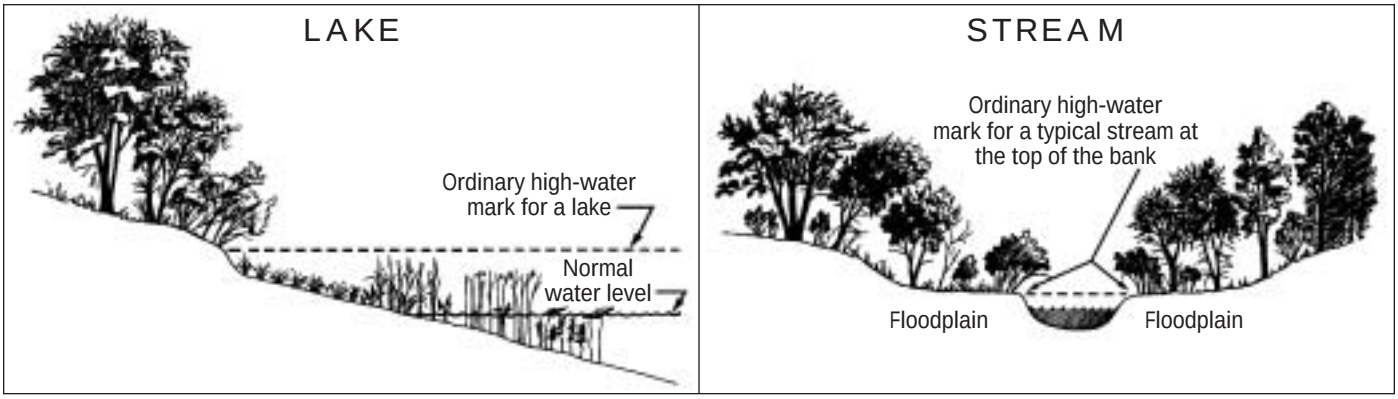

Figure 5-11: Ordinary high-water mark for a lake and stream.

LAKE/POND
A still waterbody that 1) is navigable, 2) has an ordinary high-water mark, and 3) has a bed and banks, and is a "reasonably permanent" body of water, although it may dry up during periods of drought.

STREAM
A watercourse that 1) has an ordinary high-water mark, 2) has bed and banks, 3) flows at least periodically, and 4) does not lose its character as a watercourse even though it may become braided in a wetland complex. There are two kinds of streams:

- **Perennial streams** have constant flow except during droughts.
- **Intermittent streams** flow only after rainstorms or snowmelt, and are dry most of the year. Intermittent streams must be protected because they channel runoff into perennial streams and lakes, and may become part of the aquatic ecosystem when water flows into them.

ORDINARY HIGH-WATER MARK
The point on a bank or shore up to which the presence and action of water is so continuous that it leaves a distinct mark either by erosion, destruction of terrestrial (land) vegetation, or other easily recognized characteristics.

NAVIGABLE
A waterway is navigable if it has bed and banks, and it is possible to float a canoe or other small craft in the waterway on a regular reoccurring basis – even if only during spring runoff.

NOTE: Lakes and streams (perennial and intermittent) identified on current U.S. Geological Survey (USGS) topographical maps (7.5 minute/1:24,000 scale), should be considered navigable. Other lakes and streams may be determined to be navigable by a Wisconsin DNR water management specialist. If you have a question about navigability, contact a Wisconsin DNR water management specialist.

Existing Regulations

All cutting practices next to lakes and navigable streams must be consistent with local county shoreland and wetland zoning ordinances. Wisconsin Administrative Code NR 115 provides state-required minimum standards for the cutting of trees and shrubbery to be included in county shoreland ordinances to protect the natural beauty, control erosion, and reduce the flow of effluents, sediments and nutrients from the shoreland area. A special exception (or conditional use) permit may be required to harvest next to lakes and navigable streams. When planning to harvest within the RMZ, contact your local county zoning office before beginning any harvesting. For more information about Administrative Code NR 115, see Appendix E.

Stream crossings, grading next to lakes and streams, and other forestry activities are also subject to permits as described in Appendix F. Contact a Wisconsin DNR water management specialist for more information.

BMPs FOR RIPARIAN MANAGEMENT ZONES

BMPs: Riparian Management Zones

There are three categories of riparian management zones for BMPs:

- Lakes and navigable perennial streams
- Navigable intermittent streams
- Non-navigable streams

BMPS COMMON TO ALL THREE RMZ CATEGORIES

✓ Locate roads outside the RMZ unless necessary for stream crossings. For stream crossings, follow recommendations in the Stream Crossings section of Chapter 11: Forest Roads.

✓ Locate landings outside the RMZ.

✓ Do not move into or pile slash within the RMZ. Keep slash out of lakes and stream channels, and away from areas where it may be swept into the water.

✓ Minimize soil exposure and compaction to protect ground vegetation and the duff layer.

NOTE: On steep slopes or highly erodible soils, you should widen the RMZ.

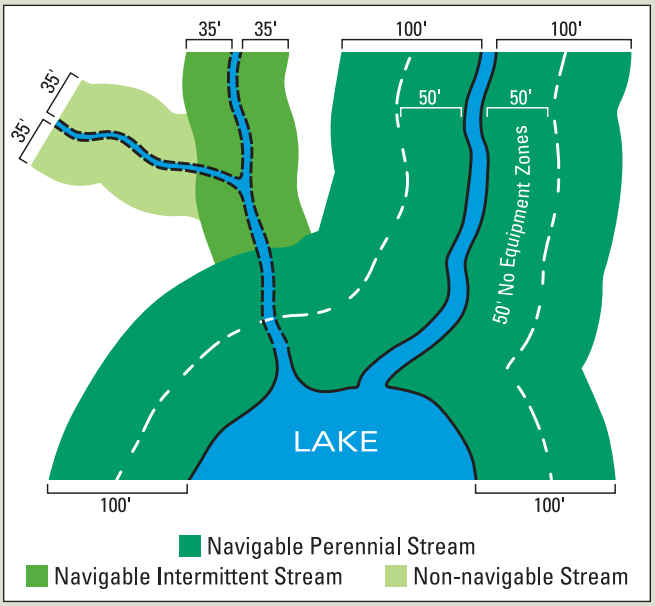

Figure 5-12: Three riparian management zone categories.

Figure 5-13: The RMZ is a strip of land alongside streams and lakes beginning at the ordinary high-water mark, and extending 35 or 100 feet landward as shown in Figure 5-12.

BMPs: Lakes and Navigable Perennial Streams

- ✓ The RMZ for these waters is a strip of land running along the shoreline of lakes and on each side of streams. It begins at the ordinary high-water mark and extends a minimum of 100 feet landward.
- ✓ Harvesting plans should leave at least 60 square feet of basal area per acre in trees five inches diameter breast height (DBH) and larger, evenly distributed.
- ✓ Harvesting intervals should be a minimum of 10 years.
- ✓ Do not operate wheeled or tracked harvesting equipment within 50 feet of the ordinary high-water mark except on roads or at stream crossings.
- ✓ Use selective harvesting and promote long-lived tree species appropriate to the site. Long-lived tree species include 1) hardwoods such as sugar and red maple, white and black ash, elms, and oaks, and 2) conifers such as eastern hemlock, white pine, red pine, and white cedar.
- ✓ Develop trees 12 inches DBH and larger.

BMPs: Navigable Intermittent Streams

The RMZ for these streams is a strip of land on each side of the stream, beginning at the ordinary high-water mark and extending a minimum of 35 feet landward.

- ✓ Operate wheeled or tracked harvesting equipment within 15 feet of the ordinary high-water mark only when the ground is frozen or dry.
- ✓ Harvesting plans should leave at least 60 square feet of basal area per acre in trees five inches DBH and larger, evenly distributed.
- ✓ Use selective harvesting and promote long-lived tree species appropriate to the site. Long-lived species include 1) hardwoods such as sugar and red maple, white and black ash, elms, and oaks, and 2) conifers such as eastern hemlock, white pine, red pine, and white cedar.
- ✓ Harvesting intervals should be a minimum of 10 years.

BMP: Non-navigable Streams

Non-navigable streams are found in the field but may not be identified on current USGS topographical maps (7.5 minute/1:24,000 scale).

The RMZ for these streams is a strip of land on each side of the stream, beginning at the ordinary high-water mark and extending a minimum of 35 feet landward.

- ✓ Operate wheeled or tracked harvesting equipment within 15 feet of the ordinary high-water mark only when the ground is frozen or dry.

WETLANDS

Wisconsin state statutes (section 23.32) define a wetland as "an area where water is at, near or above the land surface long enough to be capable of supporting aquatic or hydrophytic (water-loving) vegetation, and which has soils indicative of wet conditions." Wisconsin wetlands include marshes, bogs, floodplain forests, wet meadows, and low prairies. These wetlands provide many functional values in the ecosystem.

- **Shoreline protection.** Shoreline vegetation absorbs the force of waves and currents, protecting against erosion. Roots of wetland plants hold together lake shores and streambanks.
- **Flood protection.** By storing runoff from heavy rain and snowmelt, wetlands reduce flood damage.
- **Water quality protection.** Wetlands store and filter pollutants such as sediment and the nutrients in sediment. Also, wetlands can transform some pollutants into non-polluting forms.
- **Groundwater recharge and discharge.** Some wetlands recharge groundwater by moving surfacewater into the groundwater system. Groundwater discharge occurs when groundwater flows to the surface and into streams, lakes and wetlands. This discharge is especially important in summer by providing stream baseflows critical to aquatic life.
- **Animal and plant habitat.** Many animals spend their lives in wetlands, while others use wetlands for feeding, breeding, resting, nesting, escape cover, or travel corridors. Wetland plants provide food and shelter for many animal species. Many of the rare and endangered plant species in Wisconsin are found in wetlands.

Forestry BMPs in wetlands protect water quality from erosion, and minimize changes to the surface and below-surfacewater movement that can occur from rutting and road building. Changing the surface and below-surfacewater movement can affect the health of the wetland ecosystem and its flood protection function.

Activities in wetlands are often subject to municipal, county, state, and federal permit and regulatory requirements. Some of these regulations are listed in Appendix E: Regulations (see Section 404, Chapter NR 103, and Chapter NR 117). When you suspect your project involves a wetland and want to know what regulations apply, the sequence of contacts include 1) your county zoning office, 2) a Wisconsin DNR water management specialist, and 3) the U.S. Army Corps of Engineers.

Maps from the Wisconsin Wetland Inventory can help you make a preliminary determination as to whether your project will affect wetlands. These maps may be reviewed at DNR offices and county or municipal zoning offices, or purchased from the Wisconsin Department of Natural Resources, Bureau of Fisheries Management and Habitat Protection, PO Box 7921, Madison, WI 53707-7921.

BMPs: General

- ✓ Follow all planning BMPs on pages 86 and 87 of this chapter. Whenever practical, avoid locating roads and landings in wetlands.
- ✓ Whenever possible, forest management activities in wetlands should occur on frozen ground during the winter to minimize rutting.
- ✓ For activities in wetlands, consider allowing more flexibility for completion dates in timber sale contracts to allow the logger time to complete logging activities during firm or frozen ground conditions.
- ✓ Identify riparian management zones along all streams and lakes.
- ✓ Do not move slash from upland sites into wetlands, and keep slash out of open water.
- ✓ Only use pesticides labeled for use in wetlands.
- ✓ If possible, avoid equipment maintenance and fueling in wetlands – otherwise, use extreme caution. Clean all spills promptly and properly (see Chapter 10: General Operational Guidelines).

WISCONSIN FOREST MANAGEMENT GUIDELINES

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Wisconsin Department of Natural Resources
Division of Forestry
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6

Chapter 6

CULTURAL RESOURCES

CHAPTER 6 — CULTURAL RESOURCES

CULTURAL RESOURCES 90
Forest Management for the Protection of Cultural Resources 90
What Cultural Resources Are 91
Economics of Cultural Resource Management (CRM) 91
Potential Impacts 92
Cultural Resource Management (CRM) and the Law 92
Cultural Resource Inventories 93
Assessing Cultural Resources 93
Field Identification of Cultural Resources 94
Assessing Management Alternatives 94
When Accidental Discovery Occurs 94

CULTURAL RESOURCES

Figure 6-1: Indian burial mounds are a cultural resource that can be found in many Wisconsin forested areas. Although not as large as some, this mound is easily spotted because the understory has been removed. Other mounds may not be as easily detected when forest operations are conducted.

Forest Management for the Protection of Cultural Resources

This chapter of the guidelines was developed to provide landowners, loggers and resource managers with an increased awareness of cultural resources and recommendations on how to protect them during forest management activities. Those involved in managing forestlands need to understand that:

- Cultural resources are scarce and nonrenewable.
- Good forestland management is compatible with the protection of cultural resources.

There is a growing recognition that cultural resources have value and should be wisely managed. Cultural resources represent parts of an inheritance shared by all people. This heritage is of fundamental value to modern-day societies. Cultural resources often possess spiritual, scientific and other values that are weighed differently by different cultures. Today the management of cultural resources is a necessary component of land stewardship.

What Cultural Resources Are

Cultural resources include historic structures, archaeological sites, cemeteries, and traditional-use areas. Together, they represent roughly 13,000 years of human occupation in Wisconsin – from the end of the last ice age to the present day. Prehistoric cultural resources reflect the activities of Indian people prior to initial French contact in 1634. Since the first written records of Wisconsin began at that time, 1634 marks the beginning of the historic period. To be considered important, a cultural resource has to be at least 50 years old. Types of cultural resources include:

- **Historic Structures**
  - Houses, barns and outbuildings
  - Lime kilns
  - Bridges and railroad trestles
  - Schools and churches
  - Stores and office buildings
  - Mills and factories
- **Cemeteries**
  - Platted cemeteries
  - Family cemeteries and individual graves
  - Burial mounds
- **Archaeological Sites**
  - Campsites and villages
  - Caves and rock shelters
  - Quarries and flintknapping workshops
  - Large animal kill and butchering stations
  - Ridged fields and other types of garden beds
  - Enclosures and earthworks
  - Fish weirs
  - Rock art sites
  - Ruins of trading posts and homesteads
  - Shipwrecks
- **Traditional-use Areas**
  - Sugar bushes
  - Medicine gathering areas
  - Sacred springs
  - Ceremonial sites

Figure 6-2: This millstone was found near the site of a grist mill that burned to the ground in the early 20th-century.

Economics of Cultural Resource Management (CRM)

Economically, CRM will not usually pay for itself, but some forest landowners will discover that reserved and protected cultural resources can be financial assets.

- Cultural resource conservations often contribute to soil, water and wildlife habitat conservation measures.
- The return on investment in the preservation, rehabilitation and adaptive reuse of above-ground cultural resources is often reflected in increased resale values, and may be used as an effective tool for developing a sense of corporate or community identity that encourages new investment.
- A growing number of federal and state laws provide financial incentives for preserving and protecting cultural resources. For example, through conservation easements, landowners may qualify for a federal income tax deduction or property tax credits.

Potential Impacts

In general, cultural resources are fragile. Many archaeological deposits lie within a few inches of the ground surface. Hence, even very shallow ground disturbance can destroy the context of artifacts or features such as the dirt floors of ancient houses. Threats range from natural forces (e.g., erosion, flooding, weathering, and fire) to human action (e.g., logging, agriculture, mining, land development, and vandalism). Potentially damaging effects to cultural resources resulting from forestland management activities include:

- Soil disturbance and/or compaction
- A change in the vegetation that is part of a traditional-use area
- Damage to above-ground features

Cultural Resource Management (CRM) and the Law

The legal basis for CRM is rooted in federal and state legislation concerned with natural resource conservation and environmental protection going back to the early 1900s. The National Historic Preservation Act (NHPA) of 1966, as amended, is the centerpiece of the national historic preservation program. It established the National Register of Historic Places and provides for State and Tribal Historic Preservation Officers to implement the national preservation program. Section 106 of NHPA requires that federal agencies consider the effects of their activities on cultural resources. Federal law applies whenever activity takes place on federal land, will use federal funds, or will require a federal permit.

The Wisconsin Field Archeology Act requires state agencies to contact the Wisconsin Historical Society if the agency's actions may impact an archaeological site, burial site or historic structure listed in cultural resource inventories. State law applies whenever the activity is on state-owned land, will use state funds, or requires a state permit. However, timber harvesting is exempt from review unless new logging roads are to be constructed.

State law affords special protection to burial sites, regardless of age or land ownership (including private lands). All human burials are afforded the same legal protection as platted cemeteries.

Figure 6-3: On this 1,000-year-old Indian village site, archaeological deposits lie only six to 10 inches below the ground surface, and harm can easily be done by very shallow ground disturbance.

Figure 6-4: Few abandoned buildings from the 19th-century are as intact as this old log house, sometimes found in forested areas of Wisconsin. You are more apt to find rotted wood and a cellar depression.

Cultural Resource Inventories

The Wisconsin Historical Society maintains an inventory of archaeological and burial sites as well as historic structures reported to their office. However, since most of the state has never been formally surveyed, unreported cultural resources likely outnumber those listed in their inventories. Archaeological sites are more apt to be inventoried if they have been plowed, exposing artifacts on the field surface, or if they have above-ground features such as burial mounds or piles of logging camp refuse. Access to archaeological and burial site inventories is restricted to protect sites from looting, discourage trespass, and show respect for sites that some regard as sacred. The statewide inventory of known historic structures is openly available through the Wisconsin Historical Society's web site.

Assessing Cultural Resources

If a forest management site has not been previously surveyed for cultural resources, individuals may conduct their own assessment of the area's potential. One might begin by checking existing maps, air photos and printed historical information, and then assess the landscape. The following have high potential for cultural resources:

- Current shorelines or terraces adjacent to lakes, rivers or streams, and shorelines of ancient lakes and old river channels
- Junctions of waterbodies, including river junctions, and lake inlets and outlets
- Peninsulas or points of land along a shoreline, including islands
- Good places to camp, including areas where people camp now
- Areas adjacent to fish spawning beds, good fishing spots and wild rice beds
- Transportation routes (e.g., old trails, roads or portages)

Field Identification of Cultural Resources

During a walk-over inspection of the management area, in preparation for a timber sale, forest managers and landowners may discover unrecorded cultural resources. Some things to look for are:

- High spots offering a panoramic view
- Unusual natural features
- Surface artifacts (check bare spots, tree tip-ups and cut banks)
- Surface features
  - Cellar and well holes
  - Cement or asphalt slabs
  - Fieldstone foundations
  - Miscellaneous building materials (bricks, roofing materials, plaster, and stucco)
  - Metal well pipes
  - Earthen berms and trenches
  - Shallow depressions (such as graves or ricing pits)
- Milled lumber (such as boards suitable for burial crosses, spirit houses or building construction)
- Domestic or exotic plants (including lilac bushes, fruit trees and daylilies)
- Old roads, trails and portages (especially where two come together)
- Trash dumps containing antique items or jumbo-sized tin cans
- Standing structures and buildings

Assessing Management Alternatives

- **Protection by law.** If the pre-field review indicates the project area contains a site protected by law (such as a burial site), further action will be determined by statute or regulations.
- **Identification as a low-sensitivity site.** If no cultural resources have been recorded and the pre-field review and walk-over inspection yielded no indications of important cultural resources, the site would have low sensitivity. Proceed with the management activity.
- **Identification as a high-sensitivity site.** If cultural resources are known to exist or if the pre-field review and walk-over inspection indicate their presence, the site has high sensitivity. In this case, it is recommended that the forest manager avoid the sensitive area or bring in a cultural resource management professional to conduct a survey.

When Accidental Discovery Occurs

Unrecorded cultural resources may be discovered during operations. Guidelines for proceeding depend on the nature of the discovery.

- In the case of human burials, if such discovery occurs, temporary suspension of operations in the vicinity of the discovery is required. **If a human burial site is accidentally discovered, contact the Burial Sites Preservation Office at the Wisconsin Historical Society.**
- For other types of cultural resources, such as archaeological artifacts, temporary suspension is not required, but is recommended. Suspending operations in the immediate vicinity of the cultural resource will provide time to contact a cultural resource professional, or develop plans to apply appropriate guidelines to avoid or mitigate potential effects.
- Documentation of cultural resources discovered during forest management activities is not required. However, landowners and operators are encouraged to make a written record of their discoveries, and share that information with the Office of the State Archaeologist at the Wisconsin Historical Society.

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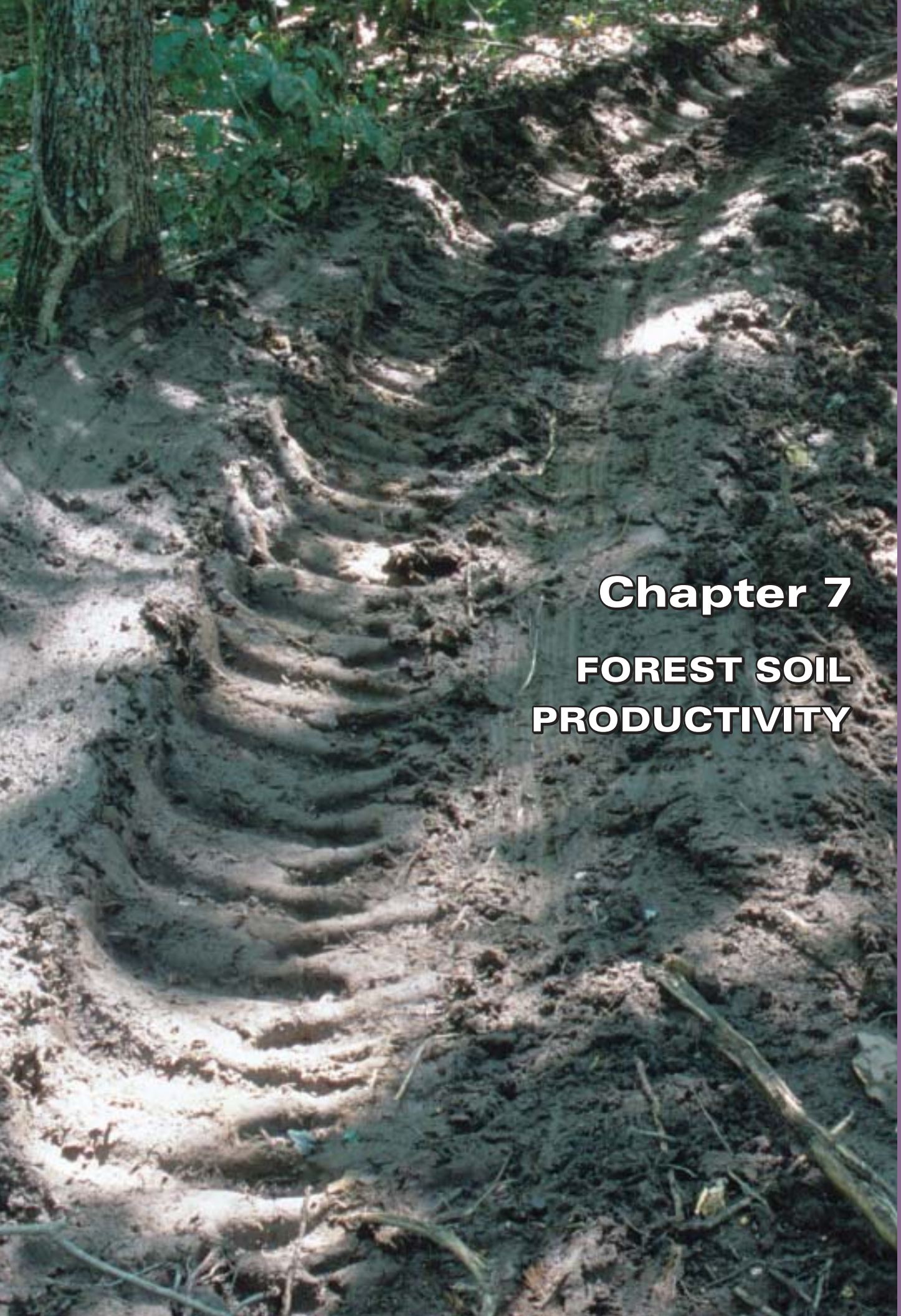

Chapter 7

FOREST SOIL PRODUCTIVITY

CHAPTER 7 — FOREST SOIL PRODUCTIVITY

THE VALUE OF FOREST SOIL PRODUCTIVITY.....96
Sustainable Soil Productivity.....96

SOIL CHARACTERISTICS AND POTENTIAL IMPACTS.....97
Three Related Groups of Soil Characteristics.....97
Characteristic 1: Physical Characteristics of Soil and Potential Impacts.....97
Characteristic 2: Chemical Characteristics of Soil and Potential Impacts.....101
Characteristic 3: Biological Characteristics of Soil and Potential Impacts.....103

APPLYING GUIDELINES TO VARYING SITE CONDITIONS.....104

THE VALUE OF FOREST SOIL PRODUCTIVITY

Figure 7-1: A handful of soil can tell a forester much about the management prospects for a property.

Sustainable Soil Productivity

Soil productivity is defined as the capacity of soil, in its normal environment, to support plant growth. It is reflected in the growth of forest vegetation or the amount of organic material produced by plants and animals. In forest management, soil productivity is often measured in volume of trees produced, but, other methods of determining productivity exist.

Soil is the fundamental resource of the forest. Without it, other resources of the forest would vanish over time. Identifying and reducing impacts to the soil is an essential part of a strategy for sustainable forest management. Primary considerations in maintaining soil productivity include the following:

- Soil productivity is a major factor in determining the amount of timber harvesting that can be sustained over time. It also affects other forest attributes, such as wildlife habitat and biodiversity.
- Soil productivity limits the kinds of tree species that will grow on a site as well as their rate of growth.
- Maintaining soil productivity keeps forest soils in a condition that favors regeneration, survival and long-term growth of desired forest vegetation.
- Maintaining forest soil productivity is less costly than correction or mitigation (after the fact).
- Maintaining the productivity and sustainability of forest soils is key to meeting society's need for forest products and other amenities of the forest.

A certain amount of soil impact is inevitable when conducting some forest management activities. Many of the recommended practices are aimed at keeping this impact to a minimum level.

SOIL CHARACTERISTICS AND POTENTIAL IMPACTS

Three Related Groups of Soil Characteristics

Soils have physical, chemical and biological aspects. All three characteristics are closely interrelated, and impacts on one may influence others.

- The physical properties of soil include such factors as texture, structure, porosity, density, drainage, and hydrology.
- The chemical properties of soil include its nutrient status and rates of cycling, and pH.
- The biological properties of soil include the multitude of organisms that thrive in soil such as mycorrhizae, other fungi, bacteria, and worms.

Because of the nature of forest management activities, the risk or significance of impacts to soil properties appears to be highest for physical properties, followed by chemical properties, and then biological properties. For example, forest sites where nutrient loss has occurred are few, while sites that have suffered due to physical impacts are relatively common. If the physical and chemical properties of the soil are not damaged, then the biological aspects take care of themselves. However, if a soil is severely compacted, plants cannot utilize nutrients because of the poor physical rooting environment, and the soil organisms responsible for nutrient cycling are also limited.

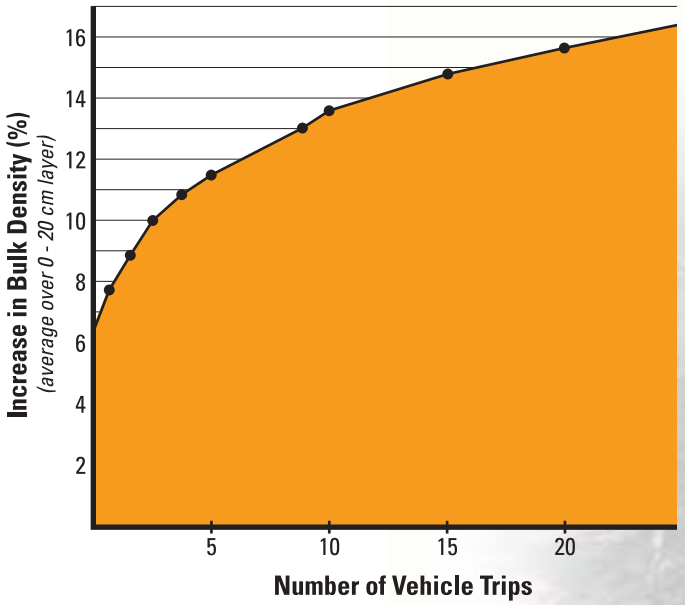

Figure 7-2: Effect of vehicle trips on soil density.

Characteristic 1: Physical Characteristics of Soil and Potential Impacts

Soil physical properties are very important in determining species composition and rate of growth. These properties affect the ease of root penetration and depth of rooting, the availability of water and the ease of water absorption by plants, the amount of oxygen and other gasses in the soil, and the degree to which water moves both laterally and vertically through the soil.

SOIL COMPACTION

Soil compaction is one of several types of closely related physical soil disturbances that can occur during timber harvesting and forest management activities. The other types of physical soil disturbance include puddling, rutting and displacement. These disturbances often occur simultaneously and are almost exclusively caused by movement of heavy equipment during felling, forwarding, skidding, and site preparation operations. Vehicle tires bearing heavy loads compress and pack the soil down, resulting in soil compaction.

Soil compaction is the increase in soil density resulting from loads applied to the soil surface. During the compaction process, soil volume is decreased primarily through the elimination of macropores (pores greater than 0.002 inches in diameter). Pore volume and pore size are key properties that govern air and water movement in the soil. Because of their relatively large diameter, macropores are particularly important in regulating the rates of water and gas movement.

The first few trips with heavy equipment over the soil surface produce the greatest increase in soil density (i.e., the most compaction; see Figure 7-2). Machine vibration may also contribute to compaction.

Recovery of compacted soil is variable depending on the severity of the compaction and local conditions. Compaction is a long-term rather than short-term effect. Severely compacted soils may require up to 40 years or more to recover naturally, according to Hatchell and Ralston, 1971. Froehlich and McNabb, 1984 state that "... the effects of soil compaction should be assumed to persist for several decades on forest sites."

Even in cold climates, where the action of freezing and thawing presumably loosens soils quickly, the density of compacted soils decreases slowly (Voorhees, 1983 and Corns, 1988). In an ongoing study in Minnesota and the Lake States (Stone and Elioff, 1998), no reduction in soil density has been measured after five years of intentional compaction.

Cattle can also cause soil compaction when allowed to trample the soil in forests and woodlots. Damage can be particularly severe when grazing pressure is heavy, soils are wet, and livestock use continues over a long time period. The physical damage to soils begins with the mixing and trampling of the cushioning forest floor layer, which quickly disappears under heavy livestock use. The bare soil is then compacted by repeated trampling – infiltration slows, runoff increases, and soil erosion occurs. Cattle also affect vegetation. In extreme cases, the herbaceous layer may disappear leading to additional loss of infiltration capacity and reductions in soil moisture. Aggressive non-native plants, many of which are spread by cattle, easily invade disturbed areas like these. As forest health declines, litter inputs are reduced and soil organic matter decreases, impacting site fertility. Tree roots may be directly damaged by hoof impacts that create wounds where insects and diseases can enter trees. Seeds, seedlings, and saplings of many tree species are browsed, reducing or eliminating forest regeneration and recruitment. Spiny or thorny plants that cattle do not eat are allowed to grow and may become overabundant, creating an impenetrable bramble. Livestock should be excluded from woodlands that support any quality trees or other desirable vegetation.

Soil compaction can decrease the rate of tree growth by altering the processes involved. Soil aeration is diminished, making oxygen less available for respiration in tree roots. Concentrations of carbon dioxide and other toxic gasses can build up, injuring roots. Soil micro-organisms that play a role in making nutrients available to plants are also negatively affected by the lack of oxygen and high levels of injurious gasses. Compaction further affects root growth by increasing soil resistance to root penetration. It decreases pore space, which reduces soil infiltration capacity (the rate of water movement into the soil), so that less moisture is available for plant growth. Also, when infiltration rates are reduced, more rainfall flows overland, which can increase erosion and sedimentation.

Fine- and medium-textured soils are more easily compacted than coarse, sandy soils. Most compaction occurs when soil moisture conditions are near or at saturation. Dry soils are less susceptible to compaction. Limiting equipment traffic to drier seasons of the year is one way to reduce compaction and other physical damage to the soil. Frozen soils are also relatively resistant to compaction, so winter operations are often an option for wetter sites.

PUDDLING

Puddling is the loss of soil structure that results from squeezing and churning wet soils with the tires or tracks of heavy equipment. Puddling often occurs in ruts with standing water. Soil particles become dispersed in water, and after they have dried and settled, the smaller particles form a crust on the surface. Puddled soils affect forest regeneration and growth in ways similar to compacted soils.

Figure 7-3: Severe soil compaction in this heavily grazed woodlot caused accelerated water runoff, which has eroded a deep gully.

RUTTING

Rutting is the creation of depressions made by the tires of vehicles such as skidders, log trucks and pickup trucks, usually under wet conditions. Rutting occurs when soil strength is not sufficient to support the applied load from vehicle traffic.

- Rutting directly affects the rooting environment. It physically severs roots, compacts and displaces soil, and reduces aeration and infiltration, therefore, degrading the rooting environment.
- Rutting disrupts natural surface water hydrology by damming surfacewater flows, which creates increased soil saturation up-gradient from ruts. Alternatively, ruts that run parallel to a slope gradient can divert water flow away from a site, drying or draining it, and sometimes contributing to erosion and sedimentation.
- Soil rutting occurs along with other physical soil impacts, including compaction and puddling.

DISPLACEMENT

The surface layers of most forest soils are very important to site productivity. These layers are rich in organic matter, contain the bulk of the soil's nutrient and moisture-holding capacity, and support the microbial population. Surface horizons cushion soil from traffic and buffer extremes in temperature. Organic matter contributes to soil aeration, and provides sites for seedling germination and rooting. Conserving organic matter is an important factor in maintaining site productivity. Displacement of surface soils, whether moved within a stand or removed from the site, can be detrimental.

Loose, sandy soils are sometimes impacted by heavy equipment that removes or wears away the surface vegetation during skidding and hauling – leaving the soil unprotected. On slopes or roadcuts, these sandy soils can slump downhill due to gravity, or can be eroded by wind and water. The continual displacement of the surface soil prevents revegetation on these areas, and removes them from productivity.

Figure 7-4: In this case, soil compaction and erosion is the result of heavy foot traffic on shallow soil along a popular trail. Injuries to roots and reduced aeration can kill trees. Similar damage can also be caused by livestock grazing, vehicle traffic, and other concentrated land uses.

SOIL EROSION

Soil erosion is a type of physical soil impact that is usually not a factor in forest management in Wisconsin except on roads and skid trails. Erosion seldom occurs on areas with vegetative cover, or on flat areas. Clearcut harvesting that temporarily removes all forest cover on steeper slopes can occasionally result in accelerated erosion. Extra care should be taken on silt, silt loam, loam, very fine sandy loam, sandy clay loam, silty clay loam and clay loam soils, as these soils tend to erode more easily when disturbed or exposed, especially on long slopes or slopes greater than 10 percent.

PROTECTING SOIL PHYSICAL PROPERTIES

- **Compaction and Rutting:** Soils most susceptible to compaction and rutting include fine-textured soils (silty clay, sandy clay and clay) and medium-textured soils (fine sandy loam, very fine sandy loam, loam, silt loam, silt, silty clay loam, clay loam, and sandy clay loam). Poorly and very poorly drained soils of any texture are susceptible to compaction and rutting during most years when not adequately frozen.

  The susceptibility of soil to compaction and rutting is primarily dependent on soil texture and moisture content. Soils are most susceptible to compaction, puddling and rutting when they are saturated. Such conditions occur during spring and early summer months, immediately following heavy rains, and in the fall after transpiration has ceased but before freeze-up.

  Timing of forest management activities, development of infrastructure, and selection of equipment and operating techniques are all critical factors that affect the soil resource. It is important to avoid operating heavy equipment on a site when adverse soil impacts are likely, and to limit direct trafficking of a site to the smallest area possible.

  The preferred operating season for any one site may vary depending on local climatic conditions, equipment being used, and operating techniques. The use of low ground pressure (LGP) equipment and operating techniques such as the use of slash mats can extend operating seasons on low-strength soils. Infrastructure development, including roads, landings and skid trails, almost always results in direct soil compaction and reductions in forest growth. It is critical to minimize the area occupied by infrastructure to reduce the impact to soil productivity. For more information on how to obtain soil interpretations for equipment operation, see the Resource Directory.

- **Soil Displacement:** Mechanical site preparation techniques often involve soil displacement. Severe treatments that remove or displace the surface organic and mineral soil layer may result in nutrient removal and other site degradation (i.e., soil erosion or compaction).

  Site preparation techniques that move surface soil away from seedlings (e.g., dozing soil into windrows) should be avoided, as these practices remove much of the nutrient and moisture supply that a seedling needs.

The loss of surface soil is exaggerated with extremes of soil types. Coarse, dry soils and wet, fine soils, or soils shallow to bedrock, are most likely to be severely impacted (see Chapter 13: Mechanical Site Preparation, for more discussion on selecting methods).

Retaining slash on site provides shelter and organic matter for seedlings. Although it may be difficult to plant a site with slash present, windrowing or piling of slash should be avoided, and scattering of slash should be encouraged.

Prescribed fire is sometimes used to reduce slash before planting, control competing vegetation, or expose mineral soil for seeding. Fire “mineralizes” soil nutrients, making them readily available to plants, but leaching can also occur. Fire-adapted ecosystems in Wisconsin are generally restricted to sandy outwash plains, where vegetation is adapted to fire and can take up the nutrients quickly. However, sites without native ground vegetation may be subject to leaching losses. Extremely hot fires may volatilize some nitrogen, but most is retained under conditions prevalent in most prescribed burns.

Erosion can be a severe problem on roads and skid trails that lack vegetative cover, resulting in downcutting of the roadbed and sediment delivery to streams. Techniques for limiting soil erosion and sedimentation from roads are discussed in Chapter 11: Forest Roads.

Figure 7-5: Excessive ruts caused by logging equipment should be dealt with promptly – before rain or melt water turns them into major gullies.

Figure 7-6: Soil compaction and rutting can create areas where water infiltration is slowed and ponding occurs. These ponds may benefit amphibians, but reduce forest productivity, and limit equipment travel. On slopes, such sites can result in erosion and sedimentation.

Characteristic 2: Chemical Characteristics of Soil and Potential Impacts

Soil chemical properties include nutrient status of a soil and soil pH. Soil chemical characteristics are influenced by many factors, including soil origin, soil texture and drainage, degree of soil weathering and development, and organic matter content. Forest management affects the nutrient status of a soil/site through 1) removal of nutrients in forest products, and 2) disturbance of surface soils through harvesting and site preparation activities.

NUTRIENT CYCLING

Nutrient cycling is the process by which nutrient elements move into, out of and within an ecosystem. Forested ecosystems receive natural inputs of nutrients through atmospheric deposition and mineral weathering (see Figure 7-7).

Throughout the life of a stand, these inputs can be very significant. Outputs of nutrients occur through timber harvesting or other practices that remove soil or organic material from a site, and through leaching and surface runoff.

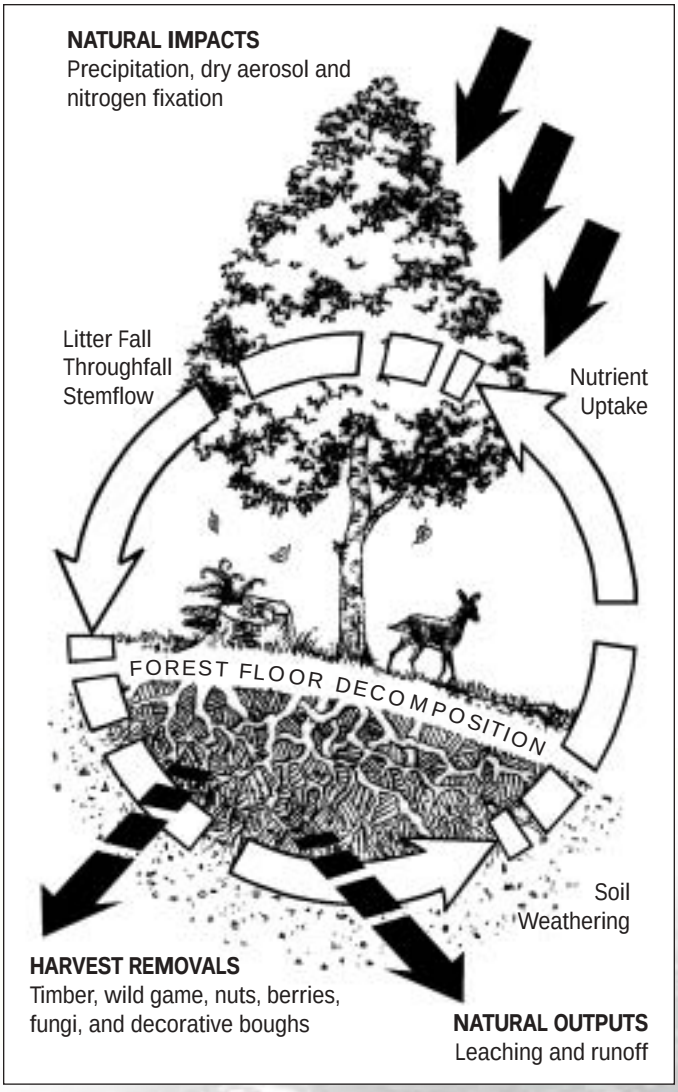

Figure 7-7: Nutrient Cycling

In contrast to the annual harvests associated with agriculture, a forest harvest typically occurs only once per rotation, or every 40 to 120 years. This reduces the rate of nutrient removal as compared with agriculture, and allows sufficient time for replacement by atmospheric deposition and weathering of soil minerals.

In forest ecosystems, timber harvesting and some site preparation practices can remove nutrients and have the potential to create deficiencies. Nutrient depletion could occur if removal is greater than replenishment that occurs between harvests. The likelihood of nutrient depletion is greater with shorter rotations, nutrient-demanding species, whole tree harvesting, and on sites with low inherent nutrient reserves.

Figure 7-8: Retaining slash on skid trails is an effective way of reducing soil compaction and rutting from use of heavy logging machines.

NUTRIENT STATUS AND REMOVALS

The initial nutrient capital of a site varies widely by soil type. For example, a loamy soil formed in loess over glacial till may contain several times the amount of calcium in the rooting zone, than a sandy soil formed in outwash deposits.

Different nutrients are stored in different parts of a tree, and different tree species store the nutrients in different relative abundance. In general, the greatest portion of mineral nutrients is stored in the leaves, followed by small branches, large branches, and boles (Kramer and Koslowski, 1979). Some species, however, store more calcium and magnesium in the bark than in the leaves. For example, aspen utilizes a relatively high amount of calcium, and stores roughly 50 percent of the calcium in the bole-wood and bark. Harvesting species that store relatively high levels of nutrients in the bole-wood and bark will potentially remove greater amounts of nutrients from a site.

Nutrient removal associated with timber harvest is dependent on 1) the species and portions being harvested, and 2) the season. For example, a whole-tree harvest during the growing season will remove virtually all nutrients stored in the above-ground part of the trees. In the case of bole harvest, with limbing at the stump, nutrients in the crown and other non-merchantable portions are retained on site. If trees are skidded to a landing before limbing, the nutrients in the crown are removed from the immediate vicinity, but could be moved back into the stand.

There is no evidence that nutrient depletion has occurred in Wisconsin due to forest management. Studies in Michigan on sandy outwash soils found nutrient depletion in conjunction with whole-tree aspen harvest (Stone, 2001). This could become a concern for sites with similar characteristics.

NUTRIENT-RETENTION STRATEGIES

- Retain or redistribute slash on the site
- Avoid whole-tree harvesting
- Addition of nutrients to the site
- Avoid shortened rotations

Many modern harvesting systems require full-tree skidding for efficiency of the operation. In these situations, slash can be redistributed out to the site from the landing. Caution should be exercised during non-frozen seasons to avoid trafficking additional areas while redistributing slash. The negative effects of soil compaction due to increased trafficking could outweigh the positive benefits of redistributing slash. It may be advantageous to leave clumps of slash (drags left along skid trails) or leave slash in the skid trails.

Characteristic 3: Biological Characteristics of Soil and Potential Impacts

- Biological characteristics of soil include the populations of plants and animals, including microflora (fungi, bacteria, algae) and microfauna (worms, arthropods, protozoa). Forest soils contain a multitude of microorganisms that perform many complex tasks relating to soil formation, slash and litter decomposition, nutrient availability and recycling, and tree metabolism and growth. Generally, the number of organisms are greatest in the forest floor and the area directly associated with plant roots (Pritchett, 1979).

  The population of soil organisms (both density and composition) and how well that population thrives is dependent on many soil factors including moisture, aeration, temperature, organic matter, acidity, and nutrient supply (Pritchett, 1979).

- Mycorrhizae are soil fungi that grow into tree root hairs, forming a symbiotic relationship that is very important in nutrient uptake for most tree species, particularly on nutrient-poor sites. Mycorrhizal tree species include pines, spruces, firs, maples, ashes, birches, beeches, oaks, basswoods, black walnut, black cherry, and willows. Afforestation has proven difficult in areas where mycorrhizae are not present in the soil, and trees planted in such sites are sometimes inoculated with a mycorrhizal fungus to improve establishment. Loss of the forest floor layer, or deforestation that dries and warms a site, can negatively impact populations of mycorrhizal fungi.

- Infiltration of moisture into the soil is aided by dense ground vegetation and thick forest floor, or duff layers, that act to intercept and hold rainfall. Activities that remove or thin the herbaceous plant cover and duff layer will contribute to greater runoff and potential erosion. The use of vehicles in forested sites can damage ground vegetation and remove or displace the forest floor layer. Trampling and grazing by cattle can also have these effects, particularly when combined with soil compaction that also reduces infiltration capacity. Some non-native invasive shrubs contribute to reduced infiltration, by capturing virtually all available sunlight so that no herbaceous plants grow beneath them, leaving the soil bare and unprotected.

- "Pit and mound topography" is a term that refers to the soil surface in a forest where occasional large trees have fallen or been blown down. The tree's root system pulls up a mound of soil, leaving a pit where the tree formerly stood. These pits are important sites for water infiltration into soils, especially on slopes, and also create puddles and ephemeral pools that benefit amphibians and invertebrate organisms. Harvesting reduces the likelihood of treefalls that create pits and mounds, and equipment travel tends to smooth the surface of forested sites. Maintaining a component of reserve trees that are allowed to fall down can help retain pit and mound topography.

- Physical and chemical soil characteristics can be influenced by forest management as previously discussed. Impacts to these soil properties may directly impact soil biology, thereby impacting the functions of the organisms – many of which are beneficial to plant growth. Implementation of practices that protect the physical and chemical properties of the soil also protects the habitat of the soil organisms and sustains their populations.

Figure 7-9: Buckthorn, a non-native invasive species, has invaded this woodland in southern Wisconsin, depleting vital nutrients needed by more desirable species.

APPLYING GUIDELINES TO VARYING SITE CONDITIONS

Forests in Wisconsin grow on a variety of soils and site conditions. Some of these include 1) loamy and clayey soils formed in rolling glacial till, often overlain with a silt loam "loess cap" deposited by wind after glaciers melted, 2) silty or loamy soils formed in alluvial plains along rivers, 3) droughty sands formed in outwash plains or sandy lake sediments, and 4) organic soils formed in wetlands.

Topography also varies greatly throughout Wisconsin. Much of the state displays glacial features like steep, hilly end moraines, gently rolling ground moraines, and nearly level outwash and lake plains. The "Driftless Area," which was not glaciated during the Wisconsin Ice Age, has steep eroded hillsides and level valley bottoms. The Lake Superior clay plain has fine-textured clay soils that are highly-erodible, and if not managed properly can contribute a significant amount of sediment to streams.

Because site conditions vary, it is important for individuals making forest management decisions to evaluate the soil and topography of each site. Site-specific information helps the manager develop individualized prescriptions to ensure productive capacity is not reduced as a result of forest management activities.

Figure 7-10: Skidder traffic, and hence soil compaction, can be reduced when the operator pulls cable to the logs instead of driving the machine to each one.

Figure 7-11: Retaining slash may be a bit unsightly, but it provides some shelter for new seedlings and adds organic matter and nutrients to the soil. When crushed by heavy equipment, it decomposes rapidly.

WISCONSIN FOREST MANAGEMENT GUIDELINES

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October, 2003

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Chapter 8

ECONOMICS

CHAPTER 8 — ECONOMICS

BALANCING ECONOMIC CONSIDERATIONS AND OTHER FOREST VALUES 107

BASIC FOREST MANAGEMENT AND ECONOMICS: THREE THINGS EVERY FOREST LANDOWNER SHOULD KNOW 108

1. How to Increase the Returns from Forestry Investments 108
2. How Forest Products Are Sold 111
3. How to Get Fair Market Value for Your Timber 111

ADVANCED FOREST ECONOMICS: AN INVESTMENT ANALYSIS PRIMER 115

TAX AND RECORD-KEEPING CONSIDERATIONS 120

The Original Basis: A Key Tax Consideration 120
Forestry-related Tax Deductions 123

RESOURCES FOR ADDITIONAL INFORMATION 124

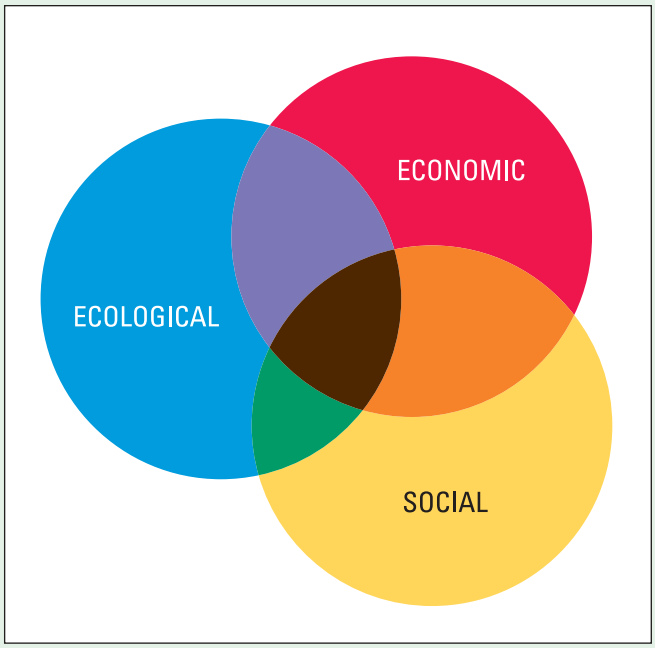

Figure 8-1: Sustainable forestry is based on the three pillars of ecological, economic, and social sustainability. All three must be met for practices to be truly sustainable.

A COUPLE WORDS OF CAUTION

First, when investing in financial markets, most people combine their own research with the advice of a broker or financial planner before making an investment decision. In a similar vein, landowners can usually benefit from the information and assistance of a professional forester, when making decisions about how to manage their forests.

Second, "economic" arguments are sometimes presented as justification for engaging in unsustainable forestry practices, such as high grading, that "takes the best and leaves the rest." Not all management that is financially attractive is sustainable, and not all practices that maximize forest growth are necessarily good financial investments (see Figure 8-1). Many practices will cost money, either out-of-pocket, or in the form of reduced income. Forest management is a lot like maintaining an automobile – you can skimp on routine maintenance to save a few dollars in the short run, but you usually pay for it later with more expensive repair bills!

About 262,000 Wisconsinites own forestland, mostly for its recreational and aesthetic values. While producing timber or managing the forest as an investment are not the primary reasons most people own forestland, landowners are sensitive to what it costs them, and at some point, they usually have an opportunity to realize income from their forest. Like everyone else, forest landowners also invest in stocks, bonds or mutual funds. Yet all too often, forestry investments are not scrutinized as critically as other financial investments. As a result, forestry investments capable of generating a favorable rate of return are not recognized, or conversely, investments are made that are sometimes not justified financially. Just as forestry involves good stewardship of natural resources so, too, sound financial management requires careful stewardship of investment capital. This chapter provides an overview of the basic principles and methods of investment analysis, and a number of tips on how to help maximize the returns from your forestry investments.

Figure 8-2: Large, high quality trees, such as this walnut, have a very high value. However, the time required to reach this size should also be considered by the wise investor.

BALANCING ECONOMIC CONSIDERATIONS AND OTHER FOREST VALUES

Figure 8-3: Harvesting on steep terrain affects both skidding and road construction costs. In addition, extensive measures (BMPs) are needed to prevent soil erosion. This translates into higher logging costs which mean lower stumpage returns to the landowner.

There are many benefits from owning and managing forests. Stocks and bonds are usually purchased for the sole purpose of making money, and their financial performance is judged on that basis alone. But forests are more than mere collections of trees, and landowners benefit from a wide array of non-timber goods and services like berries and mushrooms, recreational enjoyment, aesthetics, water quality, and wildlife. Some of these are traded in the marketplace, for example income from leasing hunting rights, but most are not, and there is no easy way to determine their value to the landowner. These non-market benefits can have significant value though, as evidenced by the prices paid for forestland. Even land that is a long distance from a population center and has no unusual attractions, such as lakes or streams, will typically be bought and sold for much more than its value for timber production alone.

Investment analysis that focuses only on costs and returns from timber production will ignore important non-market benefits, and will provide an incomplete measure of total investment performance. In theory, it would seem easy to incorporate non-market benefits into the calculations, but in reality it is often difficult even for economists to value such benefits.

One way to address this inability to deal directly with non-market benefits is to evaluate proposed projects in a two step process. The first step is to analyze the investment based only on measurable costs and revenues. If the investment meets the investment performance criteria established, then the project is probably financially sound. If the project does not meet traditional investment criteria, but the landowner feels that the enjoyment and other non-market benefits associated with establishing and managing their forest offset the shortfall in revenue, it may still be a sound investment.

BASIC FOREST MANAGEMENT AND ECONOMICS: THREE THINGS EVERY LANDOWNER SHOULD KNOW

1. How to Increase the Returns from Forestry Investments

Forests grow without the assistance of humans. The whole point of management is to meet the landowner's objectives, whether they are for wildlife habitat, recreation, or timber production. When it comes to timber production, a number of management strategies can improve economic returns.

PROTECT AND UTILIZE THE SITE FULLY

Any given plot of ground has a defined productive capacity, and it is important to avoid practices that degrade that production potential. Simply said, an acre will grow about the same volume of wood, regardless of the number of trees on it, as long as there are enough to occupy the site fully. Other things being equal, the fewer the number of trees, the larger they are likely to be; the greater the number of trees, the smaller they will be in diameter. Interestingly, height growth is not dependent on stocking level. This ability to focus diameter growth on fewer trees is the underlying principle behind many forest management treatments.

Stocking charts (see Chapter 16: Intermediate Silvicultural Treatments) have been developed to identify the relationships between diameter growth and various levels of stand density. If a landowner is interested in increasing the stand's value for sawlog production, careful attention should be paid to thinning periodically. Periodic thinnings will keep residual basal area densities at the recommended levels, maximize diameter growth, and concentrate growth on high quality trees with the greatest potential for grade increase (see Figure 8-4). Thinning can also maintain vigorous, healthy trees that can defend themselves from insect and disease attacks.

DIAMETER RESPONSE TO THINNING IN NORTHERN HARDWOODS

Thinning does not increase total volume produced, but thinning "frees up" resources for the residual trees, thereby concentrating growth on the remaining trees, improving their diameter, quality and value. One study conducted on the Argonne Experimental Forest in northeastern Wisconsin to measure the growth response of second growth northern hardwoods at different residual stocking levels had the following results:

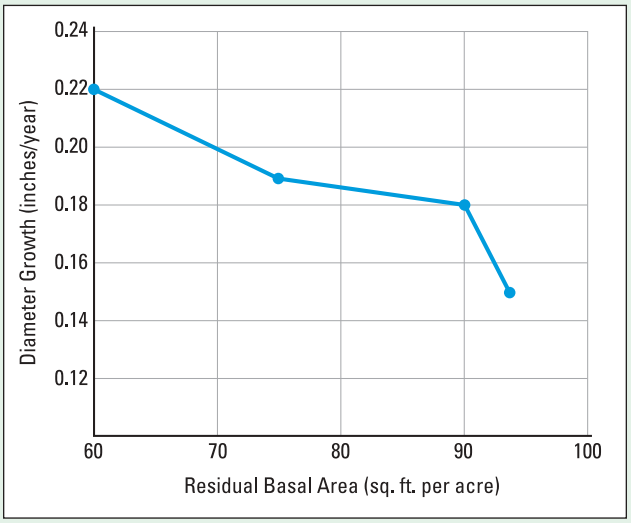

Figure 8-4: Periodic annual sawtimber diameter growth rates in relation to residual stocking for northern hardwoods.

Numerous researchers have reported that timely thinning can also improve tree quality in northern hardwoods, sometimes by as much as one grade.

MANAGE FOR QUALITY

Higher quality products bring higher prices. Tree diameter is an important determinant of product value and tree quality, particularly in the case of sawlogs. Pulpwood is ground up and reconstituted into paper, flake board, and other similar products. Sawtimber, on the other hand, is cut into solid boards, making it necessary for trees to be of a certain minimum **diameter at breast height (DBH)**. Normally a nine to 11 inch DBH is required (depending on the species) to have any sawlog value at all. Tree grade also relates directly to DBH.

The current U.S. Forest Service minimum DBH for grades 1, 2, and 3 trees are 16 inches, 13 inches, and 10 inches, respectively.

The typical product progression from pulpwood to sawlogs to veneer logs is based largely on size and quality, and this translates into a price function with dramatic increases as trees reach the specifications for different products (see Figure 8-5, page 109).

Figure 8-6 further illustrates the impact of grade change on tree value. Notice that early internal rates of return are particularly dramatic as a tree passes from pulpwood to sawlog size. This is a function of both the large difference in product value (pulp versus lumber), and the minimal current investment. As a tree gets larger and produces higher grade logs, it experiences its largest increases in absolute value, even though internal rates of return decline due to the higher investment in growing stock being carried. As trees reach their maximum grade potential, whether that be prime veneer or one of the lower grades, the value increases come only from the additional volume produced. As a result, absolute value increases decline, dramatically reducing the internal rates of return, even though overall individual tree value is at its peak. Since the butt log (the lowest, or "first log") normally makes up such a large percentage of a trees total value, its grade potential is particularly important when evaluating whether to harvest a particular tree, or let it continue to grow.

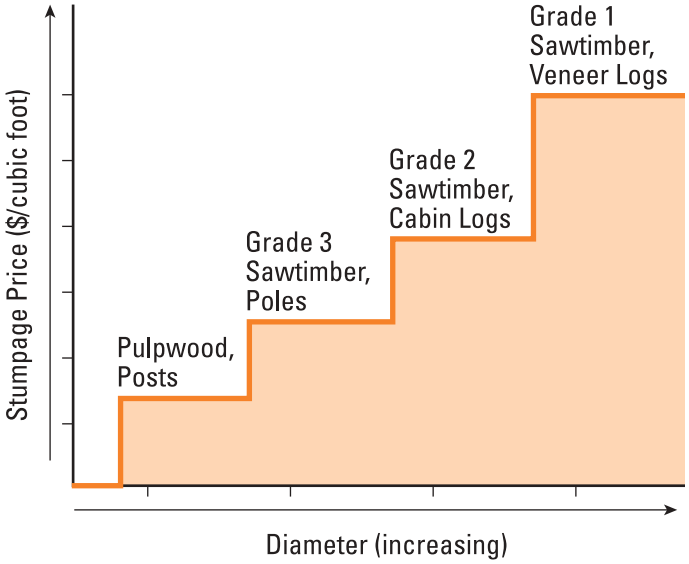

Figure 8-5: Schematic representation of the increase in stumpage price for timber as diameter increases. Note that very small diameter trees have no product value.

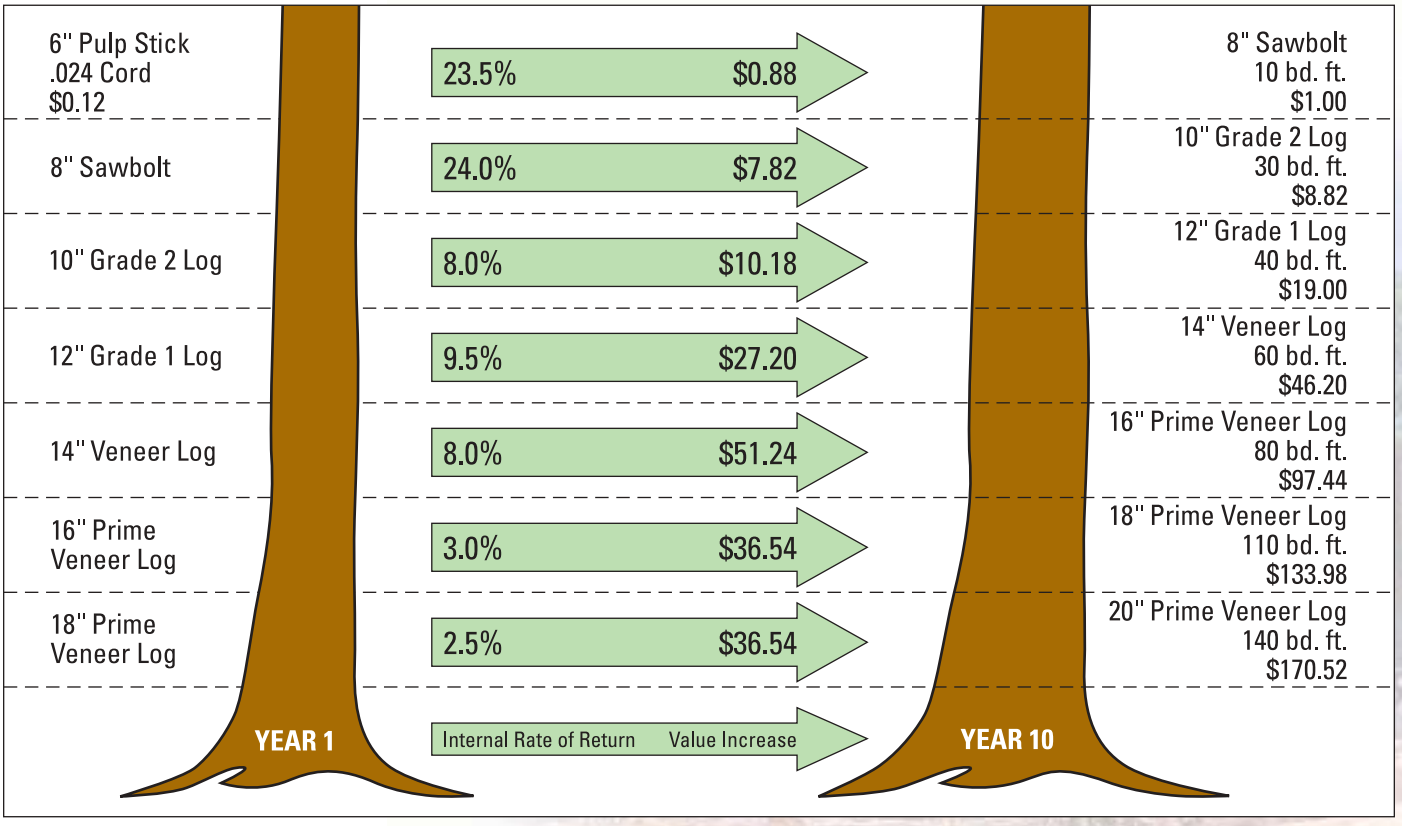

Figure 8-6: Relationship between grade change, volume growth, value increase and Internal Rate of Return for red oak. The volumes and values used in this example are based on one 100" pulp stick, or eight foot sawlog and are intended only to illustrate relative changes as trees increase in size and/or grade. Red oak stumpage prices were taken from a 1999 Timber Mart North Price Report©. Pulpwood $5/cord; sawbolts $25/cord; grade 3 logs $122/MBF; grade 2 logs $294/MBF; grade 1 logs $475/MBF; veneer logs $770/MBF; prime veneer logs $1,218/MBF.

DIVERSIFY AND GROW MULTIPLE PRODUCTS

Trees can be grown and marketed for many different products, and the relative value of these products is reflected in their prices. For example, pine can be grown for sawtimber, which is more valuable than pulpwood, but trees in the sawtimber size class can also be used for utility poles or cabin logs. On a per unit volume basis, these products can be even more valuable than sawlogs. Researchers report that utility poles are the most valuable products that can be produced from red pine, and that trees that qualify for poles sell for twice their value as sawtimber. Utility poles can be produced from trees 10" to 16" in diameter, but trees need to have minimal sweep and few knots, especially in the bottom portion of the pole. Some stands will yield a few trees that qualify for utility poles by happenstance, but not all sites are capable of growing poles.

Involve a forester early in your decision-making relative to your product goals. Management practices for producing poles, for example, differ from those for more typical pulpwood-sawtimber products, so landowners need to consider carefully from the very start what their final product objectives are. Some early management decisions can limit later opportunities. Planting too few red pine seedlings per acre, for example, could result in too many knots and too much taper to qualify trees for utility poles when they are harvested decades later. A forester can help landowners think through management objectives.

MINIMIZE EARLY INVESTMENTS AND TRY TO GET SOME RETURN AS SOON AS POSSIBLE

Forestry is a long-term venture, and as a result, the financial returns from forestry investments are greatly influenced by interest rates. Costs incurred at the start of a project reduce profitability on a dollar-for-dollar basis, whereas costs that can be delayed until later in the life of the project are discounted significantly and do not weigh as heavily in the calculations.

Early investments can often be reduced by matching goals with the capability of the site (see Chapter 2: Generally Accepted Silvicultural Principles). Not "fighting mother nature," but rather growing those forest types best suited to a site can minimize the need for costly intensive site preparation, and non-commercial intermediate treatments.

On the other hand, early revenues start earning interest sooner. Early thinnings, followed by regular follow-up thinnings, also have the benefit of increasing diameter growth, and shortening the time until higher value products are produced.

Figures 8-7 and 8-8: These tall straight red pines, having little taper, will make high quality utility poles and generate excellent financial returns to the landowner.

2. How Forest Products Are Sold

- Forest products are normally sold on the basis of their **stumpage value**, which is the value of a tree still standing on the stump. This value is lower than the price a logger receives when the cut logs or pulpwood are delivered to the mill. The price difference is a result of the sawing, bucking, skidding, road building, hauling, and other costs of production incurred by the logger, as well as the need to make a profit. Different stumpage prices are established for each different type of cut product – pulpwood, posts, poles, sawlogs, cabin logs, and veneer logs. Stumpage prices also vary by species. In a few cases, products are cut, skidded, and piled along the road by the landowner, and sold as **cut products**. Since much of the production cost is borne by the landowner, prices for cut products are higher than the normal stumpage price, but still lower than a delivered price. The price paid for cut products is normally negotiated on a case-by-case basis by product and/or grade.

- Stumpage can be sold on a "lump sum" or "scaled" basis. In the case of **lump sum sales**, the buyer submits one bid for all the stumpage available on the sale. A single payment or series of partial payments are normally made depending on the size of the sale, before any harvesting is done. In the case of a **scaled sale**, the buyer submits a bid based on a unit of volume (piece, cord, or board foot) by species, product, and sometimes grade. The products are paid for as they are removed, based on a scale (actual measurement of the cords and/or board feet removed) by the landowner, or a cooperating mill. Each method of sale has advantages and disadvantages relative to the time and expertise required to establish the sale, and administer the cutting operation. Depending on the frequency of sales, the method of sale can also have income tax implications.

3. How to Get Fair Market Value for Your Timber

If you want to get the best price for your timber, you need to do your homework, and that includes developing a rough idea of what it might be worth and why.

- The first step is to investigate stumpage price levels in your area. There are several sources of information on stumpage prices for Wisconsin timber.

  The Wisconsin DNR collects stumpage price information for the purpose of assessing the yield tax under the Forest Crop Law and Managed Forest Law programs. The stumpage rate schedule is published in chapter NR 46, Wisconsin Administrative Code, and is also posted on the DNR Division of Forestry's private forestry web site. The schedule is updated annually after hearings. Stumpage prices are reported for each of 13 regions to provide more localized information.

  County, State and National Forests can also provide stumpage price information on the timber they sell, and in some instances, this data might also be applicable to nearby private lands.

  Consulting foresters operating in your area are also a valuable source of stumpage rate information. Some firms even produce detailed reports on stumpage prices. An example would be the George Banzhaf & Company in Milwaukee, which publishes the *Timber Mart North Price Report*©. It is available separately for Michigan, Minnesota and Wisconsin on a subscription basis at a modest cost, and is published twice annually. Wisconsin statewide average prices are reported, as well as for each of three regions within the state. Information is available by product and species, and for stumpage as well as for delivered cordwood and sawlogs.

- Regardless of the source, the next step is to adjust average price information to reflect the specific "production factors" associated with each timber stand:
  - **Felling and Bucking:** This step involves severing the tree from the stump and cutting it up into products. Felling and bucking costs are affected by the volume to be removed per acre, average diameter, and the number of pulp sticks or logs per tree, thinning versus clearcut, limbiness, and slash control needs. In general, stands with more removable volume per acre, larger trees, with fewer limbs command a higher stumpage value.

- **Skidding:** Skidding involves moving the cut product from the stump to a landing or roadside for hauling. Skidding costs are affected by hilliness, wetness, the amount of residual stand to work around, sale design, skidding distance, and any equipment restrictions that might be required. Timber stands on flat, dry land with few residual trees or clumps to work around, and with shorter skidding distances bring a higher price.
- **Road Construction and Maintenance:** Normally road construction costs are borne by the contractor, so the length of roads, rockiness, soil type, wetness, need for extensive BMP work, and stream crossings needs, will all factor into a contractors stumpage bid.
- **Hauling:** The distance to the nearest mill, road quality, and seasonal road restrictions will also affect the cost of getting the products to market, and therefore, what the buyer can afford to pay for a stand of timber.
- **Marketability:** Each species normally commands a different price. In addition, seasonal fluctuations in price may result from supply and demand and/or weather patterns. If every farmer has a pile of pulpwood behind the barn following a winter with unusually good access to lowland stands, it might be best to hold off selling your black spruce for a while, likewise if the local sawmill is full of logs from a recent windstorm.
- **Quality:** The amount of defect, crook, and quality affect the value of both pulpwood and sawtimber. The quality premium is usually much higher for hardwood species than for softwoods. For example, the price of delivered grade 2 hardwood sawlogs in Wisconsin is typically 150 to 200 percent the price of grade 3 logs, and grade 1 logs bring a similar premium compared to grade 2 logs (George Banzhaf & Company, 2002). Since it costs about the same to cut a log out of a tree and deliver it to the mill regardless of the log grade, quality differentials for logs can translate into big differences in the value of standing trees.

The evaluation of these production factors requires a lot of local knowledge as to what is "average" in a given area. Some above-average factors may offset the impact of below-average factors. A forester can be a great help to a landowner trying to assess how the particular timber and harvesting factors for their situation will affect the value of their timber.

COMPETITIVE BIDDING CAN MAKE A BIG DIFFERENCE

The competitive bidding process is an important tool a landowner can use to ensure a realistic, fair price for their timber. Values offered for timber may vary for a number of reasons. Contractors do not all have the same equipment. Some may be very busy when you want to sell while others are looking for work. Some may have markets for specific products. Stumpage appraisal based on production factors is not an exact science. For these and many other reasons, try to get as many bids on your timber as possible.

Several studies report both increased income and satisfaction from competitively bid sales. One of the studies that analyzed 164 lump sum timber sales in Massachusetts found that the average difference between the high and low bid on sales that had two or more bids was $11,000. (Kittredge, D. B. and W. Halsam, 2000).

The example below shows the difference in prices offered in 1999 for one Wisconsin landowner's stumpage involving 107,980 board feet of sawtimber, and 260 cords of hardwood pulpwood. The actual submitted total bids were:

Bid 1: $42,077	**Bid 3: $48,262**
Bid 2: $42,948	**Bid 4: $65,044**

The forest owner hired a consulting forester to handle this sale. The consultant charged $4,590 for services. In addition to securing top value through competitive bids, the forestry consultant marked the timber, planned best management practices to protect water quality, assembled the bid packet, advertised the sale, negotiated the timber sale contract, collected harvest payments, and monitored contract compliance. Professional attention to all of these timber sale details can help maximize returns, and minimize expenses over the long-term.

In addition to the bid price, remember that it is important to select a contractor that will do a quality job in a timely manner!

SOME SPECIES ARE MORE VALUABLE THAN OTHERS

The unique wood properties and characteristics of different tree species govern their suitability for specific uses. Size, structural strength, appearance and "workability" are important considerations. Red oak sawlogs, for example, command a higher lumber price than weaker, plainer, less workable basswood. Red pine and jack pine, with their longer fibers, command a higher price for pulpwood than shorter fiber aspen. The straightness, strength and the amenability to preservative treatment makes pine more valuable for posts and poles, while white pine, with its traditional appearance, commands top prices for cabin logs. Relative prices may change as a result of technology, consumer preferences, and availability, but in general, products that require larger diameter trees, and lend themselves less to substitution tend to bring higher prices, and increase in real price over time. On the other hand, many of the more valuable species are only suitable for a limited number of sites, and require higher establishment and maintenance investments, which may offset some of their increased value.

Figure 8-9: All the production factors involved in getting timber from the stump to the millyard affect its stumpage value.

SOFTWOOD LOG GRADES

Veneer Grade	• Logs must be 16" or larger, 8' 8" or longer. Surface clear.
No. 1 Grade	• Logs must be 12" or larger, 8' or longer, with a net scale after deduction for defect of at least 50% of the gross contents of the log, 6" trim. • Three faces surface clear. • Maximum knot size 3", or no larger than 1/6 scaling diameter. • No black knots allowed.
No. 2 Grade	• All logs must be 10" or larger, 8' or longer, and a net scale after deduction for defect of at least 50% of the gross contents of the log. 6" trim, 3" maximum knot size or 1/6 scaling diameter.
No. 3 Grade	• Logs must be 9" and larger, 8' and longer. 50% of gross scale. Maximum knot size 4", 6" trim.

Table 8-1: Softwood Logs Grading (see also Tables 8-2 and 8-3, page 114).

Figure 8-10: High quality hardwood trees should be carefully bucked to maximize the yield of high value veneer and sawlogs.

HARDWOOD VENEER LOG GRADING RULES

GRADE FACTORS	PRIME VENEER	VENEER
Min. Diameter	14"	12"
Log Length	8' 8" to 17' 6"; Other lengths specified; 8" trim allowance.	
Surface Defects	None	• 8' 8"; one allowed. • 17' 6"; two if one falls in each half of the log. • Two defects allowed as one if perfectly in line. • Knots not to exceed 3". • Bark distortion is a surface defect. • Seam straight and tight up to 4' considered as one standard defect. • 10' and 12'; two defects in line. • 14' and 16'; two defects if one in each half.
End Defects	• Well-centered doze and holes individually or in combination allowed. • 12" and 13" diameter up to 2" 14" diameter up to 3" 5" diameter up to 4" • Logs must be free of mineral, ring shake and heavy bird peck. • One worm hole allowed in one end. • 50% heart allowed in hard maple. • Starred hearts, bark pockets, ring shakes, and flutted butts will not be accepted.	
Straightness	• Logs 13" or under must be straight. • 14" and up allowable sweep is 1/6 the diameter of the small end of the log.	
Grain Direction	• No wavy, curly, figured, or cross grain logs accepted. • Spiral grain allowed only if not more than 1" in 12" of length.	
Additional Notes	• Variations of this standard should be agreed upon by both buyer and seller. • Veneer logs graded on four faces.	

Table 8-2: Hardwood Veneer Log Grading Rules.

HARDWOOD SAWLOG GRADES FOR STANDARD LUMBER

GRADE FACTORS	LOG GRADE 1	LOG GRADE 2	LOG GRADE 3
Minimum Diameter	12"	10"	10"
Minimum Length* (including trim)	8' 4"	8' 4"	8' 4"
Clear Cuttings (on the three best faces)			
Length (minimum)		3'	2'
12"-15" Diameter**	7'		
16"-19" Diameter	5'		
20"+ Diameter	3'		
Number on Face (maximum)	2		Unlimited
8'-11'		3	
12'+		3	
Yield in Face Length (minimum)	5/6	4/6	3/6
Sweep and Crook Deduction (maximum)	15%	30%	50%
Cull Deduction, Including Sweep (maximum)	40%	50%	50%
Sound End Defects, Area (maximum) (see instructions)			

Exceptions:

- Grade 2: 10" d.i.b. must be one grade; surface quality.
- Grade 2: 11" d.i.b. limited to two cuttings.
- Sweep and crook allowance reduced 1/3 in logs with more than 1/4 diameter in sound end defects.
- 60% cull deduction permitted in grade 2 if otherwise of grade 1 quality.
- 60% cull deduction permitted in grade 3 if otherwise of grade 2 quality.

* Unless mill requires more trim.

** Grade 1: 8' long logs must be 5/6 clear (6-2/3") in one cutting on three best faces. Two cuttings 3'+ admitted to logs 20" and up in diameter.

Table 8-3: Hardwood Sawlog Grades for Standard Lumber.

Tables 8-1, 8-2 and 8-3: Official Grading Rules for Softwood Logs, Northern Hardwoods, and Tie Cuts, Effective January 1, 2001.

(Adopted by the Timber Producers Association of Michigan and Wisconsin, Inc.)

ADVANCED FOREST ECONOMICS: AN INVESTMENT ANALYSIS PRIMER

The successful operation of a forest property requires the integration of business methods, and technical knowledge in the management of a complex biological entity – a forest – to achieve a desired result. A forest landowner is continually faced with choices:

- **To plant or not to plant?** How would an investment in growing trees compare with the rate of return on savings bonds or other investment opportunities (see Example 1, page 117)?
- **Do it now, or do it later?** Would it be better to invest some money up front, or wait and later spend a little more on projects needed to ensure tree survival and enhance future growth and quality (see Example 2, page 118)?
- **To cut or leave?** Which tree should be marked for harvest (see Example 3, page 119)?

There are many such questions, but they all revolve around the relationship between inputs and outputs. **Forest financial analysis** is a particular form of investment analysis conducted from the perspective of the forest landowner. It takes into account the costs and revenues that the landowner expects to realize as a consequence of implementing a proposed action.

While a financial analysis can provide useful guidance, it must be remembered that the future is never certain, and management decisions should be flexible enough to adjust to changes in conditions over time. Forest management is a long-term proposition. For example, a stand regenerated this year may not be ready for final harvest (and subsequent regeneration) for 100 to 200 years. Projecting long-term financial performance is an inexact science based in part on historical information, but it requires a lot of assumptions about forest health, interest rates, costs, revenues, rate of inflation, and socioeconomic conditions.

All investment analyses require information about 1) the physical **inputs and outputs** associated with a project, 2) the **expenditures and revenues** these inputs and outputs generate, and 3) the timing when each will occur. In addition, an appropriate **discount rate** must be selected as well as **investment performance criteria**.

INPUTS AND OUTPUTS

Inputs and outputs are the physical resource flows that the project entails. Inputs might include such things as hours of labor or machinery rental, number of seedlings planted, and the amount of fertilizer or pesticide spread. Outputs in most cases will be the volumes of timber produced, but can also include non-timber forest products such as berries, nuts, mushrooms, hunting leases, or recreational user fees.

In some cases, it is possible to bypass estimating the units of physical resource used. For example, it is common to use an average per acre cost for mechanical or chemical site preparation, without going through the process of estimating the actual hours of machinery use, chemicals and labor that determine the cost.

Figure 8-11: The rate of return on initial investments, like tree planting, can be weighed against later timber revenues by conducting a financial analysis.

EXPENDITURES AND REVENUES

Expenditures and revenues are the monetary costs, and incomes, associated with the physical inputs or outputs. Landowners who invest their own labor in forestry projects should include the cost of their labor if they want to get a true picture of the financial soundness of their investment. In practice, though, many landowners derive significant recreational or other benefit from such work, and do not consider it a cost at all. If no earnings are forfeited when working in the forest, the landowner's personal labor cost can be excluded from the analysis.

Since most investment analyses involve estimating incomes and costs at some future date, it is necessary to project what they will be in **nominal**, also called market or current dollar, or **real**, also called constant dollar, terms. Nominal prices and costs contain inflation; real prices and costs have the inflation removed. The long-term rate of inflation over the period 1926 to 2000 was approximately three percent, which also happens to be what it averaged during the decade of the 1990s. Either real or nominal values can be used so long as they are used consistently throughout the analysis. It is usually easier to work with real values, though, and all examples in this chapter will be presented in real terms.

THE DISCOUNT RATE

The discount rate is similar in concept to an interest rate. Interest is the "rent" one pays, or gets paid, for the use of capital. The discount rate represents the rate of return on money invested.

Financial analysis involves adjusting expenditures and revenues for the effects of interest over time. Interest is **discounted** (subtracted), or **compounded** (added) as needed to reflect the value of revenues and expenditures at the same point in time. For example, the present value of a dollar to be received 10 years from now after being invested at five percent interest is only $0.61 (see Table 8-4), while the future value of one dollar invested for 10 years at five percent interest is $1.63 (see Table 8-5).

Years in Investment Period	INTEREST RATE				
	3%	4%	5%	6%	7%
10 Years	$0.74	$0.68	$0.61	$0.56	$0.51
20 Years	$0.55	$0.46	$0.38	$0.31	$0.26
30 Years	$0.41	$0.31	$0.23	$0.17	$0.13
40 Years	$0.31	$0.21	$0.14	$0.10	$0.07
50 Years	$0.23	$0.14	$0.09	$0.05	$0.03
60 Years	$0.17	$0.10	$0.05	$0.03	$0.02
70 Years	$0.13	$0.06	$0.03	$0.02	$0.01
80 Years	$0.09	$0.04	$0.02	$0.01	$0.00
90 Years	$0.07	$0.03	$0.01	$0.01	$0.00
100 Years	$0.05	$0.02	$0.01	$0.00	$0.00

Table 8-4: Discounted value of one dollar for different interest rates and time periods.

Years in Investment Period	INTEREST RATE				
	3%	4%	5%	6%	7%
10 Years	$1.34	$1.48	$1.63	$1.79	$1.97
20 Years	$1.81	$2.19	$2.65	$3.21	$3.87
30 Years	$2.43	$3.24	$4.32	$5.74	$7.61
40 Years	$3.26	$4.80	$7.04	$10.29	$14.97
50 Years	$4.38	$7.11	$11.47	$18.42	$29.46
60 Years	$5.89	$10.52	$18.68	$32.99	$57.95
70 Years	$7.92	$15.57	$30.43	$59.08	$113.99
80 Years	$10.64	$23.05	$49.56	$105.80	$224.23
90 Years	$14.30	$34.12	$80.73	$189.46	$441.10
100 Years	$19.22	$50.50	$131.50	$339.30	$867.72

Table 8-5: Compounded value of one dollar for different interest rates and time periods.

A very quick way to obtain a rough estimate of the effect of compounding and discounting is based on "the rule of 72." This rule states that the time it takes money to double when compounded (or halved when discounted) at a fixed interest rate is given by dividing the interest rate into 72. For example, money invested at 10 percent interest will double in just over seven years; at five percent, it will take about 14.5 years.

• EXAMPLE 1 •

Can I get a 5% or greater rate of return on a $250 per acre investment to plant a stand of trees, if I expect an income of $450 per acre to be generated by a thinning at age 30, and an additional $2,025 per acre to be generated in the final harvest at age 50 (assume there are no other costs or revenues, and all values are in real terms)?

ACTIVITY	YEAR OCCURRED	COSTS	REVENUES	YEARS IN INVESTMENT PERIOD	(1) DISCOUNTING FACTOR	(2) CURRENT VALUE
Planting	0	$250/acre		1	1.00	$250/acre
Thinning	30		$450/acre	30	0.23	$103.50/acre
Harvest	50		$2,025/acre	50	0.09	$182.25/acre

(1) Discounted value of one dollar at five percent interest rate; from Table 1, page 116.
(2) Actual value of all costs and revenues in year one.

Since, in this example, the total revenues ($285.75) exceed the total costs ($250), this investment would yield a rate of return greater than 5%. Note that if the final harvest was put off until year 60 (only another 10 years), the value of the final harvest would only be $101.25 (assuming no change in the type of product harvested), and the total revenue ($204.75) would no longer exceed costs, which means the rate of return would be less than 5%.

Figure 8-12: The planting of trees is just one of a number of forestry investments that can be evaluated using investment analysis techniques.

INVESTMENT PERFORMANCE CRITERIA

A number of criteria can be used to evaluate the financial performance of forestry investments. Net present value, internal rate of return, and payback period, are normally used when deciding whether or not to make a specific investment. When analyzing the relative merits of a number of alternative actions, however, the criterion might simply be which alternative offers the greatest expected rate of return (see the Wisconsin DNR *Silviculture and Forest Aesthetics Handbook, 2431.5*, for a more detailed discussion of these and other investment criteria).

• EXAMPLE 2 •

You plan to replant a poor quality mixed hardwood stand with oak following a harvest. You expect quite a bit of competition from the brush and red maple spouts on the site, and feel something might need to be done to ensure the new oak seedlings are not shaded out. One option would be to spray the area with a herbicide prior to planting, but you are not sure it is absolutely necessary. Another option would be to wait 10 years, and then hand cut the competing brush and sprouts if necessary. The first option would be much less expensive, but it will be a wasted investment if it turns out not to be needed. Should you go ahead and spray now, and not take a chance on having to do the more expensive treatment later? You expect to make the final harvest in the stand at age 80, and whichever option you choose, you want a 5% rate of return on your investment.

ACTIVITY	YEAR OCCURRED	COSTS	YEARS IN INVESTMENT PERIOD	(1) COMPOUNDING FACTOR	(2) FUTURE VALUE
Herbicide Release	0	$70/acre	80	49.46	$3,469.92
Hand Release	10	$110/acre	70	30.43	$3,347.30

(1) Compounded value of one dollar at five percent interest rate; from Table 2, page 116.
(2) Actual cost of the investment at the end of the time of final harvest in year 80.

In this case, it would make more financial sense to wait and conduct the hand release later, if it is needed. The reduced interest charged on the shorter investment period associated with the hand release (70 years versus 80 years) more than offsets the increased cost of the treatment. If it turns out the treatment is not necessary, even more money will have been saved. Finally, it is important to remember that trying to forego needed investments, such as the ones illustrated in this example, is really false economy, since the entire initial investment in planting may well be lost.

This analysis only tells us which of the two release options has the lowest overall cost over the entire investment period. In order to evaluate the rate of return on the entire planting project, revenues would also have to be estimated and included in the analysis, as in Example 1. (The long-time intervals and the risk and uncertainty involved in forestry investments also help explain why governmental cost-sharing programs can be helpful incentives to motivate some landowners to engage in forest management activities.)

Figure 8-13 and 8-14: Conducting a site preparation treatment before planting to ensure survival of planted trees versus a more costly herbicide release operation later, are typical of economic investment choices faced by forest landowners.

• EXAMPLE 3 •

One-third of Wisconsin's forests are northern hardwoods. Most stands were once or still are even-aged, but many landowners are converting them to uneven-aged stands. Long-term studies conducted on the Argonne Experimental Forest showed that the single-tree selection system with a medium level of residual basal area (75 sq. ft. per acre) economically outperformed both unmanaged stands, and stands that had been subjected to a diameter limit harvest.

A landowner who is practicing uneven-aged management asks a consultant forester to mark trees for harvest under the selection system, and to administer the timber sale. The forester does not expect that the stand will be ready for another harvest until 10 years have passed. As the forester begins marking the stand, she decides that one of two sugar maple trees needs to be removed in order to meet the stocking guidelines. Both trees are 15 inches in diameter, have two merchantable logs, and a volume of 135 board feet worth $50 today. Both trees are also of comparable risk and vigor (see Chapter 2: Generally Accepted Silvicultural Principles).

Each of the two trees is expected to add two inches of diameter growth over the next ten years, if the other one is removed to provide extra growing space. Both trees will therefore have a volume of 180 board feet in 10 years if they are left to grow, but tree 2 will improve its butt log to grade 1, whereas in tree 1 the butt log will remain grade 2. The estimated value ten years in the future is $68 for tree 1 and $90 for tree 2.

Which tree should the forester mark for removal?

Even without doing any calculations, it is pretty obvious that tree 2 is the better investment, and makes the better crop tree. The actual rate of return for each tree is as follows:

TREE 1

$$\text{Discount Factor} = \frac{\text{Future Value}}{\text{Present Value}} = \frac{\$68}{\$50} = 1.36$$

3% Rate of Return over a 10-year investment period (see Table 8-5, page 116)

TREE 1

$$\text{Discount Factor} = \frac{\text{Future Value}}{\text{Present Value}} = \frac{\$90}{\$50} = 1.80$$

6% Rate of Return over a 10-year investment period (see Table 8-5, page 116)

Cutting tree 1 and leaving tree 2 makes the most economic sense, and also illustrates the powerful influence that quality has on timber value. This situation also demonstrates how many times what makes the most sense from a silvicultural viewpoint can also makes good economic sense. Of course, this will not always be the case, but economics is all about making trade-offs.

TAX AND RECORD-KEEPING CONSIDERATIONS

Forestry is subject to numerous risks and uncertainties, most of which are beyond the control of the owner. But one factor that can either contribute to or detract from financial success is under the direct control of the owner/manager – income taxes. There are a number of sound business practices that landowners should consider relative to taxes:

- **Have a forest management plan.** A management plan, complete with projections of future growth and yield, and associated anticipated costs and revenues, provides strong evidence that you are treating your forestland as a business, should you be questioned by tax authorities.
- **Build tax planning into your management,** including estate tax considerations.
- **Utilize the tax advantages available to forest landowners.** Tax advantages, such as the reforestation tax credit and amortization provisions of the federal income tax code, can reduce the after-tax cost of early investments. Similarly, cost-sharing programs provide help with the costs of a wide range of forestry practices.
- **Keep good financial records,** not just because they are required by the IRS, but also because it is good business practice. It is hard to determine if past management and investment decisions were sound if you have no information with which to evaluate them. The difference between financial success and failure often depends directly upon whether adequate records have been kept to document expenditures and deductions, and the best place to start keeping good records is when you first acquire forestland assets.

The Original Basis: A Key Tax Consideration

One of the first important tasks a new landowner should undertake is the establishment of the **original basis**, or value, of all land and merchantable timber at the time of acquisition. Later, when income is received from a timber harvest, the adjusted (updated) basis for that potion of the timber sold can be claimed as a depletion allowance when computing income tax. Timber sale income can also qualify for more favorable capital gains tax treatment if the sale is structured correctly, and other requirements, such as the length of the holding period, are met. Capital gains are also exempt from self-employment (Social Security) tax.

CALCULATION OF THE ORIGINAL BASIS

Exactly what constitutes the basis depends upon how the assets were acquired, for example, whether they were purchased, inherited, or received as a gift. Since the details of the tax code are complicated, no general discussion can be sure to cover the specifics of an individual landowner's situation.

In most cases, however, the original basis of assets purchased is their acquisition cost, plus any additional expenses directly associated with the purchase, such as legal and accounting fees, closing costs, recording fees, costs of surveys, and even real estate taxes, if they are not otherwise deductible. The important point is that **the basis usually includes more than just the purchase price**.

The basis should be established when the assets are acquired, but often landowners do not become aware of this requirement until some time later. The cost basis can be established at a later date in certain situations, but it is more difficult technically, and could invite closer scrutiny by the IRS than if it were done at the time of acquisition. When considerable time has passed since the acquisition occurred, it simply might not be worth the bother trying to establish the original cost basis, because it will cost more than will be saved in taxes.

ALLOCATION OF THE BASIS

The procedure for establishing the initial or original cost basis each of the assets included in the acquisition is called **allocating the basis**.

Essentially, it involves allocating the total acquisition costs among the assets in proportion to their fair market value on the date of acquisition relative to the total fair market value of all the assets acquired. For example, if on the date of acquisition the fair market value of land represents 50 percent of the total fair market value of all the assets acquired, then 50 percent of the total original cost basis of the assets should be allocated to the land (see Example 4).

• EXAMPLE 4 •

Mr. and Mrs. Jones just purchased a 40-acre parcel of forestland. It is stocked with an average of 3,000 board feet per acre of hardwood sawtimber. A barbed wire fence surrounds the property. The Jones' paid $55,000 for the parcel. Closing costs were $250, and they also paid their attorney $270 to review the paperwork.

The estimated fair market value of the timber on the date of acquisition, if sold as stumpage, is $275/mbf, the bare land is worth $500/acre, and the fence has a value of one dollar per linear foot.

STEP 1: DETERMINE THE TOTAL COST OF THE ACQUISITION, THE ORIGINAL BASIS.

ASSETS ACQUIRED	ACQUISITION COST
40 Acres of Forestland	$55,000
Attorney's Fees	$275
Closing Costs	$250
Total Acquisition Costs (Original Cost Basis)	**$55,525**

STEP 2: ESTIMATE OF THE FAIR MARKET VALUE OF THE THREE ASSETS ON THE DATE THEY WERE ACQUIRED.

ASSET	AMOUNT	UNITS	FAIR MARKET VALUE PER UNIT	TOTAL FAIR MARKET VALUE	PROPORTION OF TOTAL FAIR MARKET VALUE
Land	40	Acres	$500	$20,000	34.3%
Timber	120	MBF	$275	$33,000	56.6%
Fence	5,280	Feet	$1.00	$5,280	9.1%
				$58,280	**100.0%**

NOTE: It is very common for the total acquisition cost to be different from the fair market value of the assets. Markets are not always perfect, and the fair market value could be greater or less than the acquisition costs.

STEP 3: ALLOCATE THE ORIGINAL COST BASIS AMONG THE THREE ASSETS.

ASSET	AMOUNT	UNITS	PROPORTION OF TOTAL FAIR MARKET VALUE	ORIGINAL COST BASIS	ORIGINAL COST BASIS PER UNIT
Land	40	Acres	34.3%	$19,045	$476.12
Timber	120	MBF	56.6%	$31,427	$261.89
Fence	5,280	Feet	9.1%	$5,053	$0.96
			100.0%	**$55,525**	

As timber volumes increase over time, Mr. and Mrs. Jones will need to update their records by calculating the **adjusted cost basis** of the timber, as shown below.

Initial Timber Volume	120 MBF
Adjustment for Growth	80 MBF
Adjusted Timber Volume	200 MBF

Original Cost Basis	$31,427
Adjusted Cost Basis Per Unit:	**$157.14/MBF**

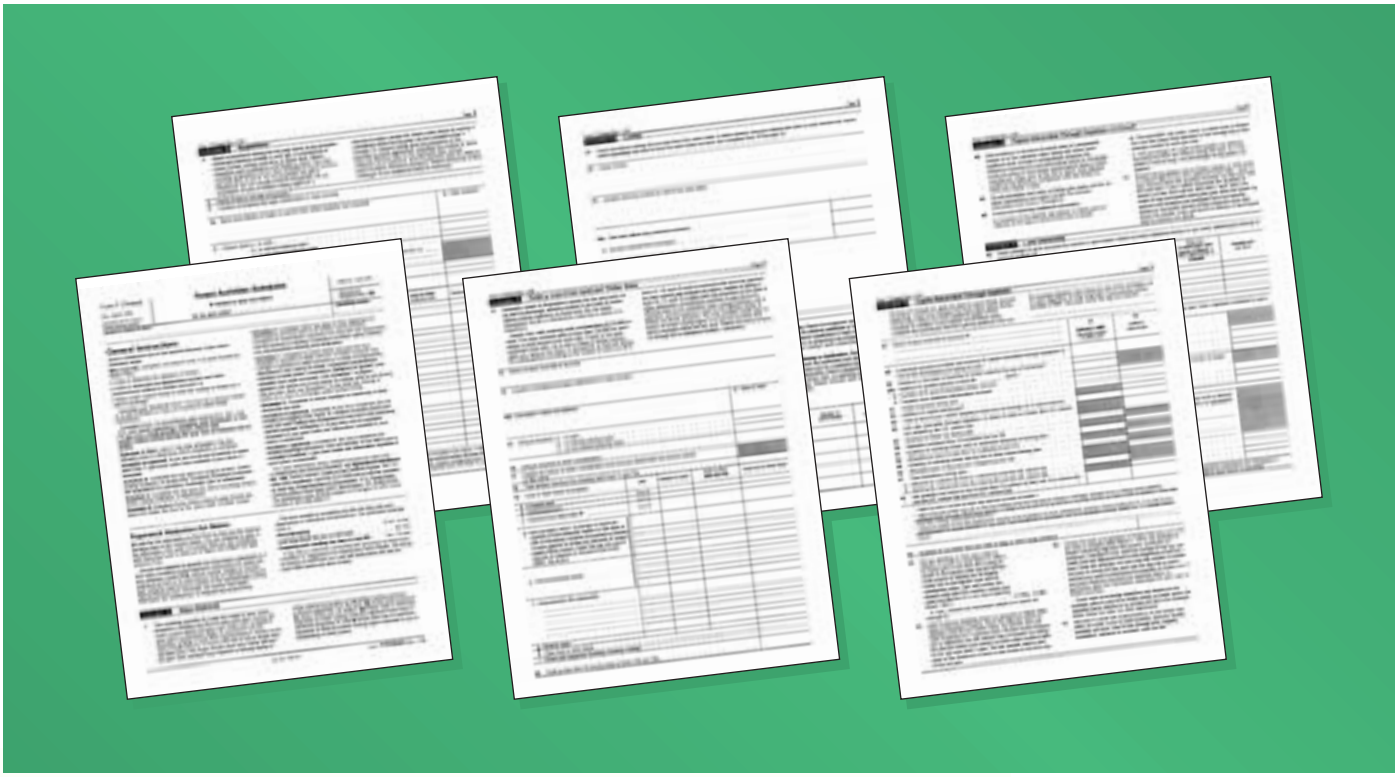

Figure 8-15: Complete and accurate records are key to managing a successful forestry business. IRS Form T categorizes the types of records that are critical.

THE IRS DOES NOT SPECIFY WHAT KIND OF BOOKKEEPING SYSTEM A TAXPAYER MUST USE

At a minimum, however, your records should include accounts with the amounts and cost basis of land, merchantable timber volume, and merchantable timber value. In Example 4 (see page 121), the landowners should also maintain a depreciation account to keep track of the cost basis of their fence, and how it changes as the depreciation allowances are claimed.

Perhaps the best guide to what kinds of records are useful is **IRS Form T: Forest Activities Schedule** (see **www.timbertax.org** for a copy of Form T). While not all items of information on Form T will be needed by all landowners, the form is a good guide both to the kinds of information larger forestry businesses must document, and how the information is used when filing tax returns.

Forestry-related Tax Deductions

- Timber is subject to **damage and loss** as a result of tornados, ice storms, fire, and even theft. The basic rule under the income tax code, however, is that if a taxpayer cannot demonstrate a cost basis in the damaged asset, no income tax deduction will be permitted.

- One of the most beneficial provisions of the federal tax code relates to the **reforestation tax credit and amortization**. The first provision permits a 10 percent tax credit on up to $10,000 of qualifying reforestation expenses. The amortization provision permits expenses to be recovered over eight tax years. There are some restrictions if both provisions are utilized, and the taxes saved are subject to recapture if certain conditions are not met, but the overall financial effect can be very beneficial.

Exactly which forest management expenses may be deducted when calculating taxable income depends on how the forestry operation is structured. An active business is the best option, but many landowners do not meet the IRS requirements for "active participation," and instead participate only passively or treat their forestland as an investment. Others fall into the "hobby farm" category. Each of these situations has different implications under the tax code for how income and expenses can be treated (for more information, see the references listed in the Resources for Additional Information section on page 124).

AMORTIZING REFORESTATION EXPENSES

A landowner spends $10,000 on reforestation, and claims the 10 percent investment tax credit. The amortization for each tax year is calculated by first subtracting 50 percent of the amount claimed as a tax credit [$10,000 - (0.5)($1,000) = $9,500], and then applying an annual amortization factor to the remainder. The calculations are illustrated below.

YEAR	DEDUCTION FOR AMORTIZATION (FRACTION)	DEDUCTION FOR AMORTIZATION (AMOUNT)
1	7.0%	$679
2	14.0%	$1,357
3	14.0%	$1,357
4	14.0%	$1,357
5	14.0%	$1,357
6	14.0%	$1,357
7	14.0%	$1,357
8	7.0%	$679
Totals	**100.0%**	**$9,500**

Figure 8-16: Forest management plans are often modified by natural disturbances like this major wind storm in a northern Wisconsin hemlock stand.

RESOURCES FOR ADDITIONAL INFORMATION

CASUALTIES, THEFTS AND INVOLUNTARY CONVERSIONS: SOME INCOME TAX TIPS FOR WOODLAND OWNERS

Stier, J. C. (1996). *Casualties, thefts and involuntary conversions: Some income tax tips for woodland owners.* University of Wisconsin-Madison, Department of Forest Ecology and Management. Forestry Fact No. 16. 8p.

DETERMINE YOUR BASIS…AND KEEP MORE TIMBER INCOME

Martin, J. (1994). *Determine your basis…and keep more timber income.* University of Wisconsin-Madison, Department of Forest Ecology and Management. Forestry Fact No. 71. 4p.

ESTATE PLANNING FOR FOREST LANDOWNERS

Haney, H. L. Jr. and Siegel, W. C. (1993). *Estate planning for forest landowners.* USDA Forest Service General Technical Report SO-97.
www.timbertax.org/estate_laws/fs_pub.asp?id=estate&topic=estateplan

FINANCIAL RECORD BOOK FOR TIMBER GROWERS (4TH ED.)

Stier, J. C. (2003). *Financial record book for timber growers (4th ed.).* University of Wisconsin-Madison, Department of Forest Ecology and Management.

FOREST LANDOWNERS' GUIDE TO THE FEDERAL INCOME TAX

Haney, H. L. Jr., Hoover, W. L., Siegel, W. C., and Greene, J. L. (2001). *Forest landowners' guide to the federal income tax.* USDA Agricultural Handbook No. 718.
www.timbertax.org/research/aghndbk/aghndbk.asp?id=research&topic=aghndbk
www.fs.fed.us/spf/coop/Forest%20_Tax_%20Guide31201.pdf

NATIONAL TIMBER TAX WEBSITE

www.timbertax.org

WHAT WILL A FOREST TREE EARN?

Martin, J. (1988). *What will a forest tree earn?* University of Wisconsin-Madison, Department of Forest Ecology and Management. Forestry Fact No. 38. 3p.

WHAT'S A FOREST TREE WORTH?

Martin, J. (1988). *What's a forest tree worth?* University of Wisconsin-Madison, Department of Forest Ecology and Management. Forestry Fact No. 39. 5p.

WHEN TO HARVEST TIMBER – NOW…OR LATER?

Martin, J. (1991). *When to harvest timber – Now…or later?* University of Wisconsin-Madison, Department of Forest Ecology and Management. Forestry Fact No. 53. 8p.

These resources are specific to the information in this chapter only. Refer to the Resource Directory for additional resources related to this chapter.

WISCONSIN FOREST MANAGEMENT GUIDELINES

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www.dnr.state.wi.us/org/land/forestry/

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Chapter 9

FOREST MANAGEMENT PLANNING

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FOREST MANAGEMENT PLANNING 126
Incorporating Sustainability Into Forest Management Plans.....126
Forest Management Plan Elements 130

FOREST MANAGEMENT PLANNING

A forest management plan is a written document designed to 1) identify the landowner's goals and objectives, 2) describe the resource and its condition, and 3) list appropriate management prescriptions and a timetable for their completion. Plans, simple to complex, take many forms and fulfill different needs. All plans should:

- Be tailored to the landowner's individual needs and objectives within the capability of the land.
- Make clear to the owner how carrying out the plan will help achieve their goals.
- Follow generally accepted silvicultural principles.
- Avoid technical forestry terminology, or define all technical terms used.
- Be based on ecosystem considerations.
- Be concise – include information that's relevant to the parcel and accurate.
- Provide a timetable for accomplishing needed forestry practices.
- Identify legal permits required to carry out the plan.
- Incorporate publications or other attachments to describe routine, repetitive information.
- Explain where a landowner can get help to follow through with the plan.

Incorporating Sustainability Into Forest Management Plans[1]

The essence of developing a sustainable forest management plan is an understanding of forest community dynamics as a function of site and disturbance, and identifying a much wider range of acceptable silvicultural options than that based simply on the forest cover types currently occurring. This concept was introduced in Chapter 2: Generally Accepted Silvicultural Principles, Site Evaluation and Stand Delineation, and will be further explained in the following steps.

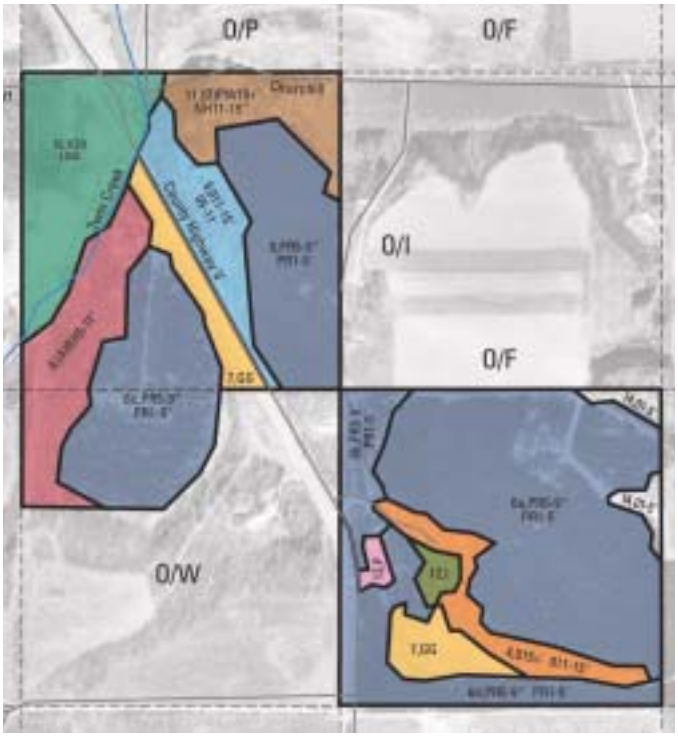

Figure 9-1: An important step in planning is to identify site types, delineate individual stands, and prepare a map of the property.

STEP ONE: IDENTIFYING LANDOWNER GOALS

Forest resource professionals must communicate with the landowner to identify their long-term goals for ownership and management of their forestland. Communication skills, particularly the ability to listen, are required. Sample goals may be 1) to create habitat for a wide range of wildlife species; 2) to maximize income from wood production; or 3) to provide the best possible deer habitat.

At first, a landowner may not have clearly articulated objectives, or may not be aware of opportunities on their land. Use of the planning process can help the landowner learn more about various management opportunities, and better define objectives. Foresters and other resource managers should carefully consider the objective statement provided by the landowner, and help refine it, if necessary, with the landowner's involvement.

1 *This section is adopted from Kotar, J. 1997. Approaches to Ecologically Based Forest Management on Private Lands. University of Minnesota Extension Service, publication NR-604.*

STEP TWO: CONDUCTING A SITE EVALUATION AND DELINEATION OF SITE TYPES

Secure aerial photographs, topographic maps, soil surveys, Natural Heritage Inventory (NHI), cultural heritage, and other resources available to analyze the property. Sources of this information include local offices including: Soil and Water Conservation District (SWCD), USDA Natural Resource Conservation Services (NRCS), Department of Natural Resources (DNR), and county land departments.

Conduct an on-the-ground evaluation of the land. It is important to have firsthand knowledge of the area being considered. Evaluate soil conditions to determine tree species, preferred seasons of operation, site preparation and regeneration techniques, and other information related to forest management decisions. Identify resources, features and site conditions that may require special attention (e.g., perennial and intermittent streams, lakes, wetlands and seasonal ponds, steep slopes, rock outcrops, unstable or poorly-drained soils, sinkholes, seeps and springs, infestations of non-native invasive plants, snags and nesting sites). Assess cultural resource potential, and endangered, threatened or specialist interest (ETS) species.

While identifying the physical characteristics of a site, think about how the characteristics might affect the planning and design of a particular forest management activity. Some of these considerations include soil capabilities and limitations; location and width of filter strips and riparian management zones (RMZs); stream crossings; visual sensitivity; and the network of access roads, approaches, trails, and landings needed to access the site.

Delineate site types (see Chapter 2: Generally Accepted Silvicultural Principles). Land within an ownership can be relatively homogeneous or heterogeneous in terms of its ecological capability. Major factors affecting species' ability to grow, reproduce and compete include soil depth, texture and chemical properties, and position on the landscape (such as north or south slope aspect, ridge or valley, etc.). Any areas within the ownership that can be differentiated on the basis of such factors should be identified as "site types." In some areas, formal site classification systems have been developed.

Figure 9-2: An important first step in developing a management plan is to identify the landowner's specific objectives, and list them in the written plan.

Figure 9-3: Frequent communication between the forester, landowner and other resource professionals helps insure that management objectives are fully achieved.

STEP THREE: DELINEATION OF STANDS WITHIN SITE TYPES

Because stands (vegetative units) represent communities of different compositions and structure, and therefore different stages of development cycles, they must be considered separately if management based on ecological principles is to be attempted. Each stand is considered to be an "ecological opportunity unit." A forest manager may elect to divide a site type into more than one stand in order to apply a mixture of treatments (or passive management) to meet a variety of landowner objectives.

STEP FOUR: IDENTIFICATION OF SILVICULTURAL AND ECOLOGICAL ALTERNATIVES FOR EACH STAND

Short- to mid-term compositional and structural changes in most vegetation units are relatively predictable. Current development trends, however, are not necessarily the only ecologically acceptable pathways, and they may not meet the landowner's goals. Before deciding on the most viable management option, a resource professional should attempt to identify other ecological alternatives.

Each stand, if properly delineated, can be expected to respond uniformly to a given natural disturbance or management action. Although there are definite limitations due to site, stand composition, and availability of external seed sources, there is almost always more than one ecologically sound silvicultural alternative available. All too often, regenerating the existing cover type is the only option considered. Such a choice may not always be ecologically desirable, nor may it best meet the landowner's goals. More management options can be offered to the landowner if all ecologically feasible alternatives are first identified.

Systematically identify ecological and silvicultural alternatives by evaluating the following factors:

- **Successional role of each species comprising the current stand (overstory and understory).** This information is essential for planning changes in stand composition and regeneration techniques.
- **The age structure of the stand.** Species and age structure are two fundamental properties of any forest stand. They must be taken into account in any management consideration.
- **Relative growth potential of each species on the identified site type.** This may be the most important information for any management decision because growth potential relates not only to economic outputs, but also strongly affects forest dynamics.
- **Presence of advance regeneration.** Presence of advance reproduction to a large extent dictates the type of regeneration techniques that will be applied. Also, advance reproduction may or may not be of the desired species.

Figure 9-4: An inventory of each stand will provide basic information to guide management decisions. The chart in this photo indicates the board-foot volume per acre by species and diameter for a specific stand.

- **Expected reaction of advance regeneration to different types of stand manipulation.** If advance reproduction is of mixed species, different growth rates can be expected with different degrees of canopy removal. Seedlings of most species benefit from complete canopy removal, but some shade-tolerant species respond best to gradual canopy removal.
- **Expected effect of competing vegetation after opening of the canopy.** Understory plant species respond differentially to removal of the forest canopy, and present different degrees of competition to tree seedlings. Response of competing vegetation also varies among site types. Generally, the more mesic the site, the stronger the understory competition. However, potential competing species are not necessarily present in every stand. Some non-native invasive plants are very competitive and can limit regeneration and growth.
- **Potential for inducing advance reproduction of each canopy species.** Regeneration requirements vary greatly with species. Some conditions are more difficult to meet artificially than others.
- **Existing and potentially-damaging agents.** Some species are more susceptible to specific damaging agents (e.g., insects, pathogens, frost, windthrow) in certain regions or on specific site types.

STEP FIVE: IDENTIFICATION OF VIABLE ALTERNATIVES BY EVALUATING LANDOWNER'S CONSTRAINTS AND OPPORTUNITIES

- **Landowner's Resource Constraints:** Some silvicultural and ecological opportunities identified previously may not meet an owner's financial expectations, or may exceed their commitment of time.

- **Regional Ecological Issues and Concerns:** Management practices that are ecologically sound on a site or local ecosystem level may not address landscape and regional concerns. Although private owners are not obligated to consider regional ecological concerns (other than those specifically covered by law, e.g., the Endangered Species Act), many of them are interested and often eager, to accommodate them within limits of economic efficiency. Resource professionals working with private owners should be aware of such issues, and bring them to the owner's attention when preparing management plans. Such issues vary greatly from region to region, and cannot be addressed comprehensively.

  The following are some examples of regional ecological considerations:
  - Lack of large contiguous blocks of specific habitats to accommodate wide-ranging animal species, or those that do not thrive in edge habitats.
  - Need for special wooded corridors to accommodate movement of some animal species between suitable habitat patches.
  - Loss of certain vegetation types (and accompanying fauna) due to changes in natural disturbance regimes (e.g., loss of oak savannas or pine forests due to suppression of wild fires).
  - Shortage of mature stages of forest development due to uniformly applied economic rotation age.
  - Reduced compositional and structural diversity of forest communities due to prevailing management practices.
  - Lack of tree regeneration, and reduction of shrub/herb density and diversity due to high deer populations.

- **External Socioeconomic Constraints:** Certain activities may be constrained by zoning laws or forest practice regulations, while others may simply conflict with the prevailing attitudes of neighbors or the general public. While the latter doesn't bind an owner, a conscientious resource professional will keep landowners informed in order to minimize potential future conflicts.

- **Socioeconomic Incentives:** Socioeconomic constraints often can be balanced by incentives. These may include lower property taxes on managed forestland, income tax deductions for forest management investments, government cost-sharing for management practices, and others. Some practices may also engender greater public acceptance than others without compromising a landowner's goals.

STEP SIX: DEVELOP MANAGEMENT OBJECTIVES FOR EACH STAND

The steps described previously identify ecologically sound silvicultural alternatives for individual stands, and eliminate from consideration those that cannot be supported on socioeconomic terms. The landowner now must select the management (or silvicultural) objectives for each stand (i.e., what to grow and how to grow it as explained in Chapter 2, page 44).

STEP SEVEN: PREPARING THE MANAGEMENT PLAN

Only when management objectives have been defined through this type of process should the management plan (i.e., the "action plan") be developed. The management plan is a written document that summarizes all of the above information, and then clearly prescribes management unit activities and a timeline for accomplishing them.

Detailed silvicultural prescriptions are not part of the initial management plan – these are developed immediately prior to a scheduled management practice in order to take into account unique stand conditions. For example, a timber harvest or tree planting project should have a detailed project plan with specific instructions or performance criteria.

A suggested process to develop management options is depicted in Figure 9-5. It should be emphasized that this is a process (i.e., a sequence of steps to consider) and not an outline of items to be specifically included in actual management plans (which are covered in Table 9-1, see pages 131 and 132).

Forest Management Plan Elements

As noted at the beginning of this chapter, a forest management plan may be brief or detailed, depending on its purpose and the interests of the landowner. For purposes of state and federal programs in Wisconsin, forest management plans usually fall into two categories:

- **Basic Plans** address a specific management practice(s) and may be in the form of a letter or summary of management prescriptions. They are often used as a follow-up to an initial contact with a new landowner to augment verbal recommendations, and lay the groundwork for further action in the future. A Basic Plan might not meet the plan standard requirements for cost-sharing or forest tax programs, but should still incorporate the sustainable forestry principles described in the first section of this chapter.
- **Comprehensive Plans** such as Managed Forest Law (MFL) Plans and Forest Stewardship (FS) Plans, are more complete than Basic Plans. They incorporate sustainable forestry principles and may go into some detail to identify and describe activities to enhance or protect soil, water, aesthetic quality, recreation, timber, water, and fish and wildlife resources based on the landowner's objectives for the land.

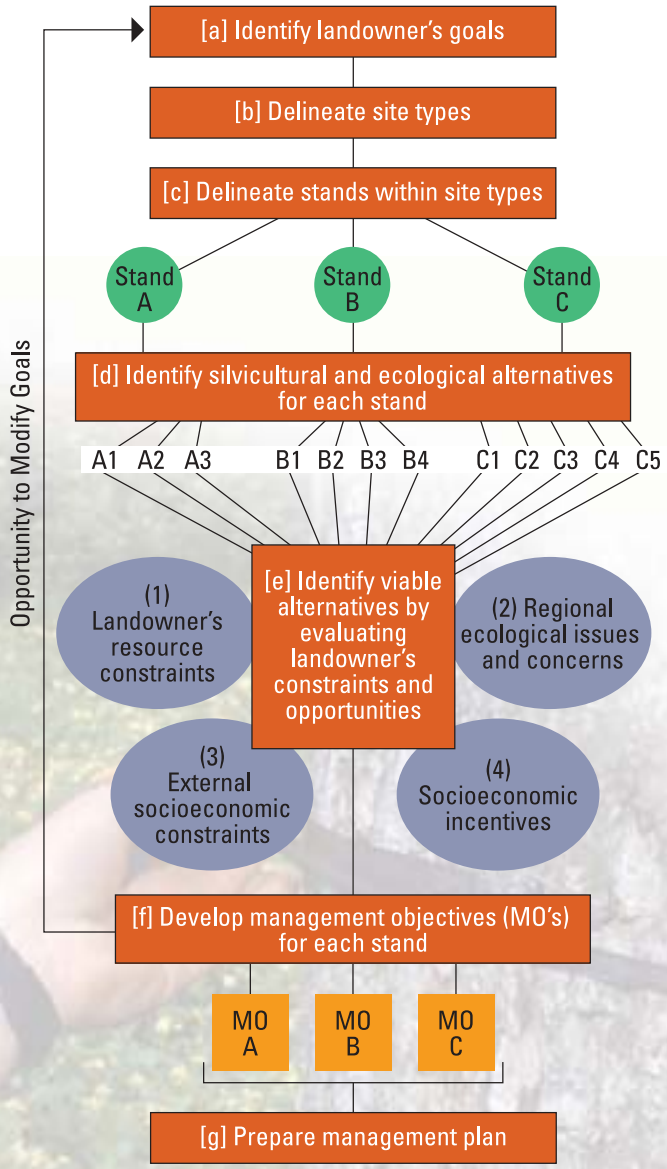

Figure 9-5: Model of an approach to the development of ecologically sound forest management plans.

Figure 9-6: Having a trained forester collect inventory data for each stand on the property is necessary before prescriptions can be developed to achieve the management objectives.

■ Required ● Recommended

Plan Component	Managed Forest Law Plan	Forest Stewardship Plan	Basic Plan*
#1: IDENTIFICATION			
a. Landowner name, address, with necessary signatures and dates.	■	■	●
b. Landowner signature of approval.	■	■	
c. Plan preparer name, address and phone number.	■	■	●
d. Plan preparation date.	■	●	●
e. Legal description (T, S, R minimum).	■	●	●
f. Planned acres.	■	■	●
g. Plan length (shows number of years covered by plan).	■	●	
h. Overall landowner goals and objectives for the property.	■	■	●
i. The pages are numbered sequentially, order number on all pages.	■		
#2: DESCRIPTION (May be presented in a narrative or tabular format as appropriate.)			
a. Map with property boundaries, cover types, water, roads, adjoining land use, acreage, etc., clearly and adequately labeled.	■	■	●
b. General property description.	●	■	
c. Regional landscape overview.	●	■	
d. Interaction with surrounding properties.	●	●	
e. Soils information (can be generalized over entire property when soils are uniform; may be included in a data table).	■	■	
f. Stands by cover type and area (acres).	■	■	●
g. Descriptive overview of the timber type.	■	●	●
h. Stand silvicultural objective (what you are trying to grow and how you intend to achieve it; indicate target timber type or land cover, and the even-aged or all-aged technique used for this objective). Provide a link to landowner's objectives where practical.	■	■	●
i. Forest characteristics; Land Exam Form 2450-128 Part A (and Part B for MFL) or similar stand-based table (providing a copy to the landowner is recommended though not required).	■	■	
j. Plan addresses known, threatened and endangered species, and cultural/historical resources.	■	■	■

Table 9-1: Wisconsin Forest Management Plan Standards which summarizes recommended and required elements in forestry plans (continued on next page).

■ Required ● Recommended

Plan Component	Managed Forest Law Plan	Forest Stewardship Plan	Basic Plan*
#3: MANAGEMENT ACTIVITIES			
a. Recommendations consider landowner's available time, interest, money and energy based on landowner's objectives.	●	●	●
b. Plan identifies and describes actions (practices) to be taken by the landowner to protect soil, water, range, aesthetic quality, recreation, timber, and fish and wildlife resources in a manner that is compatible with landowner objectives.	■	■	●
c. MFL Mandatory Practices**	■		
d. MFL Optional Practices**	■		
e. Year practices should/must be completed (a chronological summary of mandatory or recommended activities is also desirable, but not required).	■	●	●
f. Enforceable language: Specific requirements as appropriate (basal area residuals, trees per acre, follow-up requirements, etc.).	■		
g. Prescriptions are consistent with Wisconsin DNR approved silvicultural standards.	■	■	■
h. Gypsy moth control considerations.	■	●	
#4: PRESENTATION			
a. The plan information is presented in a logical format that is easy to follow.	●	●	●
b. The writing style is easy to read and understand, and presented in a professional manner.	●	●	●
c. The writer reasonably avoids wordiness, jargon, and mistakes in grammar, spelling and formatting.	●	●	●
d. The plan meets the landowner's needs and provides useful advice in a skillful way.	●	●	●

* Foresters will need to use judgment in deciding which components in addition to those designated in the chart are needed for each individual Basic Plan. A CRP Planting Plan, for example, might require many of the same components as a Forest Stewardship Plan.

** Mandatory and Optional Practices are required to be included in MFL plans to the extent needed to address sound forestry and the landowner's objectives listed in the plan.

Note: An MFL checklist is included in Appendix C, covering all the items needed in a fieldwork packet for an MFL entry.

Table 9-1: Wisconsin Forest Management Plan Standards (continued from previous page).

WISCONSIN FOREST MANAGEMENT GUIDELINES

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Wisconsin Department of Natural Resources
Division of Forestry
PO Box 7921
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October, 2003

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Chapter 10

GENERAL OPERATIONAL GUIDELINES

CHAPTER 10 — GENERAL OPERATIONAL GUIDELINES

OPERATIONAL CONSIDERATIONS 134

Timing and Coordination of Activities 134

Designing Operations to Fit Site Conditions 135

Managing and Minimizing Infrastructure 135

PROTECTING CULTURAL RESOURCES 136

FUELS, LUBRICANTS, WASTE, AND SPILLS 137

Fuels, Lubricants and Waste 137

Spills 137

BMPs: Spills 137

POST-OPERATIONAL ACTIVITIES 138

BMPs: Nonpoint Source Pollution Prevention 138

OPERATIONAL CONSIDERATIONS

Timing and Coordination of Activities

Timing forest management or recreational activities can be constrained by 1) pre-existing conditions, regulations, or limitations such as road load limits, forest access limitations, and forest fire hazard conditions, and 2) seasonal conditions that specify appropriate times for such activities as herbicide treatments, tree planting and road construction.

- Conduct forest management activities when soil conditions are firm enough to support the type of equipment being used, in order to protect soil productivity and minimize damage to any cultural resources that may be present.
- In wetlands, plan to conduct forest management activities when soil is frozen or firm enough to support equipment being used. Evaluate the site based on weather conditions to ensure adequate support for equipment to prevent or minimize rutting. Examples of weather conditions that could be cause for concern include heavy rain, flooding, significant snow before frost, and three consecutive nights above freezing after frost has been established.
- Plan for removal of equipment and cut material from wetland areas prior to thawing at the end of the winter season, or leave it until the next winter.
- Plan to conduct all activities during the preferred operating periods for site and soil conditions. Preferred operating periods for a site may vary due to local and seasonal climatic conditions, equipment being used, and operating techniques.
- Combine and integrate forest management activities where appropriate to reduce or eliminate the need for multiple entries by heavy equipment. For example, full-tree skidding may be used for preparation of jack pine seed beds, eliminating the need for additional site preparation.
- Protect reserve areas and structural habitat components retained in previous stand treatments.

Figure 10-1: Winter harvesting is one example of timing forest management activities to protect soils, especially in lowland areas such as this black spruce stand.

TIMING AND COORDINATION OF ACTIVITIES TO REDUCE NOISE AND VISUAL IMPACTS

- Avoid management operations during periods of peak recreational use whenever possible.
- Reduce noise in early morning, late evening and other appropriate times when possible.
- Selectively restrict use of recreational facilities to avoid conflict with management activities.
- Temporarily relocate recreation trails away from management activity areas.
- Inform and educate recreational users regarding management issues, limitations and timing prior to, during and after management activities.
- Time management activity with consideration for public-use patterns.
- Minimize direct conflict with forest recreational users during peak use and special event periods.

Designing Operations To Fit Site Conditions

- Avoid unwanted impacts to a site by determining the preferred operating season, as well as the costly process of moving equipment from a site, or shutting down operations if negative impacts are occurring.
- Take into account that the preferred operating season may vary for any one site depending on soil characteristics, local climatic conditions, equipment being used, and operating techniques. The use of low ground pressure (LGP) equipment and such operating techniques as using slash mats to drive on, can extend operating seasons on low-strength soils.
- Identify occurrences of non-native invasive species, and evaluate their levels of threat to the regeneration of forest or other desirable vegetation, as well as human health and safety. To help prevent spread of invasive species, monitor, control and treat infestations prior to and after completion of forest management activities. Keep in mind that moving equipment from site to site may aid in the spread of problem species or vegetative parts that can take root in the new location. Equipment may need cleaning before it is moved from an infested site into an area that is free of problem invasives.

Figure 10-2: The new leaves of buckthorn emerge beside the berries from last year.

Figure 10-3: At the end of a forest operation, a simple earthen traffic barrier may be satisfactory for preventing unwanted vehicle traffic.

- Soil susceptibility to compaction, rutting and puddling is primarily dependent on soil texture and moisture content. Use caution when operating heavy equipment on sites whenever adverse soil impacts are likely, especially during the following times:
  - During spring and early summer months.
  - Immediately following heavy rains.
  - During the period between when transpiration ceases in the fall and before freeze-up occurs.

Managing and Minimizing Infrastructure

In the context of forest management activities, infrastructure is defined as the network of access roads, approaches, trails, and landings used to move equipment onto and around a forest management site. Any reduction in the total amount of area occupied by such infrastructure reduces the impact on soil productivity, as well as potential impacts to cultural resources, riparian areas, and wildlife habitat.

- Consider future management activities that use common infrastructure for management of adjacent stands or ownerships. Develop or plan infrastructure accordingly.
- Examine existing access routes to determine if they are appropriate. Consider whether relocation would provide a better long-term access route.
- Where appropriate, limit direct trafficking of sites to the smallest area needed when planning management activities such as harvesting and site preparation.

PROTECTING CULTURAL RESOURCES

Figure 10-4: To be effective, gated road closures must be located properly. Otherwise, vehicle traffic will simply go around as they have on this forest road.

Some types of cultural resources are protected by federal or state law (see Chapter 6: Cultural Resources, Cultural Resource Management and the Law).

- When feasible, avoid management activities within cultural resource areas. Delineate such areas with flagging, signs or temporary fencing, and make sure that loggers and equipment operators understand that there is to be no work in the marked area.
- When it is not feasible to avoid cultural resource areas during forest management activities, protect resources by one of the following measures:
  - Temporarily brace walls and board up windows and doors of historic buildings.
  - Avoid felling trees onto historic buildings, structures or surface features of archaeological sites.
- For cultural resources that cannot be protected from damage, consider data recovery (professional excavation of archaeological sites or documentation of above-ground cultural resources).
- **If a human burial site is accidentally discovered during operations, cease operations immediately in the vicinity of the discovery.** Contact the Burial Sites Preservation Office at the Wisconsin Historical Society, and your local law enforcement agency.
- For the accidental discovery of other types of cultural resources such as archaeological artifacts, temporary suspension is recommended but not required. Suspending operations in the immediate vicinity allows time to contact a cultural resource professional.

FUELS, LUBRICANTS, WASTE, AND SPILLS

Fuels, Lubricants and Waste

Logging, road building and other forest activities require motorized equipment. Antifreeze, fuels and lubricants used in machinery can potentially pollute lakes, streams, wetlands, and groundwater. Planning for forestry operations should include practices to handle solid and liquid wastes generated in the field.

Spills

Report all hazardous substance spills immediately to the Wisconsin Department of Natural Resources by calling the **24-hour Emergency Hotline number at 1-800-943-0003**.

Spills of fuel, lubricants or pesticides during forest management operations can occur as a result of fueling, hydraulic hose breaks, mechanical damage, or vandalism. All spills of hazardous substances that adversely impact or threaten to adversely impact public health, welfare or the environment must be 1) immediately reported to the DNR and 2) cleaned up. In some instances, small quantities of petroleum products and agrichemicals do not require reporting to the DNR. During timber harvesting operations, reporting a spill is not necessary for a gasoline spill less than one gallon, or for a diesel or hydraulic fluid spill less than five gallons, as long as there is no threat to the environment. However, the spill still needs to be cleaned up.

For more details on spill reporting guidelines or cleanup, contact your local DNR Regional Spill Coordinator:

Eau Claire	715-839-3775
Green Bay	920-492-5592
Madison	608-275-3332
Milwaukee	414-229-0838
Rhinelander	715-365-8963
Superior	715-392-0802

Note: Proper equipment maintenance will prevent many spills.

BMPs: Spills

The following BMPs are general guidelines for spills of fuel and lubricants used in forestry field operations. These practices complement specialized training given to persons using pesticides or other hazardous materials.

✓ Maintain a spill-containment and cleanup kit appropriate for the materials on the operation. At a minimum, a kit for petroleum products should include:
1) Plugs and clamps to control a hydraulic line break.
2) A container to catch leaking fluid.
3) A shovel, and
4) Absorbent material such as sawdust to absorb fluid which is especially useful in the winter when soil is frozen.

✓ If a spill should occur, use the following order:
1) Protect yourself and others. Wear protective clothing and use equipment appropriate for any hazardous materials on the operation. Avoid coming in contact with any toxic drift or fumes that may be released.
2) If able, control the spill; stop the leak.
3) If able, contain the spill; keep it from spreading. Shovel a dike around the spill. Use absorbent material such as sawdust or loose soil to soak up fluid. Place a bucket under a hydraulic hose break. Keep the spill from flowing into lakes or streams.
4) Isolate the spill material.
5) **Report all hazardous substance spills immediately to the Wisconsin 24-hour Emergency Hotline at 1-800-943-0003.**
6) Contact your local DNR regional office for disposal guidance.

POST-OPERATIONAL ACTIVITIES

Figure 10-5: Honeysuckle is a prevalent invader of many Wisconsin woodlands.

- Consider closing roads after operation completion if they will provide access to a cultural resource.
- Remove flagging, signs or other markings that identify a cultural resource when a forest management activity is completed.
- Restore watercourses to approximate their natural condition by removing temporary drainage structures and stabilizing the soil along the banks.
- Stabilize bare soil areas and install water diversion devices and erosion control barriers where appropriate, to prevent or minimize erosion and sedimentation from roads, skid trails and landings into surface water and cultural resource areas.
  - Seed and fertilize as appropriate. Do not use non-native invasive species or seed mixtures that are not certified weed-free.
  - Fill in ruts as necessary, weighing the benefits of filling in ruts on skid trails against the potential for additional impact to soil productivity as a result of equipment used to eliminate ruts.
  - Inspect erosion control measures periodically and maintain or remove as needed.

BMPs: Nonpoint Source Pollution Prevention

The following BMPs will help prevent nonpoint source pollution from fuels, lubricants and wastes during forest management activities.

✓ Use biodegradable lubricants whenever practical. Biodegradable lubricants are less toxic than other lubricants, but still need to be disposed of properly. To contact manufacturers of biodegradable lubricants, see the Resource Directory: Wetlands Protection.

✓ Maintain equipment regularly. Check hoses and fittings to prevent leaks or spills.

✓ Designate specific areas for equipment maintenance and fueling. Locate these areas on level terrain, a minimum of 100 feet from all streams and lakes.

✓ Collect all waste lubricants, containers and trash. Store them in leak-proof containers until they can be transported off-site for recycling, reuse or disposal at an approved site. Call your local DNR regional office for more information. **Note: It is illegal to dump fuel and lubricants on the land or in waters in the state of Wisconsin.**

✓ Separate all fluids and materials, and keep in different labeled containers to avoid creating "hazardous waste" and expensive waste disposal. Call your local DNR regional office to determine if a waste is hazardous, and for disposal guidelines.

- Place traffic barriers where appropriate to prevent vehicles from disturbing recently stabilized areas. Barriers should be visible and well-marked, and they should not present a safety hazard.
- Conduct follow-up visits to areas where structures (e.g., culverts or waterbars) or other protection measures (e.g., seeding of bare areas) are used to minimize impacts on water quality and wetlands. Such visits can help assure that protection measures remain functional.

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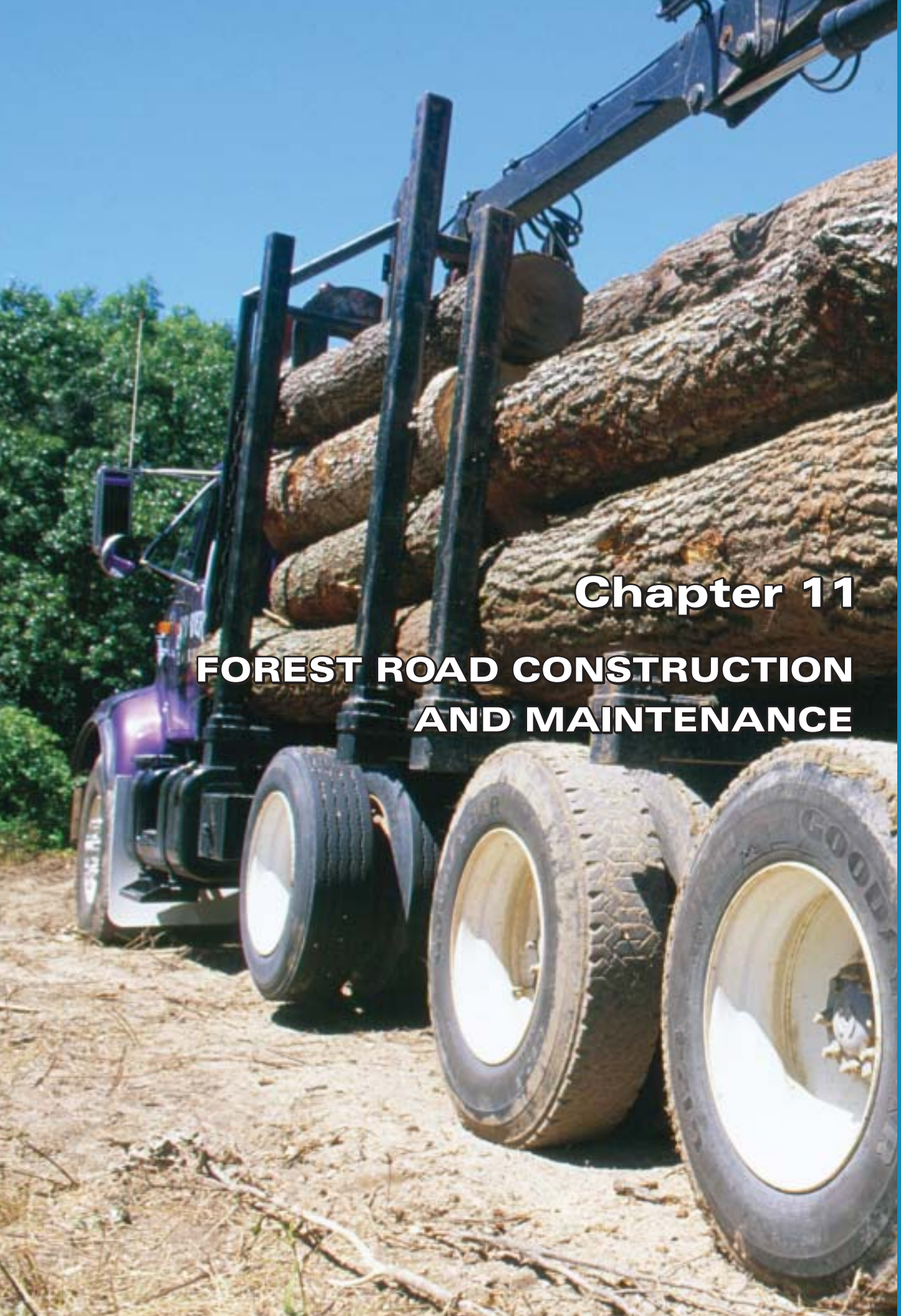


Chapter 11

FOREST ROAD CONSTRUCTION AND MAINTENANCE

CHAPTER 11 — FOREST ROAD CONSTRUCTION AND MAINTENANCE

Integrated Resource Management Considerations 140

UPLAND FOREST ROADS 142

BMPs: Planning, Location and Design 142

STREAM CROSSING DESIGN AND CONSTRUCTION 143

BMPs: Fords 143

BMPs: Stream Crossings 144

BMPs: Pipe Culverts for Stream Crossings 145

ROAD CONSTRUCTION AND DRAINAGE 147

BMPs: Road Construction and Drainage 147

DRAINAGE STRUCTURES 149

BMPs: Drainage Structures 149

BMPs: Pipe Culverts for Cross-drains 150

BMPs: Open-top Culverts 150

BMPs: Broad-based Dips 151

BMP: Waterbars 151

SOIL STABILIZATION 152

Mulch and Seeding 152

BMP: Mulch and Seeding 152

BMP: Diversion Structures 152

BMP: Sediment-control Structures 153

WETLAND FOREST ROADS 154

BMPs: Wetland Roads, Skid Trails and Landings 154

15 FEDERAL REQUIREMENTS 155

BMPs: Forest Roads in Wetlands 155

ROAD MAINTENANCE 156

BMPs: Road Maintenance 156

Roads, skid trails and landings are all part of a forest transportation system (skid trail and landing BMPs are covered in Chapter 12: Timber Harvesting). Roads connect the forestland to existing public roads. They provide forest access for such activities as managing timber, improving fish and wildlife habitat, fighting fires, and recreation.

Forest roads located, constructed or maintained poorly are the largest source of nonpoint source pollution from forest management activities. Roads over steep slopes, erodible soils, or stream crossings hold the greatest potential for degrading water quality.

There are three types of forest roads: temporary roads, permanent seasonal roads, and permanent all-season forest roads. Make sure to identify the type of road system you need during your planning phase.

- **Temporary Roads:** These are the most common type of forest road. They are designed and constructed for short-term use during a specific project such as timber harvesting. These roads are used only when the ground is frozen or firm. When the project is complete, the temporary road is closed, all stream crossing structures are removed, and the road is naturally or artificially revegetated.
- **Permanent Seasonal Roads:** Maintained as part of the permanent road system, seasonal roads are designed for use only when the ground is frozen or firm. These roads are generally narrower than all-season roads, built to lower engineering standards, and have minimal surface gravel.
- **Permanent All-season Forest Roads:** These roads usually have gravel surfaces and are designed for year-round use. However, there may be some restrictions on use at various times of the year.

Integrated Resource Management Considerations

A well-planned access system is a sound method of reducing erosion and sedimentation in areas requiring frequent or temporary access. Proper location and construction of roads will provide for safety, longer operating periods, lower maintenance and operating costs, and minimal impacts to forest resources.

Figure 11-1: Seeding can be as easy as spreading grass seed by hand as this landowner is doing on his freshly-graded woods road. Use non-invasive species and certified weed-free seed.

Servicing as many acres of forest with as few roads as possible is a sound method of reducing impacts to forest resources from road construction.

FACTORS IN DECISION-MAKING

- The number, size and design of forest access roads will be influenced by the frequency of access, amount of anticipated traffic, seasons during which access is required, and safety concerns.
- Distribution of necessary management activities will affect the number and location of access roads.
- Choices regarding road construction standards and maintenance activities will be influenced by site characteristics, and the value of the resources served. Culverts and ditches may be necessary with any road construction technique.
- Surfacing can be the major cost of low-volume road construction. Alternatives should be evaluated according to expected use and potential impact on sediment load. Where grades make the potential for surface erosion significant, the road should be surfaced with materials such as crushed rock, compacted gravel, sod, or asphalt that will minimize potential water quality and soil productivity impacts.

MINIMIZING THE IMPACTS OF ROADS

- Visual impacts and excessive noise can result from poor design, construction and maintenance of forest access roads. Take into account the following considerations when planning to reduce noise and visual impacts associated with the design and use of forest access roads:
  - Noise from traffic, especially large trucks, buses and heavy equipment.
  - Potential increased costs of building forest access roads to accommodate visual quality concerns, and potential increased costs of using existing roads that require traveling greater distances.
  - The limited road construction season that generally coincides with the tourist season.
  - Traffic during wet periods that can increase maintenance needs, and create unsightly ruts and mudholes.

- Visual impacts and noise impacts created by gravel pits are not compatible with recreational user sensitivities. Take into account the following considerations when planning to reduce noise and unsightliness related to gravel pits:
  - Local sources of gravel are necessary for efficient, cost-effective road building and maintenance.
  - Recreational use of gravel pits may cause conflicts.

- Site-specific soil, topographic and forest inventory information will assist resource managers or landowners in planning road location and layout. For more information, see the Resource Directory.

- Because roads take soils out of production, effort should be made to keep the length and width of roads to a minimum without sacrificing safety.

- To minimize road mileage and reduce costs, coordination with adjacent landowners may be desirable.

- The greatest potential for soil erosion occurs immediately after construction. Disturbed areas should be shaped and stabilized as soon as possible to minimize erosion potential.

- Seed disturbed areas (landings and skidroads) as soon as feasible in order to re-establish desirable species, and retard possible invasion by non-native invasive species.

MAINTENANCE NEEDS

- The purpose of maintenance procedures is to ensure measures taken to minimize impacts on forest resources are working, and continue to work into the future. Surfacing materials and the amount of use determine the level of maintenance required.

- Roads that are open for use require more maintenance than roads that are closed to vehicular traffic. Inactive roads (roads currently not in use) whether closed temporarily or permanently, require occasional work to reduce potential impacts on streams, lakes, wetlands, and seasonal ponds.

- Road layout, construction methods and erosion, and access control all contribute to the longevity, utility, safety, and maintenance cost of roads.

- Monitor for non-native invasive species, control their spread, and eradicate them if possible. Clean equipment as needed.

PROTECTING WATER QUALITY AND WATER FLOW

- Incorporating guidelines to protect water quality into overall road project design can minimize the potential impact of wetland roads on water quality, as well as alterations to normal water flow patterns.

- Effective road construction techniques minimize the disturbance to the natural flow of water over the landscape, and ensure the structural integrity of the road embankment.

The goals are to provide a simple road structure of adequate strength to support heavy vehicle traffic, and provide drainage structures to pass water at its normal level through the road corridor.

UPLAND FOREST ROADS

BMPs: Planning, Location and Design

Decisions made at the planning stage will affect a road's construction costs, long-term maintenance needs, service life, and the amount of nonpoint source pollution it causes. Loggers and landowners should plan, locate and design the road system together.

✓ Plan road systems that minimize the number, width and length of roads to limit the total area of the site disturbed. Remember to:
- Consider future uses of the road system
- Coordinate development with adjoining landowners when possible; and
- use temporary roads where practical

✓ Use existing roads when they provide the best long-term access. Consider relocating existing roads if doing so improves access and reduces environmental impacts. Reconstruct existing roads to provide adequate drainage and safety. Do not disturb stable road surfaces.

✓ Select road locations that allow for drainage away from the road.

✓ Minimize the number of stream crossings.

✓ Identify optimum stream crossing locations before locating the rest of the road. Optimum locations include straight and narrow stream channels with low banks and firm rocky soil. Roads should approach streams with the least gradient possible.

✓ Where possible, locate roads on well-drained soils.

✓ Locate roads outside riparian management zones except at stream crossings. For more information, see Chapter 5: Riparian Areas and Wetlands.

✓ Road grades should not exceed 10 percent. If road grades greater than 10 percent are necessary, limit grade length to minimize erosion, or break the grade using drainage structures (see "Drainage Structures" on page 149). Graveling the road surface on steep grades can also help maintain stability. Note: Optimum road grades should be less than five percent (see Figure 11-2).

✓ Locate roads to follow natural contours and minimize cut-and-fills. Balance cut-and-fills to minimize the need for fill or removing excess materials (see Figure 11-3).

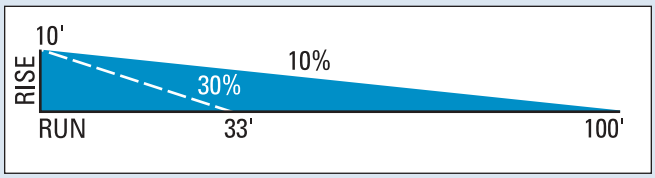


Figure 11-2: Road Grade % = Rise ÷ Run x 100.

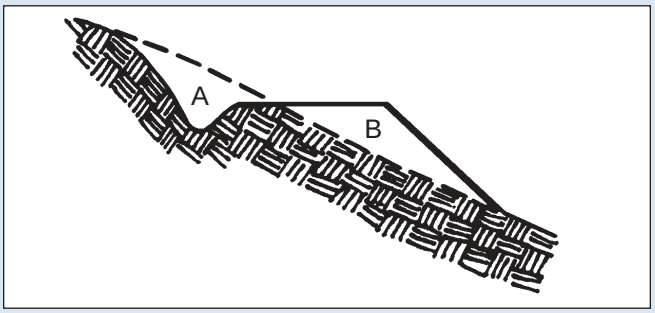


Figure 11-3: A side-hill cross-section illustrating how cut materials (A) equals fill materials (B).

REDUCING VISUAL IMPACTS DUE TO ALIGNMENT AND LOCATION OF ROADS

- Minimize the number of roads approaching travel routes or recreation areas.
- Locate roads and trails to minimize visibility from nearby vantage points such as scenic overlooks, streams and lakes.
- Minimize total road mileage and ground disturbance required to meet landowner objectives and anticipated traffic loads.
- Avoid tracking mud onto highways by using appropriate road surface material.
- Reduce visual penetration with appropriate curves in the road alignment.

STREAM CROSSING DESIGN AND CONSTRUCTION

Operating equipment in or near perennial or intermittent stream channels may add sediment directly to streams. Stream crossings poorly located or constructed may erode streambanks.

As roads approach a stream crossing, proper road drainage is critical to avoid sedimentation in streams. Three common stream crossing structures include culverts, bridges and fords.

Stream crossings must be designed, constructed and maintained to safely handle expected vehicle loads and minimize disturbance of streambanks, channels, and, ultimately, aquatic organisms. Consider streambed material, stream size, storm frequency, flow rates, intensity of use (permanent or temporary), and the passage of fish when planning crossings. The USDA Natural Resources and Conservation Service, your local land conservation department, or a private consultant can help with designing fords and culverts. To design a bridge, contact a private consultant or experienced contractor.

Figure 11-4: Seeding a logging road helps prevent soil erosion while providing wildlife food and habitat. This road curves after entering the woods and thereby reduces visual penetration.

BMPs: Fords

Use fords for crossing dry streambeds, or where fording would cause minimal water quality impacts.

✓ Locate fords where streambanks are low.

✓ Streambeds should have a firm rock or gravel base. Otherwise, install stabilizing material such as reinforced concrete planks, crushed rock, riprap, or rubber mats on streambeds.

Figure 11-5: A ford was approved for this stream crossing because the stream banks are low, and the streambed is gravel.

BMPs: Stream Crossings

- ✓ A permit is required to construct a ford or install a culvert/bridge across any navigable intermittent or perennial stream. A stream is navigable if it has bed and banks, and it is possible to float a canoe or other small craft in the waterway on a regular reoccurring basis – even if only during spring runoff. Streams identified on current U.S. Geological Survey (USGS) topographical maps (7.5 minute/1:24,000 scale) should be considered navigable. Other lakes and streams may be considered navigable by a Wisconsin DNR water management specialist. If you have a question about navigability, contact a Wisconsin DNR water management specialist.
- ✓ For temporary stream crossings for skid trails, see the Stream Crossings for Skidding section in Chapter 12: Timber Harvesting.
- ✓ Use soil stabilization practices on exposed soil at stream crossings. Use seed and mulch, and install temporary sediment control structures such as straw bales or silt fences immediately following construction to minimize erosion into streams. Maintain these practices until the soil is permanently stabilized (see Soil Stabilization, page 152).
- ✓ Design, construct and maintain stream crossings to avoid disrupting the migration or movement of fish and other aquatic life. Bridges or arch culverts that retain the natural stream bottom and slope are preferred for this reason.
- ✓ Install stream crossings using materials that are clean, non-erodible and non-toxic.
- ✓ Install stream crossing structures at right angles to the stream channel.
- ✓ Minimize channel changes and the amount of excavation or fill needed at the crossing.
- ✓ Limit construction activity in the water to periods of low or normal flow. Keep use of equipment in the stream to a minimum.
- ✓ Construct a bridge or place fill directly over a culvert higher than the road approach to prevent surface runoff from draining onto the crossing structure and into the stream (see Figure 11-6).
- ✓ Divert road drainage into undisturbed vegetation, preferably outside the RMZ, so the drainage does not directly enter the stream (see Figure 11-7 and Diversion Structures on page 149).
- ✓ Stabilize approaches to bridge, culvert and ford crossings with aggregate or other suitable material to reduce sediment entering the stream.
- ✓ Anchor temporary structures on one end with a cable or other device so they do not float away during high water. Install them so they can be easily removed when no longer used, regardless of the season.

Figure 11-6: Use of fill when placing a culvert.

Figure 11-7: Example of a diversion ditch.

BMPs: Pipe Culverts for Stream Crossings

- ✓ Install pipe culverts long enough so that road fill does not extend beyond the ends of a culvert.
- ✓ Install permanent culverts that are large enough to pass flood flows, and are a minimum of 12 inches in diameter. Culverts that are too small can plug up with debris and result in the road washing out, or in flooding upstream. Wisconsin law states that the landowner and/or contractor are responsible to obtain a flood easement from any affected property owners upstream of culvert crossings that are not designed to pass the 100-year flood. The USDA Natural Resources and Conservation Service, your local land conservation department or a private consultant (i.e., engineer or registered land surveyor) can help with sizing culverts.
- ✓ Install culverts so there is no change in the stream bottom elevation. Culverts should not cause damming or pooling (see Figure 11-8).
- ✓ Firmly compact fill material around culverts, particularly around the bottom half. Cover the top of culverts with fill to a depth of one-third of the pipe diameter or at least 12 inches, whichever is greater, to prevent crushing (see Figure 11-9).
- ✓ Use riprap around the inlet of culverts to prevent water from eroding and undercutting the culvert. For permanent installations, use filter fabric under the riprap. In addition, consider using flared-end culvert sections for inlets (see Figure 11-10).
- ✓ Keep culverts clear and free of debris so that water can pass unimpeded at all times. This is especially important in areas where beaver are present.

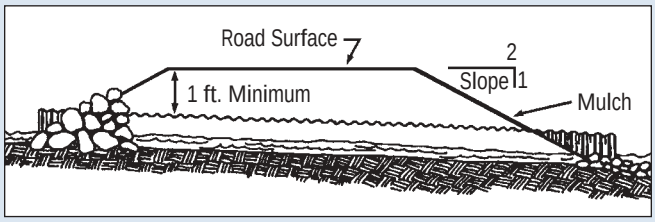


Figure 11-8: Install culverts so there is no change in the stream bottom elevation.

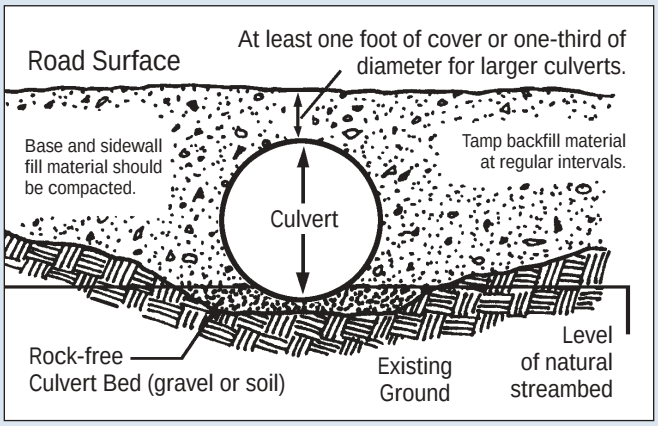


Figure 11-9: Installation of culverts.

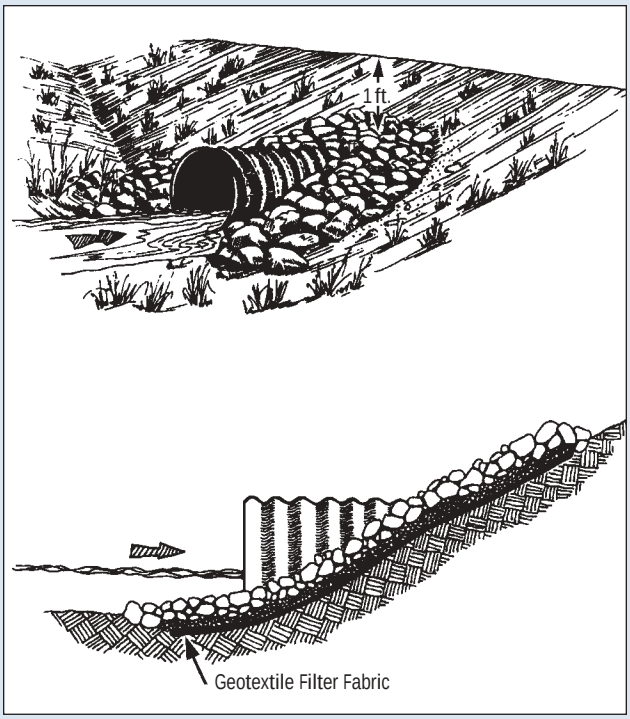


Figure 11-10: Use riprap around the inlet of culverts. Also use geotextile filter fabric for permanent installations.

Figure 11-11: The number and size of culverts depends on stream size, rate of flow, and flood potential.

Figure 11-12: This box culvert, made from two-inch lumber, helps to divert water runoff to the road's downhill side.

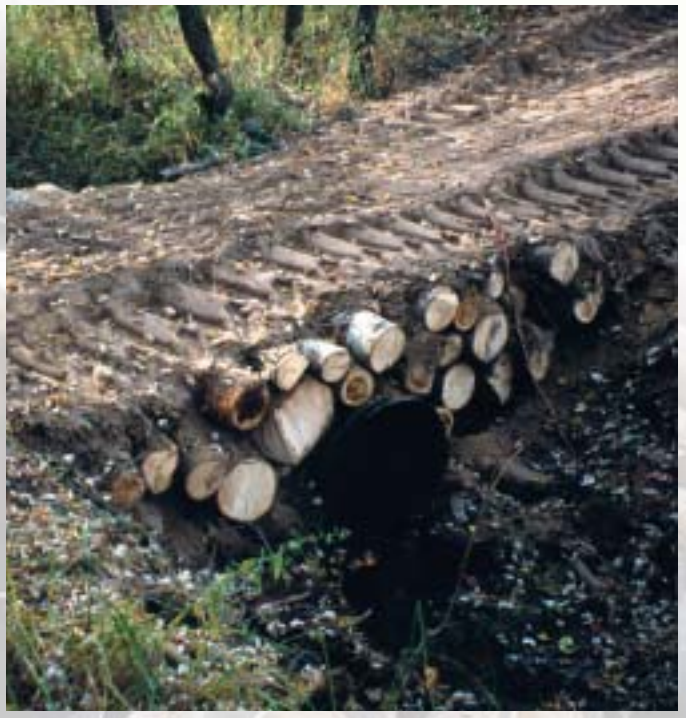


Figure 11-13: Pulpwood stacked above the culvert elevates this woods road, and reduces the approach grade at the steam crossing. This helps minimize erosion potential from water runoff.

Figure 11-14: This culvert, half-full of sediment, should be cleaned out to enable it to handle water runoff. Periodic maintenance is essential if water handling structures are to function properly.

ROAD CONSTRUCTION AND DRAINAGE

The most effective method to control erosion on forest roads is to keep water from accumulating on the road surface. Fast-moving water can easily erode soil from road surfaces and ditches, but road erosion can be controlled when water drains off the road surface, and is dispersed into vegetation and ground litter.

Figures 11-15 and 11-16: This road shows past erosion and grading will clear up the problem temporarily. However, high berms (right photo) alongside the road prohibit water from running off, and erosion is likely to reoccur. A ditch is needed to properly handle the water runoff.

BMPs: Road Construction and Drainage

- ✓ Design and construct roads to remove water from road surfaces to keep roads dry and structurally sound. Figure 11-17 shows three common designs: crowned, outsloped and insloped. Install insloped roads with ditches and adequate cross-drainage. Outsloped roads (usually outsloped one to two percent) are less expensive to construct and maintain; use them on roads with moderate gradients and stable soils.
- ✓ Construct stable cut-and-fill slopes that will revegetate easily, either naturally or artificially.
- ✓ Do not bury debris in the road base. It causes uneven settling that can lead to erosion and frost-heaving that creates mud holes.
- ✓ Compact the road base material or allow it to settle before using the road to reduce the amount of water that soaks into it. This will increase the road's carrying capacity, reduce road maintenance, and reduce erosion.
- ✓ Surface the road with gravel where steep grades, erodible soils or high-traffic volume make the potential for surface erosion significant.
- ✓ Locate gravel pits outside RMZs using proper location, development and soil stabilization practices to minimize erosion from the pits.

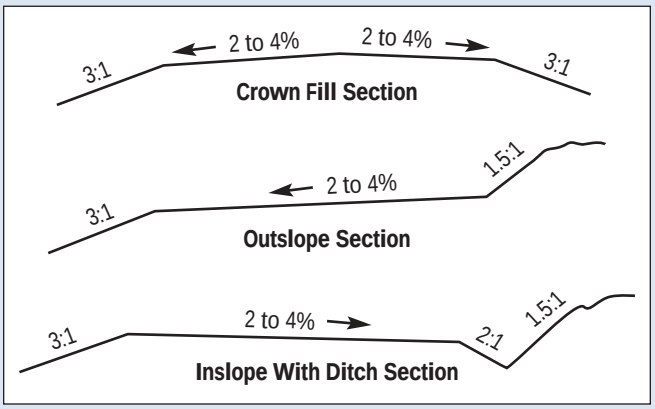


Figure 11-17: Typical road designs for drainage and stability.

Figure 11-18: This waterbar, placed at the proper angle to the road, will intercept runoff water and direct it into the adjoining vegetation.

REDUCING VISUAL IMPACTS OF ROAD CLEARINGS

- Utilize merchantable timber within road clearings.
- Burn, screen or bury road-clearing debris such as stumps, rocks and boulders, so it is not visible from travel routes or recreation areas.
- Move cleared debris outside of the travel route right-of-way so it is minimally apparent.
- Avoid creating a corridor of debris.
- Do not leave jackstrawed or overturned stumps in the immediate foreground.
- Reduce the height of dozed clearing debris during road construction.

REDUCING NOISE AND VISUAL IMPACTS OF GRAVEL PITS AND BORROW AREAS

- Locate borrow pits and crushing operations out of the visible corridor as much as possible.
- Screen pits from travel routes or recreation areas using existing vegetation or landscape berms.
- Reduce noise in early morning, late evening and other appropriate times whenever possible.
- Develop gravel or borrow pits from the back to the front of pits (moving toward the predominant view or vantage point).
- Rehabilitate pits upon completion of use.

DRAINAGE STRUCTURES

BMPs: Drainage Structures

Road-drainage structures include cross-drains (pipe culverts, open-top culverts, broad-based dips, and waterbars) and water-diversion structures. Cross-drains allow water from roadside ditches to move from one side of the road to the other.

✓ Where necessary to protect water quality, install road-drainage structures to remove storm water or seepage from the road surface and ditches. Space these structures at intervals close enough to minimize waterflow volume and speed, avoiding ditch erosion. As road grades increase, use drainage structures more often (see Table 11-1).

✓ Where necessary, provide erosion protection for outflows from road-drainage structures to minimize erosion and disperse the water, allowing it to soak into the soil. Riprap, mulch and/or seeding may be necessary (see Soil Stabilization, page 152).

ROAD GRADE	DISTANCE BETWEEN WATERBARS	DISTANCE BETWEEN BROAD-BASED DIPS AND CROSS-DRAIN CULVERTS
1%	400 Feet	500 Feet
2%	250 Feet	300 Feet
5%	130 Feet	180 Feet
10%	80 Feet	150 Feet
15%	50 Feet	130 Feet
25%+	40 Feet	110 Feet

Table 11-1: Recommended distances between drainage structures on forest roads and skid trails.

Figure 11-19: This truck haul road has just been graded at the close of timber harvesting activities. Water diversions, seed and gate closures will be completed next.

Figure 11-20: A seeded logging road with a properly located gate to limit motorized access mark the end of this timber sale.

BMPs: Pipe Culverts for Cross-drains

- ✓ Install pipe culverts to provide cross-drainage on road grades at regular intervals immediately above steep grades, below bank seepages, and where water will run onto log landings or forest roads.
- ✓ Install pipe culverts long enough so that road fill does not extend beyond the end of a culvert.
- ✓ Install cross-drain pipe culverts at grades at least two percent more than the ditch grade, and angled 30º to 45º to improve inlet efficiency (see Figure 11-21).
- ✓ Select the size of cross-drain culverts according to the size of the road and area drained by the ditch. To avoid clogging, permanent culverts should be at least 12 inches in diameter. The USDA Natural Resources and Conservation Service, your local land conservation department, or a private consultant (i.e., engineer or registered land surveyor) can help with sizing culverts.
- ✓ Install pipe culverts on a surface of compacted granular material. Firmly compact fill material around culverts, particularly around the bottom half. Cover the top of the culvert with fill to a depth of one-third of the pipe diameter, or at least 12 inches (whichever is greater) to prevent crushing (see Figure 11-9, page 145).
- ✓ Use riprap around the inlet of culverts to prevent water from eroding and undercutting the culvert.

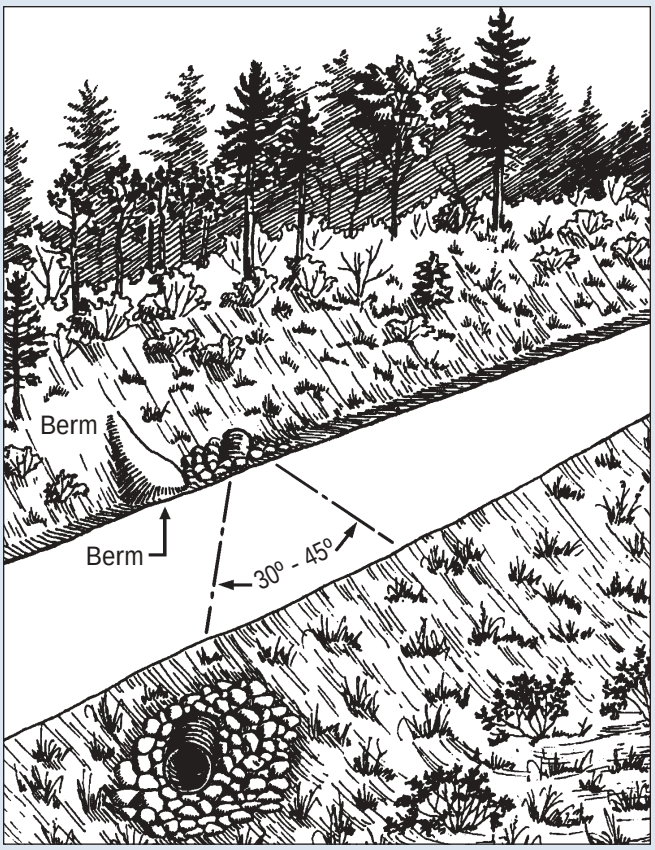


Figure 11-21: Cross-drain culvert.

BMPs: Open-top Culverts

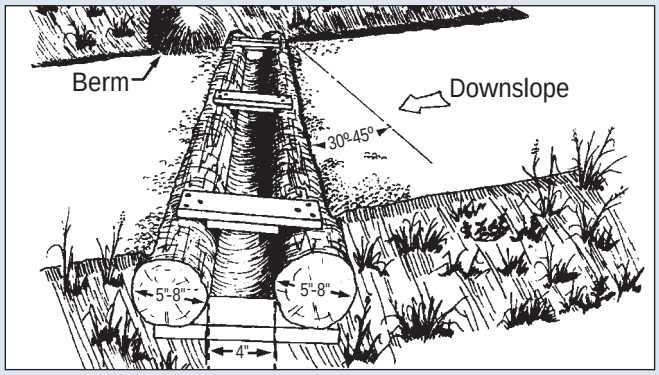


Figure 11-22: Open-top log culvert.

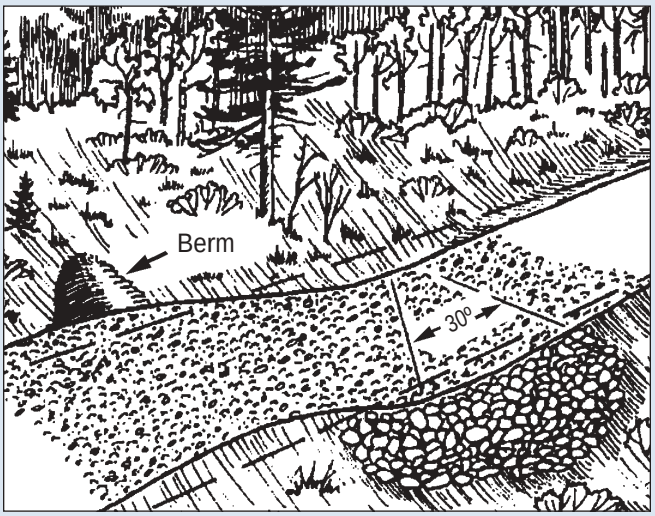
Open-top culverts provide cross-drainage and road-surface drainage, and are usually installed on seasonal or temporary roads (see Figure 11-22).

- ✓ Install open-top culverts to provide cross-drainage immediately above steep grades, below bank seepages, where water will run onto log landings or forest roads, and on road grades at regular intervals.
- ✓ Clean open-top culverts frequently since they easily fill in with debris.

BMPs: Broad-based Dips

Broad-based dips can provide cross-drainage and road-surface drainage for roads and skid trails with a gradient of 15 percent or less. Broad-based dips can be used instead of culverts, usually at lower cost and with lower maintenance. Dips are not used for draining seeps, or for intermittent or permanent streams (see Figure 11-23).

- ✓ Construct broad-based dips deep enough to provide adequate drainage and wide enough to allow trucks and equipment to pass safely.
- ✓ Place a surface of crushed stone or gravel on the dip, and mound for soils and conditions where rutting may occur.



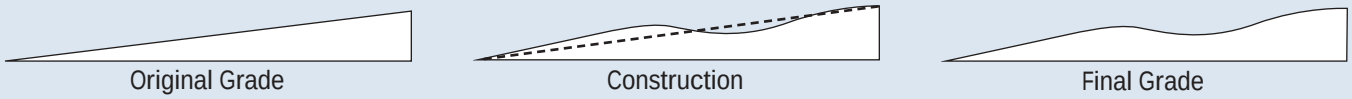


Figure 11-23: Broad-based dip (and cross-section).

BMP: Waterbars

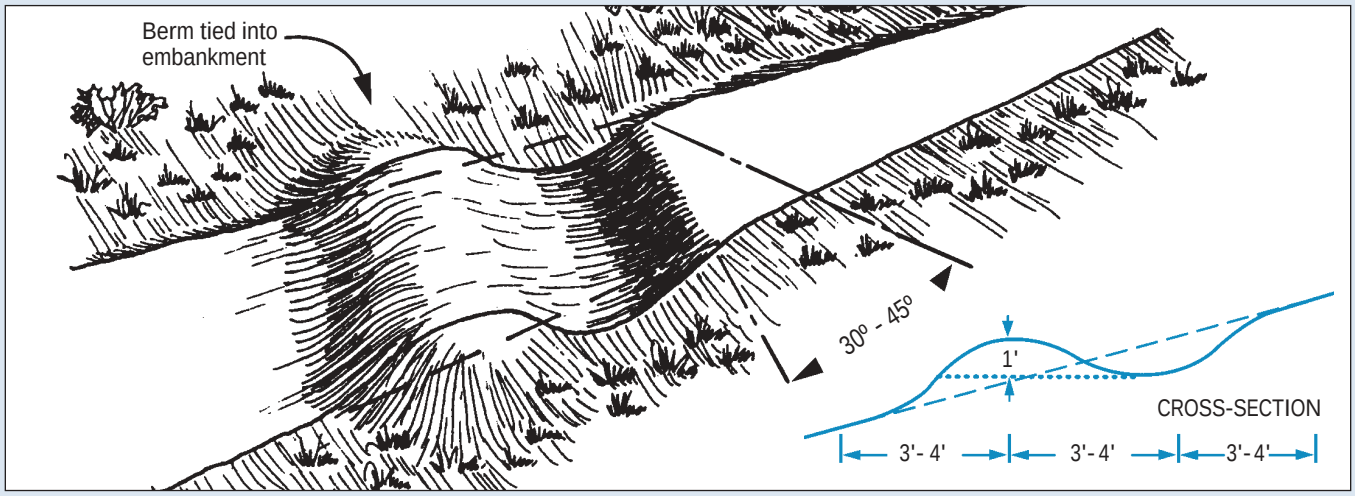


Figure 11-24: Waterbar.

A waterbar is a shallow trench with a mound (or berm) which provides cross-drainage and intercepts runoff from skid trails, recreational trails, firebreaks, or inactive or closed roads. Constructing a waterbar will minimize erosion and provide conditions for natural or artificial revegetation (see Figure 11-24).

- ✓ Place waterbars at a 30º to 45º angle with a cross-drainage grade of two percent.

SOIL STABILIZATION

Soil stabilization practices are used where soil is exposed, and natural revegetation is inadequate to prevent soil erosion and subsequent sedimentation into streams, lakes and wetlands. This occurs during road construction, and when the road system is being used (active) or is closed (inactive). Practices include mulching, seeding, and installing sediment control structures. References include the Wisconsin DNR's *Wisconsin Construction Site Erosion Control Handbook* and Chapter 10 in the *Wisconsin Department of Transportation's Erosion and Sediment Control Facilities Development Manual*. To obtain these references, see the Resource Directory. Contact a Wisconsin DNR forester or the USDA Natural Resources and Conservation Service for more information.

It is always more efficient and cost-effective to prevent erosion than to repair damage after the fact.

Mulch and Seeding

Mulch such as straw, woodchips or bark, retains soil moisture important for seed germination, and protects the soil surface from erosion due to runoff and raindrop impact. Mulch can be used to: 1) promote natural revegetation or 2) protect seeds spread over an area. If you seed, apply mulch immediately afterward. Netting may be necessary to hold mulch in place on steep slopes or on areas where water flow concentrates.

Figure 11-25: Once recommended as a wildlife planting, multiflora rose has become quite invasive in many locations.

BMP: Mulch and Seeding

✓ Use mulch and/or seed where necessary to minimize soil erosion into streams, lakes and wetlands.

Seed mixtures should include fast-growing species for quick soil protection, plus perennial species for longer soil protection until native vegetation returns to the site. Do not use mixtures that contain aggressive or non-native invasive species like reed canary grass, birds-foot trefoil, crown/hairy vetch, or tall fescue; use certified weed-free seed. Recommendations for seed mixes that are best for specific regions in Wisconsin are available from your local Wisconsin DNR Wildlife Management Specialist, and USDA Natural Resources and Conservation Service (NRCS) office. However, a suggested generic seed mixture, applied at the rate of 31 lbs./acre, is as follows:

White Dutch Clover .....8 lbs./acre
Perennial Rye Grass.....5 lbs./acre
Annual Rye Grass .....8 lbs./acre
Creeping Red Fescue.....10 lbs./acre
Total .....31 lbs./acre
(Note: One acre equals 43,560 square feet.)

A list of seed mixtures based on physical site characteristics is contained within the technical guide critical area planting standard 342. This technical guide is available from USDA NRCS offices, or on-line at **www.wi.nrcs.usda.gov/fotg/standards4.asp**

BMP: Diversion Structures

Diversion ditches, or berms, divert water away from roads and side ditches, and channel it into vegetation. These structures are often used before stream crossings to ensure that water will be diverted into vegetation, and not directly into a stream, lake or wetland (see Figure 11-7, page 144).

✓ Construct diversion ditches so they intersect the roadside ditch at the same depth, and are outsloped one to three percent.

BMP: Sediment-control Structures

✓ Install sediment-control structures where necessary to slow the flow of runoff, and trap sediment until vegetation is established at the sediment source. Sediment-control structures include straw bale fencing, silt fencing and sediment traps. Maintain, clean or replace sediment-control structures until areas of exposed soil are stabilized (see Figures 11-26, 11-27 and 11-28).

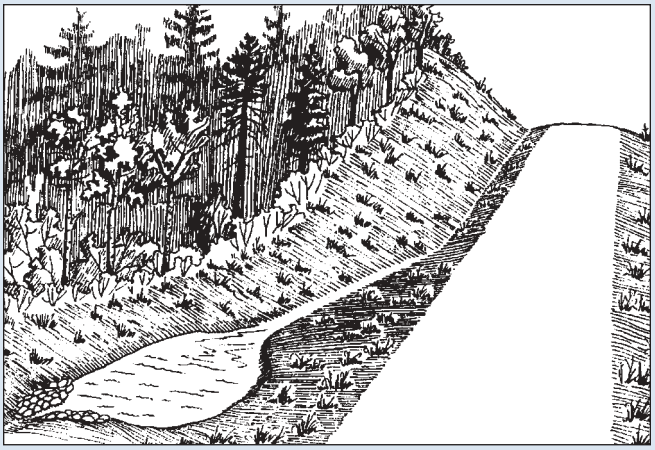


Figure 11-26: A sediment trap to slow runoff and trap sediment for channelized flow.

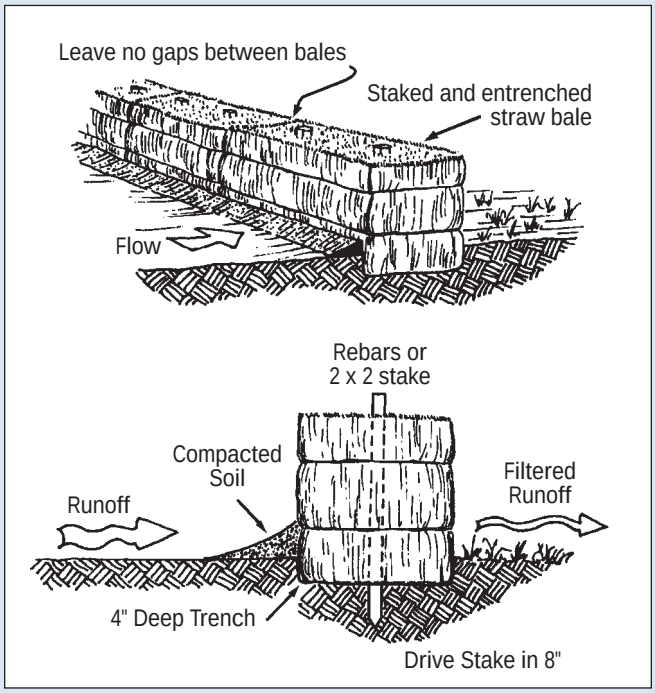


Figure 11-27: Straw bale fencing to slow runoff and trap sediment for sheet flow or channelized flow.

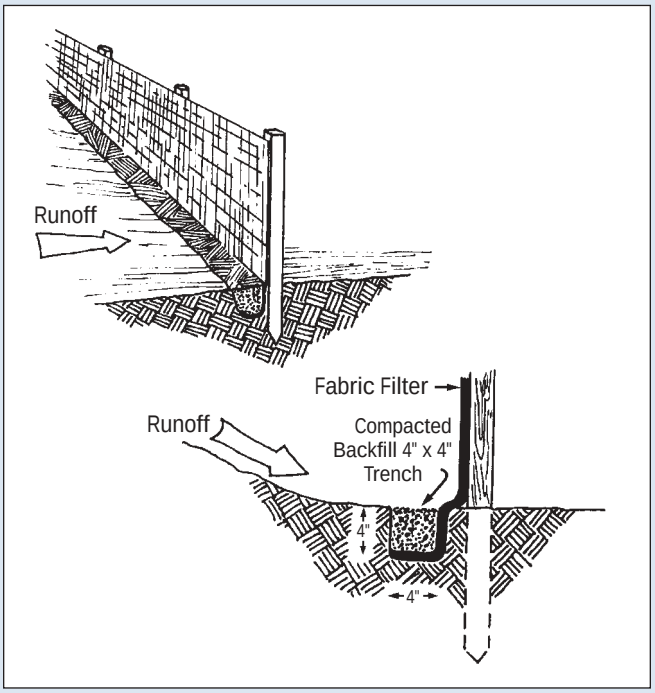


Figure 11-28: Silt fencing to slow runoff and trap sediment primarily for sheet flow, not channelized flow.

WETLAND FOREST ROADS

BMPs: Wetland Roads, Skid Trails and Landings

Planning, Location and Design: Wetland Roads, Skid Trails and Landings

Temporary roads, skid trails and landings require firm or frozen ground. Permanent roads in wetlands that require road-fill material must follow existing regulations, and be built carefully to avoid restricting the natural waterflow of the wetland under the road.

✓ Construct upland road approaches to wetlands so surface runoff is diverted away from the road and does not enter the wetland (see Drainage Structures, page 149).

✓ If landings are necessary in a wetland, build them to the minimum size required for the operation and to achieve the landowner's objective.

✓ Avoid operating equipment in areas of open water, springs or seeps.

✓ Provide for adequate cross-road drainage to minimize changes to natural surface and subsurface flow in the wetland.
- For permanent fill roads, use permeable fill material for at least the first layer of fill, and install culverts or bridges a minimum of 300 feet apart and at all natural drainageways. Install at least one drainage structure at each wetland crossing.
- For temporary roads, provide adequate cross-road drainage at all natural drainage ways. Temporary drainage structures include culverts, bridges and porous material such as corduroy or chunkwood. Temporary non-organic structures such as metal culverts and bridges, should be removed promptly when work is complete.

✓ Equipment operations should cease when rutting becomes excessive.

✓ Use low-ground pressure equipment such as wide-tire or tracked equipment, if necessary, to minimize rutting.

✓ Minimize rutting in wetlands by conducting forestry activities on firm or frozen ground that can support the equipment used. To achieve this:
- Operate equipment on a day-to-day basis depending on weather conditions.
- Consider using corduroy, chunkwood or rubber mats to improve the soil's ability to support traffic.

IN THE WINTER:
- To promote frost penetration, compact snow, grass, and brush.
- Monitor air temperatures daily. As air temperatures rise above freezing, you may not be able to operate equipment beyond late morning without creating ruts. Soil frost begins to disappear when night temperatures stay above freezing for three or four consecutive nights.

IN THE SUMMER:
- Operate equipment only when soils are dry enough to support equipment. Soils may become too wet after storms and extended wet spells.

15 FEDERAL REQUIREMENTS

BMPs: Forest Roads in Wetlands

The following 15 BMPs must be implemented in order to qualify for the silvicultural exemption from a federal section 404 permit when building a temporary or permanent road or skid trail in a wetland (33 CFR Part 323.4). The silvicultural exemption is only applicable when the primary purpose of the road is for normal silvicultural purposes. This listing is an attempt to explain the 15 BMPs in layman's language. The exact language of the law may be obtained by contacting the Army Corps of Engineers.

- ✓ Limit the number, length and width of roads and skid trails to the minimum necessary to accomplish the landowner's objective.
- ✓ Locate roads outside riparian management zones except at stream crossings.
- ✓ Road fill must be bridged, culverted or otherwise designed to prevent restriction of expected flood flows.
- ✓ Properly stabilize and maintain road fill during and after road construction to prevent erosion.
- ✓ While building a road with fill material, minimize the use of road construction equipment in the wetland area that lies outside the boundaries of the road fill.
- ✓ Minimize disturbance of vegetation while designing, constructing and maintaining roads.
- ✓ Correctly design, construct and maintain wetland road crossings to avoid disrupting the migration or movement of fish and other aquatic life.
- ✓ Use fill from upland sources whenever feasible.
- ✓ Place fill in a way that does not take or jeopardize the continued existence of a threatened or endangered species (as defined under the Endangered Species Act) or adversely modify or destroy the critical habitat of such species.
- ✓ Avoid placing fill in breeding and nesting areas for migratory waterfowl, spawning areas, and wetlands if practical alternatives exist.
- ✓ Fill shall not be placed near a public water supply intake.
- ✓ Fill shall not be placed in areas of concentrated shellfish production.
- ✓ Fill shall not be placed in waterbodies or on land regarded as part of the National Wild and Scenic River System.
- ✓ Use fill free from toxic pollutants in toxic amounts.
- ✓ Completely remove all temporary fills and restore the area to its original elevation.

ROAD MAINTENANCE

BMPs: Road Maintenance

Roads must be well-maintained or water quality protection structures may quickly degrade. For both active and inactive roads, follow BMPs in Soil Stabilization, page 152).

ACTIVE ROADS

- ✓ Inspect the road system at regular intervals, especially after heavy rainfall, to detect problems and schedule repairs.
- ✓ Clear debris from culverts, ditches, dips, and other drainage structures to decrease clogging that can lead to washouts. Place the debris where it cannot be washed back into these structures or into open water.
- ✓ Keep traffic to a minimum during wet periods and spring breakup, to help reduce maintenance needs.
- ✓ Shape road surfaces periodically to maintain proper surface drainage. Fill in ruts and holes with gravel or compacted fill as soon as possible to reduce erosion potential.
- ✓ Remove berms along the edge of the road if they will trap water on the road.
- ✓ When dust control agents are used, apply them in a manner that will keep these compounds from entering lakes, streams and groundwater. Consult a qualified road engineer from the County Highway Commissioner's Office or Wisconsin Department of Transportation for assistance in selecting the appropriate chemicals and amounts. **Note: It is illegal to spread oil on roads, land or water in Wisconsin.**

INACTIVE ROADS

When forest roads are inactive for extended periods, closing the system will help to protect the road surface and the water quality protection structures. Consider erecting a barrier to traffic such as a gate or berm, and post "Closed" signs at the entrance of temporarily closed roads. Stating the length of time and/or reason for closure, and inviting acceptable uses may be helpful to assure compliance.

- ✓ Remove all temporary drainage and stream crossing structures.
- ✓ Shape all road system surfaces to maintain proper surface drainage, if necessary.
- ✓ Install waterbars where necessary (see page 151 and follow the recommendations in Table 11-1 on page 149).
- ✓ Inspect and maintain road surfaces, permanent drainage and stream crossing structures (ditches, culverts, bridges, etc.) to minimize erosion.

Figure 11-29: Maintaining woods roads helps prevent erosion. This grader is shaping the road surface so that water runs off properly.

WISCONSIN FOREST MANAGEMENT GUIDELINES

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October, 2003

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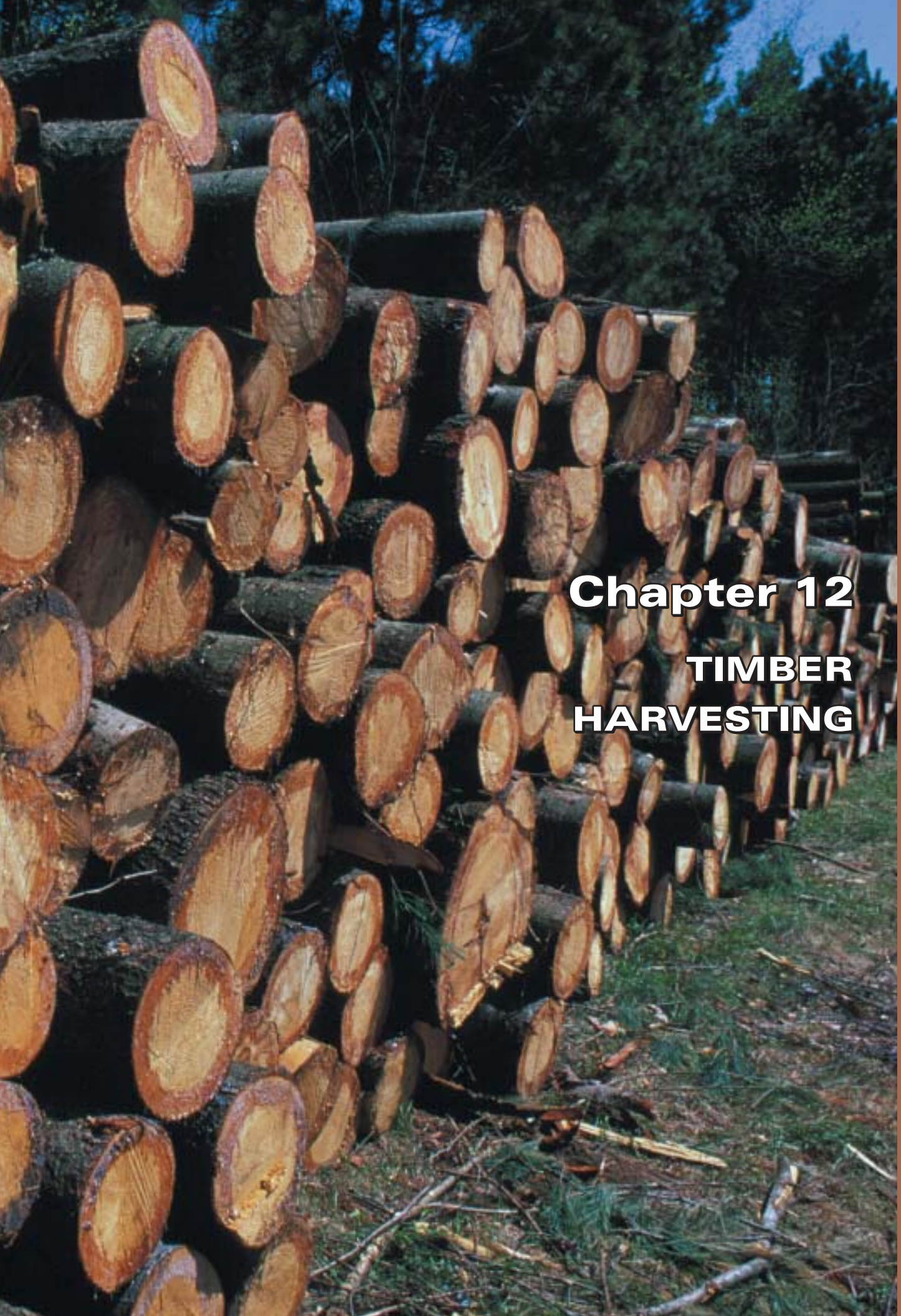

Chapter 12

TIMBER HARVESTING

CHAPTER 12 — TIMBER HARVESTING

Integrated Resource Management Considerations 158

PLANNING AND DESIGN CONSIDERATIONS 159

Soil Productivity 159
Water Quality and Wetlands 159
BMP: Planning and Design 159
Visual Quality 159
Cultural Resources 166
Slash Management and Landings 166
Leave (Reserve) Trees, Coarse Woody Debris, and Snags 167

OPERATIONAL CONSIDERATIONS 168

Protecting Soil Productivity 168
Protecting Water Quality and Wetlands 168
BMPs: Protecting Sensitive Areas 168
Protecting Cultural Resources 169
Skid Trails 169
BMPs: Skid Trails 169
BMPs: Stream Crossings for Skidding 169
Landings 170
BMPs: Landings 170
Minimizing Rutting 170
BMP: Rutting 170
Managing Slash 170
BMP: Slash 170
Snags (Standing Dead Trees) 171
Leave (Reserve) Trees 171
Providing Coarse Woody Debris 172
Managing the Harvesting Process 172
The Timber Sale Contract 172
Five Steps in a Careful and Successful Timber Sale 173
Understanding the Sample Timber Sale Contract 174
Contract Breach: A Very Serious Decision 174
What is Reasonable? 174

POST-OPERATIONAL ACTIVITIES 176

Timber harvesting involves: 1) cutting trees and moving them to a landing, 2) processing, sorting and loading, and 3) transporting materials.

Integrated Resource Management Considerations

- Special soil conditions and topographic features make some areas of the state more sensitive than others to soil disturbance. Two primary examples of these localized sensitive areas are the red clay soils along Lake Superior, and the steep slopes in the driftless area in southwestern Wisconsin.
- If done incorrectly, harvesting activities can result in sediment, chemical, nutrient, and debris movement into streams, lakes, wetlands, seasonal ponds, and ground water.
- Wetlands are highly productive sites for a variety of ecological functions, as well as for the enhancement of water quality. All forest management operations in or adjacent to wetlands should be planned and conducted in a manner that protects these functions.
- Visual sensitivity levels should be considered in determining the level of effort appropriate to minimize visual impact.
- The silvicultural system needed to regenerate a stand affects the visual impact of the harvest. In general, partial cutting has less impact in more aesthetically sensitive areas. The type of harvest (partial cut versus clearcut) also affects user perception of apparent size.
- The visual impact of a harvest and the timing of adjacent harvests will be affected by 1) the length of time needed to re-establish forest regeneration; and 2) the severity of treatments required to assure survival of the new growth.
- The average life span of a species affects the frequency of regeneration harvests and the time available to complete a harvest. Upon reaching old age, short-lived species tend to lose vigor over a relatively short time period with entire stands suffering disease or insect mortality all at once. Long-lived species tend to lose vigor more slowly, and suffer mortality on an individual tree basis.

Figure 12-1: An aerial view of part of the Northern Highland-American Legion State Forest where aesthetic management guidelines have been applied for many years to manage the visual impact of harvesting operations.

- Flexibility, in terms of stocking or density level, varies from species to species. Some (e.g., red pine, white pine, aspen, northern hardwoods and oak) can be maintained at levels above or below normally recommended standards without substantial losses in quality or increased mortality. Others (e.g., jack pine, white birch, hemlock, balsam fir and spruce) must be kept very near recommended levels, or insect and disease susceptibility are substantially increased.
- In some cases, a deviation from normal management practices, even if silviculturally sound, may not be feasible due to potential insect or disease problems.
- Timber harvesting activities can impact cultural resources if not identified and protected.
- Wildlife habitat quality is influenced by timber harvesting activities. Care must be taken to maintain the structural components of the stand (live trees, snags, woody debris, shrubs, and ground cover) that are needed by wildlife.

PLANNING AND DESIGN CONSIDERATIONS

- A comprehensive, detailed plan is a critical part of any successful harvesting operation. In addition to what, where and how, the plan should consider follow-up regeneration needs and specific measures designed to address other important forest resources.

Soil Productivity

- Identify areas with special soil conditions and topographic features that make them more sensitive to disturbance than others, and design operations accordingly to minimize any adverse impacts.
- Minimize soil impacts by limiting the soil area impacted by infrastructure (roads, landings and primary skid trails) and by careful consideration of timing, equipment being used, and harvesting methods. Planning considerations should include careful determination of appropriate operating seasons for any given soil, as well as using harvest layouts, strategies, and equipment that minimize the surface area of a site that is trafficked. As a general rule, 15 percent or less of the harvest area should be devoted to haul roads, skid trails and landings.
- Employ appropriate timber harvesting strategies and practices to ensure that harvest operations do not reduce the productive capacity of forest soils through removal of nutrients or disruptions of nutrient cycles.

SHORT-LIVED SPECIES	MEDIUM-LIVED SPECIES	LONG-LIVED SPECIES
Aspen	Hickory	Ash
Balsam fir	Red maple	Basswood
Jack pine	Tamarack	Beech
Paper birch		Cedar
		Elm
		Hemlock
		Oak
		Red pine
		Spruce
		Sugar maple
		White pine
		Yellow birch

Water Quality and Wetlands

- Consider water quality concerns as harvest plans are developed:
  - Include provisions for water protection in the timber sale contract.
  - Avoid building landings, skid trails and roads in wetlands.

See Chapter 5: Riparian Areas and Wetlands and Chapter 11: Forest Roads, for general BMPs related to wetlands and planning.

BMP: Planning and Design

✓ Limit the length and number of skid trails, and the number of landings and stream crossings, to the minimum necessary to conduct the harvest operation and meet the landowners objectives.

Visual Quality

Wisconsin forests are composed of a wide variety of species. Some occur as pure stands, while others occur in association with each other in complex communities. Each species has a unique set of silvical characteristics, which result in different silvicultural requirements (see Chapter 2: Generally Accepted Silvicultural Principles). As a result of these differences, each species presents a different aesthetic management challenge. In order to most effectively reduce the visual impact of harvesting, it is necessary to carefully evaluate the specific biological requirements of each species as well as the physical and structural characteristics of the stands in which they occur. Elements that can be used to minimize or enhance visual impact must be identified and imaginatively employed. At the same time, alternative management strategies must be devised to overcome less favorable elements.

- When stands contain mixtures of short- and long-lived species, careful consideration should be given to the opportunities available to mitigate the visual impact of a harvest operation through retention of some portion of the long-lived species as individual trees or in scattered clumps.

Figure 12-2: In visually sensitive areas, thought should be given to retaining selected long-lived trees until the new stand is fully developed.

Figure 12-3: In this jack pine clearcut, long-lived red pine trees were left in both clumps and as scattered individuals to minimize the visual impact of this harvest along a major recreational highway.

Figure 12-4: Residual trees were left in this clearcut as both "islands" and "fingers" to provide better wildlife cover and travel corridors.

- Tree selection criteria and residual density levels can be modified in more visually sensitive portions of a particular stand to foster a more natural appearance and/or enhance visual diversity.

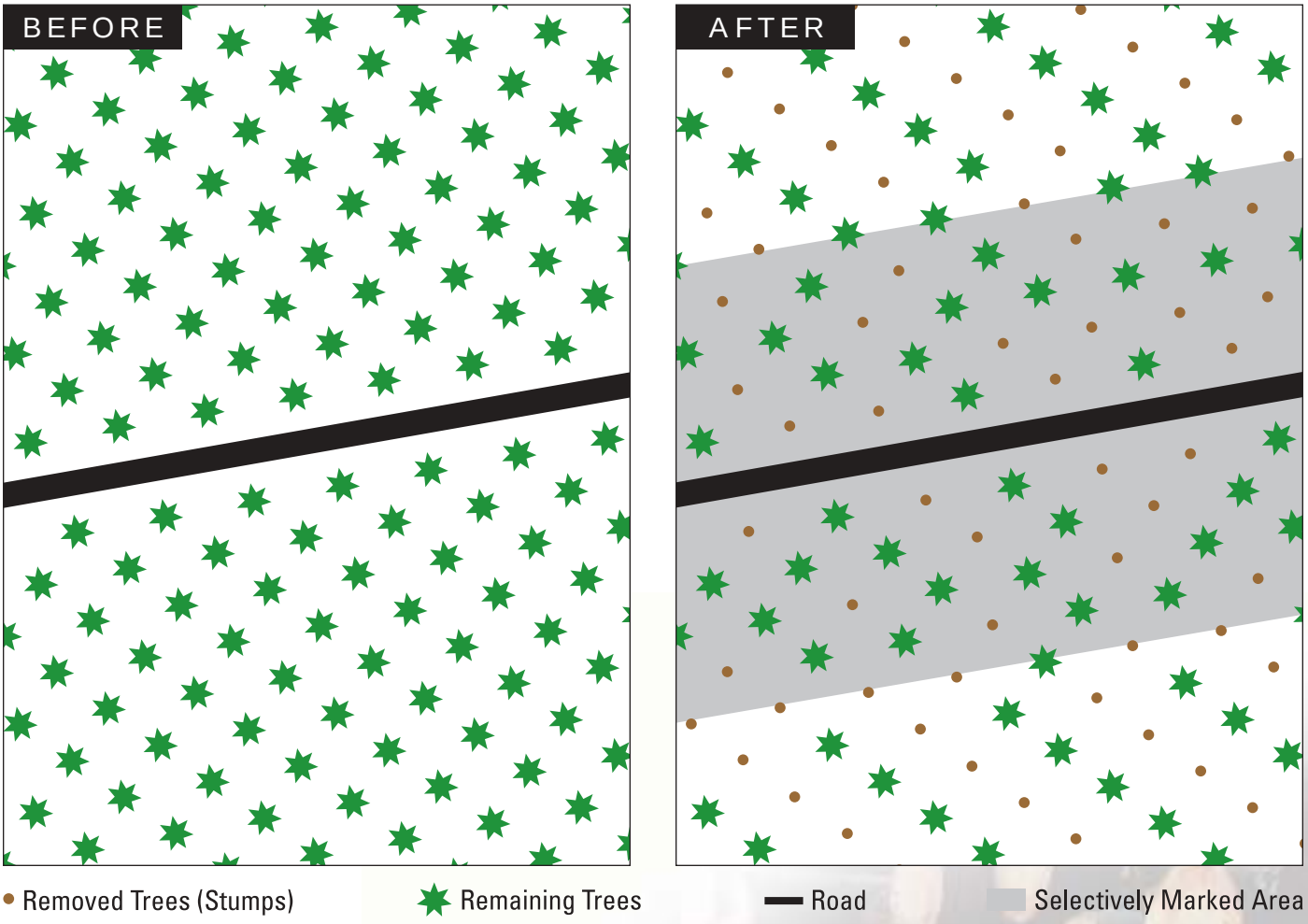

Figure 12-5: When plantations are established with the rows perpendicular to primary roadways, the appearance can be somewhat artificial. The first thinning in such plantations normally requires the removal of entire rows in order to allow harvesting machinery room to gain access, which creates an even more unnatural appearance. In this example, an area along the roadway was selectively thinned to create a more natural appearance. Harvesting entire rows in the remainder of the stand will make it possible to selectively thin the entire stand in subsequent thinnings.

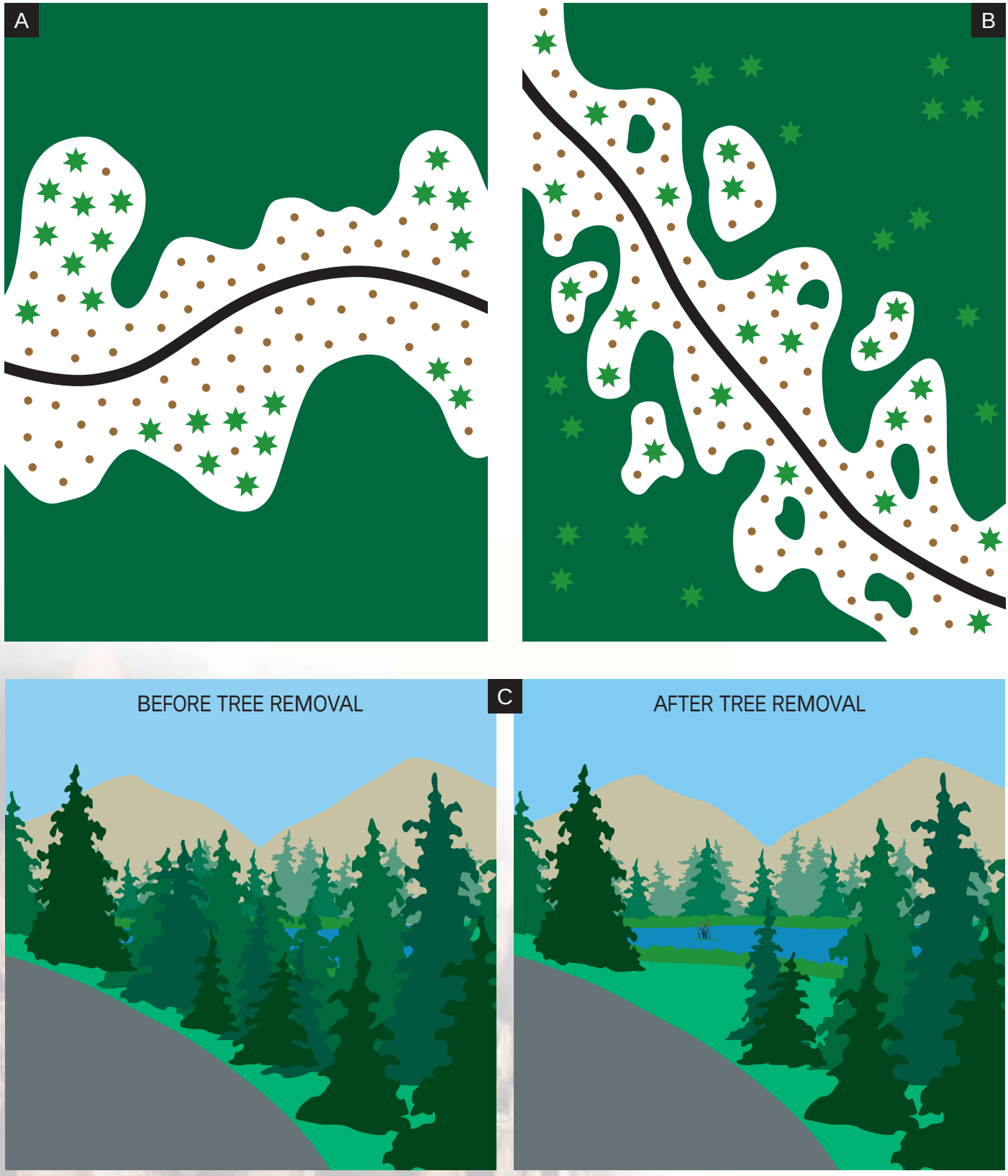

Figure 12-6: In the first of these examples, clumps of long-lived trees were retained along the roadside (A). In the second, individual trees were retained (B). In the third, a small vista was created through the judicious removal of selected trees (C). All of these treatments enhance visual diversity.

- As a stand of trees grows, it passes through a number of stages in its life cycle. Each of these stages presents differing degrees of aesthetic management value and flexibility. Harvesting strategies should reflect the positives and negatives of each.

Figure 12-8

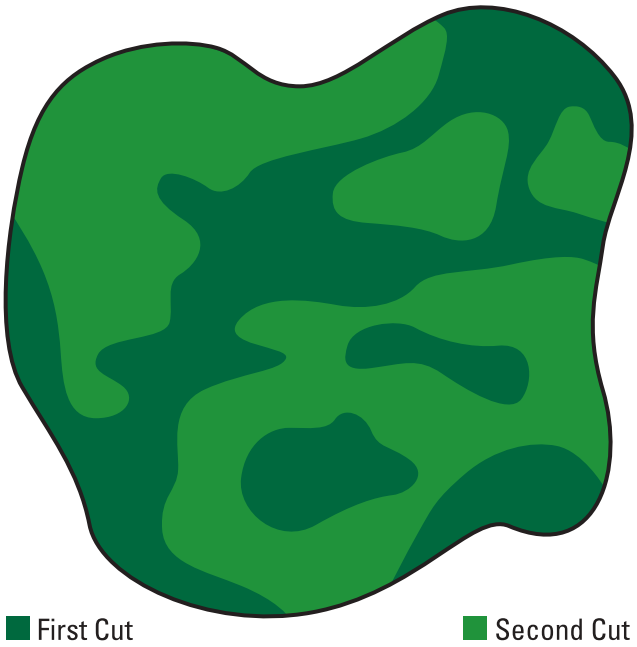

Figure 12-7: This stand of mature timber has been divided into two harvest areas to allow as much time as possible between harvests. Shape was used to reduce the visual impact. If this stand were younger, smaller blocks could be harvested separately over a longer period with a still greater reduction in visual impact.

Figure 12-9

Figure 12-10

Figures 12-8, 12-9 and 12-10: These aerial and ground photographs show a mosaic of stands with different species, age classes, densities and shapes. They were developed over many years to reduce the visual impact of future harvest operations in what was once a large monotype.

- The entire vegetative community occurring in a stand should be considered in the development of an aesthetic management plan – not just that portion being harvested. A well-developed understory can be used to great advantage in reducing the visual impact of a harvest operation.
- Use topography and other land features when possible to minimize the visual impact of harvest operations.

Figure 12-11: This even-aged, short-lived white birch stand occurs in a visual zone classified as "most sensitive." Creative integration of the understory and topography into the harvest design would be crucial for protecting visual quality during a timber sale. Seasonal harvesting restrictions, logging methods, road systems, slash treatment, and follow-up site preparation are also important considerations that could have an effect on visual objectives.

- Use natural features and avoid artificial patterns where possible. These natural features may correspond to changes in topography, soils, wetland interfaces, and timber types.
- Use shape to address viewing duration and intensity when designing harvest boundaries in areas of high visual sensitivity.

Figures 12-12: Stream corridors provide excellent opportunities for both visual screening and the protection of riparian areas. When used as a sale boundary, the need for stream crossings is also reduced.

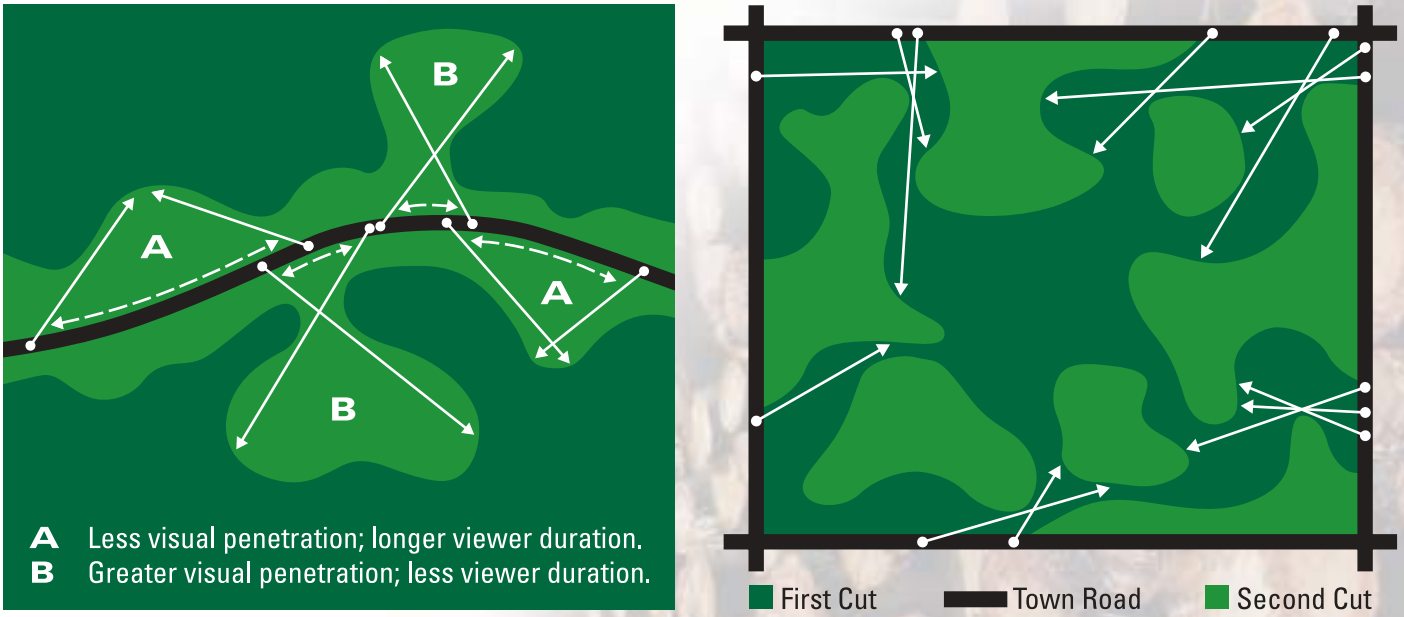

Figure 12-13 In these examples, the harvest area has been designed so that the longer a viewer can see an area (viewing duration), the shorter the distance they can see (visual penetration). The goal is to provide some visual diversity, while at the same time reducing the apparent size of the harvest area.

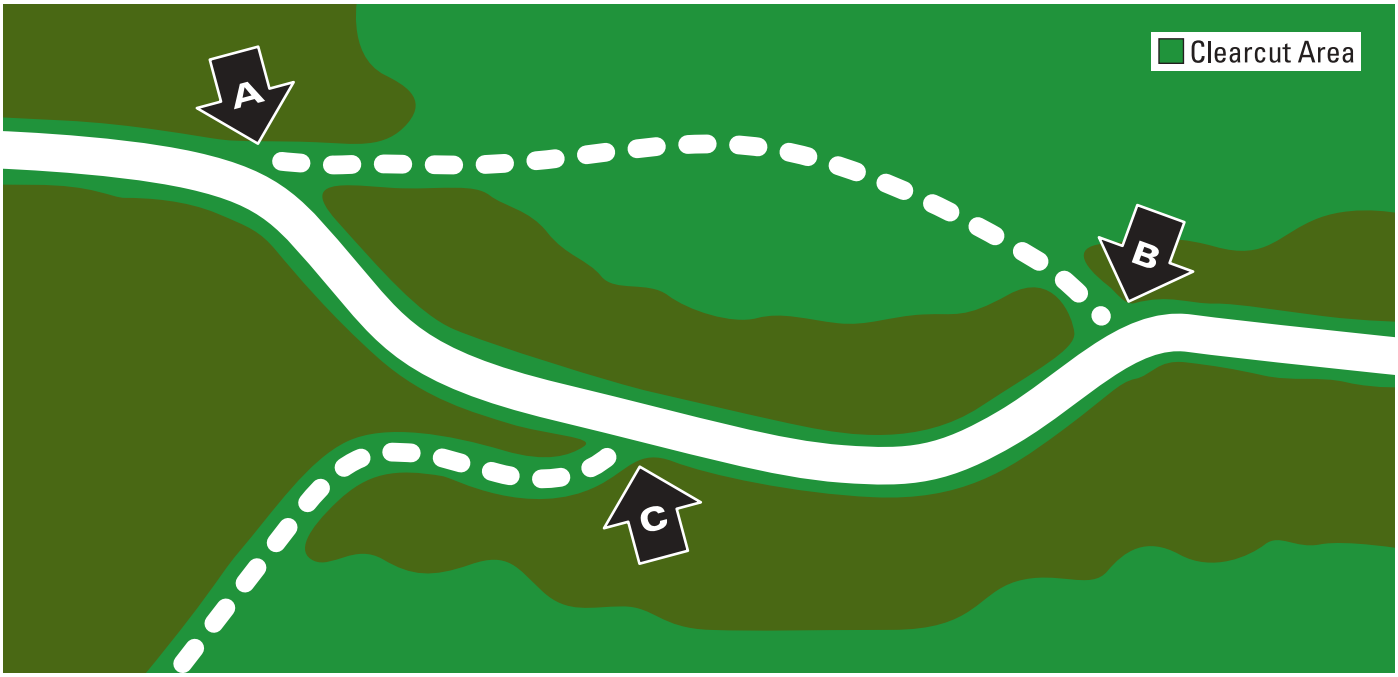

Figure 12-14: The logging road entrances at "A" and "B" permit excessive visual penetration directly into the harvest area. They also present a safety hazard by joining the main road on curves. A more preferred entrance location at "C" breaks the line of sight into the harvest area and also exits onto the main road at a 90° angle in a safe area.

- Road layouts should consider visual quality as well as timber management needs. A good road system should:
  - Minimize the number of exits onto sensitive roadways.
  - Facilitate re-entry of deferred harvest areas.
  - Be compatible with follow-up management operations (firebreak needs, tree planting, timber stand improvement, etc.).

Cultural Resources

- If practical and feasible, protect cultural resource areas by:
  - Excluding cultural resource areas from the timber sale area.
  - Keeping roads, skid trails and landings away from cultural resource areas.

Slash Management and Landings

- Slash is unavoidable when harvesting timber. Slash management plans should be developed prior to beginning the harvest, and also spelled out in the harvesting contract.
- Slash treatment has a definite cost.
- Slash near streams, lakes and wetlands is subject to special regulation.
- Slash provides soil nutrients.
- Slash can provide shelter for wildlife.
- The size and number of landings are affected by silvicultural considerations, the logging system used, sale size, and timber sale design.
- Topography can limit both the placement and number of landings.
- Proximity of harvest to sensitive travel routes or use areas can affect placement of landings.
- Proposed use of a landing area (e.g., as a parking area along a recreational trail or as a wildlife opening) can affect the size and placement of a landing.

Figure 12-15: In this jack pine clearcut, residual trees were left in both clumps and as scattered individuals to maintain good wildlife habitat and reduce the visual impact of the harvest.

Leave (Reserve) Trees, Coarse Woody Debris, and Snags

- Consider leaving individual trees and/or groups of trees unharvested for reasons other than providing seed for regeneration of the stand. Such reasons may include:
  - Provision of den and nest trees, food sources, cover, travel corridors, and special habitat needs for wildlife.
  - Reduce the unobstructed line of vision in clearcut areas, and provide any additional diversity in future stands.
  - Retain selected high quality trees for additional growth and future harvest.
  - Reduce runoff and erosion in sensitive areas.
- Potential problems that need consideration relative to retaining leave or reserve trees include:
  - Susceptibility to windthrow on wet soils, or for shallow rooted species.
  - Potential for damage during harvesting operations.
  - Increased potential for epicormic branching.
  - The shade from reserve trees could retard growth of reproduction underneath them.
  - Damage could occur to the new stand if reserve trees were harvested mid-rotation.
- Consider the need to retain coarse woody debris for wildlife habitat purposes (see Chapter 3: Wildlife Habitat for more information).
- Snags can enhance the quality of wildlife habitats by providing nesting, denning, feeding and roosting sites as well as escape areas, but a potential safety hazard for logging operations must be considered.

OPERATIONAL CONSIDERATIONS

- Conduct on-site meetings with the logger, landowner and resource manager prior to moving equipment onto a site. Such meetings can help assure common understanding of landowner objectives, timber harvest specifications and site conditions.

Protecting Soil Productivity

- Identify soil or site conditions that may dictate specific timing, harvest methods or equipment to be used, or that may lead to weather-related or seasonal closure of the operation.

Protecting Water Quality and Wetlands

- Minimize the crossing of intermittent or perennial streams and open water wetlands. On both upland and lowland sites, install bridges, culverts, snow or ice bridges, fords, or other means, if necessary, to prevent repeated soil and streambank disturbance where no practical alternative exists to crossing a stream. **IMPORTANT: Such activity may require a permit from the DNR.**
- Approach water crossings at or near right angles to the stream direction, and use measures to minimize streambank disturbances.
- Incorporate water diversion devices where needed during timber harvesting activity. Divert surface flow before it enters landings or a water body. Incorporate water diversion devices during construction rather than as a remedial activity (see Chapter 11: Forest Roads).
- To prevent repeated rutting deeper than six inches on wetlands, shift harvest operations to a stable portion of the harvest area or alter operating techniques. Alternative techniques include:
  - Employing low ground pressure (LGP) equipment
  - Using slash on skid trails as a driving surface.
  - Minimizing the amount of off-trail equipment operation to reduce the area disturbed by heavy equipment.
  - Waiting for colder weather to freeze the site or enhance freezing of the site by packing snow and ground vegetation with LGP equipment.

Figure 12-16: Conducting on-site meetings with a logger, landowner and resource manager prior to moving any equipment helps ensure a common understanding of contract specifications, timber harvesting regulations, landowner objectives, and site conditions.

BMPs: Protecting Sensitive Areas

- ✓ Avoid operating equipment where excessive soil compaction and rutting may cause erosion that affects water quality. The use of low ground pressure (LGP) equipment may allow operations to continue.
- ✓ Whenever possible, winch logs from steep slopes, if conventional skidding could cause erosion that affects water quality.
- ✓ When harvesting near streams or lakes, follow BMPs for water quality (see Chapter 5: Riparian Areas and Wetlands).
- ✓ Inspect soil-stabilization practices periodically, during and immediately after, harvest operations to insure they are successful and remain functional. Follow BMPs in Chapter 11: Forest Roads, Road Maintenance.
- ✓ For winter harvesting, mark stream channels and existing culvert locations before snowfall.

Protecting Cultural Resources

- If harvesting will take place in the area of a cultural resource, employ measures to reduce soil disturbance, including (but not limited to) hand felling, limited-area feller buncher, low ground pressure (LGP) equipment, cut-to-length systems, and temporary protection such as slash, corduroy, tire mats, or fill over geotextile.

Skid Trails

- Plan progressive harvesting techniques that avoid trafficking over pre-cut areas when possible.

BMPs: Skid Trails

Skid trail restrictions in riparian management zones are described more in detail in Chapter 5: Riparian Areas and Wetlands.

✓ Where possible, keep skid trail grades less than 15 percent. Where steep grades are unavoidable, break the grade, install drainage structures, and use soil-stabilization practices (as described in Chapter 11: Forest Roads) where needed to minimize runoff and erosion. Grades greater than 15 percent should not exceed 300 feet in length.

✓ Use existing trails if they provide the best long-term access. Consider relocating existing trails if both access and environmental impact can be improved.

Figure 12-17: A skid trail during active harvesting.

BMPs: Stream Crossings for Skidding

✓ For skidding across streams, use permanent crossings as described in Chapter 11: Forest Roads, General BMPs for Stream Crossings, or use temporary crossings such as pole and frozen fords.

✓ Pole fords may be used in small streams by placing poles (or small logs) side by side on the streambed. Pole fords must be removed immediately after use, or before the upstream end becomes clogged with debris and impedes streamflow (see Figure 12-18).

✓ Frozen fords are used in small streams when ice is thick enough, or the streambed is frozen enough, to protect the streambed.

Reminder: Stream crossing permits are required before installing a crossing on any intermittent or perennial navigable stream.

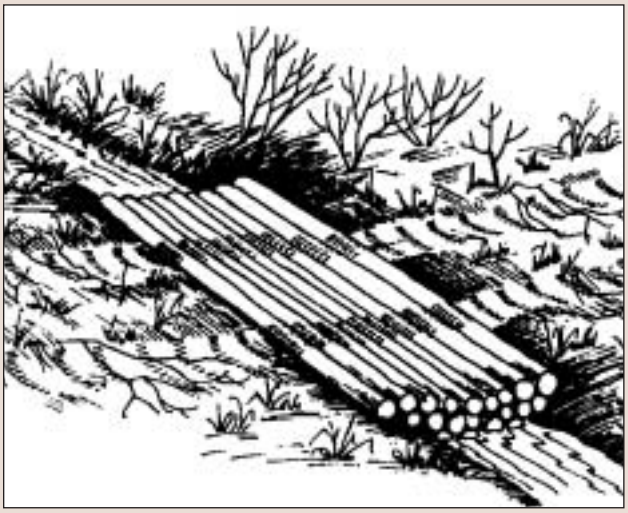

Figure 12-18: Pole ford for a small stream crossing. Pole fords must be removed immediately after use or before the upstream end becomes clogged with debris and impedes streamflow.

Landings

BMPs: Landings

- ✓ Locate landings outside of all riparian management zones.
- ✓ Locate landings on frozen ground or firm, well-drained soils with a slight slope, or on ground shaped to promote efficient drainage. Landings may need a crown shape to allow for drainage.
- ✓ Use existing landings if possible. Close existing landings in riparian management zones unless construction of new landings will cause greater harm to water quality than using existing landings.
- ✓ Locate residue piles (sawdust, field chipping residue, etc.) away from drainages where runoff may wash residue into streams, lakes or wetlands.

REDUCING THE VISUAL IMPACTS OF LANDINGS

- When possible, avoid landings within view of travel routes or recreation areas. If it is not possible to avoid landings within these areas, screen landings from view as long as possible during logging.
- Keep the number of landings to a minimum, and plan them to access future sales.
- Seed, plant and regenerate landings promptly.
- Remove all products promptly when development of visible landings is necessary.
- Dispose of grubbed stumps and trees so they are not visible.
- Treat any slash at landings as soon as possible.
- Remove all trash upon completion of harvesting.

Minimizing Rutting

- Minimize rutting on primary skid trails, roads and landings, and avoid rutting in the general harvest area.
- If alternative operating techniques fail to eliminate rutting, stop harvesting operations.

BMP: Rutting

- ✓ Fill in ruts, apply seed and mulch, and install sediment-control and drainage structures on skid trails and landings where needed to prevent erosion and sedimentation into surfacewaters (see Chapter 11: Forest Roads).

Managing Slash

- Favor practices that allow for dispersed slash on the site, rather than piling slash, where dispersed slash does not conflict with management objectives or reforestation. When piling slash, piles should be kept away from cultural resources.
- If moving slash on-site is desirable, use equipment that minimizes soil disturbance.
- Stump heights should not exceed the diameter of the stump.

REDUCING VISUAL IMPACTS OF SLASH

- Encourage maximum utilization of all felled trees in the harvest area.
- Minimize visual exposure to slash piles and windrows.
- Limit slash not screened from view to a reasonable height to avoid a negative visual effect.

BMP: Slash

- ✓ Do not pile slash in drainage areas where runoff may wash slash into streams, lakes or wetlands.

Snags (Standing Dead Trees)

- Leave as many snags as possible standing in harvest areas, consistent with the exceptions outlined in the next section.

Leave (Reserve) Trees

Two general options are recommended for retaining leave trees (live trees which are left unharvested). Plans for retaining leave trees may utilize one of these options or, when appropriate, they may use the two options in combination.

OPTION 1: CLUMPS, STRIPS OR ISLANDS

- Retain leave trees in clumps, strips or islands in each harvest unit. Benefits of clumping leave trees include:
  - Potential to meet multiple management objectives simultaneously.
  - Visual quality.
  - Equipment maneuverability.
  - Longevity and durability of leave trees.
  - Potential for greater biodiversity within clumps.
  - Easier application in larger harvest units.
  - Breakup of harvest area and reduction in apparent harvest size.
  - Better regeneration of intolerants on the rest of the site.
  - Potential to provide nesting sites for some interior forest species when clumps exceed two acres.
  - Increased animal feeding efficiency and protection from predators.

- Clumps, islands or strips should:
  - Be distributed throughout a harvest unit.
  - Be adjacent to the RMZ for even-aged management.
  - Vary in size, with a minimum of one-quarter acre per clump.
  - Center around or coincide with such features as:
    1) Wetland inclusions and seasonal ponds
    2) One or more large (greater than 18 inches DBH) active den trees or cavity trees
    3) Mast trees
    4) Preferred tree species (such as large white pine)
    5) Raptor nests or rookeries
    6) Sensitive communities or sites
  - Minimal harvesting within clumps is acceptable as long as the integrity of the clump or key leave trees are not disturbed.

OPTION 2: SCATTERED INDIVIDUALS

- As an alternative or supplement to clumps, employ scattered individual leave trees, especially if they are larger, wind-firm specimens of preferred species. Scattered leave trees may be easier to apply to small or narrow harvest units than clumps. Use the following guidelines for scattering individual leave trees:
  - On most clearcut sites where this method is employed, leave six to 12 trees standing per acre, selecting trees preferentially. For preferred characteristics, see Chapter 3: Wildlife Habitat and Appendix A: Wildlife Crop Tree Criteria.
  - On non-clearcut sites, (including selection or partial-cut), be sure that the remaining stand includes a minimum of six cavity trees, potential cavity trees and/or snags per acre.
  - Distribute leave trees throughout the harvested site as much as possible.

- During initial harvest entries of seed-tree or shelterwood cuts, select ultimate leave trees using the following guidelines:
  - Leave a variety of sizes and species of trees, along with the intended seed-/shelter trees, to be retained during the final harvest.
  - Plan for and protect integrity of reserve tree clumps in initial harvest entries.
  - Prevent damage to leave trees in initial and follow-up harvest entries.

- **Exceptions** to the previous leave tree and snag guidelines may be made for a number of reasons:
  - Operator safety (of loggers, aerial spray applicators, and others).
  - Public safety (hazard trees near right-of-way, recreation sites, or airport vicinities).
  - Specific forest management applications (e.g., genetic considerations for seed reproduction systems).
  - Visual quality.
  - Alignment of skid trails.
  - Surrounding landscape concerns (e.g., adjacent sites to Sharp-tailed Grouse management units).
  - Forest insects and diseases (such as dwarf mistletoe on black spruce, gypsy moth or pine bark beetles).
  - Shallow-rooted trees that have little wind resistance.

Providing Coarse Woody Debris

- Avoid having equipment disturb pre-existing large downed logs, stumps and uprooted stumps.
- If a snag must be dropped, leave it where it falls whenever possible.
- Create at least two to five bark-on downed logs greater than 12 inches in diameter per acre, if fewer than this number already exist. In choosing candidates for leave logs, consider the following:
  - Hollow butt sections or other defective lengths of at least six feet are preferred.
  - Sound logs and six- to 12-inch diameter logs may be used if they represent the best available candidates.
  - Hardwood logs have more hollows or cavities, and are favored by certain amphibians.
  - Conifer logs decay more slowly, thus remain present as structure on a site longer than hardwoods.
  - Using pines as downed logs, especially in summer, increases the risk of bark beetle damage to adjacent healthy pines.
- Scatter leave logs across the site, including a few near wetlands.
- **Exceptions** to guidelines for providing coarse woody debris may be made for a number of reasons, including:
  - Alignment of skid trails
  - Specific silvicultural applications (e.g., insect pests)
  - Visual quality issues

Figure 12-19: One harvesting option is to leave six to 12 scattered cavity trees, potential cavity trees, or snags per acre to enhance wildlife habitat.

Managing the Harvesting Process

Even the best harvesting design may fail for lack of vigorous, on-going, contract administration. Harvesting operations may extend over several months, and sometimes years. Problems need to be identified and dealt with early, before they become unmanageable. Efforts to minimize logging damage to the residual stand or to advance regeneration, the lopping and scattering of slash, the clean-up of road entrances, control of erosion, and many other activities need to be done concurrently with the cutting operation if they are to be most effective.

- The creation of "cutting zones" can be used to help administer large harvest areas. In this way, the cutting can be limited to only a specific portion of the harvest area until that "zone" is satisfactorily completed.
- A complete, accurate timber sale map (see Figure 12-20) is an extremely important tool for effective harvest administration. On complex cutting operations, it is absolutely essential. The map should be a part of the timber sale contract, and copies provided to everyone working on the job.

The Timber Sale Contract

A timber sale contract is the most important document involved in the timber harvesting process.

A well-prepared contract, along with a timber sale map, ensures that all parties have a mutual understanding of the operational considerations previously discussed. This section describes and clarifies the Sample Timber Sale Contract included in Appendix B. The Wisconsin Department of Natural Resources, the Wisconsin Woodland Owners Association, and University of Wisconsin-Extension jointly developed it as part of the Forestry Facts series. The sample contract suggests key elements for inclusion in any private timber sale contract whether a landowner uses the one in the appendix or one from another source. The same concepts are also generally present in timber sale contracts on public land.

Five Steps in a Careful and Successful Timber Sale

Landowners are encouraged to hire a professional forester to help with any of these steps. A *Directory of Foresters (Pub-FR-021)* is available from the DNR. Useful information can also be found in the UW-Extension Forestry Fact #75: Hiring a Consulting Forester.

Step 1: Prepare a written forest management plan that addresses your personal objectives and the desired future condition of the woodland. The plan should explain harvesting techniques, and any follow-up work that may be needed to achieve the preferred results.

Step 2: Develop a harvest plan that describes the practices, locations, and expectations for the harvest. This document should include a map of the harvest site.

Step 3: Develop a comprehensive, written timber sale contract* that will be available as part of your timber sale advertisement.

Step 4: Get competitive bids to help secure a fair offer and to find a skilled, careful logger that is experienced with your type of sale.

Step 5: Check references and the performance history of both the consulting forester (if you plan to hire one) and the timber producer you are considering for your timber harvest. The Wisconsin Department of Agriculture and Consumer Protection (DATCP) has a Consumer Protection Hotline at **1-800-422-7128** that you can call to check for past complaints. If the forester you select is expected to scale or grade the cut products, make sure the he/she is qualified to perform the work.

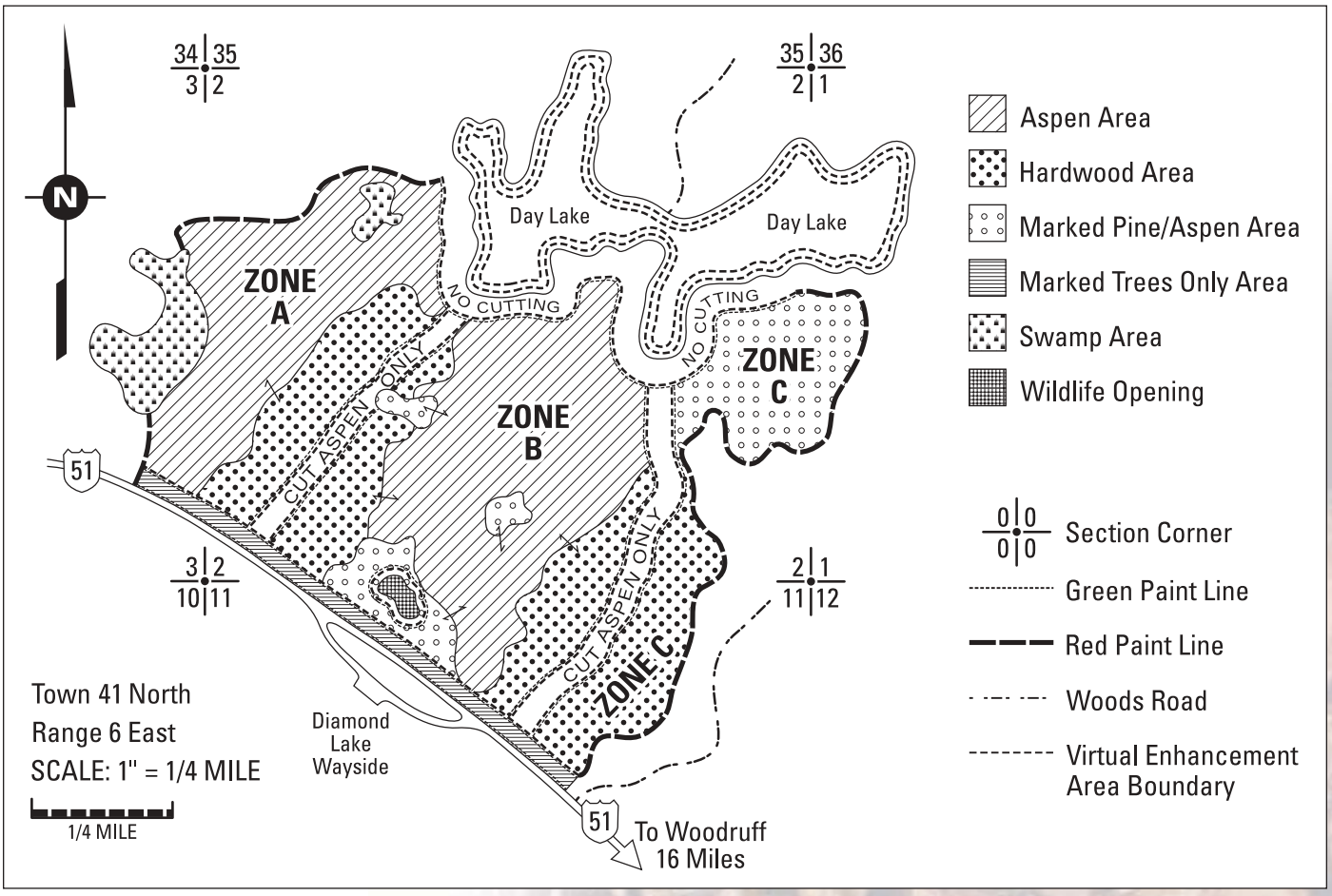

Figure 12-20: A timber sale map should be clear, concise, and contain all the information a logger needs to determine what needs to be done and where. Boundary line locations, other ownerships, paint line colors, cutting specifications, cutting zones (if any), and any other pertinent information, should be completely spelled out.

* *A sample timber sale contract may also be downloaded in digital format from the following web site:* ***www.dnr.state.wi.us/org/land/forestry/Private/index.htm***

Understanding the Sample Timber Sale Contract

The Sample Timber Sale Contract explained in this section contains a number of options. You will need to select the provisions and language that are appropriate for your harvest. The list of contract provisions is not meant to be exhaustive or necessarily applicable to every situation. You may choose to add or delete (by striking out) provisions. Landowners are encouraged to work with an attorney and professional forester in drafting a timber sale contract. Timber sale contracts usually include provisions that outline who, what, where, when, and how a timber sale will occur. Contracts will also spell out remedies in the event of a dispute. More stringent contracts may result in fewer bidders and, potentially, lower bids. Less restrictive contracts provide for less control. The section titles and provision numbers in the following explanations correspond to the section titles and paragraph numbers in the Sample Timber Sale Contract. Some sections are self-explanatory and not included.

Contract Breach: A Very Serious Decision

Deciding that the Purchaser has breached a timber sale contract should not be made lightly or over trivial matters. Contract breach is a very serious step that can have ramifications for you and the Purchaser well beyond this one event. Reputation is critical to a timber harvester's livelihood and to your ability to sell or resell your timber. You may also be sued – it is that important. Breach should truly be the final straw. Intermediate steps might include visiting with the Purchaser to hash out differences, having a third party intervene, or shutting the sale down temporarily.

What is Reasonable?

Throughout the Sample Timber Sale Contract, there are references to actions being "reasonable." In legal terms, reasonable means fair, proper, just, moderate, and suitable under the circumstances. The basic question to ask is: Would an outside observer familiar with harvesting practices feel the action was adequate and satisfactory?

If you have never harvested timber before or visited a logging site, it is important that you learn about and understand normal logging practices and their impact. Either visit logging sites or hire a consultant forester to help you determine if your expectations of post-harvest conditions are "reasonable."

PROVISIONS 1-4

Contract performance, period, extensions, and termination. Beginning and ending dates of the contract are established. The phrase, "For Time is of the Essence," demands reasonable diligence and completion within the period of the contract. Delays should only be authorized for reasons beyond the control of the Purchaser. This is essential to achieve your management objectives. Some provisions give you the flexibility to protect the land should unanticipated events or conditions occur. The Purchaser's authority to go onto your land and conduct operations is through the contract.

PROVISIONS 5-8

Down payment, bond, remedies and damages. Sellers and Purchasers use down payments as earnest money. Down payments are not performance bonds. Performance bonds assure that costs incurred due to breach can be recovered from the bond, rather than going to court or otherwise recovering costs from the Purchaser. Be aware that many Purchasers may not agree to provide a performance bond unless it is to be held by a consulting forester or an objective third party such as an escrow agent. The Seller's remedies in the event of a breach are not just limited to routine contract damages. Other penalties or remedies may be pursued if the Seller so chooses.

PROVISIONS 9-11

Products to be removed. Specifications for how trees are marked or designated for harvesting are explained (for example, "trees marked with orange paint," or "all trees within a red marked boundary"). Be certain that your property boundaries are well-defined and understood by the Purchaser. If the boundary has not been formally surveyed, you should meet with the adjoining landowners to agree on the location of the property boundary. The Seller retains sole control over the timber until payment is made. Timber cannot be removed from the property until paid for, or until payment arrangements have been made.

PROVISIONS 12-13

Sale type, scaling, hauling, and payments. There are many ways to sell timber. Each affects the point at which ownership of cut products moves from the Seller to the Purchaser, and who reaps the benefit of product sort and grade. This section defines condition of cut products to be removed from the property, how and by whom the cut products are to be measured, and when the Seller receives payment. Scaling procedures include on-site and mill scale. The Seller should be aware that some mills will send mill slips to the Seller, but others do not. Prior to signing the contract, seek the advice of a tax specialist to determine whether income may be treated as a capital gain or regular income. Spreading the payment over two years may minimize your tax liability in any single year.

PROVISIONS 14-17

Timber products table. The table summarizes the type and volume of timber expected from the harvest, and the price the Purchaser agrees to pay by unit. This information is important in all sales, even lump sum sales, where the price per unit information can be used for damages or contract adjustments, if necessary. In some cases, the term "mixed hardwoods" is used to describe products to be removed. Mixed hardwoods are small quantities of hardwood tree species of low relative value, or are not in sufficient quantity to be marketed in separate species categories. High-value species or products should be identified separately, even if the volume is small. In general, the use of mixed hardwoods should be restricted to pulp.

PROVISIONS 18-28

Utilization and operations. Detail any timber and site protection measures here. Be specific about erosion control, weather, disease and insect prevention, timing, equipment use (e.g., width or size limitations, use of a forwarder or skidder, horses, etc.), operations during hunting seasons, or other constraints you or your foresters consider necessary. Use Wisconsin's Forestry Best Management Practices (BMPs) for Water Quality to protect water resources. If critical BMP needs exist on your property, itemize them. Check and document that the Purchaser and timber operators have completed Wisconsin BMP training. Include any considerations for archeological sites or endangered and threatened species where appropriate or required by law. Be aware that some requirements may affect the price that the Purchaser may offer for the timber.

PROVISIONS 29-31

Notice of intent to cut and compliance with laws. Specify the party responsible for filing cutting notices and reports with the county clerk and the DNR. Notices must be filed at least thirty days before cutting begins. County cutting notices must be renewed on January 1 of each year. If the land is enrolled in a DNR forest tax law program, the landowner will be responsible for paying a five percent (Managed Forest Law (MFL)) or 10 percent (Forest Crop Law (FCL)) severance tax on the timber cut. Regardless of contract provisions, state statutes hold landowners liable for penalties related to non-compliance with MFL and FCL cutting notice and report laws.

PROVISIONS 32-33

Title, boundary lines and access. These clauses outline three important duties you have as the Seller. First, you assure that you have the authority to sell the timber and will defend that right in court if necessary. A mortgage or land contract may require that the Seller seek permission of creditors before selling. Where there are multiple owners, all should consent. Tax program participants should ensure that the harvest is consistent with the approved forest management plan, and that all required notices are submitted. Second, you will mark the boundary of the timber sale prior to harvest. Third, you will acquire written permission to cross a neighbor's land, if necessary.

PROVISIONS 34-36

Liability and insurance. These provisions protect the Seller from liability arising from the Purchaser's harvesting operation. The Purchaser is required to show proof of workers' compensation and public liability insurance. Be aware that a logger's liability insurance does not normally include damages caused by fire or timber trespass unless purchased as an option.

PROVISION 43

Contact information. This exchange of information between the Purchaser and Seller will ensure that both parties can contact each other easily. If you're using a Seller's agent, provide his/her contact information, too.

POST-OPERATIONAL ACTIVITIES

Figure 12-21: A forwarder offloads pulpwood at a woods landing. Forest management objectives may influence your equipment choice. Forwarders carry wood, thus causing little soil disturbance. Skidders scarify the soil by dragging trees or logs – a plus for natural regeneration where erosion is not a problem.

- Evaluate the harvesting operation, and plan future adaptations at post-harvest conferences with the logger and landowner.
- Plan for removal of equipment and cut material from wetland areas at the end of the winter season prior to thawing.
- Avoid removing soil from the general harvest area to rehabilitate roads, landings and skid trails. Use already-disturbed soil, if needed, rather than disturbing additional soil.
- Inspect and maintain any soil-stabilization practices installed. Rehabilitate landings and skid trails when necessary to mitigate soil compaction and help to reduce erosion.
- Monitor the sale area and access routes for non-native invasive species, and take the necessary steps to eradicate any species that may have been introduced through harvesting activities.
- Evaluate the adequacy of advance regeneration, and/or the need for reforestation.
- Conduct additional site preparation work, as needed, to ensure successful regeneration.

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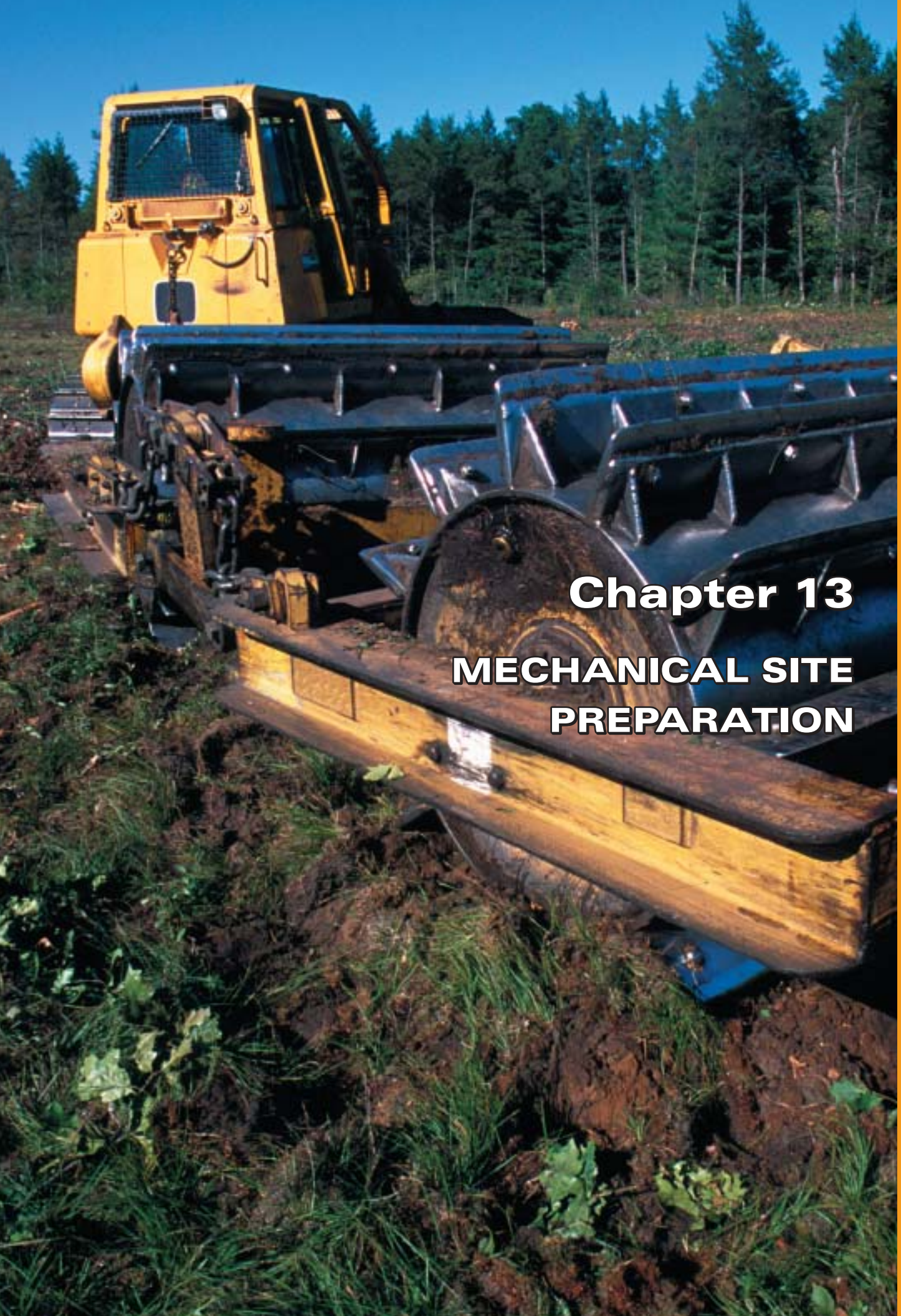

Chapter 13

MECHANICAL SITE PREPARATION

CHAPTER 13 — MECHANICAL SITE PREPARATION

Integrated Resource Management Considerations 178

PLANNING AND DESIGN 180

Layout and Design Considerations 180
Timing and Intensity of Activities 180
Selecting Application Methods 181
BMP: Selecting Application Methods 181

OPERATIONAL CONSIDERATIONS 183

Managing Slash and Windrows 183
Protecting Resources 183
BMPs: Protecting Resources 183

POST-OPERATIONAL ACTIVITIES 184

Figure 13-1: A two-row Bracke Scarifier that is towed behind a prime mover to prepare planting scalps in a recently logged area.

Figure 13-2: Close-up of a Bracke Scarifier working in pine slash. The machine removes soil only from the small areas where seedlings will be planted.

Site preparation is the practice of altering site conditions to favor the establishment, survival and growth of a desired tree species, browse or other vegetation. Site preparation can be accomplished through mechanical means, prescribed fire, the use of herbicides, or any combination of these approaches.

Mechanical site preparation accomplishes two goals:

- It facilitates planting, direct seeding and natural regeneration.
- It provides partial initial control of vegetation competing with crop trees for light, water and nutrients.

Common mechanical site preparation techniques include patch scarification, row scarification, raking, disking, bedding, roller chopping, and shearing. Herbicides are often applied in conjunction with mechanical site preparation, to increase control of competing vegetation.

The guidelines in this section focus on mechanical site preparation. For chemical use in a mechanical site preparation method, refer to the guidelines in Chapter 14: Pesticide Use. For prescribed burning, refer to the guidelines in Chapter 17: Fire Management.

Integrated Resource Management Considerations

- Maintaining good soil condition is critical to accomplishing the goals of site preparation (to favor the establishment, survival and growth of a desired tree species). Practices that result in excessive exposure of mineral soil, compaction or rutting of soil, or removal of surface soil should be avoided. If soils are negatively impacted in the process of site preparation, then the “advantage” of the site preparation is reduced either through poor establishment or poor survival, or more often, lowered growth and productivity.
- Properly planned harvesting operations should include consideration of mechanical site preparation needs. Site preparation methods that minimize the potential for surface erosion should be evaluated prior to the implementation of site preparation operations.
- Selecting the appropriate technique, intensity and timing of a site preparation activity is important in maintaining the soil productivity of a site. Heavy equipment should be operated on a site when adverse soil impacts are most unlikely.

Figure 13-3: Scarified patches by a Bracke Scarifier in a cutover stand. Patch or row scarification reduces competition for the new seedlings, yet has a low impact on the planting site.

- Mechanical site preparation techniques and intensity for a given site should be determined by soil/site conditions, the silvicultural requirements of the tree species to be regenerated, and site preparation objectives. Specific site conditions (including soil characteristics, topography, vegetation, access, and distance to surfacewater) dictate what techniques may work best or provide the best operating window for any given site. Some sites may be planted with no site preparation other than removing the overstory.
- Practices that result in exposure of mineral soil or soil compaction on erodible slopes should not be used where surface erosion or runoff is likely to result in sedimentation of water or wetlands. For sources of information and planning assistance, see the Resource Directory.
- Activities that disturb soil such as disking, scarification, rock raking, and shearing, may not be appropriate within cultural resource areas.
- Contour preparation methods can minimize erosion, as well as the cost of remedial action or repair.
- Site preparation methods vary considerably, depending on the desired regeneration species.
- Every site preparation method has a different cost. For any method being considered, costs (both short- and long-term) should be balanced against effectiveness of the method in attaining visual quality objectives.
- Composition and condition of the original stand can impact the regeneration method chosen for a particular site.

PLANNING AND DESIGN

Layout and Design Considerations

- Consider alternative methods of site preparation, such as non-mechanical, or combinations of mechanical and non-mechanical methods, to accomplish site preparation goals while minimizing disturbance.
- Design mechanical treatments of regenerating stands to protect reserve areas and structural habitat components retained in previous stand treatments.
- Favor practices that do not remove surface soils, or only remove surface soils from the small areas in which an individual seedling will be planted.
- Identify occurrences of non-native invasive species, and if necessary, treat infestations prior to mechanical site preparation to help prevent spread. Monitor and control new infestations after site preparation activities are completed. Moving equipment from site to site may spread seeds of problem species or vegetative parts that can take root in the new location. Equipment cleaning may be needed before moving from an infested site into an area that is free of problem invasives.
- Favor practices that allow for dispersed slash or slash in small piles on the site, rather than piling or windrowing, in situations where residual slash does not conflict with management objectives or reforestation.
- Select appropriate species and stocking levels for reforestation, and plan site preparation intensity accordingly.
- Plan for a diversity of tree species where possible.
- Design practices to avoid direct runoff of sediment into water and wetlands.

Timing and Intensity of Activities

- Enter a site the fewest number of times necessary, and avoid multiple passes of equipment over the same spot.
- Time site preparation activities and use proper equipment to minimize rutting and compaction of soils.
- Avoid shearing and raking operations on organic soils except under frozen conditions.
- In some cases it may be necessary to time site preparation work to coincide with a good seed year in order to maximize the chances of success.

DESIGN OUTCOMES TO MAINTAIN SOIL PRODUCTIVITY

Site preparation activities should be designed and implemented to achieve the following beneficial outcomes regarding soil productivity:

- Soil in a condition that favors the establishment, survival and long-term growth of the desired tree species.
- Displacement of only enough soil as needed to effectively accomplish tree establishment.
- Site preparation techniques employed so surface soils: 1) remain intact; 2) are only displaced a short distance (such as in scalping); or 3) are incorporated (such as in disking).
- Slash dispersed on the site, rather than piled or windrowed, where appropriate.
- Site preparation practices employed so they avoid funneling water (such as furrowing, scarification, and scalping on the contour).
- No additional establishment of non-native invasive species.

Figure 13-4: A Two-row Leno Scarifier set up to create scarified patches in a clearcut. This approach causes minimal site disturbance, yet provides exposed soil for ideal planting conditions.

Selecting Application Methods

Common site preparation techniques include scarifying, shearing, raking, disking, and roller chopping. Select a technique based on specific site characteristics including soil, topography, vegetation, access, and distance to surface waters. Prescribed burning and herbicides are also used for site preparation; BMPs for these management tools are listed in Chapter 14: Pesticide Use and Chapter 17: Fire Management.

- To increase success of oak regeneration, use such pre- and post-harvest techniques as burning, stump sprout thinning, or scarification.
- Consider targeted mechanical site preparation methods (low-intensity, spot or band) in preference to broadcast applications.
- Use equipment that minimizes soil disturbance when moving slash on-site.

REDUCING VISUAL IMPACTS OF MECHANICAL SITE PREPARATION

- Use low-impact site preparation methods, such as patch or row scarification.
- Use spot or strip treatment of herbicides rather than broadcast treatment applications.
- Initiate revegetation efforts as soon as possible.
- Use land contours in site preparations.
- Avoid the effect of linear straight rows and resulting visual penetration immediately alongside travel routes or recreation areas.
- Avoid or screen windrows and slash piles.

BMP: Selecting Application Methods

✓ Use patch or row scarification as the preferred mechanical site preparation method for artificial regeneration when terrain or soil type necessitates minimal soil disturbance.

Figure 13-5: A Marden Duplex Roller Chopper provides area site preparation, crushing logging slash over the entire cutover area.

Figure 13-6: Close-up of a TTS 35-disc trencher that is used for row scarification in cutover areas prior to tree planting.

OPERATIONAL CONSIDERATIONS

- Conduct on-site meetings with the contractor, landowner and resource manager prior to moving equipment onto a site. Such meetings can help assure an understanding of landowner objectives, contract specifications, and site conditions.

Managing Slash and Windrows

- Where shearing or windrowing slash is necessary, avoid scraping soil material or forest floor into windrows or piles. Preferred practices include:
  - Shearing and raking under frozen conditions
  - Light raking, which only removes slash
- Avoid placing residues into wetland areas from operations on upland sites. Deposit residues in stable upland locations.
- Locate windrows and slash disposal piles to:
  - Avoid cultural resources.
  - Minimize interference with natural drainage patterns.
  - Be outside of riparian management zones. Refer to Chapter 5: Riparian Areas and Wetlands.
  - Follow contours when possible to mitigate the effects of overland flow.

Protecting Resources

- Scarify or trench only the area necessary for seedling establishment and growth.
- Avoid operations during periods of saturated soil conditions when such operations may cause rutting, compaction or accelerated erosion.

BMPs: Protecting Resources

✓ Operate mechanical site preparation and tree planting equipment on the contour where necessary to minimize erosion in waterbodies.

✓ Avoid operating mechanical site preparation and tree planting equipment on slopes greater than 30 percent, where the slopes drain directly into a waterbody.

✓ Minimize raking in areas, or under conditions, in which soil could erode and enter waterbodies. Two preferred practices are: (a) shearing and raking when soil is frozen and (b) raking lightly to remove slash only.

✓ Suspend operations during wet periods if equipment begins to cause excessive soil disturbance that will increase erosion into waterbodies.

✓ Deposit site preparation residues in stable locations outside riparian management zones.

✓ Use patch scarification or low-intensity prescribed burns on sites that have steep slopes, erodible or saturated soils, and on sites that drain to surfacewater.

POST-OPERATIONAL ACTIVITIES

- Regenerate the site quickly after site preparation.
- Soil disturbance can result in the establishment of non-native invasive species. Monitor and control any new infestations.
- Evaluate site preparation methods relative to site conditions and silvicultural prescriptions. Be sure to monitor and manage the site to ensure success of establishment, and minimize the need for a repeat operation.

Figure 13-7: A Leno Scarifier that is mounted directly to the prime mover, allowing the operator to turn the machine easier in tight quarters.

Figure 13-8: A Wisconsin Conservation Corps crew leader begins pulling garlic mustard, a non-native invasive species, along a woodland edge.

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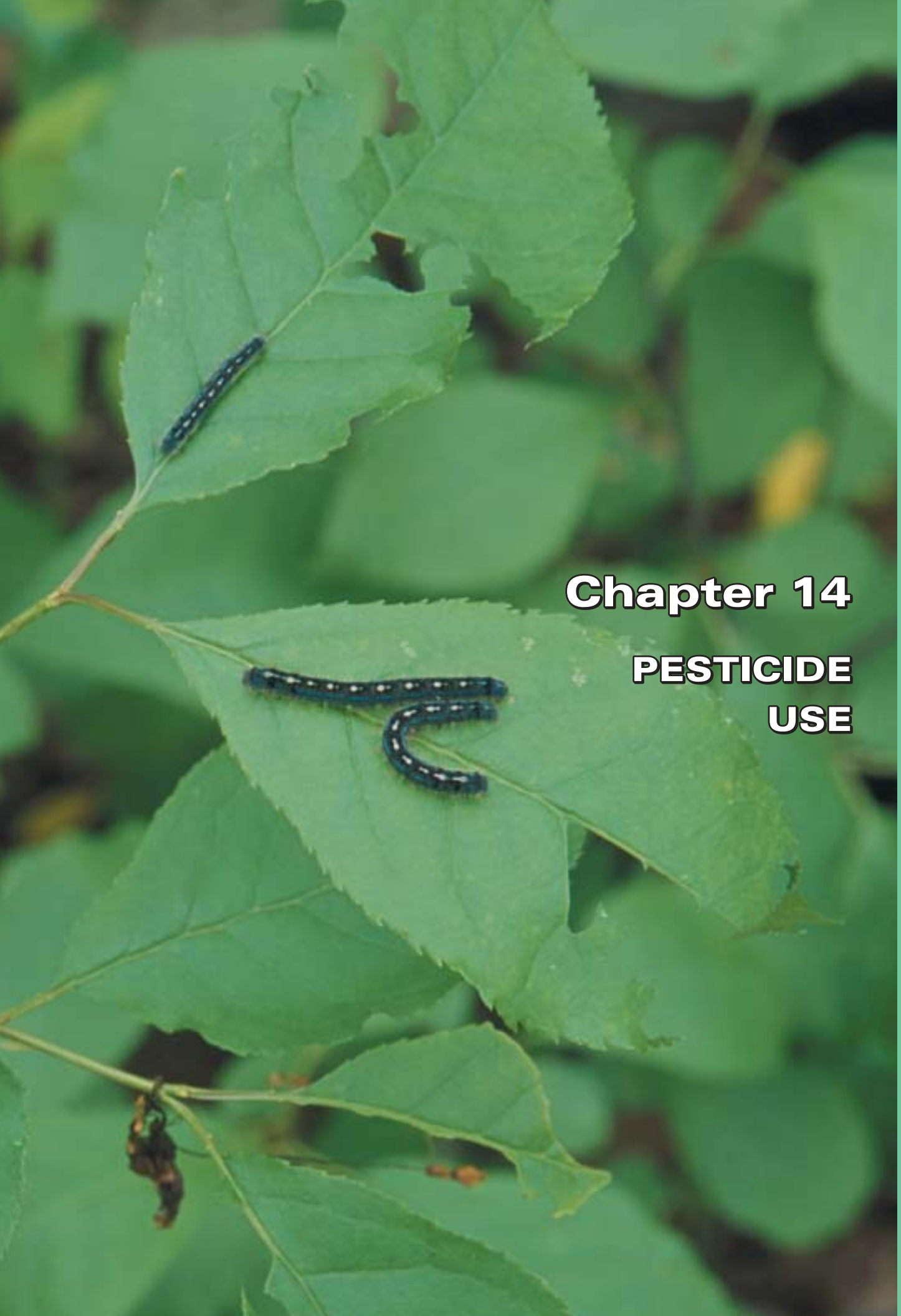

Chapter 14

PESTICIDE USE

CHAPTER 14 — PESTICIDE USE

Integrated Resource Management Considerations 186

PLANNING 187

Considering All Your Options: Integrated Pest Management 187
Pesticide Characteristics Affecting Ground and Surfacewater Contamination Potential 187
Selecting Pesticides 188
Selecting Application Methods 188
Spill Response 189
BMP: Spill Response 189

OPERATIONAL CONSIDERATIONS 190

Transportation of Pesticides 190
Storage of Pesticides 191
Emergency Planning and Community Right-To-Know 191
Mixing and Loading Operations 192
BMP: Mixing and Loading Operations 192
Pre-Application Activities 192
Timing and Weather Considerations 193
BMP: Timing and Weather Conditions 193
Applying Pesticides 193
BMPs: Applying Pesticides 193
Protecting Water Resources 194
BMPs: Protecting Water Resources 194

POST-OPERATIONAL ACTIVITIES 195

Equipment Clean-up and Container and Waste Disposal 195
BMP: Equipment Clean-up 195
BMP: Container and Waste Disposal 195

RESOURCES FOR ADDITIONAL INFORMATION 196

Figure 14-1: A spray plane equipped with special wing-mounted hoppers for dispensing Phermone Flakes mixed with glue to control the spread of Gypsy Moths.

Pesticides are chemical compounds that can assist in meeting forest management, utility, and right-of-way objectives by promoting the establishment, survival, growth, or maintenance of desired species or conditions.

Best Management Practices (BMPs) for water quality and other guidelines for use of pesticides are outlined in this chapter. Prominent pesticide related rules referenced include Chapters ATCP 29, 30 and 33, Wisconsin Administrative Code; Federal Insecticide, Fungicide and Rodenticide Act (FIFRA); Federal Worker Protection Standards; and Chapters NR 107 and 140, Wisconsin Administrative Code. Users must also adhere to instructions and prohibitions printed on pesticide labels (see Appendix D for additional pesticide regulations). **The safety measures described here are important to follow regardless of whether they are designated as formal BMPs or laws – your health and protection of the environment depend on the responsible handling and application of pesticides!**

Integrated Resource Management Considerations

- Planning is the essential first step in reducing pest problems. Maintaining water quality and protecting other resources is an important consideration in all aspects of pesticide operation planning.
- The effective treatment time for pesticides varies depending on the product and objectives. Some are most effective during the active growing season, which corresponds with the summer tourist/recreational-use season. Some can be applied during the dormant season.
- Broadcast application methods for herbicides may have a greater visual quality impact than band or spot treatment methods.

PLANNING

Consider All Your Options: Integrated Pest Management

Think about your objectives and develop a strategy to reach them. Determine what problems exist and what options you have to minimize them. When planning to use a pesticide, the target organism can be an insect, disease-causing organism or weed. Many insects, diseases and weeds may not significantly impact the objectives of the management plan, so a careful evaluation of the potential impact of these organisms must always take place before deciding to apply a pesticide.

Integrated Pest Management (IPM) can be defined as an ecological approach to pest management in which all available necessary techniques, including pesticides, are combined into a unified program. The goal is to manage pest populations in a way that avoids economic or aesthetic damage and minimizes the adverse side effects.

Pesticide use should be considered as part of an overall program to control pest problems. Integrated pest management strategies have been developed to control forest pests without relying solely on chemical pesticides.

For additional sources of information on IPM programs, see the Resource Directory.

Pesticide Characteristics Affecting Ground and Surfacewater Contamination Potential

The three main pesticide characteristics that can greatly affect a pesticide's potential to contaminate surface or groundwater are solubility, adsorption and half-life.

- **Solubility** is the ability of a pesticide to dissolve in water. The greater the solubility, the greater the chance that the pesticide will leach to groundwater or move in solution in surfacewater. Pesticides with very low water solubility's tend to remain at the soil surface and potentially move to surfacewater attached to sediment carried in runoff.

- **Adsorption** is the inherent ability of a pesticide to attach to soil particles. Some pesticides stick very tightly to soil, while others are easily dislodged. Adsorption increases as soil organic matter increases. An index or measure of soil adsorption is expressed by the **Koc Value**.
  - The greater a pesticide's ability to adsorb to soil particles, the less the potential for that pesticide to move (except by soil erosion in surface runoff).
  - Conversely, the lower a pesticide's ability to adsorb to soil particles, the greater the potential for that pesticide to leach into groundwater or move in solution in surface runoff.

- **Half-life** is the time it takes for a pesticide in soil to be degraded so that its concentration decreases by one-half. Each pesticide will have successive half-lives that will continually decrease concentrations by one-half.

The persistence of the pesticide in soil is the time it takes for the pesticide to degrade to the point where it is no longer active. Pesticides that do not break down quickly can be a hazard if they move into groundwater or surfacewater in toxic forms.

There are also soil and site characteristics that influence whether or not a pesticide will reach groundwater or surfacewater.

- Soils that are deep, high in organic matter, medium- to fine-textured (silty or clayey), and structurally sound are relatively good at "capturing" pesticides until they can be broken down by microbial activity. In general, the greater the depth to groundwater, the more the filtering action of the soil.

- Soils that are shallow (less than 20 inches), very coarse (sandy or gravelly) or drought-prone, are more likely to leach pesticides. Soils that are crusted or compacted are more likely to encourage pesticide runoff in surfacewater. A shallow depth to groundwater with highly permeable soils will also increase the chances of pesticide movement into groundwater. Surfacewater contamination can easily occur when pesticides are applied to sites adjacent to lakes, streams, wetlands, and natural drainage ways. If there is a quick conduit from the surface to the water table, such as a sinkhole, pesticides can be washed directly into the groundwater.

Selecting Pesticides

When the decision is made to use pesticides, choose products suitable for use on the target species and registered for the intended uses.

- Only use pesticides registered by the U.S. Environmental Protection Agency and the Wisconsin Department of Agriculture, Trade and Consumer Protection. Make sure the product is labeled for the intended purpose/application. Restricted Use Pesticides (RUPs) can only be purchased and applied by someone who is certified and licensed by the Wisconsin Department of Agriculture, Trade and Consumer Protection.
- Read and follow all label directions carefully prior to using any pesticide. The pesticide label is the information printed on or attached to the pesticide container or wrapper. The label and supplemental labeling are legally binding documents; you must follow them explicitly.
- Maintain current labels and Material Safety Data Sheets (MSDS). The MSDS is a source of cautionary information and data.
- Evaluate other factors besides effectiveness and cost when selecting among pesticide options. Factors that influence potential impacts on water quality and other forest resources include site characteristics, pesticide characteristics, application conditions, delivery systems, and application techniques.
- Select only pesticides labeled for aquatic use on sites where surfacewater is present at the time of application, or pesticides labeled for wetland use where water is near the surface. Make certain the product is labeled for the intended purpose/application.
- Select pesticides, application methods, equipment, and formulations that:
  - Avoid the potential for pesticide drift. **Drift** is the movement of pesticide in air currents or by diffusion onto property beyond the boundaries of the target area. Drift may occur as solid or liquid particles, or as vapors.
  - Avoid overspray or the application of pesticide beyond the boundaries of the target area.
  - Avoid pesticide residue movement to surfacewater and groundwater.

Selecting Application Methods

Choosing the proper application method will help ensure the target organism is affected, and help prevent drift, non-uniform coverage, and exposure to non-target organisms. There are several application methods including but not limited to broadcast, directed spray, foliar, foliar and stem, basal, cut-stump, frill and hatchet injection, spot and soil application, injection, or incorporation. Your choice should be based on careful consideration of the nature and habits of the target organism, the site, pesticide chosen, available equipment, cost, and efficiency. As mentioned previously, drift, overspray, and surface and groundwater contamination must be avoided.

- Select the application method that is appropriate for the site and is needed to obtain your goal(s). For example, a targeted application that provides a low intensity, spot or band treatment may be preferable over a broadcast treatment.
- Use pesticide application equipment that minimizes soil disturbance.
- The visual impact of vegetation treatment can be minimized by favoring band or spot treatment over broadcast, and by leaving untreated or selectively treated areas adjacent to travel routes and recreation areas.
- If an endangered, threatened or special concern species is known to be present, select pesticides, application method, and equipment with consideration to protect those species.

Figure 14-2: A handful of Phermone Flakes used for Gypsy Moth control instead of a chemical pesticide.

Spill Response

A **spill** is the release of a compound into the environment, including air, water, soil, etc., in any manner other than its intended use. Forestry pesticides that are spilled can enter surfacewater or groundwater. Spills near or in geologically-sensitive areas have a high probability of a portion of the spill reaching groundwater.

Treat spills properly. Recommended steps include the following:

- Protect yourself. Be sure you wear the necessary protective clothing and equipment so that you do not expose yourself to the material.
- Control the spill (stop the leak).
- Contain the spill (keep it from spreading). Contain the spilled material in as small an area as possible; construct a dam to prevent the chemical from spreading. It is particularly important not to allow any chemical to get into any body of water, including storm sewers.
- Guard the site.
- Notify the authorities (see contact information).

BMP: Spill Response

✓ Maintain a spill containment and clean-up kit appropriate for the site as well as all materials on the operation, and report all spills. See additional BMPs for Spills in Chapter 10: General Operational Guidelines, page 137.

- Clean up the spill. Specific recommendations regarding clean-up procedures can be obtained from the chemical manufacturer. The chemical manufacturer lists an emergency number on the product label, which anyone can call for information regarding how to respond to an emergency situation that involves a specific product. Each product also has a Material Safety Data Sheet (MSDS) that outlines what to do in case of a spill.

Contact the Wisconsin DNR whenever a spill occurs. Phones are answered 24 hours a day. Call 1-800-943-0003. NR 706 provides specific guidelines for reporting spills to the DNR.

OPERATIONAL CONSIDERATIONS

- **Conduct on-site meetings with the contractor, landowner and resource manager prior to moving equipment onto a site.** Such meetings can help assure a common understanding of landowner objectives, contract specifications, and site conditions.
- **Know the law.** The Wisconsin Department of Agriculture, Trade and Consumer Protection administers Chapter ATCP 29 and 30, WI Administrative Code, Pesticide Use, Control and Restrictions, which is the primary regulation concerning pesticide use in Wisconsin. ATCP 29 and 30 provide details regarding all aspects of pesticide use, and **must be followed**.
- **Read the label.** The pesticide label is the information printed on or attached to the pesticide container or wrapper. The label and supplemental labeling are legally binding documents; you must follow them explicitly.

Proper pesticide management practices make efficient use of chemicals while preventing or minimizing impacts on surfacewater, groundwater and other forest resources. Residues of pesticides used in forestry can affect these resources at any time – from transporting pesticides to container and waste disposal.

Transportation of Pesticides

The Federal Department of Transportation has designated many chemical compounds, including some pesticide active ingredients, as hazardous materials. Special training is required to transport hazardous materials. For questions on this topic, contact the Wisconsin State Patrol.

- The safest way to transport pesticides is secured in the back of a truck; never carry pesticides in the passenger compartment of any vehicle. Do not allow passengers or pets to ride in the back of the truck with the pesticide. Do not carry food, feed, seed, propagation material, or fertilizer with pesticides in the back of a vehicle.
- Inspect all containers prior to loading, and ensure that all caps, plugs and bungs (stoppers) are tightened.
- Wear the proper protective work clothes and chemical-resistant gloves even when handling unopened pesticide containers.
- Select transportation routes to minimize the impact of a potential spill on water quality.
- Never leave pesticides unattended.
- Keep the emergency number for reporting spills handy; **call 1-800-943-0003**.

Figure 14-3: Exercise caution when mixing and loading pesticides into the spraying tank. Carefully measure the required amount in accordance with the pesticide label.

Storage of Pesticides

If you store pesticides, you must protect and secure the area to keep out unauthorized people and animals. Also, post signs that clearly indicate you store pesticides in the building. Read and follow the storage statements on the label.

- Locate pesticide storage facilities at sites that minimize the possibility of impacts on water quality in case accidents or fires occur. Locate the facility down wind and down hill from sensitive areas such as houses, play areas, and livestock facilities.
- Select unloading and operational storage locations where spills resulting from accidents or vandalism will not have impacts on water quality.
- Use storage buildings that have floors constructed of concrete or other impermeable materials, so that spills are easy to clean up. Storage buildings should contain drains or sills with sumps large enough to contain the contents of the largest container stored in the buildings. Insulate building to keep the temperature between 40ºF and 100ºF. Keep the area well-ventilated by installing an electrically-shielded, exhaust-type, ventilating fan. Put up "no smoking" signs, and let the fire department know the storage area's location and contents.
- Avoid storing pesticides for extended periods of time. The shelflife of a pesticide is hard to predict. To prevent deterioration, mark each container with its date of purchase and use older products first; buy only what you need.
- Store only pesticides and pesticide equipment in storage facilities. Never store pesticides with food, feed, seed, plant propagation material, fertilizers, veterinary supplies, or personal protective equipment.
- ATCP 33, the Bulk Pesticide Storage Rule, must be followed if liquid containers larger than 55 gallons, or solid pesticides in undivided quantities greater than 100 pounds, are stored.

Emergency Planning and Community Right-To-Know

- The federal Emergency Planning and Community Right-To-Know Act and the Wisconsin Superfund Amendments and Reauthorization Act (SARA) provide guidance for communities to prepare responses to accidental releases of chemicals listed as extremely hazardous substances. OSHA and SARA maintain lists of substances considered extremely hazardous. Some pesticides appear on these lists.
- The EPA also prepared a list of extremely hazardous substances and their threshold planning quantities (TPQs). If you use or store any listed substance in a quantity at or greater than its TPQ at any one time, you must contact the State Emergency Response Board and your local emergency planning committee. The local committee should assist you in preparing a facility site plan. Employers who are subject to OSHA's right-to-know law are also subject to community right-to-know reporting requirements.
- For a complete list of extremely hazardous substances or for more information regarding the Emergency Planning and Community Right-To-Know Act, contact the State Emergency Response Board at **608-242-3232**.

Figure 14-4: Triple-rinse all containers and measuring cups, and add rinse water to the spray solution.

Mixing and Loading Operations

The hazard involved in mixing and loading pesticides requires you work with at least one other person. Wear personal protective equipment listed on the product label. If there are no specific instructions, wear at least a chemical-resistant apron and gloves, protective eyewear, and work clothes.

BMP: Mixing and Loading Operations

✓ Mix and load pesticides outside of riparian management zones and, where practical, in upland areas.

- Review the label before opening the container to ensure familiarity with current use directions.
- Exercise care and caution during mixing and loading of pesticides.
- Do not fill/clean pesticide equipment where pesticide might enter a well or surfacewater, or where rising water could flood the filling/cleaning site.
- It is **illegal to fill pesticide equipment** directly from waters of the state other than from public water supplies or private wells fully protected against back-siphonage either by an air gap or other equivalent protection device. Protect your water supply from contamination by using an air gap or an antisiphoning device.
- Comply with spill containment surface requirements if you mix, load or transfer more than 1,500 pounds of active ingredient at one site in a calendar year, or if you do so within 100 feet of a well or surfacewater.
- Do not mix or load pesticides within eight feet of a well or surfacewater under any circumstances.
- Fill a tank from surfacewater if the tank is used for water ONLY; **no pesticide container should come within eight feet of any surfacewater.**
- Transport and store hoses used to fill pesticide application equipment in a manner that prevents direct contact with pesticides, gasoline or oils, or surfaces on which these substances have been spilled.
- Replace the pour caps, and close bags or other containers immediately after use.
- Do not leave a spray or mix tank unattended while it is being filled.
- Triple-rinse all empty plastic and metal pesticide containers, and add the rinse water to the spray solution. You can use the rinsate in a future mix provided the pesticide in the rinsate is labeled for the site, and the final mix does not exceed label rates.

Pre-Application Activities

Ensure that pesticide applicators are properly licensed in the appropriate category by the Wisconsin Department of Agriculture, Trade and Consumer Protection when a license is required – see the Resource Directory for more information.

- Refer to and follow label directions before applying a pesticide.
- Mark the boundaries of the area for treatment.
- Protect vegetation that is part of a cultural resource (such as historic homestead sites) if it will be impacted by herbicide applications.

Timing and Weather Considerations

BMP: Timing and Weather Conditions

✓ Apply chemicals only under favorable weather conditions.

- Avoid applying pesticides when the likelihood of significant drift exists. Use a drift control agent when appropriate.
- Consider applying pesticides near dawn or dusk, when wind speeds are generally lowest.
- Follow the directions on the label that tells you not to spray when the wind speed is above a certain threshold.
- Limit broadcast applications (both aerial and ground) to appropriate temperature and relative humidity conditions. High temperatures enhance loss of volatile pesticides and the rate of evaporation of droplets. Relative humidity also influences the rate of evaporation, with the rate increasing with decreases in humidity. Apply chemicals only under favorable weather conditions.

Figure 14-5: Apply chemicals with the right equipment during calm weather to avoid unwanted drift. Band or spot applications, seen above in a walnut plantation, are preferred to broadcast spraying.

Applying Pesticides

BMPs: Applying Pesticides

✓ Prevent chemical leaks from equipment. Check all equipment for leaking hoses, connections and nozzles.

✓ Calibrate spray equipment to apply chemicals uniformly and in the correct quantities.

✓ Follow all EPA label instructions on containers.

✓ When conducting aerial applications:
- Hire a licensed aerial applicator.
- Identify and avoid riparian management zones and surfacewater to prevent chemicals not labeled for aquatic use from drifting over open water, or from accidentally being applied directly on the water.

- Read and follow all label directions carefully prior to using any pesticide. The pesticide label is the information printed on or attached to the pesticide container or wrapper. The label and supplemental labeling are legally binding documents; you must follow them explicitly.
- Employ the lowest reasonable equipment pressure when applying pesticides.
- Mix pesticides in upland areas, where practical.
- Select a nozzle type that produces the largest drops at a given rate and pressure appropriate to the chemical being applied.
- Avoid applying pesticides on small wetland inclusions in upland areas unless that application is part of the management objective. If unable to avoid pesticide use in these areas, select only pesticides labeled for aquatic use when surfacewater is present at the time of application. Select pesticides labeled for wetland use when the water table is near the surface.

- Avoid broadcast application methods within riparian management zones (RMZs). Appropriate treatments within RMZs include:
  - Use of pesticides labeled for aquatic use
  - Manual or mechanical treatments
  - No treatment
  - Spot, banded, stump, basal bark, hack and squirt, frill, or injection treatments
  - Use of less soil-mobile pesticides
  - Increasing filter strip width when using toxic to highly-toxic insecticides

- **Applicator Certification/licensing Requirements:** Pesticide Applicator Training (PAT), provided by the University of Wisconsin Extension, provides the training and certification to people who want to mix, load, supply, or direct the use of restricted-use pesticides. Only a certified applicator may work with restricted-use pesticides. PAT is also recommended for any person working with pesticides. Participation in this program, certification and licensing may be required for person's involved with pesticides, depending on the activities planned. Contact the Wisconsin Department of Agriculture, Trade and Consumer Protection (see the Resource Directory) to determine whether or not you need to be certified or licensed.

- **Other Training Requirements:** Employees covered by the Worker Protection Standards (other than members of an agricultural owner's immediate family) must be trained on general pesticide safety principles every five years. This training may be obtained through PAT or through training programs in compliance with the EPA.

Protecting Water Resources

Pesticides spilled or applied to the surface of the land can be carried or leached down to groundwater by water moving through the soil. Pesticides can also reach surfacewater in runoff or in contaminated groundwater that is discharging to surfacewater. **ATCP 29 and 30** outline the WDATCP's regulatory program for the prevention and control of ground and surfacewater contamination. **Chapter NR 140** also contains rules that the DNR has written to govern groundwater protection.

BMPs: Protecting Water Resources

- ✓ Use chemicals in riparian management zones with guidance from a trained natural resource professional.
- ✓ When applying chemicals not labeled for aquatic use in riparian management zones, use spot-injection or stump treatment methods.
- ✓ Avoid applying herbicides in areas where the chemicals can kill stabilizing vegetation on slopes, gullies and other fragile areas subject to erosion that drain into surfacewater.

- Avoid applying pesticides directly to water except where the pesticide is specifically labeled for application to water. When the pesticide does not have a full aquatic label, avoid riparian management zones, filter strips or shade strips and other reserve areas adjacent to all streams, lakes, wetlands, and ditches that contain water at the time of application. Always refer to the label to determine legal use and application.

- Avoid applying herbicides in areas where the chemicals can kill stabilizing vegetation on slopes, gullies and other fragile areas subject to erosion, that drain into surfacewater.

- Prohibit aircraft transporting pesticides from crossing open water where practical. Aircraft also should not fly down the course of any recognizable stream. Where stream crossings cannot be avoided, they should be made at right angles to the stream course. Chemical application should be shut off during turns and over water.

- Select potential heliport or helipad locations with consideration for two conditions that could affect water quality: 1) flight patterns in relation to waterbodies; and 2) locations adjacent to waterbodies.

POST-OPERATIONAL ACTIVITIES

Equipment Clean-up and Container and Waste Disposal

BMP: Equipment Clean-up

✓ Rinse spray equipment and discharge rinse water only in areas that are part of the application site.

BMP: Container and Waste Disposal

✓ Dispose of pesticide wastes and containers according to state and federal laws. Some pesticide wastes are specifically identified as hazardous wastes by law – these must be handled and disposed of in accordance with hazardous waste regulations. For sources of information about proper management of waste pesticides, see the Resource Directory.

Figure 14-6: Use only properly maintained spraying equipment that has been checked for leaks. Make sure the nozzle type produces the largest drops at a given rate and pressure appropriate to the chemical being applied.

The federal government regulates the disposal of pesticide waste under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and the Resource Conservation and Recovery Act (RCRA). In Wisconsin, the DNR further regulates such disposal under Administrative Codes NR 500 series and NR 600 series.

- Clean equipment on a concrete pad with a collection basin and tanks to hold rinsewater. Use the rinsewater for preparing future mixes for a labeled site. Never clean in areas where pesticide residues will enter streams, lakes, wetlands, or groundwater.
- Rinse mixing apparatus at least three times. Apply rinsate in spray form to the area to be treated, being sure not to exceed label recommendations.
- Rinse all empty plastic and metal pesticide containers three times, and add the rinsewater to the spray solution. To properly triple-rinse containers:
  - Empty the pesticide into the spray tank and allow the pesticide container to drain.
  - Fill the container 10 to 20 percent full with water (or solvent, in some cases), rinse, and pour the rinse water into the spray tank.
  - Repeat the previous step two more times, and apply rinsate to the spray site.
  - Apply all leftover solutions and rinsates to the treatment area, being sure not to exceed label recommendations.
- Puncture and flatten containers not intended for return to the manufacturer.
- Refer to the product label for additional information on proper disposal.
- **It is illegal to bury or burn any pesticide containers in Wisconsin.**
- Dispose of triple-rinsed containers in one of four ways:
  - Return them to the dealer for reuse or refilling.
  - Recycle them through the Wisconsin Fertilizer and Chemical Association Plastic Pesticide Container Recycling Program.
  - Bring them to a county Pesticide Clean Sweep program.
  - Dispose of them at an approved landfill.

RESOURCES FOR ADDITIONAL INFORMATION

INFORMATION ON PESTICIDE LABELS
www.cdms.net/pfa/LUpdateMsg.asp

WDATCP PESTICIDE DATA BASE SEARCH SITE
www.kellysolutions.com/wi/

TO REPORT PESTICIDE SPILLS
Contact the Wisconsin DNR at **1-800-943-0003**.

These resources are specific to the information in this chapter only. Refer to the Resource Directory for additional resources related to this chapter.

WISCONSIN FOREST MANAGEMENT GUIDELINES

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Wisconsin Department of Natural Resources
Division of Forestry
PO Box 7921
Madison, Wisconsin 53707

For additional information, call **608-267-7494** or visit our web site at:
www.dnr.state.wi.us/org/land/forestry/

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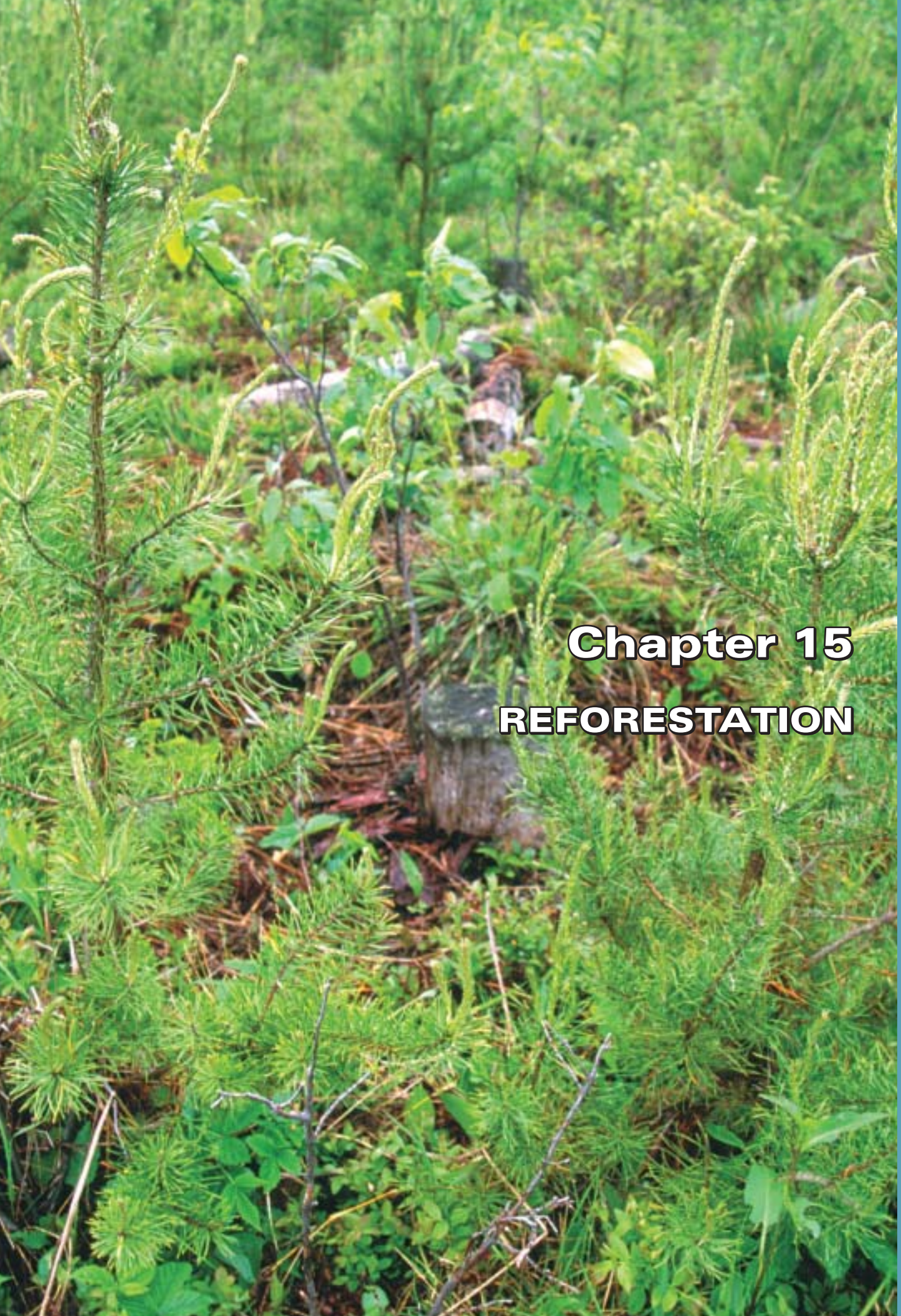

Chapter 15

REFORESTATION

CHAPTER 15 — REFORESTATION

Integrated Resource Management Considerations 198

PLANNING AND DESIGN 199

Setting Goals 199
Site Evaluation 199
Planting Design 201
Species Selection 202
Spacing 202
Planting Arrangement 203
Direct Seeding vs. Seedlings 204
Seed Source Selection 205
Stock Type Selection 206

OPERATIONAL ACTIVITIES 207

Site Preparation 207
Planting 208

POST-OPERATIONAL CONSIDERATIONS 211

Monitoring Program 211
Vegetation Control 211
Animal Control 212
Insect and Disease Control 212
Weather and Environmental Damage 213

RESOURCES FOR ADDITIONAL INFORMATION 214

Reforestation is the practice of regenerating and growing healthy trees on previously forested sites. Reforestation can include both natural and artificial methods.

- **Natural regeneration methods** include root suckering, stump sprouting, or natural seeding as a result of the application of one of the silvicultural systems as described in Chapter 2: Generally Accepted Silvicultural Principles.
- **Artificial regeneration methods** involve aerial or ground seeding, or planting seedlings by hand or with a planting machine.

This chapter provides an overview of the planning, design, site preparation, and planting methods needed to successfully establish forest tree plantings in Wisconsin.

Afforestation is the practice of planting trees to create a forest on non-forested land.

Species conversion is changing the species composition of a forest from one forest cover type to another.

Restoration is the process of reintroducing and maintaining native flora on a given site.

Integrated Resource Management Considerations

- A written reforestation plan will increase the likelihood of success by clarifying all of the site preparation and planting details, and identifies measures needed to minimize any impacts on other important resources.
- Landowners should analyze their available budget, time constraints, and access to reforestation resources (e.g., nursery stock, equipment, and labor) when considering a reforestation project. **A realistic budget must account for the cost of establishment and follow-up care,** such as weed control treatments.
- Species selection, site preparation and planting methods, and plantation design can affect 1) visual quality, 2) the degree of soil disturbance, and 3) wildlife habitat values.
- Reforestation considerations should be part of any harvesting plan.
- Protection of cultural resources may require modification of reforestation efforts.
- Endangered, threatened and special concern species can be impacted by reforestation projects.

Figure 15-1: Artificial regeneration methods include machine planting which is quite appropriate when old farm fields are planted, in this case, to red pine.

Figure 15-2: Natural regeneration methods, like the shelterwood harvest that resulted in these young red oak seedlings, are described in Chapter 2: Generally Accepted Silvicultural Principles.

PLANNING AND DESIGN

Setting Goals

The first step in planning a reforestation project is to think about how it relates to both short- and long-term landowner goals. Such goals might include producing income from timber, improving habitat for specific wildlife species, restoring a natural plant community, reducing soil erosion, improving water quality, or enhancing the aesthetics of the land. **Remember that many goals are compatible with each other, allowing a single forest planting to serve multiple purposes.**

Site Evaluation

Planning reforestation activities begins with evaluating the planting site. Knowledge of potentially limiting site factors such as soils, existing vegetation, and productivity potential will aid in selecting suitable species, preparing the site, and prescribing post-planting management practices.

CLIMATE

Tree species are adapted to a specific range of climatic conditions. Since Wisconsin has a wide range of climates, our state hosts a wide variety of native tree species. Therefore, it is important to select species that are adapted to the climatic conditions of the planting site. For example, several species reach the northern limit of their range in Wisconsin. Species like black walnut are limited to the southern portion of the state by climatic factors such as minimum winter temperature. Other climatic factors to consider when initiating a plantation are timing and amounts of precipitation, the potential for ice storms and snow loads, and risks associated with early or late frosts.

SOILS

Soil properties affect the moisture and nutrients available for tree growth. Therefore, a careful analysis of the soil characteristics and uniformity is a critical step in selecting trees species that are well-adapted to the planting site. **If possible, examine the soil to a depth of two to five feet, paying particular attention to:**

- Soil texture – is it too coarse or sandy?
- Depth of topsoil – what is the available rooting depth?
- Parent material – is high or low soil pH a potential problem?
- Available moisture – is there adequate organic matter in the soil?
- Internal drainage – does water drain freely or puddle following rain?
- Nutrients – does current vegetation appear lush or chlorotic?
- Bulk density – is the soil compacted or have a hard pan due to past land use?
- Erosion patterns – has original topsoil been heavily eroded?

A careful soil examination is the best way to evaluate the potential of any site to support tree growth. Site quality is almost impossible to change significantly once trees are planted, so a careful assessment of soil and site characteristics is essential. Soil uniformity can also be checked so that species recommendations can be customized to fit the site. Alternative methods of soil evaluation include the use of published soil surveys, and completion of soil lab analysis. Soil survey reports and/or soil maps offer a general assessment of landscape soil features, but may not be sufficiently detailed to help with small plantings. Also, older soil surveys may not reflect current conditions if intensive agriculture or other development has reshaped the local soil resource. A soil lab analysis provides information on selected soil properties, and can identify possible nutrient deficiencies (see the Resource Directory for sources of both soil survey reports and a soil lab analysis).

COMPETING VEGETATION

Existing and potential vegetation will compete with young seedlings for moisture, nutrients and light. **Not all vegetation is alike in its ability to compete with young trees,** and must be evaluated in order to determine the timing and extent of appropriate control measures. Vegetation existing on the planting site is an obvious consideration, but other plants that regenerate readily from dormant seeds or from well-established root systems also pose potential problems. The types and amounts of competing (or potentially competing) vegetation must be considered when selecting appropriate planting stock, site preparation treatments and maintenance activities.

TOPOGRAPHY

Elevation, slope, aspect (north, south, east or west), and surface drainage affect the local environmental conditions of a planting site. For example, northern aspects generally have lower evaporation rates, and therefore, greater available soil moisture to support plant growth. Topographic affects may influence more than just growth potential. Occurrences of white pine blister rust can be worse in certain landscape positions (e.g., certain drainage channels, or some ridges) where humidity and the aerial movement of spores increase.

PRODUCTIVITY

Site productivity is the capacity of a site to yield a given forest product in a specified period of time, and has traditionally been measured as gross volume per acre per year. Evaluation of productivity levels will help in the selection of species that will exhibit optimal growth on the planting site. Productivity can be evaluated in several ways:

- **Site Index:** Examining the growth rates of existing or adjacent forest trees.
- **Habitat Type Classification:** Using other plant community information.
- **Site Productivity History:** Examining the records of past yields or performance.

Some of these measures are indirect, and provide estimates of potential productivity rather than precise measurements. Keep in mind that productivity generalizations from one species to the next vary greatly – what may be viewed as adequate productivity for one species may prove to be inadequate for others.

LANDSCAPE POSITION

The benefits of a forest planting can be enhanced if it is compatible with and complimentary to the surrounding forest cover types and ecological communities. Examine the broader landscape to assess existing cover types, habitat needs, and management trends. For example, tree planting may be used to establish mast-producing species, such as red oak, in areas where the oak resource is declining due to natural succession or species conversion. Alternatively, past development practices may have fragmented a landscape that can now be coalesced via a successful planting.

INSECTS, DISEASES AND ANIMALS

Insects, diseases and animals can have locally devastating impacts on young plantings, and hamper reforestation success. Proper site evaluation must include an assessment of these risks. **The key to recognizing potential pest or predation problems is to examine the following:**

- Site history – were earlier forest stands disease or predation prone?
- Population trends – are new pests/pathogens present?
- Evidence of pests and alternate hosts on the planting site – are site conditions conducive to problems?
- Vulnerability of tree species to infection based on site characteristics – does the preferred reforestation species have a history of pest/predator problems?

SUCCESSION

Forest plantings can have long-term effects on the landscape. Planted species may begin to regenerate naturally, affecting the future species composition on the current and nearby sites. Landowners may wish to purposely introduce a seed source into a new planting, in the expectation that it will create natural regeneration opportunities at stand rotation. A mixed red and white pine plantation that has developed an understory of white pine seedlings is a good example of the long-term effects of seed source introduction.

ENDANGERED RESOURCES

Endangered, threatened and special concern species can be impacted by site preparation activities, by altering the existing vegetation, or by introducing new species. Perform a Natural Heritage Inventory (NHI) screening prior to reforestation activities in order to identify and address potential impacts. You may need to alter your choice of species or regeneration technique (see Chapter 3: Wildlife Habitat for more information on NHI).

Planting Design

A planting design will provide specific details for the creation and management of a planting including acreage, species, number of trees, spacing, nursery stock type, arrangement, site preparation and planting method, layout of roads and firebreaks, and any post-planting maintenance. A written reforestation plan and map should be developed to help clarify all these details, and facilitate any modifications prior to planting. A plantation map can help show precise planting locations, species arrangement, and access roads.

A planting design is directly tied to a landowner's goals, and the resources and capabilities of the planting site.

Figure 15-3: Promoting a mixture of species encourages and maintains diversity – which also provides wildlife habitat diversity – and the positive visual impact of a natural-appearing landscape.

EXAMPLES OF GOALS AND THEIR ASSOCIATED DESIGN CONSIDERATIONS

Timber Management

- Match species with area market demands and opportunities.
- Provide equipment access for thinning, pruning, and harvesting.
- Include harvest roads and firebreaks.
- Add species that will create future natural regeneration opportunities.
- Leave space around powerlines, underground cables and gas lines.
- Avoid steep slopes and wet areas.
- Provide closer spacing of hardwoods to improve sawtimber quality.

Aesthetics

- Use a variety of species, including wildlife shrubs.
- Use non-row plantings, curved rows, and irregular edges for a more natural effect.
- Plant species with desirable fall color.
- Leave openings or islands of various sized and aged trees.
- Retain landmarks and distinct features.
- Create or retain scenic views.
- Locate trails or roads to take advantage of scenic quality.

Wildlife Management

- Enhance biological diversity and complement habitat in the surrounding landscape.
- Offer habitats that are in locally short supply.
- Choose species which provide preferred food for desired wildlife.
- Establish or expand travel corridors so they connect habitats.
- Create irregular boundaries for more habitat options.
- Enhance interior forest habitat by planting artificial openings, such as isolated fields.
- Plant around existing "wolf" trees.
- Leave frost pockets and odd corners unplanted to improve habitat variety.
- Leave wildlife openings.

Erosion Control

- Leave grass buffer zones near streams to help prevent siltation.
- Plant trees along contours to help control runoff.
- Leave drainage pathways covered in grass.
- Concentrate trees in "problem" areas.
- Plant tree species in riparian zones that have a long life expectancy.
- Plant highly erodible upland fields to decrease runoff.

Species Selection

The tree species selected for reforestation must be compatible with the landowner's management goals, and biologically-suited to the planting site. After determining the potential advantages and limitations of the planting site, select a species or combination of species that emphasize the advantages and overcome the limiting factors. Consider the following:

- Site requirements, especially soil factors
- Climatic suitability
- Potential growth rate on site
- Sunlight requirements
- Potential competition problems
- Potential for insect and disease problems
- Wood and fiber properties and potential markets
- Compatibility with other species
- Timber, wildlife, erosion control, and aesthetic values

Detailed information on individual tree species' characteristics is available in the Wisconsin DNR *Silviculture and Forest Aesthetics Handbook, 2431.5*.

ADVANTAGES AND DISADVANTAGES OF WIDE AND CLOSE SPACING

WIDE SPACING ADVANTAGES

- Planting costs are less.
- Trees attain larger diameters and become merchantable sooner.
- Trees may produce greater quantities of seed/mast at an earlier age.
- Increased understory growth will provide wildlife food and habitat.

WIDE SPACING DISADVANTAGES

- Increased weed competition and maintenance.
- Reduced stem quality due to greater taper and longer branch retention.
- Increased fire hazard.
- Reduced erosion control.

CLOSE SPACING ADVANTAGES

- Faster crown closure resulting in less weed competition and maintenance.
- Improved stem quality (straighter boles and small, self-pruning branches).
- Large wood volumes accumulate in early years.
- Greater number of trees to select from during thinning operations.

CLOSE SPACING DISADVANTAGES

- Increased site preparation, planting, and seedling costs.
- Early timber stand improvement may be needed to reduce crown competition.
- Access during initial thinning operations may be difficult.

Spacing

Initial spacing will affect both the productivity and the management of a plantation. The choice of spacing will depend on the species selected, product desired, need for and intensity of intermediate stand treatments, expected initial survival, and cost.

Figure 15-4: Successful planting requires vigorous seedlings of sufficient size with a healthy root system.

Height growth can be reduced at extremely high or low densities. Fortunately, the most commonly used tree planting densities fall within a range that does not reduce dominant tree height (see Table 15-1).

	4'	5'	6'	7'	8'	9'	10'
4'	2,722						
5'	2,178	1,742					
6'	1,815	1,452	1,210				
7'	1,556	1,244	1,037	889			
8'	1,361	1,089	908	778	681		
9'	1,210	968	807	691	605	538	
10'	1,089	871	726	622	545	484	436
12'	907	726	605	518	454	403	363
15'	726	581	484	415	363	323	290

Table 15-1: Number of trees per acre by spacing (in feet). The shaded areas represent the more commonly recommended spacings for reforestation purposes.

Generally, for quality hardwood tree production, choose a closer spacing to encourage straight boles, and small, lower branches that self-prune easily. Hardwood plantings for wildlife purposes can use wider spacing to encourage crown development and earlier seed production. Note that plantation spacing requirements may be specified by some cost-sharing and tax law programs (see the Resource Directory for information on these programs).

Planting Arrangement

Planting arrangement refers to the pattern or distribution of tree and shrub species across a planting site. The arrangement of species may be varied to match topographic features, changing soils or site conditions. For example, a mixed hardwood plantation may concentrate black walnut seedlings on the deeper topsoils of the lower slope, and place red and white oak seedlings near the ridge tops and convex slopes. The arrangement should also consider the growth characteristics and compatibility of species planted next to each other. For example, due to the fast juvenile growth of green ash, an alternating pattern with white oak may result in suppression of the oak. One solution is to group the species within the planting to minimize problems associated with very different juvenile growth rates.

Recently, conifer and hardwood mixtures have been recommended for afforestation in Wisconsin. The benefits of these conifer-hardwood mixtures include:

- Conifers assist in early crown closure and capturing the site.
- Cost of plantation establishment is less than for a pure hardwood plantation.
- Conifers improve the quality of hardwoods by shading out lower branches, and forcing hardwoods to grow straight.
- Conifers provide wind protection and offer an easy alternative for a first thinning.

One disadvantage to this mixture is that, once established, the options for chemical release of the plantation are more limited than pure conifer plantings. **Initial site preparation treatments are critical for successful conifer-hardwood plantations.** In addition, alternate row plantings may necessitate the removal of all conifers during the first thinning, unless other thinning methods are designed into the plantation.

Figure 15-5: In addition to other benefits, mixtures of hardwoods – planted here in tree shelters – and conifers may be more resistant to insect and disease pests than monocultures.

Interplanting is the practice of planting new seedlings between or among existing forest growth. Sometimes forests fail to regenerate as expected after a harvest, and interplanting provides a way to supplement natural regeneration. The planting arrangement in this situation will depend on an evaluation of the number, size, and spatial distribution of desirable advanced reproduction. Do not forget to factor in the contribution of stump or root sprouts to fill all or part of the reproduction deficiency. Interplanting is almost always accomplished by hand planting. Interplanted trees will be in competition with other vegetation so their success can be measured against the growth of dominant competing vegetation. Generally, larger sized seedlings (e.g., 2-0 or 3-0 hardwoods and 3-0 or transplant conifers, see "Planting Stock Age Classes – What Do Those Numbers Mean?" sidebar on page 206 for clarification) are needed to compete with the advanced reproduction and sprouts. These types of plantings generally require some type of release early in the establishment phase.

Direct Seeding vs. Seedlings

One of the initial planning decisions is whether to plant seeds or seedlings. Each method has advantages and disadvantages in terms of ecology, operation and expense.

The advantages of direct seeding include:

- Less expense for conifer plantings or small areas.
- Quick establishment of tree cover to "capture" the site.
- Applicable on difficult terrain or shallow soils.
- Good root development with no transplant shock.
- More uniform stocking than in a naturally regenerated stand.
- Improved hardwood stem quality in high density plantings.

Direct seeding is often times not successful, although many such instances can be attributed to improper planning. Multiple factors influence seed germination, making careful planning critical in highly variable field environments.

Other disadvantages include:

- Necessity for intensive site preparation and follow-up weed control.
- Difficulty controlling stand density.
- Greater costs for hardwoods depending on the quantity of seed used.
- Small planting areas may be subject to heavy seed predation.
- Hardwood seed is difficult to obtain in most years and does not store well.

Proper seed collection, handling and storage are critical to the establishment of direct seeded plantations. Seed collected during an abundant seed year is usually higher quality, especially if mature seeds are collected just before, or simultaneously with, seed fall. Always consider seed source by collecting from quality trees that are within 100 miles of the planting site, or from sources that have proven performance through genetic testing. Properly store, stratify and treat seed to maximize germination rates. Additional seed handling information on particular species is available in the *USDA Forest Service Woody Plant Seed Manual*.

Figure 15-6: Interplanting spruce seedlings by hand in a harvested hardwood stand to augment natural regeneration, and provide species diversity.

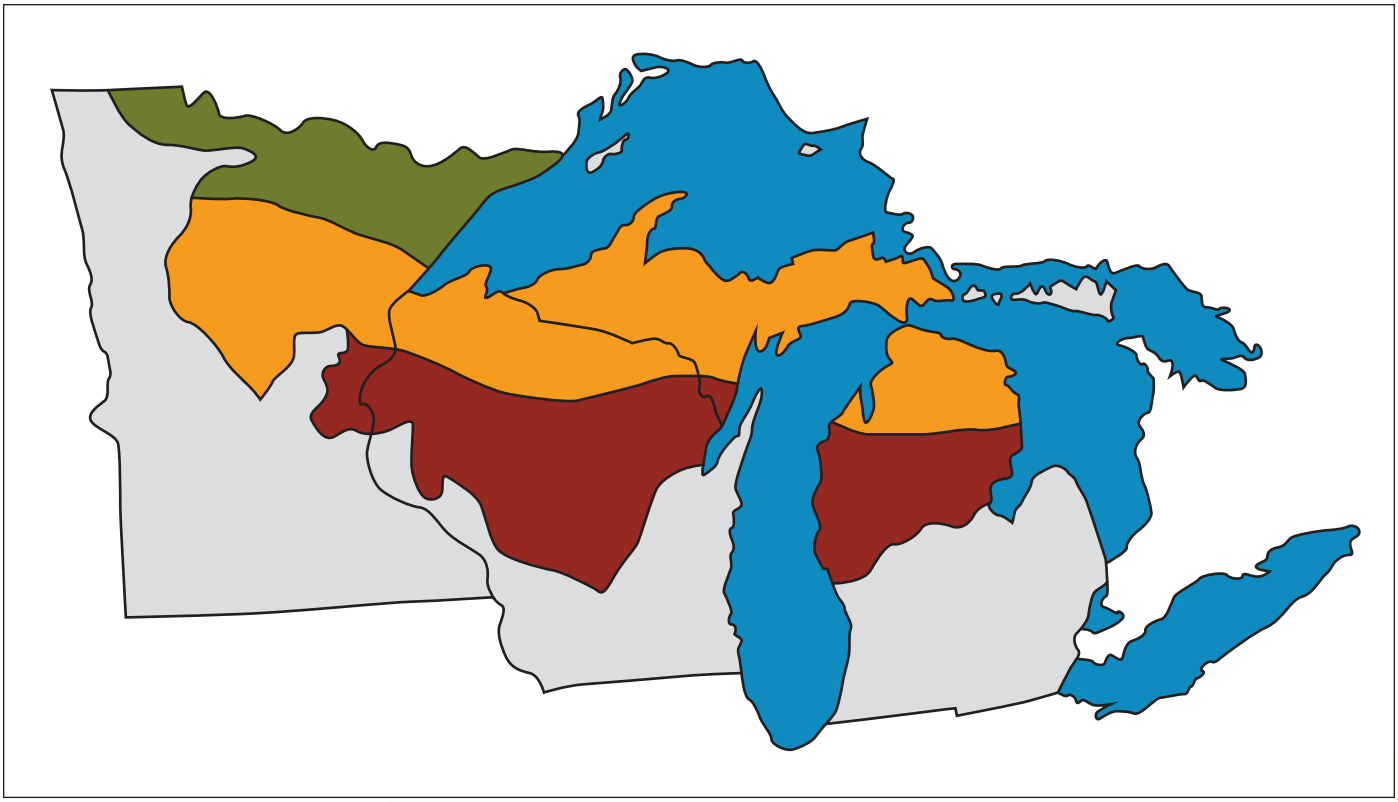

Figure 15-7: Jack Pine Seed Source Trial (20-year Results). Seed zones established for the appropriate movement of jack pine seed sources in Wisconsin. Tree performance is generally best when seed sources are kept within a particular zone.

Seed Source Selection

Seed source is an often overlooked but critical component in a successful reforestation program. **Selecting appropriate seed sources will improve the overall productivity of the plantation, since the trees will be adapted to the environment of the planting site.** Appropriate seed source selection will also reduce catastrophic plantation losses due to poorly adapted genetic material. Poorly adapted seed sources can survive and grow for many years, until an environmental event, such as an early frost or extremely cold winter, results in catastrophic losses.

Local seed sources (e.g., Wisconsin) are the most appropriate unless proven otherwise through genetic testing. For example, genetic testing has revealed that southern Ontario white spruce sources are well-adapted to Wisconsin's environmental conditions, and also offer improved growth rates over local sources. Tree improvement efforts continue to examine seed source performance across Wisconsin in order to identify appropriate sources and seed zones (see Figure 15-7). Advanced tree improvement practices include 1) the establishment of seed production areas to facilitate the collection of seed from quality, native stands, 2) the establishment of progeny tests where individual families are tested and selected for high performance, and 3) seed orchards for the production of high quality seed with superior genetic potential.

Stock Type Selection

Selection of the best nursery stock type for a given situation depends upon the identification of planting site factors that influence seedling establishment and early growth. **Consider the relative advantages and disadvantages of containerized versus bareroot stock** in order to select seedlings that will meet the landowner's goals, and overcome any limiting factors of the planting site.

Containerized stock is usually less than one-year-old and is grown, shipped and planted in a soil "plug" of peat, perlite (or vermiculite) and sand. Usage in the Lake States has been restricted primarily to conifer seedlings, but recent advances in pot sizes have allowed some production of containerized hardwoods. The advantages of containerized stock include the fact that seedlings can be grown in six to 15 weeks, they have high survival rates, superior initial height growth, more uniform size, and good plantability, especially on rocky sites where it may be difficult to open a large hole for bareroot seedlings. In addition, these seedlings are less likely to experience transplant shock since the tree is planted in the rooting medium, and the process makes more efficient use of seed. Finally, containerized stock extends planting seasons, and seedlings can perform well on adverse sites. Containerized seedlings also are more resistant to heat and drying stress, so transportation and storage are less problematic. Containerized stock, however, is more expensive than bareroot stock, more bulky to transport and handle, less able to compete with weeds, susceptible to deer browse, prone to frost heaving when planted on bare mineral soil, and often smaller in size.

PLANTING STOCK AGE CLASSES – WHAT DO THOSE NUMBERS MEAN?

Bareroot stock is often sold using an age class designation, such as 1-0, 2-0, 3-0 or 2-1. The first numeral refers to the number of years spent in a seedbed. For example, a 2-0 designation means the tree spent two years in a seedbed. The second numeral refers to the number of years spent in a transplant bed. For example, a 2-1 designation means the tree spent two years in a seedbed and one year in a transplant bed (transplanting improves root development).

Bareroot stock is seeded and grown in nursery beds for one to three years, and may be moved to a transplant bed to improve root development. Conifer seedlings should have a four to six millimeter caliper, and a 2:1 shoot to root ratio (i.e, a shoot twice the length of the root). Hardwood seedlings should have good lateral root development with a minimum of five primary lateral roots (greater than one millimeter in diameter) for optimal seedling survival and growth. Advantages of bareroot stock include lower costs, ease of transportation and storage, competitive advantage over weeds, less susceptibility to deer browse, and faster root regeneration. Bareroot stock, however, takes longer to grow, can dry out quickly due to exposed roots, is prone to root damage and deformity during planting operations, and may require special planting considerations due to the larger seedling size.

Figure 15-8: Soil scarification with a spiked anchor chain is a type of mechanical site preparation that prepares a seed bed for acorns in oak forests.

OPERATIONAL CONSIDERATIONS

Site Preparation

Site preparation is the creation of a favorable growing environment for tree seeds or seedlings. The biggest obstacle facing seedling establishment is competition from other vegetation. Effective site preparation will reduce competing vegetation, and create a sufficient number of suitable growing sites without causing excessive soil disturbance.

Mechanical site preparation typically disturbs the soil and reduces competing vegetation by plowing, disking, raking, chopping, scalping, and trenching, among other approaches. In some cases, mechanical site preparation can be valuable, as exposing and disturbing mineral soil can have the added benefits of increasing root zone temperatures, aerating the soil, and improving drainage. **However, when mechanical site preparation is done incorrectly, it can result in soil erosion, compaction and rutting.** Also consider the potential competing vegetation that may develop from dormant seeds after the soil is exposed. A combination of both mechanical and chemical techniques can be used for added control. Chapter 13: Mechanical Site Preparation provides additional guidance on mechanical site preparation techniques, and the considerations involved in the selection of a particular method.

Chemical site preparation can be an effective method to control vegetation, and increase the amount of sunlight and water available for plant growth. Chemical methods may involve simple equipment, can be less expensive, and provide longer control than mechanical site preparation. **However, chemical effectiveness depends on the appropriate herbicide selection, the timing of application, application rate, and weather conditions.** Herbicide applications may need to be repeated for several years to ensure stand establishment. All herbicides must be applied in accordance with label recommendations and their registered use. Detailed forestry herbicide information is available in Forestry Facts Sheet #76, University of Wisconsin Extension (see Chapter 14: Pesticide Use, for additional information on the safe use of herbicides).

Prescribed burning, or controlled ground fires, can be an effective and inexpensive means of removing or reducing vegetation, and preparing a suitable seedbed. Burning can also improve soil nutrient levels and ectomycorrhizal development. Prescribed burning, however, can reduce the effectiveness of pre-emergent herbicides and can increase solar heating at the groundline, leading to seedling mortality. The use of fire as a vegetation management technique is very appealing to many small landowners because it appears "natural" – but it can be dangerous. **Effective and safe use of prescribed fire requires appropriate equipment and training** (see Chapter 17: Fire Management and the Resource Directory for sources of technical assistance and information on any permits required).

Cover crops are appropriate for afforestation sites where they are grown to prevent invasion by noxious weeds, non-native invasive species, or other competing vegetation. Cover crops can also control soil erosion, improve soil condition, and increase water-holding capacity. When selecting a cover crop, choose a species that will accomplish the site preparation objectives, but not adversely impact tree growth. Legumes are sometimes selected as cover crops because they can enhance soil nitrogen. Small grain crops, such as winter wheat and rye, can inhibit weed growth, and add organic matter to the soil while providing limited competition for tree seedlings. Winter wheat can be spring seeded to produce a less vigorous but effective cover crop.

Figure 15-9: Herbicide strips free seedlings from competition for water and nutrients, harmful allelopathic chemicals produced by grasses, and potential girdling by rodents that use grass as cover.

Former agriculture fields present a unique set of site preparation challenges. Fields that were in row crops the previous year, such as corn or soybeans, generally require a pre-emergent herbicide after planting to control germination of stored weed seed. Cover crops may also be used to control invasive weeds. Alfalfa, clover, or some perennial grasses provide fierce competition for tree seedlings and seeds. Alfalfa and sod are easiest to control during the year prior to planting, with an early fall application of herbicide when the plants are still actively growing. Alternatively, rotation into a row crop or other desirable cover crop, followed by planting of seedlings, has been especially effective for hardwood plantings on heavy soils.

Planting

PACKAGING

Plastic-lined boxes or bags are preferred for shipping bareroot seedlings because they help prevent physical damage and keep seedlings moist. Paper bags or burlap bales provide less protection from physical damage. Bales will suffice for very short storage or transport periods, but bales leave the shoots exposed and subject to drying. All packaging methods can slow air circulation when stacked. Containerized seedlings are shipped in the plastic or styrofoam container in which they grew at the nursery, therefore, the roots are protected. However, care should be taken to protect the exposed shoots during transportation. Also, regularly monitor the moisture level in the containers.

SEEDLING CARE AND HANDLING

Reforestation surveys indicate that the most common problems facing seedling survival are moisture stress, poor handling, and physical damage before planting. From the time seedlings are lifted from the nursery bed, to the time they are planted, it is critically important to keep the seedlings moist (relative humidity 90 to 95 percent) and cool (34ºF to 36ºF). Seedlings must remain in a state of dormancy during this period. As temperatures rise, plants begin to respire, and can quickly deplete their energy reserves. Damaging molds can also grow on seedling roots under warm conditions. If seedlings are allowed to dry out, the root hairs become permanently damaged, and are unable to absorb adequate water and nutrients. Physical damage from handling can impair root hairs, shoot tips, and buds, which will slow initial growth of the seedlings.

ROOT PRUNING AND CULLING

Root pruning may be necessary for seedlings with long fibrous root systems in order to facilitate proper planting. **Remember that the key to seedling establishment and survival is a vigorous root system, so approach root pruning conservatively.** Severe root pruning can quickly lead to seedling mortality after planting because seedlings will not have sufficient root area to absorb water. Recommendations for pruning 2-0 conifer nursery stock are to clip the root system eight to 10 inches below the root collar. Larger conifer nursery stock, such as 3-0 or transplants, require a larger root system in order to maintain a proper shoot to root ratio. Most hardwood nursery stock can be pruned to eight to 10 inches below the root collar, and the lateral roots can be pruned at four inches from the main taproot. Remember that larger hardwood stock must be pruned more conservatively, and may require specially designed planting equipment to prepare adequate planting holes. Root pruning must be done in a cool environment where the seedlings will not be exposed to the drying effects of wind and sun, therefore, the planting site is often the worst place to conduct root pruning.

It may be necessary to **cull weak seedlings** at this time. Bulk orders include extra seedlings to allow for (or offset losses from) culling. The nursery often provides specifications on what should be culled from a bulk order. Eliminate the wilted, discolored, damaged, or "scraggly" seedlings. Keep seedlings moist during the entire pruning and culling process. Place the seedlings back into their packaging, remoisten, and reseal the packages tightly to keep in moisture.

Figure 15-10: Machine planting hardwood seedlings along the edge of a farm field found in southern Wisconsin.

MACHINE PLANTING

Machine planting is well-suited for large orders, planting on even terrain, and planting hardwoods with large root systems. Planting machines generally require a 30 to 50 horsepower tractor. Three people are recommended – one to drive the tractor, another to ride the planting machine, and a third to provide seedlings to the planter and check for proper planting technique. The same stock handling principles listed previously apply to machine planting. Do not load too many trees in the machine's storage bins at one time. Instead, supply stock in small amounts to keep seedlings moist and cool. The average machine planting crew can plant 5,000 trees per day.

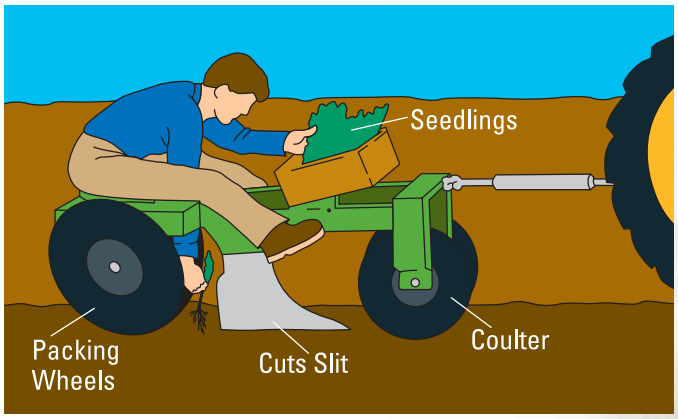

Figure 15-12: A planting machine. It works by opening a slit about 10 inches deep into the soil. A person on the machine inserts a seedling into the slit, and holds it at the appropriate planting depth until the rear packing wheels close the slit. Hardwoods often require a wider and deeper planting slit than conifers to accommodate the large, fibrous root systems.

Figure 15-11: This tree planter is using a hoedad to hand plant jack pine seedlings on this harvested and site-prepped area in the Black River State Forest.

HAND PLANTING

Hand planting is necessary when the terrain is rough, the seedlings are too large for machine planting, or when interplanting within an existing stand or plantation. The most common tools used for hand planting include a shovel, planting bar ("dibble"), or hoedad. The average inexperienced tree planter can hand plant about 500 seedlings per day, depending on site conditions and stock type. A professional tree planter can often hand plant 1,000 or more seedlings per day. For an instruction sheet regarding proper hand planting techniques, contact your local DNR office.

When planting by hand, remember to keep the seedlings shaded, cool and moist at all times. Do not leave packages of seedlings exposed to sunlight and warm temperatures at the job site. Utilize a reflective tarp, and consider delivering the stock in stages during the workday. Carry seedlings in a planting bag or bucket along with wet burlap to keep the root systems moist. **Handle the roots as little as possible, and do not carry the seedlings exposed to the air or immersed in water.** The roots should hang freely in the planting hole and not be twisted or crooked. The new soil line should be slightly above the seedling's root collar. The soil should be packed firmly around the seedling to maintain good soil to root contact and eliminate air pockets.

TRANSPORTING

Seedlings are most at risk from overheating, moisture stress, and physical damage during transportation and immediately before planting at the field sites. Plants must be kept cool and free from wind and sunlight exposure. For large orders, a refrigerated truck is recommended. If a pickup truck is used, place a foam sheet on the truck bed, and spacer boards between the foam and boxes for ventilation. Cover the packages with a solar reflective tarp (reflective side down) to prevent heat build-up. For small orders, use a refrigerated van or well air conditioned car. Use insulation, ice packs, snow, or large coolers to help keep the seedlings cool.

Do not place seedlings in a hot car trunk or leave them in a sunny location. If you suspect the seedlings have not been kept consistently cool since leaving the nursery, sprinkle cool water on the roots and reseal the packages.

SEEDLING STORAGE

Most people do not have access to truly adequate long-term storage. Always minimize storage time and plant seedlings as soon as possible after delivery. Storage only allows more time for problems to develop. If seedlings must be stored for short periods of time (one to two days), seek out local cold storage facilities such as produce businesses or orchards. Keeping a constant temperature below 40ºF is the key to proper storage. Unheated basements and root cellars may work for very short periods, if the temperature is constant and below 40ºF. Do not use storage sheds or similar buildings because the temperatures can fluctuate greatly during the day. **Do not immerse seedlings in water for long periods of time as this can damage fine root hairs.** Heeling in or planting in a shallow trench can also lead to root damage and additional transplant shock.

DIRECT SEEDING

Seed can be sown with a variety of equipment, such as seeding sticks, dribblers, broadcast seeders, or seed drills. The most effective means of direct seeding will depend on the species and seed size, and the planting site characteristics. Detailed information on seeding equipment and techniques is available in the Wisconsin DNR *Silviculture and Forest Aesthetics Handbook, 2431.5*.

REFORESTATION AIDS

There are a wide variety of products available to aid in the survival of a plantation.

Tree shelters protect trees from animal browse and improve initial height growth by creating a greenhouse effect. They make seedlings easier to locate, and protect the trees from herbicide damage. Tree shelters do not eliminate the need for vegetation control and require annual maintenance. **Netting should be placed on the top of shelters to prevent the accidental death of birds in search of nesting sites.** Shelters block a significant quantity of incoming light, so they should be used in full sun conditions. Tree shelters are used primarily with high value hardwoods, and the cost may not be economically justified for many landowners. Other problems associated with the use of shelters include stem dieback and rodent nesting. After a few years, tree shelters may actually inhibit sapling growth, so they should be removed once terminal shoots have emerged from the shelter top, and the sapling becomes rigid enough to stand on its own.

Mulches and vegetation mats are used to suppress weed growth, retain soil moisture and reduce erosion. Mulches can include bark, sawdust, straw, wood chips or other materials. Mulches must be applied to a depth adequate to suppress weed growth (i.e., two to three inches), but should not be heaped or mounded immediately next to the seedling. Mulches are labor intensive to apply and can attract rodents seeking nesting areas. Vegetation mats are typically made from plastics or natural fibers. They suppress weed growth while still allowing water infiltration. The primary disadvantage of mats is the high cost.

Root dips and gels are hydrating gels used to coat seedling roots prior to handling and planting operations. Their primary purpose is to prevent drying of the seedling's roots during the planting process.

POST-OPERATIONAL ACTIVITIES

Monitoring Program

Some monitoring process should be used to evaluate plantation survival and assess maintenance needs. A regular program of monitoring helps ensure the success of a reforestation project. At a minimum, plantations should be evaluated during the first growing season, four to five months after planting (although earlier evaluations may make problem diagnosis easier), and again during the third growing season to verify survival and establishment. During the evaluation process make note of insect, disease, animal, and/or competing vegetation problems.

Survival counts are a quick way to determine if replanting is necessary in order to meet management goals. Estimating survival on random 1/100 acre plots throughout the plantation can assess seedling survival. This can be accomplished in a few easy steps. First, attach an 11.8 foot length of cord to a stake to represent the radius of a 1/100 acre plot. Then place the stake in the center of each plot, and use the cord to determine which trees fall within the plot. Count the number of live and dead trees within each plot. Since each tree counted represents 100 trees per acre, multiply the number of live trees by 100 to determine the average number of live trees per acre. The number of live trees per acre divided by the total number of both live and dead trees per acre equals the survival percentage. Average the values from all the plots tallied to determine the survival for the whole plantation. The number of plots required to obtain a reliable survival estimate depends on the size of the plantation and the variability of survival within the plantation. A rule of thumb is to do one survival plot per acre for the first 10 acres, and one additional plot for each additional five acres of plantation. An alternative method (faster, but potentially less accurate) is to select a row and count the number of live and dead trees. Switch rows periodically to sample across the entire plantation.

Vegetation Control

The success of a planting will often be determined by the control of competing vegetation before and after the trees are planted. **Good site preparation will get seedlings off to a fast start, but weed competition may need to be controlled for at least three growing seasons, or until the trees are well-established.**

Herbicides are often the most effective method for follow-up weed control. The proper choice of herbicide, timing and method of application are critical to insure that planted trees are not damaged. Detailed forestry herbicide information is available in Forestry Facts Sheet #76, University of Wisconsin Extension (see Chapter 14: Pesticide Use, for more information on the use of herbicides).

Mechanical weed control may be suitable for some post-planting situations. Shallow disking or rototilling between rows is effective if care is used to avoid damaging the trees and their root systems. Mowing can reduce weed maturation and seed production, and minimize rodent habitat, but it may also stimulate grass root growth and intensify competition for soil nutrients and water. Mowing can prevent the physical smothering of trees (i.e., lodging) as grasses and broadleaf plants die and fall over the winter. Hand or mechanical cutting of woody vegetation may effectively release young seedlings, but repeated treatments may be needed due to stump sprouting.

Figure 15-13: Rapid tree growth results from proper care and planning (e.g., grass control when seedlings were young and adding white pines to help trees grow tall and straight) as evidenced by this 30-year-old black walnut plantation in Dane County.

Animal Control

Most forest plantings will experience some type of animal damage (e.g., browsing, rubbing, rodent bark feeding), however, the severity of that damage will vary across planting sites and between tree species. Many different techniques can be employed to discourage severe wildlife damage.

POPULATION CONTROL

Hunting can be an effective way to reduce local deer and rabbit populations. **Rodenticides have been used to control mice, pocket gophers and meadow voles, however, these baits are hazardous and can affect non-target organisms.** Rodenticides may be restricted and require a license (see the Resource Directory for sources of assistance).

HABITAT MANIPULATION

Wildlife damage can be minimized by manipulating the habitat in and around the plantation. Mowing and other grass control measures will reduce rodent damage by removing their habitat, and increasing access by predators such as hawks. Constructing **raptor perches** (posts that are placed throughout the plantation to allow raptors to sit above the plantation) can also improve rodent predation. The removal of brush and hedgerows virtually eliminates rabbit damage, since they do not venture far from shelter. Manipulating the planting design can protect high hazard areas and discourage animals from entering the plantation. For example, plant several rows of less palatable trees, such as spruce, next to existing woodlands or along obvious travel corridors.

PROTECTION DEVICES

There are a wide variety of products available to protect seedlings. Electric fences, tree shelters, bud cap protectors, and bud nets create a physical barrier between the seedling and animal. **These devices must remain intact to be effective and maintenance is often required.** Repellents rely on fear, conditioned avoidance, or taste to discourage animal browse. Repellents can work for short periods, but their effectiveness is reduced with time.

Insect and Disease Control

All plantations will experience some degree of insect and disease damage. If local pockets of damage develop, or problems persist, carefully identify the pest organism and assess the degree of damage prior to developing control recommendations. Once trees are damaged and weakened, they become susceptible to further attacks by pests. Proper identification becomes complicated when more than one organism or injury is present (see the Resource Directory for sources of assistance in insect and disease identification). Additional information on pests that affect young plantations is available in the Wisconsin DNR *Silviculture and Forest Aesthetics Handbook, 2431.5*.

Insects causing the most damage to young tree plantations fall into three categories:

- **Main stem and root pests,** such as weevils and white grubs, feed on the main stem or root system, and can cause serious tree mortality.
- **Shoot or branch pests,** such as scales and spittlebugs, feed on or within the shoots, causing branch damage or death.
- **Defoliators,** such as caterpillars and sawflies, feed on the leaves or needles.

Diseases can also be grouped into three categories:

- **Root rots** cause slowed leader growth and yellowing of the crown. Mushrooms may be evident around the base of an infected tree. Direct contact between roots will cause the spread of the disease and infection pockets will occur.
- **Cankers, stem rusts, and shoot blights** are seen as lesions and/or swellings on stems and branches. These lesions will eventually cause dieback by girdling the stem.
- **Foliage diseases,** such as anthracnose and needle casts, appear as spots or lesions on needles and leaves.

Figure 15-14: Pine plantations hold an allure for rural builders, but such settings pose problems. Soil compaction and root injuries commonly lead to tree mortality near homes. Thinning to keep trees healthy is often impractical in housing developments. Poor air circulation, mold and extreme fire hazard are troubles experienced by homeowners.

Weather and Environmental Damage

DROUGHT

Adequate soil moisture is crucial when the trees are young and lack fully developed root systems. Trees damaged by drought appear wilted and have yellow or brown foliage. The symptoms should appear similar throughout the plantation. Recovery is possible if seedlings get water before extensive damage is done. Drought will weaken seedlings and predispose them to insect and disease attacks.

FROST/FREEZE INJURY

Frost damage generally occurs in depressions or low areas where cold air settles. The foliage and/or young shoots will curl and die. Freeze injury can cause hardwood stems to die back the following growing season. Trees from inappropriate southern seed sources, and species on the edge of their natural range, are particularly susceptible. Frost damage rarely kills trees, but it does slow growth and predispose the seedling to insects and diseases.

DESICCATION

Dry winter winds may cause desiccation of conifer seedlings, and turn needles reddish brown. This damage is mostly an aesthetic concern.

HERBICIDES

Improper application or timing of a herbicide can damage or kill seedlings. Foliage and shoots will usually appear yellow and have distorted growth (see Chapter 14: Pesticide Use).

POLLUTANTS

Damage from pollutants can resemble many different problems, and is difficult to identify. Sulfur dioxide, ozone, and road salt are common tree damaging pollutants. White pine is particularly susceptible and should not be planted in areas frequently exposed to air pollution or road salt.

FIRE

The best way to prevent a fire is to reduce the amount of fuel in and around your plantation. Establish and maintain disked firebreaks and mowed access roads in order to prevent the spread of a fire, and provide easy access by fire control equipment.

RESOURCES FOR ADDITIONAL INFORMATION

HERBICIDES FOR FOREST MANAGEMENT
Herbicides for Forest Management, Forestry Fact Publication No. 76, University of Wisconsin Extension
http://forest.wisc.edu/extension/publications/76.pdf

SILVICS OF NORTH AMERICA
Silvics of North America, USDA Forest Service
www.na.fs.fed.us/spfo/pubs/silvics_manual/table_of_contents.htm

SILVICULTURE AND FOREST AESTHETICS HANDBOOK, PUBL. NO. 2431.5
Wisconsin Department of Natural Resources. (2002). *Silviculture and forest aesthetics handbook*. Madison: Wisconsin Department of Natural Resources.
www.dnr.state.wi.us/org/land/forestry/publications/2431_5/index.htm

UNIVERSITY OF WISCONSIN PEST DIAGNOSIS LAB
www.entomology.wisc.edu/entodiag.html

UNIVERSITY OF WISCONSIN PLANT DISEASE DIAGNOSTIC CLINIC
www.plantpath.wisc.edu/pddc/index.htm

UNIVERSITY OF WISCONSIN SOIL AND PLANT ANALYSIS LABS
http://riprock.soils.wisc.edu/

UNIVERSITY OF WISCONSIN-MADISON FORESTRY EXTENSION
http://forest.wisc.edu/extension/forfact.htm

WISCONSIN NURSERY DIRECTORY
Wisconsin Nursery Directory, Forestry Fact Publication No. 14, University of Wisconsin Extension.
http://forest.wisc.edu/extension/publications/14.pdf

WOODY PLANT SEED MANUAL
Woody Plant Seed Manual, USDA Forest Service
http://wpsm.net/

These resources are specific to the information in this chapter only. Refer to the Resource Directory for additional resources related to this chapter.

WISCONSIN FOREST MANAGEMENT GUIDELINES

PUB-FR-226 2003

Wisconsin Department of Natural Resources
Division of Forestry
PO Box 7921
Madison, Wisconsin 53707

For additional information, call **608-267-7494** or visit our web site at:
www.dnr.state.wi.us/org/land/forestry/

October, 2003

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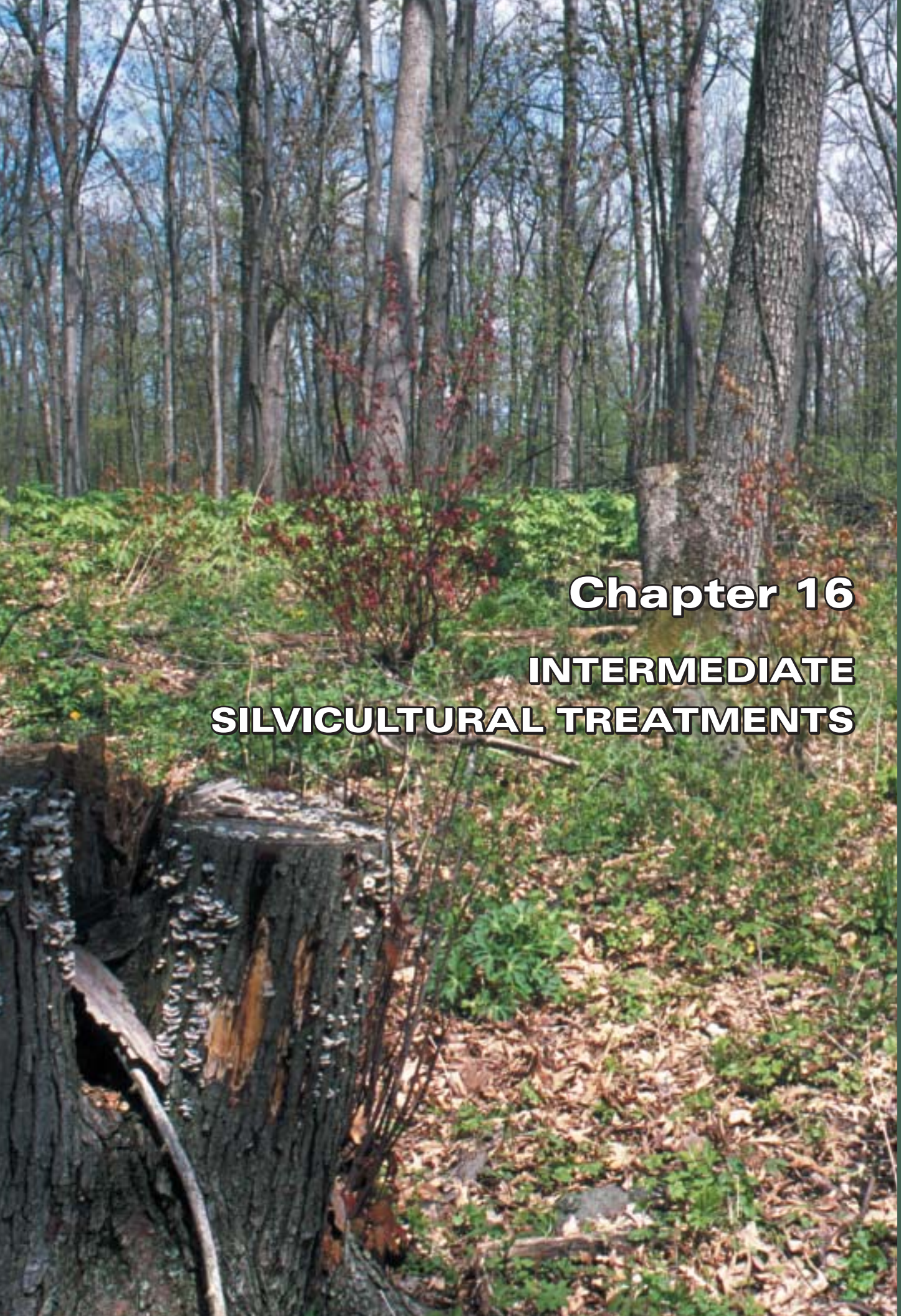

Chapter 16

INTERMEDIATE SILVICULTURAL TREATMENTS

CHAPTER 16 — INTERMEDIATE SILVICULTURAL TREATMENTS

Integrated Resource Management Considerations 216

PLANNING 217

OPERATIONAL CONSIDERATIONS 218

Release 218
Thinning 220
Improvement Cutting 225
Salvage and Sanitation Cutting 225
Pruning 226

POST-OPERATIONAL ACTIVITIES 227

RESOURCES FOR ADDITIONAL INFORMATION 228

Figure 16-1 and 16-2: The importance of tending an even-aged stand is illustrated by comparing these two plots in the famous Star Lake thinning experiment started by Fred Wilson with red pine planted in 1913. Figure 16-1 (left) shows the poor growth and mortality in the plot that was never thinned. The adjoining plot, Figure 16-2 (right), shows the impact that periodic thinnings (every five to 10 years starting in 1943) can have on red pine growth and quality.

Intermediate treatments begin after regeneration is established and are carried out as needed throughout the life of a forest stand. These treatments make up the "tending" portion of an overall silvicultural system. **Primary goals include improvement of stand composition, structure, growth, quality, health, and the production of specific benefits desired by the landowner.** Some intermediate treatments, often called **timber stand improvement (TSI)**, are non-commercial, requiring outright investment by the landowner. Other intermediate treatments can generate enough revenue to offset the cost of their implementation.

Integrated Resource Management Considerations

- Intermediate treatments can affect timber productivity, stand structure, wildlife habitat, species and habitat diversity, aesthetics, water quality, and soil condition. Careful consideration must be given to all the ramifications of a planned treatment.
- Intermediate treatments generally improve tree vigor and health, but high intensity treatments in stands lacking vigor and strength can cause stress and short-term predisposition to health problems. Logging damage can cause wounds that predispose trees to future health problems.
- Non-native invasive species can be encouraged or discouraged by intermediate treatments and operations. They can preclude the success of treatments. Exotics should be controlled and/or eliminated during intermediate treatments to the greatest extent possible.
- Intermediate treatments can increase visual penetration and access. Season or hours of operations may need to be restricted to mitigate visual impacts.
- Heavy equipment can damage cultural resources.

PLANNING

- Conduct on-site meetings with the landowner, forest resource manager, and logger prior to implementing operations. Clarify objectives, specifications, regulations, and site limitations.
- Identify crop tree management objectives, characteristics, number per acre and spacing.
- Consider the retention of reserve (leave) trees, snags, and coarse woody debris.
- In some cases, logging residues (slash) and stumps can facilitate infestations, and may require treatment. Timing of cutting (and other operations) should consider disease and insect cycles.
- Evaluate soil conditions and control heavy equipment operations to limit compaction, rutting, and erosion.
- If necessary, evaluate the need for additional slash control measures, or seasonal operating restrictions to mitigate visual impacts.
- Identify any cultural resources that may occupy the site and develop measures to protect them.
- Identify occurrences of non-native invasive species, and, if necessary, treat infestations prior to conducting stand improvement activities to help prevent spread.

Figure 16-3: Having a trained forester collect inventory data for each stand on the property is necessary before prescriptions can be developed to achieve the management objectives.

Figure 16-4: Frequent communication between the forester, landowner and other resource professionals helps insure that management objectives are fully achieved.

OPERATIONAL CONSIDERATIONS

Intermediate treatments can be grouped into release, thinning/improvement, salvage/sanitation, and pruning operations.

Release

Release is a treatment designed to free young trees (saplings and seedlings) from undesirable, usually overtopping, competing vegetation. **The purpose is to regulate species composition and to improve growth and quality.** Release treatments are designed to provide potential crop trees with sufficient light and growing space, by freeing their crowns and controlling competition.

The need for release treatments are based on a number of considerations.

- An assessment of the relative growth rates (height growth in particular) of the competing and desired species.
- The degree of impact the competing species has on the health and vigor of the desired species.
- The relative cost/effectiveness of a partial versus complete release versus no action.

Complete release involves the release of an entire layer of vegetation. Examples would be the control of aspen suckers and brush in a new pine plantation, or the control of competing red maple stump sprouts after the establishment of red oak seedlings following a shelterwood harvest. In these situations, essentially all of a particular species in the stand are considered crop trees. The objective is not necessarily to kill the competing species, but to set back and/or retard their growth so as to allow the desired species to gain dominance. A complete release normally occurs soon after a new stand is established, when competing vegetation begins to interfere with the free growth of the desired species and/or individuals.

Partial release involves the release of only selected crop trees. A partial release is usually done before the main stand is 15 years of age, and involves the following criteria:

- Crop trees are selected based on landowner objectives, species, tree vigor, and tree quality.

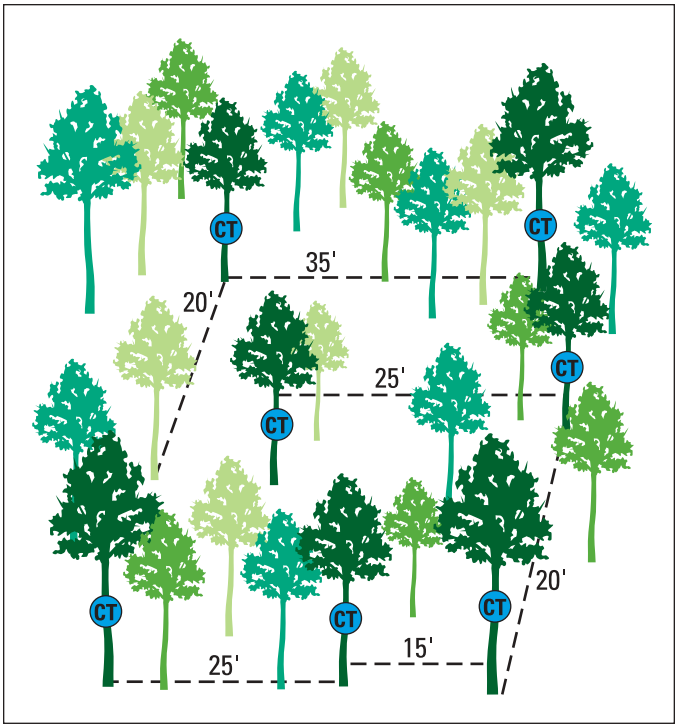

Figure 16-5: Spacing is an important consideration when selecting crop trees (CT). If you space crop trees 25' apart, you will end up with about 70 crop trees per acre. Some crop trees can be spaced 15' apart, while others can be spaced 35' apart.

The maximum number of well-spaced crop trees per acre generally ranges from 50 to 200, depending on landowner objectives and stand condition (see the crop tree selection guidelines in Appendix A).

- Only the direct competitors are cut. Any plant that is not going to suppress, endanger, or hamper the growth of desired individuals is left to grow. All trees with crowns that touch or interfere with each crop tree are removed.
- When sprout clumps are involved, all but the best one or two stems are cut. Healthy, low sprouts originating less than six inches above the ground with a u-shaped stem attachment, of a relatively large size, well-shaped and with a well-developed crown, are selected for retention.

There are three types of release treatments: weeding, cleaning, and liberation. They are differentiated based on the type, age, and size of vegetation eliminated. Within a stand, they can be applied individually or in concert, once or multiple times.

WAYS TO CONTROL COMPETING SPECIES	
Physically Tear the Plant Out of the Soil	• A very effective but expensive method.
Cutting	• Effective against species that do not sprout, e.g., most conifers. • Species that sprout may require repeated treatments to effectively control. Cutting in late spring and summer is most effective. • Relatively expensive, unless a product can be harvested.
Girdling (see Figure 16-6)	• Effective against species that do not sprout. • Most effective when done in late-spring and summer. • Generally applied only to trees greater than 4" DBH.
Fire	• Usually kills trees by girdling. • Generally not used to release young trees.
Herbicides	• Very effective and often the most cost-effective. • Methods of application for release operations include: aerial spraying, ground-level foliar spraying, basal spraying, stump spraying, and bark incisions. • Herbicides are toxic chemicals, see Chapter 14: Pesticide Use.

Figure 16-6: Girdling can be an effective way to remove selected larger trees from a stand with minimal damage to surrounding reproduction.

Some general operational considerations relative to release treatments that remove large, overtopping trees are:

- Cutting may allow the realization of income, but protection of the young stand from felling and harvesting operations is critical.
- Care should be taken that following the elimination of high shade, intense crown competition from sprouts or the release of fast growing weed species does not develop.
- Reserve trees can provide benefits related to wildlife, aesthetics, water and soil quality, protection of special or sensitive sites, landmarks, and, in certain cases, timber production. Where objectives include the retention of reserve trees, residual crown closures of less than 20 percent generally will not significantly impair the development of the young stand.
- In most cases, nearly full sunlight is preferred to promote optimum growth of young, established stands.

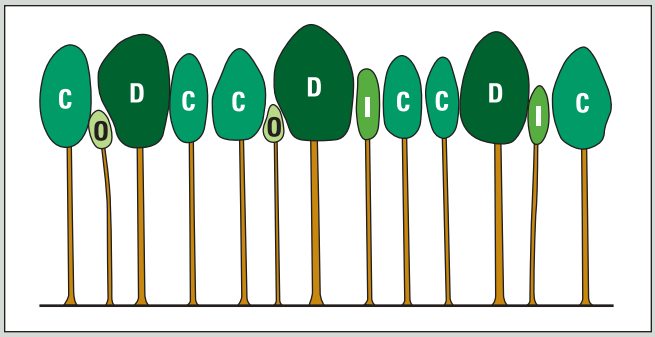

Figure 16-7: This illustration shows the relative positions of trees in the different crown classes in an even-aged stand that has not been thinned.

DOMINANT (D)

Dominant trees have crowns extending above the general level of the crown cover, and receive full light from above and partly from the side. Dominant trees are larger than the average trees in the stand, and have well-developed crowns that may be somewhat crowded from the sides.

CODOMINANT (C)

Codominant trees have crowns forming the general level of the crown cover, and receive full light from above but comparatively little from the sides. These trees usually have medium-sized crowns that are often crowded on the sides.

INTERMEDIATE (I)

Intermediate trees are shorter than dominant and codominant, but have crowns extending into the crown cover formed by codominant and dominant trees. Intermediate trees receive a little direct light from above, but none from the sides. They usually have small crowns that are considerably crowded on the sides.

OVERTOPPED (O)

Overtopped, also called suppressed, are trees with crowns entirely below the general level of the crown cover. Overtopped trees receive no direct light either from above or from the sides.

Thinning

Thinning is a cultural treatment, in stands past the sapling stage, made to reduce the stand density of trees primarily to improve growth, enhance forest health, or recover potential mortality. Typically, **it entails the removal of trees to temporarily reduce stocking to concentrate growth on the more desirable trees.** Normal thinning does not significantly alter the gross production of wood volume. Thinning impacts stand growth, structure and development, and increases economic yields. Individual thinnings can be commercial or non-commercial (TSI), depending on landowner objectives and local markets for materials cut in the thinning operation.

How and when thinnings are applied depends on landowner objectives and the desired benefits. A schedule of thinning for a stand should identify the thinning methods to be used, the intensity of application, and when thinnings will occur. Ideally, a thinning schedule should be systematic, flexible, and consistently followed throughout the rotation. In selecting trees for thinning, primary focus should be on the trees that will remain, as opposed to those to be cut.

There are five basic methods of thinning. Stand conditions and thinning needs vary over time, often resulting in the application of more than one method over a stand's rotation. The five methods of thinning are: low thinning, crown thinning, mechanical thinning, dominant thinning, and free thinning.

LOW THINNING

Low thinning, or thinning from below, (see Figure 16-8) involves removal of trees from the lower crown classes to favor those in the upper crown classes. This strategy of removing the smallest trees and retaining the largest trees accelerates and simulates somewhat the natural elimination of the lower crown classes through competition.

- This type of thinning generally removes smaller diameter trees, and marketability can sometimes be difficult.
- Light- to medium-intensity low thinnings (removing suppressed and intermediate trees) are not recommended except in specific cases. They facilitate utilization of trees that would otherwise die due to suppression (competition), but the release of the remaining trees from competition is minimal.
- Heavy low thinnings are generally recommended. They involve the removal of some codominants in order to create canopy openings and release the crowns of crop trees to stimulate their growth. Stocking guides are used to help determine residual density levels.

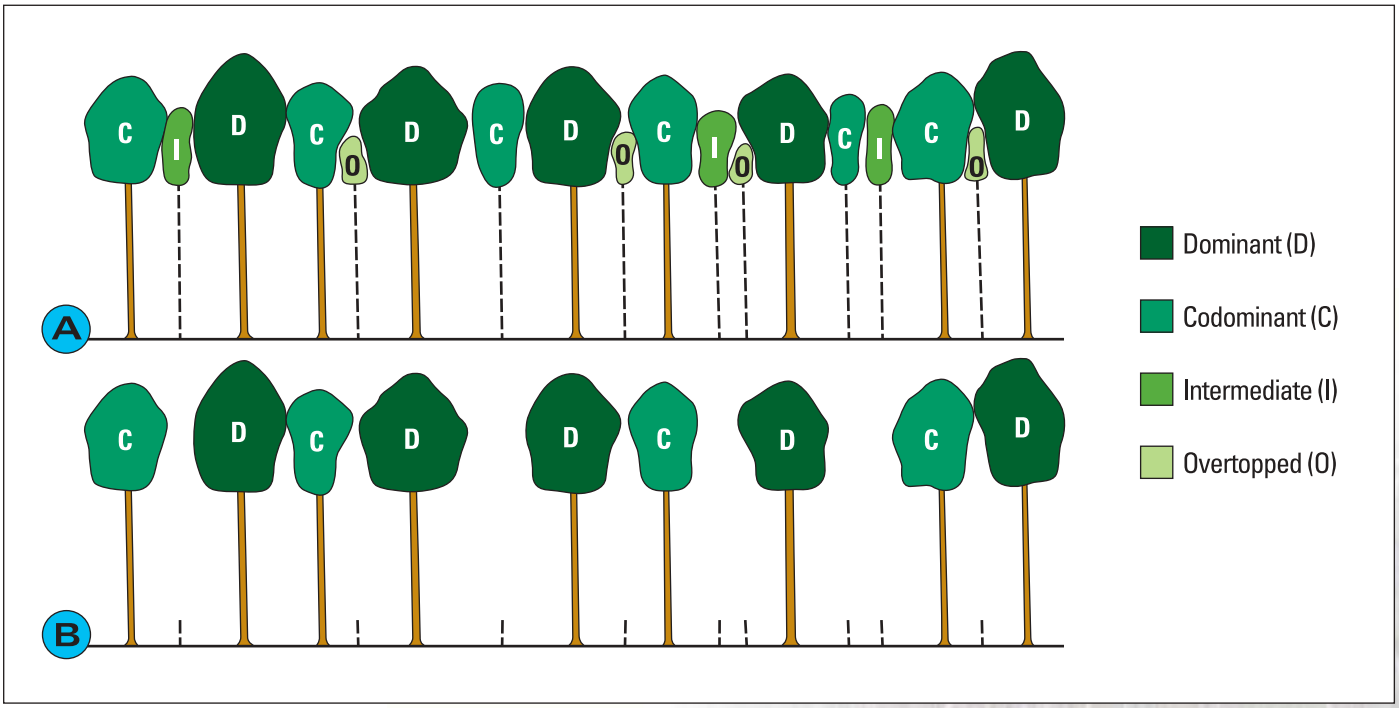

Figure 16-8: How a stand might look before (A), and after (B), a low thinning. The letters on the tree crowns denote crown classification.

CROWN THINNING

Crown thinning, or thinning from above, (see Figures 16-9 and 16-10) involves removal of trees from the dominant and codominant crown classes in order to favor the best trees of those same crown classes. Large intermediates that interfere with crop trees also can be removed. The method stimulates the growth of selected, preferred trees (quality) without sacrificing the production of quantity.

- Crown thinnings are normally used to develop quality sawtimber. They are usually commercial operations and the trees removed are relatively large.
- Crop trees are selected based on landowner objectives, species, vigor, quality, strength, and health (see the crop tree selection guidelines in Appendix A).
- Crown thinnings are recommended as the primary method to develop and manage quality hardwood stands for the production of high value sawtimber and veneer logs.
- 20 to 150 well-spaced dominant and codominant crop trees per acre are released. In fast growing young stands with small crowned competitors, crop trees are released on four sides. In slower growing older stands with larger crowned competitors, crop trees are released on one to three sides.
- To optimize growth, the remaining stand should also be thinned. Release the best dominant and codominant trees by removing high risk, low vigor competitors. Stocking guides are used to determine residual stand density.
- To be most effective, crown thinning requires considerable skill in tree selection and density management. The timing and intensity of a particular thinning is important in managing stem form and natural pruning.

Figure 16-9: This crop tree, released on two to three sides by cutting competing trees, is now free to grow.

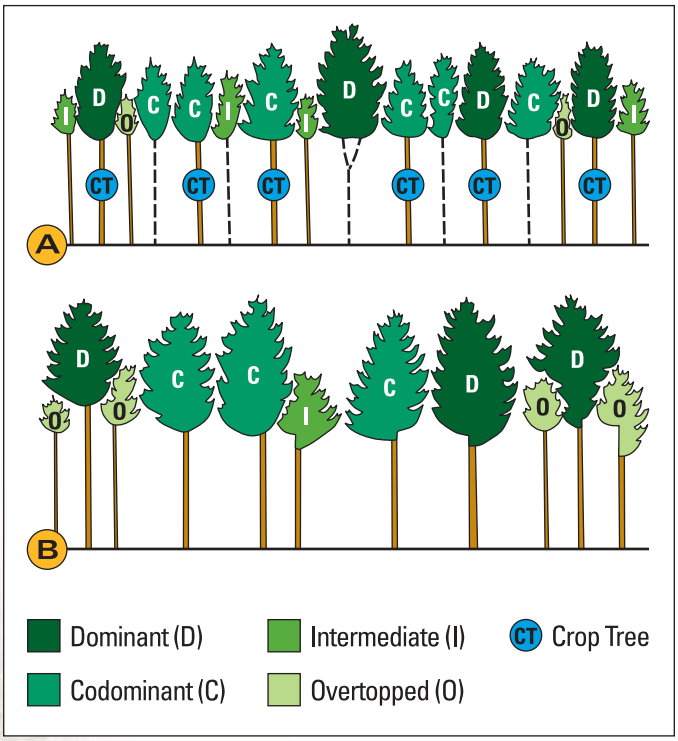

Figure 16-10: The upper sketch (A) shows a coniferous stand immediately before a crown thinning. The crop trees are indicated by the blue circles marked "CT." The lower sketch (B) shows the same stand about 20 years after the crown thinning, which has reclosed to the point where a low thinning would be desirable.

MECHANICAL THINNING

Mechanical thinning is the removal of trees in rows, strips, or by using fixed spacing intervals.

- Frequently, these are the first thinnings in young stands that are densely crowded and/or relatively uniform with little differentiation into crown classes. This method becomes less suitable as variation in the size and quality of the trees increases.
- **Row thinnings** (see Figure 16-11) cut all trees in rows or strips at fixed intervals throughout the stand. They are often utilized for the first thinning(s) in plantations where the rows are readily apparent. The removal of every third row is the most common practice. They are also used to provide access for harvesting equipment in dense, unthinned stands.
- **Spacing thinnings** involve selection of trees at fixed intervals for retention and cutting the rest. This strategy is most applicable as the first thinning in very overcrowded young stands developed from dense natural reproduction.

DOMINANT THINNING

Dominant thinning, or selection thinning, involves the removal of trees in the dominant crown class in order to favor the lower crown classes. This method is suitable only for limited purposes.

- The most common dominant thinning applications are in the management of tolerant conifers, where the objective is to grow as many trees as possible to medium-size for the production of pulpwood, poles, or other small diameter wood products.
- This thinning system is not applicable to quality hardwood management.

FREE THINNING

Free thinning is the removal of trees to control stand spacing (density) and favor desired crop trees, using a combination of thinning criteria without strict regard to crown position. In application, this method is a free combination of selected concepts and techniques garnered from any of the other four thinning methods. Thinnings of this type are sometimes applied as the initial thinning in previously untreated natural stands in preparation for a more systematic future program. Skillful employment of this system can be used to manage and maintain stands of mixed composition, density, or age.

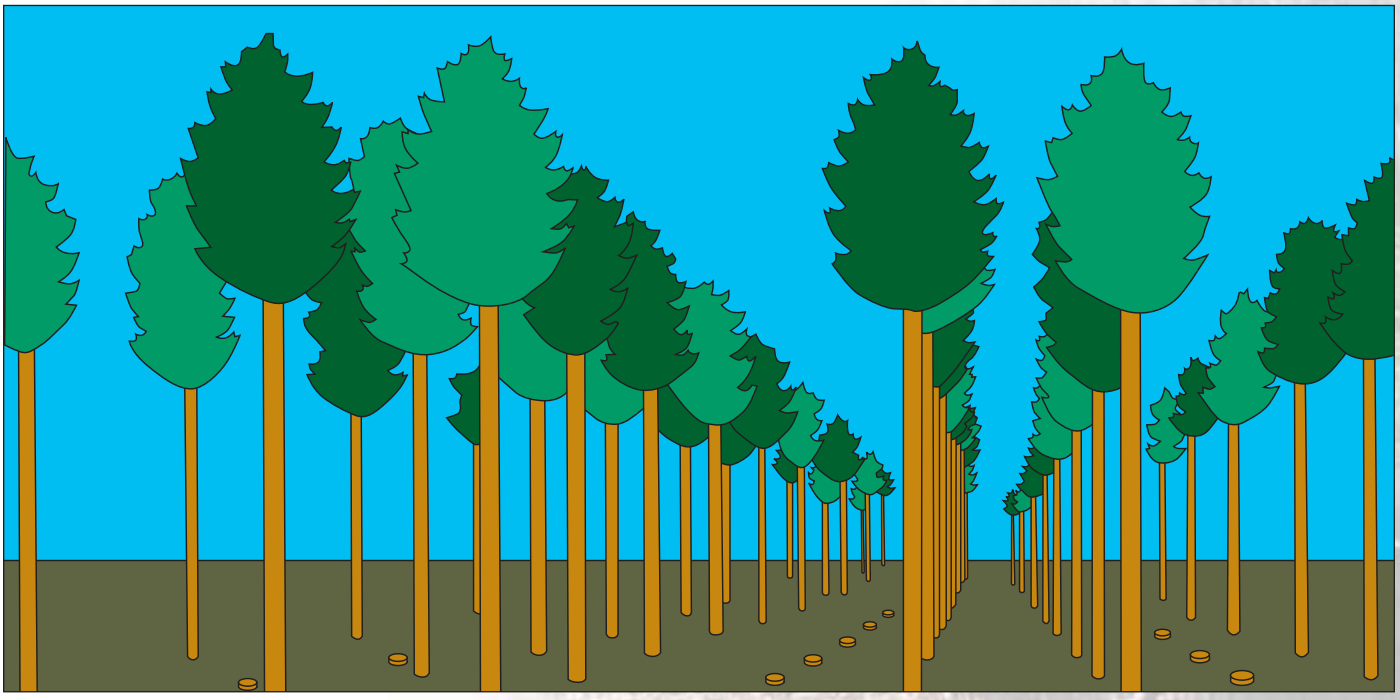

Figure 16-11: A mechanical row thinning in a pine plantation in which every third row of trees has been removed. The opening in the canopy should close in a few years.

SOME OPERATIONAL CONSIDERATIONS RELATIVE TO THE TIMING AND INTENSITY OF THINNING OPERATIONS

- The timing and intensity of each thinning depends on landowner objectives, stand composition and structure, stand condition and health, and other past and planned management activities. A tentative schedule should be developed, indicating the projected timing and intensity of each thinning.
- The intensity of thinning refers to the proportion of the stand removed in a particular thinning.
- As intensity increases, frequency usually decreases.
- Target stocking levels are determined based on optimizing stand growth and yield for a specific forest cover type. Stocking guides (see Figure 16-12) define the lower and upper limits of stand density on a given site. The lower limit (see Figure 16-12, B-line) is normally used to guide thinning applications. Regular reduction of stand density to the lowest level at which full occupancy is maintained should result in the most rapid diameter growth that can be maintained without reduction in total volume yields.
- Initial thinnings normally begin when crowns begin to touch each other. Precommercial thinning (TSI) requires an investment, but can increase net returns over the rotation. It is typical, however, to postpone the initial thinning until an immediate profit can be produced.
- Normally, a thinning is indicated when 1) the live crown ratios of crop trees begin to decline, 2) the diameter growth of crop trees begins to decline, 3) stand density increases to near or above specified upper limits delineated in stocking charts, and/or 4) sufficient timber volume accumulates to support a harvest.
- The effects of thinning are temporary. After each thinning, the remaining trees grow taller, diameters increase, crowns expand, and canopy gaps close.
- Thinning every five to 15 years, is a recommended general guideline for commercial thinnings.

It is important to control logging damage when thinning. Logging wounds can predispose the remaining trees to disease and decay. Thinnings are meant to increase resistance to damage (insects, disease, wind, etc.), however, they can also temporarily predispose stands to damage, especially where trees are not particularly vigorous or strong.

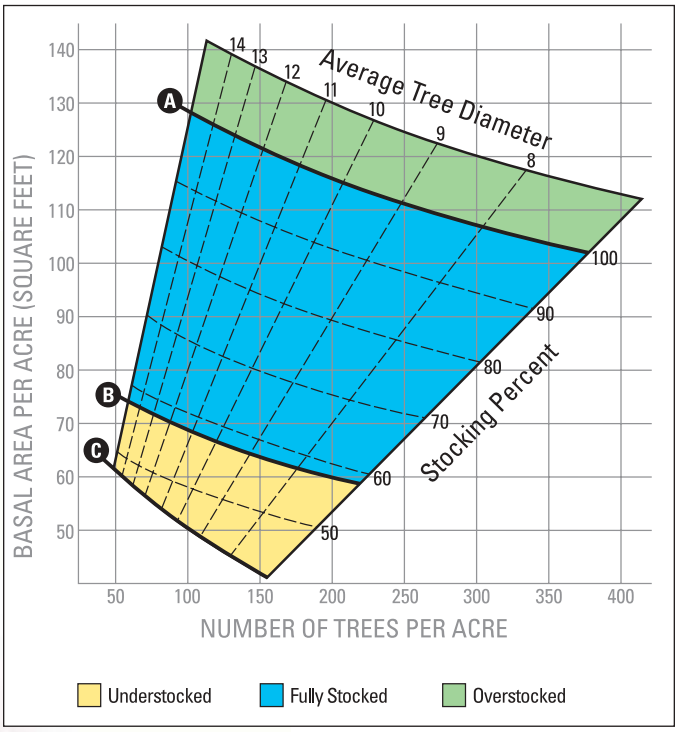

Figure 16-12: Stocking guide/chart for upland central hardwoods displaying the relation of basal area, number of trees, and average tree diameter (the tree of average basal area) to stocking percent. The area between A-line and B-line indicates the range of stocking where trees can fully utilize the site. C-line shows the limit of stocking necessary to reach the B-line level in 10 years on average sites. Similar guides are available for each species.

Improvement Cutting

Improvement cutting is the removal of less desirable trees of any species in a stand of poles or larger trees, primarily to improve composition and quality. Trees are removed to encourage the growth of more desirable trees within or below the main canopy. Trees considered for removal include inferior species, poorly formed trees, overmature individuals, and injured or unhealthy trees. Potential crop trees should be a preferred species and relatively well-formed, vigorous, and healthy.

Improvement cuttings are widely needed and commonly practiced. They usually are applied to stands that have been unmanaged, neglected, or poorly managed. The intent is to remove undesirable material, and set the stage for productive management to accomplish landowner objectives. In most cases, stand improvement can be completed in one to three operations. In cases where the current stand is of such poor quality that rehabilitation is untenable, the preferred choice is to initiate regeneration to develop a vigorous, new stand.

Figure 16-13: An improvement cut in this upland hardwood stand removed overtopping, undesirable trees, thus "releasing" small poletimber from competition that reduces growth rate.

Salvage and Sanitation Cutting

Salvage cutting is done to remove dead, damaged, or dying trees resulting from injurious agents other than competition. The goal is to recover economic value that would otherwise be lost. Salvage operations are done for profit, with the intent of utilizing damaged trees and minimizing financial losses. Salvage should be conducted as soon as possible following a damaging event. Dead trees deteriorate rapidly during the first growing season after death. Severe stand damage will require the implementation of regeneration methods.

Presalvage cutting involves removal of valuable trees at high risk of injury or mortality from damaging agents. The method attempts to anticipate damage by removing vulnerable trees that are in imminent danger of being damaged or killed.

Sanitation cutting removes trees that are a threat to stand health by stopping or reducing the actual or anticipated spread of insects or disease. It is precautionary protection implemented to reduce the spread of damaging organisms, or in anticipation of attacks to prevent or delay the establishment of damaging organisms. Sanitation cuttings eliminate trees that are present or prospective sources of infection for insects or fungi that might attack other trees. The removal of trees must actually interrupt the life cycle of the organisms sufficiently to reduce their spread to other trees.

Pruning

Pruning is a silvicultural technique, typically applied to improve timber quality and value. It is the removal, close to the branch collar or flush with the stem, of side branches and multiple leaders from a standing tree. Branches are removed because they form knots, which are a common defect of lumber, and reduce timber value. The retention of large, dead branches low on the trunk is particularly counterproductive. Multiple leaders are removed to improve stem form. Sometimes, pruning is applied to control disease, or improve aesthetics or accessibility.

Pruning is expensive. Only the best quality crop trees on good sites should be selected for pruning. It is most commonly applied to conifer plantations of species which are poor natural pruners, but which can significantly increase value by producing clear lumber (e.g., white and red pines). Pruning can enable more aggressive thinning strategies, if the promotion of natural pruning is no longer a concern. Combining pruning and aggressive thinning can facilitate the production of increased value in a shorter period of time, by stimulating rapid healing of wounds and promoting the production of clear wood.

Some operational considerations relative to pruning are:

- Careless, poorly implemented pruning can cause tree injury. Avoid excessive green pruning of live branches.
- The best time to remove a branch is just before death or within several years thereafter.
- Pruning should occur in young stands before the lower branches become relatively large. Removing large (greater than one to two inch diameter), live branches can damage quality.
- Pruning is best done in the dormant season – fall to late-winter is best.
- The first pruning should be in young, vigorous poletimber, following early initial thinning.
- Candidates for pruning should be the most vigorous, healthy, dominant (tallest), and largest diameter crop trees for the dominant age class – the very best individuals.
- Before implementing, identify the minimum tree specifications and the maximum number per acre. Typically 50 to 200 crop trees are pruned per acre, generally in two to three operations.
- A typical final objective as a result of pruning is a clear trunk to 17 feet; prune at least to nine feet. Each pruning is done to the topmost whorl of dead branches or into the lower portion of live crown. The ratio of live crown to tree height after pruning should exceed 50 percent.
- Cuts should be made close to the branch collar or flush with the stem – no splinters or broken stubs. Do not tear or loosen bark around a branch stub. Combining hand and pole saws provides an effective and economical choice. Other tools and machines are available, and may be preferable depending on species, limb characteristics, and pruning height.

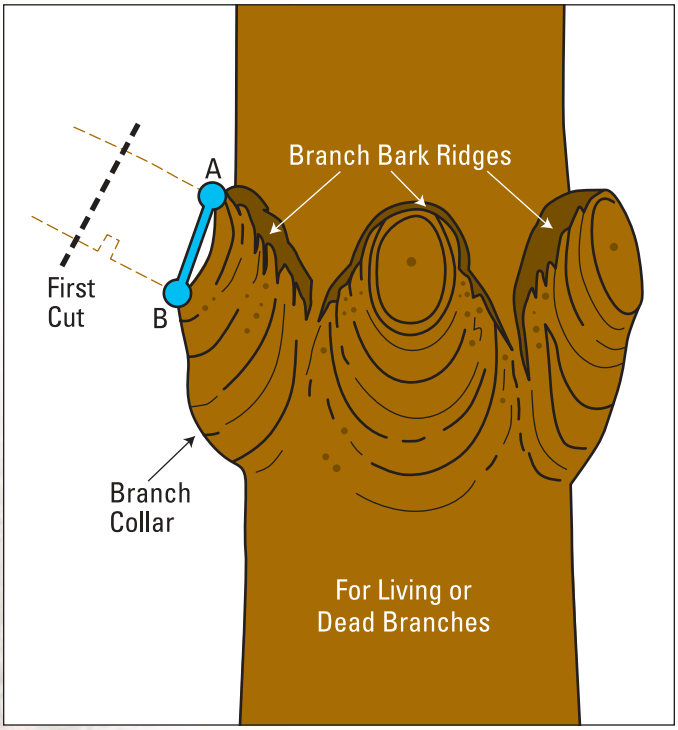

Figure 16-14: When pruning, leave the branch collar. Cut from point "A" to point "B."

POST-OPERATIONAL ACTIVITIES

- Rehabilitate landings, skid trails, and access roads to mitigate soil erosion, rutting, and compaction.
- Monitor and control any new infestations of non-native invasive species. Clean equipment before moving from any infested site to an area that is free of invasives.
- Careful records should be kept of intermediate treatments in order to assess the growth response, economic viability, and the need to refine future thinning schedules.

Figure 16-15: A dense thicket of non-native invasive honeysuckle on one side of a property fence. Honeysuckle on the near side was cut, and the stumps were treated with herbicide.

Figure 16-16: Seeding can be as easy as spreading grass seed by hand as this landowner is doing on his freshly-graded woods road. Use non-invasive species and certified weed-free seed.

Figure 16-17: Retaining slash on skid trails is an effective way of reducing soil compaction and rutting from use of heavy logging machines.

RESOURCES FOR ADDITIONAL INFORMATION

CROP TREE MANAGEMENT IN EASTERN HARDWOODS

Perkey, A. W., Wilkins, B. L. & Smith, H. C. (1993). *Crop tree management in eastern hardwoods.* NA-TP-19-93. USDA Forest Service. Morgantown: NESPF.

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Helms, J. A. (Ed.). (1998). *The dictionary of forestry.* Society of American Foresters.

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Huebschmann, M. & Martin, J. (1987). *Intermediate cuttings in forest management.* Wisconsin Woodlands G3398. University of Wisconsin Extension.

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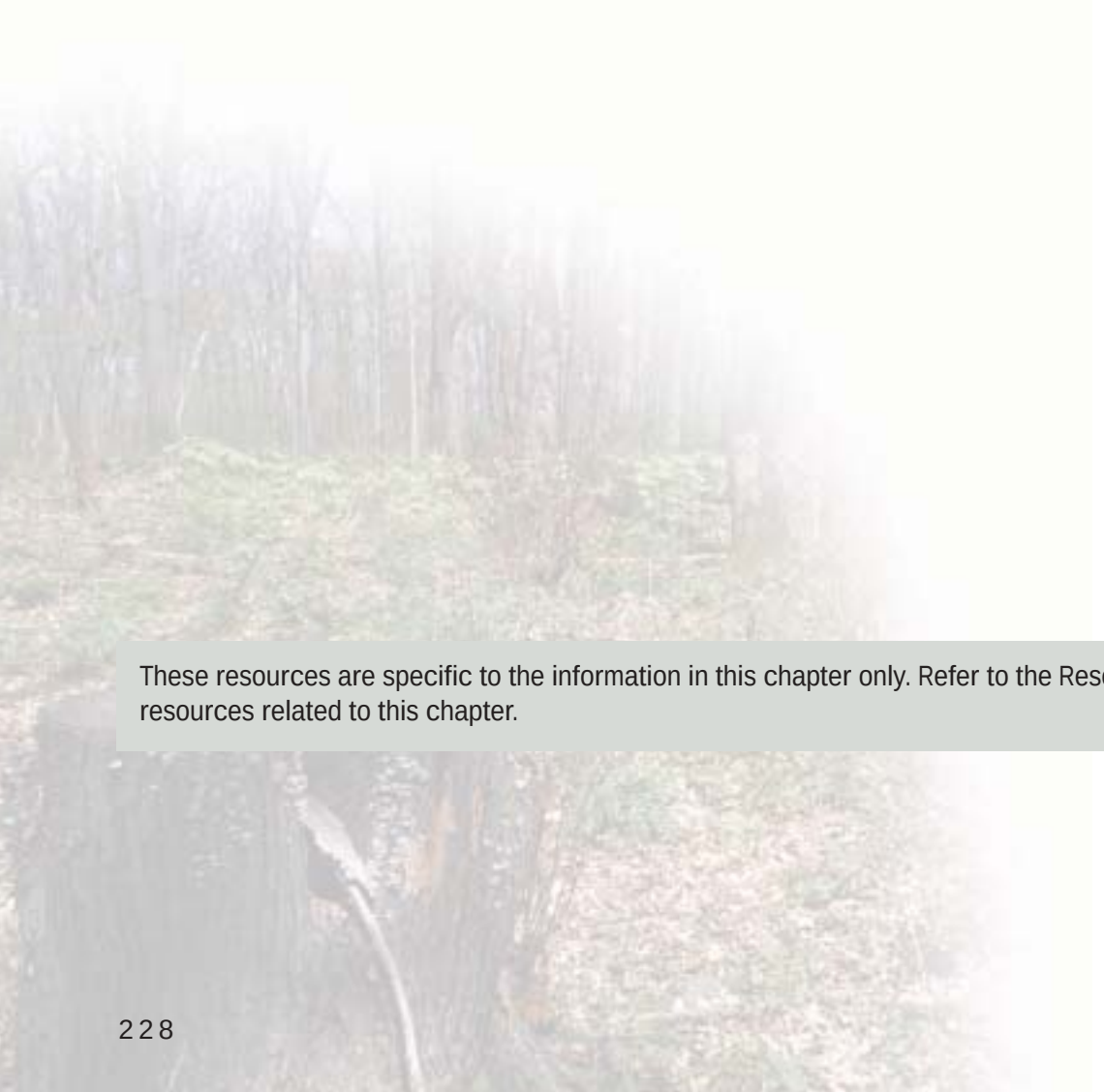
Smith, D. M. (1962). *The practice of silviculture (7th ed.)*. New York: Wiley.

SILVICULTURE: CONCEPTS AND APPLICATIONS

Nyland, R. D. (1996). *Silviculture: Concepts and applications.* New York: McGraw-Hill.

SILVICULTURE AND FOREST AESTHETICS HANDBOOK, PUBL. NO. 2341.5

Wisconsin Department of Natural Resources. (2002). *Silviculture and forest aesthetics handbook*. Madison: Wisconsin Department of Natural Resources.



These resources are specific to the information in this chapter only. Refer to the Resource Directory for additional resources related to this chapter.

WISCONSIN FOREST MANAGEMENT GUIDELINES

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Division of Forestry
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October, 2003

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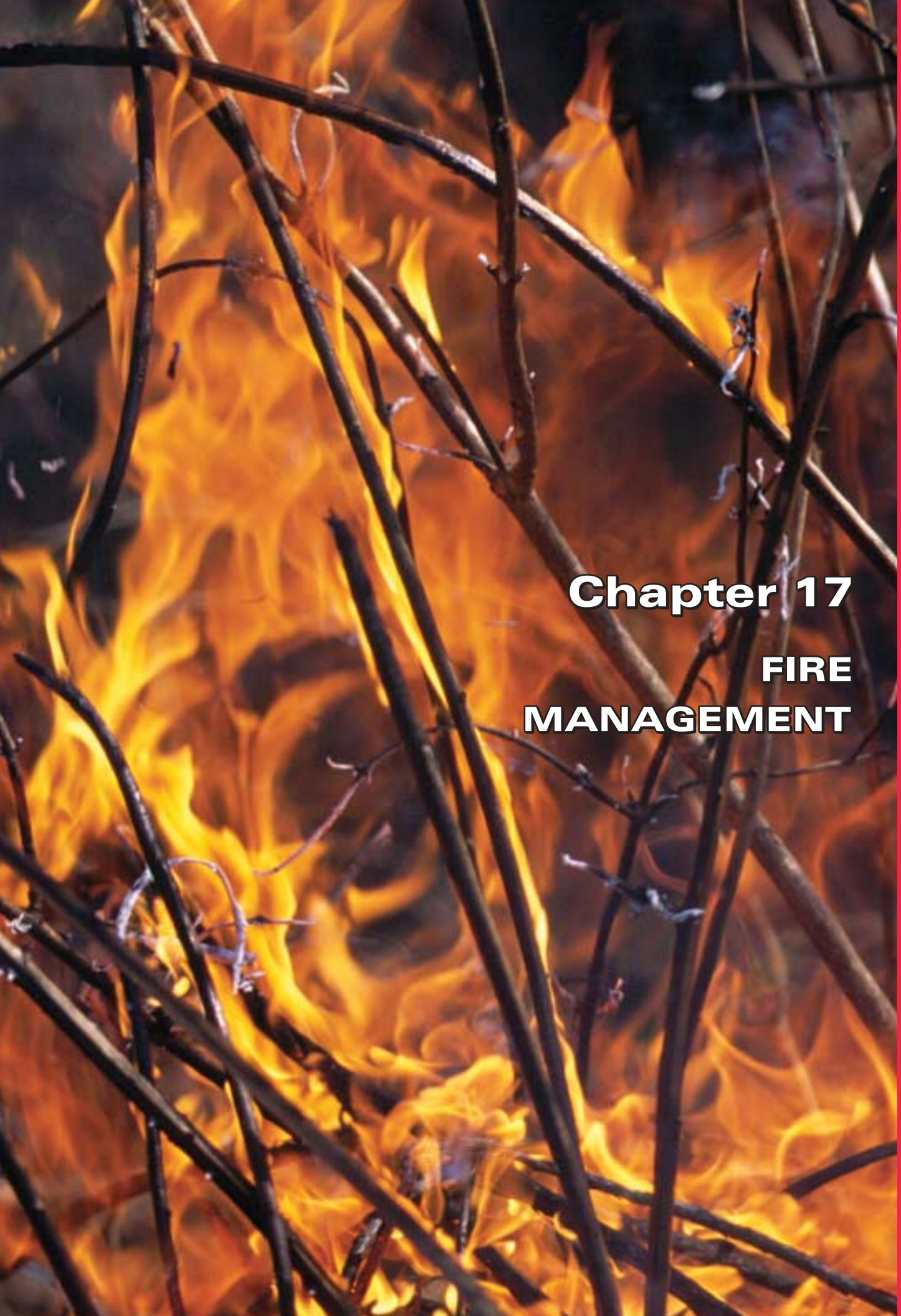

Chapter 17

FIRE MANAGEMENT

PART I: WILDFIRE MANAGEMENT

Protection of Resources from Wildfire 231
Protection of Property from Wildfire 231

PART II: PRESCRIBED FIRE MANAGEMENT

Integrated Resource Management Considerations 232

PLANNING AND DESIGN 233
Burn Plan Management 233
BMP: Burn Plan Management 233
Land Management Objectives 234
Factors Influencing Fire Behavior 234

OPERATIONAL CONSIDERATIONS 236
Fire Spread Patterns 236
Ignition patterns 236
Firebreaks 239
Managing Fuelbreaks and Accesses 241
BMP: Managing Fuelbreaks and Accesses 241
Protecting Water Quality and Wetlands 242
BMPs: Protecting Water Quality and Wetlands 242
Smoke Management Considerations 242
Safety Considerations 243
Pre-burn Briefing 244

POST-OPERATIONAL ACTIVITIES 245
Post-burn Monitoring 245
Fire Effects Evaluation 245
BMPs: Post-operational Activities 245

RESOURCES FOR ADDITIONAL INFORMATION 246

PART I: WILDFIRE MANAGEMENT

Figure 17-1: A Wisconsin DNR tractor and fire plow construct a control line to protect a home from a wildfire in Marquette County. Careless people cause over three-fourths of such wildfires, debris burning being the number one origin. Many of these fires can be prevented and losses minimized with diligent precautions and fuel management.

Wildfire management involves the control, containment and suppression of a wild or uncontrolled fire. A **wildfire** is defined in Wisconsin state statues as an uncontrolled, wild or running fire burning in forest, marsh, field, cutover, or other lands.

Every year, more than 2,500 wildfires occur in Wisconsin, causing thousands of dollars of damage to property, and destroying natural resources. Wildfire managers prioritize the protection of lives, property, and resources – in that order. The challenge of every manager is to minimize the damage done by wildfire, while at the same time ensuring the safety of everyone involved.

Protection of Resources from Wildfire

The protection of forest resources is vital to maintain the economics and aesthetics of Wisconsin forests. Landowners can implement a number of simple strategies to protect our valuable forest resources.

- **Maintain access trails and roads.** The spread of wildfire can be slowed by these barriers, thus limiting potential fire damage. Well-maintained roads also allow fire suppression crews to more easily access the wildfire area, speeding up suppression and mop-up.
- **Construct firebreaks or barriers** to fire, to protect high value forest resources, such as conifer plantations. The construction of firebreaks involves the elimination of flammable natural fuels, such as grass and leaves. Removal of the fuels down to bare mineral soil, will slow/stop the spread of wildfire into protected areas.
- **Remove the lower limbs of conifers and small trees near larger conifers** to help minimize the potential of catastrophic crown fires. The elimination of these "ladder fuels" will not allow a fire burning in surface fuels to climb into the crowns or tops of the existing trees. **Crown fires,** or fire in the tops of conifers, destroy the economic value and kill the trees. Crown fires also have the greatest potential for damage to lives, property, and natural resources, and are extremely difficult and dangerous to control once they are started.

Protection of Property from Wildfire

Protecting property such as buildings, homes, and garages is a high priority. Property owners in wildland areas can take some simple precautions to assist in protecting their property from the ravages of wildfire. The objective is to create an environment where buildings can survive a wildfire without the intervention of firefighters.

PLANNING PRECAUTIONS

- Plant fire resistant landscaping vegetation around homes. Deciduous plants hold more moisture and are less flammable than conifer plants. Carefully space plants and prune them regularly. Remove dead leaves and other litter from around the plantings.
- Construct buildings using fire resistant materials when at all possible. Such materials include cement, stucco, plaster, steel, masonry and fireproof sidings. Roofing materials should also be fire resistant. Available materials include Class A shingles, metal sheeting, or ceramic tile. Embers and sparks igniting nonfire resistant roofs have played a major role in the destruction of buildings on large forest fires.
- Plan a defensible space extending 30 feet around the building as free of combustible fuel as possible.

EXISTING STRUCTURES

- Maintain building driveways to a standard of 12 feet wide and 15 feet high. This allows fire trucks access, and forms a firebreak to slow or stop wildfire. The driveway should also include a turnaround near the buildings to allow fire suppression equipment to easily escape to safety.
- Clear the roof and gutters of needles, leaves, and other debris.
- Screen outside openings to the basement, attic, and roof vents.
- Mow the lawn and keep all vegetation healthy and well-watered.
- Clean up leaf and needle litter, especially against buildings and under porches and decks.
- Store woodpiles and other flammable materials at least 30 feet away from structures.
- Maintain a defensible space extending 30 feet around the buildings. The objective is to create an environment where the buildings can survive a wildfire without direct intervention from fire suppression crews. This 30 foot zone of protection should be as free of combustible fuel as possible to limit any ignitions from the wildfire. Trees should be pruned up six to 10 feet, and all tree limbs within 15 feet of the building removed. Any dead vegetation such as leaves, needles, twigs, and branches should be removed. The grass should be mowed and adequately watered.

PART II: PRESCRIBED FIRE MANAGEMENT

Prescribed fire is the intentional application of fire to wildland natural fuels, under specific environmental conditions, to accomplish planned land management objectives. It is a commonly suggested management strategy, and one of the most complicated and complex operations to implement.

Integrated Resource Management Considerations

- Prescribed burns can impact wetland areas and water quality if not carefully planned and conducted.
- Prescribed burns should be planned to avoid nesting seasons and other critical wildlife use periods.
- Prescribed burning can reduce the amount of course woody debris on a site.
- Be aware of the fact that certain non-native invasive species can become more abundant after fire, and burned areas are ideal seedbeds for others. Note that fire equipment can transport seeds to new locations.
- Smoke and blackened vegetation can affect visual quality in sensitive areas.
- Burning in standing timber may affect merchantability, since pulp and paper industries cannot accept charred wood.
- Prescribed burning, particularly firebreak construction, can adversely impact cultural areas.
- Repeated intense burns may affect soil productivity. When conducting prescribed burns, use low- or moderate-burning intensity so that the minimum amount of forest floor is consumed consistent with meeting the objectives of the burn, especially for dry, sandy soils or shallow soils over bedrock.

TO BURN OR NOT TO BURN?

Prescribed fire is a versatile tool in land management. Sometimes, however, it is not the best choice. If any of the following situations exist, the use of prescribed fire is NOT a viable option:

- Federal or state regulations prohibit burning.
- Local ordinances or zoning rules prohibit burning.
- Safety factors cannot be mitigated to ensure personnel safety.
- Containment risk factors exceed acceptable limits.
- Endangered resources or natural communities are subject to harm, or their status is in doubt.
- Fire behavior or fire effects will not meet the objectives for the burn area.
- Local residences would be in jeopardy.
- Smoke sensitivity issues cannot be mitigated satisfactorily.

PLANNING AND DESIGN

Figure 17-2: A pre-burn briefing conducted prior to every prescribed fire addresses a number of critical items.

Prescribed burn plans generally involve a written document that addresses a number of factors. The plan should clearly describe the existing vegetation on the burn area, and the desired future condition. The plan should also spell out the specific weather conditions and ignition patterns required to achieve the desired fire behavior. Any issues relating to adjacent lands, communities, structures, roads, smoke management, and traffic control needs should also be addressed. Finally, the plan should identify the people and equipment needed to safely complete the burn, and include a detailed contingency plan for reacting to any emergency.

BMP: Burn Plan Management

✓ Before conducting any prescribed burn in Wisconsin, apply for a burning permit from the Wisconsin Department of Natural Resources, or your local municipal or township authorities.

Burn Plan Management

- Consult with local DNR personnel trained and experienced in prescribed burning for pertinent assistance in planning and conducting burns.
- Include cultural resource information in both wildfire suppression and prescribed burn plans. Important information includes:
  - Locations of known cultural resources.
  - Locations of high probability areas for the occurrence of cultural resources.
- Consider protection of the largest coarse woody debris from fire, if practical.
- Identify occurrences of non-native invasive species, and evaluate the effects fire is likely to have on them. Identify any need to treat infestations prior to burning, or any integrated pest management (IPM) treatments to be used in conjunction with burning to prevent new infestations.

Land Management Objectives

Accomplishing land management objectives are the primary consideration for conducting prescribed burns. These objectives are varied and diverse. Some examples are:

- **Fuel reduction to reduce the risk of catastrophic wildland fire.** This objective is especially important in forests in proximity to urban areas. Reducing fuel loads is one of the most effective elements of any fire prevention and protection program.
- **Site preparation for natural seeding or mechanical replanting forests.** Prescribed burning is one of the least expensive and most environmentally sound ways to accomplish this practice. Nutrients are released into the soil during burning to further enhance the re-establishment of a new forest.
- **Restoration of fire dependent ecosystems.** Fire is a natural and necessary component of some ecosystems, such as native prairies and oak savannah. Periodic fire is required for regeneration and growth of fire adapted species within these systems. Prescribed burning assists in restoring and maintaining these rare plant and animal communities.
- **Improvement of wildlife habitat.** Fire and wildlife have a long and intimate association both in and out of the forest environment. Prescribed fire is rarely lethal to most wildlife, yet has a profound effect on habitat by increasing browse – creating edge and increasing productivity.
- **Controlling vegetative competition.** Examples would include burning to decrease woody vegetation in grass duck nesting fields, or to control maple sprouts while favoring more desirable oak seedlings.
- **Controlling forest insects and diseases through the use of fire.** Certain pathogens and insects can be controlled through the timely use of prescribed fire.
- **Improved pasture conditions for livestock is possible through prescribed burning.** Research has shown forage for livestock can be improved in quality and quantity with timely burning.
- **Control of non-native invasive species and noxious weeds** can be accomplished, in some cases, by exploiting sensitivities to fire.
- **Enhance desired aesthetic qualities** by favoring specific plant species, or enhancing herbaceous components.

Factors Influencing Fire Behavior

A prescribed fire is designed around a carefully developed burning prescription designed to generate the specific fire behavior needed to accomplish the intended land management objective. The following are key components that must be considered.

FUEL

Fuel is defined simply as any combustible material. Wildland fuels consist of live and dead plant materials. Some factors of wildland fuel affect the prescribed burn planning.

- **Fuel types** are classified by the primary carrier of the fire. Light fuels are grasses, leaves and small twigs, which burn rapidly and completely. Heavy fuels – made up of branches, limbs and trees – burn hotter, longer, and more slowly.
- **Fuel moisture** is the amount of water in a fuel. The higher the moisture the slower a fuel will burn. Both live and dead fuel moisture has to be considered before burning. Light fuels take on and lose moisture much faster than heavy fuels.
- **Fuel loading** (see Figure 17-3) is a very important consideration in planning a prescribed burn. The fuel load is the quantity of fuel available for combustion. The higher the fuel load, the more intense a given fire.
- The horizontal continuity of fuels is important to predict the spread of a prescribed fire. **Uniform fuels** are continuously distributed over a given area. **Patchy fuels** would indicate uneven distribution of fuels.
- The vertical arrangement of fuels is also important. **Ground fuels** are fuels able to burn under the surface of the ground such as deep duff, tree roots and peat soils. **Surface fuels** are combustible materials on the surface, such as grass, leaves, shrubs, and stumps. **Aerial fuels** are the fuels located above the surface in the canopy including leaves, needles, branches, snags, and tree crowns.

Figure 17-3: Light fuels tend to burn rapidly and completely. They also dry out much faster than heavier fuels when the relative humidity decreases.

WEATHER CONDITIONS

Weather conditions are another important consideration. Weather conditions must be closely monitored before and during prescribed burning. Both predicted and actual weather will influence the decision to burn. Some basic weather parameters that must be evaluated in the development of a burning prescription include:

- **Temperature:** A measure of warmth that directly influences fuels. Higher ground and fuel temperatures make the fire burn hotter and faster.
- **Wind:** The primary factor influencing the rate and direction of fire spread. Wind encourages the combustion process and spread of fire by increasing the supply of oxygen, drying out fuels and carrying firebrands ahead of the main fire.
- **Relative Humidity:** The ratio of the amount of moisture in the air to the amount of moisture the air could carry at saturation. Fuels and the air are constantly exchanging moisture. Light fuels, such as grass, gain and lose moisture quickly with changes in relative humidity. A **low relative humidity** means the air will take moisture from light fuels, making it easier to ignite and burn rapidly. Heavy fuels exchange moisture with the air much slower, and respond to changes in the relative humidity much slower.

TOPOGRAPHY

Topography is the configuration of the earth's surface, including its relief and position of its natural land features. Topographical influences on the behavior of a fire can be predicted. Several topographic terms are important to understand in relationship to fire behavior.

- **Aspect:** The direction a slope faces. A south facing slope will absorb more of the radiant heat of the sun, therefore, the fuels on that slope will have a lower fuel moisture allowing for easier ignition and rapid spread of fire. North facing slopes will have wetter fuels, therefore, less intense fire.
- **Slope:** The steepness of a hillside. Fires burn more rapidly uphill than downhill. The steeper a slope, the faster a fire burns uphill. Slope also causes concern where burning materials can roll downhill and ignite fires below the main fire.
- **Elevation:** The height of terrain above mean sea level. Elevation can play an important role in the types and conditions of fuel. Fuels at lower elevation generally dry out earlier in the year than higher elevation fuels.
- **Shape:** The rugged topographic features of the landscape, such as box canyons, ridges, and saddles. These features can affect the rate, direction and intensity of a fire burning near them.

OPERATIONAL CONSIDERATIONS

Once the decision to conduct a prescribed burn has been made, the next step is to evaluate a number of operational considerations that are key to conducting a successful burn.

Fire Spread Patterns

The direction of fire spread, relative to the wind direction, is an important factor in managing the fire behavior relative to the land management objectives of the burn. Fire spread can be categorized into three basic types: backing fire, head fire, and flank fire.

BACKING FIRE

Backing fire is a fire that backs INTO the prevailing wind or downslope. Fires of this type transfer heat to adjacent fuels through radiation. Backing fires produce short flame lengths, slow rates of spread, and low smoke densities. **Backing fires burn fuels for a longer duration and at higher temperatures, and consume more total fuel than flanking fires.** Overall prescribed burn costs per acre are higher because of the longer time needed to complete a burn. Backing fires work well when wind velocities are low and from a constant direction. Burning downward on slopes has a similar effect as backing fires in flat areas.

HEAD FIRE

A **head fire** is a fire that burns WITH the wind or upslope. This type of fire spread transfers heat to adjacent fuels by convection. Wind drives convective heat into fuels downwind – lowering fuel moistures, raising fuel temperatures, and lowering ignition temperatures. Head fires burn fastest, hottest, and with the longest flame lengths. **Head fires are the most difficult to control because of the greater potential for firebrands to ignite fuel outside the burn area.** Head fires also burn cooler at the surface with greater smoke volumes than backing or flanking fires. Containment is critical with this kind of fire, especially as wind speed and the amount of fuel increases.

FLANK FIRE

Flank fire is a fire spread that burns at OBLIQUE ANGLES to the prevailing wind direction or slope direction. Flanking fires transfer heat through both radiation and convection. **Rates of spread, flame lengths, and fire intensity are between the extremes of head fire and backing fire.** Spotting can still occur with flanking fire, but at shorter ranges. Flanking fires are set parallel to control lines on a prescribed fire and spread at right angles.

Ignition Patterns

Specific ignition patterns are used for each type of fire spread. The ignition pattern and ignition sequence are key to achieving the objectives of the burn, and meeting the containment requirements of the burn area with a minimum of risk.

BACKING FIRE IGNITION PATTERN

This firing pattern (see Figure 17-4) involves lighting a fire along the upwind side of an established control line, and letting it back into the wind. It is commonly used in closed canopy forests. **The advantages of this pattern include ease of control, low intensity, low rates of spread, and low scorch of trees and shrubs.** The negatives are slow moving fire, increased costs per acre, and patience.

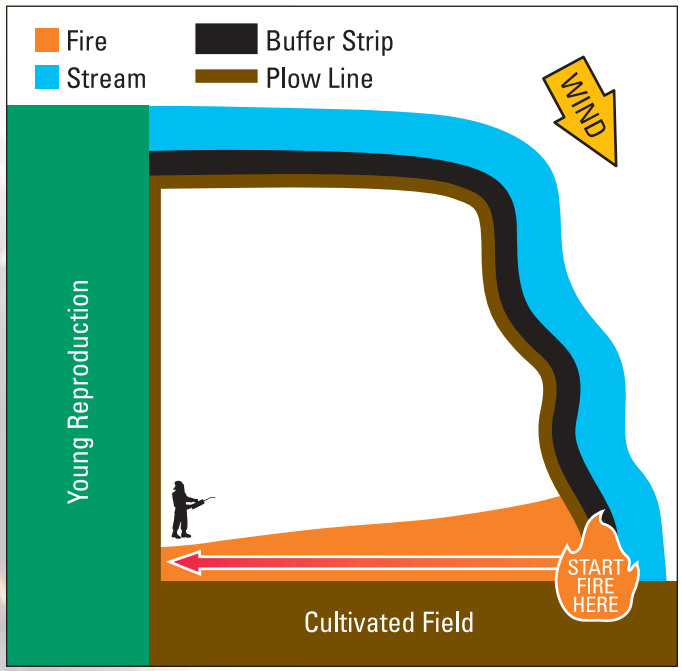

Figure 17-4: Backing Fire Ignition Pattern

STRIP HEAD FIRE IGNITION PATTERN

Strip head fire ignition (see Figure 17-5) involves igniting a series of short duration head fires, by moving perpendicular to the wind from one side of the prescribed burn area to the other. The first strip is initiated at the downwind end of the burn area, and each progressive upwind strip of head fire burns into the area already blackened by a previously burned strip. Adjusting the width of the strip adjusts the intensity of the fire. This pattern is commonly used in grassy areas where greater control is needed. **The advantages of this ignition pattern are that is fast, inexpensive, can be used on large areas, and helps alleviate some smoke management concerns.** The smoke rises faster and to greater heights. The disadvantages are fast rates of spread, increased spotting potential, and greater burning intensities.

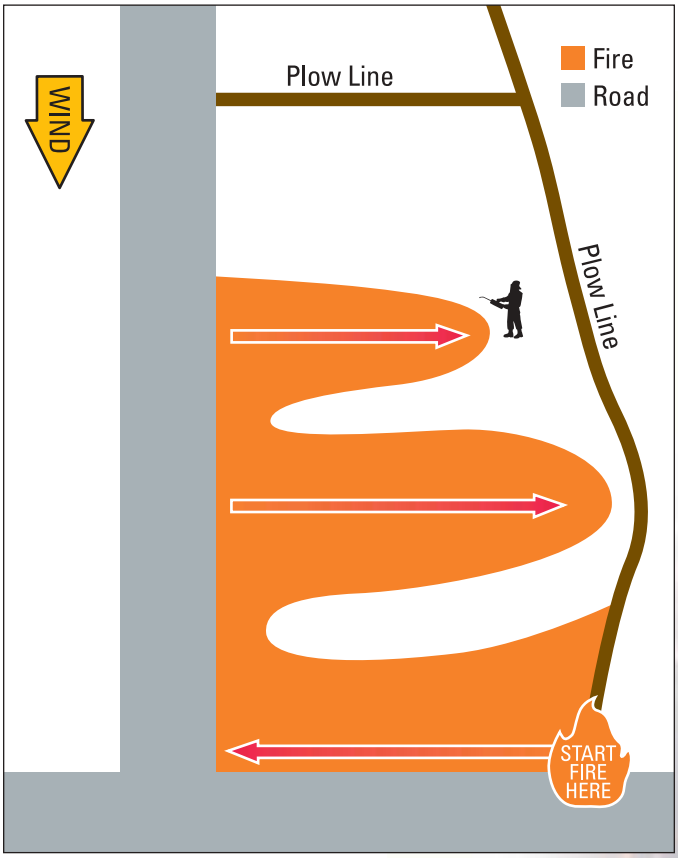

Figure 17-5: Strip Head Fire Ignition Pattern

FLANK FIRE IGNITION PATTERN

Flank firing ignition (see Figure 17-6) involves firing parallel with and into the wind or with slope. It can be used in a variety of situations from large broadcast burns to an underburn in closed canopy forests. Multiple ignition personnel can be used for large area burns. **The advantages of this ignition pattern are safety (no head fire), moderate burn intensities, and relatively low costs.** The disadvantages are a greater need for coordination and timing, and the potential that a wind shift could quickly endanger the safety of the ignition personnel, and threaten the control of the burn.

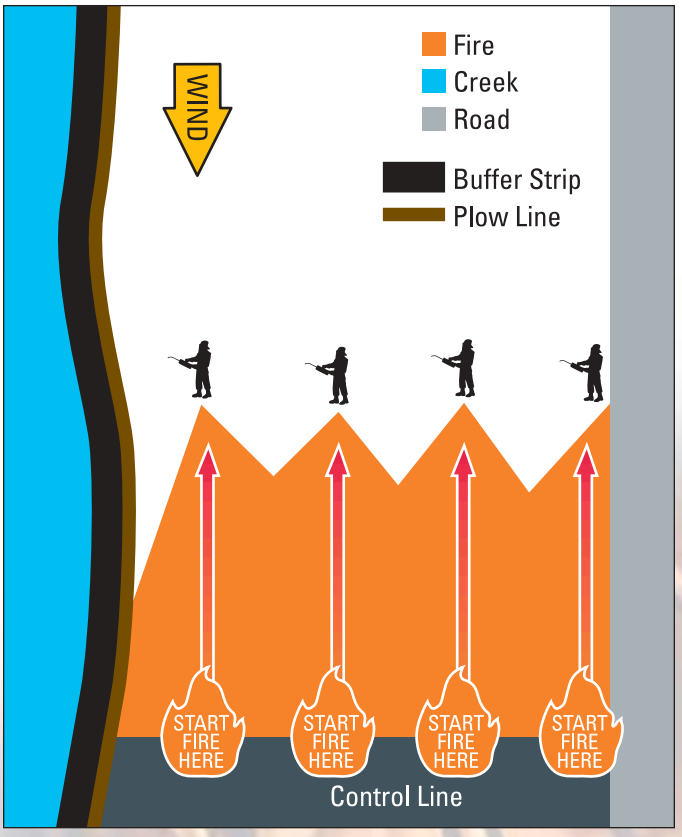

Figure 17-6: Flank Fire Ignition Pattern

CIRCULAR FIRE IGNITION PATTERN

The circular pattern, also called the ring firing pattern or the perimeter firing pattern, (see Figure 17-7) is a common ignition pattern that involves lighting fire around the perimeter of a burn area with the fire converging towards the center. **This pattern is most commonly used because of the ease of coordination, safety and speed.** It can be the most cost-effective burn pattern. A backing fire is first lit along an established firebreak on the downwind side of the burn area. A flanking fire is then initiated up the sides of the burn area along firebreaks. When the backing fire has burned out an area of sufficient width, a head fire is ignited along the upwind edge of the burn area. The separate fires then converge in the middle of the burn unit. **This pattern also allows for maximum smoke lift and dispersion.** The disadvantages of this pattern are high fire intensities in some areas of the burn, and the difficulty and danger involved in stopping the head fire, should the burn have to be aborted.

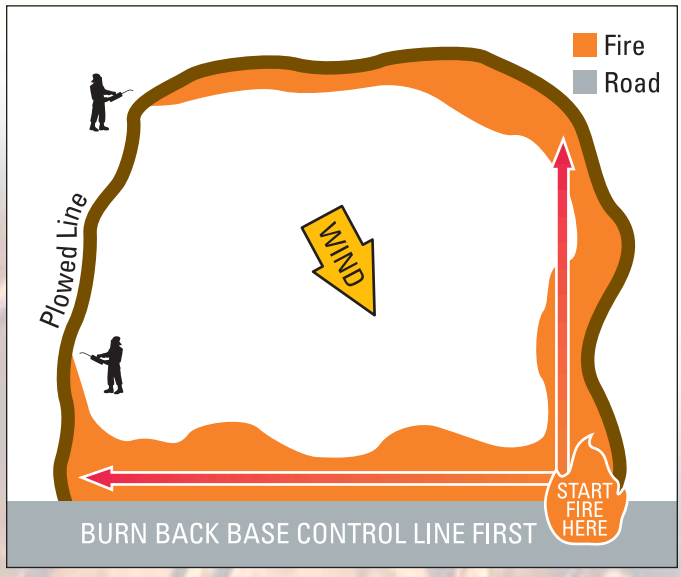

Figure 17-7: Circular Fire Ignition Pattern

SPOT FIRING IGNITION PATTERN

Spot or dot firing (see Figure 17-8) involves the setting of many small fires that burn together quickly. **This pattern of ignition controls the intensity of the resulting fire.** This pattern can be effective in either grass or forested areas.

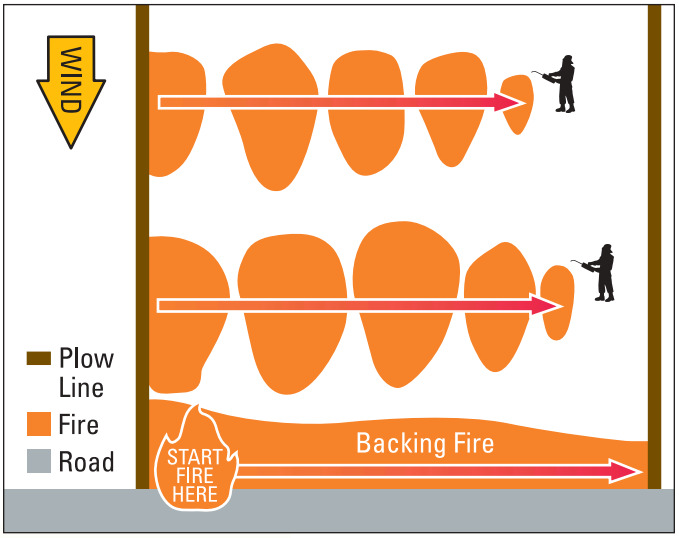

Figure 17-8: Spot Firing Ignition Pattern

Figure 17-9: Igniting a backing fire along a freshly prepared firebreak in a hardwood stand.

Figure 17-10: Constructing a mineral soil firebreak prior to prescribed burning in a Wisconsin woodland.

Figure 17-11: Igniting one side of the burn area where a circular, or perimeter, ignition pattern was used.

Firebreaks

Confining prescribed fire to the areas that are intended to burn is the most critical element to the operational phase of a prescribed fire. A firebreak is a natural or constructed barrier able to stop or check fire spread, and to provide a control line from which to work. An effective firebreak must interrupt the continuity of the fuel bed, and provide containment of the fire under prescribed weather conditions.

- **Natural and artificial firebreaks** are existing features of the landscape. Natural firebreaks include lakes, streams, rivers, wetlands, snow banks, and rockslides. Artificial firebreaks include roads, ditches, trails, and tilled farmland. Utilization of such firebreaks can lower the costs of containment and aid burning operations. When using roads as firebreaks, smoke management must be considered, and traffic control measures may be required.

- **Wet lines or foam lines** can be used as firebreaks where there are environmental or cultural resource concerns. Wet lines and foam lines are inexpensive and easily constructed with common firefighting tools. A wet line is constructed by spraying water on fuels immediately prior to ignition. A foam line is constructed with chemically treated water. Class A foam additives raise the efficiency of water by lowering its surface tension, making it three to five times more effective in wetting fuels. Approved Class A foams are biodegradable and environmentally safe. Foam lines are also more persistent and visible than plain water. The disadvantages to these firebreaks are that they require additional crewmembers, equipment, and large amounts of water. Wet lines and foam lines will also evaporate in fine fuels, requiring a more cautious initiation of firing.

- **Mowed firebreaks** are the least desirable of firebreaks because they do not remove all of the fuel. Mowed firebreaks must be very wide (25 to 50 feet) to be effective – even in grass fuel types. The cut vegetation should be removed or blown to the outside of the firebreak prior to fire ignition. These firebreaks can be prepared in advance, but still require increased patrols and surveillance by control crews to prevent fires from escaping. Wet lines and foam lines are usually used in conjunction with mowing to ensure safety and control of the burn.

Figure 17-12: Localized fuel concentrations can result in "hot spots" with increased fire intensity.

Figure 17-13: With secure firebreaks, stable weather, and well-executed firing patterns, hand tools like backcans, swats, and shovels may be all that are needed by foot patrols to contain a burn.

Figure 17-14: Fires that crown-out in conifers can throw sparks great distances, which could cause a prescribed burn to escape control.

Figure 17-15: Although this type of plowed fuelbreak is more common on wildfires than prescribed burns, a bare mineral soil break provides one of the best anchors for ignition lines.

- **Burned firebreaks or black line firebreaks** involve the use of controlled fire to create a firebreak. Burned firebreaks are constructed prior to burning the whole prescribed fire area. Fire suppression crews must extinguish both sides of a line of fire to construct this type of break. The technique involves a lot of hot, difficult work by lots of firefighters, as well as large quantities of water or foam, since it requires setting and extinguishing fires two different times on the same land area.
- **Bare ground or mineral soil firebreaks** are constructed in areas lacking natural firebreaks. The construction of a mineral soil firebreak involves physically removing all fuels by rotovating, bulldozing, plowing, or disking with machinery to expose bare soil. The constructed firebreak width should be one and one-half times the flame length exposed to the firebreak. A typical constructed firebreak is from six to 15 feet wide. Mowing vegetation from six to 20 feet adjacent to the firebreak can diminish flame lengths along firebreaks. This mowing effectively increases the size of the fuelbreak.

Figure 17-16: Mop-up involves extinguishing all burning materials in the burn unit, such as this old log and stump.

Managing Fuelbreaks and Accesses

- Construct fuelbreaks outside of cultural resource areas. Use cultural resource professionals or tribal representatives to help determine fuelbreak location.
- Construct fuelbreaks only deep enough and wide enough to control the spread of the fire.
- Avoid construction of fuelbreaks for fire management that result in drainage directly into a waterbody.
- Provide adequate filter strips when constructing fuelbreaks that expose bare soil near wetlands.
- Use fuelbreak construction methods in wetlands that do not expose bare soil whenever practical. These may include wet lines, existing constructed or natural barriers, foam, or retardants. If techniques result in exposure of bare soil, such areas must be restored if wetland hydrologic functions are impacted.
- Employ suitable water diversion structures on fuelbreaks, approaches to water crossings, or on roads and trails found within the riparian management zone to divert water off of the right-of-way before it reaches the waterbody.
- Monitor the effectiveness of cultural resource management practices during prescribed burns and wildfire suppression activities.
- Control access to sensitive cultural resources.

BMP: Managing Fuelbreaks and Accesses

✓ Where possible, locate bladed firelines on the contour. Construct waterbars as needed to direct surfacewater off firelines and into undisturbed forest cover. Recommended specifications for building waterbars and their spacing can be found in Chapter 11: Forest Roads, Drainage Structures, page 149.

Protecting Water Quality and Wetlands

BMPs: Protecting Water Quality and Wetlands

- ✓ Carefully select fireline locations and consider weather, fuel, soil, and topographic conditions in the burn area to minimize impacts on water quality.
- ✓ Avoid intense burns that remove forest floor litter which may expose soil in riparian management zones, and on slopes where eroded soil may drain to surfacewater.
- ✓ Avoid burning piles of slash in riparian management zones.
- ✓ Use natural or existing barriers (e.g., roads, streams, and lakes) where possible, or wet lines for firelines where bladed/plowed firelines will erode soil and degrade water quality.
- ✓ Avoid plowed and bladed firelines in riparian management zones except where necessary to control wildfire.
- ✓ Avoid applying chemical fire retardants over surfacewater. Prevent chemical fire retardants from flowing into surfacewater.

- Establish unburned zones containing no fuelbreaks to protect water quality in situations where steep slopes, highly erodible soils, or the likelihood of substantial organic matter removal are present.
  - Follow manufacturer recommendations.
  - Avoid cleaning fire retardant application equipment in lakes or streams.

Smoke Management Considerations

Smoke can contribute to air quality concerns. A prescribed burn should be conducted in ways that minimize adverse environmental effects, and are in compliance with local and state air quality regulations. The following are some considerations relative to smoke management:

- Moist fuels produce more smoke than dry fuels.
- Head fires produce more smoke than slower backing fires.
- Smoke problems are more pronounced at night than during daylight. Burn during the day to maximize convective lift.
- Stable air mass conditions help to restrict smoke convection and dispersion. Burn in slightly unstable air mass conditions.
- Check for possible restricted air space that smoke could impact, especially around airports and/or military bases.
- Check for smoke sensitive areas (nursing homes, schools, and residential areas) and avoid sending smoke that would impact them. Notify sensitive receptors of burning plans as a common courtesy.
- Estimate and predict smoke duration and concentration to assess the risks of burning.
- Use test fires to confirm smoke behavior.
- Have an emergency plan to extinguish the fire if smoke conditions change adversely.
- Comply with all local and state air quality regulations.
- Avoid smoke on any public roadway. If necessary, implement traffic controls for the safe passage of motorists.

Safety Considerations

- Safety should be the foremost consideration on every prescribed fire. The protection of lives, including firefighters, is the primary concern for all fire managers. Safety is promoted through training, removal of hazards, and the use of personal protective equipment. Firefighters have been injured and killed on the most innocent of prescribed fires.
- Everyone involved with prescribed fire should be wearing full personal protective clothing for his or her safety. Clothing and equipment worn should include all of the following:
  - Hard hat or helmet
  - Leather gloves
  - Nomex or other fire resistant shirt and pants
  - Leather boots
  - Goggles

The 10 Standard Fire Orders were developed in 1957 by a task force studying ways to prevent firefighter injuries and fatalities. Shortly after the Standard Fire Orders were incorporated into firefighter training, the 18 Situations That Shout Watch Out were developed. These 18 situations are more specific and cautionary than the Standard Fire Orders and described situations that expand the 10 points of the Fire Orders. If firefighters follow the 10 Standard Fire Orders and are alerted to the 18 Watch Out Situations, much of the risk of firefighting can be reduced.

10 STANDARD FIRE ORDERS

Fire Behavior

1. Keep informed on fire weather conditions and forecasts.
2. Know what your fire is doing at all times.
3. Base all actions on current and expected behavior of the fire.

Fireline Safety

4. Identify escape routes and make them known.
5. Post lookouts when there is possible danger.
6. Be alert. Keep calm. Think clearly. Act decisively.

Organizational Control

7. Maintain prompt communications with your forces, your supervisor and adjoining forces.
8. Give clear instructions and insure that they are understood.
9. Maintain control of your forces at all times.

If One Through Nine (Above) are Considered, Then...

10. Fight fire aggressively, having provided for safety first.

The 10 Standard Fire Orders are firm. WE DON'T BREAK THEM; WE DON'T BEND THEM. **All firefighters have a right to a safe assignment.**

18 SITUATIONS THAT SHOUT WATCH OUT

1. Fire not scouted and sized up.
2. In country not seen in daylight.
3. Safety zones and escape routes not identified.
4. Unfamiliar with weather and local factors influencing fire behavior.
5. Uninformed on strategy, tactics, and hazards.
6. Instructions and assignments not clear.
7. No communication link between crewmembers and supervisors.
8. Constructing line without safe anchor point.
9. Building line downhill with fire below.
10. Attempting frontal assault on fire.
11. Unburned fuel between you and the fire.
12. Cannot see main fire, not in contact with anyone who can.
13. On a hillside where rolling material can ignite fuel below.
14. Weather gets hotter and drier.
15. Wind increases and/or changes direction.
16. Getting frequent spot fires across line.
17. Terrain or fuels make escape to safety zones difficult.
18. Feel like taking a nap near fireline.

Pre-burn Briefing

A pre-burn briefing is necessary before every burn. All participants must be present before any prescribed fire activities can commence. The briefing should cover the following topics:

- Hand out maps to all participants.
- Review current weather and expected fire behavior.
- Explain the burn plan, and describe the ignition pattern to be used.
- Ensure everyone understands how to communicate. Test all radios.
- Check all equipment to ensure that they are all operating properly.
- Identify a burn boss. Assign personnel and equipment:
  - Assign specific control crew segments of the burn perimeter.
  - Assign an ignition crew and review firing sequence.
  - Control traffic, if needed.
  - Observe weather conditions.
- Identify water fill sites to be used.

COMMON DENOMINATORS OF FIRE BEHAVIOR ON TRAGEDY FIRES

A **tragedy fire** is a fire that caused serious injuries or death(s):

- Most incidents happen on smaller fires, or on isolated portions of larger fires.
- Most fires are innocent in appearance before unexpected wind shifts in direction and/or speed results in flare-ups or extreme fire behavior. In some cases, tragedies occur in the mop-up stage.
- Flare-ups generally occur in deceptively light fuels, such as grass and light brush.
- Fires run uphill – surprisingly fast in chimneys, gullies, and on steep slopes.
- Some suppression tools, such as helicopters or air tankers, can adversely affect fire behavior. The blasts of air from low flying helicopters and air tankers have been known to cause flare-ups.

- Cover contingency plans in case of spot fires/breakouts.
- Check for appropriate personal protective clothing and equipment.
- Review appropriate safety procedures.
- Ask for questions – clarify if necessary.
- Conduct a test fire to confirm fire behavior and smoke dispersal.

Figure 17-17: Wearing full personal protective clothing is necessary for the safety of all crewmembers.

Figure 17-18: A fire crew reviewing escape routes and safety zones prior to a prescribed fire.

POST-OPERATIONAL ACTIVITIES

Post-burn Monitoring

The fire is not over until all of the burn area is completely extinguished, the fuel is cold, and there is no smoke being produced. There are generally three steps to post-burn assessment:

- **Perimeter monitoring** of the burn area must be continuous from the onset of burning until the burn boss declares the fire out. Perimeter monitoring must ensure that the fire is kept within the burn unit boundaries. This activity is most critical as the main fire front passes a given area. At least one person must be kept back to periodically patrol the perimeter of the burn until it is declared out, even if the rest of the burn team moves on to other burn areas.
- **Mop-up** is the action of extinguishing all burning materials in a burn unit. Mop-up is the hard work of prescribed burning. It involves the most time and effort of all of the activities on a prescribed fire. Mop-up is not complete until the burn boss declares the fire out.
- **Abandonment standards should include 100 percent extinguishment** of burning or smoldering materials. Wisconsin state statues prohibit leaving a fire that is not extinguished completely.

Fire Effects Evaluation

The goal of any prescribed fire is to accomplish a land management objective. After the prescribed fire, an effective evaluation should be conducted to measure the success in meeting the stated objective. Post-burn evaluations are the key to improved future prescribed fire prescriptions. Evaluations should include pre-burn, burn, and post-burn operations to improve all aspects of the prescribed burning. The following are some, but not all, important items that should be evaluated: 1) success in vegetative manipulation, 2) prescribed versus actual results, 3) post-burn vegetative condition, 4) accidents, 5) fire control problems, 6) smoke management problems, 7) burning pattern effectiveness, 8) cost effectiveness, and 9) corrective actions needed.

BMPs: Post-operational Considerations

- ✓ Do not clean chemical application equipment in surfacewater, or in locations that drain directly into surfacewater.
- ✓ Use erosion control measures for firelines that could erode soil into lakes, streams, and wetlands. Erosion control measures include revegetation and installing waterbars. Placing sod back into plowed furrows at appropriate intervals can act as waterbars (see Chapter 11: Forest Roads, Soil Stabilization).
- ✓ Maintain soil stabilization practices until the site is fully revegetated and stabilized.
- ✓ Use mowing or other practices that do not expose soil as alternatives to blading or disking, for maintaining firebreaks where erosion may degrade water quality.

- **Assess the condition of cultural resources** that may have been affected by prescribed burning or wildfire suppression activities.
- **Field inspect the burned area** to identify cultural resources that may not have been previously identified, but have been newly exposed by the fire.
- **Remove temporary fire management features** that are inappropriate to the historic character of adjacent cultural resources.
- **Restore water source sites** used for fire management activities as soon as possible following control, or at the completion of mop-up activities.
- **Monitor the burned area and access routes for non-native invasive species,** and take steps to eradicate any that have been introduced by activities related to the burn. Fire equipment may need to be cleaned before it is moved from an infested site into an area that is free of problem invasives.

RESOURCES FOR ADDITIONAL INFORMATION

DEPARTMENT OF NATURAL RESOURCES, BUREAU OF FIRE MANAGEMENT

Information on burning permits, wildfire activity, fire weather forecasts, and fire departments.
www.dnr.state.wi.us/org/land/forestry/fire

FIRE MANAGEMENT, FIRE SUPPRESSION AND PRESCRIBED FIRE HANDBOOK

This handbook from the Department of Natural Resources contains information on fire suppression tactics and training, and the use of prescribed fire, along with technical information on the Wisconsin Division of Forestry Fire Management Program (see the Resource Directory for contact information).

FIRELINE HANDBOOK

A pocket guide covering all aspects of wildfire management and safety. Contact the publications section of **www.nwcg.gov/** to purchase a copy.

FIREWISE

Information on ways to protect homes located in fire prone areas.
www.firewise.org

FLORIDA DIVISION OF FORESTRY

Information on the use of prescribed fire to protect homes and benefit ecosystems.
www.prescribed-fire.org

NATIONAL FIRE PLAN

Information on the impact of wildfires on communities and the environment.
www.fireplan.gov

NATIONAL INTERAGENCY FIRE CENTER

Wildland fire information, fire statistics, and links to other agencies.
www.nifc.gov

NATURE CONSERVANCY

Information on the use of prescribed fire and training.
www.tncfire.org

NORTHERN PRAIRIE WILDLIFE RESEARCH CENTER

Information on the use of fire in wildlife management.
www.npwrc.usgs.gov

U.S. FOREST SERVICE, FIRE AND AVIATION MANAGEMENT

Information about wildfire activity and situation reports, fire management, training, fire use, and fire prevention.
www.fs.fed.us/fire/

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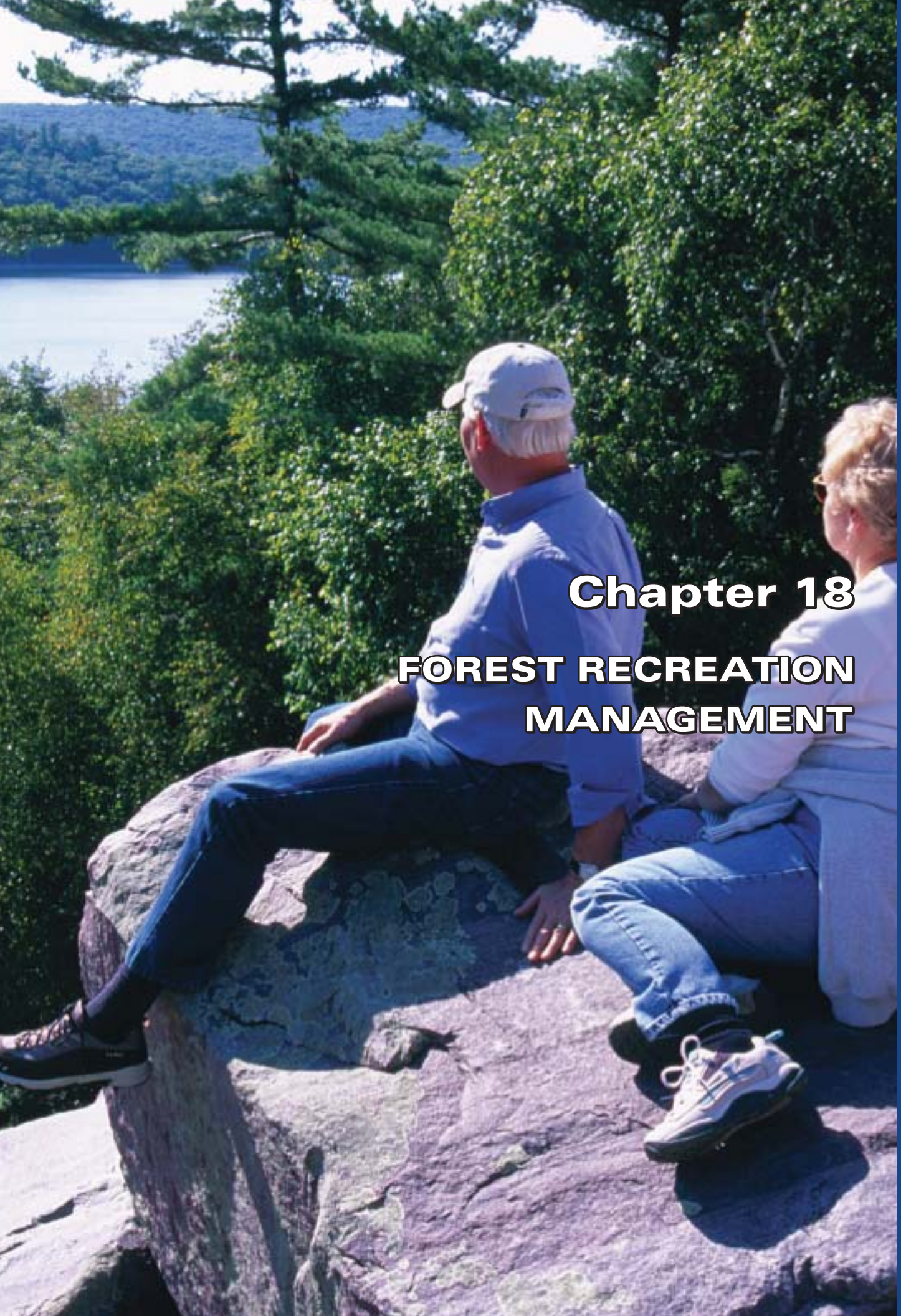

Chapter 18

FOREST RECREATION MANAGEMENT

CHAPTER 18 — FOREST RECREATION MANAGEMENT

Integrated Resource Management Considerations 248

PLANNING AND DESIGN 249

OPERATIONAL CONSIDERATIONS 251

Construction 251

Operations 251

RESOURCES FOR ADDITIONAL INFORMATION 252

Forest recreation management involves the selection, development, operation, and maintenance of recreation areas to provide quality outdoor experiences for the recreation user.

Forest-based recreation is frequently a primary objective of private forestland ownership. University of Wisconsin Extension research indicates that the most popular recreational pursuits of private forest woodland owners include hunting, camping, snowmobiling, hiking, fishing, ATV riding, wildlife watching, off-road bicycling, cross-country skiing, and berry picking. Proper forest recreation management can enhance the recreation experience, while at the same time, complementing a number of other landowner objectives.

Integrated Resource Management Considerations

- Forest recreation related development can impact **riparian areas and wetlands** if not carefully planned and constructed. Improper location, careless construction, and overuse of recreation sites can damage vegetation needed to retain sediments and stabilize banks and shorelines.
- **Soil productivity** can be reduced when soils are compacted, rutted, displaced, or eroded. Some equipment used in developing recreation sites can cause these kinds of soil damage. Soil damage can also be caused by recreational vehicles (ATVs, pickups, dirt bikes, snowmobiles when there is not enough snow, mountain bikes), horses, or by the trampling of too many hiking boots.
- Poorly designed and/or overused recreational developments adjacent to waterbodies have the potential to impact **water quality**. Water quality BMPs and local zoning regulations are important considerations.
- Recreational activities can introduce and/or spread a variety of **non-native invasive species**. Planning for recreational development should include plans for monitoring and controlling invasives.

Figure 18-1: Multiple-use trail systems are common in many public and industrial forestlands. These areas often receive a lot of traffic, and may need special protective measures to guard against soil erosion and other site damage.

- Trails, campsites and other recreational developments can increase **wildlife** viewing opportunities, but careful planning is needed to avoid degradation of unique habitats, and adversely impacting rare or sensitive species through increased human use.
- **Visual quality** is normally a primary consideration in the development of recreational areas. Care must be taken to ensure that construction methods and standards, maintenance activities, levels of use, and potential user conflicts are also considered in order prevent visual degradation of both the developed area and the adjacent surroundings.
- Carefully designed **timber harvests** can present opportunities for later use of haul roads and landings for recreational purposes.
- **Cultural areas** can provide excellent recreational/educational opportunities, but protection from possible overuse, vandalism, theft, and other potential problems associated with increased human use must be carefully considered.

PLANNING AND DESIGN

Figure 18-2: Bird watching is a popular activity throughout Wisconsin's forestland.

Well, thought out recreation areas are easy to use, inviting, and make sense. You may consider hiring a landscape architect to assist with planning for more extensive developments. As you plan your own recreation development, think back to sites you have used that worked well. Recall what their orientation was. For example, beaches generally should face south or west, but ski trails last longer facing north or east. Sketch out your plan on topographic maps and air photos to consider the relationships between different recreation uses, forest cover, slope, orientation, and other factors. Discuss plans with others that have already done similar work, and consider their comments. Keep an open mind and re-examine your initial thoughts before committing to a set plan.

- **Recreation management begins with an assessment of an owner's values and goals for the forestland.** Some things to think about include:
  - What are the desired activities?
  - Is enough space available for the desired activities?
  - Can uses be separated by season or distance? For example, can hunting trails be used for cross-country skiing trails in the winter? Is your desired hunting experience compatible with ATV trails?
  - What activities are occurring on adjoining land?
  - Who may be using the forestlands? Are they private or public lands?
  - How long will the land be held? Can significant development be justified?

- **Consider other resource activities that may be compatible** with recreational development, and integrate planning whenever possible. Forest management activities, for example, can be part of an effort to develop recreational opportunities. Consider laying out harvest roads to accommodate trail development, and include site remediation as part of the timber sale contract. Revenues generated can be used to fund efforts to enhance the habitat value of landings and create wildlife viewing areas.

- **An assessment of the "carrying capacity" of the land is a key element** of recreation management planning. Different activities have specific spatial needs, and similarly, the lands ability to sustain a particular level of use varies by activity. Responsible planning is required to care for the site and meet the expectations of the user. Consider limiting the quantity of activities in order to provide a higher quality experience. Seek advice from landscape architects or other qualified planners for large scale or intensive development. These professionals can save a great deal of money and frustration.

- **Environmental considerations** should be part of the planning process. Recreational development should be environmentally responsible. Consider soil types, topography, and water resources. Resources are available from a number of sources to assist in providing information and technical advice (see the Resource Directory). Efforts should also be made to identify any threatened and endangered species or rare habitats that may occur on sites to be developed (see Chapter 3: Wildlife Habitat).

Figure 18-3: A snowshoer wanders the woodlands of northern Wisconsin.

Figure 18-4: An urban park provides the opportunity for some city dwellers to experience a local forest.

- **Consider how to address conflicts between users and groups of users.** You may have to separate uses by space or scheduling to avoid conflicts. Depending on ownership, you may need to consider providing law enforcement, trail patrols, and emergency medical treatment.
- **Maintenance** of a recreation area is seen as part of the recreation experience by some. Others want to minimize this task and maximize their recreation time. Maintenance needs should be considered as plans are developed. Generally, well-planned and constructed facilities are easier and less costly to maintain. Check with other operators of recreation areas for advice on surface finishes, trail construction, mowing equipment, etc..
- **Cultural resources** like Native American burial sites or work sites, logging camps, or homestead sites can be very interesting and also provide historical insights. Planning for recreational development should address cultural resource issues in terms of both protection and interpretation. Existing cultural resource inventories should be reviewed early in the planning process. If no information is available, field inspections should be conducted before development plans are finalized to determine presence or absence of cultural resources. If cultural resources are present in the development area, it may be possible to modify construction plans to reduce or eliminate damage to the resources. Cultural resource professionals can help determine the best approaches to the mitigation of potential damage (see the Resource Directory for sources of cultural resource assistance).
- **Check with local authorities to assure any planned developments meet code and zoning requirements.** Working with local zoning and code enforcement personnel before planning gets too far along can help you avoid costly re-work later. They are also familiar with local recreation sites, and can be a valuable source of information.
- **Handicapped access needs** should be evaluated and made part of the planning process – particularly if public use is anticipated.
- **How will you pay for your development?** Funding through the Wisconsin Forest Landowner Grant Program or federal cost-sharing assistance programs may be available for forestry projects that enhance recreational, historic or aesthetic features on private property. Activities eligible for financial assistance must be included in a DNR-approved Forest Stewardship Plan for the land. Contact your local DNR forester or DNR Service Center for additional information and application material. Grants may also be available from state and federal agencies to assist with the development of recreation sites on publicly-owned land. Consult with DNR Community Financial Assistance staff for more information about that opportunity.

Figure 18-5: A turkey hunter in southern Wisconsin.

OPERATIONAL CONSIDERATIONS

LIABILITY – CAN I BE SUED?

Landowners, including governmental bodies and non-profit organizations that own, lease, or occupy land, or have a recreational agreement with another owner, have certain protections against liability under Wisconsin's Recreation Use Statute, 895.52. This important law says that landowners do not have a duty to inspect the property, keep it safe, or give warning of an unsafe condition. Only when a landowner acts maliciously or fails to disclose a known hazard, may he/she be liable. The law covers nearly every outdoor recreation activity, except organized team sports. Discuss this statute with your insurance provider as you consider risk management for your property. For more information, see **www1.uwex.edu/ces/pubs/pdf/G3326.pdf**.

Construction

- Install and maintain appropriate erosion control structures to protect water quality and soil productivity (see Chapter 11: Forest Roads).
- Use "fill-only" construction techniques in the area of the cultural resource.
- Do not allow surfaces in archaeologically sensitive areas to erode, slump or wash out. Implement temporary stabilization methods to preserve the shape, slope, elevation, and contours of archaeological sites and historic features. Stabilization should not alter the historic character of the cultural resource.
- If practical and feasible, avoid cultural resource areas when constructing recreational facilities. If it is not possible to completely avoid a cultural resource, minimize or eliminate soil disturbance and erosion in the vicinity of the resource.
- The *Wisconsin DNR Trails and Design Handbook* can be of assistance when planning trails, and includes such concerns as marking and signing, trail width, surfacing material, grades, and on-going maintenance. It provides detailed diagrams as well as signage suggestions (see the Resource Directory for a web link to DNR handbooks).
- The *Wisconsin DNR Trails and Design Handbook* can also be used as a guide to the development of general recreational facilities. It has chapters that include picnic areas, swimming beaches, trails, camp areas, parking lots, and fishing facilities, and provides guidance on developing facilities that are accessible.
- When landscaping sites, make sure to choose plants that are appropriate to your area and are quality stock. Plant according to specifications, and provide adequate follow-up care.

Operations

- When operating within a riparian management zone, confine recreational off-highway vehicle use and other non-foot traffic to trails that are designed, constructed and maintained using guidelines for skid trails and forest roads. Refer also to appropriate guidelines in Chapter 12: Timber Harvesting, Skidding and Skid Trails, and Chapter 11: Forest Roads.
- All sites need to be inspected periodically. Look at your recreation site from a critical perspective. It is easy to overlook conditions that you see every day, so ask an associate or even a customer for critical feedback on your maintenance program. This work will pay off in reduced risk and improved understanding of the way others see your facility. At minimum, you need to inspect for diseased and defective trees, surface irregularities, signage, and other safety related conditions in your recreation area. In areas that will receive a lot of traffic (pedestrian or vehicular), periodically inspect the facility to determine whether a cultural resource is being damaged by public use of the area. If so, special protective measures may be desirable.
- Monitor recreation areas for the introduction of non-native invasive species, and take action as necessary to control them as necessary.
- If your facility is for-profit, you will want to consider marketing. There are a number of local, regional, state, and national associations and agencies eager to assist with the promotion of recreation facilities. The easiest way to get started is to contact your local Chamber of Commerce or Visitor and Convention Bureau.

RESOURCES FOR ADDITIONAL INFORMATION

WISCONSIN DEPARTMENT OF NATURAL RESOURCES (DNR)

Talk to local state forest or park staff, or with the Bureau of Recreation Lands and Facilities for practical advice in recreational management. Specialists in drinking water, wastewater, water regulation and zoning, and other areas may also be valuable to you. The DNR also has a series of handbooks to guide in the operations of recreation facilities. These handbooks are designed for internal use, but may provide tips for your operation. The Bureau of Community Financial Assistance provides grants and loans to develop recreation sites.
www.dnr.state.wi.us

COUNTY FORESTS AND COUNTY PARKS

County Forestry and Parks Departments also operate recreational sites, and are a great source if you need additional advice.

UNIVERSITY OF WISCONSIN EXTENSION

The "Wisconsin Idea" promotes connections between people and the university. Extension agents and staff are available to assist with business ventures and with planning.

FEDERAL AGENCIES

The Forest Service and National Park Service provide publications to guide the development and maintenance of recreation sites.
www.fhwa.dot.gov/environment/trailpub.htm

WISCONSIN DEPARTMENT OF HEALTH AND FAMILY SERVICES (DHFS)

DHFS regulates some of the activities normally associated with forest-based recreation. DHFS Administrative Code 175 covers Recreation and Education Camps, Code 178 regulates campgrounds, and Code 195 regulates hotels, motels, and tourist rooming houses.
www.legis.state.wi.us/rsb/code/hfs/hfs110.html

WISCONSIN PARK AND RECREATION ASSOCIATION

Founded in 1965, the Wisconsin Park and Recreation Association is a statewide, voluntary organization dedicated to enriching the professional and educational opportunities available to leisure service personnel in parks, recreation, therapeutic recreation, and related fields, so that they may better service the needs of their communicates and or participants, and to advocate and promote the benefits of parks and leisure services to the general public.
www.wpraweb.org/

WISCONSIN ASSOCIATION OF CAMPGROUND OWNERS (WACO)

WACO, a non-profit association, is a federation of private Wisconsin campgrounds dedicated to the promotion, usage, growth, and improvement of campgrounds in the State of Wisconsin.
www.wisconsincampgrounds.com/about.html

DEPARTMENT OF TOURISM

The Wisconsin Department of Tourism provides guidance and leadership to Wisconsin's tourism industry, and ensures that tourism is a top contributor to the state's economy and quality of life.
http://agency.travelwisconsin.com/

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WISCONSIN FOREST MANAGEMENT GUIDELINES

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Glossary

GLOSSARY

Forest Cover Type

Riparian Management Zone

Harvesting

Wetland

A

ANGLE OF REPOSE
The maximum slope or angle at which a material, such as soil or loose rock, remains stable (stable angle).

ARCHAEOLOGICAL SITE
A geographic location where archaeological artifacts, features and other materials are found.

B

BANK
The land surface abutting the bed of any navigable waterway which, either prior to any project or alterations of land contours, or as the result of the proposed project or alteration, slopes or drains without complete interruption into the waterway (NR 340.02(2)).

BASAL AREA (BMPs for Water Quality Definition)
The cross-sectional area four and one-half feet above ground in square feet of all trees with a diameter of five inches or greater.

BASAL AREA (Forestry Definition)
1. The cross-sectional area of a single stem, including bark, measured at breast height (four and one-half feet above ground).
2. The cross-sectional area of all stems in a stand expressed per unit of land area.

BASEFLOW
The portion of streamflow which comes from groundwater.

BEST MANAGEMENT PRACTICES (BMPs)
Practical and economically-achievable practices for preventing or reducing nonpoint source pollution.

BIOLOGICAL DIVERSITY (Biodiversity)
The spectrum of life forms and ecological processes that support and sustain them. Biodiversity occurs at four interacting levels: genetic, species, community, and ecosystem.

BOARD FOOT
The amount of wood contained in an unfinished board one inch thick, 12 inches long, and 12 inches wide.

BROAD-BASED DIP
A surface drainage structure specifically designed to drain water from an access road while vehicles maintain normal travel speeds.

BRUSH BARRIER
A sediment control structure created of slash materials, piled at the top slope of a road or at the outlets of culverts, turnouts, dips, and waterbars.

BUFFER AREA
A designated area around a stream or waterbody of sufficient width to minimize entrance of forestry chemicals (fertilizers, pesticides, and fire retardants) into the waterbody.

C

CAVITY TREE
A hollow tree used for the roosting and reproduction of wildlife.

CHECK DAM
A small dam constructed in a gully to decrease the flow velocity, minimize channel scour, and promote deposition of sediment.

CLEARCUTTING
A silvicultural system in which all merchantable trees are harvested within a specified area in one operation to create an even-aged stand.

CLIMAX FOREST
An ecological community that represents the culminating stage of a natural forest succession for its locality and environment.

COARSE WOODY DEBRIS
Stumps and fallen trunks or limbs of more than six-inch diameter at the large end.

CO-DOMINANT TREE
A tree whose crown helps to form the general level of the main canopy in even-aged stands, or, in uneven-aged stands, the main canopy of the tree's immediate neighbors, receiving full sunlight from above and comparatively little from the sides.

COMMUNITY
An assemblage of plants and animals living together and occupying a given area.

CONTOUR
An imaginary line on the surface of the earth connecting points of the same elevation. It also applies to a line drawn on a map connecting the points of the same elevation. The steeper the slope, the closer the contour lines will be.

CORD
A stack of wood that measures 4 feet x 4 feet x 8 feet (128 cubic feet).

CORDUROY
Logs placed over a wetland to reinforce the natural root mat for the purpose of stabilizing the road foundation.

CROWN (BMPs for Water Quality Definition)
A convex road surface that allows runoff to drain to either side of the road prism.

CROWN (Forestry Definition)
The part of a tree bearing live branches and foliage.

CROWN CLASS
A category of tree based on its crown position relative to those of adjacent trees.

CULL
Any item of production (e.g., tree, log, lumber, seedling) rejected because it does not contain certain specifications of usability or grade.

CULTURAL RESOURCE
An archaeological site, cemetery, historic structure, historic area, or traditional-use area that is of cultural or scientific value.

CULVERT
A metal, wooden, plastic or concrete conduit through which water can flow under or across roads.

CUMULATIVE EFFECT
The impact on the environment that results from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such action.

CUT-AND-FILL
Earth-moving process that entails excavating part of an area and then using the excavated material for adjacent embankments or fill areas.

D

DIAMETER (AT) BREAST HEIGHT (DBH)
The diameter of the bole of a tree measured at 4.5 feet (1.37 meters) from the ground.

DISKING (Harrowing)
A mechanical method of scarifying the soil to reduce competing vegetation and prepare a site to be seeded or planted.

DOMINANT CROWN CLASS
A tree whose crown extends above the general level of the main canopy, receiving full light from above and partial light from the sides.

DRAINAGE STRUCTURE
Any device or land form constructed to intercept or aid surfacewater drainage.

DUFF
The accumulations of needles, leaves and decaying matter on the forest floor.

E

ECOSYSTEM
A spatially-explicit, relatively homogeneous unit of the earth that includes all interacting organisms and components of the abiotic environment within its boundaries.

ENDANGERED SPECIES
A species threatened with extinction throughout all or a significant portion of its range.

ENVIRONMENT
The sum of all external conditions affecting the life, development and survival of an organism.

ERODIBLE SOILS
Soils that are likely to have high soil loss when exposed to water runoff. Soils having a Natural Resources and Conservation Service (NRCS) erosion hazard rating of "moderate" or "severe" should be considered erodible. Erosion hazard ratings for different soil types are listed in "Woodland Suitability" tables in NRCS soil survey manuals. Generally, forest soils occurring on 15 to 35 percent slopes have a moderate rating, and soils occurring on greater than 35 percent slopes have a severe rating. Contact your local NRCS office for more information.

EROSION
The process by which the surface of the earth is worn away by the action of wind or water in the form of rain drops, surface runoff or waves.

F

FELLING
The process of cutting down standing trees.

FILL SLOPE
The surface formed where earth is deposited to build a road or trail.

FIRE RETARDANT
Any substance, except plain water, that by chemical or physical action reduces the flammability of fuels or slows their combustion rate.

FIREBREAK
Naturally-occurring or human-made barrier to the spread of fire.

FIRELINE
A barrier used to stop the spread of fire constructed by removing fuel or rendering fuel less flammable by use of retardants.

FLOODPLAIN
Land which has been or may be covered by flood water during the regional floods (floods expected to occur once in every 100 years).

FORD
Submerged stream crossing where the streambed may need to be reinforced to bear intended traffic.

FOREST COVER TYPE
1. A category of forest usually defined by its vegetation, particularly its dominant vegetation as based on percentage cover of trees.
2. The plant species forming a plurality of composition across a given area.

FOREST FILTER STRIP
Area between a steam and construction activities that achieves sediment control by using the natural filtering capabilities of the forest floor and litter.

FOREST HEALTH
The perceived condition of a forest derived from concerns about such factors as its age, structure, composition, function, vigor, presence of unusual levels of insects or disease, and resilience to disturbance.

FOREST MANAGEMENT
The practical application of biological, physical, quantitative, managerial, economic, social, and policy principles to the regeneration, management, utilization, and conservation of forests to meet specified goals and objectives while maintaining the productivity of the forest.

FOREST ROAD
A temporary or permanent road connecting the most remote parts of the forest to existing public roads. They provide access to forestlands for timber management, fish and wildlife habitat improvement, fire control and a variety of recreational activities.

FORWARDING
The operation of moving timber products from the stump to a landing for further transport.

G

GEOTEXTILE
A product used as a soil reinforcement agent and as a filter medium. It is made of synthetic fibers manufactured in a woven or loose non-woven manner to form a blanket-like product.

GRADE (Gradient)
The slope of a road or trail expressed as a percent of change in elevation per unit of distance traveled.

H

HABITAT
1. A unit area of environment.
2. The place where an animal, plant or population naturally or normally lives and develops.

HABITAT TYPE
1. A land or aquatic unit consisting of an aggregation of habitats having equivalent structure, function and responses to disturbance.
2. An aggregation of units of land capable of producing similar plant communities at climax.

HABITAT TYPE CLASSIFICATION SYSTEM
A site classification system based on the floristic composition of plant communities. The system depends on the identification of potential climax associations, repeatable patterns in the composition of the understory vegetation, and differential understory species. It groups land units with similar capacity to produce vegetation. The floristic composition of the plant community is used as an integrated indicator of those environmental factors that affect species reproduction, growth, competition, and community development. A system used to classify forest plant communities and the sites on which they develop.

HARVESTING (Logging)
The process of gathering a timber crop. It includes felling, skidding/forwarding, on-site processing, and removal of products from the site.

HIGH-WATER MARK
See “ORDINARY HIGH-WATER MARK.”

I

INTEGRATED PEST MANAGEMENT (IPM)
Selection, integration and use of management actions based on scientific knowledge of forest systems, including insects and pathogens, in order to achieve desirable economic, ecological and sociological forest management goals.

INTERMITTENT STREAM
A stream that flows only after rainfall or snowmelt, and, therefore, is dry most of the year.

L

LAKE
A still waterbody which (1) is navigable, (2) has an ordinary high-water mark and (3) has a bed and banks and is a “reasonably permanent” body of water although it may dry up during periods of drought.

LANDING (Log Deck)
A place where trees and logs are gathered in or near the forest for further processing or transport.

LARGE WOODY DEBRIS (BMPs for Water Quality)
Large logs, generally at least 12 inches in diameter with an anchored root ball, that have fallen into streams creating stable structures and a diversity of cover conditions and habitat for aquatic organisms.

LEAVE TREES
See "RESERVE TREES."

LOGGING DEBRIS
See "SLASH."

LUMP SUM SALE
A timber sale in which the buyer and seller agree on a total price for marked standing trees, or for trees within a defined area before the wood is removed.

M

MANAGEMENT GOAL
A broad, general statement (usually not quantifiable) that expresses a desired state or process to be achieved.

MANAGEMENT OBJECTIVE
A concise, time-specific statement of measurable planned results that correspond to pre-established goals in achieving a desired outcome.

MANAGEMENT PRESCRIPTION
A set of management practices and intensities scheduled for application on a specific area to satisfy multiple goals and objectives.

MERCHANTABILITY
Trees of size and quality suitable for commercial marketing and utilization.

MULCH
A natural or artificial layer of plant residue or other materials covering the land surface that conserves moisture, holds soil in place, aids in establishing plant cover, and minimizes temperature fluctuations.

MULCHING
Providing any loose covering to protect exposed forest soils such as grass, straw, bark, or wood fibers, to help control erosion.

N

NAVIGABLE
A waterway is navigable if it has bed and banks, and it is possible to float a canoe or other small craft in the waterway on a regular reoccurring basis – even if only during spring runoff.

NON-NATIVE INVASIVE SPECIES
Plant species accidentally or intentionally introduced from another country or geographic region, having the ability to significantly displace desirable vegetation or reduce crop yields. These plants may also be termed "exotic," "alien," or "weedy." They are likely to cause economic or environmental harm, or harm to human health.

NONPOINT SOURCE POLLUTION
Occurs when rainfall or snowmelt runoff moves across the ground, carrying pollutants into streams, lakes, wetlands, and groundwater. For example, soil can become a pollutant when water runoff moves across a road and carries large amounts of soil into a waterbody.

O

OPERABILITY
Level of merchantable volume per acre.

ORDINARY HIGH-WATER MARK
The point on the bank or shore up to which the presence and action of the water is so continuous as to leave a distinct mark either by erosion, destruction of terrestrial vegetation, or other easily-recognized characteristic.

ORGANIC DEBRIS
Particles of vegetation or other biological material that can degrade water quality by decreasing dissolved oxygen and by releasing organic solutes during leaching.

OUTSLOPE
Shaping the road surface to cause drainage to flow toward the outside shoulder.

OVER MATURE
1. A tree or even-aged stand that has reached the stage of development when it is declining in vigor and health, and reaching the end of its natural life span.
2. A tree or even-aged stand that has begun to lessen in commercial value because of size, decay or other factors.

OVERSTORY
That portion of the trees in a forest forming the uppermost canopy layer.

P

PERENNIAL STREAM
A stream that flows throughout most (i.e., greater than 50 percent) of the year.

POLETIMBER
Hardwood trees ranging in size from five to 11 inches DBH, and conifers ranging in size from five to nine inches DBH.

PRESCRIBED BURNING
The controlled application of fire to wildland fuels in either their natural or modified state, under specified environmental conditions. These conditions allow the fire to be confined to a predetermined area, while at the same time producing the fire intensity and rate of spread required to attain planned resource management objectives.

PRIMARY TYPE
Forest type named after the tree species that is being managed for a harvest cycle, and usually comprises over 50 percent of the stand.

R

RAKING
A mechanical method of removing stumps, roots and slash from a future planting site.

REGIONAL FLOOD
A flood which is expected to occurs on a particular lake, river or stream once every 100 years (also known as a “100-year flood”).

RESERVE TREES
Scattered, living individual trees and/or groups of trees left unharvested within a stand for reasons other than the purpose of regeneration. Synonyms may include leave trees, green tree retention, and standards.

RIPARIAN AREA
The area of land and water forming a transition from aquatic to terrestrial ecosystems along streams, lakes and open water wetlands.

RIPARIAN MANAGEMENT ZONE (RMZ)
Land and vegetation areas next to lakes and streams where management practices are modified to protect water quality, fish and other aquatic resources. These areas are complex ecosystems that provide food, habitat and movement corridors for both aquatic (water) and terrestrial (land) communities as well as helping to minimize nonpoint source pollution impacts to surfacewater.

RIPRAP
Rock or other large aggregate that is placed to protect streambanks, bridge abutments, outflow of drainage structures, or other erodible sites from runoff or wave action.

ROTATION
In even-aged silvicultural systems, the period between regeneration establishment and final cutting. Rotation may be based on many criteria including culmination of mean annual increment, mean size, age, attainment of minimum physical or value growth rate, and biological conditions.

RUT
Depressions made by the passage of a vehicle or equipment.

S

SAPLINGS
Trees ranging from one to five inches DBH.

SAWBOLT
A small diameter log that does not meet the minimum specifications for a "sawlog," but is sorted for sawing rather than being used for chips, pulpwood or fuel. Dimension lumber cut from sawbolts is generally used for low-value products such as 2 inch x 4 inch studs or wood pallets.

SAWLOG
A cut forest product meeting the minimum specifications for "Sawlog - Board Feet" in Chapter NR 46.02 (22), Wisconsin Administrative Rules.

Position in Tree	Butt or upper
Minimum Diameter[1] Small End: Hardwoods	10.6"
Minimum Diameter[1] Small End: Conifers	9.6"
Minimum Length Without Trim[2]	8' (except walnut and cherry which are 4')
Sweep Allowance[3]	__ of diameter small end for each 8' length
Maximum Scale Deduction for Unsound Defects	50%
Clear Cuttings Free of Knots or Other Defects	No requirements.
Sound or Unsound Surface Defect Limitations	Diameter of knots, rot, holes, etc., may not exceed $^1/_3$ the diameter of the log at the point of occurrence.
Sound End Defects	No requirements.

1 Diameter inside bark.
2 The maximum trim allowance is 8". Cut products that exceed the 8" trim allowance will be classified as misbucked, and will be scaled as sawlogs at the next whole foot increment.
3 Sweep is defined as the maximum departure distance of a line drawn between the ends of a log from the nearest surface of the log.

SAWTIMBER, LARGE
Standing trees larger than 15 inches in diameter at 4.5 feet above the ground.

SAWTIMBER, SMALL
Standing hardwood trees ranging in size from 11 to 15 inches in diameter at 4.5 feet above the ground, and conifer trees ranging in size from nine to 15 inches in diameter at 4.5 feet above the ground.

SEDIMENT
Soil that has eroded from the land surface, often by overland water flow, that is then transported and deposited away from its original location.

SHEARING
A site preparation method that involves the cutting of brush, trees or other vegetation at ground level using tractors equipped with angled or V-shaped blades.

SILT FENCE
A temporary barrier used to intercept sediment-laden runoff from small areas.

SILVICULTURAL PRESCRIPTION
A planned series of treatments designed to change current stand structure to one that meets management goals and objectives. The prescription normally considers ecological, economic and societal constraints.

SILVICULTURAL SYSTEM
A planned program of vegetative treatment during the entire life of a stand including tending, harvesting and regeneration, which are named after the stand age class structure and regeneration method employed.

SITE
1. The total of environmental conditions surrounding and available to a plant. The physical (climate, topography, soil) and biotic (plants, animals) factors interact to yield the light, heat, water, and chemicals that are directly available and used by the plant, as well as other chemical and mechanical disturbance factors.
2. The area in which a plant or stand grows, considered in terms of its environment, particularly as this determines the type and quality of the vegetation the area can carry.
3. A spatially-explicit, relatively homogeneous portion of land characterized by specific physical and chemical properties that affect ecosystem functions, and where a more or less homogenous forest type may be expected to develop.

SITE INDEX
A species-specific measure of actual or potential forest productivity (usually for even-aged stands) expressed in terms of the average height of trees included in a specified stand component (dominants, codominants, or the largest and tallest trees) at a specified index or base age.

SKID (Skidding)
Short-distance moving of logs or felled trees from the stump to a point of loading.

SKID TRAIL
A temporary, nonstructural travel way for logging equipment, called skidders, to drag felled trees or logs to the landing for further processing, loading and transport to a mill.

SLASH
Any tree tops, limbs, bark, abandoned forest products, windfalls, or other debris left on the land after timber or other forest products have been cut.

SLOPE
Degree of deviation of a surface from the horizontal, measured as a numerical ratio, percent or in degrees. Expressed as a ratio, the first number is the horizontal distance (run) and the second number is the vertical distance (rise), as 2:1. A 2:1 slope is a 50 percent slope. Expressed in degrees, the slope is the angle from the horizontal plane, with a 90º slope being vertical (maximum) and a 45º slope being a 1:1 slope.

SNAG
A standing dead tree.

STAND
1. A contiguous group of trees sufficiently uniform in species composition, structure and age class distribution, and growing on a site of sufficient uniform quality, to be a relatively homogeneous and distinguishable unit.
2. A contiguous group of similar plants.

STAND STRUCTURE
1. The physical and temporal distribution of plants in a stand.
2. The horizontal and vertical distribution of components of a forest stand including the age, height, diameter, crown layers, and stems of trees, shrubs, herbaceous understory, snags, and down woody debris.

STREAM
A watercourse that (1) has an ordinary high-water mark; (2) has bed and banks; (3) flows at least periodically; and (4) does not lose its character as a watercourse even though it may become braided in a wetland complex.

SUCCESSION
Gradual supplanting of one community of plants by another.

SUPPRESSED (Overtopped) CROWN CLASS
A tree whose crown is completely overtopped by the crowns of one or more neighboring trees.

T

TAKE
To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, root up, cut, sever, or to attempt to engage in any such conduct upon an animal or plant. This term is used with discussions on endangered and threatened animal or plant species.

THREATENED SPECIES
A species likely to become endangered in the foreseeable future throughout all or a significant portion of its range.

TIMBER HARVESTING
See “HARVESTING (Logging).”

TRANSPIRATION
Evaporation which enter the atmosphere from the soil through plants.

TURNOUT (BMPs for Water Quality)
A drainage ditch that drains water away from roads and road ditches.

U

UNDERSTORY
All forest vegetation growing under an overstory.

V

VISUAL QUALITY
A subjective measure of the impact that viewing an object, landscape or activity has on a person's perception of attractiveness.

W

WATERBAR
A shallow trench or diversion dam which diverts roadside ditch and surfacewater runoff from roads (inactive or closed), firebreaks, or skid trails (active or inactive) into a dispersions area. Waterbars are used to minimize erosion and provide conditions for natural or artificial revegetation.

WATER QUALITY
The chemical, physical and biological characteristics of water, usually in respect to its suitability for a particular purpose.

WATERSHED
The surrounding land area that drains into a lake, river or river system.

WET LINE
A line of water or water and chemical fire retardant sprayed along the ground, and which serves as a temporary fireline from which to ignite or stop a low-intensity fire.

WETLAND
An area where water is at, near or above the land surface long enough to be capable of supporting aquatic or hydrophytic (water-loving) vegetation and which has soils indicative of wet conditions.

WILDFIRE
Uncontrolled fire occurring in forestland, brushland and/or grassland.

WILDLIFE
All forms of life that are wild, including plants, animals and microorganisms.

WINDROW
Logging debris and unmerchantible woody vegetation that has been piled in rows to decompose or be burned, or the act of constructing these piles.

WINDTHROW
A tree or trees uprooted by the wind (also known as "blowdown timber").

Y

YARDING
Method of transport from harvest area to storage landing.

YIELD
The amount of wood that may be harvested from a particular type of forest stand by species, site, stocking, and management regime at various ages.

FINAL NOTE: Additional forestry definitions can be found in the Wisconsin DNR *Silviculture and Forest Aesthetics Handbook, 2431.5,* by visiting **www.dnr.state.wi.us/org/land/forestry/publications/2431_5/index.htm**

Appendices

APPENDICES

APPENDIX A: MARKING AND CROP TREE SELECTION GUIDELINES 264

Marking Priority Guide 264

APPENDIX B: SAMPLE TIMBER SALE CONTRACT 267

Contract Performance, Period, Extensions, and Termination 267
Downpayment, Bond, Remedies, and Damages 268
Products To Be Removed 269
Sale Type, Scaling, Hauling, and Payments 269
Utilization and Operations 271
Notice of Intent To Cut and Compliance With Laws 273
Title, Boundary Lines, and Access 273
Liability and Insurance 273
General 274

APPENDIX C: MFL ENTRY REVIEW CHECKLIST 275

APPENDIX D: PESTICIDE LAWS AND RULES 277

APPENDIX E: REGULATIONS RELATING TO FOREST MANAGEMENT AND WATER QUALITY 279

Federal Laws 279
State Laws 279

APPENDIX F: PERMITS 284

Permits for Water Quality 284
Other Permits 284

APPENDIX G: CITED REFERENCES 285

APPENDIX A: MARKING AND CROP TREE SELECTION GUIDELINES

The information in this Appendix was taken from the Wisconsin DNR *Silviculture and Forest Aesthetics Handbook, 2431.5*. A system for evaluating risk and vigor primarily for timber management considerations is described, as well as crop tree selection criteria for a number of forest management objectives.

Readers should refer to the *Silviculture and Forest Aesthetics Handbook* for additional marking criteria relative to wildlife, aesthetics, and water quality.

MARKING PRIORITY GUIDE

	VIGOR		
RISK	**1**	**2**	**3**
1	10th	9th	6th
2	8th	7th	5th
3	3rd	2nd	1st
Cull	-	4th	-

Marking Priority Guide

Risk refers to the mechanical stability of the tree. It is the estimate of chance or degree of probable loss within the next cutting cycle.

Vigor is the measure of growth potential of an individual tree. It describes the tree, and its ability to grow at a rapid rate and increase in net volume.

To properly apply these marking guides, classify the tree first by risk, and then by vigor using the "Tree Risk and Vigor Grading Rules" charts found on this page and on page 265. The next step is to determine how the tree ranks in terms of cutting priority by referring to the "Marking Priority Guide" found above.

A tree classified as Risk 2 and Vigor 3 would be ranked fifth in marking priority. A Risk 3/Vigor 3 tree would receive the highest marking priority whereas a Risk 1/ Vigor 1 tree would receive the lowest marking priority. Risk 3 trees receive a higher priority than cull trees because of the potential for higher value loss.

Frequent initial reference to this tree classification system will quickly establish familiarity with the system, and proper marking habits.

TREE RISK GRADING RULES

TREE RISK QUALIFICATIONS	GOOD GROWING STOCK (Risk 1)	FAIR GROWING STOCK (Risk 2)	POOR GROWING STOCK (Risk 3)	CULL (Risk 4)
Risk of mortality after moderate partial cuts	Good mechanical stability; roots firm; lower and upper bole sound; all large, high crotches strong; no windfall or main stem breakage anticipated.	Average mechanical stability; roots firm; moderate rot in lower trunk has no effect on risk of loss; large, high crotches strong; loss of tree not likely within 10 years.	Poor mechanical stability; roots sprung; large, high, weak crotches; weak, butter-churn butts; excessive dieback; epidemic disease or insect damage; loss of tree likely within five to 10 years.	Cull

TREE VIGOR GRADING RULES

TREE VIGOR QUALIFICATIONS	Vigor 1	Vigor 2	Vigor 3	Vigor 4
Crown Class	Head dominant; dominant; co-dominant.	Dominant; co-dominant; intermediate; free to grow if overtopped.	Suppressed (Suppressed not free to grow are always Vigor 3).	Cull
Crown Size	In hardwoods, a full crown concentrically. In conifers, a good crown:length ratio.	In hardwoods, a full crown concentrically. In conifers, a fair to good crown:length ratio.	In hardwoods, a crown less than half full concentrically. In conifers, a poor crown:length ratio.	Cull
Crown Density and Leaf Condition	Good silhouette; healthy leaf; occasional dead branch in outer crown; permits natural pruning.	Fair silhouette; fair leaf condition; some dead branches in outer crown; large branch stubs on upper bole.	Poor silhouette; leaves small, yellowing; considerable dieback and many branch stubs on upper and middle bole.	Cull
Bole Length and Form	Useable length commensurate with site; DBH:length ratio good; no usable length stoppers.	Useable length fairly commensurate with site; DBH:length ratio fair; usable length stopper on upper bole.	Useable length far short of the average for the site; DBH:length ratio poor; trees permanently sub-merchantable in length are always Vigor 3 or worse.	Cull
Rot and Decay	Cull loss never exceeds 10%; slight crook or sweep will cut out.	Cull loss never exceeds 20%; moderate crook or sweep will not cut out.	Cull loss never exceeds 60%; heavy crook or sweep will not cut out.	Cull

TIMBER CROP TREE SELECTION CRITERIA

- Dominant/codominant trees (at least 25 feet tall)
  - Healthy crown; large in relation to DBH.
  - No dead branches in upper crown.
  - Either low-origin stump sprouts (less than six inches at groundline) or seedling-origin stems are acceptable.
  - U-shaped connections are acceptable; avoid V-shaped connections.
- High quality trees
  - Butt-log potential of Grade 1 or 2.
  - No epicormic branches (living or dead) on butt-log.
  - No high risk trees (leaners, splitting forks, etc.).
- High value commercial species.
- Expected longevity of 20 plus years.
- Species well-adapted to the site.

WILDLIFE CROP TREE SELECTION CRITERIA

MAST-PRODUCING SPECIES

- Dominant/codominant trees
  - Healthy crown; large in relation to DBH.
  - A few dead, upper-crown branches are acceptable.
  - Stump-sprout or seedling-origin stems are acceptable.
- Hard-mast producers preferred over soft-mast producers; strive for species variety.
- Expected longevity of 20 plus years.
- Cavities and large, broken branches are acceptable.

CAVITY TREES*

- Trees of any species, size class, and crown position are acceptable.
- Dead, upper-crown branches and cavities in the main bole are acceptable.
- Expected longevity of tree is not important.

---

* If a cavity tree is also a mast producer, release it. Otherwise, it need not be released.

AESTHETIC CROP TREE SELECTION CRITERIA

- Species that produce attractive flowers or colorful foliage.
  - Healthy crowns; large relative to DBH.
  - Few dead, upper-crown branches are acceptable.
  - Stump-sprout or seedling-origin stems are acceptable.
  - Understory trees acceptable if release is not high risk.
- Visible from travelways and adjacent to streams, when opportunity exists.
- In many cases, expected longevity of 20 plus years.
- Unique trees (old pasture trees with spreading branches, unusually shaped trees, trees with attractive bark characteristics, etc.).

WATER QUALITY CROP TREE SELECTION CRITERIA

- Dominant/codominant trees
  - Healthy crown; large in relation to DBH.
  - A few dead, upper-crown branches are acceptable.
  - Stump-sprout or seedling-origin stems are acceptable.
- Expected longevity of 20 plus years.
- Species that are good nutrient accumulators.
  - Young trees
  - Deciduous trees
- Trees tolerant to flooding.

APPENDIX B: SAMPLE TIMBER SALE CONTRACT[1]

This Contract is entered into, by and between _____ (Seller), and _____ (Purchaser). Contact information is listed in par. 43 of this agreement.

The Seller hereby authorizes the Purchaser to enter upon the following described lands (the Premises) for purposes of cutting and removing timber marked or otherwise designated by the Seller:

County:_____ Town Name:_____

Town:_____ N; Range_____ ; Section_____ ; Legal Description(s):_____

Town:_____ N; Range_____ ; Section_____ ; Legal Description(s):_____

Those Premises are further described on the map(s) or diagram(s) attached to and made a part of this Contract.

FOR AND IN CONSIDERATION of the following terms and conditions, the Seller and Purchaser mutually agree:

Contract Performance, Period, Extensions, and Termination

1. PERFORMANCE

a. Commencement. Cutting and removal of timber in conformance with this Contract may commence and continue only after the signing of this Contract by both parties, and only after submission and maintenance of all bonds, certificates or statements required under it.

b. Contract Oversight. Cutting and removal of timber purchased under this Contract shall be conducted in conformance with this Contract, and in a good and workman-like manner with reasonable diligence to assure completion of all performance within the Contract period specified in par. 2. The Purchaser shall notify the Seller or the Seller's Agent 36 to 48 hours prior to commencing harvest of the timber designated herein, and upon completion of the cutting. In the event that the harvest is temporarily discontinued for more than one week, the Purchaser agrees to notify the Seller or the Seller's Agent _____ (Agent's Name) both upon discontinuance and resumption of harvest. Notification under this paragraph may be made by telephone to _____ (Phone Number). The Seller or the Seller's Agent may require an on-site meeting before commencement of harvesting.

2. CONTRACT PERIOD

a. All work under this Contract shall be completed between the signing of the Contract by both Parties and by _____ (Contract ending date), FOR TIME IS OF THE ESSENCE. Contract amendments or extensions may not be relied upon by the Purchaser for the purpose of completing performance under this Contract.

b. The Seller may temporarily suspend operations under this Contract due to excessive property damage, wet conditions, or at other reasonable[2] times upon notice to the Purchaser or other persons operating on the sale area under this Contract with subsequent equitable adjustment of this Contract as mutually agreed upon by the parties.

3. CONTRACT EXTENSIONS

If extensions of this Contract are deemed reasonable by the Seller, the stumpage price agreed upon herein shall be adjusted as follows:

a. First six-month extension: 0% increase
b. Second six-month extension: 5% increase
c. Additional six-month extensions: 10% increase
d. Other applicable charges or fees:_____

1 Where options are listed with "OR," strike the option(s) that do(es) not apply.

2 "Reasonable" in this Contract is defined as fair, proper, just, moderate, and suitable under the circumstances, not arbitrary or capricious.

4. TERMINATION

The Seller may terminate this Contract by oral or written notice to the Purchaser upon its breach. Upon such notice, the Purchaser shall cease all operations on and immediately leave, and not return to, the Seller's property unless otherwise provided by the Seller.

Downpayment, Bond, Remedies, and Damages

5. DOWNPAYMENT

The Purchaser has given the Seller a down payment in the form of cash, a certified check, or other form acceptable to the Seller in the amount of $_____ (if none, enter "zero") to commit to completion of the timber sale in a timely manner as specified in the Contract.

6. BOND

The Purchaser has deposited cash, a surety bond, a certified check, or other form acceptable to the Seller in the amount of $_____ (if none, enter "zero") as a performance bond to assure proper performance. The performance bond is to be held by the Seller until the Purchaser has completed or complied with all Contract conditions. Upon breach of any condition of this Contract, the performance bond shall be applied to actual damages incurred by the Seller. The performance bond (or any balance after damages are deducted) shall be returned to the Purchaser within 60 days of the completion of the harvest consistent with the Contract, if the Purchaser notifies the Seller in writing that the harvest is finished.

7. REMEDIES

If timber or other forest products not specifically described in this Contract or designated by the Seller for cutting are cut, unreasonably damaged, or removed by the Purchaser, the Seller may pursue any and all remedies for the unlawful use of the Seller's property and the cutting, unreasonable damage, or removal of property without consent, including the seeking of criminal or civil charges for theft, timber theft, or criminal damage to property, in addition to any Contract remedies for breach.

8. DAMAGES

The damages to be paid to the Seller upon the Purchaser's failure to perform this Contract include, but are not limited to:

a. The difference between the Purchaser's bid value of timber not cut and removed under this Contract, and the value returned to the Purchaser. The Seller agrees to mitigate the damages for breach by offering the timber for resale within 12 months if the Seller determines the timber is salable based upon its volume or quality.
b. Triple average stumpage rate established in NR 46.30, Wisconsin Administrative Rules, for timber cut, removed or unreasonably damaged without authorization under or in violation of this Contract. The Seller's decision to assess triple damages as provided here, and to allow the Purchaser to continue performance under this Contract shall not be construed as a waiver of other Contract performance requirements.
c. All costs of sale area clean-up or completion of performance not completed by the Purchaser.
d. All costs of resale of timber not cut and removed as required under this Contract.
e. The Purchaser agrees if the timber identified in this Contract for cutting is to be resold due to a breach of this Contract, the Seller is not obligated to give oral or written notice to the Purchaser of the resale.
f. Additional damage provisions:_____

_____
_____
_____
_____
_____
_____

Products To Be Removed

9. NO FOREST PRODUCTS MAY BE REMOVED FROM THE PREMISES until the Purchaser pays for the products or guarantees payment for the products to the satisfaction of the Seller.

10. TITLE TO STUMPAGE AND ANY FOREST PRODUCTS CUT UNDER THIS CONTRACT shall remain with the Seller until payment is received. Title to stumpage and cut products that are not cut and removed before the end of the Contract period, even though paid for, shall revert to the Seller, and the Seller shall be under no obligation to return payments to the Purchaser.

11. DURING THE PERIOD OF THIS CONTRACT, the Purchaser is authorized and shall cut, remove and pay for the timber or forest products marked or designated as follows:_____

_____

_____

_____

_____

_____

_____

_____

Sale Type, Scaling, Hauling, and Payments

12. SALE TYPE[3] (select one of the following three choices and strike the others).

LUMP SUM SALE: The Purchaser agrees to pay Seller an amount of $_____, to be paid in full prior to the commencement of timber cutting, based on the volume estimates and unit values in par. 14 Timber Products Table. The Seller is not obligated to return the payment or any portion of it in the event the Purchaser fails to remove all timber or forest products authorized for removal.

-OR-

SCALED PRODUCTS SALE, FLAT RATE METHOD: The payment as established by the price per unit in par. 14 shall be based on sawtimber, cordwood, or piece product volume as measured by product dimensions. The price paid per board feet, cord or piece is a flat rate regardless of the quality, final destination or use of the cut product. Hardwood less than 10.6 inches in diameter at the small end of the log, inside the bark (d.i.b.), shall be measured as cordwood and 10.6 inches or greater d.i.b. as sawtimber. For conifers, the division between cordwood and sawtimber is 9.6 inches d.i.b. Sawtimber with 50% or more cull shall be measured as cordwood. The volume shall be measured by _____ (Name), an agent of the Seller/Purchaser/primary processing facility (the Mill or its agent) to whom the Purchaser delivers the product and to whom the cut product is sold (strike the choices that do not apply).

-OR-

SCALED PRODUCTS SALE, GRADED PRODUCT METHOD: The payment as established by the price per unit in par. 14 shall be based on the volume of graded products including fuel wood, pulpwood, sawbolts, sawtimber by grade, veneer by grade, and piece products (such as posts and utility poles) by grade. In addition to product dimension, the price paid depends upon the quality or intended use of the cut product or type of processing facility the cut product is destined.[4] The volume and grade shall be determined by _____ (Name), an agent of the Seller/Purchaser/primary processing facility (the Mill or its agent) to whom the Purchaser delivers the product and to whom the cut product is sold (strike the choices that do not apply).

3 Lump sum and scaled products-flat rate methods are the most commonly accepted sale types. Landowners may have difficulty in finding purchasers willing to enter into graded product method sales, which are more difficult to administer.

4 For example, cordwood delivered to a paper mill would be paid for as pulpwood. Cordwood delivered to a sawmill would be paid for as sawbolts or sawlogs.

13. HAULING PROCEDURE[5] AND PAYMENT SCHEDULE FOR SCALED SALES. (Select one of the following two choices and strike the other.)

ON-SITE SCALE: No products may be hauled from the Seller's property until scaled and paid for or payment has been arranged to the Seller's satisfaction in writing. Removing products otherwise shall be a violation of this Contract and considered theft.

-OR-

MILL SCALE: The Purchaser shall keep a record of each load removed and its destination. Addresses of the Mills where wood products are to be delivered shall be given to the Seller before cutting begins. The Purchaser shall provide Mills with the Seller's name and address for each load and request Mills to provide copies of the mill scale slips to the Seller within _____ days of receipt of the wood products. Failure to keep a record of any load and its destination shall be a violation of this Contract and considered theft. Payments shall be made according to the following schedule (pick one of the following three choices and strike the others):

The Purchaser shall pay the Seller for the products delivered to the Mill, as measured on the mill scale slip, within _____ days of delivery. The Purchaser shall include copies of the mill scale slips with payments.

-OR-

Payment to the Seller shall be made in advance of hauling, with the value of the measured volume on the mill scale slips deducted from the Purchasers stumpage payment balance. The Seller agrees that advance stumpage payments shall not be used for any purpose other than the stumpage account, and that any excess payments will be returned to the Purchaser within 60 days after the last load is hauled from the Seller's property.

-OR-

The Mill shall make payments for delivered products directly to the Seller within _____ days of delivery by the Purchaser. Copies of the mill scale slips shall be included with payments to the Seller.

14. TIMBER PRODUCTS TABLE. The Purchaser agrees to pay the Seller the unit price for the volume of product by species that is harvested. In the case of lump sum sales, the unit prices shall be used for sale add-ons or calculation of damages.

Species to be Harvested	Product (Sawtimber, Cordwood, Posts, Poles, etc.)	Estimated Volume	Price per Unit (MBF[6], Cord, Piece, etc.)	Total Value of Estimated Volume
			Total Estimated Value:	

15. SAWTIMBER VOLUMES SHALL BE DETERMINED by the Scribner Decimal C System (required for land enrolled under the Managed Forest Law or Forest Crop Law programs in Wisconsin).

5 Information about an additional "Ticket System" for log hauling is also available from DNR, but is seldom used on private lands.

6 "MBF" means "thousand board feet."

16. CORD MEANS 128 CUBIC FEET OF WOOD[7], AIR AND BARK ASSUMING CAREFUL PILING. Peeled cordwood and chips shall be converted to standard cords using the Wisconsin DNR conversion specifications published in Chapter NR 46.30 (1) c and e, Wisconsin Administrative Code.

17. THE VOLUMES OF TIMBER INDICATED IN THIS CONTRACT or other appraisal or cruise documents of the Seller are estimates. The Seller gives no warranty or guarantee respecting the quantity, quality or volume of marked or otherwise designated timber or forest products on the sale area.

Utilization and Operations

18. STUMP HEIGHT; TOPS. Tree stumps shall be cut as close to the ground as practical, otherwise maximum stump height shall not exceed stump diameter; and for stumps ten or more inches in diameter, stumps shall not exceed 10 inches in height. For sales including cordwood products, trees shall be utilized to a four inch minimum top diameter. Title to tops shall remain with the Seller and may not be utilized by the Purchaser, or at the Purchaser's direction, unless otherwise specified in this Contract.

19. WASTE. The Purchaser agrees to complete all operations and performance as described in this Contract without waste or nuisance on the sale area, or any other property of the Seller, or adjoining land used in conjunction with the harvest, and use reasonable care not to damage trees not designated or marked for cutting. Young trees bent or held down by felled trees shall be promptly released.

20. ZONE COMPLETION. The Purchaser agrees to complete all operations on each portion of the sale area or each zone as designated on the sale area map, or other attachments or in the cutting requirements before beginning cutting in the next portion or zone, unless agreed to otherwise by the Seller.

21. ROADS, LANDINGS, MILL SITES, CAMPSITES, EROSION CONTROL, BEST MANAGEMENT PRACTICES (BMPs).

a. When not otherwise designated by the Seller, the location of roads, landings, mill sites, and campsites on Seller's property are subject to advance approval and under the conditions established by the Seller. All restoration, clean-up or repair of roads, bridges, fences, gates, landings, mill sites, and campsites, or the cost of the clean-up, if not completed by the Purchaser to the reasonable satisfaction of the Seller, is the responsibility of the Purchaser.
b. Logging debris accumulated at landing areas shall be scattered within the sale area to the reasonable satisfaction of the Seller.
c. Berms constructed on the Seller's property shall be leveled to restore the area to the Seller's satisfaction unless they are constructed at the direction of the Seller under sub "d" (see below).
d. Roads and landings shall be graded or closed upon the request of and to the Seller's satisfaction upon completion or termination of this Contract.
e. Other restoration requirements (e.g., seeding, gravel, rutting, culvert removal, etc.):_____
_____
_____
f. The Purchaser agrees to comply with the Best Management Practices (BMPs) guidelines as described in *Wisconsin's Forestry Best Management Practices for Water Quality* published by the Wisconsin Department of Natural Resources, publication FR-093. Identify BMPs of particular concern:_____
_____
_____

22. OTHER APPROVALS. Logging roads that intersect town, county or state roads, or highways must have the intersections approved by the proper authorities prior to construction, and cleared of all unsightly debris at the time of construction. The Purchaser agrees to apply for and obtain all approvals. The Purchaser also agrees to fully comply with all terms and conditions of intersection approvals.

7 *Mills may measure cordwood with a four inch trim allowance, resulting in 133 cubic feet.*

23. SURVEY MONUMENTS. The Purchaser agrees to comply with S. 59.635, Wis. Stats., regarding perpetuation of landmarks, and pay for the cost of repair or replacement of property or land survey monuments or accessories which are removed, destroyed or made inaccessible.

24. FOREST FIRE PREVENTION. The Purchaser agrees to take reasonable precautions to prevent the start and spread of fires. Those precautions include, but are not limited to:

a. A minimum of one fully charged five pound or larger ABC fire extinguisher with a flexible spout shall be carried on each off-road logging vehicle.
b. All chainsaws and all non-turbocharged off-road logging equipment used in the operation shall be equipped with spark arrestors that have been approved by the U.S. Forest Service. Such arrestors may not be altered in any manner or removed, and shall be properly maintained.
c. If a fire occurs, the Purchaser agrees to promptly report the fire and cooperate in the control and suppression of the fire.
d. The Purchaser shall comply with requests regarding forest fire prevention and suppression made by the Seller, and take all reasonable precautions to prevent, suppress and report forest fires. Those requests may include ceasing or modifying operations.
e. The Purchaser shall be responsible for damage and forest fire suppression costs, including that provided in SS. 26.14 and 26.21, Wis. Stats., caused by their operation under this Contract.
f. Other:_____

_____

_____

25. SLASH REMOVAL. Slash as defined in S. 26.12, Wis. Stats., shall be disposed of as follows:

a. Slash falling into any lake or stream, in a right-of-way or on land of an adjoining landowner shall be immediately removed from the waters, right-of-way or adjoining land. Tops from felled trees may not be left hanging in standing trees. All trees shall be completely felled and not left leaning or hanging in other trees.
b. Other:_____

_____

_____

26. CLEAN-UP AND USE OF SALE AREA.

a. The Purchaser shall remove equipment, tools, solid waste, and trash remaining on the sale area or Seller's property or adjoining land used in conjunction with the harvest upon completion of performance under this Contract, termination of this Contract due to breach by the Purchaser, or when requested by the Seller.
b. No residence, dwelling, permanent structure, or improvement may be established or constructed on the sale area or other property of the Seller.

27. HAZARDOUS MATERIALS. The Purchaser agrees to properly use and dispose of all petroleum and hazardous products, including but not limited to oil, oil filters, grease cartridges, hydraulic fuel, and diesel fuel. Any on-site spillage must be properly reported, removed and cleaned up by the Purchaser in accordance with applicable statutes and rules of the State of Wisconsin.

28. ADDITIONAL UTILIZATION AND OPERATION REQUIREMENTS AND INSTRUCTIONS:

a. Pine products that are harvested must be removed from the site within two weeks if cut between April 15 and August 15.
b. Oak wilt prevention, where residual oak trees will be left, no cutting is allowed between April 15 and August 15.
c. No trees or products over 16 feet in length may be skidded within the cutting area without written permission of the Seller.
d. Other (If none, state None.):_____

_____

Notice of Intent To Cut and Compliance With Laws

29. THE SELLER/PURCHASER (SELECT ONE) SHALL FILE REQUIRED CUTTING NOTICES and cutting reports to the responsible DNR forester for lands that are under the Forest Crop Law and Managed Forest Law programs.

30. THE SELLER/PURCHASER (SELECT ONE) SHALL FILE A DECLARATION ANNUALLY[8] with the county clerk in any manner acceptable to the county of his or her intentions to cut forest products pursuant to section 26.03, Statutes, and comply with all other notice requirements, laws and ordinances with respect to work under this Contract.

31. THE SELLER AND PURCHASER SHALL WORK TOGETHER on acquiring other necessary permits (such as wetland or stream crossing permits).

Title, Boundary Lines, and Access

32. THE SELLER GUARANTEES TITLE to the timber and to defend it against any and all claims, and to have the boundaries marked with paint or other suitable means before any timber is harvested.

33. THE SELLER AGREES TO SECURE ENTRY AND RIGHT-OF-WAY to the Purchaser on and across the area covered by this Contract, including access via land owned by a third-party if necessary.

Liability and Insurance

34. THE PURCHASER AGREES TO PROTECT, INDEMNIFY AND SAVE HARMLESS THE SELLER and the Seller's employees and agents from and against all causes of action, claims, demands, suits, liability, or expense by reason of loss or damage to any property or bodily injury to any person, including death, as a direct or indirect result of timbering operations under this Contract, or in connection with any action or omission of the Purchaser, who shall defend the Seller in any cause of action or claim.

35. UNLESS THE PURCHASER IS EXEMPTED by the Seller from this coverage requirement as an independent contractor, as defined in S. 102.07(8)(b), Stats., and as determined by the Seller based on an affidavit submitted to it, the Purchaser agrees to elect to maintain worker's compensation insurance coverage for the cutting operation under this Contract, and any and all employees engaged in cutting on the Seller's land during the period of this Contract regardless of any exemptions from coverage under Chapter 102, Wis. Stats. The Purchaser must provide an original certificate of insurance naming the Seller as a certificate holder so the insurance carrier can notify the Seller should the insurance expire.

36. THE PURCHASER AGREES TO FURNISH THE SELLER with a certificate of public liability insurance covering the period of logging operations on the Seller's property for:

a. $1,000,000 single limit liability for personal injury, or $1,000,000 bodily injury per person and $1,000,000 per occurrence; and
b. $100,000 property damage.

8 County cutting notices expire by law on December 31 and so must be renewed annually.

General

37. THE PURCHASER IS AN INDEPENDENT CONTRACTOR for all purposes including Worker's Compensation and is not an employee or agent of the Seller. The Seller agrees that the undersigned Purchaser, except as otherwise specifically provided herein, shall have the sole control of the method, hours worked, time, and manner of any timber cutting to be performed hereunder. The Seller reserves the right only to inspect the job site for the sole purpose of insuring that the cutting is progressing in compliance with the cutting practices established under this Contract. The Seller takes no responsibility for supervision or direction of the performance of any of the harvesting to be performed by the undersigned Purchaser or it's employees. The Seller further agrees to exercise no control over the selection and dismissal of the Purchaser's employees.

38. THE SELLER AGREES TO initially designate the timber to be sold, and may make inspections for the purposes of ascertaining whether the timber has been cut and the Contract has been complied with. All work shall be performed in a workman-like manner. Work shall be performed in accordance with the requirements of the Contract. The parties stipulate that in fulfillment of the terms of this timber sale Contract, the Seller warrants that the Seller has clear and unencumbered title to the stumpage subject to this Contract.

39. THIS CONTRACT OR WORK UNDER IT MAY NOT BE ASSIGNED OR SUBCONTRACTED in part or in whole without prior written approval from the Seller, and may be changed or amended only in writing. The Purchaser agrees to notify the surety, if any, of any such change or amendment.

40. THIS CONTRACT, together with specifications in the request for bids as well as reference to parts and attachments, shall constitute the entire agreement, and any previous communications or agreements pertaining to this Contract are hereby superseded. Any amendments to this Contract shall be in writing, signed and dated by both parties.

41. NEITHER PARTY SHALL BE LIABLE FOR DEFAULTS OR DELAYS DUE TO ACTS OF GOD OR THE PUBLIC ENEMY, acts or demands of any government or governmental agency, strikes, fires, flood, accidents, or other unforeseeable causes beyond its control, and not due to its fault or negligence. Each party shall notify the other in writing of the cause of such delay within five days after the beginning thereof. If such uncontrollable circumstances continue for 30 days and prevent either party from complying with the terms of this agreement, either party shall have the option of terminating upon ten days notice to the other.

42. THIS CONTRACT shall be governed by the laws of the State of Wisconsin. The Purchaser shall at all times comply with all federal, state, and local laws, ordinances, and regulations in effect during the Contract period.

43. CONTACT INFORMATION. (Note: Separate from this form, the Seller and Purchaser are encouraged to provide one another with their Social Security Number or Federal Employer ID Number needed to file tax returns or other financial documents.)

SELLER	**PURCHASER**
Name:_____	Name:_____
Address:_____	Address:_____
_____	_____
_____	_____
Phone:_____	Phone:_____
Cell Phone:_____	Cell Phone:_____

We have read and understand this entire Contract comprised of _____ pages.

_____	_____
DATE	DATE
_____	_____
SIGNATURE OF SELLAR	SIGNATURE OF PURCHASER

APPENDIX C: MFL ENTRY REVIEW CHECKLIST

Land Owner Name: _____ Order No: _____

LAND ELIGIBILITY (ALL ANSWERS MUST BE TRUE):	TRUE	FALSE
Each parcel is at least 10 contiguous acres.	☐	☐
Each parcel is at least 80 percent productive.	☐	☐
Land is not in a city.	☐	☐
Land is not part of a recorded plat.	☐	☐
Land meets width requirement (120 ft. or 4:1 ratio).	☐	☐

ENTRY PACKET COMPLETE:

Check: ☐ Land Listing ☐ Map (original) ☐ Land Exam (original)
☐ Plan (original) ☐ Other pertinent documents/letters
☐ Complete application (including deeds, tax bills, other important documents submitted by landowner)

APPLICATION (ORIGINAL):	YES	NO	N/A
Original application (as received from Madison).	☐	☐	☐
Signed by all owners listed on the deed(s) plus spouse(s) if applicable.	☐	☐	☐
Lien holder and life estate holder signature present.	☐	☐	☐
Land contract holder signature present.	☐	☐	☐
Indicated if new entry or addition.	☐	☐	☐
Indicated choice of contract lengths.	☐	☐	☐
Indicated choice for open or closed acreage.	☐	☐	☐
Deed(s) represent the acreage being entered and includes 100 percent of ownership.	☐	☐	☐
Deed(s) show that all land being entered under same ownership.	☐	☐	☐
No timber cutting restrictions on deed, or appropriate steps taken.	☐	☐	☐

PLAN:	YES	NO	N/A
Plan addresses everything on Plan Checklist.	☐	☐	☐
Contract period correct.	☐	☐	☐
County and municipality listed correctly.	☐	☐	☐
Legal description (Tn, Rng, Sec) matches land listing, land exam, and map.	☐	☐	☐
Acreage (total) matches land listing, land exam, and map.	☐	☐	☐
Addition: acres being added are clearly identified.	☐	☐	☐
Pages numbered and includes correct order number on all pages.	☐	☐	☐
Landowner objectives completed.	☐	☐	☐
Gypsy Moth consideration included.	☐	☐	☐
NHI reviewed and mentioned.	☐	☐	☐
All landowner and spouse's signatures present and original.	☐	☐	☐
Forester's signature present and original.	☐	☐	☐

LAND LISTING:	YES	NO	N/A
Contact landowner and address matches land exam.	☐	☐	☐
All owners names listed in owner/address block or further down on form (Other Owners).	☐	☐	☐
Owners listed matches deed(s).	☐	☐	☐
Order number matches on all pages of the entry packet.	☐	☐	☐
Legal description (Tn, Rng, Sec, Descrip) matches land listing, land exam, and plan.	☐	☐	☐
Parcel I.D. numbers listed.	☐	☐	☐
Certified Survey Map listed if applicable (Lot, CSM Number, Vol, Page).	☐	☐	☐
Description codes correct (see Handbook Appendix).	☐	☐	☐
Acreage (open/closed/total) matches map, land exam, and plan.	☐	☐	☐
Addition: clearly shows acres being added.	☐	☐	☐
Using whole acres in each legal description, unless entering all of owner's land in the description -OR- the land being entered/excluded is surveyed.	☐	☐	☐
Denial code listed if entire entry is denied.	☐	☐	☐

MAP (ORIGINAL):	YES	NO	N/A
1/2 inch blank margin at top, 1/2 inch clear margin on sides and bottom.	☐	☐	☐
Neat, legible, and proper scale (8 inches = 1 mile).	☐	☐	☐
One section per map.	☐	☐	☐
Non-standard sections: section corners and 1/4 corners identified.	☐	☐	☐
Correct order number.	☐	☐	☐
Correct county and municipality listed.	☐	☐	☐
Appropriate type, size and density for each stand.	☐	☐	☐
Area(s) being entered highlighted with approved highlighter.	☐	☐	☐
Adjoining lands identified.	☐	☐	☐
Buildings, area excluded from entry, etc., are clearly identified.	☐	☐	☐
Closed area identified and within acreage limits.	☐	☐	☐
Acreage (open/closed/total) matches land listing, land exam, and plan.	☐	☐	☐
Legal description (Tn, Ran, Sec, Descrip) matches land listing, land exam, and plan.	☐	☐	☐

LAND EXAM (ORIGINAL):	YES	NO	N/A
Landowner information matches land listing (only contact landowner will be listed).	☐	☐	☐
Correct order number.	☐	☐	☐
Correct county and municipality listed.	☐	☐	☐
Legal description (Tn, Rng, Sec) matches land listing, land exam, and plan.	☐	☐	☐
One section per page.	☐	☐	☐
Acreage (total) matches land listing, land exam, and plan.	☐	☐	☐
New entry or addition checked.	☐	☐	☐
Landowner objective entered.	☐	☐	☐
Stand information complete.	☐	☐	☐
Scheduled practices and codes match the plan's stand description.	☐	☐	☐
Non-productive acreage noted in remarks.	☐	☐	☐
Other important issues explained in remarks.	☐	☐	☐
Forester's signature (original).	☐	☐	☐

APPENDIX D: PESTICIDE LAWS AND RULES

Federal Laws

Commercial Driver's License (CDL) Standards, Code of Federal Regulations, Title 49, part 383.

Comprehensive Environmental Response Compensation and Liability Act (CERCLA), Code of Federal Regulations, Title 40, parts 300-302. For information on CERCLA, call **800-424-9346**.

Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), Code of Federal Regulations, Title 40, parts 152-186, For information on FIFRA, call **703-305-5805**.

Hazard Communication Standard (HCS), Code of Federal Regulations, Title 29, part 1910.1200. For information on HCS, call OSHA's regional office at **312-353-2220**.

Hazardous Materials Transportation and Training, Code of Federal Regulations, Title 49, parts 171-177. For information on hazardous material transportation or training requirements, call **202-366-6121**.

Resource Conservation and Recovery Act (RCRA), Code of Federal Regulations, Title 40, parts 260-281. For information on RCRA, call **800-424-9346**.

Superfund Amendments and Reauthorization Act (SARA), Code of Federal Regulations, Title 40, parts 350-372. For information on SARA, call **800-424-9346**.

Workers Protection Standard (WPS) for Agricultural Pesticides, Code of Federal Regulations, Title 40, part 170. For information on WPS, call **703-305-7666**.

COPIES OF FEDERAL ACTS (EITHER COMPLETE CFR VOLUMES OR SINGLE COPIES OF DAILY FEDERAL REGISTERS) CAN BE PURCHASED FROM:

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402
Phone 202-512-1800

COMPLETE CFR VOLUMES ALSO CAN BE ACQUIRED FROM:

U.S. Government Bookstore
Suite 150
Reuss Federal Plaza
310 West Wisconsin Avenue
Milwaukee, WI 53203
Phone 414-297-1304

State Laws

WISCONSIN DEPARTMENT OF TRADE AND CONSUMER PROTECTION

Wisconsin Pesticide Law, Wisconsin Statutes, sections 94.67-94.71.

Pesticide Review Board and Pesticide Advisory Council, Wisconsin Statutes, section 140.77.

Wisconsin Groundwater Law, Wisconsin Statutes, Chapter 160.

Pesticide Use and Control, Wisconsin Administrative Code, Chapter ATCP 29.

Pesticide Product Restrictions, Wisconsin Administrative Code, Chapter ATCP 30.

Groundwater Regulatory Rule, Wisconsin Administrative Code, Chapter ATCP 31.

Pesticide Bulk Storage, Wisconsin Administrative Code, Chapter ATCP 33.

Copies of the above laws are available from:
Wisconsin Department of Agriculture
Trade and Consumer Protection
2811 Agriculture Drive
PO Box 8911
Madison, WI 53708-8911
Phone 608-224-4500

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Use of Pesticides on Land and Water Areas of the State of Wisconsin, Wisconsin Administrative Code, Chapter NR 80.

Aquatic Plant Management, Wisconsin Administrative Code, Chapter NR 107.

Implementation of Groundwater Quality Standards, Wisconsin Administrative Code, Chapter NR 140.

Hazardous Waste Management, Wisconsin Administrative Code, Chapter NR 600 Series.

Wisconsin Spill Law, Wisconsin Statutes, Chapter 144.76.

Hazardous Substances Discharge Notification and Source Confirmation Requirements, Wisconsin Administrative Code, Chapter NR 706.

Use of Pesticides to Control Wild Animals, Wisconsin Statutes, sections 29.29, 29.596, and 29.60.

Copies of the above laws and rules are available from:
Wisconsin Department of Administration
Document Sales Unit
PO Box 7840
Madison, WI 53707-7840
Phone 608-266-3358

WISCONSIN DEPARTMENT OF EMERGENCY GOVERNMENT

Wisconsin SARA Law, Wisconsin Statutes, sections 166.20-166.22.

A copy of this law is available from:
Wisconsin Department of Emergency Government
2400 Wright Street
Madison, WI 53704
Phone 608-242-3232

WISCONSIN DEPARTMENT OF TRANSPORTATION

Wisconsin Commercial Driver's License (CDL) Law, Wisconsin Act 105.

A copy of the CDL manual is available from:
Wisconsin Department of Transportation
Division of Motor Vehicles
Bureau of Driver Services
PO Box 7917
Madison, WI 53707-7917
Phone 608-266-2237
Wisconsin CDL Hotline 800-242-2514

APPENDIX E: REGULATIONS RELATING TO FOREST MANAGEMENT AND WATER QUALITY

Below is a list of regulations relating to forest management and water quality that you should be aware of. Other regulations may also apply to your operations. For more information, contact a Wisconsin DNR water management specialist. This is only a summary of laws and their provisions for your information. Please refer to actual law for their complete requirements to assure compliance. Local zoning laws may be available at county zoning or DNR offices.

Federal Laws

SECTION 404 OF THE CLEAN WATER ACT

Under section 404, the U.S. Army Corps of Engineers requires permits for the alteration of wetlands, and for the discharge of dredged or fill material into the waters of the United States (33 CFR 323.3) (Note: waters of the United States includes wetlands). There is a general exemption from section 404 for "normal farming, silvicultural, and ranching activities including plowing, seeding, cultivating, minor drainage, and harvesting for the production of food, fiber, and forest products, or upland soil and water conservation practices" (33 CFR 323.4). This is not a blanket exemption. There are 15 BMPs for "construction and maintenance of farm roads, forest roads, or temporary roads" These 15 BMPs are listed in Chapter 11: Forest Roads. This exemption also does not allow for activities that would convert a wetland from one use to another.

OCCUPATIONAL SAFETY AND HEALTH STANDARDS 29 CFR OSHA 1910.120 HAZWOPER

Hazardous waste operations and emergency response. Paragraph (q) covers competency levels people need to conduct various response actions to a spill.

State Laws

WISCONSIN STATE STATUTES

Chapter 26, Stats. - Protection of Forest Lands

S. 26.03, Stats. - Cutting Forest Products. Requires that before any person cuts a forest product in any private forest, a cutting notice must be filed with the county clerk.

S.26.12(6), Stats. - Forest Protection Areas, Organization, Emergency Fire Wardens, County Cooperation, Setting Fire - Slash Disposal. All slash, which during the process of cutting timber or taking out other forest products, falls into or is deposited in any lake or stream or on the land of an adjoining owner, shall be immediately removed therefrom by the timber owner or cutting operator when in the opinion of the department such removal is in the public interest.

Chapter 28, Stats. - Public Forests

S. 28.05(1), Stats. - Timber Sales; State Forests. Requires that cutting shall be limited to trees marked or designated for cutting by a forester.

S. 28.11(6)(b)2, Stats. - Administration of County Forests. Requires that timber sale presale appraisal methods and procedures shall be approved by the Wisconsin DNR.

S. 28.21, Stats. - Municipal Forests. In a municipal forest registered with the Wisconsin DNR, no trees shall be cut except those marked or designated for cutting by a Wisconsin DNR forester.

Chapter 29, Stats. - Fish and Game

S. 29.601(3), Stats. - Noxious Substances. Regulates the deposit of deleterious substances, such as sand, stone, garbage, and sawdust, into navigable waters.

S. 29.604, Stats. - Endangered and Threatened Species Protected. No person shall take, transport, possess, process, or sell within this state any animal specified by the DNR's Endangered and Threatened Species List. In addition, it is illegal to remove, transport, carry away, cut, root up, sever, injure, or destroy a wild plant on the Wisconsin Endangered Species List on public lands. Forestry practices are exempted from the taking prohibitions of listed plant species.

Chapter 30, Stats. - Navigable Waters, Harbors and Navigation

This chapter requires permits or approvals from the state of Wisconsin for certain activities.

S. 30.12, Stats. - Permits to Place Certain Structures in Navigable Waters. This section regulates stream fords, which are usually gravel or concrete planks.

S. 30.123, Stats. - Bridge Construction and Maintenance. This section requires permits for construction and maintenance of bridges and culverts for crossings of navigable waters. A "bridge" means a structure to convey people, animals and vehicles over navigable waters, and includes pipe arches and culverts.

S. 30.18, Stats. - Diversion of Water from Lakes and Streams. This section requires a permit for diverting water from a stream.

S. 30.19, Stats. - Enlargement and Protection of Waterways or Constructing a Pond Within 500 Feet of the OHWM of a Navigable Waterway. This section requires a permit for grading and/or removal of top soil from the bank of any navigable water where the area exposed will exceed 10,000 square feet.

S. 30.195, Stats. - Changing of Stream Courses. Permits are required to change the course of or straighten a navigable stream.

S. 30.20, Stats. - Removal of Material from Beds of Navigable Waters. This section regulates the removal of material from the beds of navigable lakes, and both navigable and non-navigable streams.

S. 30.26, Stats. - Wild Rivers. This section designates certain rivers as wild rivers, thereby preserving them in a free flowing condition, and protecting them from development. It also directs the DNR to provide active leadership in the development of a practical management policy and to work with local governments, U.S. Forest Service, timber companies, county foresters, and private landowners in implementing land use practices to accomplish these management objectives.

S. 30.27, Stats. - Lower St. Croix River Preservation. This section codifies the "national wild and scenic river" designation to the Lower St. Croix River between the dam near St. Croix Falls and its confluence with the Mississippi River. This section also provides authority for the DNR to adopt guidelines and standards for local zoning ordinances in order to protect the banks, bluffs, and bluff tops of the Lower St. Croix River.

S. 30.29, Stats. - Operation of Motor Vehicles in Waters Prohibited. This section prohibits the operation of a motor vehicle in or on any navigable water or the exposed bed of a navigable water. However, exempted activities include (1) agriculture activities (which includes forest management), and (2) operating a motor vehicle on the surface of any navigable water which is frozen.

Chapter 30.40 and 30.49, Stats - Lower Wisconsin State Riverway. S. 30.44(3), Stats. - Forestry. This section requires a permit for timber cutting and harvesting on land in the Lower Wisconsin State Riverway. The cutting and harvesting of timber shall comply with the rules regulating timber cutting and harvesting promulgated by the DNR under S. 30.42(1)(d) or by the Lower Wisconsin State Riverway Board under S. 30.43(3).

Chapter 94, Stats. - Pesticides

Regulates the Sale, Handling, and Use of Pesticides. For more information, refer to Chapter 14: Pesticide Use, or ATCP 29 Administrative Code - Pesticide Use and Control.

Chapter 281, Stats. - Water and Sewage

S. 281.20, Stats. - Department of Natural Resources, Powers and Duties.

(1)(a) This section states that the DNR, in consultation with the Department of Agriculture, Trade and Consumer Protection, may order or cause the abatement of pollution which the DNR has determined to be significant, and caused by a nonpoint source, as defined in S. 281.65(2)(b), including pollution which causes the violation of a water quality standard, and pollution which significantly impairs aquatic habitat or organisms.

(3)(a)1 If the DNR determines under sub. (1)(a) that significant pollution is caused by a nonpoint source, the department shall send a written notice of intent to issue an order to abate the pollution to the person whom the DNR determines to be responsible for the nonpoint source. The notice shall include a date by which that person is required to abate the pollution.

Chapter 287, Stats. - Solid Waste

S. 287.07(1m)(b), Stats.- Prohibits the dumping of waste oil on the ground. S. 287.15 defines waste oil as any oil after use or which is contaminated through storage or handling before that oil is recycled.

Chapter 292, Stats. - Remedial Action
S. 292.11, Stats. - Hazardous Substances Spills. This section requires that a person who causes the discharge of a hazardous substance to immediately notify state and local authorities unless the discharger holds a valid permit, and discharges the substances within the limits authorized by the permit. A hazardous substance is a substance which may pose a substantial present or potential hazard to human health or the environment because of its quantity, concentration or physical, chemical or infectious characteristics (292.01(5)).
For more information, refer to Chapter 10: General Operational Guidelines or NR 158 Administrative Code - Contingency Plan for Emergency Actions in Response to the Discharge of Hazardous Substances.

Chapter 348, Stats. - Vehicles: Size, Weight and Load
SS. 348.17, 349.15 and 349.16, Stats. - Special or Seasonal Weight Limitations. No person shall operate a vehicle in violation of special weight limitations imposed by state or local authorities on particular highways, highway structures, or portions of highways when signs have been erected giving notice of such weight limitations.

WISCONSIN ADMINISTRATIVE CODES (ADMINISTRATIVE RULES)

Chapter ATCP 29, Wis. Adm. Code - Pesticide Use and Control
This code regulates the registration, licensing, certification, manufacturing, use, storage, and sale of pesticides in Wisconsin.

Chapter NR 27, Wis. Adm. Code - Endangered and Threatened Species
Most forestry activities are exempted from regulations on impacts to endangered or threatened plant species. However, consideration for these species is encouraged by the DNR (per DNR NHI Screening Guidance). The presence of aquatic endangered species at stream crossings will be reviewed when applying for a stream crossing permit.

Chapter NR 37, Wis. Adm Code - Lower Wisconsin State Riverway Aesthetic Management Specifications for Cutting and Harvest of Timber
The rules establish management specifications for timber harvesting in the Lower Wisconsin State Riverway to minimize impacts on the scenic beauty and natural value of the riverway.

NR.37.04, Wis. Adm. Code - Timber Management Cutting and Harvesting Specifications. This section limits timber cutting and harvesting to times where the ground is frozen or dry. Also, erosion bars or culverts will be installed as necessary to prevent erosion. Contact the Lower Wisconsin State Riverway Board, 202 North Wisconsin Street, PO Box 187, Muscoda, WI 53573. **Phone 800-221-3792**.

Chapter NR 103, Wis. Adm. Code - Water Quality Standards for Wetlands
NR 103 establishes wetland water quality standards, criteria, and implementation procedures for the application of these standards. NR 103's qualitative standards are based on affects to wetland functional values. In addition, standards consider the need for a project to be located in a wetland (wetland dependency) and require the consideration of "practicable alternatives" to avoid wetland impacts. NR 103 applies to all Wisconsin DNR decisions in regulatory, planning, resource management, liaison, and financial aid determinations that may affect wetlands and require a water quality certification and determination.
Note: The BMPs in Chapter 5: Riparian Areas and Wetlands and Chapter 11: Forest Roads DO NOT meet all NR 103 standards.

For forest management activities requiring state Chapter 30, or a federal section 404 permit, the state of Wisconsin must determine if the activity meets the wetland water quality standards in NR 103. If the activity does not meet NR 103 standards, then the Chapter 30 or section 404 permit can not be issued.

- Forest management activities on state lands must consider NR 103 standards.
- Forest management activities on private lands must comply with NR 103 when a Chapter 30, or section 404 permit is required. On private lands that do not require a permit, NR 103 standards are not required.
- Forest management activities on county lands must follow NR 103 standards: 1) when a Chapter 30 or section 404 permit is required, 2) for county forest 10-year comprehensive land use plans, and 3) for county forest withdrawals.

Chapter NR 115, Wis. Adm. Code - Wisconsin's Shoreland Management Program

S. NR 115.05(3)(c), Wis. Adm. Code - Counties are required to adopt minimum standards for the cutting of trees and shrubbery in unincorporated areas to be included in county shoreland ordinances to protect the natural beauty, control erosion, and reduce the flow of effluents, sediments, and nutrients from the shoreland area. This section includes the following three restrictions:

- In the strip of land 35 feet wide inland from the ordinary high-water mark, no more than 30 feet in any 100 feet shall be clear cut.
- In shoreland areas more than 35 feet inland, trees and shrub cutting shall be governed by consideration of the effect on water quality, and consideration of sound forestry and soil conservation practices.
- The tree and shrubbery cutting regulations required by this paragraph shall not apply to the removal of dead, diseased or dying trees or shrubbery.

Many counties have adopted more protective regulations than required by Chapter NR 115.

Counties have the option to adopt language to allow submittal of a special cutting plan to allow greater cutting than permitted by the standards in Chapter NR 115. If a county has adopted this language, their shoreland zoning ordinance will authorize the Planning and Zoning Committee (PZC) or the Board of Adjustment (BOA) to issue conditional use permits or special exception permits to exceed the shoreland cutting regulations. The PZC or BOA may grant a permit only if it finds that the cutting plan will not cause undue erosion or destruction of scenic beauty. The cutting plan must also provide for substantial visual screening from the water of dwellings, accessory structures, and parking areas. If the plan calls for replacement planting, the county may require submission of a performance bond to guarantee performance of the replacement trees and shrubs. Not all counties have adopted this provision.

Counties are also required by Chapter NR 115 to limit permitted uses in shoreland-wetlands. Shoreland-wetlands are those wetlands, located within the shoreland zone, which are five acres in size or larger. Some counties regulate shoreland-wetlands under five acres, and may also regulate isolated wetlands. Silvicultural activities are generally allowed in shoreland-wetlands provided precautions are taken in the construction and maintenance of logging roads. A zoning permit is required to construct logging roads in shoreland-wetlands.

It remains the responsibility of the logger or landowner to conform and comply with all zoning requirements.

Chapter NR 116, Wis. Adm. Code - Wisconsin's Floodplain Management Program

Lands subject to hazards from the 100-year flood (also called the regional flood or the one percent chance flood) are mapped and regulated under county, city and village zoning ordinances. Chapter NR 116 does not have specific references to forest management practices, however, several sections do apply.

It is illegal to store logs and slash in the floodplain because they would be an obstruction to flood flow.

S. NR 116.12(1)(c), Wis. Adm. Code - States that municipalities shall prohibit the storage of materials that are buoyant, flammable, explosive, or injurious to human, animal, plant, fish, or other aquatic life in floodway areas (lands necessary to convey flood flows without obstruction, generally associated with moving water).

S. NR 116.12(2), Wis. Adm. Code - States that all uses and structures (for loggers this would generally refer to stream crossings or culverts) must pass the 100-year flood event without causing an increase of 0.01 feet or greater in the regional flood elevation. In the event they do not, easements may be required from affected upstream landowners for the increased flooding.

S. NR 116.13(6), Wis. Adm. Code - States that for flood fringe areas (floodplain areas outside of the floodway which are covered by flood water during the 100-year flood), the storage of any materials which are buoyant, flammable or explosive, or which in times of flooding could be injurious to property, water quality, or human, animal, plant, fish, or aquatic life, shall be either floodproofed or placed at or above the flood protection elevation. Adequate measures shall be taken to assure that these materials will not enter the river or stream during flooding.

Chapter NR 117, Wis. Adm. Code - Wisconsin's City and Village Shoreland-Wetland Protection Program
This Administrative Code requires cities and villages with wetlands greater than five acres in size in the shoreland-wetland zone, to adopt shoreland-wetland zoning ordinances. Some communities regulate shoreland-wetlands under five acres, and may also regulate isolated wetlands. Silvicultural practices are generally allowed in shoreland-wetlands provided precautions are taken in the construction and maintenance of logging roads. A zoning permit or conditional use permit may be required to construct logging roads in shoreland-wetlands. Cities and villages do have the option, however, to prohibit silvicultural activities.

It remains the responsibility of the logger or landowner to conform and comply with all zoning requirements. Contact your city or village for more information.

Chapter NR 118, Wis. Adm. Code - Wisconsin's Lower St. Croix National Scenic Riverway Program
This code prescribes minimum development standards for the Wisconsin side of the Lower St. Croix Riverway. The regulations guide development away from sensitive areas such as shorelines, wetlands, steep slopes, and unstable soils.

S. NR 118.06(11), Wis. Adm. Code - States that on lands within 200 feet of the ordinary high-water mark, and 40 feet landward of the bluffline, removal of trees and shrubs is not permitted. However, the removal of diseased or damaged trees, the pruning of trees, cutting of shrubs or grasses, or harvesting of non-wood fiber crops is allowed. Also, forestry practices are allowed on Woodland Tax Law or Forest Crop Law lands as long as it is done in a manner that protects the scenic beauty of the river. Vegetative cutting elsewhere in the Lower St. Croix River District may be conducted only where it is accessory to a permitted or conditionally permitted activity.

S. NR 118.06(12), Wis. Adm. Code - Grading and filling of the natural topography in excess of that normally required for the construction of a structure or for normal yard maintenance must comply with applicable state laws. The application for a permit must include a detailed plan and schedule of the earth moving activities including a plan that shows 1) how vegetative cover will be re-established, 2) at what density, and 3) within what timeframe.

Some municipalities have ordinances meeting or exceeding the state minimum standards.

Chapter NR 158, Wis. Adm. Code - Notification of the Discharge of Hazardous Substances
S. NR 158.05, Wis. Adm. Code - Discovery and Notification Requirements. The discharger of a hazardous substance shall immediately notify the department or the designated statewide 24-hour emergency number provided by the Division of Emergency Government. The discharger shall immediately initiate actions necessary to halt the discharge, and to restore the environment to the extent practical, and shall minimize the harmful effects from any discharge to the air, lands or waters of the state.

Chapter NR 302, Wis. Adm. Code - Management of Wisconsin's Wild Rivers
This Administrative Code protects three legislatively designated wild rivers from development – the Pike River in Marinette County, the Pine River in Florence and Forest Counties, and the Popple River in Florence and Forest Counties. Section NR 302.03(1)(e) states that on lands owned by or under control of the DNR by lease, easement or agreement, timber harvesting is not permitted within 150 feet of the bank on either side of the wild river, except as necessary for erosion control or natural restoration. Beyond 150 feet, timber cutting in accord with guidelines established in the Wisconsin DNR *Silviculture and Forest Aesthetics Handbook, 2431.5,* shall be practiced.

Chapter NR 320, Wis. Adm. Code - Bridges In or Over Navigable Waterways
This code includes provisions to protect water quality from the construction and maintenance of bridges, including those used for forest roads. Erosion control, floodflow, clearance, and navigation requirements are addressed.

APPENDIX F: PERMITS

In addition to the BMPs described in this manual, you should be aware of existing municipal, county, state, and federal regulations relating to forest management and water quality. Many of these regulations are listed in Appendix E: Regulations (see page 279). Other laws and regulations may apply. Appendix F summarizes several permits related to the regulations in Appendix E. For more information, contact your county zoning office or a Wisconsin DNR water management specialist when conducting forest management activities near streams, lakes, or wetlands.

Legal definitions of a lake, a stream (intermittent and perennial), navigability, and ordinary high-water mark are listed in Chapter 5: Riparian Areas and Wetlands and in the Glossary.

Permits for Water Quality

Several regulations in Appendix E state that certain operations in or near streams, lakes, floodplains, or wetlands require a permit. If you are planning an activity near a waterbody or wetland, investigate the need for a permit at least 90 DAYS in advance of the activity.

STREAM CROSSINGS

A stream crossing permit is required to construct a ford or install a culvert or bridge across a navigable perennial or intermittent stream (Chapter 30, Wis. Stats.). When planning to construct a stream crossing – or modify, repair, or expand an existing stream crossing – call a water management specialist at the Wisconsin DNR for information, and to apply for a permit. For stream crossings that are not designed to pass the 100-year flood without causing backwater, you will need to obtain flooding easements from affected upstream property owners.

GRADING

Grading and/or removal of top soil from the bank (see the Glossary) of any navigable stream, lake or other body of navigable water where the area exposed will exceed 10,000 square feet requires a Chapter 30 permit. Call a water management specialist at a Wisconsin DNR office to apply for a permit. Also, check with your county zoning office for local grading and excavation permits that may be required. County zoning may require permits for exposed areas less than 10,000 square feet.

WETLANDS AND FLOODPLAINS

Activities in wetlands and floodplains are often subject to municipal, county, state, and federal regulations and permit requirements. Your sequence of contacts when you suspect your project may involve a wetland or floodplain, and want to know what regulations apply is: 1) your county zoning office, 2) a Wisconsin DNR water management specialist, and 3) the U.S. Army Corps of Engineers.

Maps from the Wisconsin Wetland Inventory (see the Resource Directory for contact information) can help you make a preliminary determination as to whether your project will affect wetlands. Wisconsin Wetland Inventory maps may be reviewed at DNR offices and county or municipal zoning offices or purchased from the Wisconsin Geological and Natural History Survey.

TIMBER HARVESTING NEAR WATER

All cutting practices near lakes and navigable streams (i.e., generally within 100 feet) must be consistent with local county shoreland zoning ordinances. A special exception permit or conditional use permit may be required. Contact your local county zoning office for more information before harvesting near shoreland.

Other Permits

TIMBER HARVESTING

Before harvesting timber on private land, a cutting notice must be filed with the County Clerk in the county in which the harvesting occurs (S. 26.03 Wis. State Stats.). In addition, if land is entered under the Forest Crop Law or Managed Forest Law, you must file a notice of intent to cut with the Wisconsin DNR prior to harvesting.

Before timber may be harvested on county forest land, the DNR must be notified (S. 28.11(6)(b)2 Wis. Stats.). On municipal forests registered with the DNR, only trees marked for cutting by a Wisconsin DNR forester may be cut (S. 28.21 Wis. Stats.).

BURNING PERMITS

If you plan to conduct any open burning (i.e., slash, bark, debris), contact the Wisconsin DNR or local municipal fire authorities to determine (1) if a burning permit is required, and (2) to apply for a permit, if necessary.

APPENDIX G: CITED REFERENCES

APPROACHES TO ECOLOGICALLY BASED FOREST MANAGEMENT ON PRIVATE LANDS

Kotar, J. (1997). Approaches to ecologically based forest management on private lands. *Publication NR-604.* University of Minnesota Extension Service.

DETERMINE YOUR BASIS…AND KEEP MORE TIMBER INCOME

Martin, J. (1994). *Determine your basis…and keep more timber income.* University of Wisconsin-Madison, Department of Forest Ecology and Management. *Forestry Fact No. 71.* 4p.

THE DICTIONARY OF FORESTRY

Helms, J. A. (Ed.). (1998). *The dictionary of forestry*. Society of American Foresters.

FIFTEEN-YEAR RESULTS FROM SIX CUTTING METHODS IN SECOND GROWTH NORTHERN HARDWOODS

Erdmann, G. C. & Oberg, R. R. (1977). Fifteen-year results from six cutting methods in second growth northern hardwoods. *USDA Forest Service Research Paper NC-100.* St. Paul, MN. 12p.

FOREST MANAGEMENT: REGULATION AND VALUATION (2ND ED.)

Davis, K. P. (1966). *Forest management: Regulation and valuation (2nd ed.)*. New York: McGraw-Hill.

FORTY YEARS OF ALTERNATIVE MANAGEMENT PRACTICES IN SECOND-GROWTH, POLE-SIZE: NORTHERN HARDWOODS II: ECONOMIC EVALUATION

Niese, J. N., Strong, T. F. & Erdman, G. G. (1995). Forty years of alternative management practices in second-growth, pole-size: Northern hardwoods II: Economic evaluation. *Canadian Journal of Forest Research,* 25, 1180-1188.

HELPING NON-INDUSTRIAL FORESTLAND OWNERS SAVE TAXES ON TIMBER SALE INCOME: THE ROLE OF THE BASIS

Stier, J. C. (1997). Helping non-industrial forestland owners save taxes on timber sale income: The role of the basis. *Northern Journal of Applied Forestry,* 14, 84-89.

HOW TO RELEASE CROP TREES IN PRECOMMERCIAL HARDWOOD STANDS

Lampson, N. I., et al. (1989). How to release crop trees in precommercial hardwood stands. *NE-INF-80-88.* Northeastern Forest Experiment Station.

MANAGING APPALACHIAN HARDWOOD STANDS USING FOUR HARVEST CUTTING PRACTICES: 34-YEAR RESULTS

Smith, H. C. & Miller, G. W. (1987). Managing Appalachian hardwood stands using four harvest cutting practices: 34-year results. *Northern Journal of Applied Forestry,* 4, 180-185.

MANAGING RED PINE FOR UTILITY POLES

Dickman, D. D. & Koelling, M. R. (1997). Managing red pine for utility poles. *Michigan State University Extension Forestry Bulletin.* 26129701. East Lansing, MI. 12p.

MINIMIZING SOIL COMPACTION IN PACIFIC NORTHWEST FORESTS

Froehlich, H. A., & McNabb, D. H. (1984). Minimizing soil compaction in pacific northwest forests. In E. L. Stone (Ed.). *Forest soils and treatment impacts* (pp. 159-192). Proc. 6th North American Forest Soils Conference (June 1983). Knoxville: University of Tennessee.

NATURAL RECOVERY OF SURFACE SOILS DISTURBED IN LOGGING

Hatchell, G. E., & Ralston, C. W. (1971). Natural recovery of surface soils disturbed in logging. *Tree Planter's Notes, 22,* 5-9.

ORIGINAL VEGETATION COVER OF WISCONSIN MAP

Finley, R. W. (1976). Original vegetation cover of Wisconsin map. USDA Forest Service North Central Forest Experiment Station. St. Paul, MN.

PHYSIOLOGY OF WOODY PLANTS

Kramer, P. J. & Kozlowski, T. T. (1979). *Physiology of woody plants.* Orlando: Academic Press, Inc..

THE PRACTICE OF SILVICULTURE (7TH ED.)

Smith, D. M. (1962). *The practice of silviculture (7th ed.).* New York: Wiley.

PREDICTING SOIL COMPACTION ON FORESTED LAND

Froehlich, H. A., Azevedo, J., Cafferata, P. & Lysne, D. (1980). Predicting soil compaction on forested land. Final Report to USDA Forest Service Pacific Northwest Forest and Range Experiment Station and Missoula Equipment Development Center. Oregon State University Forest Engineering Department. Corvallis, OR.

PROPERTIES AND MANAGEMENT OF FOREST SOILS

Pritchett, W. L. (1979). *Properties and management of forest soils*. New York: John Wiley & Sons.

RELATIVE EFFECTIVENESS OF TILLAGE AND NATURAL FORCES IN ALLEVIATING WHEEL-INDUCED SOIL COMPACTION

Voorhees, W. B. (1983). Relative effectiveness of tillage and natural forces in alleviating wheel-induced soil compaction. *Soil Science Society of America Journal,* 47, 129-133.

SILVICULTURE: CONCEPTS AND APPLICATIONS

Nyland, R. D. (1996). *Silviculture: Concepts and applications*. New York: McGraw-Hill.

SILVICULTURE AND FOREST AESTHETICS HANDBOOK, PUBL. NO. 2431.5

Wisconsin Department of Natural Resources. (2002). *Silviculture and forest aesthetics handbook*. Madison: Wisconsin Department of Natural Resources.

SOIL PROPERTIES AND ASPEN DEVELOPMENT FIVE YEARS AFTER COMPACTION AND FOREST FLOOR REMOVAL

Stone, D. M., & Elioff, J. D. (1998). Soil properties and aspen development five years after compaction and forest floor removal. *Canadian Journal of Soil Science* (Vol. 78). In press.

STAND DEVELOPMENT AND ECONOMIC ANALYSIS OF ALTERNATIVE CUTTING METHODS IN NORTHERN HARDWOODS: 32-YEAR RESULTS

Erickson, M. D., Reed, D. D. & Mroz, G. D. (1990). Stand development and economic analysis of alternative cutting methods in northern hardwoods: 32-year results. *Northern Journal of Applied Forestry, 7,* 153-158.

STOCKS, BONDS, BILLS, AND INFLATION: 2000 YEARBOOK

Ibottson Associates (2000). *Stocks, bonds, bills, and inflation: 2000 yearbook*. Chicago: R. G. Ibottson Associates.

SUSTAINING ASPEN PRODUCTIVITY IN THE LAKES STATES

Stone, D. M. (2001). Sustaining aspen productivity in the Lakes States. In: W. Sheppard, D. Binkley, D. Bartos, T. Stohlgren, L. Eskew, (Eds.). *Sustaining aspen in western landscapes: Symposium proceedings* (June 13-15, 2000). USDA FS Proc. RMRS-P-18.

SUSTAINING MINNESOTA FOREST RESOURCES: VOLUNTARY SITE-LEVEL FOREST MANAGEMENT GUIDELINES FOR LANDOWNERS, LOGGERS, AND RESOURCE MANAGERS

Minnesota Forest Resources Council (1999). Sustaining Minnesota forest resources: Voluntary site-level forest management guidelines for landowners, loggers, and resource managers. St. Paul, MN.

TIMBER MART NORTH PRICE REPORT©

Timber Mart North Price Report©. (2002). Milwaukee: George Banzhaf and Company.

UNDERSTANDING THE SAMPLE TIMBER SALE CONTRACT

Wisconsin Department of Natural Resources, Wisconsin Woodland Owners Association, & University of Wisconsin-Extension (2002). Understanding the sample timber sale contract. *Forestry Facts No. 94* (also known as Wisconsin Department of Natural Resources *Publication FR 202-2002*). Department of Forest Ecology and Management, University of Wisconsin-Madison.

WISCONSIN FORESTS AT THE MILLENNIUM – AN ASSESSMENT

Finan, A. S. (2000). Wisconsin forests at the millennium – An assessment. Publication No. FR-161. Madison: Wisconsin Department of Natural Resources.

WISCONSIN WOODLANDS: INTERMEDIATE CUTTINGS IN FOREST MANAGEMENT

Huebschmann, M. & Martin, J. (1987). Wisconsin woodlands: Intermediate cuttings in forest management. *Forestry Facts No. G3398.* Department of Forest Ecology and Management, University of Wisconsin-Madison (sidebar in Chapter 16, page 220 was adapted from this publication).

WISCONSIN'S BIODIVERSITY AS A MANAGEMENT ISSUE

Wisconsin's biodiversity as a management issue. (1995). Wisconsin Department of Natural Resources.

WISCONSIN'S FORESTRY BEST MANAGEMENT PRACTICES FOR WATER QUALITY

Wisconsin's forestry best management practices for water quality. 1995. *Publication No. FR093.* Wisconsin Department of Natural Resources.

WISCONSIN FOREST MANAGEMENT GUIDELINES

PUB-FR-226 2003

Wisconsin Department of Natural Resources
Division of Forestry
PO Box 7921
Madison, Wisconsin 53707

For additional information, call **608-267-7494** or visit our web site at:
www.dnr.state.wi.us/org/land/forestry/

October, 2003

This document is intended solely as guidance, and does not include any mandatory requirements except where requirements found in statute or administrative rule are referenced. This guidance does not establish or affect legal rights or obligations, and is not finally determinative of any of the issues addressed. This guidance does not create any rights enforceable by any party in litigation with the State of Wisconsin or the Department of Natural Resources. Any regulatory decisions made by the Department of Natural Resources in any manner addressed by this guidance will be made by applying the governing statutes and administrative rules to the relevant facts.

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Please call **608-267-7494** for more information.

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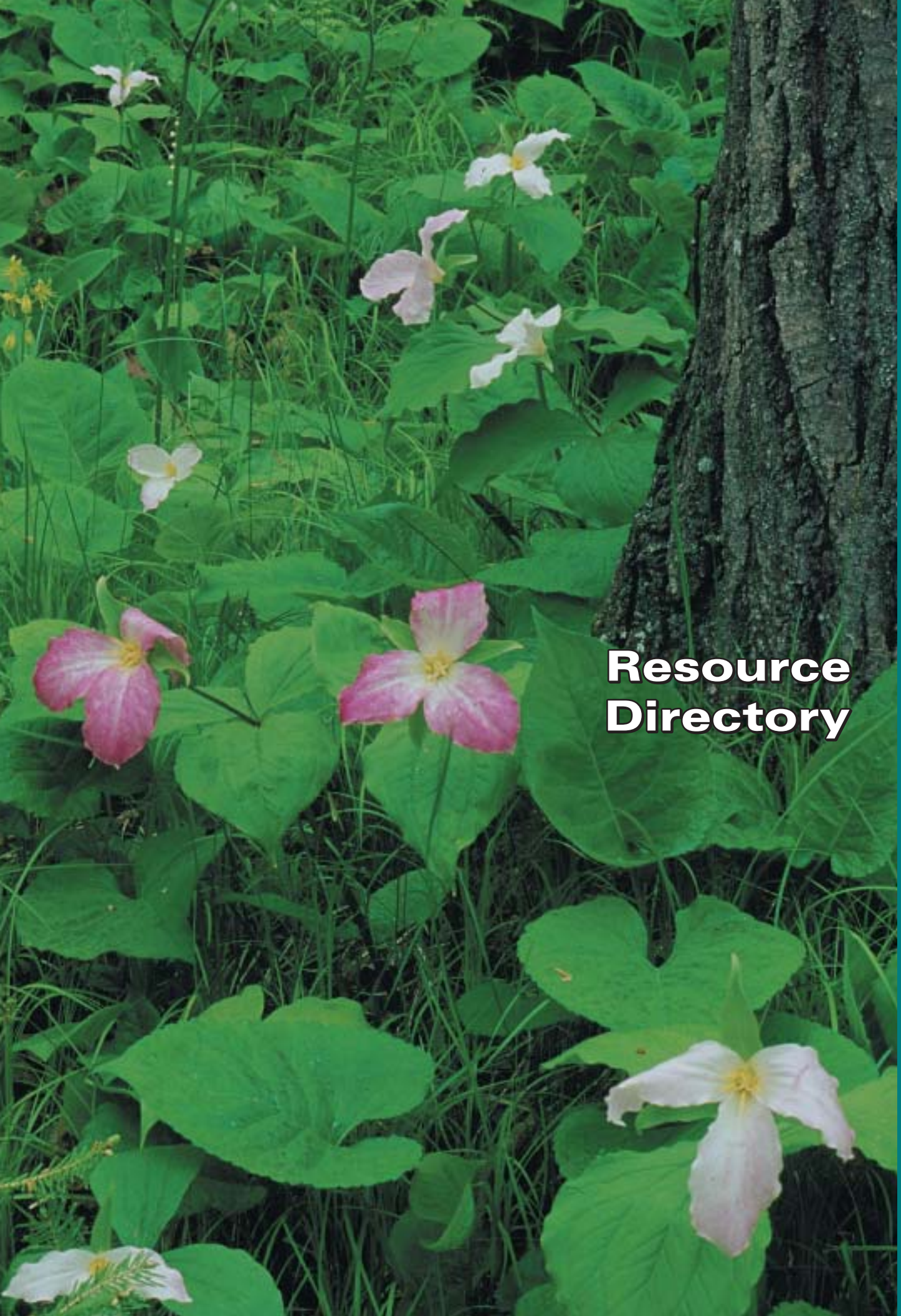


Resource Directory

RESOURCE DIRECTORY

FOREST MANAGEMENT ASSISTANCE AND EDUCATION 288

Wisconsin Department of Natural Resources 288
University of Wisconsin-Extension (UWEX).....289
Forest Industry Safety Training Alliance (FISTA) 290
Wisconsin Family Forests (WFF).....290
Community Forestry Resource Center (CMRC) 290
Gathering Waters 291
Wisconsin Forest Productivity Council (WFPC) 291
USDA Forest Service Northeast Area.....291
Wisconsin Woodland Owners Association (WWOA) 292
American Tree Farm® System (ATFS).....292
Wisconsin Walnut Council.....292

CULTURAL RESOURCE ASSISTANCE.....293

NON-TIMBER PRODUCTS 293

PETROLEUM SPILLS.....293

SOURCES OF MAPS AND PLANNING TOOLS.....294

Aerial Photography.....294
Digital Mapping Resources 294
Wisconsin Wetland Inventory Maps.....294
Topographic Maps.....295
Soil Surveys, Soil Interpretations, and Erosion Control.....295

FINANCIAL INCENTIVE PROGRAMS 296

Forest Tax Programs 296
Cost-sharing Programs.....296

FISH AND WILDLIFE HABITAT, WETLAND PROTECTION.....297

FOREST HEALTH 298

WATER CROSSINGS.....298

PRESCRIBED BURNING.....299

ENDANGERED, THREATENED OR SPECIAL CONCERN SPECIES.....299

PESTICIDE USE 299

ADDITIONAL RESOURCES I HAVE FOUND.....300

FOREST MANAGEMENT ASSISTANCE AND EDUCATION

The Resource Directory identifies sources of information and assistance in the management of forest resources. A number of organizations and agencies are listed, along with a brief description of the types of assistance they can provide, and contact information. This directory is not exhaustive. Links to other sources of information are available from the Internet sites listed within the Resource Directory. Additional resources related to specific management activities can also be found at the end of each chapter.

Wisconsin Department of Natural Resources

WISCONSIN
DEPT. OF NATURAL RESOURCES

FORESTERS EMPLOYED BY THE STATE OF WISCONSIN WHO ASSIST PRIVATE LANDOWNERS

DNR service foresters are stationed in every county. They focus on initial guidance and management planning to get landowners started with sustainable forestry, and administer forest tax and cost-sharing incentive programs. DNR foresters can also help get information for landowners from forest health specialists, wildlife biologists, and other resource managers at the DNR.

PRIVATE ENTERPRISE FORESTERS (CONSULTING FORESTERS AND INDUSTRIAL FORESTERS) THAT HAVE SIGNED A COOPERATING FORESTER AGREEMENT WITH THE DEPARTMENT

Cooperating Foresters voluntarily agree to observe DNR standards and rules whenever they assist with land management planning and timber harvesting. Cooperating Foresters also agree to attend continuing education courses to stay current in the services they offer. Consulting foresters serve or represent private landowners on a contract or fee basis, which the landowner pays. Industrial foresters are employed by wood-using industries that provide advice and assistance to private landowners to promote forestry practices approved by the companies.

Pick up a copy of the *Directory of Foresters* from DNR Service Centers and Ranger Stations, or request one by writing or calling:

Wisconsin Department of Natural Resources
Division of Forestry
PO Box 7921
Madison, WI 53707
Phone 608-267-7495

The directory may be viewed on-line, or downloaded from the DNR web site at:
www.dnr.state.wi.us/org/land/forestry/

To view the *Silviculture and Forest Aesthetics Handbook, 2431.5*, see the following web site at:
www.dnr.state.wi.us/org/land/forestry/publications/2431_5/index.htm

University of Wisconsin-Extension (UWEX)

Through county-based faculty, basin educators, and statewide extension specialists, UWEX offers a variety of research-based educational programs and opportunities including agriculture, forestry, wildlife, fisheries, family living, 4-H, and more.

For woodland owners and others interested in forestry, wildlife and related natural resource topics, UWEX works with a wide array of partners to provide education resources that include:

- Forestry and wildlife fact sheets and publications
- Woodland owner workshops and conferences
- In-depth forestry and wildlife learning experiences through COVERTS, Master Woodland Stewards, and the Woodland Leaders Institute
- Continuing education for resource professionals and others
- Assistance to the forest products industry

For more on publications, visit your local UWEX County Office, or download Extension publications from these Internet sites: **http://cecommerce.uwex.edu/** or **http://forest.wisc.edu/extension/forfact.htm**. An introduction to forest management and land ownership is available at the Wisconsin Woodland Assistance web site, **http://clean-water.uwex.edu/woodland/**. For more information on programs available through UWEX, visit your local UWEX County Office at **http://www1.uwex.edu/ces/cty/**, or contact any of the following:

UNIVERSITY OF WISCONSIN-EXTENSION

Basin Educator Forestry Team
107 Sutliff Avenue
Rhinelander, WI 54501-0695
Phone 715-365-2658, Fax 715-365-8932
Email william.klase@ces.uwex.edu
http://clean-water.uwex.edu/basins/index.html

UNIVERSITY OF WISCONSIN-STEVENS POINT

College of Natural Resources
Stevens Point, WI 54481-3897
Phone 715-346-4128, Fax 715-346-4038
Email john.duplissis@uwsp.edu
http://www.uwsp.edu/cnr/fop/

UNIVERSITY OF WISCONSIN-MADISON

Department of Forest Ecology and Management
120 Russell Labs
Madison, WI 53706
Phone 608-262-9975, Fax 608-262-9922
Email forext@calshp.cals.wisc.edu

UWEX Cooperative Extension is a partnership of Wisconsin counties, the University of Wisconsin, and the U.S. Department of Agriculture to extend research-based knowledge to people where they live and work. UWEX provides equal opportunities and programming including Title IX requirements.

LOOKING FOR EXTENDED EDUCATIONAL OPPORTUNITIES ABOUT FORESTRY?

County Extension agents and others offer an eight-session **Master Woodland Stewards** program, patterned after the Master Gardeners training. They teach skills including:

- Understanding forest ecology
- Managing for wildlife
- Managing for aesthetics
- Enhancing recreation values
- Financial and tax considerations
- Tips on timber harvesting
- Available cost-sharing programs
- Dealing with forest pests and problems
- Legal issues of woodland ownership

Another opportunity is the **Wisconsin Woodland Leadership Institute**. Each year, about 30 people interested in being active in forestry organizations are selected. They attend three seminars of two- to three-days each. A variety of instructors from the U.S. Forest Service, state and local government, the University, and private organizations conduct the classes. Contact UW-Stevens Point for more information.

Forest Industry Safety Training Alliance (FISTA)

FISTA provides training programs on logging and other forestry activities for forestry professionals and woodland owners. FISTA staff also coordinates Game of Logging training programs in the upper midwest. Game of Logging classes teach chain saw safety to loggers, foresters, homeowners, landowners, tree farm operators, and others.

FISTA, 6343 Highway 8 West, Rhinelander, WI 54501
Phone 1-800-551-2656 • Email fista@newnorth.net • www.newnorth.net/fista/

Wisconsin Family Forests (WFF)

WFF is a grassroots, community-based organization for private woodland owners that focuses on strengthening local communities through their shared interest in sustainable land management. Community connections are strengthened as neighbors work with neighbors to gain knowledge about sustainable forestry. Local resources are made available as neighbors share their forest management experiences, and work together to complete joint management projects on private lands.

The local WFF alliances, usually formed at the township level, are the substance of WFF. Each alliance operates independently at the local level, focusing on issues of common interest to its own members.

The sole function of WFF, Inc., the statewide organization, is to support established alliances, as well as to offer assistance to landowner groups interested in forming alliances in their own communities. Thus, the focus of WFF remains at the local community level. For more information on a WFF alliance near you, or for assistance in forming an alliance in your community, contact:

Wisconsin Family Forests
PO Box 682, Wisconsin Rapids, WI 54495-0682
Phone 715-213-1618 • www.wisconsinfamilyforests.org

Community Forestry Resource Center (CFRC)

CFRC, a program of the Institute for Agriculture and Trade Policy, promotes responsible forest management by encouraging the long-term health and prosperity of small, privately-owned woodlots, their owners, and their communities.

The CFRC works with private landowners in Wisconsin and other parts of the country to meet their goals for forest management. Specifically, the CFRC assists landowners interested in forming an association or cooperative, or in becoming certified through the Forest Stewardship Council (FSC). The CFRC assists with all aspects of establishing forest owner groups, and offers business, marketing and management planning, as well as membership development.

The CFRC also hosts workshops and training sessions for landowners, resource managers and loggers.

For more information about the CFRC, contact:

Community Forestry Resource Center
2105 First Avenue South
Minneapolis, MN 55404
Phone 612-870-3407
Email forestrycenter@iatp.org

To locate a wood cooperative or other local forestry association in your area, see the CFRC web site at: **www.forestrycenter.org**

Gathering Waters

Gathering Waters is a land conservation organization formed in 1995 to assist land trusts, landowners and communities in their efforts to protect Wisconsin's land and water resources. Established by a coalition of land trusts, Gathering Waters serves as an education and technical assistance center for both land trusts and landowners. But their mission goes far beyond training and providing expert advice on land conservation issues. Gathering Waters works directly with concerned landowners and existing land trusts statewide to preserve Wisconsin's natural heritage and rural landscape.

Gathering Waters
211 South Paterson Street, Suite 180, Madison, WI 53703
Phone 608-251-9131 • www.gatheringwaters.org/index.html

Wisconsin Forest Productivity Council (WFPC)

WFPC, through education, helps Wisconsin's woodland owners take the first steps toward sustainable forestry. The WFPC is best known for the county workshops they sponsor, and the resource catalogs they publish. Both help landowners become aware of the technical, financial, and educational assistance available to them in managing their timber properties. The resource catalogs, which are specific for most counties in the state, are free upon request.

The staff of the WFPC is available to answer any questions Wisconsin woodland owners may have about managing their forests. Additionally, they can provide landowners with the names of people or companies to contact in their area for assistance.

The Executive Director is available to speak on forestry issues to clubs or other organizations.

Tax guidance is also available for Wisconsin woodland owners through the WFPC. This free service is designed to answer general questions on the application of the Internal Revenue Code to timber investments.

For more information from the WFPC, contact:

Wisconsin Forest Productivity Council
803 Lincoln Street
PO Box 1375
Rhinelander, WI 54501-1375
Phone 715-369-3475
Email wfpc@newnorth.net
www.wisconsinforests.org

USDA Forest Service Northeast Area

The U.S. Forest Service provides technical assistance through its State and Private Forestry Northeast Area (NA) Office. The NA Internet site **www.na.fs.fed.us/** offers a vast selection of forestry publications from organizations around the country. If you have an Internet browser, you may want to start at "A Forest Landowner's Guide to the Internet" **www.na.fs.fed.us/pubs/misc/ir/index.htm**.

It includes links to publications for the following:

- riparian forest management
- tree identification
- forest health and protection
- special forest products
- glossaries of forestry terms
- income tax and estate planning
- and much, much more!
- wildlife/hunting
- seedling suppliers
- tree planting
- timber sales
- recreation
- silviculture

Wisconsin Woodland Owners Association (WWOA)

WWOA is a non-profit [501(c)3], educational association for the private woodland owners of Wisconsin. WWOA offers year-round educational opportunities for novice and experienced private woodland owners who want to become better stewards of their woodlands. WWOA publishes the quarterly, award-winning magazine, *Woodland Management*, and sponsors workshops, conferences, field days, and an annual meeting each year in September. Local WWOA chapters, are located throughout Wisconsin, and are a great way to learn more about local issues, and meet neighboring woodland owners. WWOA also has statewide committees on education, legislation, marketing, science, and publications to help keep members up-to-date on information in these areas. The WWOA Foundation is developing the Seno Woodland Management Center in southeastern Wisconsin as an educational facility for youths and adults. WWOA works to bridge the gap between woodland owners and natural resource professionals.

For a free information packet on WWOA, contact:

Wisconsin Woodland Owners Association
2000 Maria Drive
PO Box 285
Stevens Point, WI 54481-0285
Phone 715-346-4798
Email nbozek@uwsp.edu
www.wisconsinwoodlands.org

American Tree Farm® System (ATFS)

The ATFS is a nationwide program encouraging private forest owners to do an effective job of growing trees as a crop. You may have seen a green and white ATFS sign on your travels around Wisconsin. ATFS is sponsored by professional foresters working for government agencies, industry, and as consulting foresters. ATFS inspectors must meet minimum education and experience requirements.

If you are interested in becoming an ATFS tree farmer, contact the Wisconsin Tree Farm Committee or your local DNR forester. They will arrange to have a state, private or industrial forester look at your property to prepare a tree farm management plan. Once certified as an ATFS tree farm, you can display the sign and subscribe to the *American Tree Farmer* magazine. You will receive notices of conferences, conventions, field days, and study tours on forestry. Certified ATFS tree farm landowners are also eligible to compete in annual Outstanding Tree Farmer competitions. For information on tree farming in Wisconsin, contact:

Wisconsin Tree Farm Committee
803 Lincoln Street
PO Box 1375
Rhinelander, WI 54501-1375
Phone 715-369-3475
Email wfpc@newnorth.net

Wisconsin Walnut Council

The Wisconsin Walnut Council is a nationwide organization involved with hardwood management. The council conducts periodic field trips, and is a source of information on most aspects of growing hardwood trees.

Visit their web site at: **www.wiscwalnutcouncil.org**

CULTURAL RESOURCE ASSISTANCE

ARCHAEOLOGICAL CONSULTANTS
www.shsw.wisc.edu/arch/preserve/index.html

BURIAL SITES PRESERVATION
Wisconsin Historical Society: Burial Sites
816 State Street, Madison, WI 53706
Phone 608-264-6503

DNR ARCHAEOLOGIST
952 Tacoma Beach Road, Sturgeon Bay, WI 54235
Phone 920-743-2083

HISTORIC STRUCTURES
Wisconsin Historical Society: Historic Preservation
816 State Street, Madison, WI 53706
Phone 608-264-6512

STATE ARCHAEOLOGIST
Wisconsin Historical Society
816 State Street, Madison, WI 53706
Phone 608-264-6495

TRIBAL HISTORIC PRESERVATION OFFICERS
Lac Courte Oreilles Band of Lake Superior Chippewa
13394 West Trepania Road, Hayward, WI 54843
Phone 715-634-8934

Lac du Flambeau
PO Box 67, Lac du Flambeau, WI 54538

Menominee Indian Tribe of Wisconsin
PO Box 910, Keshena, WI 54135-0910

Red Cliff Band of Lake Superior Chippewas
88385 Pike Road, Highway 13, Bayfield, WI 54814
Phone 715-779-3648

WISCONSIN ARCHITECTURE AND HISTORY INVENTORY
www.shsw.wisc.edu/ahi/welcome.asp

NON-TIMBER PRODUCTS

Aromatics, berries and wild fruits, cones and seeds, forest botanicals, honey, mushrooms, nuts, syrup, and weaving and dyeing materials are some of the many alternative forest products that people grow and harvest. Special products like these can provide opportunities for entrepreneurs to supplement their incomes. The broader economic framework that results can ultimately help to preserve and protect sustainable forests.

For more information, see *Non-timber Products in the United States*, 2002, edited by E. T. Jones, R. J. McLain and J. Weigand. University Press of Kansas.

The following web sites list additional books, publications and articles, many of which can be downloaded. Both rural and urban forests are addressed.

www.sfp.forprod.vt.edu/pubs/pubs.htm • www.communityresources.org/ntfp.html
www.extension.umn.edu/specializations/environment/ntfp.html

PETROLEUM SPILLS

Notification of petroleum spills: Report all spills to the Wisconsin Department of Natural Resources.

24-hour Emergency Hotline Number 1-800-943-0003
When the phone is answered, press “1” for spills.

SOURCES OF MAPS AND PLANNING TOOLS

Aerial Photography

DEPARTMENT OF NATURAL RESOURCES (DNR)

The Wisconsin DNR coordinates an aerial photography project for forestry planning. Flights are repeated at least once every ten years for each county. High-resolution prints and enlargements are available for purchase. Ordering information is available from local DNR foresters, or from the central office:
Division of Forestry
PO Box 7921, Madison, WI 53707
Phone 608-267-7495

Ordering forms are available on the DNR Internet site at: **www.dnr.state.wi.us/org/land/forestry/airphoto/index.htm**, which also includes a link to digital orthophotos, which may be viewed on-line.

USDA

Landowners working with the Farm Service Agency (FSA) on farm programs have access to aerial photographs maintained by the USDA. Contact your local FSA Office (in the telephone directory) for details.

TERRASERVER AERIAL PHOTOS

Visit the TerraServer-USA web site, located at **http://terraserver-usa.com/**, which provides free public access to a vast data store of aerial photographs and topographic maps of the United States. The TerraServer web site is easy to navigate by selecting a location on a map or entering the name of a place, and is designed to work with common computer systems and web browsers over slow speed communications links.

Digital Mapping Resources

The Wisconsin Land Information Clearinghouse **(http://wisclinc.state.wi.us/)** is an Internet gateway to geospatial data, land, and reference information, and the Wisconsin agencies that produce or maintain these items.

Links are provided for the following themes:

- Internet map services (on-line maps built in a web browser)
- Political and administrative boundaries
- Image and base maps
- TIGER and line data (maps from the U.S. Census Bureau)
- Water and hydrography
- Infrastructure
- Natural resources and environment
- Soils and geology

Two federal mapping resources link users to extensive libraries of mapping data from agencies around the country:

- The **U.S. Geological Survey (USGS)** is responsible for building, maintaining, and applying The National Map **(http://nationalmap.usgs.gov/)**. It provides public access to high-quality geospatial data and information from multiple partners. You can view The National Map by using your web browser (no special software or download required).
- **Geodata.gov (www.geodata.gov/)** is a web-based portal for one-stop access to maps, data and other geospatial services. The web site helps to simplify information so everyone can easily find geospatial data, as well as learn more about geospatial projects underway.

Wisconsin Wetland Inventory Maps

Wisconsin Department of Natural Resources
Bureau of Fisheries Management and Habitat Protection
FH/3, PO Box 7921
Madison, WI 53707-7921
Phone 608-266-8852

Topographic Maps

U.S. GEOLOGICAL SURVEY

The United States Geological Survey (USGS) provides science for a changing world by delivering reliable and impartial information that describes the Earth, its natural processes, and its natural species. This information is used to manage water, biological, energy, and mineral resources, and to enhance and protect our quality of life. The USGS works with every state in the country, cooperating with more than 2,000 organizations to provide information for resource managers in the public and private sectors.
Phone 1-800-USA-MAPS
http://mapping.usgs.gov

LOCAL RETAILERS

Topographic maps are available in a number of retail locations throughout the state, including local sporting goods stores, outfitters, bookstores, and engineering supply stores (check the Yellow Pages under "Maps").

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY (WGNHS)

The WGNHS, a part of the University of Wisconsin Extension, is an interdisciplinary organization that conducts natural resources surveys and research to produce information used for decision-making, problem-solving, planning, management, development, and education. For more information, contact:

Wisconsin Geological and Natural History Survey
3817 Mineral Point Road
Madison, WI 53705-5100
Map Sales 608-263-7389
Information 608-262-1705

LOCAL LIBRARIES

Check with your local library for the availability of maps.

Soil Surveys, Soil Interpretations, and Erosion Control

WISCONSIN NATURAL RESOURCES CONSERVATION SERVICE (NRCS)

Published soil survey reports for most Wisconsin counties are available through your local NRCS or county Land Conservation Department offices. Soil survey reports include:

- Detailed soil maps on an aerial photo background
- Soil use and management information
- Descriptions of the soils
- Soil property and interpretation information in table format

More information about soil survey reports is available at: **www.wi.nrcs.usda.gov/soil/soilsurvey.asp**

SOILS LAB ANALYSIS

University of Wisconsin Soil and Plant Analysis Labs are located in Madison and Marshfield. Contact **http://uwlab.soils.wisc.edu/** for a fee schedule.

FINANCIAL INCENTIVE PROGRAMS

Wisconsin offers landowners two important categories of financial incentives to help reduce the expenses of owning and caring for woodlands:

- State forest tax laws that help reduce property taxes.
- Cost-sharing programs that are available from both state and federal sources, which reimburse landowners for allowable conservation project expenses.

Forest Tax Programs

Statewide, approximately 2,600,000 acres are enrolled in the forest tax programs. About 30,000 landowners participate. The Managed Forest Law (MFL) is open to enrollment of tracts of land ten acres and larger in size. The application forms are available from your local DNR forester or the DNR web site.

Under the MFL, landowners select a 25- or 50-year contract period. They receive a forestry plan covering mandatory and recommended practices for the chosen time period. The incentive for following the plan and complying with other forest tax program requirements is a significant reduction in property taxes. Currently, participating landowners pay a base "acreage share" tax of $.83 per acre. People who elect to close their land to public access pay an additional $1.12 per acre. The total acreage share and closed area tax is $1.95 per acre (whereas general property taxes on forestland not in MFL can be $25 or more per acre). MFL rates are adjusted by formula every five years. The next adjustment is scheduled for 2007, unless statute revisions are enacted before then.

The Forest Crop Law (FCL), now closed to enrollment, was an earlier forest tax incentive program. If you are buying forestland, you might come across FCL land. Provisions are similar to MFL, although there are differences. See your local DNR forester for details.

Cost-sharing Programs

The Wisconsin Landowner Grant Program provides $1,250,000 annually for stewardship practices on private land. A wide array of practices is eligible for cost-sharing including management plan development, wetland restoration, tree planting, forest improvement, and prairie restoration. A portion of the eligible costs can be refunded to you upon completion of the work. Landowner Grant applications are accepted continuously and approved on a first-come, first-serve basis. Contact your local DNR forester for details.

The DNR foresters also help landowners with the following federal cost-sharing programs:

- Conservation Reserve Program (CRP)
- Environmental Quality Incentives Program (EQUIP)
- Forest Land Enhancement Program (FLEP)
- Wildlife Habitat Incentives Program (WHIP)

Wisconsin Department of Natural Resources
Division of Forestry
PO Box 7921
Madison, WI 53707
Phone 608-267-7495

More information is available from the DNR Internet site: www.dnr.state.wi.us/org/land/forestry/

FISH AND WILDLIFE HABITAT, WETLAND PROTECTION

The Department of Natural Resources (DNR) and other agencies and organizations can help you manage and restore fish and wildlife habitat, and protect wetlands. DNR offices can also provide current listings of designated trout streams (and their tributaries) and designated trout lakes.

DNR WILDLIFE BIOLOGIST STATE-WIDE CONTACTS

Northeast Region

Green Bay 920-492-5800
Oshkosh 920-424-3050
Peshtigo 715-582-5000
Sturgeon Bay 920-746-2860

Northern Region

Antigo 715-627-4317
Cumberland 715-822-3590
Park Falls 715-762-3204
Rhinelander 715-365-8900
Spooner 715-635-2101
Superior 715-392-7988
Woodruff 715-356-5211

South Central Region

Dodgeville 608-935-3368
Horicon 920-387-7860
Janesville 608-743-4800
Madison 608-275-3266
Poynette 608-635-8110

Southeast Region

Hartford (Pike Lake) 262-670-3400
Kettle Moraine State Forest (North) 262-626-2116
Kettle Moraine State Forest (South) 262-594-6200
Milwaukee 414-263-8500
Plymouth 920-892-8756
Sturtevant 262-884-2300

West Central Region

Baldwin 715-684-2914
Black River Falls 715-284-1400
Eau Claire 715-839-3700
La Crosse 608-785-9000
Wausau 715-359-4522
Wisconsin Rapids 715-421-7800

ARMY CORPS OF ENGINEERS

Regulation Branch, St. Paul District
190 Fifth Street East, St. Paul, MN 55101-1638
www.mvp.usace.army.mil/

NATURAL RESOURCES CONSERVATION SERVICE

United States Department of Agriculture, Natural Resources Conservation Service
6515 Watts Road, Suite 200, Madison, WI 53719
Phone 608-264-5341
www.wi.nrcs.usda.gov/news/

U.S. DEPARTMENT OF AGRICULTURE'S CONSERVATION RESERVE PROGRAM

USDA, Farm Service Agency
6515 Watts Road, Suite 100, Madison, WI 53719
Phone 608-276-8732
www.fsa.usda.gov/wi/news/

U.S. FISH AND WILDLIFE SERVICE

Region 3: Great Lakes-Big Rivers
Federal Building
1 Federal Drive, Fort Snelling, MN 55111-4056
http://midwest.fws.gov/

Partners for Fish and Wildlife
4511 Helgesen Drive, Madison, WI 53718-6747
Phone 608-221-1206

WISCONSIN WATERFOWL ASSOCIATION

614 West Capitol Drive, Hartland, WI 53029
Phone 262-369-6309
www.wisducks.org/

FOREST HEALTH

Contact a DNR forest health specialist, pest specialist, forest entomologist, or forest pathologist.

FOREST ENTOMOLOGIST

Department of Natural Resources
810 West Maple, Spooner, WI 54801
Phone 715-635-4156

Department of Natural Resources
2300 North Martin Luther King, Jr. Drive
PO Box 12436, Milwaukee, WI 53212
Phone 414-263-8744

FOREST HEALTH SPECIALIST

Department of Natural Resources
1125 North Military Road, Green Bay, WI 54307

FOREST PATHOLOGIST

Department of Natural Resources
3911 Fish Hatchery Road, Fitchburg, WI 53711
Phone 608-275-3273

FOREST PEST SPECIALIST

Department of Natural Resources
107 Sutliff Avenue, Rhinelander, WI 54501
Phone 715-365-8934

Department of Natural Resources
1300 West Clairemont Avenue
PO Box 4001, Eau Claire, WI 54702
Phone 715-839-1632

INSECT AND DISEASE IDENTIFICATION

University of Wisconsin Plant Disease Diagnostic Clinic
www.plantpath.wisc.edu/pddc/index/htm

University of Wisconsin Pest Diagnosis Lab
www.entomology.wisc.edu/entodiag.html

PESTICIDE APPLICATOR TRAINING AND LICENSING FOR STATE CERTIFICATION

University of Wisconsin-Madison
Department of Agronomy
Pesticide Applicator Training
1575 Linden Drive, Madison, WI 53706-1597
Phone 608-262-7588

NOTIFICATION OF PESTICIDE SPILLS: REPORT ALL SPILLS TO THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES

24-hour Emergency Hotline Number 1-800-943-0003; when answered, press “1” for spills.

NUISANCE ANIMAL CONTROL

Wisconsin Cooperative Nuisance Wildlife Program
USDA Wildlife Services
1-800-433-0688

NON-NATIVE INVASIVE SPECIES

Non-native invasive species can be a serious concern for forest regeneration and growth, as well as impacting wildlife habitat and recreation. The following sources can provide information about non-native invasive species:

Wisconsin DNR, Bureau of Endangered Resources
www.dnr.state.wi.us/org/land/er/invasive/

Invasive Plants Association of Wisconsin
www.uwex.edu/ces/ipaw/index.htm

Wildland Invasive Species Team, The Nature Conservancy
http://tncweeds.ucdavis.edu/

Plant Conservation Alliance, Weeds Gone Wild
www.nps.gov/plants/alien/

WATER CROSSINGS

PERMIT REQUIREMENTS AND DESIGN STANDARDS; INSTALLATION OF BRIDGES AND CULVERTS, CONTACT:

The nearest DNR Water Management Specialist. The DNR Internet site has complete information about waterway and wetland permits:
www.dnr.state.wi.us/org/water/fhp/waterway/

FOR DESIGN ASSISTANCE, CONTACT:

Natural Resources Conservation Service (NRCS)
Wisconsin State Office
6515 Watts Road, Suite 200
Madison, WI 53719-2726
Phone 608-264-5341
www.wi.nrcs.usda.gov/news/

PRESCRIBED BURNING

BURNING PERMITS

On lands under DNR protection, contact local DNR Service Centers, Ranger Stations, and DNR Emergency Fire Wardens. On lands under USFS protection, contact USFS District Ranger Stations or USFS Fire Wardens. On lands outside of DNR or USFS protection, permits might be required from the local township (see government listings in your local telephone directories).

FIRE WEATHER

Current fire weather forecasts, fire danger ratings, and burning permit regulations are available via links on the DNR web site (navigate to the fire pages):
www.dnr.state.wi.us/org/land/forestry/

BURNING ASSISTANCE

If you need help conducting prescribed fires, see the *Directory of Foresters* for the names of consultants that offer prescribed burning services.

ENDANGERED, THREATENED OR SPECIAL CONCERN SPECIES

FEDERAL INTERNET SITE

http://endangered.fws.gov/wildlife.html

U.S. FISH AND WILDLIFE SERVICE DIVISION OF ENDANGERED SPECIES

BHW Federal Building, 1 Federal Drive, Fort Snelling, MN 55111-4056
Phone 612-713-5360

WISCONSIN DEPARTMENT OF NATURAL RESOURCES (DNR), BUREAU OF ENDANGERED RESOURCES

101 South Webster Street, Madison, WI 53707-7921
Phone 608-266-7012

WISCONSIN INTERNET SITE

www.dnr.state.wi.us/org/land/er/

PESTICIDE USE

FOR INFORMATION ON HEALTH EFFECTS OF PESTICIDES; PESTICIDE POISONING SYMPTOMS; OSHA'S STANDARDS

Department of Health and Family Services
Section of Environmental Health or Section of Occupational Health
1 West Wilson Street
PO Box 309
Madison, WI 53701-0309
Phone 608-266-0923

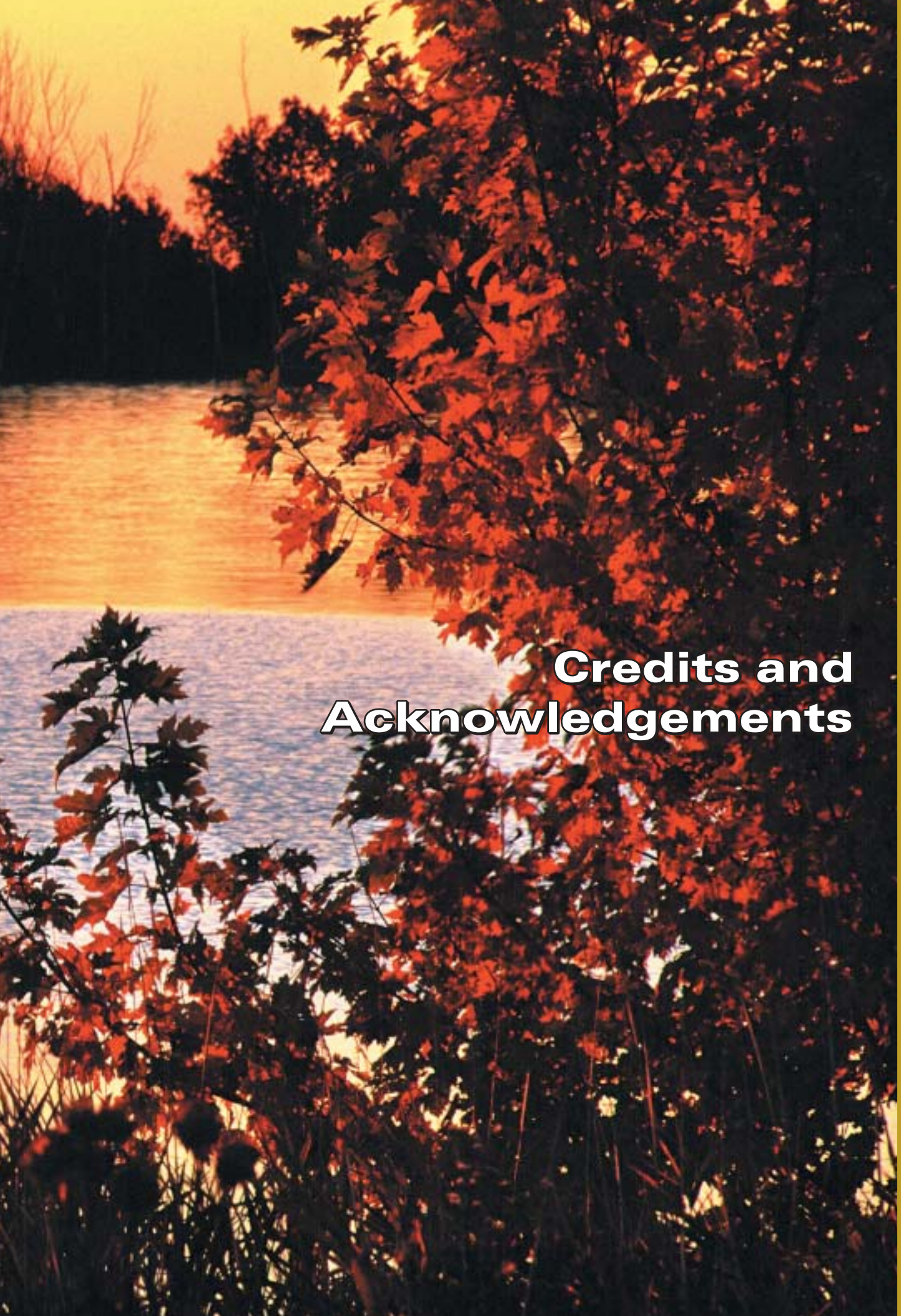
FOR INFORMATION ON PLASTIC CONTAINER RECYCLING PROGRAM

Wisconsin Fertilizer & Chemical Association
2317 International Lane
Suite 115
Madison, WI 53704
Phone 608-249-4070

FOR QUESTIONS REGARDING PESTICIDE USE AND REGULATIONS; PESTICIDE APPLICATOR CERTIFICATION AND LICENSING; PESTICIDE CLEAN SWEEP; WORKER PROTECTION STANDARDS; PERMITS FOR CONTROLLING RATS AND MICE

WDATCP, Agriculture Resource Management Division
2811 Agriculture Drive
PO Box 8911
Madison, WI 53708-8911
Phone 608-224-4500

ADDITIONAL RESOURCES I HAVE FOUND...



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and
MIKE PHILLIPS

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Reproduction of this guidebook is encouraged.
Any modifications, however, must first be approved by the
WISCONSIN DEPARTMENT OF NATURAL RESOURCES - DIVISION OF FORESTRY.

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CHAPTER 1

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CHAPTER 2

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Figure 2-5: Kotar, page 13
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Figure 2-7: DNR Photo by Jeff Martin
Figure 2-8: DNR Photo by Jeff Martin
Figure 2-9: Computer-generated simulation by Andy Stoltman
Figure 2-10: Computer-generated simulation by Andy Stoltman
Figure 2-11: Computer-generated simulation by Andy Stoltman
Figure 2-12: DNR Photo by Jeff Martin
Figure 2-13: Computer-generated simulation by Andy Stoltman
Figure 2-14: Computer-generated simulation by Andy Stoltman
Figure 2-15: DNR Photo by Jeff Martin
Figure 2-16: Computer-generated simulation by Andy Stoltman
Figure 2-17: Computer-generated simulation by Andy Stoltman
Figure 2-18: Computer-generated simulation by Andy Stoltman
Figure 2-19: Computer-generated simulation by Andy Stoltman
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Figure 2-26: DNR Photo by Jeff Martin
Figure 2-27: Computer-generated simulation by Andy Stoltman
Figure 2-28: Computer-generated simulation by Andy Stoltman
Figure 2-29: DNR Photo by Jeff Martin
Figure 2-30: DNR Photo by Jeff Martin
Figure 2-31: DNR Photo by Jeff Martin
Figure 2-32: Computer-generated simulation by Andy Stoltman
Figure 2-33: Computer-generated simulation by Andy Stoltman
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CHAPTER 3

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Figure 3-1: DNR Photo by Jeff Martin
Figure 3-2: DNR Photo by Jeff Martin
Figure 3-3: DNR Photo by Jeff Martin
Figure 3-4: DNR Photo by Jeff Martin
Figure 3-5: DNR Photo by Jeff Martin
Figure 3-6: DNR Photo by Jeff Martin
Figure 3-7: DNR Photo by Jeff Martin
Figure 3-8: DNR Photo by Jeff Martin
Figure 3-9: DNR Photo by Jeff Martin
Figure 3-10: DNR Photo by Mike McDowell
Figure 3-11: DNR Photo by Jeff Martin
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Figure 4-6: DNR Photo by Jeff Martin
Figure 4-7: DNR Photo by Jeff Martin
Figure 4-8: DNR Photo by Jeff Martin
Figure 4-9: DNR Photo by Jeff Martin
Figure 4-10: DNR Photo by Jeff Martin
Figure 4-11: DNR Photo by Jeff Martin
Figure 4-12: DNR Photo by Jeff Martin
Figure 4-13: DNR Photo by Jeff Martin
Figure 4-14: DNR Photo by Jeff Martin
Figure 4-15: DNR Photo by Jeff Martin

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Figure 5-1: Adapted from Figure RMZ-1, pg. 4, Riparian Areas, *Voluntary Site-level Forest Management Guidelines: Sustaining Minnesota Forest Resources*

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Figure 5-8: DNR Photo by Jeff Martin

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Figure 5-10: pg. 15, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 5-11: Adapted from Minnesota Department of Natural Resources, 1989

Figure 5-12: pg. 19, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 5-13: DNR Photo by Jeff Martin

CHAPTER 6

Background: DNR Photo by Jeff Martin

Figure 6-1: DNR Photo by Jeff Martin

Figure 6-2: Wisconsin DNR Archive Photo

Figure 6-3: Wisconsin DNR Archive Photo

Figure 6-4: Wisconsin DNR Archive Photo

CHAPTER 7

Background: DNR Photo by Jeff Martin

Figure 7-1: DNR Photo by Jeff Martin

Figure 7-2: Adapted from Froehlich et al, 1980

Figure 7-3: DNR Photo by Paul Pingrey

Figure 7-4: DNR Photo by Paul Pingrey

Figure 7-5: DNR Photo by Paul Pingrey

Figure 7-6: DNR Photo by Eunice Padley

Figure 7-7: Adapted from Figure S-2, pg. 17, Forest Soil Productivity, *Voluntary Site-level Forest Management Guidelines: Sustaining Minnesota Forest Resources*

Figure 7-8: DNR Photo by Jeff Martin

Figure 7-9: DNR Photo by Jeff Martin

Figure 7-10: DNR Photo by Jeff Martin

Figure 7-11: DNR Photo by Jeff Martin

CHAPTER 8

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Figure 8-4: Erdmann and Oberg, 1977

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Figure 8-13: DNR Photo by Jeff Martin

Figure 8-14: DNR Photo by Jeff Martin

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Figure 8-16: DNR Photo by Jeff Martin

CHAPTER 9

Background: DNR Photo by Jeff Martin

Figure 9-1: DNR Photo by Jeff Martin

Figure 9-2: DNR Photo by Jeff Martin

Figure 9-3: DNR Photo by Jeff Martin

Figure 9-4: DNR Photo by Jeff Martin

Figure 9-5: Adapted from Kotar, page 14

Figure 9-6: DNR Photo by Jeff Martin

CHAPTER 10

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Figure 10-1: University of Wisconsin-Kemp Station

Figure 10-2: DNR Photo by Jeff Martin

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Figure 10-4: DNR Photo by Jeff Martin

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CHAPTER 11

Background: DNR Photo by Jeff Martin

Figure 11-1: DNR Photo by Jeff Martin

Figure 11-2: pg. 22, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 11-3: pg. 23, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 11-4: DNR Photo by Jeff Martin

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Figure 11-6: pg. 24, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 11-7: DNR Photo by Jeff Martin

Figure 11-8: pg. 26, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 11-9: pg. 26, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 11-10: pg. 27, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 11-11: Wisconsin DNR Archive Photo

Figure 11-12: Wisconsin DNR Archive Photo

Figure 11-13: Wisconsin DNR Archive Photo

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Figure 11-17: pg. 28, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 11-18: DNR Photo by Jeff Martin

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Figure 11-21: pg. 30, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 11-22: pg. 31, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 11-23: pg. 32, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 11-24: pg. 33, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 11-25: DNR Photo by Jeff Martin

Figure 11-26: pg. 36, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 11-27: pg. 35, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 11-28: pg. 36, *Wisconsin's Forestry Best Management Practices for Water Quality*

Figure 11-29: Wisconsin DNR Archive Photo

CHAPTER 12
Background: DNR Photo by Jeff Martin
Figure 12-1: DNR Photo by Jeff Martin
Figure 12-2: DNR Photo by Jeff Martin
Figure 12-3: DNR Photo by Jeff Martin
Figure 12-4: DNR Photo by Jeff Martin
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CHAPTER 13
Background: DNR Photo by Jeff Martin
Figure 13-1: University of Wisconsin-Kemp Station
Figure 13-2: University of Wisconsin-Kemp Station
Figure 13-3: University of Wisconsin-Kemp Station
Figure 13-4: DNR Photo by Jeff Martin
Figure 13-5: DNR Photo by Jeff Martin
Figure 13-6: University of Wisconsin-Kemp Station
Figure 13-7: DNR Photo by Jeff Martin
Figure 13-8: DNR Photo by Jeff Martin

CHAPTER 14
Background: DNR Photo by Jeff Martin
Figure 14-1: DNR Photo by Jeff Martin
Figure 14-2: DNR Photo by Jeff Martin
Figure 14-3: DNR Photo by Jeff Martin
Figure 14-4: DNR Photo by Jeff Martin
Figure 14-5: DNR Photo by Jeff Martin
Figure 14-6: DNR Photo by Jeff Martin

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Figure 15-9: DNR Photo by Greg Edge
Figure 15-10: DNR Photo by Jeff Martin
Figure 15-11: DNR Photo by Jeff Martin
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Figure 15-13: DNR Photo by Paul Pingrey
Figure 15-14: DNR Photo by Jolene Ackerman

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Background: DNR Photo by Jeff Martin
Figure 16-1: DNR Photo by Jeff Martin
Figure 16-2: DNR Photo by Jeff Martin
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Figure 16-16: DNR Photo by Jeff Martin
Figure 16-17: DNR Photo by Jeff Martin

CHAPTER 17
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Figure 17-1: DNR Photo by Chris Klahn
Figure 17-2: DNR Photo by Jeff Martin
Figure 17-3: DNR Photo by Catherine Regan
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Figure 17-5: Provided by JLB Design, LLC
Figure 17-6: Provided by JLB Design, LLC
Figure 17-7: Provided by JLB Design, LLC
Figure 17-8: Provided by JLB Design, LLC
Figure 17-9: DNR Photo by Jeff Martin
Figure 17-10: DNR Photo by Jeff Martin
Figure 17-11: DNR Photo by Jeff Martin
Figure 17-12: DNR Photo by Chris Klahn
Figure 17-13: DNR Photo by Chris Klahn
Figure 17-14: DNR Photo by Jeff Martin
Figure 17-15: DNR Photo by Jeff Martin
Figure 17-16: DNR Photo by Jeff Martin
Figure 17-17: DNR Photo by Jeff Martin
Figure 17-18: DNR Photo by Jeff Martin

CHAPTER 18
Background: DNR Photo by Jeff Martin
Figure 18-1: DNR Photo by Jeff Martin
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