Guidelines for Red Pine Management

based on

Ecosystem Management Principles

for

State Forestland in Michigan

Prepared by the

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

NORTHERN LOWER MICHIGAN ECOTEAM

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The Mission of the Northern Lower Michigan Eco-Unit Team is to plan and coordinate management of the natural resources of Michigan's Northern Lower Peninsula through the use of ecosystem management principles.

TABLE OF CONTENTS

Preface 3
Executive Summary 4
Background 6
Statement of the Problem 8
Characterizing the Red Pine Resource 10
Ecological Suitability 11
Forest Habitat Type Classification 11
Landscape Management Units (LMUs) 14
Ecological Characteristics 15
Past Condition 15
Present Condition 17
Wildlife: Effects and a Desired Future Condition 17
Forest Health: Effects and a Desired Future Condition 20
Fisheries Considerations 22
Economic Characteristics 22
Social Characteristics 24
Future Red Pine Management: Balancing Biologic, Social and Economic Factors 25
Red Pine Forest Type Management Guidelines/Opportunities 28
Management Recommendations/Guidelines/Opportunities 29
Red Pine Type Guidelines 32
Guideline Implementation 40
Red Pine Guidelines – Ecologic, Economic and Social Trade-Offs 41
Decision Support System/Guideline Use 42
Monitoring and Feedback Loop 44
Communications Plan 45
Phase I: MDNR Staff 45
Phase II: Various Interest Groups/Other State and Federal Governments 46
Phase III: General Public 47
Appendix 48
Glossary of Terms 52
References 55

PREFACE

Achieving sustainability in our natural environment, our economy and our communities requires rethinking customary approaches to managing complex and interrelated natural resources. The fragmented and compartmentalized approaches of the past are giving way to more integrated and comprehensive strategies. Sustainability of our natural resources using ecosystem management principles is a continuing endeavor by the Michigan Department of Natural Resources. Sustainability assures the viability of biological communities and their economic vitality by protecting and maintaining the natural environment upon which people and economies depend.

Pressed by the urgent need to address the skewed age class structure of the red pine forest type, the State Forest Red Pine Type Management Project is the first broad-based effort toward the management of a forest type in a long-term sustainable manner for the State Forest system.

During the duration of this project, the Northern Lower Peninsula Ecoteam was chaired by Glen Matthews then by Penney Melchoir, Michigan DNR District Wildlife Supervisors. The Red Pine Management Project team consisted of James Bielecki (FMFMD), Robert Doepker (WLD), Frank Krist (Space Imaging Services), Larry Pedersen (FMFMD), and John Pilon (FMFMD).

Providing valuable input into the project were the following: Keith Kintigh, Lauri Marzolo, Don Kuhr, Lee Evison, Roger Hoeksema, Larry Visser, Roger Mech, Ron Murray, Matt Tonello, Mike Mang, Rex Ainslie, Joyce Angel-Ling, Dean Reid, Andy Nuhfer, Mike Walters, MSU, Joe Gates, Huron-Manistee National Forest, Al Saberniak, Hiawatha National Forest, Rich Corner, Huron Manistee National Forest, and Phyllis Higman, MNFI.

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EXECUTIVE SUMMARY

Much of Michigan's red pine resource is the result of an extensive planting program by the Civilian Conservation Corps (CCC) in the 1930s and the State of Michigan in the 1950s and 1960s. The objective was to get abandoned farm land and stump fields left from the early logging days back into forest production and to control soil erosion. By the mid-1960s, much of the available open land had been reforested. The plantings resulted in much of the current red pine resource being in single species plantations and on some sites that may be less suited for red pine than for other species. Never the less, these plantations had the secondary effect of nursing the reestablishment of deciduous forest communities on the richer and moister sites while providing significant economic returns and aesthetic value.

Significant industrial use of the red pine resource started in the early 1980s with the construction of mills designed to use mid-sized logs. Industrial demand was met through a series of thinnings, leaving trees that now have larger diameters. Contrary to the usual convention that trees get more valuable as they get larger, that is not the current case for red pine. When the logs achieve large saw log size (about twenty inches or so in diameter), they are not suitable for utility poles and they are less suited to be processed through the types of sawmills that have been built to efficiently process the mid-sized logs.

Since most of the open land was planted by the 1960s and there weren't many stands that were clear cut since then, planting of red pine has been at a very low level resulting in an uneven age-class structure for this forest type (Figure 1). Continuing to thin the red pine stands instead of final harvesting all the trees for replacement, the red pine resource will shrink as the stands move into old growth and start succeeding to other species.

In order to maintain the current red pine resource on red pine sites, it is urgent to start liquidating the 60 – 80 age class stands and replant them back to red pine. Because of this urgency, it is recommended that forest managers prescribe stand replacement harvests on about half of the 60 – 80 year old stands over the next ten to twenty years. On sites better suited for other species, there are some stands that should be liquidated and converted away from red pine or to some mixture. Consideration should also be given to liquidation of some of the many of the 40 – 50 age class stands, especially where the trees are such that they aren't expected to ever achieve utility pole quality. The overall goal is to eventually spread out the age classes of the red pine resource to assure continuation of the red pine type.

Although most of the state's red pine type is of plantation origin, Michigan also has red pine stands that originated naturally as a result of fires during the logging era, 80 to 120 years ago. Due to the absence of fire, many of these areas are beginning to convert to deciduous forest types.

There is a fundamental conflict between increasing red pine timber values and promoting biodiversity. The highest timber values are achieved through pure, densely-stocked stands that have uniform age and size (plantations). High stocking density fosters height growth and minimizes knots and defects from branching, but it reduces diversity of flora and fauna in the stand. This is the basic trade off

between timber production and biodiversity values that is encountered at several scales, from the stand level through the entire State Forest system.

While this extensive planting has resulted in large areas of red pine type in certain age classes, the overall red pine type has declined significantly across Michigan since European settlement began. With the confluence of the current red pine type's maturity, its skewed age-class structure, its location on varied habitat types, and its uncertain economic future all needing to be considered, guidelines for the management of red pine as part of a forest community were developed and are presented in this report. These guidelines give resource managers greater flexibility when managing red pine. Some of the guidelines enable them to manage red pine in a non-plantation setting on sites ecologically suited for red pine forest communities. Other guidelines point to plantation management which could still occur in some regions and areas to encourage economic sustainability. The guidelines are intended as a guide to help in decision making. Forest managers may have a good reason to not follow the guidelines, but, in doing so, are still making a more informed decision.

The Michigan DNR lacks a long range planning framework from which to address difference spatial and organizational scales. But, the guidelines presented in this report do outline a holistic forest community-based approach that enables staff to examine the past, present, and potential future context of the resource prior to making stand level decisions. In addition, the guidelines are constructed around the ecological context of red pine and its associated forest and non-forest communities. The economic and social measures that also reflect the mission of the Michigan Department of Natural Resources must be considered as well when making those decisions. To ensure that the guidelines are developed within the context of ecosystem management, a multi-criterion model was used to help set priorities and thus balance biological, social, and economic values. A process for institutionalizing and implementation of these guidelines, and a monitoring and feedback loop enabling further guideline development, is also presented in this report.

As part of guideline development, a web-based Decision Support System (DSS) has been constructed (http://www.mcgi.state.mi.us/forestHabitatTypes). The DSS, an intuitive system that can be easily used by decision-makers at all levels, provides resource managers with a set of tools that allow them to efficiently assess and implement red pine management at the stand and landscape level using a forest habitat type classification system developed for northern Michigan. With the availability of over half the State Forest compartment maps in digital form, the development of a process at the stand level, up through the Forest Management Unit (FMU) level, and across landscapes, enables the formation of goal-setting and monitoring of management actions. In addition, with the roll out of the Integrated Forest Monitoring and Prescription system (IFMAP), the guidelines and tools developed for this project will be made accessible through a desktop computer and the DSS will be used primarily for communication with interest groups and the public.

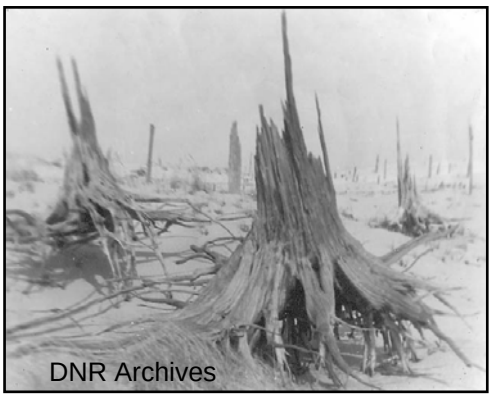
Initial training and roll out of the red pine guidelines began in August 2003 at the forest habitat type training. Staff was introduced to the red pine guidelines as an example of the use of the forest habitat type system.

Although several forest communities are examined in this report, the red pine project by itself does not address the management of all other forest types. Analyzing other forest and non-forest communities should be undertaken in a systematic manner, using the guidelines and this report as a template, moving the DNR closer to the development of holistic management guidelines for all State Forest land communities. Because this project can be used as a template and many of the results are generally applicable to the assessment of other biological communities (barrens, northern hardwoods, etc.) the development of future guidelines should be streamlined.

Throughout this report, assessment and discussion generally is limited to State of Michigan lands in the Northern Lower Peninsula (NLP) although guidelines are also written to accommodate resource managers in the Eastern Upper Michigan (EUP).

BACKGROUND

With the depletion of timber from New England and other regions in the Northeast during the mid 19th century, logging activities moved westward into the Great Lakes region (Franzen 1999). By the 1860s and until the turn of the century, Michigan led the nation in lumber production yielding over 162 billion board feet of white pine. By 1900 nearly all of the state's virgin timber was gone. Concern was not great when the pine forests ran out and the loggers moved west. Because many towns in southern Michigan were being successfully farmed after logging had cleared the land, many expected the same for northern Michigan. But northern Michigan was different. Settlers who tried to farm the droughty, frosty northern Michigan sandy soils eventually coalesced to the relatively few better sites. Millions of acres of northern Michigan reverted back to the public domain after being stripped of timber, burned over, and after failed attempts at farming (Titus 1945).



Societal attitudes and economic incentives slowly began to shift around 1900. It was realized that treating the land as a disposable commodity helped neither the state nor the land. Many proponents claimed those "worthless" northern cut over lands could indeed be productive, not for agriculture but for forestry. The Michigan legislature got the message and by establishing the State Forestry Commission in 1902, which later became the Michigan Conservation Department in 1921 and the Michigan Department of Natural Resources in 1968. It signaled that Michigan had ceased viewing the possession of its public domain as temporary and embarked on a policy of permanent ownership and use of the land.

The Conservation Department, using a survey of the potentials of wild land areas, developed innovative land use programs which coincided with the USDA's Land Use Planning Program which was a new planning procedure using county committees to make local judgment on how the land should be used. This was the beginning of informed and intelligent public input into the planning process which led to extensive reforestation.

In order to reforest much of the cut over lands, the Civilian Conservation Corps (CCC) established pine plantations across upper Michigan during the 1930s. The Michigan Department of Conservation continued the planting program in the late 1950s and early 1960s. Red pine was commonly planted due to its uniformity, wood properties, relative freedom from insect and disease pests, and aesthetic properties. These attributes continue to contribute to the high demand for this wood species. Red pine is a desirable species from its beginnings in the nursery through its many end uses. Red pine is the only species used to produce utility poles in our region. It's the best species for preservative treatments, thus making it more valuable for the utility pole, decking, construction and landscaping industries. Plantations of red pine also provided soil stability and wildlife habitat. In addition, these plantations have played an important role in allowing northern hardwood forest communities to reestablish themselves on previously deforested areas by providing shade for young seedlings.

Historically, red pine occupied a wide range of sites across northern Michigan. On these sites, widespread logging during the 19th and early 20th century greatly reduced the amount of red pine, along with other conifers, which subsequently degraded the ecological quality of sites where red pine was a component. In addition, the size and frequency of fires, which played an integral part in the regeneration of red pine, has been greatly reduced since the advent of fire control. Prior to fire control efforts, large scale fires would expose mineral soils, allowing red pine to establish itself while more frequent low-intensity fires would reduce deciduous competition. The lack of these disturbances has reduced the amount of naturally regenerated red pine stands.

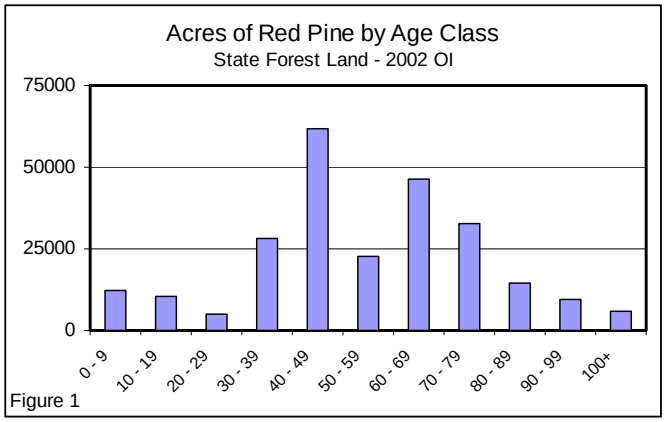


Figure 1

Due to CCC activities and suppression of fire, much of Michigan's existing red pine resource is planted and not of natural origin. Extensive planting during the 1930s and 1950s has resulted in an uneven age-class structure across the red pine forest type (Figure 1). Most of the naturally regenerated

red pine stands are the result of logging-era slash fires and now range in age from 80 to 120 years, putting it past its economic prime based on current markets. The CCC-era red pine has matured into high value log-sized timber. This resource is at an important juncture due to its maturity, age class structure, and stand composition (primarily that of a monoculture). The situation is compounded by financial factors and ecological considerations. Balanced assessment and management of the red pine forest type should include social, economic, and ecological factors in an integrated, holistic framework, rather than in the customary compartmentalized fashion. Such a multifaceted process will develop into procedures that are applicable across the state over time.

The primary goal of this project is the development of State Forest guidelines for the management of the red pine resource. In order to develop these guidelines, the resource was stratified from its ecological, economic and social perspectives reflecting Wildlife (WL) Division and Forest Mineral and Fire Management (FMFM) Division's missions. These guidelines were then developed using a Multi-Objective/Multi-Criteria (MOMC) based Decision Support System (DSS) which is presented in the latter part of this paper where they can be assessed for implementation at the landscape level. What remains is to integrate these processes at the operational level and to monitor management actions. Assessment and discussion focuses on State of Michigan lands in the NLP. Guidelines are also developed for Eastern Upper Michigan (Schmidt et al. 1997)**.**

STATEMENT OF THE PROBLEM

Regeneration of the state's red pine resource has been at a very low rate since the 1960s due to several reasons:

- Continued thinning of pine plantations and the avoidance of stand replacement harvesting and replanting.
- The lack of fires that prepared a seedbed for natural red pine regeneration and prevented succession to deciduous species.
- Management decisions that favored deciduous species.
- Lack of pine markets until the 1980s.

Continuing to manage as we have been for the past forty years will eventually result in the loss of most of the red pine type on state land as the existing trees move into old-growth and eventually succeed to other species.

Much of the state's current red pine resource originated as a result of large planting programs on barren land of all types in the 1930s and the 1950s and 1960s resulting in an age imbalance of large acreages of red pine where there is relatively little red pine older than 80 years and younger than 40 years. Even though the trees planted by the CCCs are mature and moving into a larger and less prized size class, very few acres have been liquidated and regenerated back to red pine, or allowed to convert to other species where red pine is not desirable. The trees planted in the 1950s, while perhaps not at

maximum economic value, should also be subject to consideration for liquidation and regeneration for age class distribution.

The problem of fluctuating harvest levels is compounded by the red pine supply on the two national forests in the study area, the Huron-Manistee and Hiawatha National Forests (Figure 2). The national forests tend to follow a similar pattern, with peaks reflecting planting programs in the 1930s compared to the State Forest acreage with its two peaks, reflecting similar planting programs in the 1930s and then again in late 1950s-early 1960s, with the latter being the larger of the two.

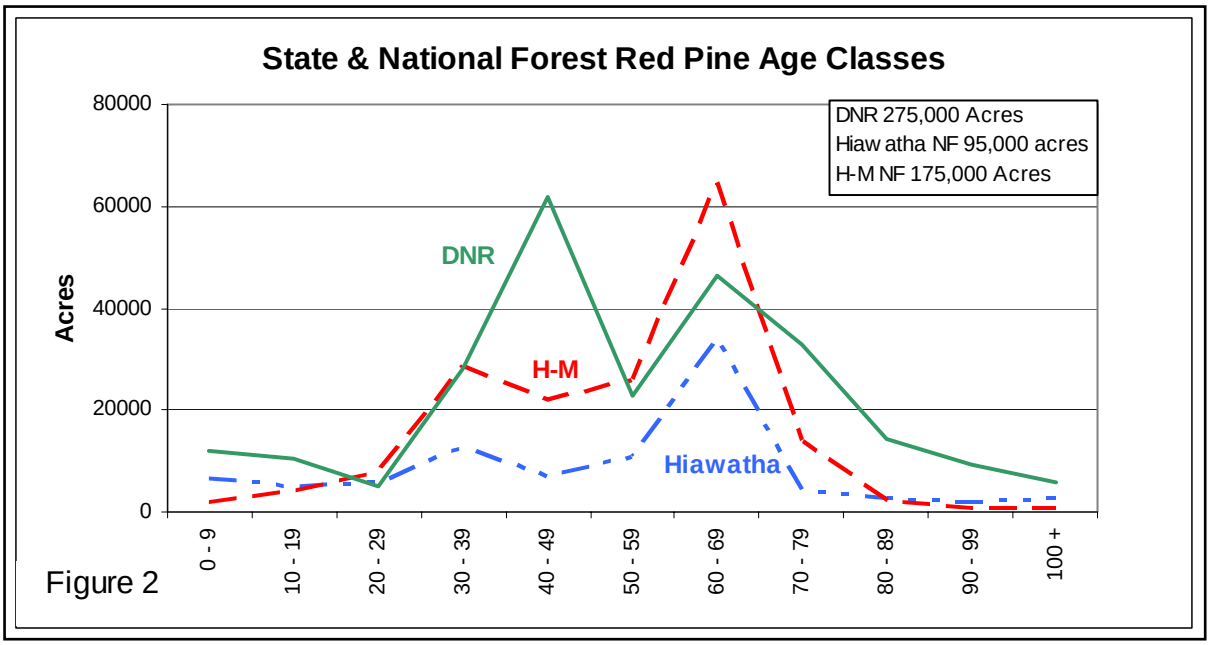


Figure 2

For the state and national forests combined, there are almost 200,000 acres of red pine between the ages of 60 and 80 years old. If the Department of Natural Resources continues to postpone red pine treatments, then such treatments could wind up coinciding with the time period that National Forest final harvest treatments will occur. This, in turn, could create a glut of red pine on the market at a time when timber supply forecasts are predicting falling real prices. Besides resulting in lower red pine prices, to postpone addressing the age class imbalance would likely strain regeneration activities in the future and could affect balanced resource decision making.

Combined, red pine planting programs on the three public forests have ranged between 500 to 1500 acres per year over the past decade. Exact harvest levels for the next two decades have yet to be determined but additional levels of final harvest should not be delayed in order to address the age class disparity and reduce fluctuations of harvest levels over time. Even if less than half of the existing acreage were to be maintained (250,000 acres), using an average regeneration cut age of 80 years, the number of acres that should be planted would exceed 3,000 acres per year (250,000/80) on an even flow basis. To

reduce the enormous age and work imbalance we face in coming decades and to ensure that a sustainable red pine forest community is maintained, even more than this may need to be done.

Red pine age-class information and extrapolations for each Forest Management Unit (FMU) were assembled as part of the workload analysis. This revealed a wide range of workload differences between FMUs this decade versus next, as well as entry year by entry year. For example, the amount of red pine over eighty years of age may be contrasted with each FMU's recent average level of final harvests. In the next decade, the Atlanta FMU will have more than ten times the annual average amount of red pine that it has been final harvesting over eighty years of age whereas the Sault Ste. Marie FMU will have an amount in the over eighty years age-class that is very close to the same as the amount that it has been final harvesting (Figure 3). Regardless, each FMU should analyze it red pine plantations and consider means of spreading age classes primarily by reducing the 60 – 80 year age class by half over the next decade (Appendix).

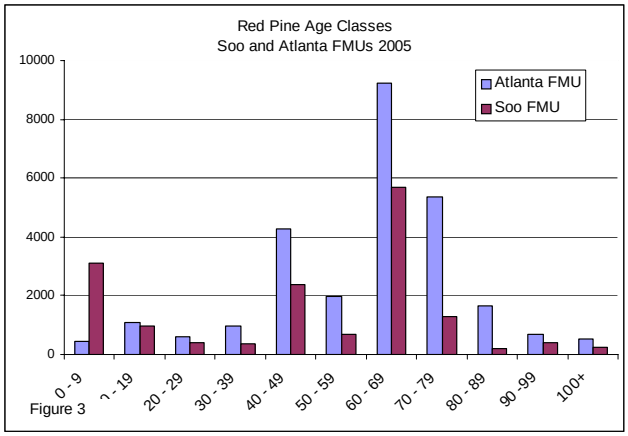


Figure 3

Another major issue with the red pine resource on State Forest lands is the overall lack of naturally regenerated stands on ecologically suitable sites. This is contributing to a decline in several wildlife species and the loss of dry-mesic, dry northern forest, and barrens communities. Although fire can significantly help with the natural regeneration of red pine and is a critical part of natural processes, reestablishing red pine stands is still difficult due to inconsistent seed production. Social constraints, such as those that limit the use of prescribed fire, also make it difficult to manage red pine naturally. As a result, this report explores opportunities to establish red pine in a quasi-natural manner through modified planting techniques including the use of fire where conditions allow.

CHARACTERIZING THE RED PINE RESOURCE

This section examines the past, current, likely future extent of red pine and naturally occurring red pine communities, including attributes (e.g. age-class, stand composition/mix of tree species in red pine types and within other forest types containing red pine), and use of red pine. In addition, alternative harvest and regeneration treatment approaches, including economic, social and ecological implications, are discussed. In order to accomplish this, the habitat suitability, past, present, and likely future extent of the red pine resource in both a natural and plantation setting will be discussed primarily across northern Lower Michigan.

ECOLOGICAL SUITABILITY

Forest Habitat Type Classification

Resource managers have customarily relied on site index, the relationship of tree height to age, as a measure of site quality and species suitability. Accordingly, site index has been used to project growth and yield, stand vigor, quality, and harvest regimes. The accuracy of site index estimates is often uncertain due to the natural variability within stands. Instead of using site index, this project utilizes forest habitat class extrapolation which offers more than site index information and provides a consistent measure for red pine suitability across a large region.

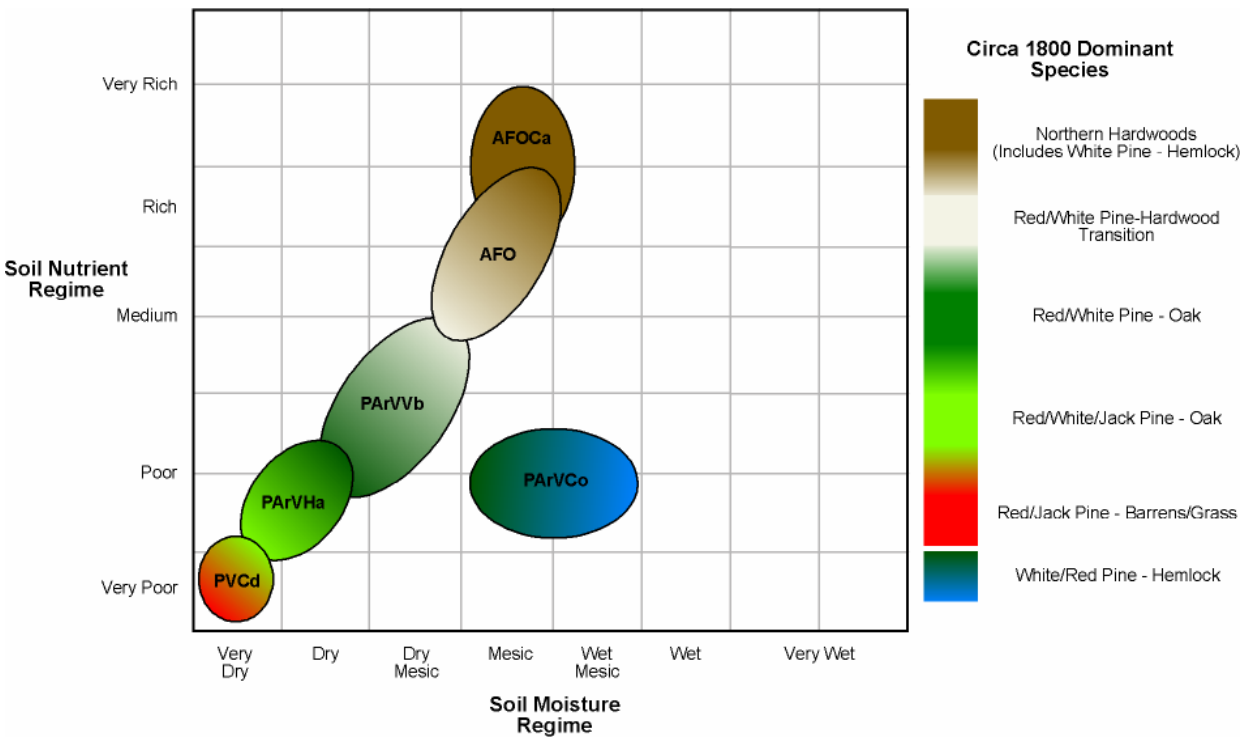


Figure 4: *Relationship of forest habitat types to soil moisture and nutrient regimes in northern Lower Michigan.*

The natural habitat range for growing red pine is determined in this paper primarily through the use of upland forest habitat type classes (Burger and Kotar 2003). In addition, the forest habitat type classes are outlined in the latter part of this report. The forest habitat type classification system is based on the identification of repeatable patterns in the composition of understory vegetation. Regions sharing the same habitat type contain similar ecosystems due to similar soil nutrient and moisture regimes (Figure 4) Habitat types are identified independent of overstory characteristics, which can vary greatly depending on

Habitat Type	Plant Association (Common Names)
PVCd	White Pine/Blueberry-Reindeer Lichen
PArVHa	White Pine-Red Maple/Blueberry-Witch Hazel
PArVVb	White Pine-Red Maple/Blueberry-Maple-Leaved Viburnum
PArVCo	White Pine-Red Maple/Blueberry-Bunchberry
AFO	Sugar Maple-American Beech/Sweet Cicely
AFOCa	Sugar Maple-American Beech/Sweet Cicely-Blue Cohosh
PVE	White Pine/Blueberry-Trailing Arbutus
PArV	White Pine-Red Maple/Blueberry
PArVAa	White Pine-Red Maple/Blueberry-Wild Sarsaparilla
ATFD	Sugar Maple-Hemlock-American Beech/Shield Fern
AFPo	Sugar Maple-American Beech/Hairy Solomon's Seal
AFOAs	Sugar Maple-American Beech/Sweet Cicely-Jack-In-The-Pulpit

Figure 5*: Upland forest habitat type naming convention based on plant names.*

past management and disturbance history of a region. The name of each habitat type is assigned based on the scientific names of plant species commonly found within each type. (Figure 5)

Utilizing a forest habitat type classification system has several advantages. Assessing the potential of a particular site can be accomplished more easily, using only understory plant identification, and often more accurately and consistently than using traditional means such as site index measures. Areas with similar ecological traits can be identified and, therefore, resource managers can make comparisons and assessments about forest community potential using forest habitat types. Forest habitat types provide information about potential tree species occurrence, composition, and successional pathways. Overall, the forest habitat type system is very easy for resource managers to implement and understand, yet provides a wide range of information that can be used to make informed management decisions.

Although forest habitat type identification is typically accomplished by field examination of understory vegetation characteristics within a stand, habitat types can also be inferred based on soil moisture and nutrient regimes found at any particular location. This relationship results from individual habitat types having specific moisture and nutrient requirements (Figures 4 and 6). The presence of high resolution soil type maps for northern Michigan, produced by the USDA Natural Resources Conservation Service (SSURGO Database), provided the opportunity to generate maps, for the NLP and EUP, depicting the spatial extent of each forest habitat type found across the region at a 1:15,840 scale (this four inch to the mile scale is the same as that used by the MDNR for compartment and stand level mapping). Within a Geographic Information System (GIS), soil maps were overlaid on the original plot network set up by Kotar and Burger across northern Michigan, identifying the forest habitat class or range of classes that occur on a particular soil type. One example is Grayling sand which supports the PVCd (NLP) and PVE (EUP) habitat types. Additional fieldwork was conducted where plot data was limited to further refine the accuracy of the maps.

To narrow the range in forest habitat types found on some soils, soil maps were intersected/stratified with a fire disturbance (fire frequency) history (MacLean and Cleland 2003), and minimum annual

temperature (PRISIM) maps within a GIS. These two maps, in particular the fire disturbance layer, provided the most consistent explanation for minor variations in forest habitat types exhibited by some soils. Also, because individual forest habitat types can overlap on the soil nutrient and moisture gradient, a soil type can fall between two habitat types despite the use of other data layers as stratifiers. These "transitional" soil types may have characteristics of two habitat types or fall into the top or bottom of a forest habitat type's range.

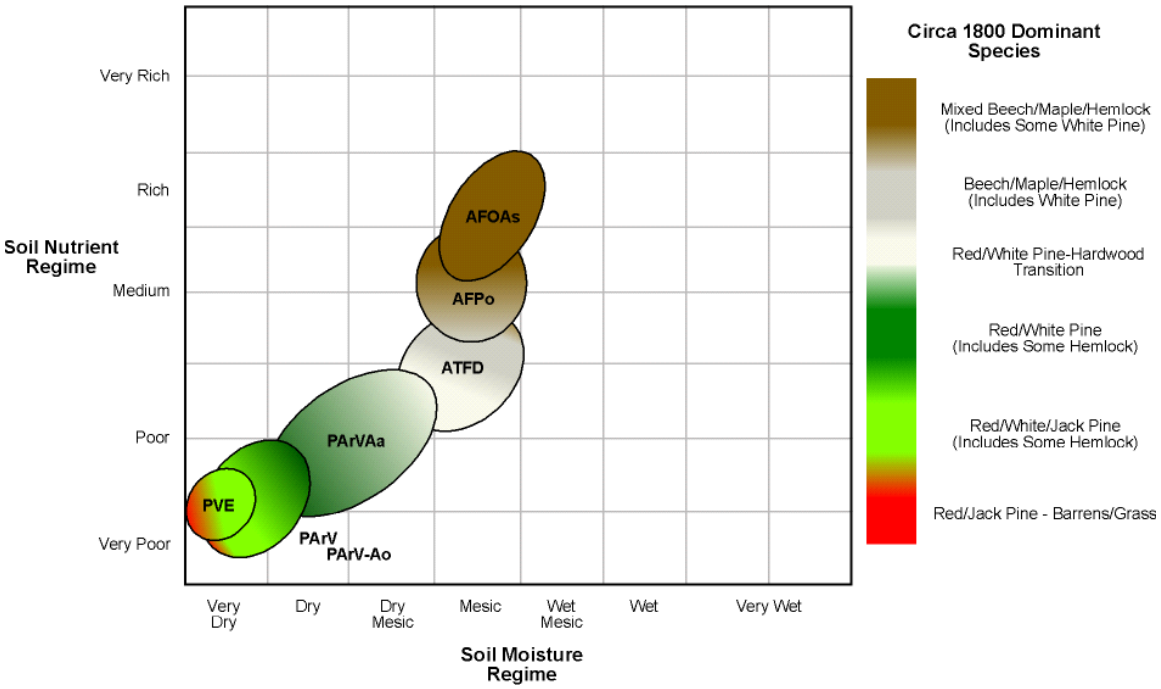


Figure 6: *Relationship of forest habitat types to soil moisture and nutrient regimes in eastern Upper Michigan.*

A land cover map generated from the General Land Office (GLO) surveyors' notes by MNFI (Comer et al. 1995), was overlaid with Kotar and Burger's original forest habitat type plots within a GIS system to examine the correspondence between the historical extent of forest types and land suitability classes. This demonstrated the aggregation of tree communities and open land conditions that were commonly associated with fire (dry northern forest, dry-mesic forest, pine and oak-pine barrens). The abundance and aggregation of these types in the central NLP suggests a landscape system driven primarily by fire. Although fire was likely an important component across eastern Upper Michigan (EUP), forest communities there often have more available moisture, due to soil composition and proximity to Great Lakes shorelines, allowing hemlock, beech, and maple to occupy sites with lower nutrient capacities than in the NLP.

Landscape Management Units (LMUs)

The identification of Landscape Management Units (LMU) in northern Lower and eastern Upper Michigan provides the opportunity for resource managers to identify, and work towards, common compositional, structural, spatial, and eco-regional goals, which are discussed in the guideline section of this report. Because the LMUs are based on the occurrence of forest habitat types, they provide a means of assessing where regions containing a prevalence of similar habitat types occur and therefore where similar types of management could occur at regional levels.

The LMUs are also designed to provide a means of setting goals at the regional level for ecological communities in which red pine is typically a component. For example, the Barrens LMU is dominated by the driest habitat type (PVCd) and, compared to circa 1800, contained the majority of the grassland, pine barrens, and oak-pine barrens ecosystems occupying the NLP. Therefore, areas within this LMU offer numerous opportunities to manage for red pine as it existed in a pine barren community. Because this LMU has seen a reduction in biodiversity (specifically loss of grassland plant and animal species), the Barrens LMU also offers significant opportunities for improving the habitat of threatened and endangered species. In this regard, LMUs also provide a basis or framework for identifying regions in which emphasis should be placed on improving biodiversity.

Four landscape management units were identified across northern Michigan: Barrens, Pine, Northern Hardwood, and Wetland (Figure 7). The following forest habitat types were lumped together in order to define each LMU:

- **Barrens:** Habitat sites with the lowest moisture and lowest nutrient availability.
  PVCd, PVCd/PArVHa (NLP); PVE, PVE/PArV (EUP)

- **Pine**: Habitat sites with moderate moisture and moderate nutrient availability.
  PArVHa, PArVHa/PArVVb, PArVVb, PArVVb/PArVCo, PArVCo (NLP); PArV, PArV/PArVAa, PArVAa (EUP)

- **Northern Hardwood:** Habitat sites with the highest moisture and highest nutrient availability.
  PArVVb/AFO, AFO, AFO/AFOCa (NLP); PArVAa/ATFD, ATFD, ATFD/AFPo, AFPo, AFPo/AFOAs (EUP)

- **Wetland:** Unclassified wetlands. (All poorly and very poorly drained areas not assigned an upland forest habitat type.)

ECOLOGICAL CHARACTERISTICS

Past Condition

While this report is not suggesting to attempt a return the forest to pre-settlement conditions, the circa 1800 GLO survey provides the earliest available systematically collected information for analysis of the distribution and abundance of forest cover in Michigan. Despite potential limitations and conjecture, the GLO surveys provide a relatively reliable method for reconstructing ecological community distributions and broad-scale landscape vegetation patterns that existed prior to Euro-American disturbances (Barnett 2003, Bourdo 1955, Curtis 1959, Whitney 1989, Frelich 2002).

Although Native Americans across eastern North America frequently cleared tracts of forests (often 100 –150 acre patches) for agriculture and villages (Kapp 1999), the impact of native peoples on circa 1800 forests across Northern Michigan was likely minimal in most areas.

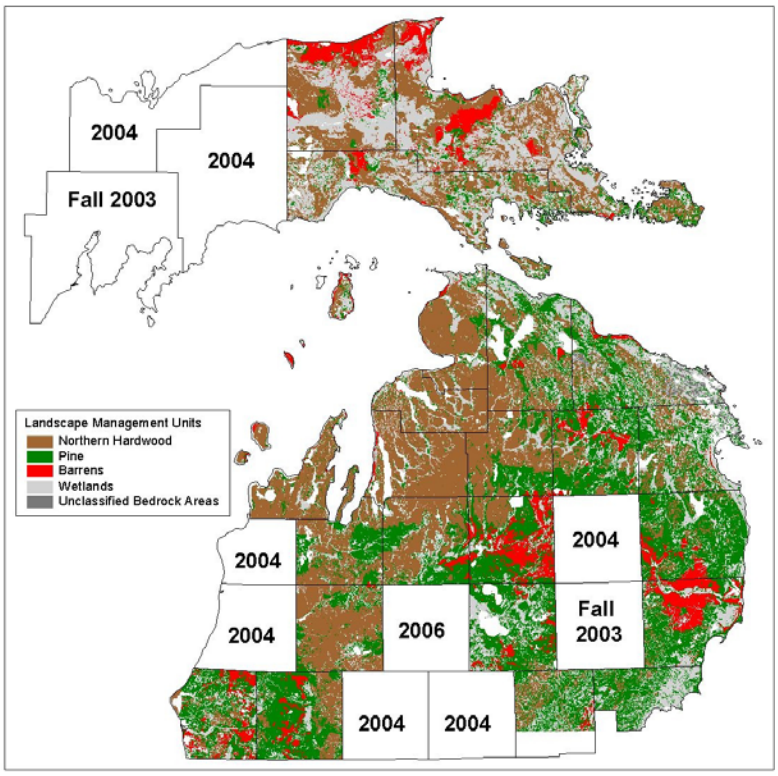


Figure 7: *Landscape management units across northern Lower and Eastern Upper Michigan. The year missing soil data will become available indicated for each county.*

Prior to 1800, most of Michigan's thirty-seven million acres were forested (Kapp 1999). On the roughly 1.8 million acres in northern Michigan where red pine was the dominant tree species, approximately 1.4 million acres occurred in the NLP; 225,000 acres in the western Upper Peninsula (WUP); and 165,000 acres in the eastern Upper Peninsula (EUP). Most of the red pine was occurred in a

mixed forest condition with jack and white pine. Of this mixed condition, the majority, 62%, was classified as a red pine-white pine mix, while 28% was classed as red pine-jack pine.

On State Forest land in the NLP, red pine historically occurred on primarily three forest habitat types that ranged from sites of moderate moisture and nutrients to very dry and poor nutrients (PArVHa-ParVVb, 30%; PArVHa, 30%; and PVCd, 29%. On each of these forest habitat types, and in particular on the drier sites (PArVHa and PVCd), fire acted as a major factor in maintaining red pine. Fire aided in regenerating red pine stands and by discouraging deciduous competition. Investigation of the connection between circa 1800 land cover types and forest habitat types indicated a strong relationship existed between areas classified as jack pine, red pine, and open land with the poorer quality forest habitat types. The relationship of these three land cover types in the central NLP with broad flat outwash channels containing forest habitat types low in nutrient and moisture content indicate a fire prone landscape dominated by open land communities (Figure 8).

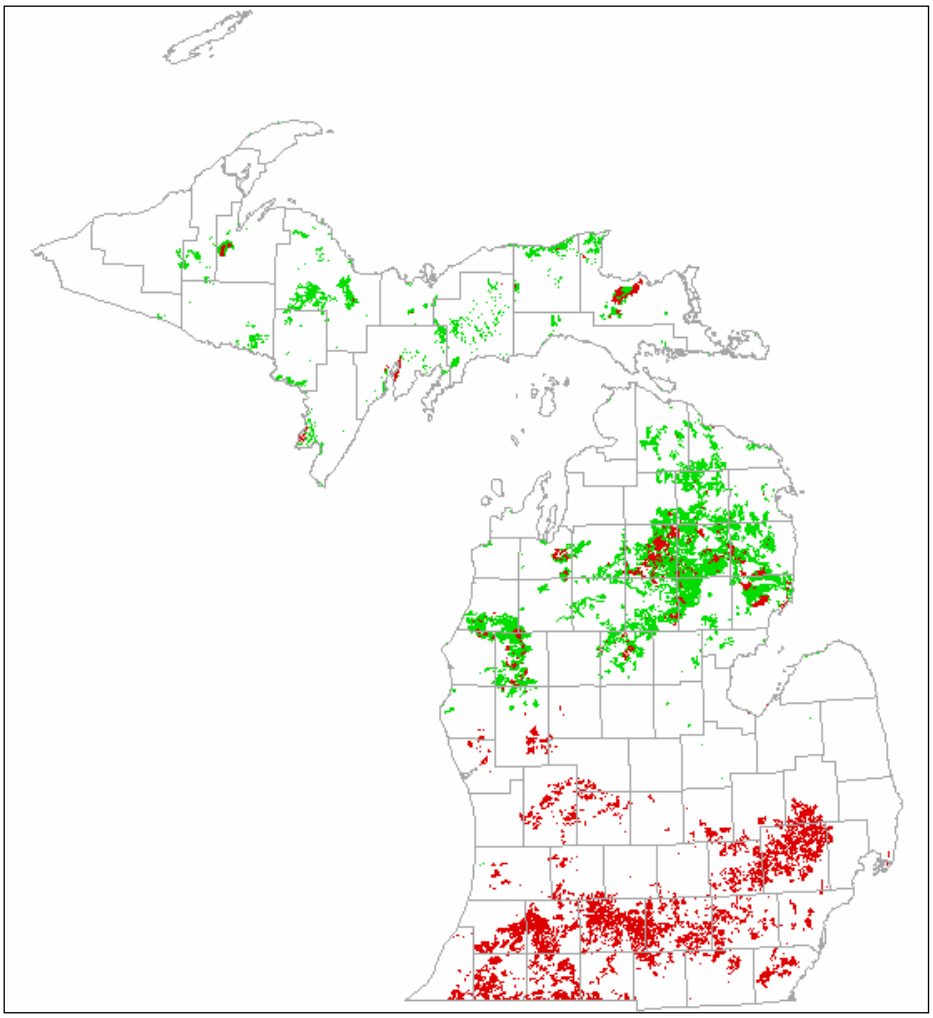


Figure 8: *Circa 1800 distribution of forest communities with a Red Pine component (green - dark) and barrens/grassland/savanna (red - light).*

Present Condition

Using circa 1800 as a point of comparison to the past, the greatest decline in forest cover type acreage has occurred in mesic (moderately moist) conifer-dominated forest types: hemlock, 99% decline; spruce-fir, 88% decline; red pine, 59% decline; and white pine,15% decline. Jack pine, a xeric-associated (dry site) species, increased 73%. Upland deciduous forest type acreage increased dramatically, with the largest increase being 100,000 acres for aspen/birch (1,570%) and 250,000 acres for oak. Northern hardwoods, including beech, sugar maple, and yellow birch, collectively declined 39% despite the overall increase in deciduous species.

Natural forest communities of which red pine was a dominant or co-dominant species have seen a significant decrease since circa 1800. Only 0.2% of the original circa 1800 dry-mesic forest community remains intact in Michigan (Cohen 2002b). The absence of intense fire has resulted in the conversion of the red pine dominated community to early successional deciduous species such as aspen and birch in many instances. Once aspen is established on a site it may take multiple fire events to remove the species. Relative to GLO, much of the barrens areas have also been converted to jack pine plantations in an effort to advance Kirtland's Warbler habitat.

The extensive logging and land clearing activities and resultant fires of the late 1800s created large areas of "wasteland" that was target by early conservationists to get back into production. The state of Michigan established a seedling nursery and started planting red pine when the State Forestry Commission dedicated the Houghton and Higgins Lake State Forests Reserves in 1902. The majority of pine plantations were established by the CCC in the 1930s and by the state in the 1950s. Since the plantings on open lands were completed in the 1960s, red pine planting has been at a much reduced level since then. Less than 19% of the current red pine resource on State Forest lands is the result of natural regeneration.

The age and size class of Michigan's red pine type is skewed significantly by the planting programs of the CCC era and the 1950s. The 1930s-era stands are now mid-sized saw timber size and the 1950s - 1960s era stands are small saw timber size. Over the next two decades, a majority of the stands should be final harvested and regenerated. Forest managers should also consider final harvesting and regenerating some of the 1950s-era stands so as to start spreading age classes.

Wildlife: Effects and a Desired Future Condition

Historically, fire, insects, disease, wind throw, and climatic conditions were the primary natural disturbance agents on forests. Starting in the mid-1800s, (Franzen 1999), timber harvesting became the dominant action influencing forest composition and structure. Natural disturbance and timber harvesting differ in their impacts on forest stands and landscapes, and consequently, wildlife species. Timber harvest rotations are generally shorter than natural fire cycles and usually results in fewer poorly-stocked and open areas, more rapid regeneration of fully-stocked harvest areas, and less coarse woody debris accumulating on the site. In addition, short rotation intervals influence tree species composition, usually

resulting in an increase of early successional deciduous forest species on mesic sites and conifers on xeric (jack pine) and hydric (black spruce, tamarack). For example, deciduous species composition has increased dramatically from pre-European settlement times to present for Michigan and the rest of the Lake States (Frelich 2002).

The increase in early successional young deciduous forests at the landscape scale reduces biological diversity for those species associated with open, grassland areas; old forest conditions; and mixed or conifer dominated stands. Even-aged management change age-class distribution of forest types at the stand, and cumulatively, the landscape scale. As a result, there are more early successional or young forests and less mature and old forest conditions.

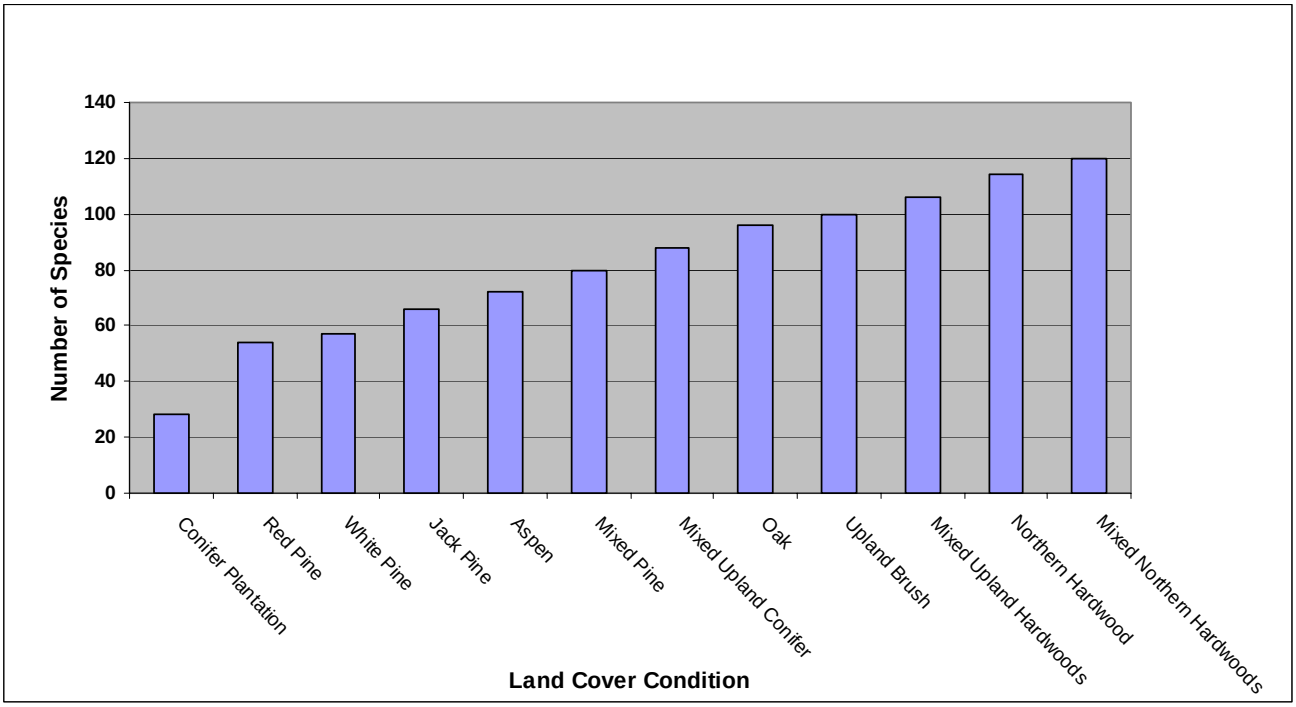


Figure 9: Estimated number of wildlife species utilizing various land cover condition in Michigan (source MIWILD)

To assess the impacts of changes in forest habitat conditions on wildlife species, MIWILD, a wildlife species habitat database developed by the Michigan Department of Natural Resources, was used to generate estimates of wildlife species increases and decreases (Doepker et al 2000). These increases and decreases are not based on actual population estimates but rather depict the relative amount of habitat loss and gain. Figure 9 is a summary from the MIWILD database showing the number of species utilizing various cover types for habitat. MIWILD analysis suggests that the increase in deciduous habitat conditions since circa 1800 benefits approximately 90 species primarily associated with young forests. Despite the increase that has occurred and the species richness that is often present in deciduous forest communities, a loss in biodiversity has occurred in several native ecosystems relative to pre-European

settlement times. Due to the decline in mesic conifers and the degradation of dry northern and dry-mesic northern forest communities, conifer associated wildlife species show the greatest decline of forest dwelling species (Cohen 2002a, 2002b). This includes 26 species that the models in MIWILD indicate have lost potential habitat. A similar decline has taken place in xeric barrens ecosystems with a total of 41 plant, animal, or insect species being listed as state special concern, threatened, or endangered. Of these, 24 are only found in either pine or oak-pine barrens ecosystems. The decline in grassland associated species, such as sharp-tailed grouse, is probably related to a reduction in the size of openings and the fact that many openings are on sites that did not contain grass, barrens, or brush historically. Such sites do not provide the same ecologic functions and relationships as they did historically. Many open lands circa-1800 were larger than 150 acres whereas very few are today. Only 18% of these openings are located on the PVCd forest habitat type on which over 70% of grasslands, barrens, and brush were located historically.

It is recommended the mesic conifer decline be addressed by emphasizing mixed forest conditions on state land. Approximately 155,000 acres classified as red pine type is considered to be almost pure, having stands with greater than 80% of its volume in red pine. In addition, opportunities to enhance (increase the within stand component) or expand (conversion) mesic conifers, including red and white pine, in deciduous dominated forest cover types occurring on suitable forest habitat types can be considered. To lessen the loss in biodiversity, management for mixed red/white pine stands should be focused on sites of moderate moisture and nutrients (PArVHa, PArVVb, PArV, PArV-Ao, and PArVAa) forest habitat classes where approximately 40% of the mixed pine type originally occurred. The best opportunity for emphasis of red pine-white pine is in the following forest management units: Grayling, Atlanta, Roscommon, Traverse City, and Newberry. Silvicultural practices including, but not limited to, manipulating forest overstory and understory to encourage mesic conifers and desirable deciduous species, under-planting, prescribed burning and/or scarification could be employed to promote the establishment of mixed species stands.

Many openings, particularly those found on the drier forest habitat types such as PVCd, have converted to forested conditions, primarily jack pine and oak. Twenty-six species of grassland birds are of management concern in Michigan and Wisconsin. Many of these species are area-sensitive including the upland sandpiper, sharp-tailed grouse, greater prairie chicken, and northern harrier. Some species, including the upland sandpiper, Henslow's grasshopper and savannah sparrows, use the short grass conditions present on barrens and larger grassland areas.

Forest Health: Effects and a Desired Future Condition

The impacts of management strategies on forest health are often very significant. Therefore, careful consideration of forest health as it relates to the future management of red pine is critical in order to ensure the continued management of a "…healthy, productive, and undiminished…" red pine resource (FMFM Mission). This section will examine both general trends relating to red pine site quality and forest health, and also discuss the management issues related to five pests currently affecting the resource.

As a general rule, forest health concerns for red pine are lowest on higher quality (containing adequate soil moisture and nutrients) sites (ParVVb in the NLP and ATFD in the EUP, and above) while risk of infestation and dieback are greatest on poor quality sites (PVCd in the NLP). Red pine in the NLP is along its southern range in this region, compounding the stress it encounters on the poorest sites. In the EUP, where coarse sandy soils are often influenced by a high water table and the annual precipitation is higher than much of the NLP on average, forest health concerns are not as prevalent on poor quality sites (PVE, PArV). In general, due to the moisturizing effects of the Great Lakes, the driest sites, on which trees experience frequent stress, in both the NLP and EUP, are found in interior regions such as the Raco plains (EUP) and the Grayling area (NLP).

Established red pine on high quality sites are generally less susceptible to drought stress, winter burn and other environmental stressors that can predispose trees to damage by forest pests. Proper site preparation is critical to ensure adequate establishment of red pine on high sites. This is especially true on the high moisture and high nutrient forest habitat types (AFO and AFOCa in the NLP), and AFOAs and AFPo in the EUP) where hardwood competition is often established, or where hardwood encroachment is a concern. Controlling competition is particularly important during the first five to eight years on these sites. An exception is bracken fern, which is not an aggressive competitor and may serve to moderate temperatures and winds during the first few years of establishment. These issues point strongly to matching trees to "suitable" habitat types in order to minimize health issues.

In addition to site quality, management practices, weather conditions, and many other factors can have a great impact on red pine forest health. These impacts vary depending on the type of forest pest involved:

- **Redheaded Pine Sawfly:** Avoid red pine management in areas with dense patches of bracken fern (although bracken fern may protect seedlings in some cases), wet areas (ParVCo in the NLP), heavy sod (AFOCa and AFOAs) and other stressful site conditions such as drought prone areas (PVCd and PVE) that can predispose trees to attack. Avoid hardwood edges (AFOCa, AFO) where shade and encroachment can stress red pine.
- **Saratoga Spittlebug:** Avoid sites with large areas of this pest's alternate host, sweet fern, which is most common on the PVCd and PVE forest habitat types, or treat/control sweet fern prior to planting.

- **Pine Bark Beetle:** Even forest habitat types relatively high in moisture and nutrients (ParVVb, AFO, ATFD, and AFPo) can be susceptible to bark beetle attack during extended droughts. This is especially true in stands that are overstocked. Following prescribed thinning guidelines will help minimize problems. Also, avoiding damage to residual trees is important, as is restricting on-site decking. Prompt salvage of dead and dying timber and the removal of a one chain sanitation buffer of healthy trees will reduce the risk of expansion of established bark beetle pockets. After logging, disperse slash for quick drying, and especially do not pile slash around residual trees.
- **Sphaeropsis:** As with bark beetle, there is a strong correlation between tree stress and outbreaks. In addition, proximity to established infections increases the likelihood of new infection. This is particularly true when hail storms, wind storms, ice storms or other damaging events create wounds that allow the pathogen to enter trees. Infected nursery stock may also be a factor and is the focus of current research. Finally, two-story stands (shelterwood, plantation-age red pine bordered by mature red pine and or jack pine stands) are at higher risk for infection by Sphaeropsis because spores fall from the taller trees onto the small trees.
- **White Grubs:** Avoid planting abandoned fields on forest habitat types high in nutrients and moisture such as AFO and AFOCa with established grub populations (roughly 0.5 grubs per cubic ft. of soil). Transitional (poor) hardwood sites (PArVVb/AFO) are particularly problematic and should be avoided when high grub populations are present. Sites with heavy grub populations need to be furrowed and left fallow for two years before planting. An alternative is to apply herbicides to eliminate grasses and other grub host plants. Historically grubs have been a greater problem in the Upper Peninsula while problems in the NLP have been local or sporadic.
- **Scleroderris:** This is a serious problem in heavy snow areas of the Upper Peninsula, where quick establishment of trees is recommended. Frost pockets are also high risk if the disease is already present.
- **Other:** Red pine growing within a ¼ mile of Scotch or Austrian pine may be affected by Pine Root Collar Weevil. On sites with an oak or hardwood component, Armellaria Root Rot may affect red pine seedlings. Seedlings should be planted away from residual hardwood stumps where possible.

Red pine frequently inhabits dry-mesic and xeric sites, and replacing red pine with early successional deciduous species not well suited to these sites, can result in forest health problems. This is particularly true for aspen, which, especially when grown on these sites, is very susceptible to hypoxylon canker. Hypoxylon is the primary cause of premature aspen mortality with nearly 30% of the net growth of species being lost to this disease in the Great Lakes region. On surviving trees, hypoxylon canker results in poor form and lower timber values and can also reduce its value to wildlife. In addition to hypoxylon canker,

the stress of droughty nutrient poor sites makes aspen more susceptible to mortality when subjected to defoliation or frost damage.

Fisheries Considerations

In order to maintain water quality and habitats for various fish species, Best Management Practices (BMP) guidelines, Natural River Guidelines, and Forest Certification Work Instructions should be applied where relevant. Memorandums of understandings and other documents may also pertain.

ECONOMIC CHARACTERISTICS

The red pine resource, both plantation and natural, is an important economic resource in Michigan. Red pine products include utility poles, lumber, cabin logs, pulp, oriented strand board, decking and landscape timbers.

Michigan red pine timber markets have been strong and prices have nearly doubled between 1993 and 2001. During this same period, red pine revenues from state lands grew from slightly under $1 million to over $5.6 million. In recent years, red pine revenues accounted for over one-fifth of the state's timber revenue.

Most of this revenue stems from thinning treatments which often also remove other timber species in addition to red pine. Between 1993 and 2001, less than one-tenth of red pine treatments were stand replacement harvests (clearcuts). Since red pine's best economic return comes when the trees are between 14 and 18 inches in diameter, much of the current resource (60 – 80 year age-class) is ready for stand replacement by economic standards.

Timber supply experts are warning that the value of domestically grown softwood timber could diminish as softwood from overseas plantations finds its way into the domestic market. Lower real prices would result in lower timber revenues. A decline of just 10% would amount to a reduction of several million dollars annually. This suggests that it would be wise to take advantage of existing favorable red pine markets by increasing treatments now.

The major conclusions of the red pine financial analyses are as follows (all analyses were conducted using data from the NLP only):

- **Extended rotations may dramatically lower returns:** This is particularly true as the diameter at breast height increases beyond the optimal 14 to 18 inch range to above 20 inches resulting in fewer bids and much lower prices offered for saw logs larger than 20 inches. In addition, while mortality does not set in (as it does with aspen and jack pine), growth rates fall off dramatically with older-aged red pine. Finally, the difference in product outputs with three 60-year rotations versus two 90-year rotations can be substantial. The stand may "hold," but postponing treatments can dramatically diminish returns.

- **Red pine significantly outperforms (by multiples) other species:** Red pine will provide higher financial returns on forest habitat types ranging from lower (PVCd/PVE) to moderate (ParVVb/ATFD). On the hardwood sites (AFO/AFPo), returns are at least equal to Northern Hardwoods.
- **Red pine is a very efficient revenue producer:** Red pine comprises 7% of the cover type acres on State Forest lands, but currently makes up over 20% of timber sale revenues.
- **On low sites (PVCd, PVCd/PArVHa, PVE, PVE/PArV), quality and survival makes red pine a questionable choice when compared to jack pine:** Red pine growing on the poorer sites are often significantly understocked and not uniformly distributed in the stand. Trees are often short with a high degree of taper and large limbs. Analyses run for the low sites assumed 50% stocking for red pine on these xeric sites may be optimistic. Because of the native range for jack pine and red pine, and due to increased moisture, returns may be higher in the EUP on poor sites than the NLP. Jack pine was assumed to produce fully stocked stands. Red pine showed better economic returns on these sites when compared to jack pine even when stumpage rates were dropped to very low rates. This is primarily due to the very good prices currently being received for red pine products.
- **Despite the additional costs of managing hardwood competition, economic returns are very high on some northern hardwood sites (AFO – AFOCa, ATFD - AFOAs):** Even the high regeneration costs often associated with herbicide use and other site preparation activities do not cancel out the favorable returns from such activities. Such highly productive sites allow for relatively short-term rotations with high product values. A negative aspect of this struggle is the use of herbicides often necessary to attain a “free to grow” status for newly planted red pine to become established in the first 5-10 years of the rotation. Herbicide use in forest management operations is not viewed favorably by portions of the public.
- **Maintaining a mixed stand condition:** More analysis and study is needed to determine silvicultural regimes that could be implemented to maintain this desired condition along with their costs and benefits. Red pine mixed with other species is not a static condition that can not be maintained over long periods. However, the mixed condition can be present in landscape, but only as a dynamic condition that must mover around the landscape as stand senter and leave various successional stages.
    - Many planted red pine stands on mesic sites will ultimately develop a hardwood component in the understory whether desired or not. Various options for silvicultural manipulation of the vegetative cover on these sites can either enhance or minimize the hardwood component. These options need to be more carefully studied and analyzed to determine their economic feasibility and biological desirability.

- Alternating rotations of red pine with northern hardwoods, oaks, and aspen may be feasible. These scenarios would require planting red pine and allowing the hardwood species to develop naturally, or with cultural assistance throughout the first rotation of the pine. Preliminary evaluations would indicate that mixed stand scenarios such as these would reduce pine economic yields significantly. These scenarios are not sustainable for more than a single rotation without starting over with an “open field” planting of red pine. Without disturbance these stands will succeed to northern hardwood, or oak depending on the particular site in question.
- Growing mixed stands of red and white pine may be feasible. Red pine does well when planted in open, full sunlight situations. White pine is attacked by a number of pests when planted in full sunlight, but does much better if nursed during its first decade under a light overstory of another species. The precise silvicultural operations necessary for this to be done effectively and efficiently would need to be worked out and their economics studied in more detail.

SOCIAL CHARACTERISTICS

Social characteristics may function as either soft or hard constraints for site specific forest management options. Soft constraints such as visual management and archaeological considerations can vary greatly in their required management depending on the situation. With a soft constraint, resource managers generally have multiple management options and are often not precluded from their desired goals. Hard constraints, such as an old growth designation, are much more rigid, often restricting a resource manger to a single management option.

Because planting techniques often require trenching and thus subsurface soil disturbance, red pine management will likely impact cultural resources through the potential destruction of archaeological sites. Since the artifacts found at archaeological sites in Michigan are often at or near the ground surface, even minimal soil disturbance can be very destructive to sites. Generally, areas likely to be archaeological sites can be harvested during the winter when the ground is frozen and protected from rutting. Road building and other earth moving activities should be avoided in areas where archaeological sites are likely. Archaeological sites containing features such as mounds, cellar pits, and earthen foundations should be avoided regardless of the season.

The public’s desire for recreation opportunities affects red pine management in several ways. First, the restoration of natural red pine communities could provide opportunities for ecotourism by creating habitat for rare birds and plants. In addition, the shape and form of red pine trees often produces esthetically pleasing stands, especially when juxtaposed with other stands, throughout the seasons, enhancing recreation opportunities such as hiking and snowmobiling. Therefore, red pine is a valuable species for visual management particularly near areas that are used for recreation. Although many red

pine plantations have helped to restore deciduous species on forest habitat types with relatively high nutrient and moisture contents, continued red pine management will prevent these species from thriving on these sites. Therefore in some areas, red pine management conflicts with recreation opportunities particularly with the development and maintenance of habitat for game species such as ruffed grouse, which require deciduous species for their lifecycle.

State forest lands adjacent to population areas or heavily traveled roads also can limit the types of management regimes that are undertaken, regardless of generally accepted cultural views throughout a region. For example, prescribed burning of stands in regions with higher human populations pose a high risk of public conflict despite the ability of this type of management to improve biodiversity and maintain rare ecosystems. Similarly, frequent herbicidal applications, needed on high end sites (AFO, AFOCa, AFTD, AFPo, and AFOAs) to maintain red pine, are likely to create conflicts in some areas, particularly in the NLP where population densities are higher, despite the aesthetic value red pine may be providing in some regions. A social value placed on “naturalness” may also reinforce this latter concern. Thus, given the long-term unpredictability of sociopolitical values, there may be a rationale to be somewhat circumspect about establishing red pine on sites where it faces greater competition and requires herbicides; and although fire is a critical part of natural red pine community regeneration and maintenance, other options for restoring natural communities will have to be considered for some areas.

Future Red Pine Management: Balancing Biologic, Social, and Economic Factors

In order to develop a balanced assessment and management strategy for the red pine resource, biologic, social, and economic factors, the three pillars of ecosystem management, are considered. This section examines how these factors were combined in order to identify where, and on what forest habitat types, red pine management should occur and what types of management should be utilized. To accomplish this, a multi-criteria model (weighted linear combination) was constructed and calculated using a spreadsheet.

The values depicting the ecological suitability of each forest habitat type for sustaining red pine were determined by overlaying the MNFI circa 1800 cover type map onto the forest habitat type maps. The percent of each forest habitat type that was occupied by a cover type with red pine as a dominant or co-dominant was calculated. This ensured that estimates were not biased by the size or area a forest habitat type represents. The forest habitat type(s) with the lowest percentage of red pine in circa 1800 were given a ranking of one while the habitat type with the highest percentage was given a value of ten (Figure 10). By cross-walking timber sale records with forest habitat types, per acre monetary returns were examined for each type. To account for various management strategies an average return value (based on all management practices occurring on a type) was generated for red pine by each forest habitat type. A fairly linear relationship exists between the forest habitat types and the return rates with the most nutrient rich sites yielding the highest returns (Figure 10). Returns are still high enough on the driest nutrient poor

sites to warrant a value of two. Rankings for the likelihood of red pine encountering forest pest infestations that would result in mortality were generated based on staff knowledge about regions previously affected by disease, and the ability of red pine to resist or recover from disease on various sites.

Habitat Type	Ecological Suit.	Health Suit.	Economic Suit.	Social Suit	Suitability
AFOCa	0	6	10	0	**4.0**
AFO/AFOCa	0	6.5	10	2	**4.6**
AFO	0	7	10	3	**5.0**
PArVVb/AFO	2	8.5	9.5	1	**5.3**
PArVVb	7	10	9	3	**7.3**
PArVCo/PArVVb	1	7	8	5	**5.3**
PArVCo	1	5	7	8	**5.3**
PArVHa - PArVVb	10	8	7.5	7	**8.1**
PArVHa	9	6.5	6	8	**7.4**
PVCd/PArVHa	10	4.5	4	10	**7.1**
PVCd	6	3	2	10	**5.3**
AFOAs	0	6	10	4	**5.0**
AFPo/AFOAs	0	6.5	10	4	**5.1**
AFPo	0	7	10	5	**5.5**
ATFD/AFPo	0	7.5	10	6	**5.9**
ATFD	0	8	9.5	7	**6.1**
PArVAa/ATFD	0	8.5	9	8	**6.4**
PArVAa	0	10	8	9	**6.8**
PArV/PArVAa	1	9	7	10	**6.8**
PArV	3	8	6	10	**6.8**
PVE/PArV	8	7	6	10	**7.8**
PVE	10	6	6	10	**8.0**

Figure 10: *Criteria ranks for forest habitat types occurring in the NLP and EUP.*

The risk of disease is highest on sites with low nutrient and moisture contents while sites rich in nutrients and moisture also pose some risk due to competition primarily from deciduous species (Figure 10). Stress on nutrient poor sites in the EUP are less than those in the NLP due primarily to climatic conditions. Social values were the most difficult to rank and will likely require future adjustment. These rankings were based primarily on the potential for conflicts to arise based on the need to regenerate early successional deciduous stands to provide habitat for various game species such as sharp-tailed grouse and the fact that herbicide is required to control vegetation on nutrient rich sites. In the EUP, however, herbicide application has not resulted in the social conflicts that it has in the NLP. Therefore hardwood sites were given a much higher suitability than similar sites in the NLP. The presence of significant numbers of shrub species such as maple-leaved viburnum and beaked hazelnut (Burger and Kotar 2003), compounded by the fact that herbicide use is often needed to eliminate deciduous competition on the

PArVVb habitat type, give it a fairly low ranking of three, for example. After ranking each habitat type all factors were given equal weight and were combined using a linear weighted combination.

The results of the linear combination indicate that, when all factors are given equal weight, the best management opportunities (with the least conflicts) in the NLP for red pine would be on the PArVHa/PArVVb habitat type, a transitional type typically found on Graycalm sand (Figure 4). PArVVb sites, which border on the AFO habitat type (in the upper half of the PArVVb and lower half of the AFO nutrient and moisture regime), drop in their suitability for red pine management due to their ability to provide game and non-game species habitat and the increase in deciduous competition. Without fire disturbance or herbiciding, these sites are more suited to a mix of white pine, aspen, maple, and or oak which often occupied this habitat type in circa 1800. In the EUP the driest forest habitat types are the most suitable for red pine management. Hardwood sites also have some potential for red pine management, particularly since social conflicts with herbicide use appear to be less in the EUP than the NLP.

The criteria values used in the linear combination were also used to aid in the identification of suitable forest habitat types for restoration of natural red pine communities. Criteria values demonstrate that the PVE, PVE/PArV, PVCd, PVCd/PArVHa, PArVHa, PArVHa/PArVVb habitat types provide some immediate opportunities for red pine community restoration. On these forest habitat types, red pine was often a dominant or co-dominant species (Cohen 2000, 2002a, 2002b, Comer 1996) and social, forest health, and economic conflicts with red pine management are likely to be minimal. In addition, examination of MNFI community abstracts and crosswalks between these communities and forest habitat types indicate that the PVE, PArV, PVCd, and PArVHa types have the potential to support habitat for at least 50 state threatened, endangered, or special concern plants, animals and insects. Thus, restoration of natural red pine communities, such as the oak and pine barrens, dry northern forest, and dry-mesic forest, could increase biodiversity on xeric, and dry-mesic sites. Despite their being at risk for infestation of insects and disease on nutrient poor xeric/dry sites, a natural management strategy in which there are expectations of fewer red pine trees per acre, and with trees being regenerated using fire and or scarification techniques, will minimize some of the forest health impacts. However, those practices resulting in fewer trees per acre will obviously lessen future commercial timber revenues.

RED PINE FOREST TYPE MANAGEMENT GUIDELINES/OPPORTUNITIES

The guidelines presented here were developed as part of the Michigan Department of Natural Resources (MDNR) Red Pine Community Project. It is difficult to draw up detailed management guidelines that properly address all of the possible management practices involving the red pine community. A silvicultural practice that may benefit one type of red pine mixture may be detrimental to another (e.g. a prescribed burn beneath a mature red pine stand for the purpose of eliminating red maple seedlings will effectively destroy any white pine regeneration that is also found growing in the understory). In the interest of simplicity, the recommendations that follow specifically address the issues related to managing and maintaining the red pine forest type as the primary or secondary species on forest habitat types within various Landscape Management Units in both northern Lower and eastern Upper Michigan. The effects these guidelines will have on the age class composition of red pine are also presented.

A guiding principle should be to not postpone stand management, even if it will "hold," until the next decade. Even if mortality is not imminent, postponing management decisions has and will compound future decision-making and likely will result in lost ecological and economic opportunities. Given the age class structure of the red pine forest type, there will be many more decisions to make in future decades. The sooner resource managers begin the decision-making process, the better the results will be.

Three primary types of management are referred to throughout this discussion: "Classic", "modified classic", and "natural".

- "Classic" management consists of stands of densely planted rows of red pine. Frequently "classically" managed red pine on abandoned agricultural sites with a northern hardwood habitat type (AFOCa and AFO in the NLP and AFOAs and AFPo in the EUP) result in a stand devoid of ground cover vegetation and a shrub understory, due to the persistence of a thick sod layer prior to planting.
- A "modified classic" strategy results in row/trench planted red pine with the rows being further apart, less red pine stocking density, and other forest types being allowed to inhabit the stand. Such a strategy would enhance within-stand biodiversity, and while overall timber volume may not be reduced, there would be less red pine product produced.
- When a "natural" management strategy is applied, the red pine seedlings may be inter-planted where space allows, and not necessarily row planted in trenches. Red pine stocking is less than that for "classic" stands and if trenching is used, it is usually in small isolated areas.

The use of prescribed fire is also an important part of implementing a natural management strategy. However, in some instances, the use of fire may not be an option initially or at all. For example, fire can sometimes stimulate the regeneration of aspen through sprouting in stands where aspen is present. In these stands, red pine can be planted without disturbing the aspen and prescribed burning can be used once the red pine has reached a sufficient size and the aspen has died out. In areas adjacent to private

lands or population areas, prescribed burning may not be an option due to social conflicts. In these areas, other silvicultural practices can be used to create a “quasi-natural” stand.

The forest habitat type system, as developed by Kotar and Burger (2003), is used as a basis for these silvicultural guidelines because of its ecological/biological and economic relevance. The forest habitat types described by Kotar and Burger for northern Lower Michigan span a wide range of soil nutrient and moisture regimes (Figures 4 and 6), with PVCd in the NLP and PVE in the EUP occupying the lower end (relatively low nutrient and moisture content) and AFOCa in the NLP and AFOAs in the EUP at the high end. Each habitat type has its own unique ecological signature and therefore it is appropriate that management guidelines take these differences into account. Although forest habitat type maps provide a detailed look at habitat potential both at the regional and local levels, on the ground observations confirming the existence of mapped habitat types and the validity of a selected guideline is required. In regions where forest habitat type maps are not yet available, the lack of these data should be supplemented with additional field work.

For most of the guidelines, the focus is on red pine 60 to 80 years of age. This is the age at which red pine meets the criteria for final harvested under “classical” management, although some of the overabundance of stands in the 40 to 50 year age class should receive final harvest consideration in order to address its age class distribution. Most stands older than 80 years are often either natural and/or are formally or informally being designated as potential old growth (Figure 1).

Management Recommendations/Guidelines/Opportunities

Some considerations or limitations regarding red pine management may dictate management procedures and are discussed first:

- **Riparian Buffers**: Buffers around and along wetlands, lakes, and streams, discussed in detail earlier in this report, should be applied in all regions prior to guideline implementation.
- **Forest Health**: Although there are many factors affecting red pine health, management on certain forest habitat types will likely minimize the risk of forest pest infestations. In eastern Upper Michigan, PArVAa habitat type provides some of the best opportunities to minimize forest health risks to red pine while PArVHa and PArVVb habitat types provide the best opportunities in northern Lower Michigan.
- **Sensitive Areas**: An archaeology suitability map and other layers have been constructed to aid staff in identifying areas sensitive to disturbance.
- **Social Issues**: Proximity to travel corridors, population areas and recreational areas may limit management considerations regardless of broad cultural views.

To ensure that common goals are met at the ecoregional level, Landscape Management Units are used to guide management choices/opportunities. Although the majority of the red pine resource lies

within the Pine (consisting of PArVHa, PArVVb, PArVAa, and PArV habitat types) and Barrens (consisting of PVCd and PVE habitat types) LMUs, a large proportion of the resource is also found on ecosystems dominated historically by hardwoods (consisting of AFO, AFOCa, AFOAs, AFPo, and ATFD habitat types). Over the last three decades in the EUP, in particular, red pine planting has primarily occurred on hardwood sites although the majority of 60 to 80 year old red pine is found in the Pine LMU. Below are detailed discussions about each upland LMU:

- **Barrens LMU**

  The Barrens LMU has undergone substantial changes over the past two centuries, particularly with respect to loss and fragmentation of openings and savanna habitats. As a result, several plants and animals occupying parts of these areas are now listed as endangered, threatened or special concern. In addition, the Oak-Pine Barrens and Pine Barrens communities are listed by MNFI as state imperiled and globally imperiled. Due to this loss and the inherently low soil productivity in this region, “natural” management of red pine is strongly recommended here. This objective can be reached through the placement and management of forest cover types on ecologically suitable sites as identified by the forest habitat type classification for northern Michigan. The PVCd habitat site class is the most common habitat type within the barrens unit in the NLP while PVE is most common in the EUP. Red pine stands that occur on PVCd and PVE sites often will have poorer growth and quality than those on better habitat types. In many instances, restoring pure red pine stands to jack pine, mixed stands, barrens, or grassland/savanna will improve the biodiversity of the Barrens LMU.

- **Pine LMU**

  PArVHa and PArVVb are the most common forest habitat types found on the Pine LMU in the NLP while PArVAa and PArV/PArV-Ao are most common in the EUP. Because of the relatively low soil productivity and reduction of biodiversity primarily associated with the loss of mesic conifer since European settlement, it is recommended that an emphasis be placed on restoring biodiversity in this LMU. The dry-mesic and dry northern forest communities are currently listed by MNFI as state rare and globally secure. Dry northern forest has a status of special concern globally. Sites with lower productivity in this LMU, such as PArVHa, PArVVb, (NLP) and PArVAa, PArV/PArV-Ao (EUP) habitat types offer several opportunities for restoring threatened and endangered species habitat. Areas with higher productivity such as PArVVb, AFO, and AFOCa provide opportunities for aspen, and natural and or “classic” red pine management tactics. However, areas of higher productivity also contain threatened and endangered species habitat and habitat potential and this should be considered as well when using these guidelines.

- **Northern Hardwood LMU**

  Having much higher soil productivity, the Northern Hardwood LMU provides some opportunities to emphasize economic returns on various forest habitat types. However, due to the higher soil productivity, some red pine plantations are “offsite” and the opportunity exists to restore a “natural” forest type through the eventual succession of these stands to a deciduous community. Grassland areas, generally the result of past agricultural practices, provide some of the best opportunities for future red pine management on these highly productive sites. Although the largest number of species listed as state special concern, threatened, or endangered are found on xeric and dry-mesic sites, the Mesic Northern Forest community is also listed as state rare by MNFI and has the potential to provide habitat for rare species (Cohen 2002c). In addition, mesic conifers such as white pine and hemlock have been eliminated from many northern hardwood communities. The ATFD, AFPo, AFOAs, AFO, and AFOCa habitat types are most commonly found in the Northern Hardwood LMU.

Red Pine Type Guidelines

Fourteen specific guidelines were identified for the management of red pine. Criteria for these guidelines are based on forest habitat type, LMUs as discussed above, and stand characteristics. Broad silvicultural methods for treatment are also presented in this section. The assertive treatment of the 60 to 80 year old red pine stands (and perhaps some of the 40 - 50 year old stands) and the conversion of other types such as oak to mixed pine stands over the next decade will create another large spike in the zero to nine age class. Although this spike is needed to maintain the red pine resource and to expand its presence across the landscape, it will however, necessitate further redistribution. It will take many years to fully balance the age class structure of red pine, while ensuring the resource is maintained. The economic, biological, forest health, and social aspects of implementing each of the red pine guidelines are summarized in Figure 11. The fourteen red pine guidelines are outlined in detail below:

GUIDELINES

1. CONVERT RED PINE TO BARRENS/GRASSLAND

General criteria used to identify suitable stands:

- Red pine present age class 60 – 80. (Consideration could be given to younger stands.)
- PVCd - PVCd/PArVHa (Also PArVHa adjacent to or within an area of PVCd habitat
- type.) (NLP)
- PVE – PVE/PArV. (EUP)
- Aspen not present in the overstory and or understory.
- Frost Pocket (NLP)
- FR1 fire disturbance history (NLP)

Photo courtesy of James Bielecki

"Natural" stand of red pine (probably over 200 years of age) on a PVCd site. Notice the presence of large super canopy trees in a relatively open environment.

In instances where stands of red pine already occur on the poorest PVCd, PVE, or PArV sites, patch clearcuts of various sizes could be created within the stand. Red pine growing along the periphery of these openings could then be thinned, leaving super-canopy trees, resulting in a park-like setting. Jack pine could be planted at a stocking of 600 – 1,200 trees/acre in some of these openings, or over larger areas, where needed. Adjacent regions or areas within the PVCd type containing the PArVHa habitat type provide a particularly good setting for leaving park-like super-canopy red pine trees and encouraging shrubs. The use of fire and or frost pockets should also be explored as a tool to reduce the future development of woody vegetation. Based on the requirements of grassland species, such as sharp-tailed grouse and prairie chicken, a desired minimum size for a barren should be between 200 and 500 acres. In the EUP, according to the original survey notes, barrens were typically found on the PVE/PArV forest habitat type, the largest of which was found on Raco Plains, where catastrophic fires periodically occurred. The PVE type is typically found along the Lake Superior shoreline on dune features which, due to their juxtaposition to wetlands, may not have burned as frequently. For additional information on the creation of barrens see the Oak Pine Barren and Pine Barren community abstracts produced by MNFI. There are also opportunities to maintain red pine in a forested setting both as pure stands and mixed with jack pine, oak, and possibly white pine. Each of these community types historically often occurred on the PVCd, PVE, or PArV habitat type. Jack pine placed on the poorest PVCd sites could provide extended opportunity for Kirtland Warbler management due to its slow growth and poor form on

these sites. When managing for Kirtland Warbler, however, consideration could be given to opportunities for the entire barrens community, e.g. large grass openings or savannah.

2. Convert Red Pine to Jack Pine

General criteria used to identify suitable stands:

- Red pine present age class 60 – 80. (Consideration could be given to younger stands.)
- PVCd - PVCd/PArVHa. (NLP)
- PVE – PArV. (EUP)
- Aspen not present in the overstory and or understory.

Stands of red pine, that are in the 12 – 18 inch category and occur on the PVCd, PVCd/PArVHa, PVE/PArV, and PArV forest habitat types, can be clearcut and replanted to jack pine. After harvest, the area can be trenched and hand planted to jack pine at a stocking level of about 1,200 trees/acre. Machine planting is an option in lieu of hand planting. Herbicide application is generally not required on these forest habitat types.

3. Convert from "Classic" Red Pine to "Natural" Red Pine

General criteria used to identify suitable stands:

- Red pine present 60 – 80 years of age. (Consideration could be given to younger stands.)
- The stand is currently a red pine plantation. ("classic management").
- Presence of other species in the overstory and or understory such as jack pine, oak and white pine.
- Little or no aspen present in the overstory and or understory.
- PVCd – ParVVb forest habitat types. (NLP)
- PVE - PArVAa forest habitat types. (EUP)

Depending on cone production, site quality, weather, and other factors a shelterwood cut can lead to "natural" red pine regeneration.

For mature stands of plantation red pine that currently exist on PVCd or PVE, opportunities may exist to change from "classic" to "natural" red pine management. Stands that are approximately 60 - 80 years old, and contain a mixture of other species in the overstory or understory, can be managed to increase these species. Prescribing a shelterwood or seed tree cut and leaving a mixture of trees in the overstory for seed (where possible), will help sustain stand diversity. Scheduling the timber harvest for the snow-free period will enhance soil scarification and create a seedbed better suited for oak and pine regeneration. Planting red pine and jack pine seedlings, and acorns, could be scheduled as a follow-up if natural regeneration of these

species is found to be insufficient. Mechanical scarification and direct seeding can also be considered if conditions warrant. Prescribed burning is also an option for site preparation. A "cool" under-burn can be used before or after a timber harvest to reduce logging slash, thick needle buildup, and/or hardwood competition. Note that converting from "classic" red pine management to "natural" management will most likely result in less red pine volume in future stands. It is important that a plurality of red pine be re-established so as to maintain this mesic conifer component. On inland dune complexes in the EUP, primarily the PVE habitat type, where fire can be easily controlled, prescribed burning should be used as a means of controlling vegetation and encouraging natural regeneration.

4. CONVERT "OFFSITE" ASPEN TO "NATURAL" RED PINE

General criteria used to identify suitable stands:

- Aspen present older than 40 years of age.
- Poor stocking of aspen. (A1, A2, A4, A5, A7)
- Little or no white pine in the understory.
- PVCd - PArVHa forest habitat types. (NLP)
- PVE - PArV/PArV-Ao forest habitat types. (EUP)

Aspen stands, both quaking and big tooth, that occur on the PVCd, PVCd/PArVHa, PArVHa, PVE, PVE/PArV, and PArV habitat types are often of poor quality. In many instances, where a shrub understory such as beaked hazel, witch hazel, and nannyberry, utilized by some wildlife species such as ruffed grouse, is lacking, it may be more desirable to convert these aspen stands to stands containing a mixture of other species with a plurality of red pine. Aspen is eliminated through natural mortality. White pine could be underplanted in some aspen stands where practical (primarily on the PArVHa site). Red pine could be planted in variably stocked aspen stands (in openings and in areas of low stocking and/or declining quality) either in patches or as single trees. As aspen stands further decline, the opportunity to increase the overall percentage of mesic conifers, and especially red pine, will increase. It is important that a plurality of red pine be re-established to maintain a mesic conifer component. Once the aspen component is virtually eliminated and the red pine reaches a sufficient size, prescribed burning may be an option for stimulating additional reproduction and eliminating deciduous competition. On inland dune complexes in the EUP, primarily the PVE habitat type, where fire can be easily controlled, prescribed burning should be used as a means of controlling vegetation and encouraging natural regeneration.

5. Convert "Offsite" Aspen to "Classic" Red Pine

General criteria used to identify suitable stands:

- Aspen present older than 40 years of age.
- Denser, yet poor quality aspen stocking density. (A3, A6, A8, A9)
- Little or no white pine in the understory.
- PArVHa forest habitat types. (NLP)
- PVE - PArV/PArV-Ao forest habitat types. (EUP)

Aspen stands, with higher stocking densities, require clearcutting, an herbicide application followed by trenching and planting to establish red pine. Despite an herbicide application, some aspen and other broad leaf trees are likely to survive, providing some degree of species mixture.

6. Convert Oak to "Natural" Red Pine/Oak Mix (NLP only)

General criteria used to identify suitable stands:

- Oak present at least 50 years of age.
- PVCd - PArVVb forest habitat types.

Oak stands, primarily northern pin oak, white oak, and red oak, occurring on the PVCd, PVCd/PArVHa, and or PArVHa habitat types, are often of marginal quality. In the past, most of these oak stands contained mixtures of red, jack and white pine, and oak, most of which were removed by early logging and subsequent slash fires. Much of the oak currently occupying these sites resulted from stump sprouting or seeding while pine is generally absent. In some instances, it will be desirable to convert these relatively pure oak stands to stands containing oak and a variety of conifer species. Oak stands can be converted to mesic conifers by clearcutting and herbiciding, or by relying on natural oak mortality. On the northern pin oak-dominated sites (primarily on the PVCd and PVCd/PArVHa habitat types), red pine could be planted in areas of low stocking and/or declining oak quality, either in patches or as single trees. As these northern pin oak-dominated stands further decline in quality, there will be opportunities to increase the overall percentage of mesic conifers. It is important that a representative amount of red pine be re-established as needed. Northern pin oak, a prolific stump sprouter, can be maintained, where desired, by cutting patches scattered throughout the stands. On the more nutrient and moisture rich PArVHa/PArVVb and PArVVb sites which contain increasing amounts of white and red oak, underplanting white pine has been very successful and that, combined with planting red pine in areas of low stocking and/or openings, can increase the mesic conifer component to a level more appropriate for these habitat types. Prescribed burning may be an option for stimulating additional red pine reproduction and eliminating some oak competition.

7. Convert Oak to "Modified Classic" Red Pine/Oak Mix (NLP only)

General criteria used to identify suitable stands:

- Oak present older than 50 years of age.
- PArVHa - PArVVb forest habitat types.

On forest habitat types higher in quality than PVCd and PVCd/PArVHa where higher survival of red pine is expected, oak stands can be converted to a red pine/oak mixture by clearcutting and using a "modified classic" planting technique. Once the timber harvest is completed, the area can be trenched and planted around the oak stumps at a high stocking of up to 1,000 trees/acre, with the expectation that some will be shaded out. Since most oaks produce abundant stump sprouts when cut, oak will be a major component of the new stand, growing along and with the newly planted red pine. The subsequent levels of species mixture will be dynamic based on various management factors, but there should be a goal of maintaining, at minimum, a red pine seed source.

8. Set Aside Red Pine For Biodiversity (Old Growth Potential)

General criteria used to identify suitable stands:

- Red pine present older than 80 years of age.
- PVCd - PArVVb (Including PArVCo and PArVCo/PArVVb) forest habitat types. (NLP)
- PVE - PArVAa forest habitat types. (EUP)

Although red pine stands older than 80 years are most likely to be of "natural" origin, younger stands may also be the result of natural regeneration (non-plantations) as well. In addition, silvicultural practices within red pine plantations, such as thinning and under planting white pine, can also result in a stand that appears to be the result of natural regeneration. Therefore, areas set aside for biodiversity need not always be older than 80 years of age and in some instances may include former plantations. This is not to say that priority should not be given to stands which already contain high inner-stand diversity and have not been artificially simplified. However, in some regions, the availability of such stands is limited and the conversion of artificially generated stands should be explored. Regardless of origin, fire will likely be needed to improve/maintain both the quality of the stand (ensuring that natural processes are part of the stands management) and to ensure red pine is a component. Under-burning, using a "cool" burn, can be used to reduce hardwood competition as well as to create a seedbed more conducive for pine regeneration. On inland dune complexes in the EUP, primarily the PVE habitat type, where fire can be easily controlled, prescribed burning should be used as a means of controlling vegetation and encouraging natural regeneration.

9. Maintain "Classic" Red Pine

General criteria used to identify suitable stands:

- Red pine present 60 – 80 years of age. (Consideration could be given to younger stands.)
- The stand is currently a red pine plantation. ("classic management") (> 79% BA).
- Little or no existing deciduous understory or overstory. (M or A types)
- Little or no existing deciduous (O, M or A), hemlock, or white pine, in the understory nor overstory. (EUP)
- PArVHa - AFOCa forest habitat types. (NLP)
- PArV/PArV-Ao – AFOAs forest habitat types. (EUP)

Classic red pine management can be defined as replacing an existing mature stand of red pine, or a mixed stand of pine with a red pine plurality, usually by row planting. This type of management involves clearcutting the stand once it reaches about 16 inches DBH. After the harvest, and depending on the site (most likely on ATFD, AFPo, AFOAs, AFO, AFOCa, PArV, and PArVVb habitat types), herbicide may be necessary to control the herbaceous vegetation and/or encroaching hardwood brush (e.g. cherry, maple, aspen). Once the herbicide treatment has been completed, the area will be trenched and hand planted to red pine at a stocking of about 1,000 trees per acre. Red pine, in association with clumps of hemlock, more common in the EUP particularly on PArV-Ao, should remain undisturbed.

10. Convert Red Pine to White Pine and or Mixed White Pine/Red Pine

General criteria used to identify suitable stands:

- Red pine present 60 – 80 years of age. (Consideration could be given to younger stands)
- White pine present in the understory.
- PArVHa - PArVVb (including PArVCo, PArVCo/PArVVb) forest habitat types. (NLP)
- PVE/PArV - PArVAa/PArV forest habitat types. (EUP)

White pine is well suited for a broad range of forest habitat types. However, its ability to withstand a high water table, which occurs on PArVCo, PArVCo/PArVVb types, makes it a particularly good candidate for these sites where its growth is very rapid. Stands of 60 - 80 year old red pine can be converted to white pine and or a white pine/red pine mixture depending on site conditions. This can be accomplished by prescribing a shelterwood cut that leaves a mixture of both red pine and white pine (if present) in the overstory. At times, white pine trees from adjacent stands can often supply the seed needed to establish white pine in these stands. Because white pine is more shade tolerant and longer lived than red pine, the percentage of white pine in these stands will increase over time. On the wetter PArVCo sites, where there is a relatively stagnant (often adjacent to wetlands) seasonally high water table, converting to white pine is strongly recommended. Scheduling the timber harvest for the snow-free period will increase soil scarification, creating a seedbed better suited for pine regeneration. Planting red

pine and white pine can be scheduled as a follow-up if natural regeneration is found to be insufficient after a reasonable period. Mechanical scarification and direct seeding could also be considered if conditions warrant. Prescribed burning is also an option for site preparation. A “cool” under-burn can be used before or after a timber harvest to reduce logging slash, a thick needle buildup, and or hardwood competition. Note that converting from “classic” to “natural” red pine management will most likely result in less red pine volume in future stands. On inland dune complexes in the EUP, primarily the PVE habitat type, where fire can be easily controlled, prescribed burning should be used as a means of controlling vegetation and encouraging natural regeneration. Red pine in association with clumps of hemlock, more common on PArVCo and ParV-Ao, should remain undisturbed.

11. Convert Red Pine to Northern Hardwoods

General criteria used to identify suitable stands:

- Red pine present 60 – 80 years of age.
- Northern hardwood in the understory (M2 and or M3).
- PArVVb - AFOCa forest habitat types. (NLP)
- PArVAa - AFOAs forest habitat types. (EUP)

Stands of 60 - 80 year old red pine on PArVAa and PArVVb habitat types can be converted to red maple and beech-dominated stands, although sugar maple can be present (usually very poor quality), if a well established understory of northern hardwood seedlings and saplings exists beneath the pine overstory. Likewise, red pine on AFOAs, AFPo, ATFD, AFOCa, and AFO habitat types can be converted to sugar maple-dominated stands if the appropriate understory exists. Depending on the location of these stands, the overstory red pine could be clearcut which would then release the hardwood seedlings and saplings. However, be aware that clearcutting mature red pine stands are often visually disruptive and logging damage to the hardwood seedlings and saplings can be substantial. Such clearcut sites will initially be colonized by pin cherry, blackberry and raspberry and it may take several years before the hardwood regeneration begins to assume dominance. To minimize the visual impact and to reduce logging damage to the hardwood regeneration, scheduling a modified removal cut, where varying amounts of the overstory red pine are removed, is recommended. Subsequent management could harvest the remainder of the overstory red pine or some of the trees could be left as “veterans”, either singly or in groups, scattered among the younger hardwood forest. Red pine in association with clumps of hemlock, more common on the ATFD habitat type in the EUP, should remain undisturbed.

12. Convert Red Pine to Aspen

General criteria used to identify suitable stands:

- Red pine present 60 – 80 years of age.
- Aspen present (at least 10 basal area)
- PArVVb - AFOCa, PArVCo forest habitat types. (NLP)
- PArVAa - AFOAs forest habitat types. (EUP)

Stands of 60 - 80 year old red pine that contain scattered aspen (in clones or as single trees) on more productive sites, can be converted to aspen stands relatively easy. These stands should contain at least ten square feet of basal area of aspen that is uniformly spread throughout the stand. Once these stands are clearcut, the resulting aspen sprouts will quickly expand and dominate the site. Nothing else will need to be done. Red pine in association with clumps of hemlock, more common on the ATFD, PArVCo habitat type, should remain undisturbed.

13. Convert Red Pine to Oak or Oak/Red Pine Mixtures (NLP only)

General criteria used to identify suitable stands:

- Red pine present age class 60 – 80.
- PArVHa - PArVVb forest habitat types.
- Oak regeneration present in the understory (O2 or O3).

Red Pine can be converted to a red pine/oak mixture if a well developed oak sapling understory exists. Depending on the location of these stands, the overstory red pine could be clearcut releasing the oak saplings. Be aware that clearcutting mature red pine is often visually disruptive and logging damage to the oak regeneration can be substantial. Oak, however, sprouts prolifically and damaged oak saplings will quickly re-sprout and should respond well to release. To minimize the visual impact, and to reduce logging damage to the oak regeneration, scheduling a modified removal cut, where varying amounts of overstory red pine are removed, is recommended. Future management could harvest the remainder of the overstory red pine or some trees could be left as “veterans,” either singly or in groups, scattered among the younger oak forest.

14. Convert Grass Openings to Red Pine/Other Mesic Conifer Mix

General criteria used to identify suitable stands:

- Upland brush or grass.
- PArVVb - AFOCa forest habitat types. (NLP)
- PArVAa - AFOAs forest habitat types. (EUP)

Existing grasslands (presence of a thick sod layer), as well as previously-cut areas that have not properly regenerated due to heavy elk browsing (this may include M1 or M2 stands that are being browsed down by elk), could be converted to an upland mesic conifer mixture where desired. Red

pine, white pine, and white spruce, singly or in combinations, could be hand planted at a stocking of about 400 – 500 trees/acre. Over time such stands would probably develop a hardwood understory that could be managed for hardwood, mesic conifers or a mixture thereof.

GUIDELINE IMPLEMENTATION

In order to ensure consistency in use across multiple divisions and various management units, it is recommended that the red pine community guidelines be adopted for use within the MDNR. This process will require a Decision Support System (DSS) from which resource managers can easily access the guidelines and tools presented in this report, a system for monitoring implementation of the guidelines, a feedback loop through which guidelines can be updated/modified as the knowledge base grows and or cultural values change, and a communications plan that takes into account the need for staff training and public/interest group outreach. This section will address each of these issues in more detail.

Economic, Biological, Forest Health, and Social Implications of the Red Pine Guidelines						
Guide-line	Management	Total Acres[1]	Timber Value Impacts[2]	Biological Impacts	Forest Health Impacts	Social Impacts
1	Convert Red Pine to Barrens/Grass	7,436	No Timber Revenue after Harvest	Potential to restore barrens where 41 species listed as state threatened, endangered, or special concern utilize barrens ecosystems for habitat.	None in grassland areas, possible risk for sphaeropsis where super canopy RP are near other RP/JP.	Aesthetic value of large trees may result in social conflicts when clear cutting in some regions.
2	Convert Red Pine to Jack Pine	4,956	Significantly Less Timber Revenue	Potential to restore dry northern forest and oak pine/barrens communities. Will also provide additional opportunities for Kirtland's Warbler management	Possible risk for sphaeropsis where super canopy RP are near other RP/JP in pockets of forest.	Aesthetic value of large trees may result in social conflicts when clear cutting in some regions.
3	Convert from Classic Red Pine to Natural Red Pine	9,460	Somewhat Less Timber Revenue	Potential to restore dry northern and dry music forest communities where 31 state threatened, endangered, or special concern species have as part of their habitat requirements.	Some risk particularly for sphaeropsis if older red pine are left and significant competition deciduous is present.	Conflicts with hunters possible particularly on PArVVb and PArVAa habitat types which often have high potential for game species habitat management.
4	Convert "Offsite" Aspen to Natural Red Pine	5,228	Somewhat More Timber Revenue	Potential to restore dry northern and dry-mesic forest communities.	Eliminate stands of aspen at high risk for disease and mortality. Some risk for red pine sphaeropsis if older ones are left and where deciduous competition.is present.	Some conflicts with hunters possible because of the perception that good aspen acres are being lost.
5	Convert "Offsite" Aspen to Classical Red Pine	9,192	Significantly More Timber Revenue	Loss of some biodiversity by moving toward single species management.	Few, particularly if the red pine are all even aged.	Some conflicts with hunters possible because of the perception that good aspen acres are being lost.
6	Convert Oak to Natural Red Pine/Oak Mix	16,000	Somewhat More Timber Revenue	Will help to restore the red pine (mesic conifer) component to dry northern and dry-mesic forest oak communities.	Few, particularly if the red pine are all even aged.	Some conflicts with hunters possible because of the perception that oak (deciduous) acres are being lost.
7	Convert Oak to Modified Classic Red Pine/Oak Mix	80,000	Significantly More Timber Revenue	Will help to restore the red pine (mesic conifer) component to dry northern and dry-mesic forest oak communities.	Few, particularly if the red pine are all even aged.	Some conflicts with hunters possible because of the perception that oak (deciduous) acres are being lost.
8	Set Aside Red Pine for Biodiversity	24,882	No Timber Revenue	Potential to restore old growth dry northern and dry-mesic communities which are among the rarest naturally occurring forest communities in the Great Lakes region.	Possible risk for sphaeropsis where super canopy RP are near other RP/JP.	There are social pressures to preserve old growth stands. There are also social pressures to harvest some of these stands.
9	Maintain Classic Red Pine	25,404	No Change	Minimal on hardwood sites with little understory development where RP will help to restore deciduous species. Negative impacts may be significant if extensive herbicide is applied.	Some risk particularly for sphaeropsis if older red pine are left and significant competition deciduous is present.	Aesthetic value of large trees may result in social conflicts when clear cutting in some regions.
10	Convert Red Pine to White Pine and/or White Pine/Red Pine Mix	2,832	Significantly Less Timber Revenue	Potential to restore dry northern and dry-mesic forest communities.	Minimal for both RP and WP. WP develops best in partial shade and is not susceptible to sphaeropsis.	Minimal.
11	Convert Red Pine to Hardwood ****	11,082	Significantly Less Timber Revenue	Potential to restore a hardwood community and in all likelihood increase the amount of biodiversity on the site.	Will eliminate some stands of RP at risk due to stress from competition.	Aesthetic value of large trees may result in social conflicts when clear cutting in some regions.
12	Convert Red Pine to Aspen	5,320	Significantly Less Timber Revenue	May increase the biodiversity on some sites.	Minimal.	Aesthetic value of large trees may result in social conflicts when clear cutting in some regions.
13	Convert Red Pine to Oak and/or Oak/Red Pine Mix	7,690	Significantly Less Timber Revenue	Will help to restore the oak component to dry northern and dry-mesic forest red pine communities. May increase biodiversity on some sites.	Few, particularly if the red pine are all even aged.	Aesthetic value of large trees may result in social conflicts when clear cutting in some regions.
14	Convert Grass/Upland Brush to Red Pine/Other Mesic Conifer Mix	1,252	Significantly More Timber Revenue	Has potential to begin to restore mesic northern forest communities by allowing deciduous species to be re-established.	Trenching is needed to establish RP. White grubs may be present on sites with a heavy sod layer.	Conflicts may arise if openings are being used for berry picking or hunting.

[1] Estimate based on half the stands being digitized.

[2] Economic Impacts are based on current timber values over an 80 Year period.

Figure 11: *Biological, forest health and social implications of the red pine guidelines.*

DECISION SUPPORT SYSTEM (http://www.mcgi.state.mi.us/forestHabitatTypes)/GUIDELINE USE

A web based DSS, constructed using ArcIMS™ software, from which forest habitat types maps were viewed, was modified to allow several data sets, created for and/or used in this project, to be accessed. ArcIMS™ allows the creation of web applications which include interactive maps, allowing the end user to pan, zoom, and identify features derived from GIS data sets.

Since the red pine guidelines were developed in concert with the forest habitat types and Landscape Management Units (also based on the forest habitat types), it was decided to incorporate the results of

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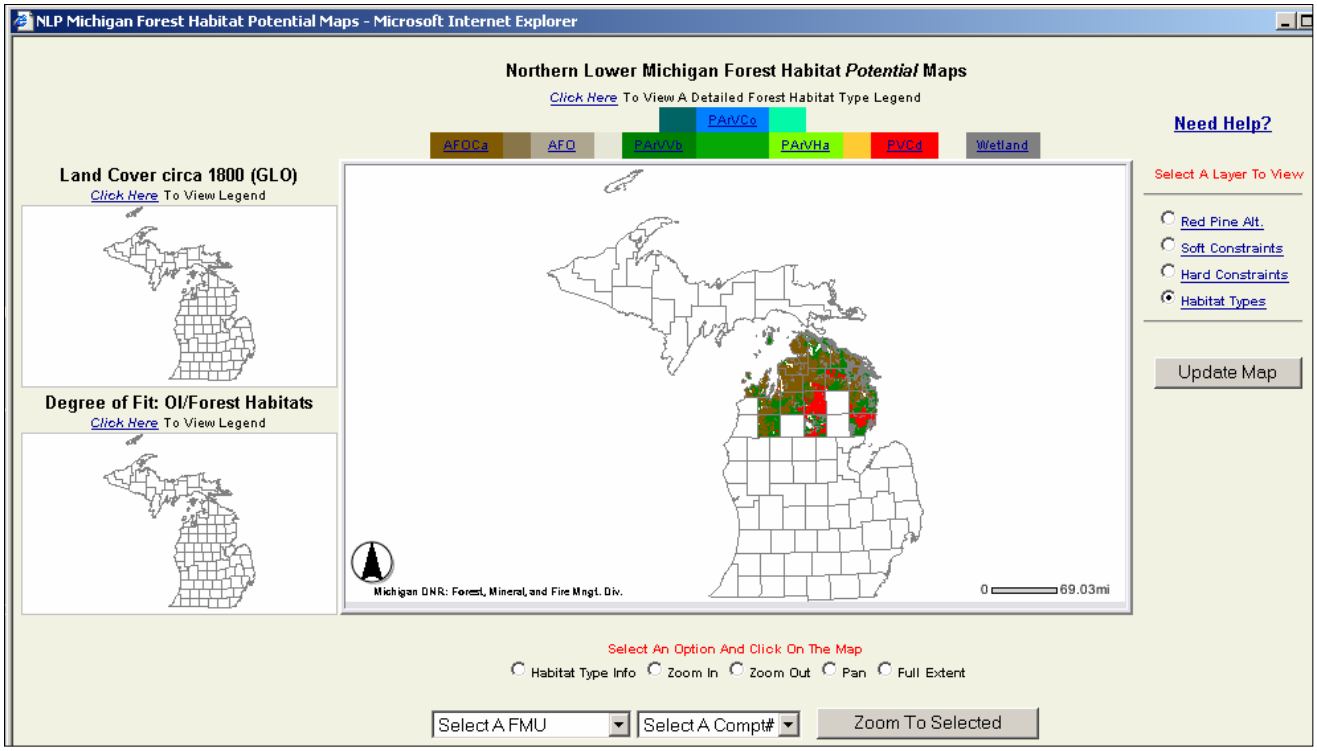


Figure 12: *Web based decision support system which will house the red pine guidelines and subsequent maps*

this project into the habitat mapping decision support systems being developed for eastern Upper and northern Lower Michigan. This decision also seemed reasonable because the DSS would allow resource managers to identify forest habitat types and the potential for various future conditions at a particular region and once doing so, have access to guidelines which are based on these types.

In addition, as a window into the future potential of a site, the forest habitat types provide insights into past potential. To provide additional context for the past and future perspectives that the forest habitat types provide, a second and third map frame, displaying the circa 1800 and the relative

“suitability” of the current condition (based on OI and the ecological range of various species) was added (Figure 12). Therefore the final DSS is based on the premise that “sound” resource management decisions are often based on an understanding of past, present, and potential future conditions for a region and the result provides this information.

A spatial dimension was added to the red pine guidelines themselves by using the criteria outlined earlier in this report to develop tabular and spatial queries which isolate stands or parts of stands as being suitable for a particular type of management. This layer, called “Red Pine Alt.” (red pine alternatives), which is accessible from the right side of the application (Figure 12), “…depicts areas suitable for management involving red pine on State Forest lands during the next decade.” The layer also provides a link to the red pine guidelines generated in this report.

Although resource managers will initially have access to the forest habitat types and the red pine alternatives through a web based DSS, these layers and documents will be added to the Integrated Forest Monitoring and Prescription (IFMAP) desktop computer application. This application will give resource managers easy access to the tools and guidelines developed for this project at all levels of the decision making process. Once the IFMAP application is fully rolled out to DNR staff, the DSS will likely not be needed by forest managers but could still be used to share information with the public and interest groups unable to access the DNR network and the IFMAP system.

Although the layers in the forest habitat type decision support systems will provide a wide range of information that can aid resource managers in decision making, this information is not intended to be a substitute for field work but rather a supplement to it. The information in the DSS does however provide a multi-level perspective that is often difficult to ascertain in the field, at the stand level, and therefore facilitates multi-scale decision making.

With the aid of this report (much of the information discussed below has been already assembled for this report), the DSS and/or the IFMAP application, it is recommended that resource managers use the following four step process, although determining the past and present condition can be done at the same time, to evaluate community conditions and opportunities before implementing the red pine guidelines on a stand, compartment, or unit level:

- **Current Condition**: Determination of the current forest/non-forest community conditions on State Forest lands at the regional and local levels. Forest and non-forest inventory data, collected during IFMAP stage 1 and 2, and the statewide land cover map within the IFMAP system, will provide a detailed picture of current cover conditions. The MIWILD database provides a means of examining the current condition of wildlife habitats. The existing OI and FIA databases, particularly where data have not been collected as part of the IFMAP system, will also be useful.
- **Past Condition**: After the IFMAP Stage 1 field examination, determine the past community conditions on State Forest land at the regional (Forest Management Unit, ecoregional) and local (compartment) levels. This should include both an examination and assessment of forest and non-

forest cover types and wildlife habitat. The red pine report, MIWILD database, and the MNFI circa 1800 cover type map, circa 1800 survey notes, all accessible from the DSS and IFMAP application, may provide the primary sources of information for this assessment (much of this information has already been summarized). Other sources of information include breeding bird surveys, fire disturbance history, archived Operations Inventory (OI) data, and Forest Inventory and Analysis (FIA) data. This assessment, including the recommendations in the red pine report, will influence the selection of areas for IFMAP Stage 2 inventory at the post Stage 1 meeting.

- **Potential Future Condition:** The DNR will be determining desired future condition of the state forest as part of the planning process required for Forest Sustainability. Once IFMAP becomes operational for the State Forest, at its post Stage 2 meeting the potential future condition for State Forest lands at the regional and local levels should be evaluated. The forest habitat type maps including soil attributes such as depth to water table, economic returns, risk of forest pest infestation, landscape management units, and management limitations such as the presence of a riparian corridor, archaeological site, and or a social constraint, will provide the primary sources of information for determining a potential future condition. The MIWILD database provides a means of examining the potential for wildlife habitats. These data will likely have the greatest influence on management decisions made during and after the IFMAP Stage 2 inventory. Once the forest habitat type(s) have been adequately confirmed, existing and desired age classes determined, red pine guidelines can be implemented.
- **Guideline Use/Compartment Review Process**: Once a complete assessment of the past, present, and potential forest/non-forest community condition has been determined in and around an area of interest, a decision can be made on the most appropriate red pine guideline(s) to use. This will likely occur at the post Stage 2 meeting which equates to the pre-compartment review in the current OI process. When discussing the selection of guidelines during the compartment review process, the data gathered on the past, current, and potential future condition of the resource should be presented as rationalization for the decision making process. Both a regional and local level perspective should be presented, providing a broader context for the decision making process.

Monitoring and Feedback Loop

To ensure that the guidelines developed in this report are implemented consistently and appropriately, it will require monitoring by forestry and wildlife planners and Timber Management Specialists (TMSs). During and after the compartment pre-review, the planners, using the DSS and the IFMAP system, will monitor stand level decisions, flagging areas which could have used the red pine guidelines and or have possibly misused the guidelines. Flagged areas should be brought to the attention of resource managers to discuss alternate prescriptions or clarify the reason for deviating from the guidelines. The TMSs will be “on the ground” ensuring that the appropriate sivilcultural actions have been

prescribed with respect to the red pine guidelines and that timber sale specs are met and a cultural follow up is done. In addition, TMSs will provide critical guidance on how the red pine guidelines can best be implemented (e.g. specifics on planting and other silvilcultural actions). The planners will also be required to monitor broad trends ensuring that DNR management units are meeting their goals of maintaining, increasing, or decreasing the amount and proper age-classes of red pine in their respective units as recommended by the Statewide Council through this report. Discrepancy/conflict should be resolved through interaction with resource managers, planners, and TMSs. If conflict cannot be resolved, the discussion should be elevated to an ecoteam for resolution. The ecoteam will determine how it should be resolved by enforcing existing guidelines and goals or if the resolution requires a change in the guidelines and/or goals set for a unit. As other ecoteams and or groups develop forest community guidelines, these should be done with the understanding that the red pine guidelines may need to be updated or adjusted based on the findings of these other workgroups. Proposals can also be submitted to the ecoteam requesting addition, revision, and/or updating of guidelines and unit goals/targets. This is critical since new knowledge and shifting cultural values will likely identify needed alterations in the guidelines and possibly the overall goals set for DNR management units. In addition, interaction with special interest groups and the public will identify areas which need revision or change. These suggestions as well should be addressed by the ecoteam. The SWC should be kept apprised of changes made to the red pine guidelines by way of the ecoteam representative. Changes in targets or goals for red pine require the approval of the Statewide Council prior to final implementation.

COMMUNICATIONS PLAN

In an effort to communicate the tools and recommendations found generated during this project to MDNR staff and the public, a communications plan consisting of three major phases will be utilized for this project. Phases one and two will have some temporal overlap.

Phase I: MDNR Staff

Introduce and train MDNR staff in the use of the red pine guidelines prior to rolling out the guidelines to the public and special interest groups. This will allow resource managers in the DNR to familiarize themselves with the guidelines and their use, particularly since they will be exposed to several new concepts concurrently. Once familiar with the guidelines, staff will have the understanding to better communicate information about the project to special interested groups and the public. Much of this communication will likely occur at the compartment review.

The process of rolling out the red pine guidelines in the EUP and NLP began with some exposure to the project during the forest habitat type training that occurred in August 2004. This is particularly appropriate because:

- The red pine guidelines were developed in and around the forest habitat types.

- Presenting these guidelines at the habitat type training demonstrated how forest habitat typing can be used to make both local and regional decisions. The web-based decision support system discussed in the previous section, which houses the forest habitat type maps, also contain both the red pine guidelines and other subsequent products from this project.

By the spring of 2004, the proposed red pine guidelines were introduced at WL and FMFM Division staff meetings. Formal training is recommended to take place on a FMU by FMU basis, interacting with both forestry and wildlife staff (fisheries and parks staff are also encouraged to attend where appropriate), much like what was done in the Atlanta and Sault Ste. Marie units. The use of the DSS, this report, and the IFMAP system will be discussed at these trainings. In addition, training will be supplemented with field visits to provide "on the ground" examples of the use of the red pine community guidelines. Prior to formal training, however, it is strongly recommended that the Statewide Council communicate to resource managers the importance of implementing/institutionalizing the guidelines and tools outlined in this report into the management decision-making process (e.g. compartment review) of the DNR due to the shift in overall direction the red pine guidelines require.

It should be noted that this project has been reviewed by both the NLP and EUP Ecoteams. This included review of documentation and several comment periods, presentations and interactive meetings, and a field trip. The chair of the NLP Ecoteam and its members has indicated that this project has met the criteria listed in the original SC charge. Two presentations were also given to the SWC, one of which included a field trip. Prior to, during, and after both presentations, the SWC was given the opportunity to comment on this report.

Phase II: Various Interest Groups/Other State and Federal Governments

Interaction with special interest groups has begun with the introduction of the red pine guidelines and the tools developed within this project to several groups through informal meetings and communications. Communications will also begin to occur at compartment reviews once guidelines are rolled out to DNR staff. The DSS has and will continue to serve as a vehicle for communication between the DNR and its various publics it serves.

The USDA Forest Service, and the Wisconsin and Minnesota DNR have expressed interest in the red pine community project. As a result, these agencies have remained informed about the project and its emerging tools, particularly the forest habitat type maps. Additional interaction will likely occur between the MDNR and these agencies as this project progresses.

Phase III: General Public

In addition to the compartment review process, the public will have access to the guidelines generated in this report through an internet based DSS much like the one discussed earlier. Discussion of guidelines can also take place at open houses as well. Depending on interest, public meetings/field trips may need to be scheduled. This type of interaction would likely begin to occur in late 2004 and 2005.

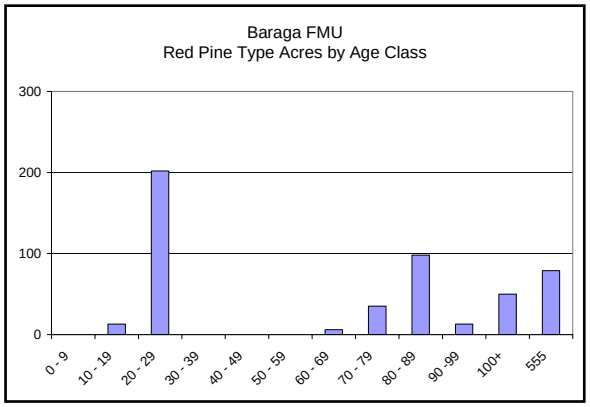
Appendix

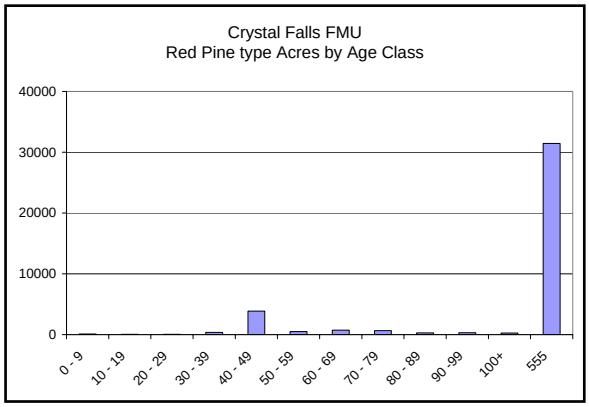
Red Pine Age Classes by Forest Management Units

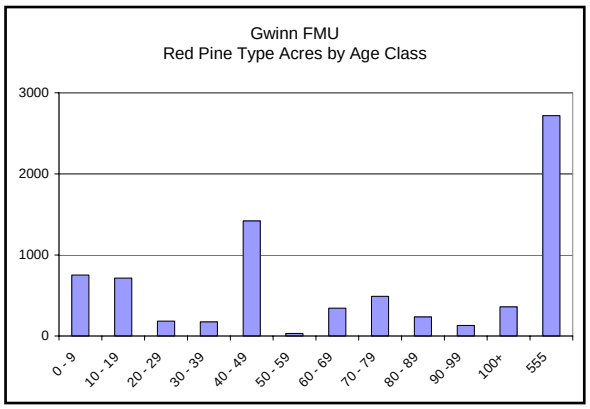
Acres of Red Pine Type by Age Class

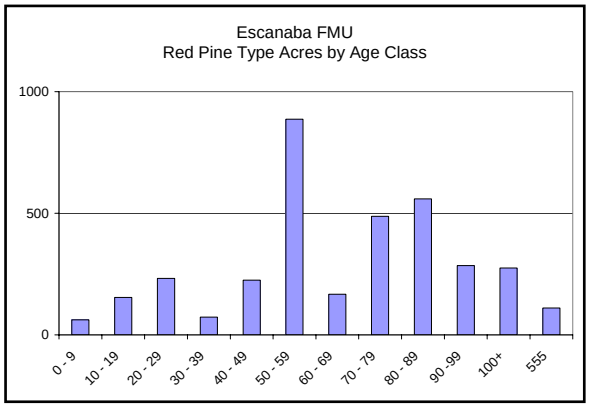
FMU	0 - 9	10 - 19	20 - 29	30 - 39	40 - 49	50 - 59	60 - 69	70 - 79	80 - 89	90 -99	100+	555
Baraga	0	13	202	0	0	0	6	35	98	13	50	79
Crystal Falls	105	46	57	345	3858	483	732	646	281	321	246	31452
Gwinn	754	715	184	174	1419	33	344	489	235	132	360	2718
Escanaba	62	154	232	73	225	887	167	487	559	285	275	110
Shingleton	1711	636	137	709	11828	6582	4052	3274	1741	1939	1212	3712
Newberry	377	195	172	285	2499	1946	3083	4023	2939	2669	1848	3881
Soo	3107	971	397	370	2396	695	5691	1280	207	405	233	144
Gaylord	451	533	1448	829	16558	2467	2797	4201	580	255	456	438
Atlanta	434	1071	596	950	4264	1975	9241	5363	1668	673	505	2488
PRC	0	289	216	107	1128	226	1787	4408	2205	398	298	1204
Traverse City	1237	3051	1827	4367	14300	5982	3583	4001	1720	418	521	733
Cadillac	503	538	1367	1086	8982	2825	2284	1027	164	246	194	1363
Grayling	605	1710	812	1269	4066	2103	3457	3115	2052	1088	585	282
Roscommon	1684	836	249	822	924	347	3276	5270	2850	828	262	377
Gladwin	136	232	153	379	2161	1050	2293	1410	182	161	123	123

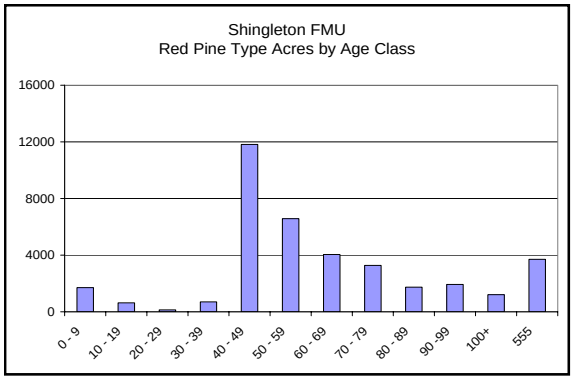
Forest management units should plan on final harvesting 50% of the 60 – 80 year age classes over the next ten to twenty years.










Shingleton FMU
Red Pine Type Acres by Age Class
16000
12000
8000
4000
0
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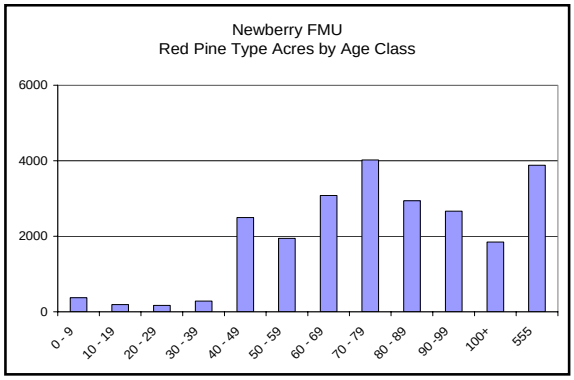
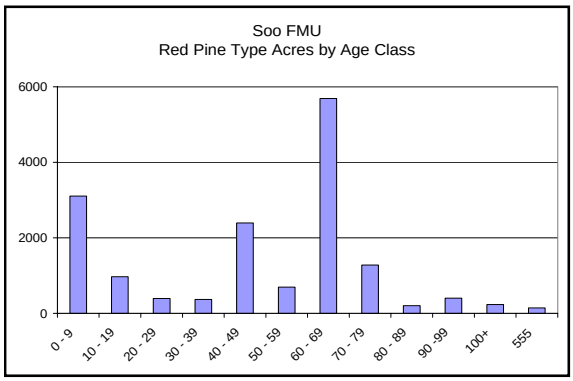
20 - 29
30 - 39
40 - 49
50 - 59
60 - 69
70 - 79
80 - 89
90 -99
100+
555


Newberry FMU
Red Pine Type Acres by Age Class
6000
4000
2000
0
0 - 9
10 - 19
20 - 29
30 - 39
40 - 49
50 - 59
60 - 69
70 - 79
80 - 89
90 -99
100+
555


Soo FMU
Red Pine Type Acres by Age Class
6000
4000
2000
0
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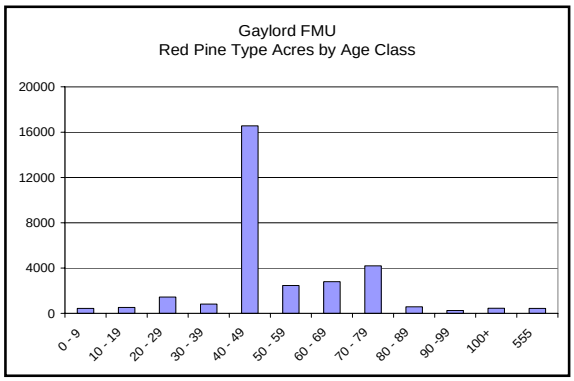
10 - 19
20 - 29
30 - 39
40 - 49
50 - 59
60 - 69
70 - 79
80 - 89
90 -99
100+
555


Gaylord FMU
Red Pine Type Acres by Age Class
20000
16000
12000
8000
4000
0
0 - 9
10 - 19
20 - 29
30 - 39
40 - 49
50 - 59
60 - 69
70 - 79
80 - 89
90 -99
100+
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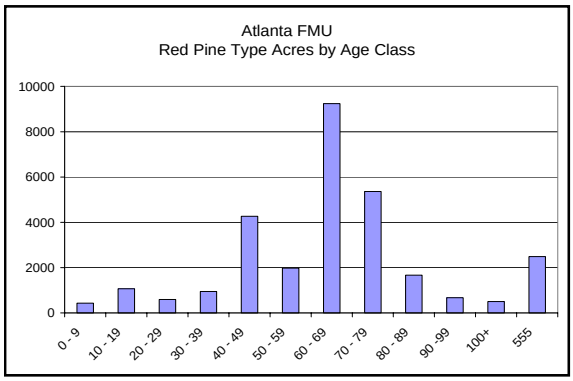
Atlanta FMU
Red Pine Type Acres by Age Class
10000
8000
6000
4000
2000
0
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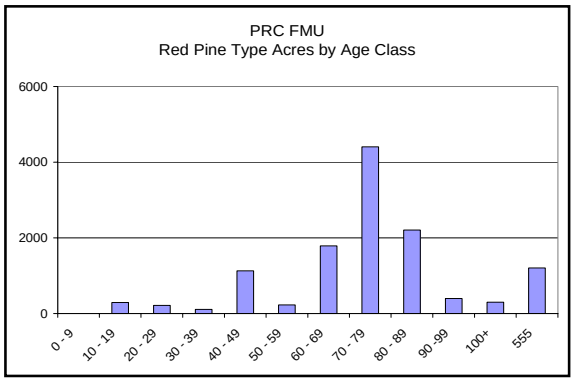
20 - 29
30 - 39
40 - 49
50 - 59
60 - 69
70 - 79
80 - 89
90 -99
100+
555


PRC FMU
Red Pine Type Acres by Age Class
6000
4000
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30 - 39
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60 - 69
70 - 79
80 - 89
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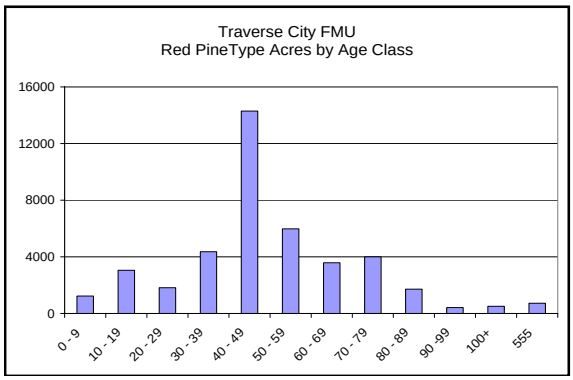
Traverse City FMU
Red PineType Acres by Age Class
16000
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8000
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50 - 59
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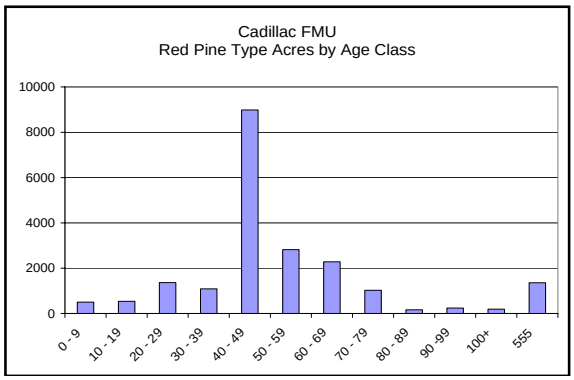
Cadillac FMU
Red Pine Type Acres by Age Class
10000
8000
6000
4000
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50 - 59
60 - 69
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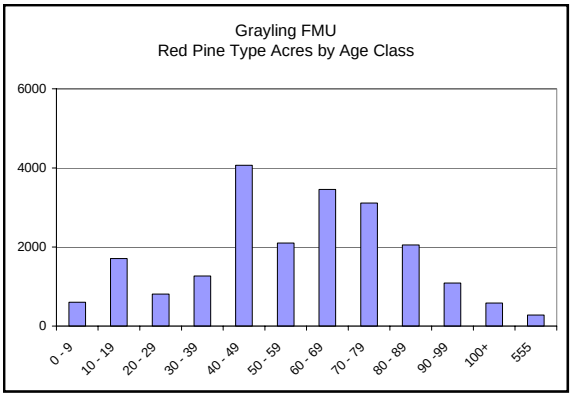
Grayling FMU
Red Pine Type Acres by Age Class
6000
4000
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10 - 19
20 - 29
30 - 39
40 - 49
50 - 59
60 - 69
70 - 79
80 - 89
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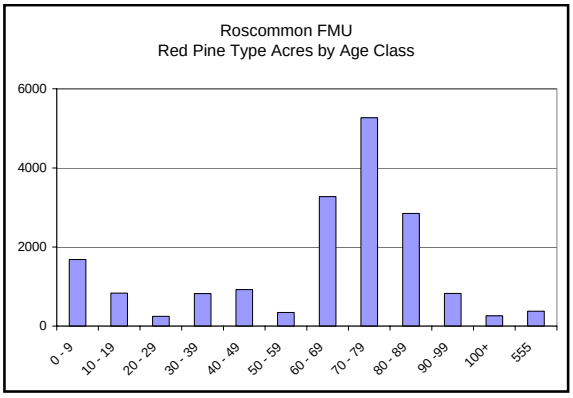
Roscommon FMU
Red Pine Type Acres by Age Class
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60 - 69
70 - 79
80 - 89
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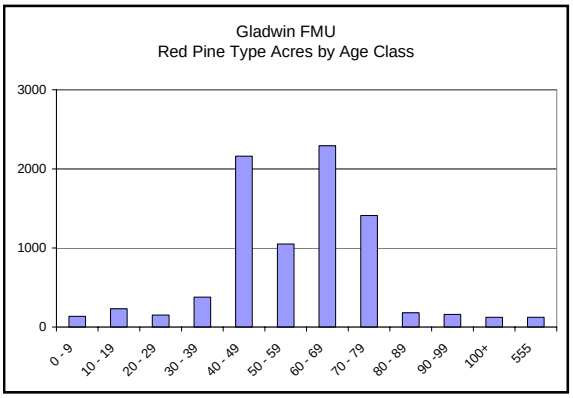
Gladwin FMU
Red Pine Type Acres by Age Class
3000
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70 - 79
80 - 89
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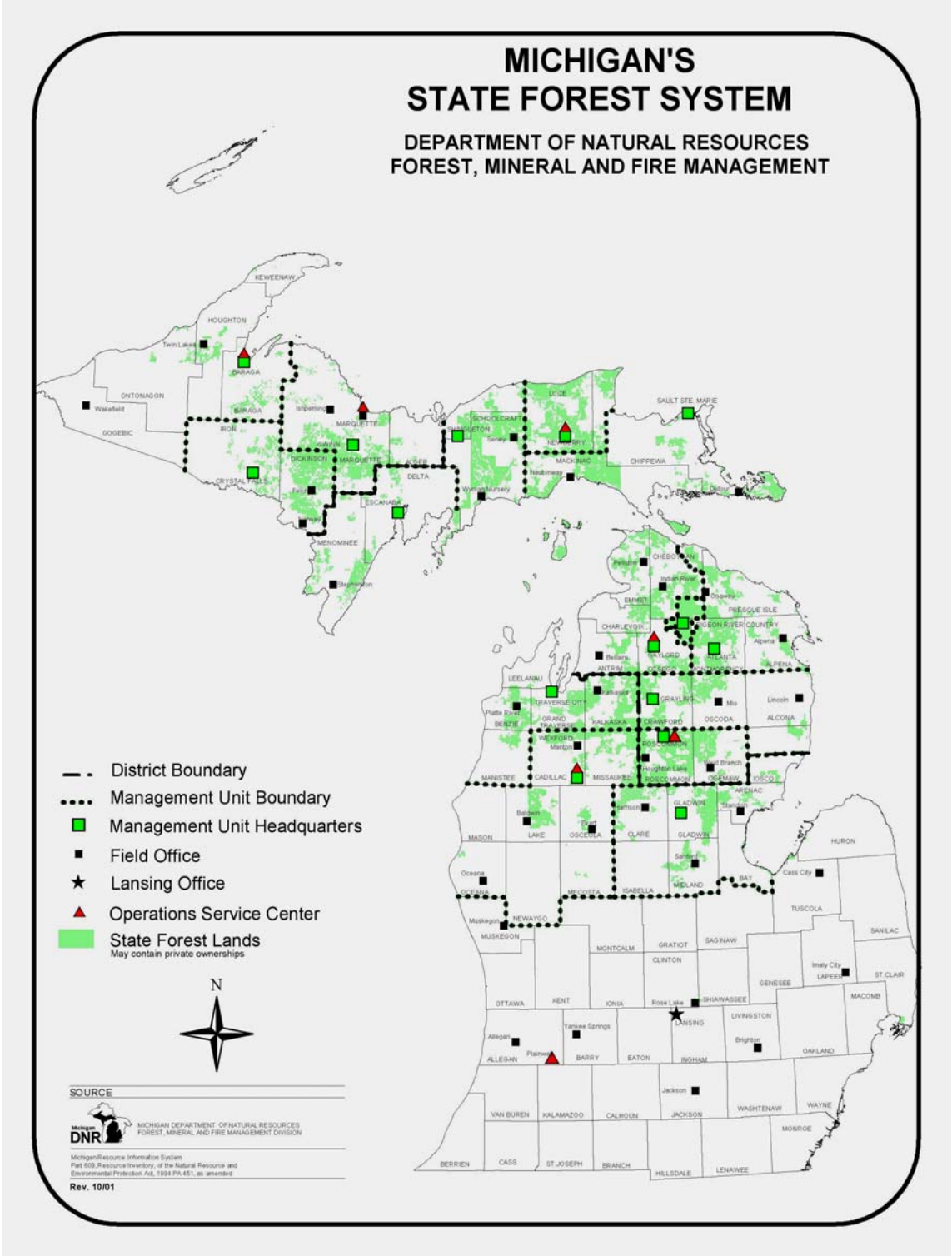
MICHIGAN'S
STATE FOREST SYSTEM
DEPARTMENT OF NATURAL RESOURCES
FOREST, MINERAL AND FIRE MANAGEMENT
District Boundary
Management Unit Boundary
Management Unit Headquarters
Field Office
Lansing Office
Operations Service Center
State Forest Lands
May contain private ownerships
N
SOURCE
MICHIGAN DEPARTMENT OF NATURAL RESOURCES
FOREST, MINERAL AND FIRE MANAGEMENT DIVISION
Michigan Resource Information System
Part 609, Resource Inventory, of the Natural Resource and
Environmental Protection Act, 1994 PA 451, as amended
Rev. 10/01

GLOSSARY OF TERMS

Barrens: land with poor soil and very few shrubs or trees.

Biodiversity: The spectrum of life forms and the ecological processes that support and sustain them. Biological diversity occurs at four interacting levels: genetic, species, community, and ecosystem.

The variety of living organisms considered at all levels of organization, from genetics through species, to higher taxonomic levels, also; the term encompasses the variety of habitats and ecosystems supporting the organisms, as well as the processes occurring within those systems.

Community: An assemblage of species living together in a particular area, at a particular time, in a prescribed habitat. Communities usually bear the name of their dominant plant species, but include all the microbes, plants, and animals living in association with the dominant plant species at a given time.

A grouping of organisms which exist in the same general place and have mutual interactions.

Ecology: The study of organisms or groups of organisms to their environment, both biotic and abiotic. A study of their linkages.

Ecosystem: A dynamic and natural complex of living organisms interacting with each other and with their associated nonliving elements in the environment.

Ecosystem management: A process that integrates physical, chemical, biological, and ecological principles, along with economic and social factors, into a comprehensive strategy aimed at protecting and enhancing sustainability, diversity, and productivity of a system.

Ecoregion: Areas of relatively homogeneous ecological systems. Ecoregions are usually based on patterns of land use, topography, present and potential natural vegetation and soils. Ecoregion designations are used by resource managers to develop logical, regional strategies for land acquisition and management.

Eco-unit: Geographic areas containing similar ecological patterns and processes whose boundaries closely align with Michigan's Eco-Regions. They were established by the DNR for organizing and administering assessment, planning, facilitating, and updating of regional ecosystem management activities. Four eco-units were established: Western Upper Peninsula. Eastern Upper Peninsula, Northern Lower Peninsula, and Southern Lower Peninsula. These four eco-units apply to all Divisions. Representatives from each division will contribute to regional ecosystem planning, assessment, and monitoring at the eco-unit level.

Eco-Unit Team: A team of DNR employees composed primarily of Management Unit Supervisors from each division along with additional support personnel who are mandated to plan and coordinate management of an eco-unit utilizing ecosystem management principles.

Endangered species: Any plant or animal species defined through the Endangered Species Act of 1976 as being in danger of extinction throughout all or a significant portion of its range, and published in the Federal Register.

A species facing imminent extinction or extirpation.

Forest: An ecosystem characterized by a more or less dense and extensive tree cover, often consisting of stands varying in characteristics such as species composition, structure, age class, and associated processes, and commonly including meadows, streams, fish, and wildlife.

A plant community or predominantly trees and other woody vegetation growing more or less closely together, its related flora and fauna, and the values attributed to it.

Forest Type: A classification of forest land based on the species forming a plurality of live tree stocking.

Habitat: The place where an organism lives and its surrounding environment including its biotic and abiotic components. Habitat includes everything an organism needs to survive.

Habitat Type System: A classification that uses the floristic composition of plant community (understory species as well as trees) as an integrated indicator of those environmental factors that affect species reproduction, growth, competition, and therefore, community development.

Hydric: Wet

Landscape: An area composed of adjacent and interacting ecosystems that are related because of geology, land forms, soils climate, biota, and human influences.

Landscape scale: The appropriate spatial or temporal scale for planning, analysis, and improvement of management activities to achieve ecosystem management objectives.

Lacustrine: Found or formed in lakes.

Mesic: Moderately moist.

Monitoring: The daily, seasonal, annual or longer-term collection and analysis of environmental and social data.

Moraine: A mass or rock, gravel and soil deposited directly by a glacier.

Public: A group of people sharing a common interest or common characteristic: snowmobilers, or residents of a county.

Rare species: Species that have a limited range, or a limited number of individuals. This could include species found in very low numbers throughout their range, or species that may have rather large local populations, but only a handful of populations total.

Removal cut: Removal of overstory trees from a small understory trees so as to release the understory stand that are less than 20 years of age.

Resource assessment: The determination of the significance, importance, or value of a resource or a set of resources.

Seed Tree Harvest: Most trees are removed from a stand, leaving a small number of designated seed trees.

Shelterwood Harvest: A cut designed to develop tree crowns in the remainder of the stand in preparation for another cut to be made in about ten years that will result in regeneration.

Spatial scale: The geographical size of a community, ecosystem, or study. Spatial scale can range from a microsite such as an underside of a leaf on the forest floor, to a forest, to a larger landscape. Operationally, spatial scale refers to the geographic extent at which certain processes operate within the environment. This could be the scale at which nutrients recycle in a wetland to the patterns of deer migration in the Upper Peninsula.

Species: A group of individuals that can interbreed successfully with one another, but not with members of other groups. Plants and animals are identified as belonging to a given species based on similar morphological, genetic, and biochemical characteristics.

Species diversity: The variety of species in an area. It includes not only the number of species in the area, but also their relative abundance and spatial distribution. Species richness is one component of species diversity, but not the only determinant.

Stakeholder: Individuals or groups impacted by and/or having an interest in the management of Michigan's natural resources and DNR programs.

State, tribal, and local government agencies, academic institutions, the scientific community, non-governmental entities including environmental, agricultural, and conservation organizations, trade groups, commercial interests, and private landowners and citizens.

Statewide Council: A team composed of all the DNR Division chiefs who meet periodically to plan and discuss policy, coordination, cooperation, and implementation of Department programs.

Succession: The natural change in vegetation over time in the absence of disturbance or the artificial change in vegetation due to natural or human-caused disturbance.

Sustainable/Sustainability: Maintenance of healthy, functioning ecosystems capable of providing goods, services, and processes upon which human welfare ultimately depends. Also, implied is the idea that the actions of the current generation will not diminish the resources and opportunities available to future generations.

Temporal scale: The time required to complete a study, a life history event or ecological process. Temporal scale can vary from a few seconds for biochemical reactions to thousands of years for ecosystem development. Operationally, temporal scale refers to the time extent certain processes operate in the environment. (The apparent spatial-operational scale of an ecological process will often change as the temporal-observational scale changes in the same process).

Threatened species: A plant or animal species likely to become endangered throughout all or a significant portion of its range within the foreseeable future.

Xeric: Dry or desert-like.

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