

Maintaining Natural Red Pine in Michigan: A Framework for Fire Stewardship and Ecological Silviculture



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Cover Photo: Collaborative prescribed fire at Camp 8 in Fond du Lac Reservation at the University of Minnesota Cloquet Forestry Center. Photo by Lane Johnson, College of Food, Agricultural and Natural Resource Sciences, University of Minnesota.

Table of Contents

BACKGROUND	1
MANAGEMENT APPROACH	3
Fire Stewardship	5
Forestry Treatments	11
CONCLUSIONS	17
NATURAL RED PINE PROJECT AREAS	19
Upper Peninsula Project Areas	21
1. Baraga FMU Project Area (C11008)	21
2. Crystal Falls FMU Project Area (C12070/71)	25
3. Escanaba FMU Project Area (C33106)	28
4. Sault Ste. Marie FMU Project Area (C45037)	31
5. Shingleton FMU Project Area (C41132)	34
6. Shingleton FMU Project Area (C41133)	37
Lower Peninsula Project Areas	40
7. Pigeon River FMU Project Area (C53005)	40
8. Pigeon River FMU Project Area (C53036)	44
9. Pigeon River FMU Project Area (C53038)	47
10. Roscommon FMU Project Areas (C71016)	49
SELECTED REFERENCES	53

List of Figures

Figure 1. Fire scars and historic fire frequency in natural red pine.	4
Figure 2. Contrasting understory composition and red pine regeneration following fire.	6
Figure 3. Anthropogenic xerification and the realized distribution of red pine	7
Figure 4. Framework for integrating fire stewardship into natural red pine management.	8
Figure 5. Red pine seedlings can survive low-severity fire.	9
Figure 6. The application of Individuals, Clumps, and Openings (ICO) management	11
Figure 7. Treatment outcomes in the absence of recurring fire	12
Figure 8. Diagram of a forest managed using the ICO approach.	14
Figure 9. An example of a Project Area with ICO Management zones delineated.	15
Figure 10. Locations of potential Project Areas	20

List of Tables

Table 1. MNFI reports informing this guidance	1
Table 2. Selected literature informing ecological management of natural red pine.	2
Table 3. Seasonality, red pine phenology, and fire effects	10
Table 4. Example sequencing framework for applying prescribed fire and ICO approach	16
Table 5. Potential natural red pine Project Areas	19

Appendix

Appendix 1. Considerations for prescribed fire implementation in natural red pine systems.	57
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BACKGROUND

Natural red pine (*Pinus resinosa*) regeneration in many Michigan forests is insufficient to meet future timber and management objectives. In the absence of fire, many natural pine forests have undergone the process of mesophication whereby the recruitment of fire-sensitive, shade-tolerant species such as red maple (*Acer rubrum*), white pine (*Pinus strobus*), and white spruce (*Picea glauca*) has dramatically increased and effectively out-competed fire-dependent species, such as red pine. Consequently, some stands have transitioned to other cover types or have been converted to red pine plantations through clearcutting, trenching, and herbicide application. While effective for regeneration, these approaches do not account for loss of biodiversity and decreased ecosystem resilience that can result from plantation forestry as well as the elimination of local seed sources needed for natural recruitment. Moreover, traditional plantation management does not replicate the mixed-severity fire regimes that historically structured these systems and allowed for natural regeneration of red pine.

Maintaining natural red pine on the landscape is a priority outlined in Michigan's State Forest Management Plan and is of strong interest to conservation and forestry stakeholders. The Michigan Department of Natural Resources (DNR) has identified a need for alternative management approaches that promote natural regeneration while supporting timber production, enhancing ecosystem resilience, and conserving biodiversity.

This report provides guidance for the management of natural red pine through general recommendations in the Management Approach section. The Natural Red Pine Project Areas section also details 10 sites across the state forest system where we offer site-specific recommendations.

The recommendations in this document are based on previous work by the Michigan Natural Features Inventory (MNFI) and this document is intended to provide a more accessible, field-oriented summary of recommended practices. This document synthesizes previous MNFI analyses and selected published literature related to natural red pine ecology, disturbance regimes, ecological silviculture, and prescribed fire in the Great Lakes Region. Selected references informing this framework are provided at the end of the report (Page 53) and we encourage readers to utilize prior MNFI reports (Table 1) for detailed references on these topics. Recommendations are informed by published research on red pine ecology and fire regimes, principles of ecological silviculture, Indigenous fire practices, and integrated fire-harvest systems. Table 2 features selected literature that has informed this document.

Significant natural red pine forests remain on state lands, and there are opportunities to apply the approach we have developed. When implemented effectively, we believe the approach will promote natural red pine regeneration, improve resilience to wildfire, reduce reliance on plantation forestry, and support long-term ecological and operational objectives.

Table 1. Prior MNFI reports informing this guidance document. Links to each report are embedded below.

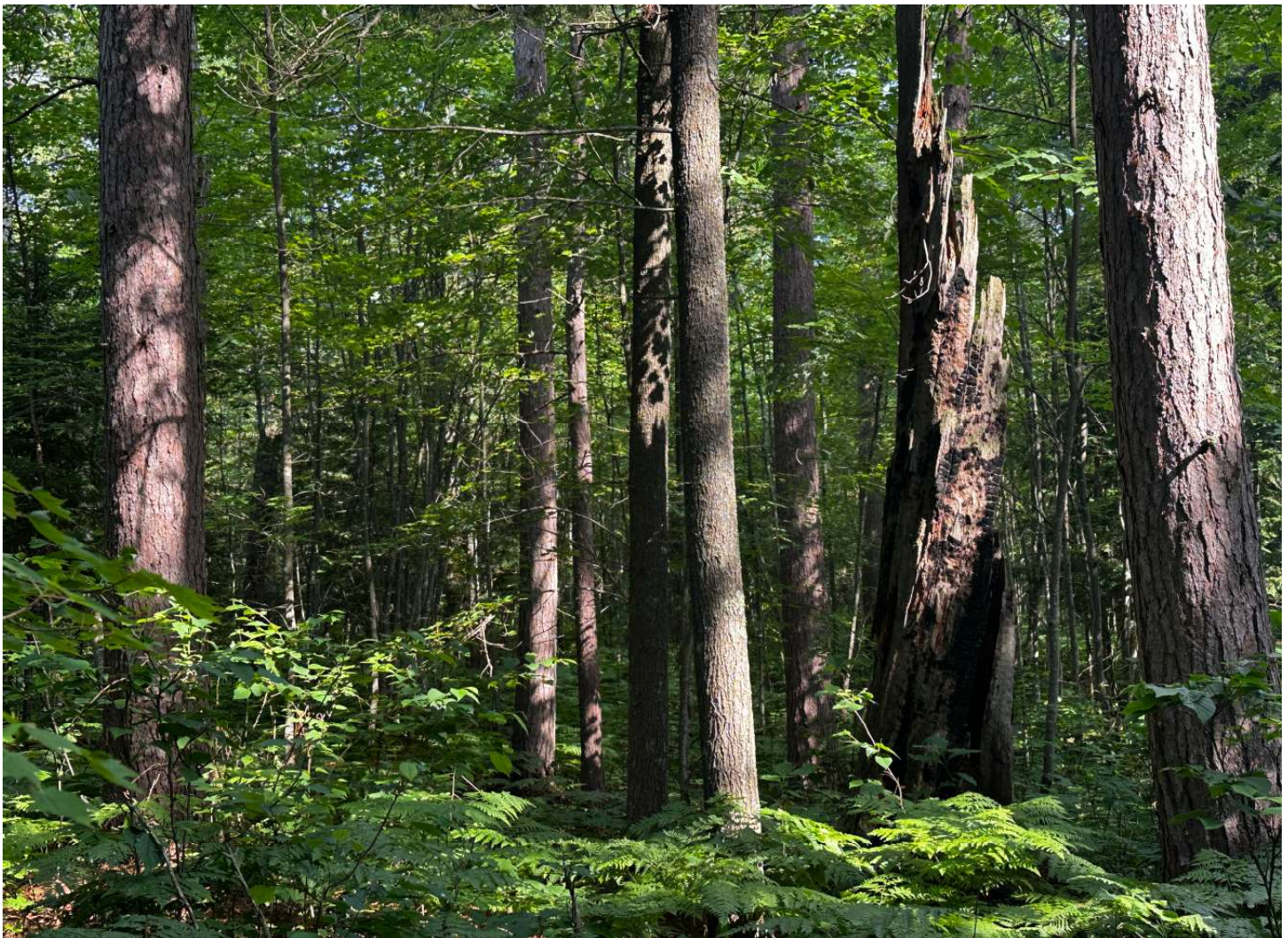
First Author	Report Title and Link	Year
Schilke	Identifying Ecologically Significant Natural Red Pine Stands in Newberry and Shingleton Units of Michigan's State Forest	2024
Lincoln	Strategies for Management of Natural Red Pine Forests Across Michigan's State Forest System	2025
Lincoln	Identifying Recoverable, Fire-Dependent Systems in the Newberry Forest Management Unit	2025



In the absence of fire, forestry intervention ensures red pine regeneration. Natural forests may be clearcut, trenched, herbicided, and planted. Photo by J.M. Lincoln.

Table 2. Selected literature informing ecological management of natural red pine. Our framework is informed by previous MNFI analyses and selected literature related to red pine ecology, fire regimes, ecological silviculture, Indigenous fire stewardship, and integrated fire and silvicultural systems.

First Author	Article Title	Journal or Press	Year
Anderton	Native American Fire-Maintained Blueberry Patches in the Coastal Pine Forests of the Northern Great Lakes	The Great Lakes Geographer	1999
Churchill	Restoring forest resilience: From reference spatial patterns to silvicultural prescriptions and monitoring	Forest Ecology and Management	2013
Kipfmüller	Historical drivers of a frequent fire regime in the red pine forests of Voyageurs National Park	Forest Ecology and Management	2017
Palik	Ecological Silviculture: Foundations and Applications	Waveland Press	2021
Razenkova	Analyzing spatial patterns of old-growth red pine dominated forests in Wisconsin and Minnesota as a tool to increase forest resilience	Forest Ecology and Management	2025
Stambaugh	Historical fire regimes from red pines (<i>Pinus resinosa</i>) across the Tension Zone in the Lower Peninsula, Michigan USA	Fire Ecology	2024



A forest in the Baraga FMU Project Area (C11008; Stand 7) with natural red pine in the canopy but an understory dominated by mesophytes such as red maple and white pine without adequate red pine regeneration. The framework presented in this document is intended to maintain continuity of red pine at such a site without conversion to plantation. Photo by J.M Lincoln.

MANAGEMENT APPROACH

This section provides guidance on the management of natural red pine forests in the Great Lakes Region. This section is separated into *Fire Stewardship* (Page 5) and *Forestry Treatments* (Page 11). The sites detailed in the following Natural Pine Project Areas section (Page 19) are specific to Michigan's State Forest system, but the approach is broadly applicable to red pine forests across the region. Management recommendations for Project Areas are designed to enhance resiliency and native biodiversity in stands where timber harvests will occur.

To identify natural red pine forests as potential Project Areas, MNFI ecologists used Michigan Forest Inventory (MiFI) data to identify potential sites suitable for natural red pine management. Following surveys, we developed Project Areas where the maintenance of natural red pine overlapped with principles of ecological silviculture. These principles include 1) maintaining continuity of forest types; 2) maintaining structural complexity and species diversity; 3) applying silvicultural interventions at ecologically appropriate time intervals; and 4) applying silvicultural interventions that preserve or enhance landscape structure and function.

As a counter to standard density-based management, we are proposing a management framework based on the ICO approach (Individuals, Clumps, and Openings). The ICO method uses timber harvest to modify stand structure and pattern in terms of individuals, clumps, and openings rather than using a density-based lens reflected in most current management strategies. This method was developed for dry forests in the western states but can be readily applied to the natural pine forests of the Great Lakes Region.

Additionally, historic red pine forests were patterned by frequent, low-severity burns initiated by Indigenous Peoples, leading to forests that were less dense, featured older trees, and regenerated naturally. Historic fire intervals documented from fire-scarred red pine indicate that many natural red pine systems experienced repeated low-intensity surface fire at intervals substantially shorter than would be expected from lightning ignitions alone (Figure 1). By combining the ICO approach with prescribed fire in a manner that reflects historic disturbance processes, we provide an ecologically-informed framework for managing natural red pine forests that promotes spatial heterogeneity, supports natural regeneration, and enhances long-term ecosystem resilience. The primary objective of our recommendations is not to replicate pre-colonial forests, but to provide

an ecologically-informed silvicultural framework that enhances resilience and other non-timber benefits while allowing for active timber management.

Initial management focuses on conditioning sites through repeated prescribed fire to reverse mesophication and establish natural regeneration prior to major canopy reduction. This is followed by subsequent long-term maintenance through recurring fire and periodic canopy reduction. We developed 10 Project Areas where we recommend applying the ICO approach to shift away from density-based, even-aged management and toward uneven-aged management that fosters forests with spatial and structural heterogeneity that more closely reflects the structure patterned by historic disturbance processes.

When combined with frequent, low-severity prescribed fire synchronized with red pine cone production, this approach can promote natural regeneration, reduce mesophytic competitors, decrease wildfire risk, and maintain timber productivity. This aligns with forest certification standards related to biodiversity conservation, forest health, climate resilience, and fire management.



A living red pine with a fire scar showing evidence of multiple fires. Red pine often preserves fire-induced wounds and is valuable for interpreting historical fire regimes. Photo by J.G. Cohen.



Figure 1. Fire scars and historic fire frequency in natural red pine. *Left panel:* red pine stump recovered from a natural red pine stand in the Traverse City FMU (Photo by J.M. Lincoln). *Right panel:* cross-section of the stump showing evidence of at least six fires, with arrows indicating fire scars and the number of years between fire events (Photo by K.F. Kipfmüller). Similar fire return intervals have been documented in natural red pine systems across the Great Lakes region and greatly exceed frequencies expected from lightning ignitions alone, indicating frequent Indigenous application of fire. The consistent, widespread survival of mature red pine following repeated fire events suggests a prevalence of low-severity, low-intensity surface fire rather than stand-replacing disturbances. This historic fire frequency and implied severities provide context for developing management guidelines around fire return intervals and desired fire effects in natural red pine forests.

Fire Stewardship

There is a deficit of fire in many natural pine stands of the Great Lakes Region. This has, in part, resulted in simpler, even-aged forests that are at greater fire and disease risk and lack adequate natural regeneration. The elimination of fire in fire-adapted forests has allowed a proliferation of shade-tolerant, fire-sensitive species such as red maple, white pine, white spruce, and balsam fir (*Abies balsamea*) that facilitate succession towards dense, mesophytic systems with less flammable vegetation and litter. This conversion to forests dominated by mesophytes further inhibits the spread of fire, reduces the viability of fire-adapted species, and generates uncharacteristically severe fires in the event of prolonged droughts. In the absence of fire, the rapid increase of mesophytic species at all but the driest sites can quickly limit red pine regeneration and result in the decline of red pine over time. Red pine is therefore considered to be a fire-dependent species.

Fire exclusion is likely the dominant process driving mesophication and regeneration failure in many

natural red pine systems, but outcomes are also shaped by soils, landforms, herbivory, altered disturbance regimes, invasive species, changing climate conditions, historical logging, and landscape fragmentation. Nearly all of the stands within our proposed Project Areas have already been thinned and our method for managing natural red pine relies on the application of fire before additional forestry treatments. Because the fire deficit in red pine forests has resulted in an increased prevalence of mesophytic species, there is generally inadequate natural red pine regeneration in most red pine stands. Thinning the canopy without fire only increases the dominance of mesophytes and makes the site more difficult to burn (Figure 2). Additionally, because of the uneven seed production across a single stand, it is difficult to know which trees will produce adequate numbers of seed any given year. Therefore, we urge the application of fire ahead of timber treatments in order to reduce competition, condition the site for future burns, and establish adequate regeneration that can inform the subsequent timber treatments.



To maintain natural red pine stands and promote natural regeneration, we are recommending the regular application of low-severity, low-intensity fire prior to timber harvest treatments. Such an application of fire is intended to minimally impact red pine regeneration and help the system perpetuate. Photo by Lane Johnson, College of Food, Agricultural and Natural Resource Sciences, University of Minnesota. Collaborative prescribed fire at Camp 8 in Fond du Lac Reservation at the University of Minnesota Cloquet Forestry Center.



Figure 2. Contrasting understory structure and red pine regeneration following fire. Two nearby natural red pine stands in the Newberry FMU of similar age and management history. *Top panel:* The stand was thinned but not burned and is dominated by mesophytic species including white spruce and white pine. *Bottom panel:* The stand was thinned and subsequently burned during the 2012 Duck Lake wildfire, resulting in patchy natural regeneration of red pine. These contrasting outcomes illustrate that recurring fire stewardship is fundamental to maintaining open understory conditions and promoting natural regeneration in red pine systems. Photos by J.M. Lincoln.

The regular application of fire stewardship is critical to promote natural regeneration of red pine, reduce mesophytic competitors, consume litter and ladder fuels, raise canopy base heights, promote disease resilience, and ensure that natural red pine systems remain resilient to wildfire. Although severe fires did historically lead to stand re-initiation, a mixed-severity disturbance regime is a better description of the origin of old-growth red pine in the Great Lakes Region, including occasional higher-severity events. Historically, anthropogenic xerification through the application of Indigenous cultural burning maintained many of these sites and increased the abundance of red pine on the landscape (Figure 3).

Initial burns in fire-suppressed pine forests may produce limited visible response, but incremental reversal of mesophication is critical for preparing forests for subsequent fires by conditioning trees, eliminating competition, and reducing fuels (Figure 4). In many sites, it will take multiple fires to reverse conditions created by over a century of fire exclusion

and mesophication. We recommend applying at least two low-severity/low-intensity burns in relatively close succession (approximately 3 to 7 years apart). We have provided general guidance for timing burns (Table 3, Page 10), a sequence of treatments (Table 4, Page 16), and additional considerations for fire practitioners (Appendix 1, Page 57).

Generally, the first burn should occur during the dormant season (early spring) to reduce surface fuels while minimizing stress to trees and roots. Even low-severity/low-intensity burns can have a transformative effect on reducing the accumulation of litter and difficult fuels, raising the canopy base height, and reducing crown fire risk. Additionally, applying initial low-severity/low-intensity fires lessens the risk of damage to the roots, particularly in areas where needle duff has accumulated from a prolonged absence of fire. Conducting the first entry burn in early spring or during the fall dormant season conditions red pine to fire, allowing them to recover with minimal stress.

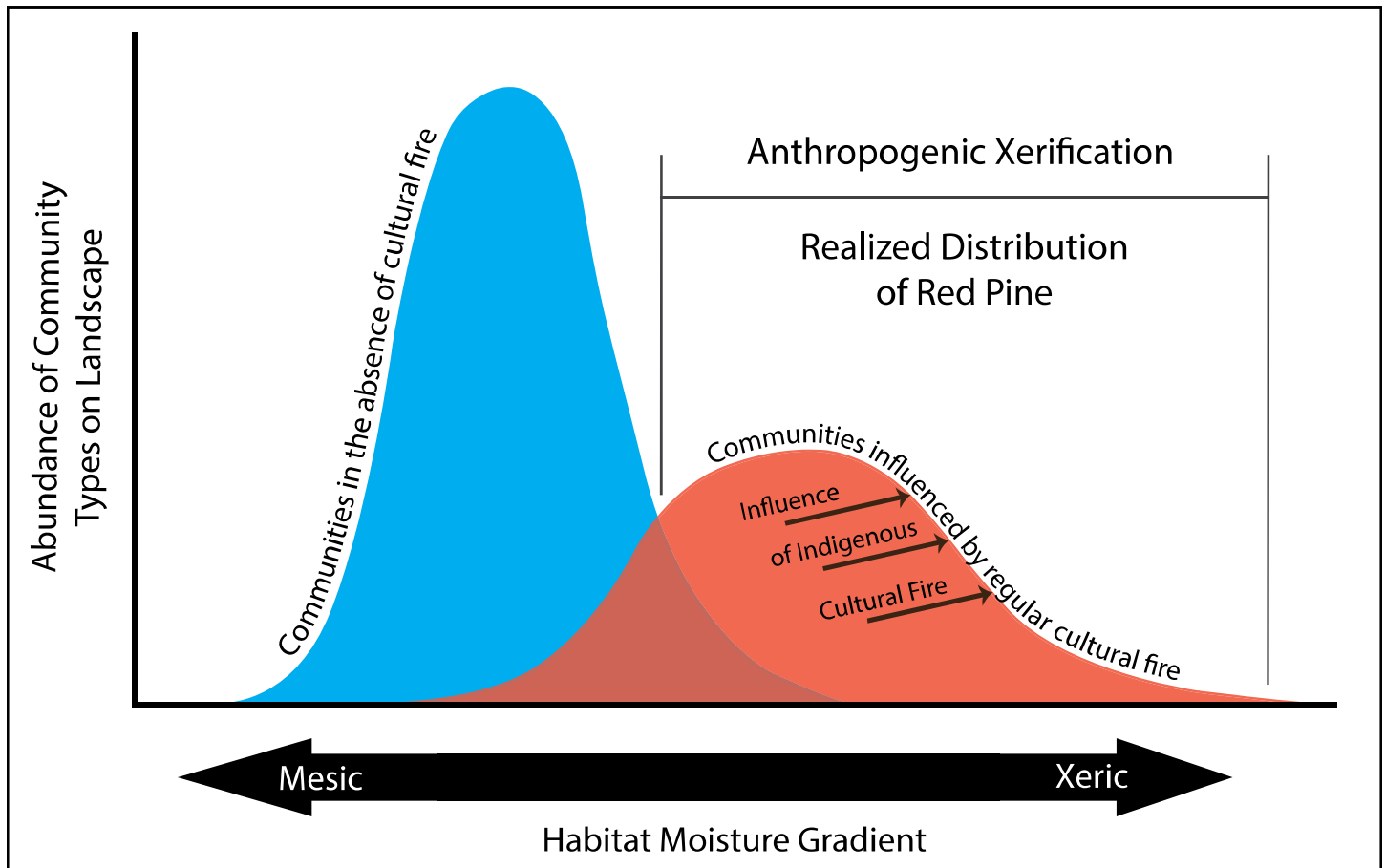


Figure 3. Anthropogenic xerification and the realized distribution of red pine. Anthropogenic xerification describes the process by which repeated Indigenous cultural burning promoted fire-adapted species such as red pine by maintaining drier, more open, and less mesophytic conditions across parts of the Great Lakes region. These recurring low-severity fires likely expanded the realized distribution and abundance of red pine into landscape positions where it would otherwise have been competitively limited by mesophytic species. The absence of recurring fire in many natural red pine systems has contributed to increasing dominance of white pine and other mesophytes, particularly in mesic and dry-mesic settings where natural red pine regeneration is often limited. Adapted with permission from Larson et al. (2021).

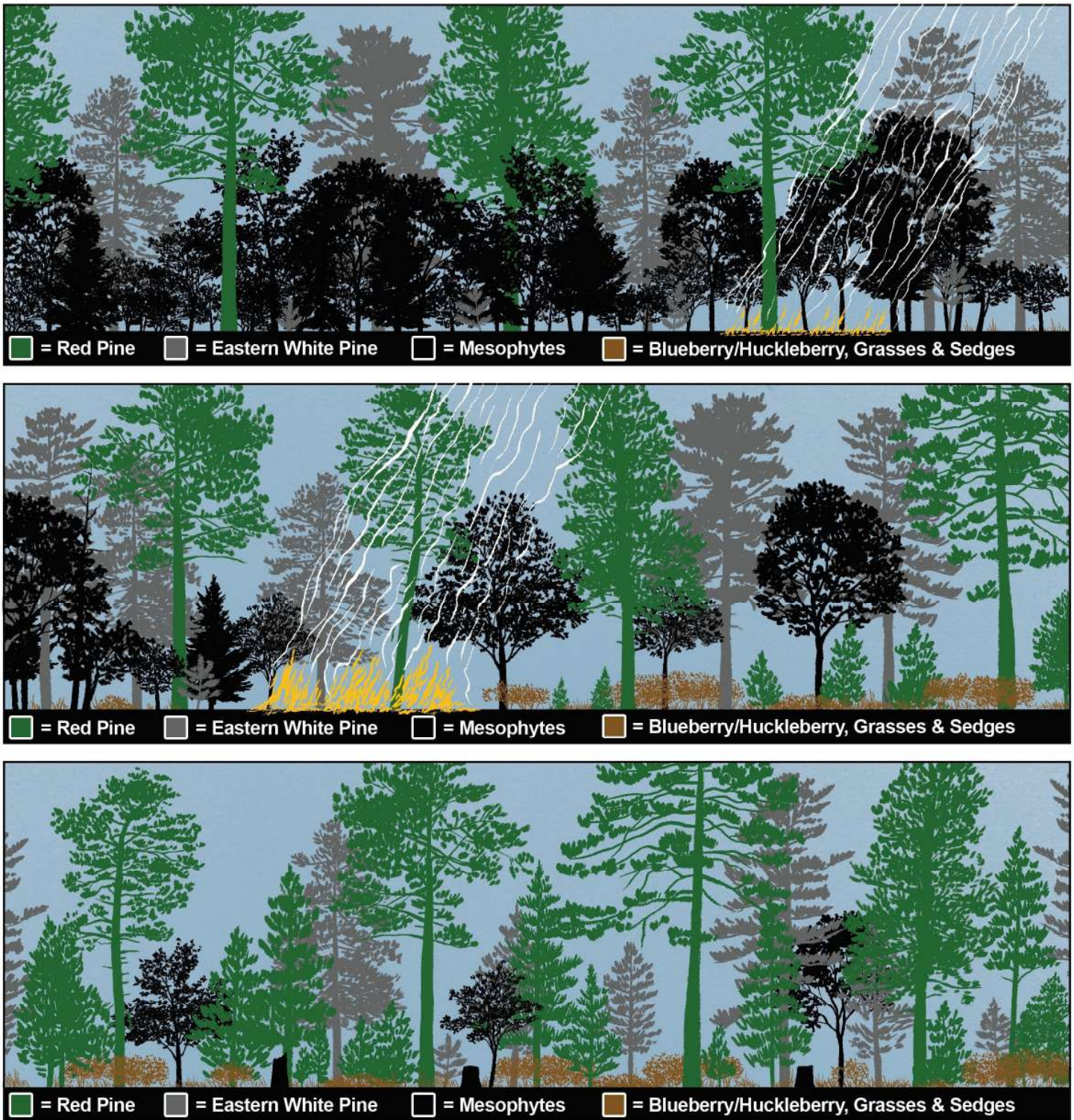


Figure 4. Framework for integrating fire stewardship into natural red pine management. *Top panel:* fire-suppressed natural red pine forest with dense mesophytic understory and limited red pine regeneration. Initial low-severity prescribed fire is recommended prior to canopy reduction to reduce mesophytic competition, improve future fire feasibility, and promote natural regeneration.

Middle panel: repeated prescribed fire prior to canopy reduction further reduces mesophytic competition and prepares the site for long-term maintenance as a natural red pine system. Applying fire during a red pine mast year may enhance natural regeneration.

Bottom panel: following repeated fire application, partial canopy reduction maintains forest continuity while allowing recurring prescribed fire and periodic timber harvest to sustain structural complexity and long-term ecological function. Illustration developed in collaboration with Querkus Creative.

Subsequent burns can be timed during the late growing season to increase effectiveness in controlling mesophytes and promoting red pine regeneration.

While an initial burn is most likely achievable during the dormant season in the early part of the year, timing subsequent burns with red pine cone production is critical for regeneration. Red pine has a two-year cone cycle and produces large seed crops every 5 to 10 years. Cones typically mature in September with seed-fall from mid-September through early October. Conducting a burn prior to seed fall (June–Sept) can improve seedbed conditions by exposing mineral soil and reducing competition, particularly if an initial burn has already been implemented. Where regeneration remains limited, continued application of fire aligned with elevated cone production may be necessary, especially in more mesic situations.

Red pine is well-adapted to survive low-severity/low-intensity fire due to thick bark and self-pruning

lower branches. However, long periods without fire can lead to fuel accumulation and increased risk of damage during fire reintroduction. Widespread and regular low-severity/low-intensity fires and variable age classes of pine forests were historically characteristic of these systems, and establishment was not limited by overstory density but instead by mortality of seedling and saplings due to fire intensity. Nonetheless, red pine saplings as young as five years can survive patchy, low-severity fire, particularly in sites that have already been conditioned with previous burns (Figure 5). For this reason, initial burns should be kept at low severity with repeated entries used to gradually reverse mesophication.

Without fire, natural red pine systems will continue to shift toward dense, mesophytic forests with limited regeneration and increased wildfire risk. Reintroducing fire is essential to maintaining natural red pine on the landscape. However, managing expectations for the first burn entry is important.



Figure 5. Red pine seedlings can survive low-severity fire. This natural red pine stand in the Huron Shores District of the Huron-Manistee National Forest was burned in 2018 and existing natural regeneration survived the fire and persists throughout the forest. As of 2025, there was no observed canopy mortality, minimal bole char, and no observed disease affecting regenerating seedlings. Photo by B.J. Stearns, USFS.

Table 3. Seasonality, red pine phenology, and fire effects. Fire application in natural red pine systems should be adapted to site conditions, fire history, fuel structure, and management objectives. Mesic and long fire-suppressed sites often require repeated entries and may exhibit substantially different fire behavior than xeric systems with intact herbaceous structure. Burn timing should be guided primarily by red pine phenology rather than calendar date, as dormancy and active growth vary regionally and annually. Green indicates preferred burn windows, yellow indicates periods requiring caution to avoid canopy injury, and orange indicates periods when fire application is generally not recommended due to increased susceptibility to crown scorch, bole injury, and growth impacts during active shoot elongation and cambial activity. Recommendations are based on observations across the range of red pine in Michigan and should be adapted by experienced fire practitioners familiar with local site conditions. Adapted with permission from communications with B.J. Stearns and J. McGowan-Stinski (2026).

Month	Red Pine Phenology	Expected Vegetation Response to Fire	First Entry Considerations	Second and Third Entry Considerations
January February March	Dormant	Promotes oak, blueberry, sedges	<ul style="list-style-type: none"> • Dormant season ideal for first entry burn • Generally target low to moderate intensity surface fire to reduce duff/litter and ladder fuels while minimizing overstory injury • Conditioning site for subsequent fire 	<ul style="list-style-type: none"> • Second entry burn more effective later in season to promote red pine regeneration and set back mesophytic competition • Can burn up to 7 days since rain if good fire effects from first burn • Good time for third entry burn; wait >7 years after second entry to allow regeneration to establish
April	Buds Swelling	Promotes cherry, blueberry, cool season grasses	<ul style="list-style-type: none"> • Ideal timing to condition rhizosphere and bole to protect against heat damage • Apply caution for sites with deep duff, where smoldering ground fire can damage fine root and cambium even under moderate flame lengths • Generally keep flame lengths 0.5 to 2 ft • Favor firing patterns that reduce residence time and smoldering near canopy trees • Ideal is 5 or fewer days since rain, though sites vary (Appendix 1 for more specifics) • Avoid burning in drought conditions; after 7 days since rain there is risk of high mortality 	
May June	Buds Elongating	Promotes serviceberry and grasses	<p style="text-align: center;">Not ideal for first entry burn; unburned stands of red pine are vulnerable to elevated mortality</p>	<ul style="list-style-type: none"> • Ideal timing for second burn 3 to 5 years after first entry • Reduce competition and promote red pine regeneration • Monitor cone development • Burn ahead of seed drop in October • Previous burns have reduced litter to manageable depth • Can burn up to 7 days since rain if good fire effects from first burn
	Needles Expanding/ Shoot Elongation	Improves conditions for red pine regeneration and promotes warm season grasses		
	Red Pine Pollination Occurring	Improves conditions for red pine regeneration and promotes warm season grasses, sets back bracken fern		
July August	Growth Complete (Bud Set)	Improves conditions for red pine regeneration and sets back mesophytes and cool season grasses		
September October	New Growth Lignified	Sets back mesophytes and cool season grasses Prepares seed bed for red pine	<ul style="list-style-type: none"> • Late season (post-hard frost) can be good for first entry burn • Can still condition rhizosphere and bole to protect against heat damage • Narrow conditions for achieving first entry burn 	<ul style="list-style-type: none"> • Generally not ideal for second burn • After red pine seed drop • Too damaging for young regeneration • A good time for burns once regeneration is >7 years old and site has been conditioned by previous fire
	Deciduous Leaves Curing/Falling	Range of responses		
October to December	Post-Frost/Freeze	Promotes oak, cool season grasses and sedges		

Forestry Treatments

We are proposing a management framework based on the ICO approach (individuals, clumps, and openings). These recommendations were informed by relevant ecological and silvicultural literature summarized in Table 2. The ICO method uses timber harvest to modify stand structure and pattern in terms of individuals, clumps, and openings rather than using a density-based lens reflected in most current management strategies. Although the ICO framework was originally developed for dry forests of the western United States, historic red pine forests of the Great Lakes Region also exhibited spatial heterogeneity, multiple age cohorts, and variable-density structure shaped by mixed-severity fire, wind disturbance, and gap dynamics (Figure 6). We believe the ICO framework is well suited for adaptation to natural red pine systems.

Forestry treatments conducted without recurring fire often produce structural and compositional outcomes that differ substantially from historically open natural red pine systems (Figure 7). Canopy reduction without fire may increase slash accumulation, promote dense mesophytic understory development, and

complicate future prescribed burning efforts. Similarly, mechanical scarification can expose mineral soil and reduce competition, but frequently fails to reproduce the heterogeneous structure, understory diversity, and reliable regeneration responses commonly associated with repeated surface fire.

Spatial heterogeneity at the landscape and stand level, especially forest structure and composition, is a critical factor contributing to ecosystem resilience. Historically, pine-dominated forests had multiple age and size cohorts of pine, often with a substantial proportion of the canopy trees over 200 years old in the oldest stands. Old trees are fire resistant, genetically diverse, and provide habitat for a range of species.

To achieve these benefits in a forest that incorporates timber harvest, there are four distinct management zones: **Individuals**, **Clumps**, **Openings**, and **Skips** – all to be included with prescribed fire. Descriptions of each management zone are provided (Page 13), but more thorough explanations are available in the reports of Table 1 (Page 1).



Figure 6. The application of Individuals, Clump, and Openings (ICO) management in ponderosa pine forest in New Mexico. This approach retains multiple age classes, protects native vegetation, and facilitates the application of recurring fire. This approach, when combined with fire stewardship, maintains continuity of forest types, promotes structural complexity and species diversity, and applies silvicultural interventions at ecologically appropriate time intervals that preserve landscape structure and function. Photo by J.M. Lincoln.



Figure 7. Treatment outcomes in the absence of recurring fire. *Top panel:* stand reduction without prescribed fire resulting in dense mesophytic understory development, slash accumulation, and limited red pine regeneration. *Bottom panel:* mechanical scarification following canopy thinning produced exposed mineral soil conditions but limited red pine regeneration despite adequate seed sources and reduced competition. In both examples, the absence of recurring fire contributes to mesophication, reduced understory diversity, and structural conditions that differ from historically open natural red pine systems. Photos by J.M. Lincoln. Photos by J.M. Lincoln.

The ICO framework is intended to be an intuitive, flexible, and efficient approach to manage natural pine forests. We have detailed prescriptions that we believe will provide enough of a framework for developing site-specific treatments by trained foresters familiar with each Project Area. However, we did not conduct thorough surveys of every stand in every Project Area and the layout of Clumps, Openings, and Skips in each Project Area are general recommendations and can be adjusted where necessary.

The Project Areas we identified for the ICO approach often include several stands and cover types, with most of the area comprising mature natural red pine or mixed pine forests. An example of a Project Area and proposed treatment areas is provided (Figure 8, Page 14; Figure 9, Page 15).

Skips (or reserves)

- Skips are permanent reserves that will not be harvested and will allow advanced age classes to develop and perpetuate
- Skips should be embedded throughout the Project Area to retain zones of low shrubs and herbaceous composition characteristic of natural red pine forests. Even placement will provide continual supplies of seed from the oldest trees throughout Project Areas
- Generally placed along the margin of wetlands, steep slopes, pockets of older trees and/or concentrations of fire-scarred trees, and areas of high-quality forest
 - Can be placed for wildlife retention areas such as goshawk nests, to retain snags and patches of dead wood, and to protect vernal pools
 - Can also be placed in areas of high herbaceous diversity often damaged by traditional forestry techniques

Individuals

- The Individuals treatment zones form the matrix of each Project Area that will be thinned at first harvest and comprises the majority of each site
- The goal is to periodically harvest much of the site through thinning so it is important to leave enough trees for the next treatment to be economically viable within 20 to 30 years
- Generally there are several stands in each Project Area, but we recommend approximately one-third of the basal area (BA) to be removed from the Individuals zone, retaining a BA range of 50 to 100 ft²/ac
- Avoid removing the oldest trees in this zone, retain snags, fire-scarred trees and stumps, and do not include snags in retention BA calculations

Clumps

- Clumps are similar to Skips and function to retain various age classes and herbaceous composition across the site, but are not intended to be permanently omitted from timber harvest
- Comprise ~10% of a Project Area (minus Skips), not concentrated in one large retention area or along edges.
- Range from 0.25 to 1.5 acres. Flexibility in determining size is encouraged
- Retention of Clumps will provide options for future harvests since it is difficult to predict each Project Area's response to fire
- Evenly spaced distribution assists natural regeneration of red pine and retains long-lived shrubs and characteristic vegetation

Openings

- Openings comprise 5 to 10% of a site where all canopy trees will be harvested. This mimics various disturbances, including windthrow and severe fire
- Recommended Opening locations are suggestions and placement is flexible and should be adjusted based on the unpredictable distribution of natural red pine regeneration expected after the initial application of fire
- ICO implementation guidelines suggest small (<0.5 acre) and large (>0.5 acre) openings. We generally developed openings ~1 acre in size with some larger targets with the intention that managers would operate within those areas to develop appropriate sizes and shapes
- Openings should be amorphous in shape rather than circular gaps and generally placed in areas of flat topography away from wetlands and in areas with fewer old trees
- New Openings should be developed in areas where there is ample regeneration and, in some cases, existing Clumps will be removed for future Openings, and future Clumps will be developed in areas that were previously Openings
- We did not include Openings in each Project Area, particularly sites that were smaller with a high proportion of sensitive habitats

It is essential to implement ICO treatments when there is adequate regeneration, and mechanical harvest should be applied in a way that does not significantly harm the regeneration achieved through the application of fire.

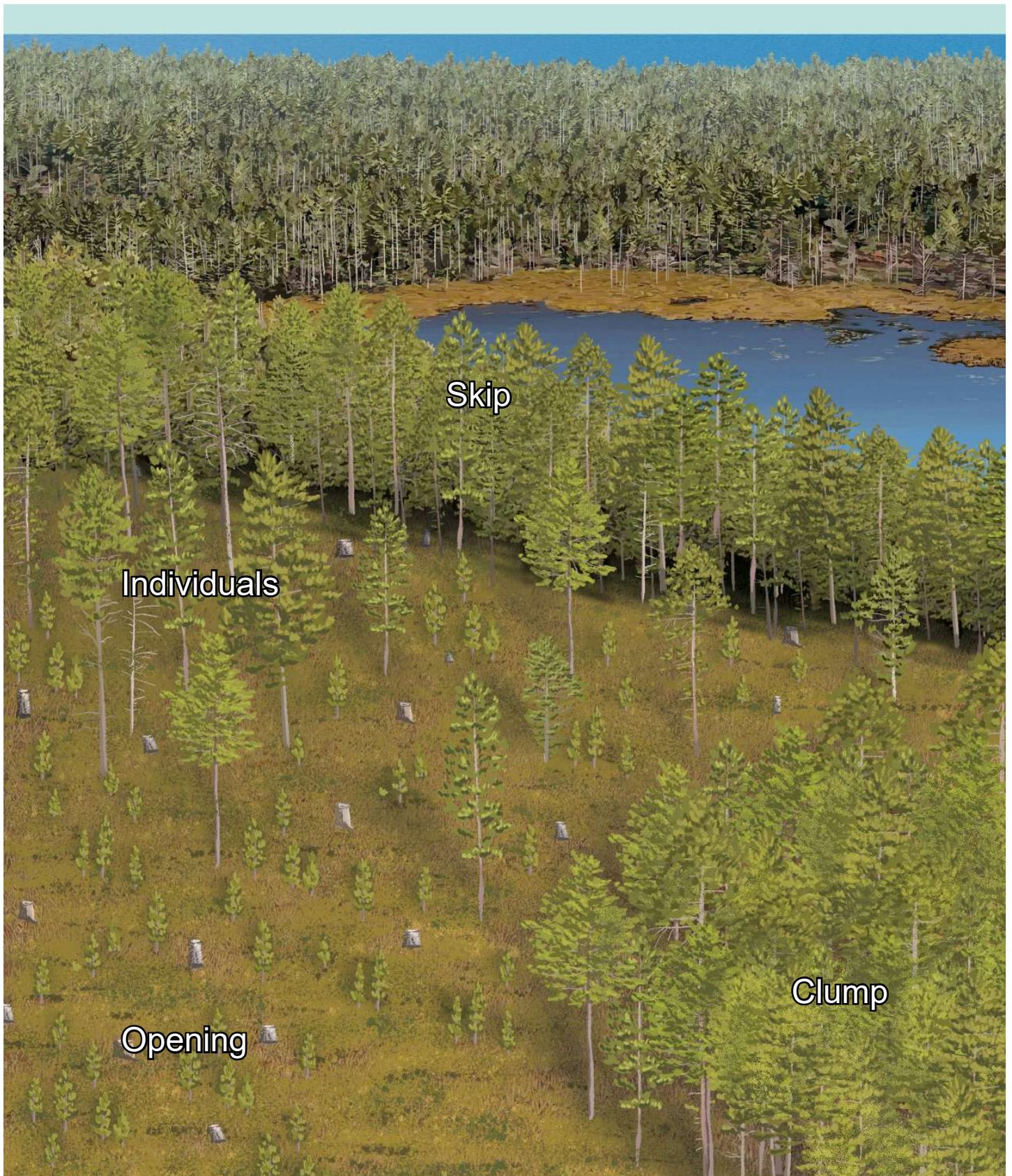


Figure 8. Diagram of a forest managed using the Individuals, Clumps, and Openings (ICO) approach. This framework integrates prescribed fire with uneven-aged silviculture to maintain structural complexity, native vegetation, and long-term forest continuity. Much of the stand is managed through partial canopy reduction (Individuals), while groups of retained trees (Clumps), small canopy openings (Openings), and permanently protected areas (Skips) increase structural heterogeneity and retain biological legacies. Wetlands and riparian areas should be protected through permanent buffer zones ranging from 100 to 300 ft depending on slope. Illustration developed in collaboration with Querqus Creative.

Additionally, because the protection of native biodiversity is a feature of this approach, timber harvests should avoid excessive soil disturbance through rutting, unnecessary paths, and scarification. Severe soil disturbance should be minimized as much as possible, particularly in and around **Skips** and **Clumps** where the ground layer is intended to remain undisturbed.

Because the Project Areas are typically large and contain multiple stands of varying age classes, it is impractical to prescribe specific targets regarding basal area (BA) and trees per acre. We provide a broad target (1/3 reduction of BA every 30 years) but the success of this approach will rely on the judgment of professionals familiar with each site and a commitment to adaptive management.

The difficulties around regeneration of natural red pine and complexities of applying prescribed fire may lead to situations where there is too much red pine regeneration and situations where there is too little. In some cases, red pine saplings may need to be reduced, or regeneration may need to be supplemented with hand planting.

Finally, it will be critical to administer timber sales in a way that protects unharvested trees and regeneration. Slash must be kept away from the base of unharvested trees to reduce damage during future fires. Regeneration and residual floristic diversity are susceptible to harvest-related mortality via felling and yarding, and measures must be taken to restrict incidental loss.

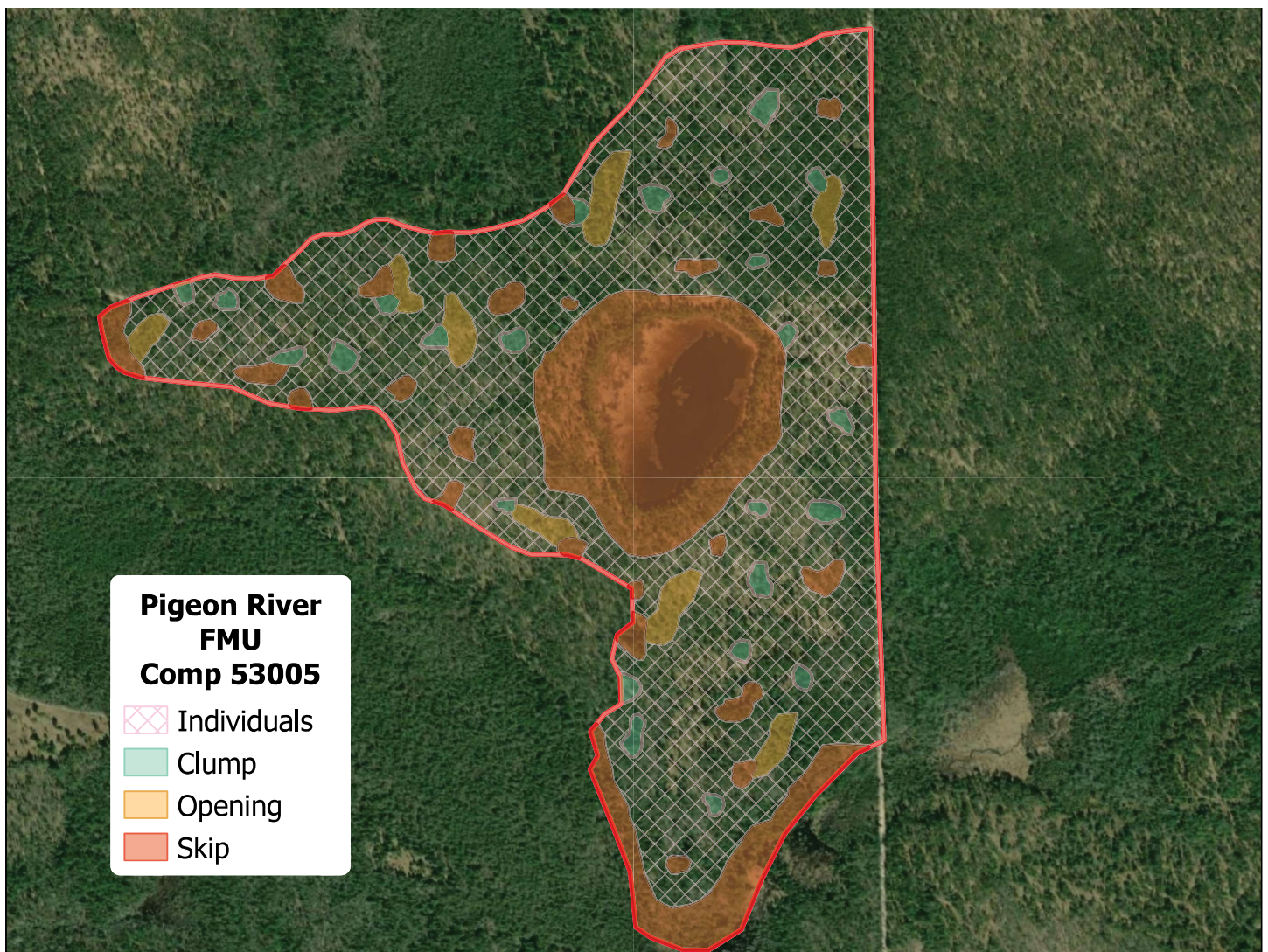


Figure 9. An example of a Project Area with ICO Management zones delineated. This Project Area in the Pigeon River FMU (Compartment 53005) includes a high-quality intermittent wetland in the center of the site. A wide forested buffer around the wetland has been proposed and is indicated as a Skip, or zone where we recommend the restriction of timber harvests. This is a large Project Area (214 acres) with several stands, each with a unique treatment history. We provide detailed recommendations for each Project Area in the Natural Pine Project Areas section (Page 19).

Table 4. Example sequencing framework for applying prescribed fire and ICO approach in dry-mesic natural red pine systems with prolonged fire suppression. A single burn may be adequate in some xeric sites. Treatment timing and sequencing should be adapted based on site conditions, regeneration response, fuel conditions, prior management history, and the judgment of experienced fire and forestry practitioners familiar with each site.

Management Phase	Approximate Timing	Treatment	Primary Objectives
Conditioning	Year 0	First prescribed fire entry	<ul style="list-style-type: none"> • Reduce fuels (duff and fine fuels) • Begin reversing mesophication
Conditioning	Year 3–7	Second prescribed fire entry (aligned with mast year)	<ul style="list-style-type: none"> • Further reverse mesophication • Reduce fuels (duff, litter) to create areas of mineral soil • Promote red pine regeneration
Transition	Year 5–10	ICO canopy reduction	<ul style="list-style-type: none"> • Develop treatment layout • Release regeneration • Establish structural heterogeneity • Monitor for invasive species
Maintenance	Recurring	Prescribed fire	<ul style="list-style-type: none"> • Maintain regeneration • Mitigate mesophication
Maintenance	~30 years	ICO canopy reduction	<ul style="list-style-type: none"> • Develop new Openings around regeneration • Retain Skips • Reduce Individuals by 1/3 BA • Harvest some Clumps



A growing season fire applied in a natural red pine stand. A major concern about applying fire in these stands is the loss of regeneration. While some of the existing red pine regeneration was consumed by the fire, more than 50% survived and additional regeneration resulted from the application of this fire. Red pine saplings as young as 5 years old can survive low severity fires. Photo by Jack McGowan-Stinski.

CONCLUSIONS

The management of natural red pine forests is a priority for the Michigan DNR. It is a challenging topic complicated by demands for timber, the need to mitigate tree damage from forest pests and pathogens, logistical considerations around the application of fire, and assured regeneration from conversion of natural forests to plantation. Therefore, density-based thinning and artificial regeneration have become common management approaches in natural and plantation origin pine stands. Evaluation of conventional management approaches of natural red pine forests suggests the need to reconsider prevailing management paradigms for pine systems.

We have developed an approach for the management of natural red pine forests that focuses on ecological stability while still providing sustainable timber harvest. This management approach employs the strategic use of prescribed fire along with timber harvest following the ICO (Individuals, Clumps, and Openings) technique. The approach also aims to reduce vulnerability to forest pathogens; improve resilience to climate change and wildfires; conserve



Natural red pine regeneration following a wildfire.
Photo by J.M. Lincoln.



Burned (left) and unburned (right) portions of a natural red pine forest following a wildfire in the Newberry FMU. The fire substantially reduced mesophytes such as red maple, white spruce, and white pine and the impacts of a single fire were obvious more than a decade later. There was also patchy regeneration, minimal canopy mortality, and very little char present on the boles of canopy trees 12 years after the fire. Photo by J.M. Lincoln.

biodiversity; and reduce costs associated with intensive management while maintaining opportunities for sustainable timber harvest.

This approach maintains continuity of forest types, promotes structural complexity and species diversity, and applies silvicultural interventions at ecologically appropriate time intervals that preserve landscape structure and function. This framework is intended to replicate the structural complexity found in natural red pine systems, supports native biodiversity, and facilitates the natural regeneration of red pine through the process that historically structured these systems. Red pine forests are not static communities, but are part of dynamic, fire-dependent landscapes shaped by repeated disturbance, spatial heterogeneity, and long temporal continuity.

This framework is divided into an initial conditioning period focused on reversing the impacts of fire suppression, including controlling mesophication and establishing red pine regeneration prior to timber harvest. This is followed by a long-term maintenance period centered on alternating applications of fire and timber harvests. A central feature of our framework is the sequencing of repeated low-severity prescribed fire prior to additional major canopy reduction. In many natural red pine stands, thinning without fire

accelerates mesophication and reduces the feasibility of future burns. By conditioning sites with repeated fire ahead of timber harvest, managers can reduce mesophytic competition, improve future fire behavior, and establish natural red pine regeneration before canopy removal occurs.

This report provides a science-based and operationally feasible framework for prioritizing prescribed fire and ecological silviculture in natural red pine stands on State Forest land. We have identified sites of natural pine where we recommend combining the application of fire and timber harvest. The framework is intended to balance timber production with protecting biodiversity, supporting adaptability to a changing climate, and maintaining the ecological character of our landscapes.

Among available management tools, prescribed fire remains the most reliable method for promoting natural regeneration of red pine. We are not suggesting universal application of this framework, but we believe it is carefully considered and worthy of implementation in several areas across Michigan. Our hope is that after successful implementation, this approach will serve as a template for management of natural red pine forests across the region for an economically and ecologically stable future.



Dense red pine regeneration was locally common within a dry northern forest that had burned in the Sleeper Lake fire of 2007. Fire is a part of these landscapes and red pine is especially adapted to survive and thrive in the presence of regular fire. Photo by J.G. Cohen.

NATURAL RED PINE PROJECT AREAS

We used Michigan Forest Inventory (MiFI) stand notes to identify areas of natural red pine that have landscape positions suitable for potential Project Areas. We completed surveys within 12 Compartments across seven State Forest Management Units (FMU) during the 2025 season. A total of ten survey areas have been developed as Project Areas (Figure 10, Table 5). These Project Areas are sites of natural pine where we recommend the application of fire and implementation of timber management using the ICO (Individuals, Clumps, and Openings) framework to enhance forest resilience and ecological benefits along with timber harvest goals.

Within the Upper Peninsula, one Project Area is in the Baraga FMU, one is in the Crystal Falls FMU, one is in the Escanaba FMU, one is in the Sault Ste. Marie FMU, and two are in the Shingleton FMU; within the northern Lower Peninsula, three Project Areas are in the Pigeon River FMU and one is in the Roscommon FMU (Figure 10, Table 5).



Project Area 7 in Pigeon River FMU features a high-quality intermittent wetland surrounded by a natural pine stand. We recommend including the wetland with prescribed burns. Photo by J.M. Lincoln.

Table 5. Potential natural red pine Project Areas identified during 2025 field surveys. Comprehensive site descriptions and management recommendations are provided for each site.

FMU	Compartment	Primary Stands	Project Area Size (Acres)	Community Type
Upper Peninsula				
1. Baraga	C11008	8, 7, 5, 4, 2, 3, 1	210	Dry -mesic Northern Forest
2. Crystal Falls	C12070 and C12071	32, 39, 40, 42, 44, 22, 54	108	Dry -mesic Northern Forest
3. Escanaba	C33106	27, 9, 57	139	Dry -mesic Northern Forest
4. Sault Ste. Marie	C45037	27, 32, 46, 71, 88	94	Pine Barrens and Dry -mesic Northern Forest
5. Shingleton	C41132	32, 23, 26	322	Dry -mesic Northern Forest
6. Shingleton	C41133	41, 40, 59, 63, 64, 69	290	Dry -mesic Northern Forest
Lower Peninsula				
7. Pigeon River	C53005 and C53004	21, 28, 30, 32, 33, 36, 37, 120, 123, 42 and 43	214	Dry -mesic Northern Forest, Intermittent Wetland
8. Pigeon River	C53036	89, 88, 90, 94, 99, 101, 103	121	Dry -mesic Northern Forest
9. Pigeon River	C53038	20, 33, 34, 35	194	Dry -mesic Northern Forest
10. Roscommon	C71016	140-143, 145, 146, 148, 153-157, and 162-166	298	Dry-mesic Northern Forest, Pine Barrens, Bog, and Intermittent Wetland

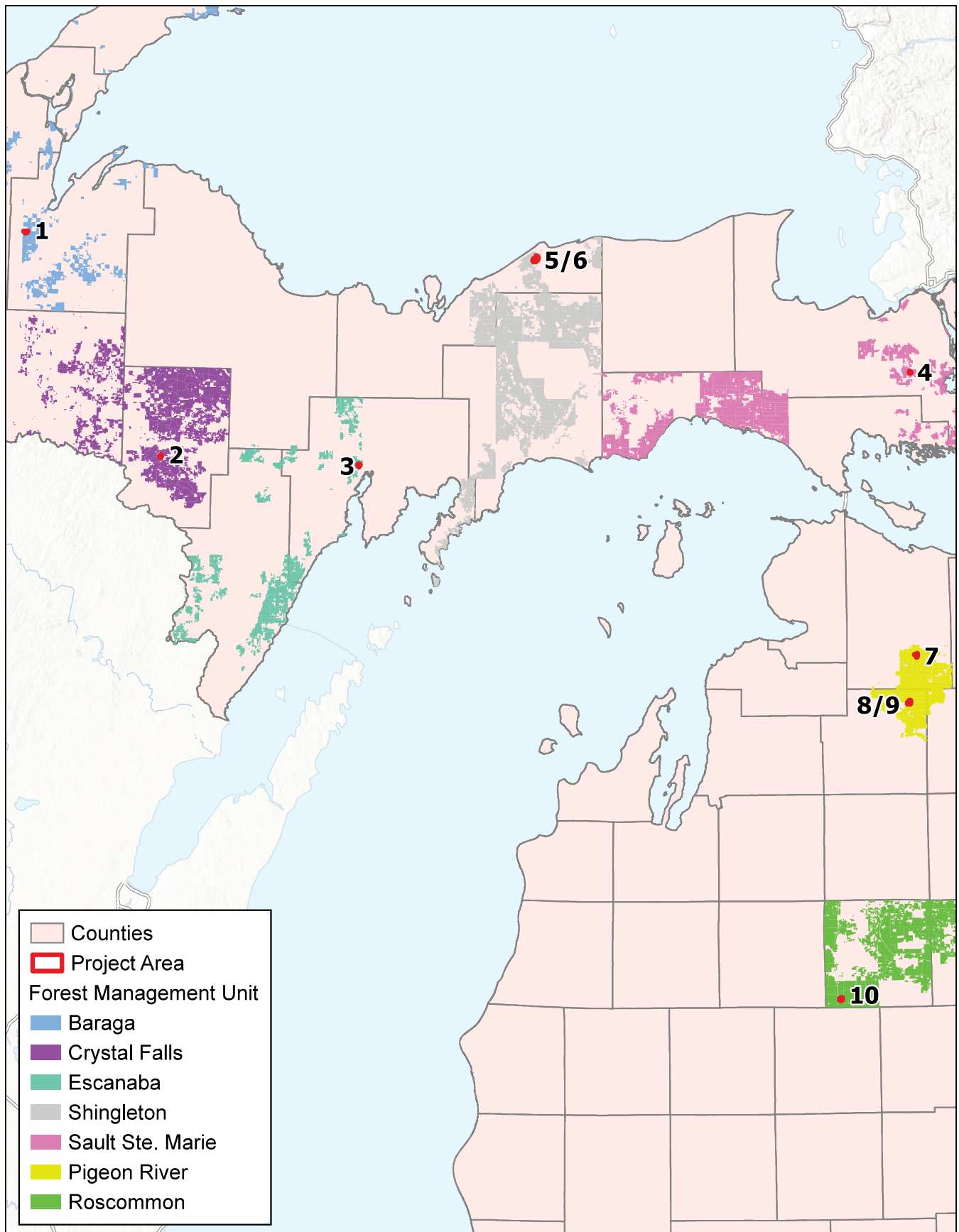


Figure 10. Locations of potential Project Areas surveyed during 2025. Numeric labels correspond to the following Project Area Compartments within the report: 1 = Baraga (C11008), 2 = Crystal Falls (C12070/71), 3 = Escanaba (C33106), 4 = Sault Ste. Marie (C45037), 5 = Shingleton (C41132), 6 = Shingleton (C41133), 7 = Pigeon River (C53005/04), 8 = Pigeon River (C53036), 9 = Pigeon River (C53038), 10 = Roscommon (C71016, Potential ERA).

UPPER PENINSULA PROJECT AREAS

1. Baraga FMU: C11008

Location: Compartment 11008 – Stands 2-5 and 7-9

Natural Community Type: Dry-mesic Northern Forest

Size: 210 acres

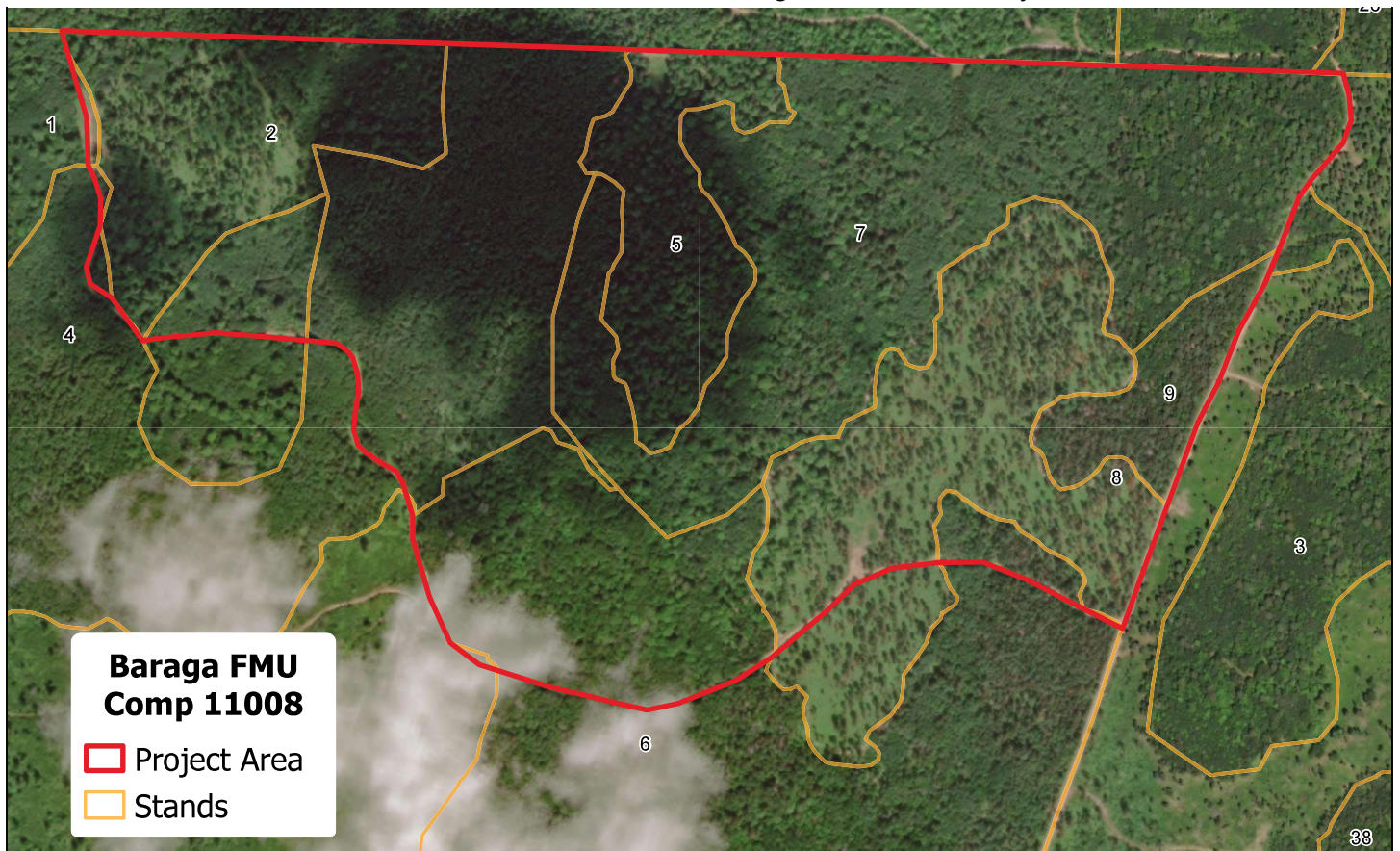
Site Summary

This project area contains multiple stands with natural red pine throughout despite most stands exhibiting a dominance of deciduous species in the understories. The site approaches the mesic limit of red pine tolerance with widespread red maple (*Acer rubrum*) and white pine (*Pinus strobus*) in the understory and low red pine regeneration.

There have been at least two prescribed burns and several thinning treatments across this project area over the past decade. While prescribed fire has consistently top-killed red maple and reduced white pine, it has not yet shifted competitive dynamics or resulted in red pine recruitment. Aspen (*Populus* spp.) and other mesic associates are contributing to dense understories that are likely to complicate burn effectiveness and regeneration.



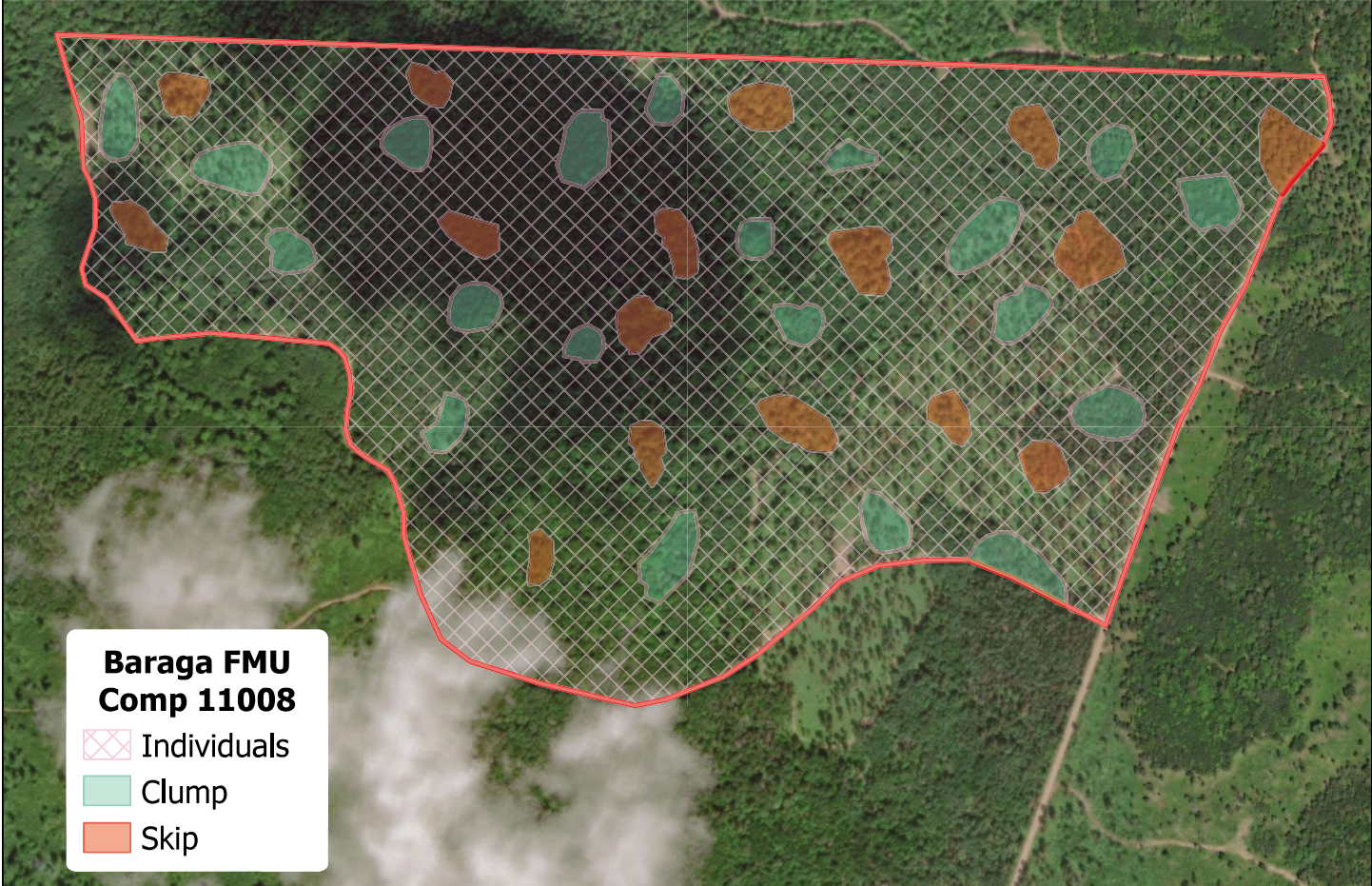
Stand 8 was recently thinned. Despite red pine in the canopy, there is no regeneration. Photo by J.M. Lincoln.



Location of Baraga FMU Project Area (Compartment 11008). The Project Area boundaries are intended to serve as a burn break for the entire project area.



The boundary between Stand 7 (Left) and Stand 5 (Right) shows the impacts that a single burn can have. Stand 5 was burned in 2017 and the red maple and white pine were substantially reduced. Because of the mesic nature of this project area, multiple burns are required to reverse the trend and promote natural red pine regeneration prior to the next timber harvest. Without that level of effort, the stands in this project area will convert to another cover type. Photo by J.M. Lincoln.



ICO Management zones for Baraga FMU Project Area (Compartment 11008).

Despite limited recruitment of red pine where fire has been applied, these treatments demonstrate that low-intensity fire can be applied without damaging canopy red pine, even under relatively mesic conditions. The site retains strong potential for natural red pine regeneration but will require repeated application of fire to overcome established mesophication.

Because of the previous investments in prescribed fire and the need for multiple fires to reverse the trend of mesophication, this is an excellent potential Project Area.

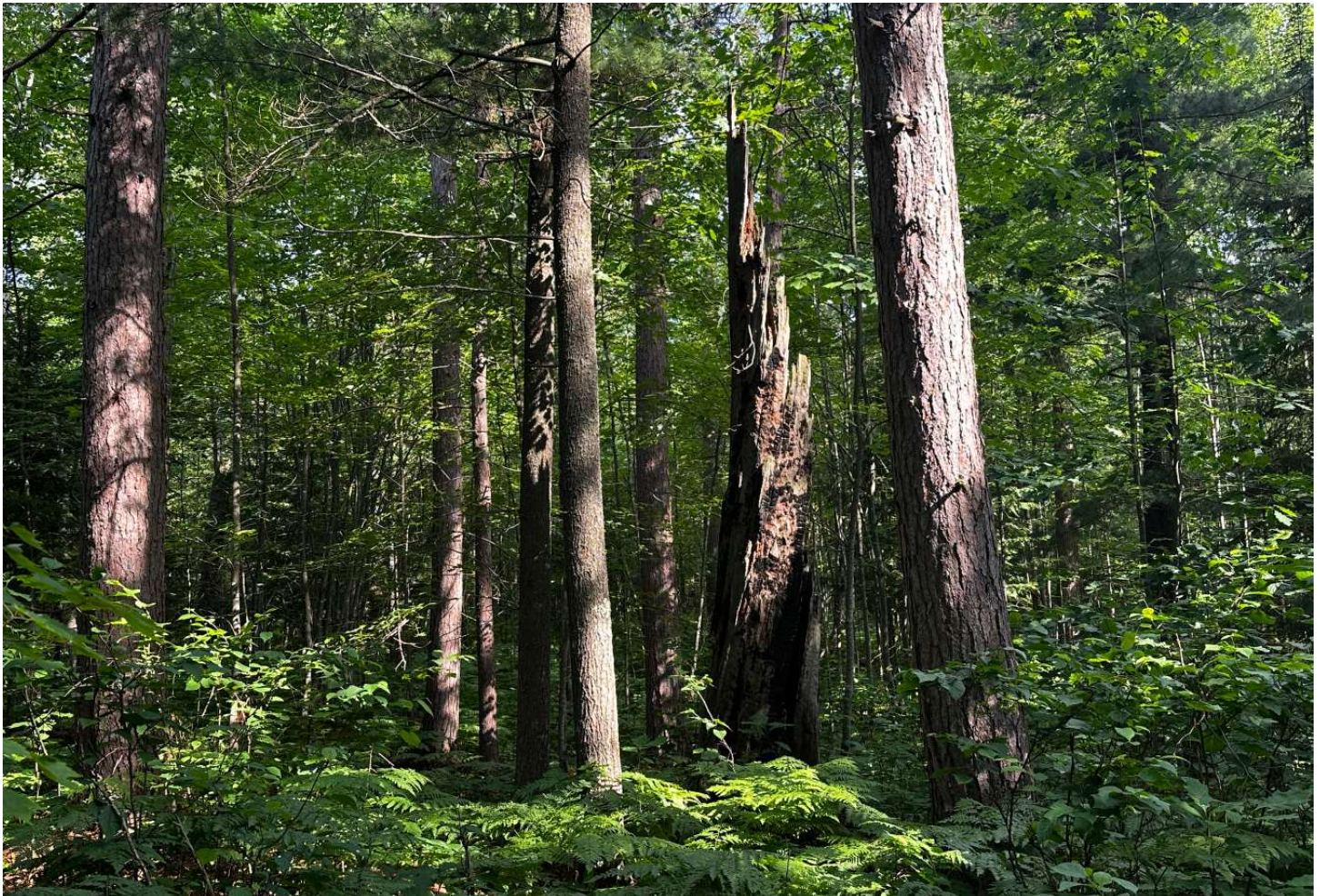
Select Stand-Level Information

- Stand 2: Thinned (unsure of year) and burned in 2016; reduced mesic species but lacking red pine regeneration
- Stand 3: Dominated by aspen saplings; selection cut in 2002
- Stand 4: Aspen-dominated (~45 years old) with some canopy white pine; no red pine in canopy and local pockets of red pine regeneration

- Stand 5: Burned in 2017; heavy white pine mortality in understory and ~50% of red maple top-killed despite minimal compositional shift; no red pine recruitment
- Stand 7: Highly mesic; dominated by red maple with no red pine regeneration; ~10% of canopy is 115-year-old natural red pine remaining from a harvest in 1993
- Stand 8: Two-aged pine-oak stand; recently thinned with dense aspen understory limiting burn carry and red pine regeneration
- Stand 9: Dominated by 47-year-old planted red pine with some 115-year-old natural red and white pine in the canopy

Management Recommendations

The overall strategy we recommend is to restore fire as a primary process and delay timber harvest until fire has reset competitive dynamics towards dry and dry-mesic species.



Stand 7 was thinned in 1993 and natural red pine was retained in several areas. Despite this retention, there is almost no red pine regeneration and the understory features dense red maple. Removal of the canopy red pine would result in a new cover type. To retain the natural pine, we suggest the application of at least two fires to condition the site and reduce mesophication. Following the second fire, timber treatments can be planned around pockets of red pine regeneration. There were several large snags with char and it is clear the stand was historically influenced by fire. It took a century for the site to shift from natural red pine; it will take time and the dedicated application of fire to reverse that trend. Photo by J.M. Lincoln.

Prescribed fire:

- Establish a large, continuous burn block across the project area using existing roads and firebreaks
- Increase fire frequency and apply multiple burns in close succession to overcome mesophication
- Burn sequence
 - Initial burn: low-intensity in the spring, ~80% coverage
 - Second burn: within 3-5 years during the late growing season (June-Oct, prior to red pine seed drop)
 - Third burn: 5-10 years post-harvest to reinforce red pine regeneration, mitigate disease risks, and reduce competition

Targeted timber harvest:

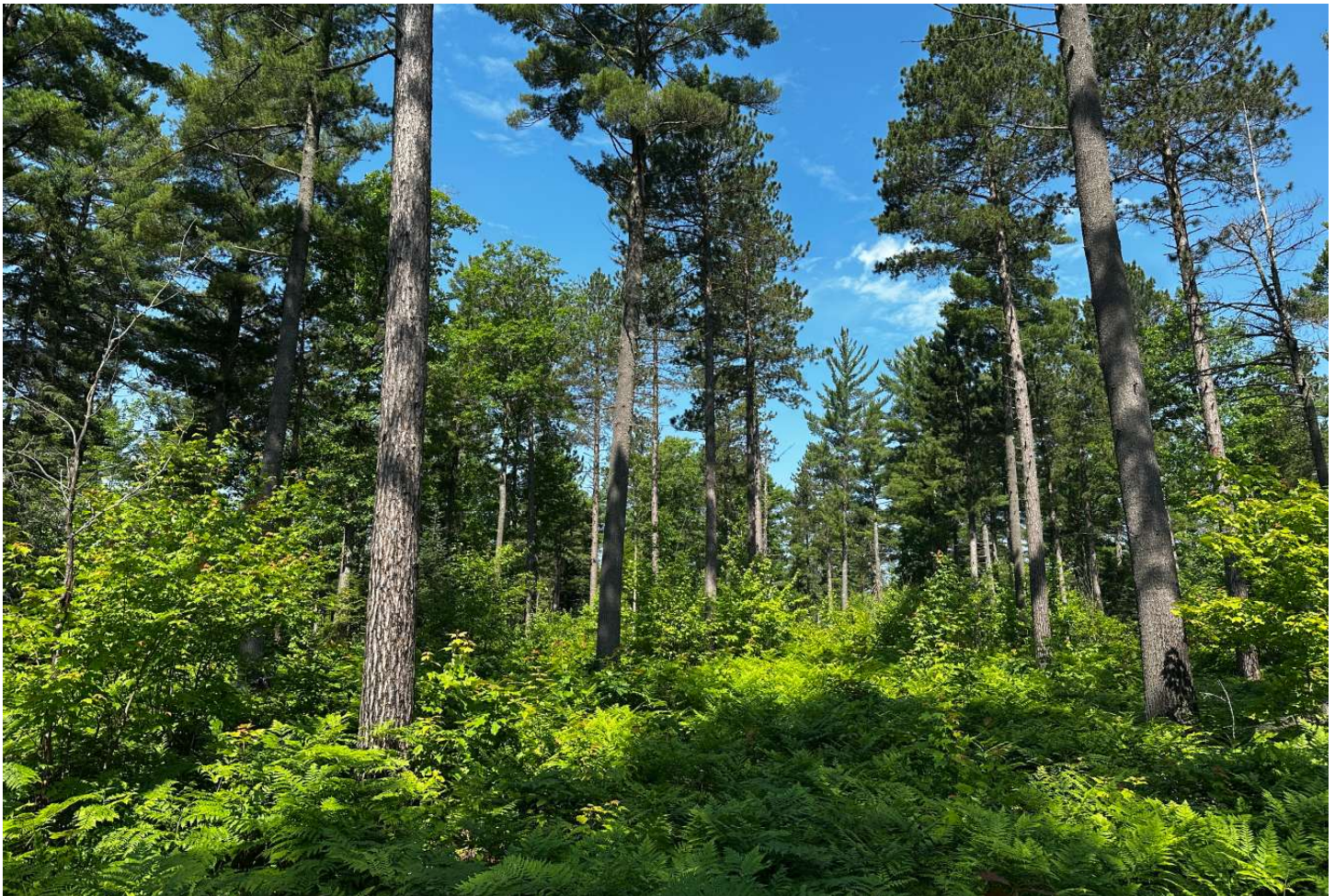
- Delay immediate timber harvests until two prescribed burns have been implemented across entire project area
- Execute a timber harvest after this second burn
 - Survey for red pine regeneration and implement treatments around releasing

existing understory red pine. Openings were not proposed but could be developed around concentrations of red pine regeneration

- Avoid harvesting within skips and clumps
- Focus on removal of mesic species, especially aspen and red maple in stands 3, 4, and 7
- Reduce white pine across the project area
- Retain most canopy red pine across the project area during initial timber harvest
- Following the first timber harvest, evaluate the project area for thinning during the next compartment review cycle after the third burn

Additional considerations:

- Monitor for invasive species along roads and trails
- Retain fire-scarred trees and legacy trees when present
- Avoid soil disturbance and equipment in saturated areas
- Recognize that regeneration response may be delayed and dependent on repeated fire



Stand 2 in the proposed Baraga Project Area was thinned (year unknown) and then burned on May 18, 2016. While there hasn't been any red pine regeneration, this is still a successful outcome for a single burn on a mesified site. Managers can increase the probability of red pine regeneration by applying subsequent burns ahead of seed release in September or October during red pine mast year. Ideally, the entire project area would be developed into a single large burn unit and multiple fires applied prior to the next timber harvest. Photo by J.M. Lincoln.

2. Crystal Falls FMU: C12070 and C12071

Location: Compartment 12070 – Stands 32, 39, 40, 42, and 44; Compartment 12071 – Stands 22 and 54

Natural Community Types Dry-mesic Northern Forest

Size: 108 acres

Site Summary

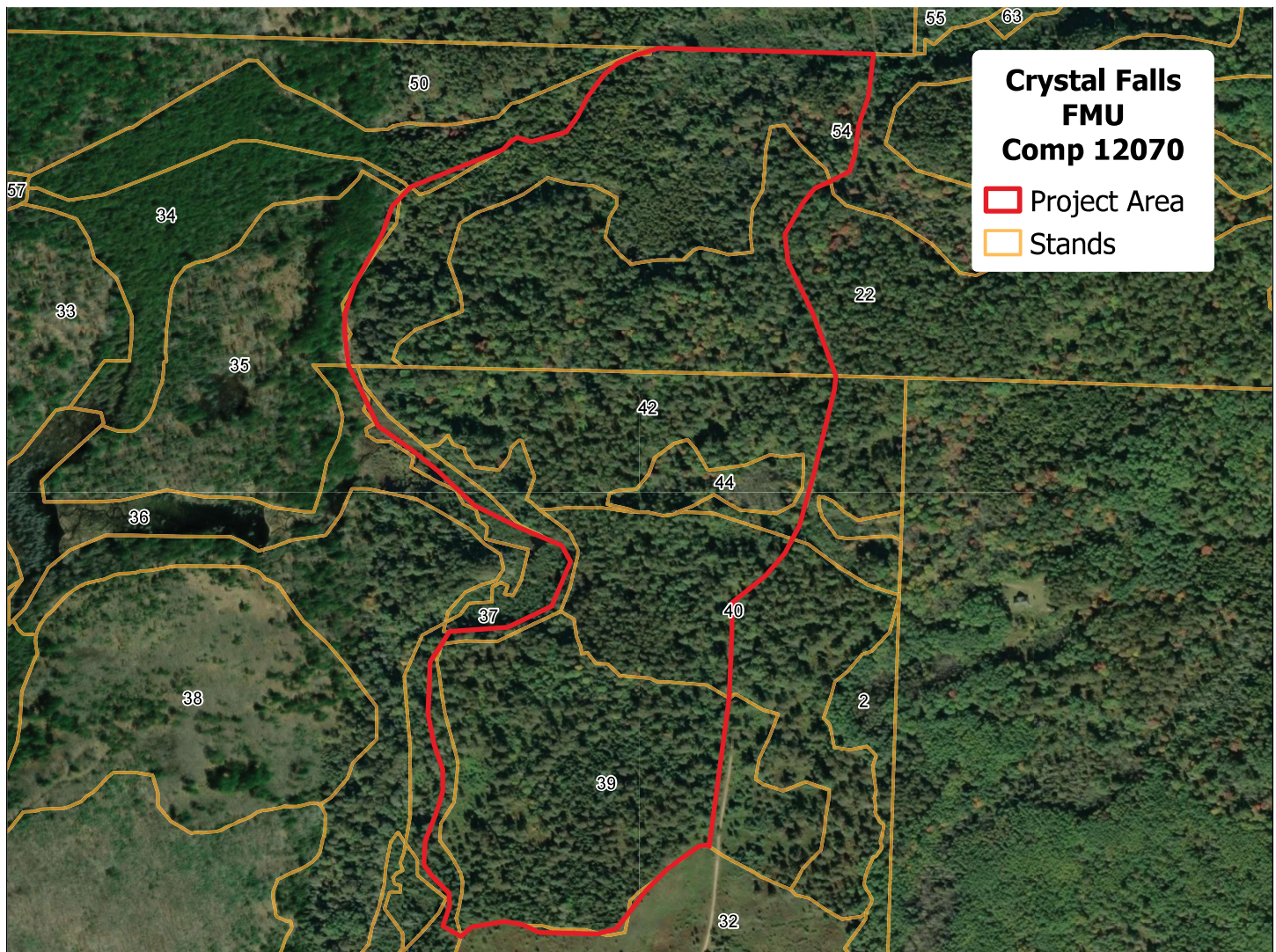
This site features natural mixed conifer forests that trend towards mesic conditions. The site includes areas of elevated conservation value, particularly where rocky outcrops support higher floristic diversity and where the conifer forest grades into a high-quality cedar swamp. A stream serves as the western boundary for the two compartments and we recommend that as a project boundary and natural burn break. Fires would therefore naturally extinguish in the adjacent cedar swamp.

Upland stands in this Project Area are dominated by red pine and white pine with cohorts generally around 100 years old. The subcanopy and understory are often dense with red maple, white pine, beaked hazelnut (*Corylus cornuta*), and other hardwood and conifer associates. Red pine regeneration is absent across the site.

Recent thinning has occurred in parts of the Project Area, including select removal of red pine. While the site retains strong restoration potential, current conditions reflect advanced mesophication, high levels of duff accumulation, and factors that may impair the spread of fire. The presence of charcoal in the soil suggests a historical fire regime that promoted the current red pine, likely reflecting past anthropogenic burning.

Select Stand-Level Information

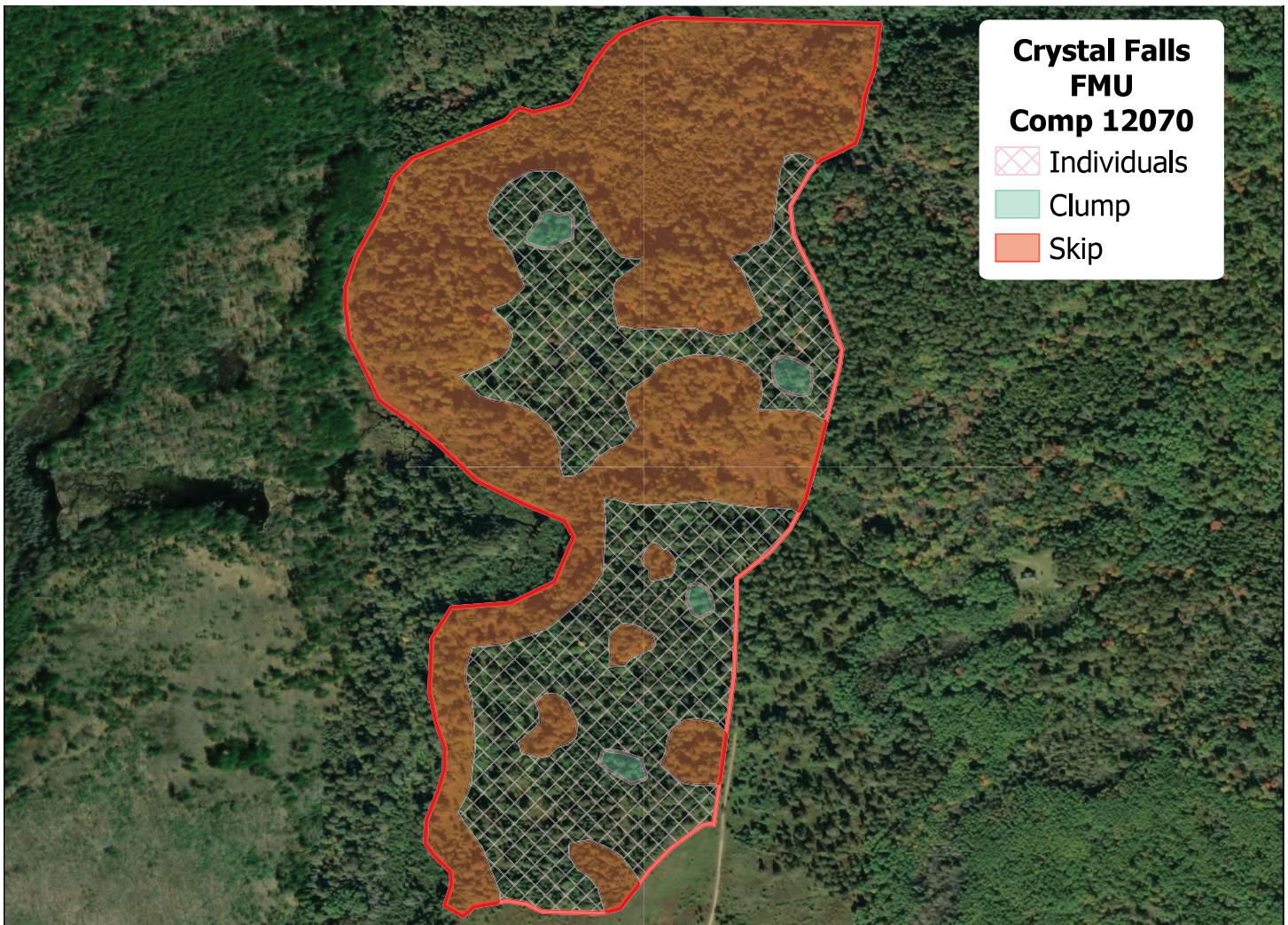
- Stands 22, 42, and 40: Thinned red pine canopy (~100 years old) with dense beaked hazelnut, red maple, and mixed conifers in the understory; aspen, white pine, and fir regeneration along edges and where red pine is sparse



Location of Crystal Falls FMU Project Area (Compartments C12070 and 12071). The Project Area boundaries are intended to serve as a burn break for the entire project area.



Stand 40 in the Crystal Falls Project Area was thinned in 2000. There is no red pine regeneration and the understory is dense with hazel, red maple, and white pine despite abundant red pine in the canopy. This will be a challenging burn to implement but the conservation value of the site warrants a careful approach. Photo by J.M. Lincoln.



ICO Management zones for Crystal Falls FMU Project Area (Compartments 12070/12071). This site has a high proportion of Skips and no Openings due to the complex terrain and extensive forested wetlands along the western and northern boundaries.

- Rock outcrops (SW portion of Stand 22): High floristic diversity and important conservation features
- Stands 54 and 44: wetlands to be included in burn units, avoid with equipment. Allow fires to naturally extinguish
- o Second burn: within 3-5 years, timed for late growing season (prior to red pine seed drop)
- o Third burn: 5-10 years post-harvest to reinforce red pine regeneration, mitigate disease risks, and reduce competition

Management Recommendations

The recommended strategy is to reintroduce fire cautiously and sequence treatments to reduce mesophytic competition, gradually restore conditions for red pine regeneration, and protect the elevated conservation potential of this site via selective timber harvests.

Prescribed fire:

- The application of fire would likely be complicated but possible
- Establish a large, continuous burn block across the project area using existing roads along the eastern boundary and the stream to the west
- Apply two prescribed burns prior to additional thinning
 - o Initial burn: low-severity/low-intensity during the dormant season, target surface fuels and partial reduction of understory density

Targeted timber harvest:

- Delay immediate timber harvests within this project area until two prescribed burns have been implemented
- Execute a timber harvest after this second burn
 - o Avoid skips and clumps
 - o Thin by 1/3 basal area with emphasis on removal of white pine
 - o Retain most canopy red pine across the project area during initial harvest
 - o Survey for red pine regeneration and implement treatments around releasing existing understory red pine

Additional considerations:

- Protect rocky outcrop areas from equipment as these support elevated diversity
- Avoid equipment on saturated soils near wetlands
- Monitor for invasive species along roads and trails
- Recognize that regeneration response may be delayed and dependent on repeated fire



Stand 22 of the Crystal Falls Project Area has several bedrock outcrops that were especially diverse. The site has been thinned but there is no red pine regeneration. A stream forms the boundaries of the compartment as well as the Project Area and we recommend managers use the stream as a natural burn break and let the fire naturally extinguish in the adjacent swamp. The outcrops and the adjacent swamp are mapped as Skips to avoid logging equipment in these zones. Photo by J.M. Lincoln.

3. Escanaba FMU: C33106

Location: Compartment 33106 – Stand 27 and adjacent stands 9 and 57

Natural Community Types: Dry and Dry-mesic Northern Forest

Size: 139 acres

Site Summary

Stand 27 is a natural red pine stand ideally situated for our management approach as the site has already been thinned and there is minimal mesophytic competition in the understory. The canopy coverage is approximately 75% (basal area ranging from 80-110 ft²/ac), dominated by red pine with minor components of white pine, red oak (*Quercus rubra*), and trace red maple.

A thinning in 2022 has improved structure and created conditions favorable for fire. The stand is currently at an ideal window for periodic fire to be effectively reintroduced in part because the understory has yet to re-establish except for white pine and sparse red pine. The low abundance of mesophytic competition would likely make red pine regeneration possible with a single, well-timed burn.

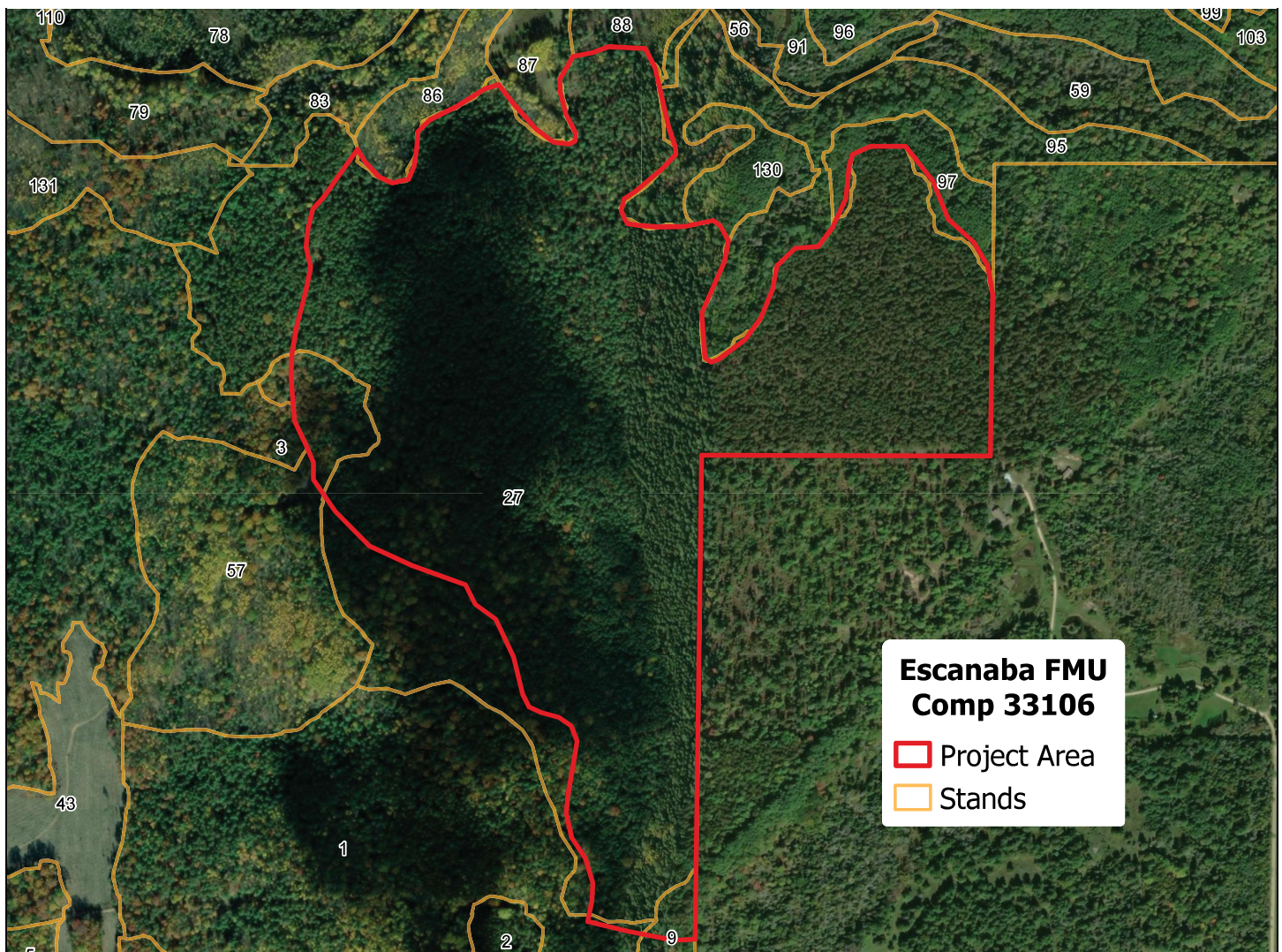
Localized areas, particularly toward the southern end, have denser mesic hardwood encroachment (red maple, beech [*Fagus grandifolia*]). Adjacent stands such as Stand 83 include red pine but are currently more constrained by dense aspen.

Select Stand-Level Information

- Stand 27: Recently thinned (2022), limited red pine regeneration
- Mixed age classes
- Semi-open conditions creating good fire carry potential; moderate canopy density (75% cover, 80-110 basal area) supports controlled burning; mesic hardwoods increasing in southern portion

Management Recommendations

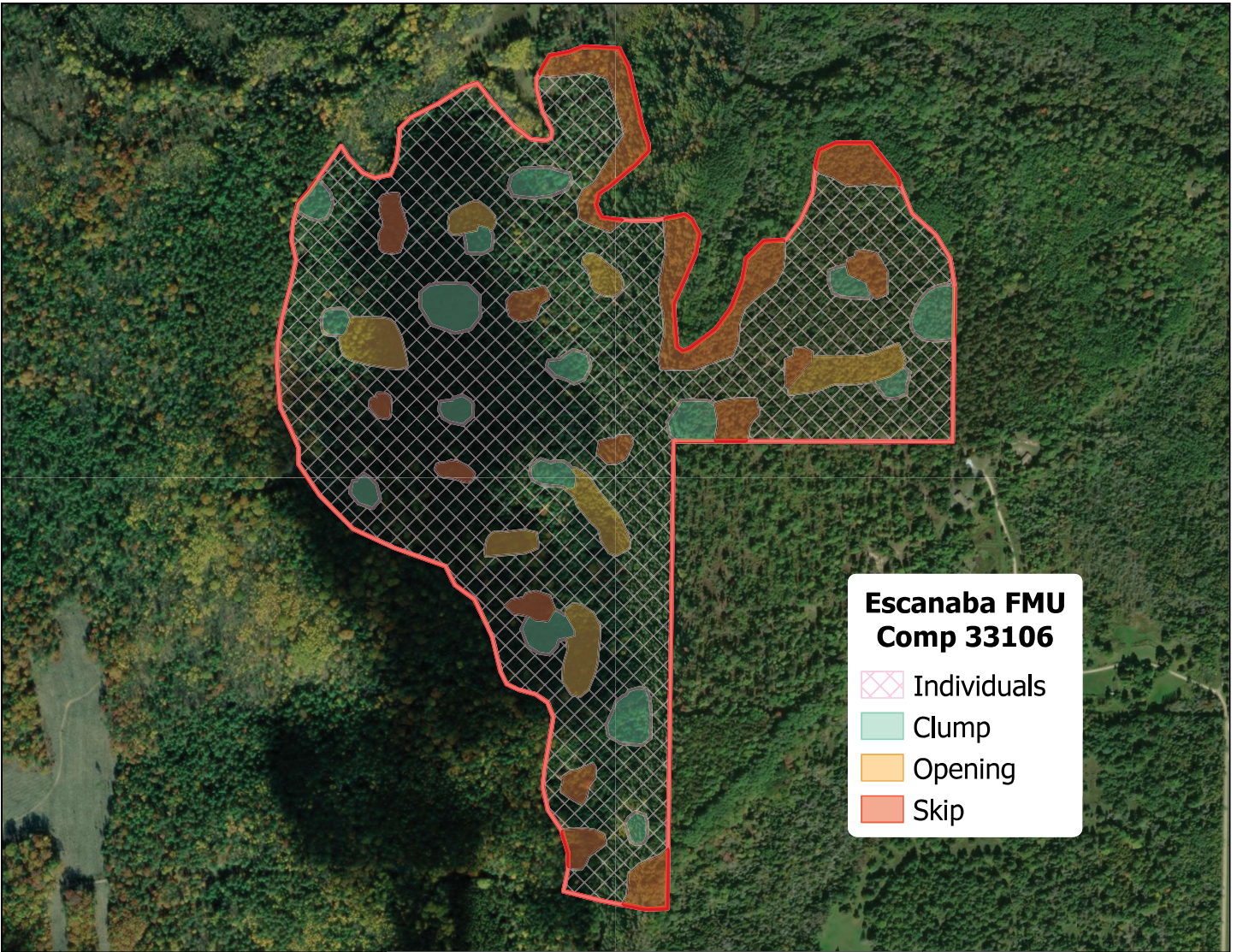
Take advantage of current stand conditions to reintroduce fire, then maintain with repeated burns before additional thinning.



Location of Escanaba FMU Project Area (Compartment 33106). The Project Area boundaries are intended to serve as a burn break for the entire project area.



Stand 27 features a canopy of mixed-age red pine with some trees in a 150-year-old cohort. A single, well-timed fire could promote red pine regeneration. Photo by J.M. Lincoln.



ICO Management zones for Escanaba FMU Project Area (Compartment 33106).

Prescribed fire:

- Establish a large, continuous burn block across the project area using the river to the north and existing roads in other areas
- Apply two prescribed burns prior to additional thinning
 - Initial burn: low-intensity in the dormant season, targeting surface fuels and partial reduction of understory density
 - Evaluate red pine regeneration following first burn
 - Second burn: if no adequate red pine regeneration, burn within 3-5 years, timed for late growing season (prior to red pine seed drop)
- Apply an additional burn 5-10 years post-harvest to reinforce red pine regeneration, mitigate disease risks, and reduce competition

Targeted timber harvest:

- Delay immediate timber harvest within this project area until at least one prescribed burn has been implemented, ideally until after two burns
- Execute a timber harvest after the second burn
 - Survey for red pine regeneration and implement Openings treatments around releasing existing understory red pine
 - Avoid Skips and Clumps
 - Thin individuals by 1/3 BA
 - Retain older cohorts of red pine and large diameter red oaks
 - Evaluate for another thinning in 20 years

Additional considerations:

- Protect oldest age classes of red pine from timber harvest
- Monitor for invasive species along roads and trails
- Eventually expand Project Area to use river to the north as natural burn break



Stand 27 in the Escanaba Project Area is an ideal place to attempt our approach. The site was thinned in 2022 and has a basal area that would facilitate a prescribed fire along with few mesophytes in the understory. Therefore, even a single application of fire is likely to be more effective at promoting red pine regeneration, particularly if timed ahead of seed drop during a red pine mast year. Photo by J.M. Lincoln.

4. Sault Ste Marie FMU: C45037

Location: Compartment 45037 – Stands 27, 32, 46, 71, and 88

Natural Community Types: Dry-mesic Northern Forest and Pine Barrens

Size: 94 acres

Site Summary

This project area contains a mix of natural and planted pine stands with limited but important occurrences of natural red pine. The site is a lower priority relative to other project areas but was retained due to the potential for managing for pine barrens and due to the limited abundance of natural red pine systems in this portion of the FMU.

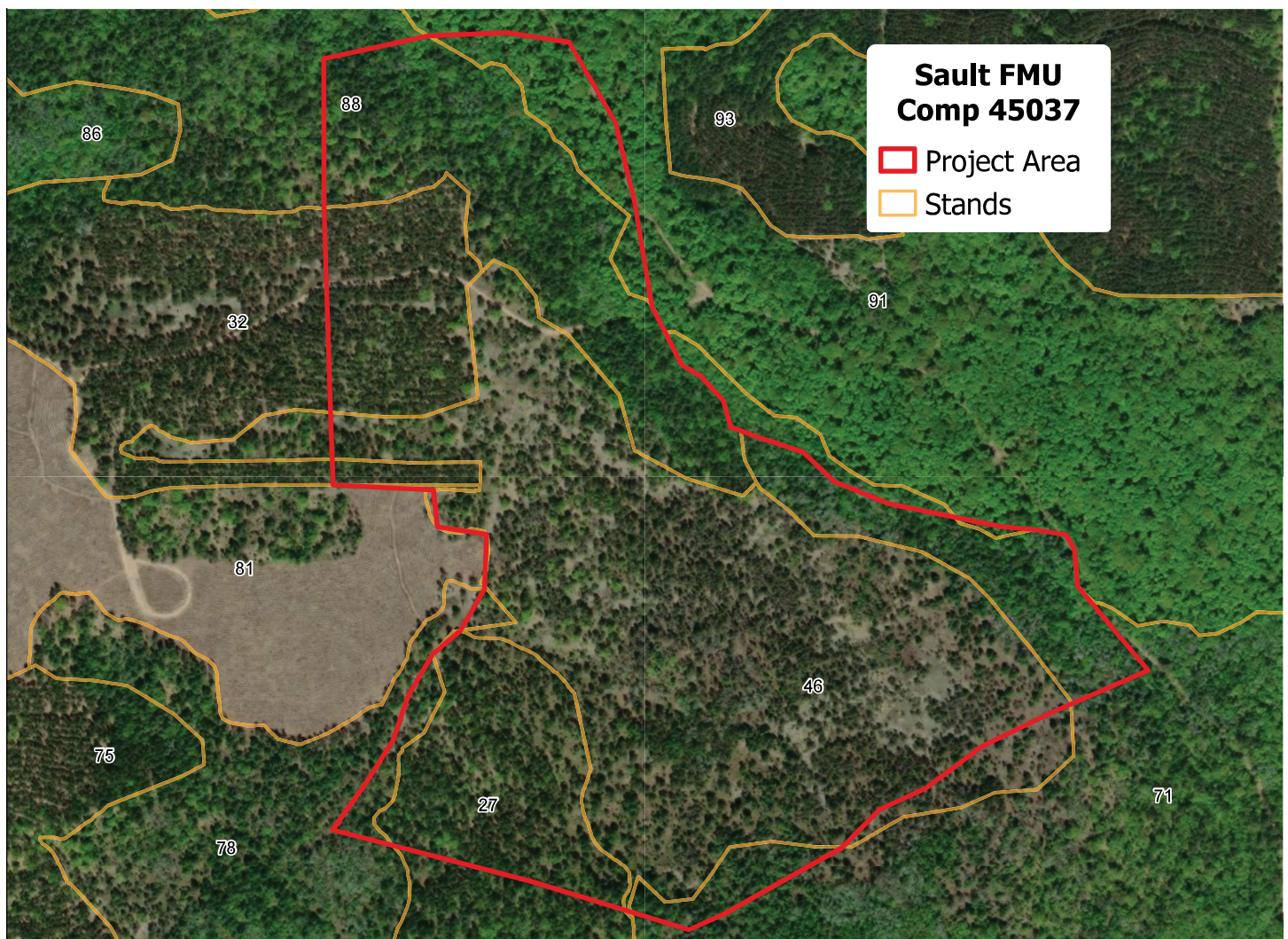
Natural red pine is present in Stand 88 and the northern portion of Stand 71, while Stands 27 and 32 are planted red pine with potential for developing toward a more natural structure. Stand 46 is a low-density jack pine (*Pinus banksiana*) stand with scattered red and white pine, exhibiting partial barrens structure but lacking the diversity of a high-quality pine barrens system. This area could be managed to promote habitat for upland sandpiper (*Bartramia longicauda*), sharp-tailed grouse (*Tympanuchus*

phasianellus), common nighthawk (*Chordeiles minor*), and Kirtland's warbler (*Setophaga kirtlandii*) which have populations in Chippewa County.

The project area includes a mix of conditions from mesified red pine stands to more open, pine barrens structure. Evidence of past fire from charred stumps suggests a fire-influenced landscape, though soils and structure of the pine barrens habitat have been altered and degraded by past management.

Select Stand-Level Information

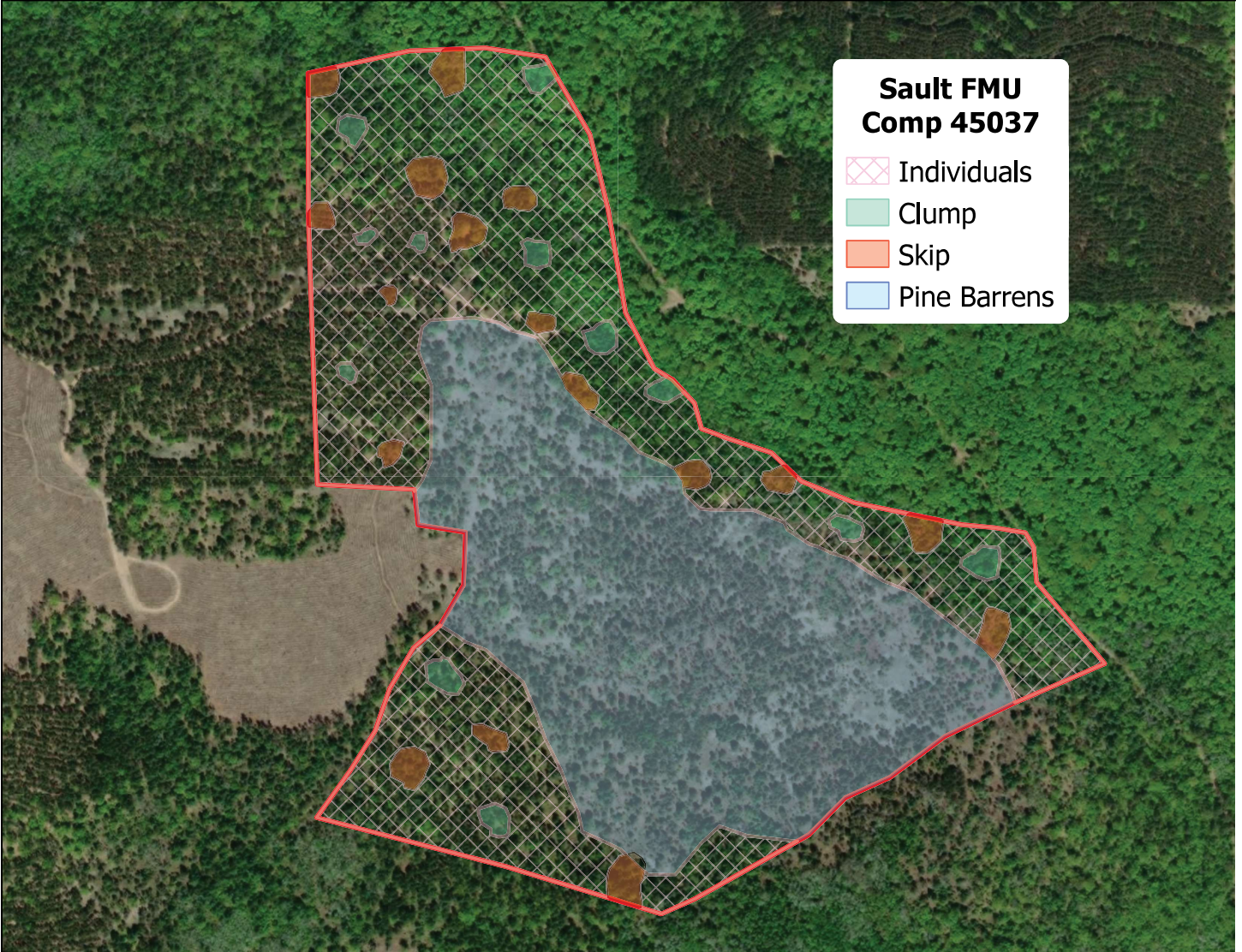
- Variable structure across the site: plantations, mesifying natural pine forests, and degraded barrens habitat
- Stands 27 and 32: Planted red pine with potential for structural and compositional restoration



Location of Sault Ste. Marie FMU Project Area (Compartment 45037). The Project Area boundaries are intended to serve as a burn break for the entire project area.



Stands 71 and 88 within the Sault Ste. Marie Project Area have canopies with red pine but little regeneration. These stands would need multiple fires to reverse the trend of mesophication. The approach could be developed here and applied to some of the other natural red pine stands in the FMU. Photo by J.M. Lincoln.



ICO Management zones for Sault Ste. Marie FMU Project Area (Compartment 45037). Commercial forestry is not recommended for the pine barrens management zone (Stand 46).

- Stand 88 and northern portion of Stand 71: Natural red pine with increasing red maple and red oak in the understory
- Stand 46: Somewhat degraded, sparse canopy jack pine with barrens structure but low floristic diversity

- o Third burn: 5-10 years post-harvest to reinforce red pine regeneration, mitigate disease risks, and reduce competition

Management Recommendations

Manage as a large, mixed-pine burn unit using repeated low-intensity fire to maintain open, pine barrens conditions in jack pine stand, reduce mesophication in natural red pine stands, and guide planted stands toward more natural structure. This is a mixed condition burn unit that should be focused on maintaining fire across a large area rather than achieving uniform outcomes.

Prescribed fire:

- Establish a large, continuous burn block across the project area using the existing roads and trails
- Apply two prescribed burns across all stands prior to additional thinning, including in plantations and jack pine areas
 - o Initial burn: low-intensity in dormant season, targeting surface fuels and partial reduction of understory density
 - o Second burn: within 3-5 years, timed for late growing season (prior to red pine seed drop)

Targeted timber harvest:

- Thin plantations in Stands 27 and 32 prior to initial burn to reduce density and improve fire behavior
- Delay immediate timber harvests in Stands 71 and 88 until two prescribed burns have been implemented
- Execute a timber harvest after the second burn
 - o Because of the arrangement of stands, there are no Opening treatments recommended
 - o Avoid Skips and Clumps
 - o Thin Individuals by 1/3 basal area
 - o Survey for red pine regeneration and implement treatments around releasing existing understory red pine

Additional considerations:

- Focus on maintaining fire across a large area rather than achieving uniform outcomes
- Monitor for invasive species along roads and trails
- Evaluate stumps for determining fire history
- Monitor for upland sandpiper, sharp-tailed grouse, common nighthawk, and Kirtland's warbler



Stand 46 features widely spaced jack pine. We recommend this area be managed with regular low-severity fire to promote pine barrens habitat for Kirtland's warbler. Photo by J.M. Lincoln.

5. Shingleton FMU: C41132

Location: Compartment 41132 – Stand 32 and adjacent stands 23 and 26

Natural Community Type: Dry-mesic Northern Forest

Size: 322 acres

Site Summary

This is a variable-structure pine system dominated by white pine with a substantial red pine component (~40%). Basal area ranges from approximately 110 to 160 ft²/ac, with a mix of older, denser zones and younger, previously managed areas. The large size, practicability for applying fire and varying structure with local red pine regeneration make this a viable Project Area for our management approach.

Portions of the stand have been thinned and scarified. This has created patches of younger forest with simplified structure, including areas dominated by bracken fern (*Pteridium aquilinum*) and reindeer lichen (*Cladonia rangiferina*). Older portions of the stand contain large, charred snags and coarse woody debris, indicating fire as a historic disturbance that shaped composition and structure.

The understory is dominated by red maple, white pine, and paper birch (*Betula papyrifera*), with little to no red pine regeneration in mature portions of the

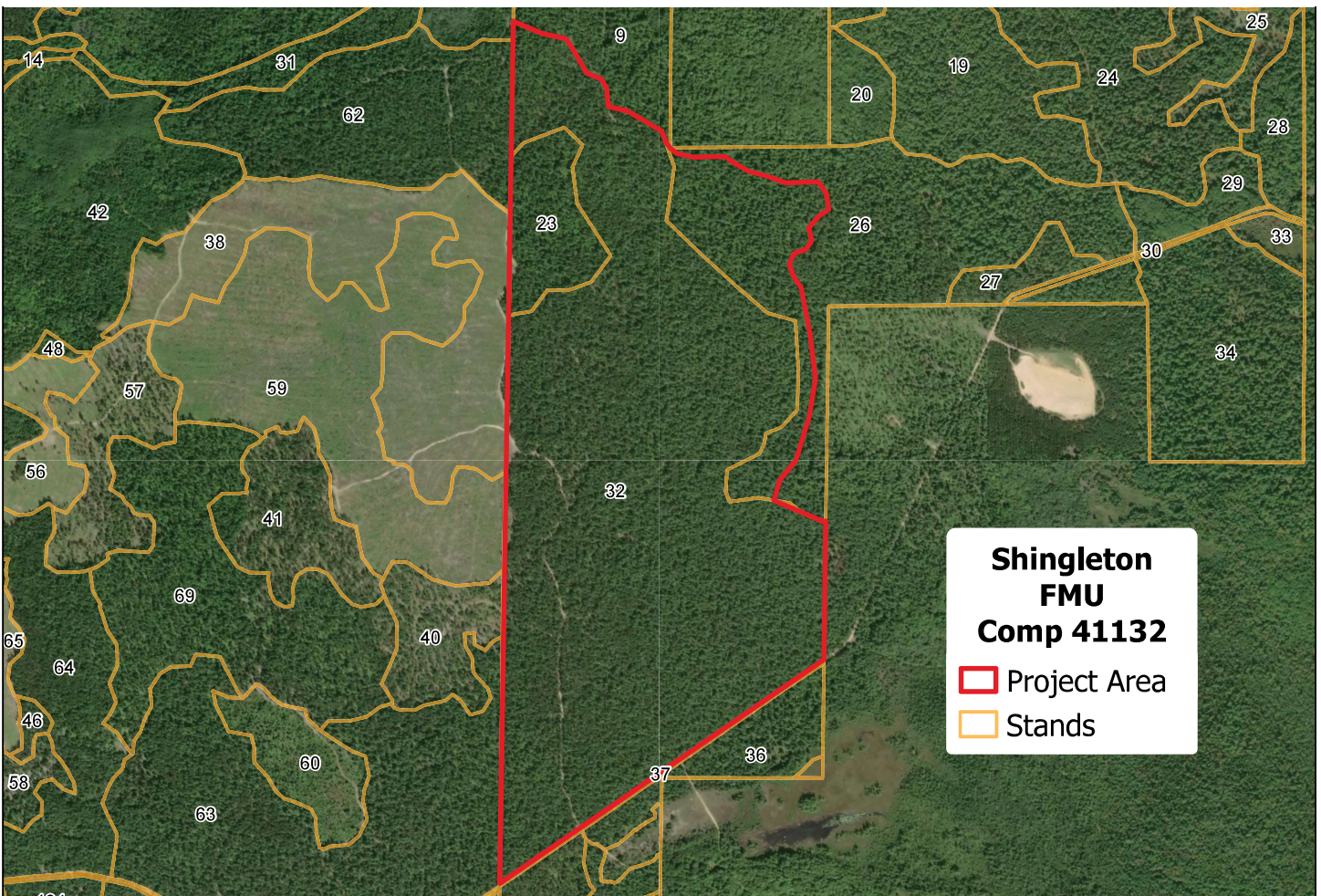
stand. Younger and previously disturbed areas have limited red pine regeneration.

Select Stand-Level Information

- Stand 32: Variable basal area (110-160 ft²/ac) with mixed age structure. A 55.2 cm dbh red pine was 122 years old. A 32.1 cm dbh red pine was 71
- White pine dominance with moderate red pine component
- No red pine regeneration in older stand zones
- Mesic hardwood and white pine dominance in understory
- Younger zones simplified following apparent scarification (lichen/bracken dominance)
- Evidence of past fire from large, charred red pine snags

Management Recommendations

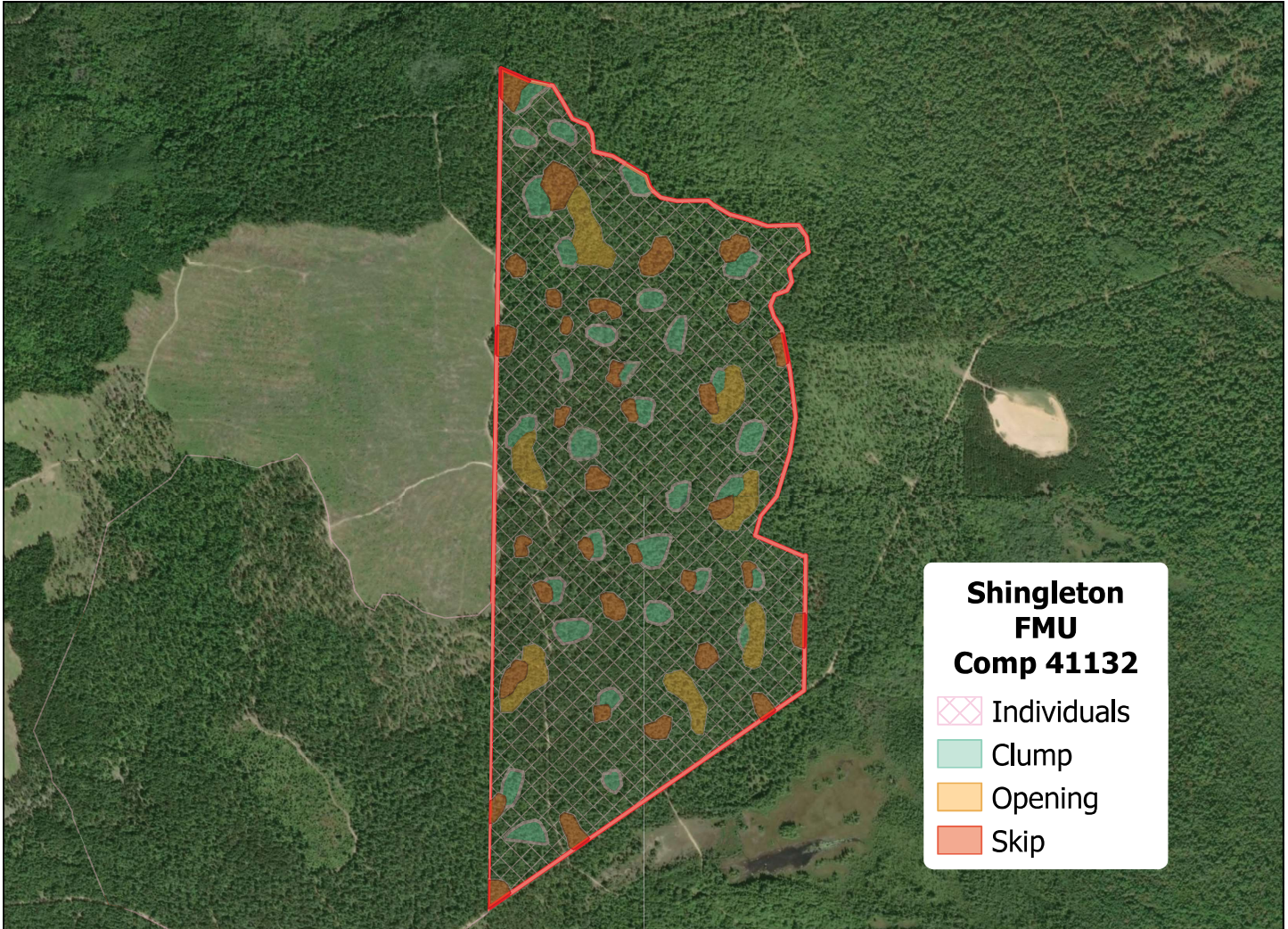
Despite relatively mesic conditions, the site has yet to mesify to a point that renders the application fire too difficult to be practical and the burn window is likely



Location of Shingleton FMU Project Area (Compartment 41132). The Project Area boundaries are intended to serve as a burn break for the entire project area.



Stand 32 has a mixed pine canopy with an understory dominated by red maple and white pine with very little red pine regeneration. It has yet to mesify to a point where fire stewardship would be too difficult to be practical and it would make an excellent Project Area. Photo by J.M. Lincoln.



ICO Management zones for Shingleton FMU Project Area (Compartment 41132).

larger than the more mesic Project Areas. The overall strategy should be to treat understory competition with repeated burns before using thinning to promote red pine regeneration.

Fire prior to additional thinning will reduce mesophytic competition while subsequent thinning with repeated fire should maintain red pine in the stand.

Prescribed fire:

- Establish a large, continuous burn block across the project area using the existing roads and trails
- Apply two prescribed burns across all stands prior to additional thinning
 - o Initial burn: low-severity/low-intensity in the dormant season, targeting surface fuels and partial reduction of understory density
 - o Second burn: within 3-5 years, timed for late growing season (prior to red pine seed drop)

- o Third burn: 5-10 years post-harvest to reinforce red pine regeneration, mitigate disease risks, and reduce competition

Targeted timber harvest:

- Delay immediate timber harvests in natural stands until two prescribed burns have been implemented
- Execute a timber harvest after the second burn
 - o Survey for red pine regeneration and implement Openings treatments around areas of regeneration releasing existing understory red pine
 - o Avoid Skips and Clumps
 - o Thin individuals by 1/3 basal area

Additional considerations:

- Retain large, standing coarse woody debris
- Monitor for invasive species along roads and trails



Stand 32 had several large red pine snags with char, particularly in the southern portion of the stand. These likely indicate historic, severe fires. There are no red pine in this stand approaching the size of historic trees. Photo by J.M. Lincoln.

6. Shingleton FMU: C41133

Location: Compartment C41133 – Stands 40, 41, 57, 60, 63, 64, and 69

Natural Community Type: Dry-mesic Northern Forest

Size: 290

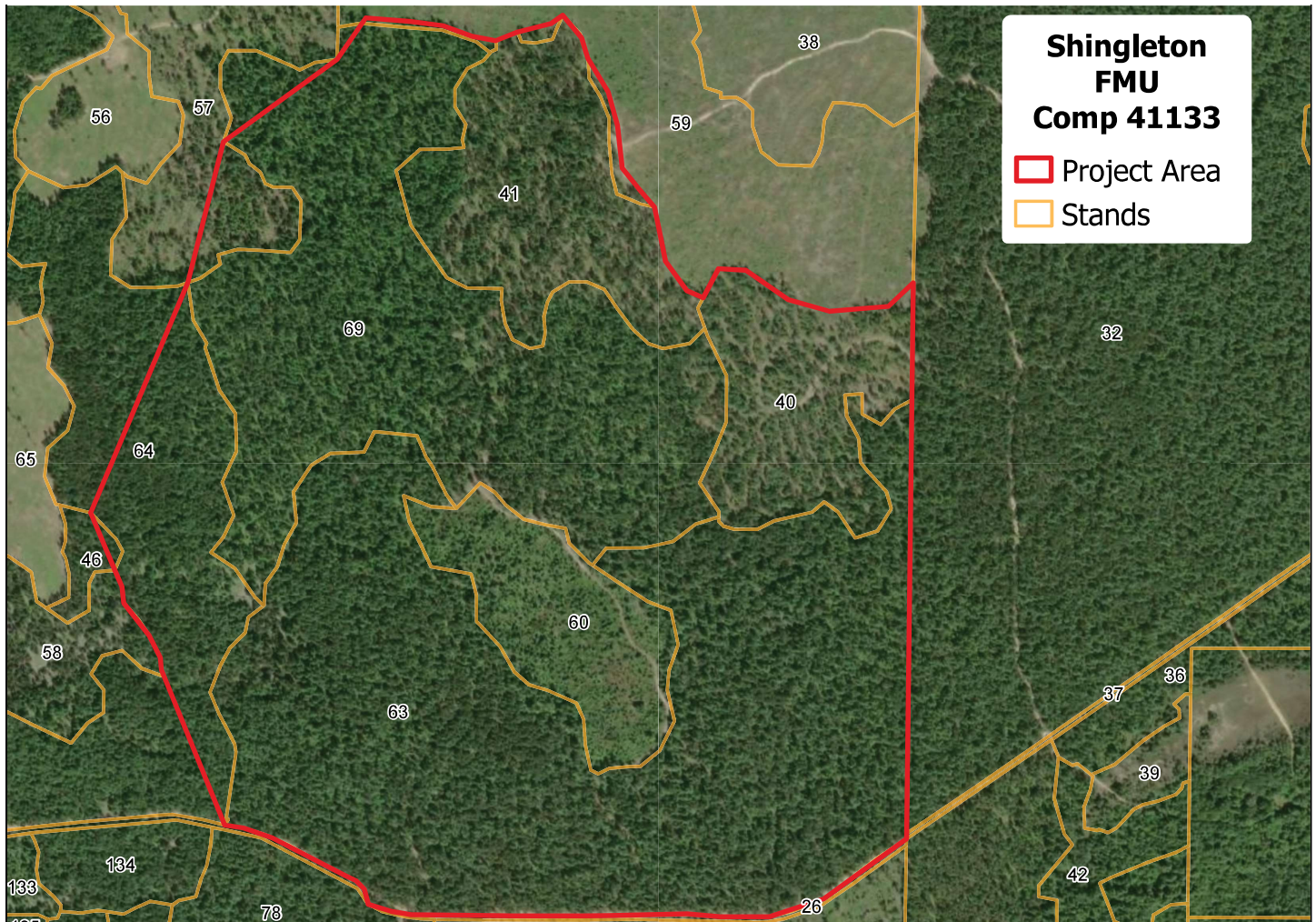
Site Summary

This project area contains multiple stands with varying treatment histories. Red pine is a canopy component of most stands but white pine and mesic hardwoods are most prevalent in the understories across this Project Area, despite areas that have been thinned and scarified. Stand structure ranges from open, previously scarified areas to well-stocked mixed pine stands with multiple cohorts.

White pine regeneration is abundant across much of the site, and red pine regeneration is infrequent. Several stands have been thinned, resulting in varying basal areas (20-110 ft²/ac) across the Project Area, though fuel conditions appear to be suitable for prescribed fire. Needle duff is likely sufficient to carry fire, and coarse woody debris is present but not excessive. Overall, this project area has good potential for fire to effectively reduce white pine competition and maintain or restore red pine prevalence.



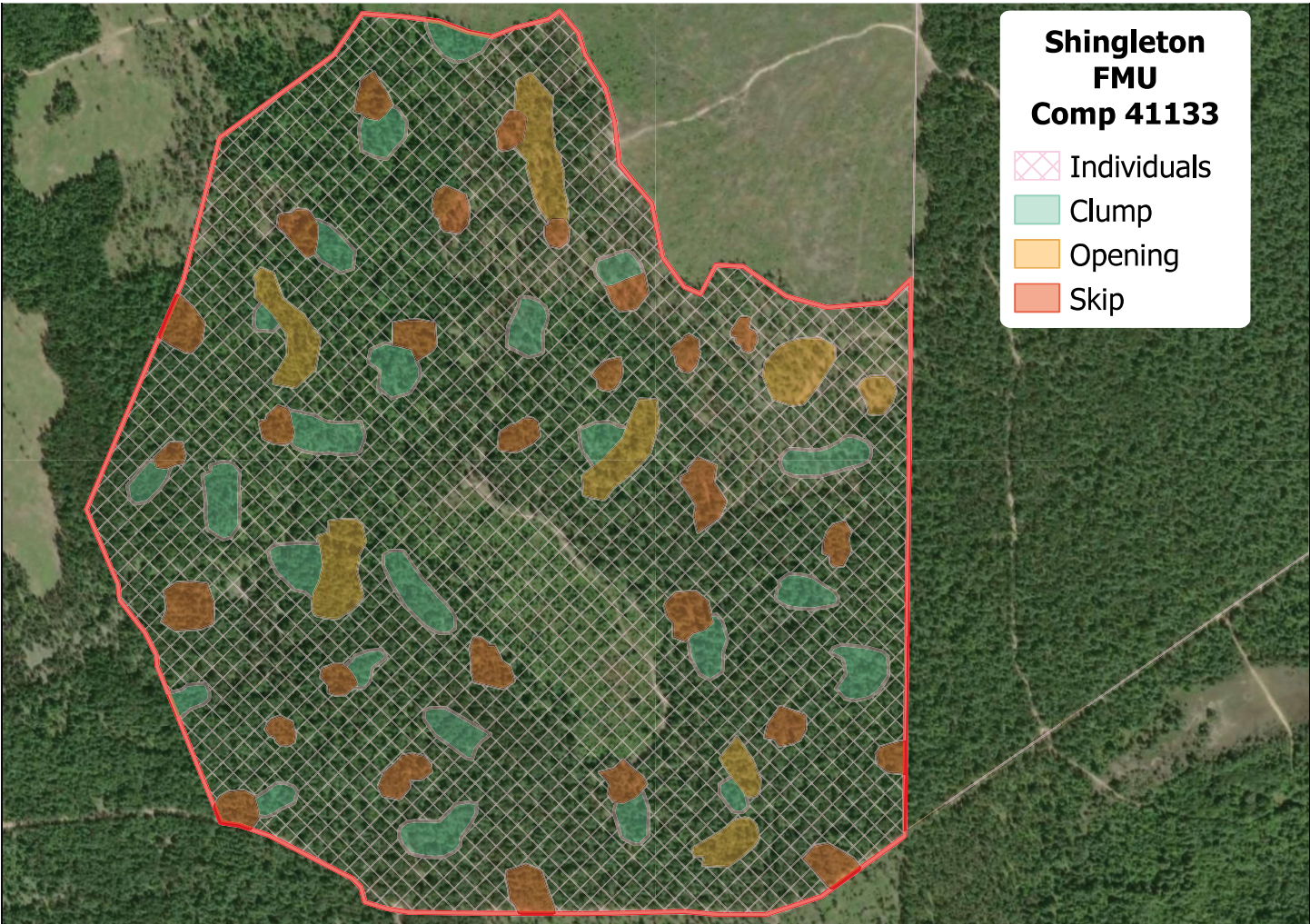
Despite repeated canopy thinnings in multiple stands in this Project Area, there was little red pine regeneration. Photo by J.M. Lincoln.



Location of Shingleton FMU Project Area (Compartment 41133). The Project Area boundaries are intended to serve as a burn break for the entire project area.



Despite repeated canopy thinnings in several stands in this Project Area, there was little red pine regeneration. Photo by J.M. Lincoln.



ICO Management zones for Shingleton FMU Project Area (Compartment 41133).

Select Stand-Level Information

- Stand 40: Recently thinned and scarified; low basal area of red pine and limited red pine regeneration; dominated by bracken fern and blueberry
 - Stand 63: White pine dominant (~75%) with moderate red pine component, higher basal area (110–120 ft²/ac)
 - Stand 64: ~80 ft²/ac basal area; multiple cohorts of red pine with subcanopy pole-size red pine; local red pine saplings with white pine and red maple dominating understory
 - Stand 69: ~100 ft²/ac basal area, dominated by red pine, thinned with multiple cohorts of red pine but regeneration primarily white pine following recent thinning
- Initial burn: low-intensity in the dormant season, targeting surface fuels and partial reduction of understory density
 - Evaluate site following initial burn to determine need for second burn
 - Second burn: within 3-5 years of first, timed for late growing season (prior to red pine seed drop)
- Third burn: 5-10 years post-harvest to reinforce red pine regeneration, mitigate disease risks, and reduce competition

Management Recommendations

This is a Project Area that will likely respond to a single fire. We recommend burning first to control white pine then thin to improve red pine dominance. Use repeated prescribed fire to control mesophytic competition and promote natural red pine regeneration then follow prescribed fire with targeted thinning to release red pine regeneration and maintain structural diversity.

Prescribed fire:

- Establish a large, continuous burn block across the project area using the existing roads and trails
- Apply a single burn across all stands prior to additional thinning

Targeted timber harvest:

- Delay immediate timber harvests in natural stands until two prescribed burns have been implemented
- Execute a timber harvest after the second burn
 - Thin stands 64 and 69 by 1/3 basal area
 - Do not thin Stand 40 during initial entry
 - Avoid Skips and Clumps
 - Thin individuals by 1/3 basal area
 - Survey for red pine regeneration and implement Openings treatments around areas of regeneration releasing existing understory red pine

Additional considerations:

- Maintain flexibility across stands to accommodate structural differences; some recently thinned areas will not need thinning during the initial timber harvest
- Monitor for invasive species along roads and trails



Stand 40 has been thinned and scarified and there are open zones dominated by reindeer lichen. Despite such treatments, there is very little red pine regeneration. Photo by J.M. Lincoln.

LOWER PENINSULA PROJECT AREAS

7. Pigeon River FMU: C53005

Location: Compartment 53005 – Stands 21, 28, 30, 32, 33, 36, 37, 120, and 123; Compartment 53004 – Stands 42 and 43

Natural Community Types: Dry-mesic Northern Forest, Intermittent Wetland

Size: 214 acres

Site Summary

This project area contains multiple stands with various treatment histories and red pine abundance leading to a variable, structurally complex red pine forest with multiple age classes and localized red pine regeneration. Basal area and structure vary by stand, but overall conditions are favorable for restoration using prescribed fire and targeted thinning.

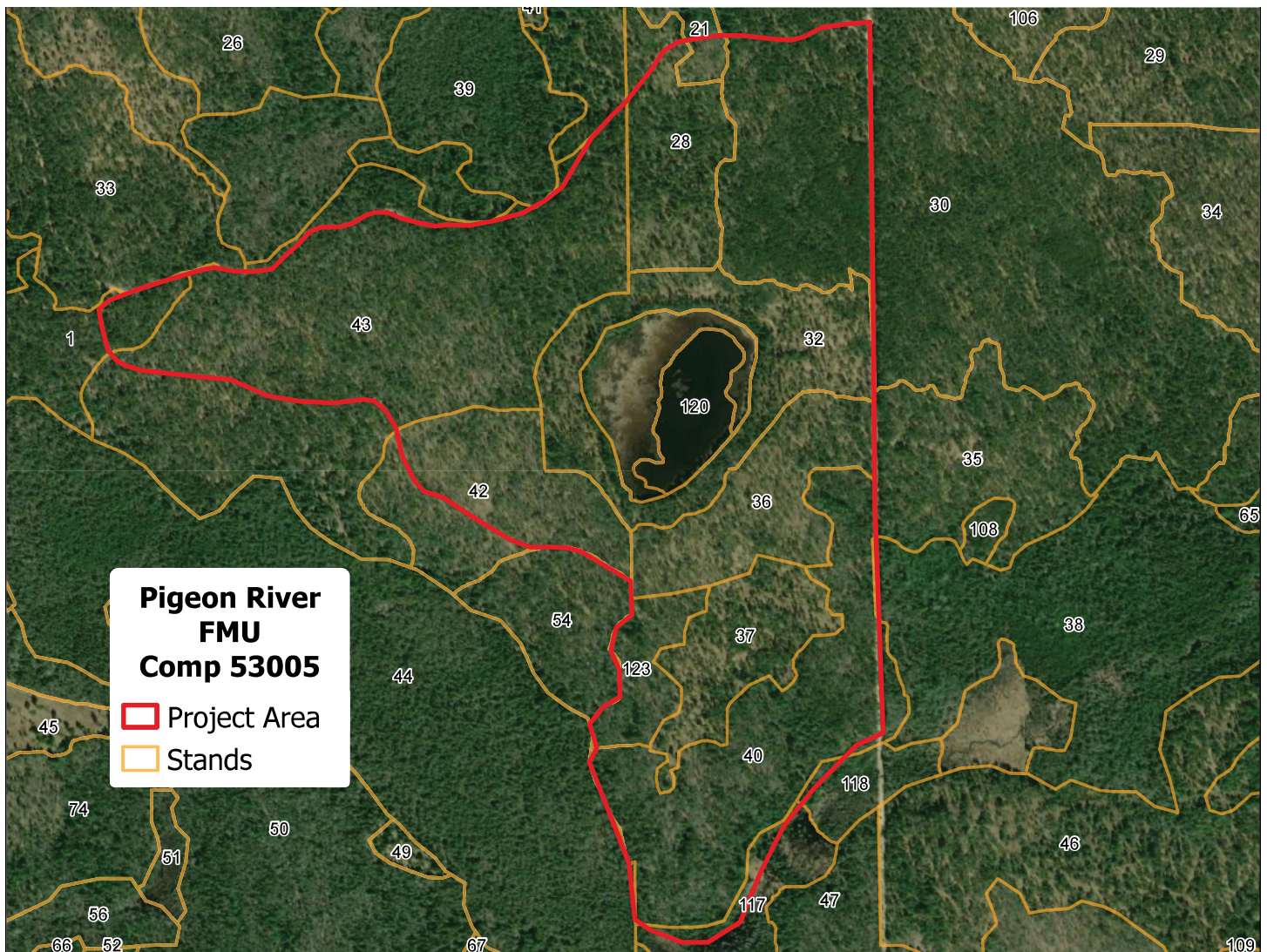
Evidence of historical fire is present from charred stumps and fire scars on live trees, particularly in Stand 32 along the wetland margins. Current fuel conditions are generally suitable for prescribed fire. This Project Area includes a high-quality intermittent

wetland (EOID 28494) in Stands 33 and 120. These wetlands add complexity but we developed this Project Area to incorporate it into the burn unit.

Mesophication is prevalent across much of this site with red maple and white pine in the understory. Red pine regeneration is locally present but overall the site is trending towards deciduous species in the absence of fire.

Select Stand-Level Information

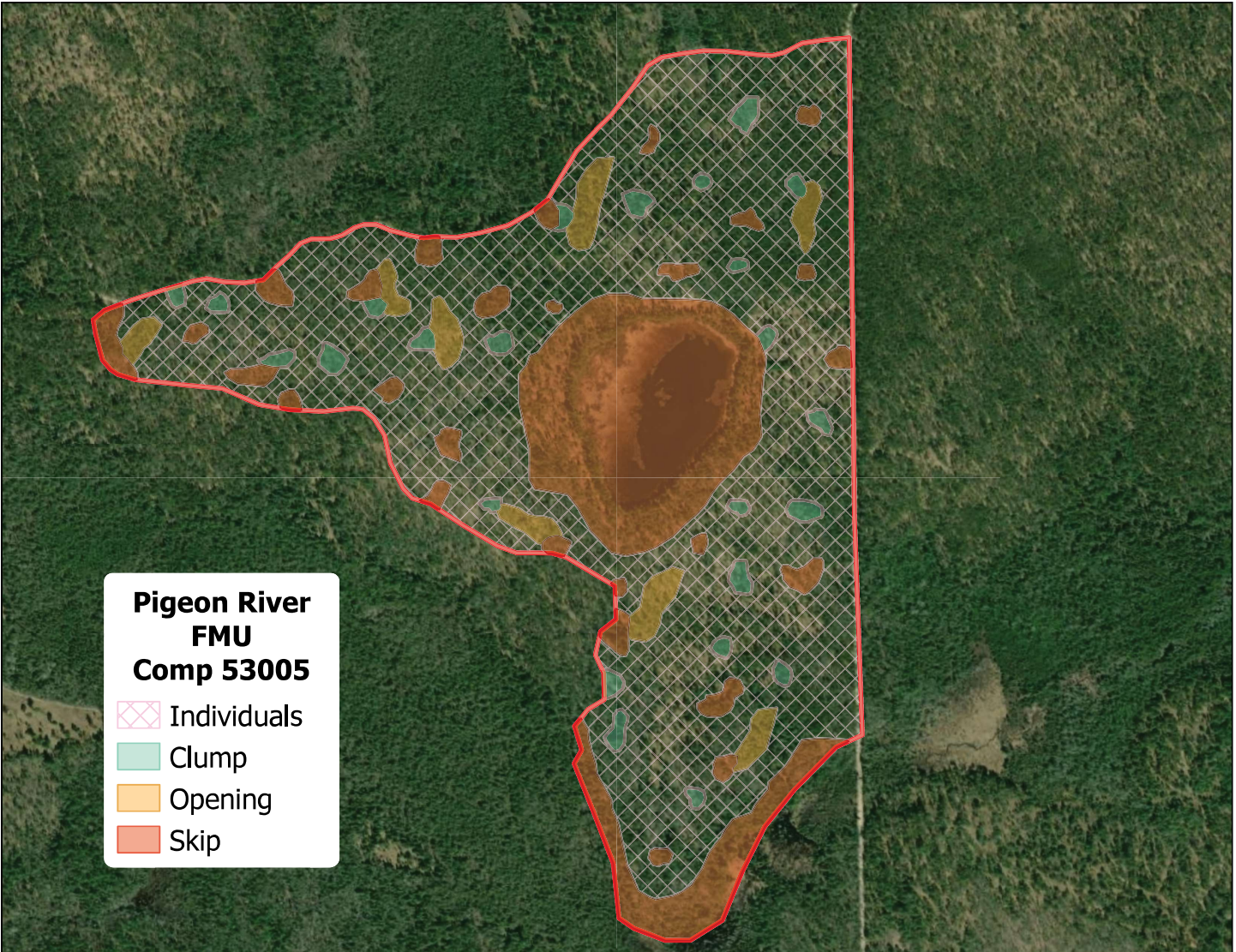
- Stand 28 (south): Older red pine with good structural legacy



Location of Pigeon River FMU Project Area (Compartment 53005). The Project Area boundaries are intended to serve as a burn break for the entire project area.



This Project Area includes an intermittent wetland that we recommend incorporating into the burn unit with no burn breaks between the wetland and adjacent uplands. Photo by J.M. Lincoln.



ICO Management zones for Pigeon River FMU Project Area (Compartment 53005).

- Stand 32: already thinned (~50 basal area); most trees around 100 years old but some legacy trees along wetland edge with fire scars, a 48.2 cm dbh red pine had 230 rings; locally abundant red pine regeneration but mesifying; a red pine stump with a fire scar had evidence of four fires with 7, 7, and 15 years between fires; do not harvest in next timber treatment
- Stand 36: Various age classes of canopy red pine, good red pine regeneration locally but increasing mesic competition; coordinate burn and thinning to prevent mesic shift
- Stand 37: Low basal area (~30-40); already open, burn only with no timber harvest in next treatment round; mesifying with white pine and red maple
- Stands 40, 42, and 43: Moderate basal area (~100-130); mixed pine/deciduous with increasing white pine and red maple in understory

Management Recommendations

This is an excellent natural red pine management opportunity. Our recommendations are to use repeated prescribed fire to control white pine and mesophytic competition followed by targeted thinning to improve red pine regeneration and maintain structural diversity. We also recommend providing a no-cut buffer around this wetland to protect concentrations of old trees and areas of dense huckleberry. Ideally the wetland would be incorporated into the burn unit with no burn breaks between the wetland and adjacent uplands.



Stand 32 around the Lost Lake intermittent wetland had several old trees with fire scars. A 48.2 cm dbh red pine had 230 rings and a red pine stump with a fire scar had evidence of four fires with 7, 7, and 15 years between fires. We recommend providing a no-cut buffer around this wetland to protect concentrations of old trees and areas of dense huckleberry. Ideally the wetland would be incorporated into the burn unit with no burn breaks between the wetland and adjacent uplands. Photo by J.M. Lincoln.

Prescribed fire:

- Establish a large, continuous burn unit incorporating intermittent wetlands and surrounding uplands
- Use streams and roads as natural burn breaks
- Apply two prescribed burns across all stands prior to additional thinning,
 - Initial burn: low-intensity in the early spring/dormant season, targeting surface fuels and partial reduction of understory density
 - Second burn: within 3-5 years, timed for late growing season (prior to red pine seed drop), targeting reduction of mesophytic competition and preparing seedbed for red pine germination
- Third burn: 5-10 years post-harvest to reinforce red pine regeneration, mitigate disease risks, and reduce competition

Targeted timber harvest:

- Delay immediate timber harvests until two prescribed burns have been implemented across the Project Area
- Execute a timber harvest after the second burn
 - Thin Stand 36 following burns, reduce canopy red maple, white pine, and aspen
 - Retain large red oak and supercanopy white pine
 - Protect existing red pine regeneration

- Thin Stand 40 by ~30-40% basal area
 - Remove canopy aspen, red maple, half of canopy white pine, and a quarter of canopy red pine
- Stand 43:
 - Canopy BA ~100, aged a red pine to 130 years old
 - Some red pine in canopy, pole-size red pine in subcanopy, and local regeneration
 - Mostly red oak and aspen in canopy
- Low basal area stands (30, 37):
 - No thinning first round, maintain with fire only
 - Reevaluate for thinning in ~20 years
- Avoid Skips and Clumps
- Thin Individuals by 1/3 basal area
- Survey for red pine regeneration and implement Openings treatments around areas of regeneration releasing existing understory red pine

Additional considerations:

- Maintain flexibility across stands to accommodate structural differences
- Provide a large buffer along wetland margins
- Retain old trees and stumps for recreating fire history
- Monitor for invasive species along roads and trails



Stand 43 has canopy red pine throughout and local red pine regeneration, but the understory is dominated by mesophytes. Photo by J.M. Lincoln.

8. Pigeon River FMU: C53036

Location: Compartment 53036 – Stand 89 and adjacent stands 88, 90, 94, 99, 101, and 103

Natural Community Type: Dry-mesic Northern Forest

Size: 121 acres

Site Summary

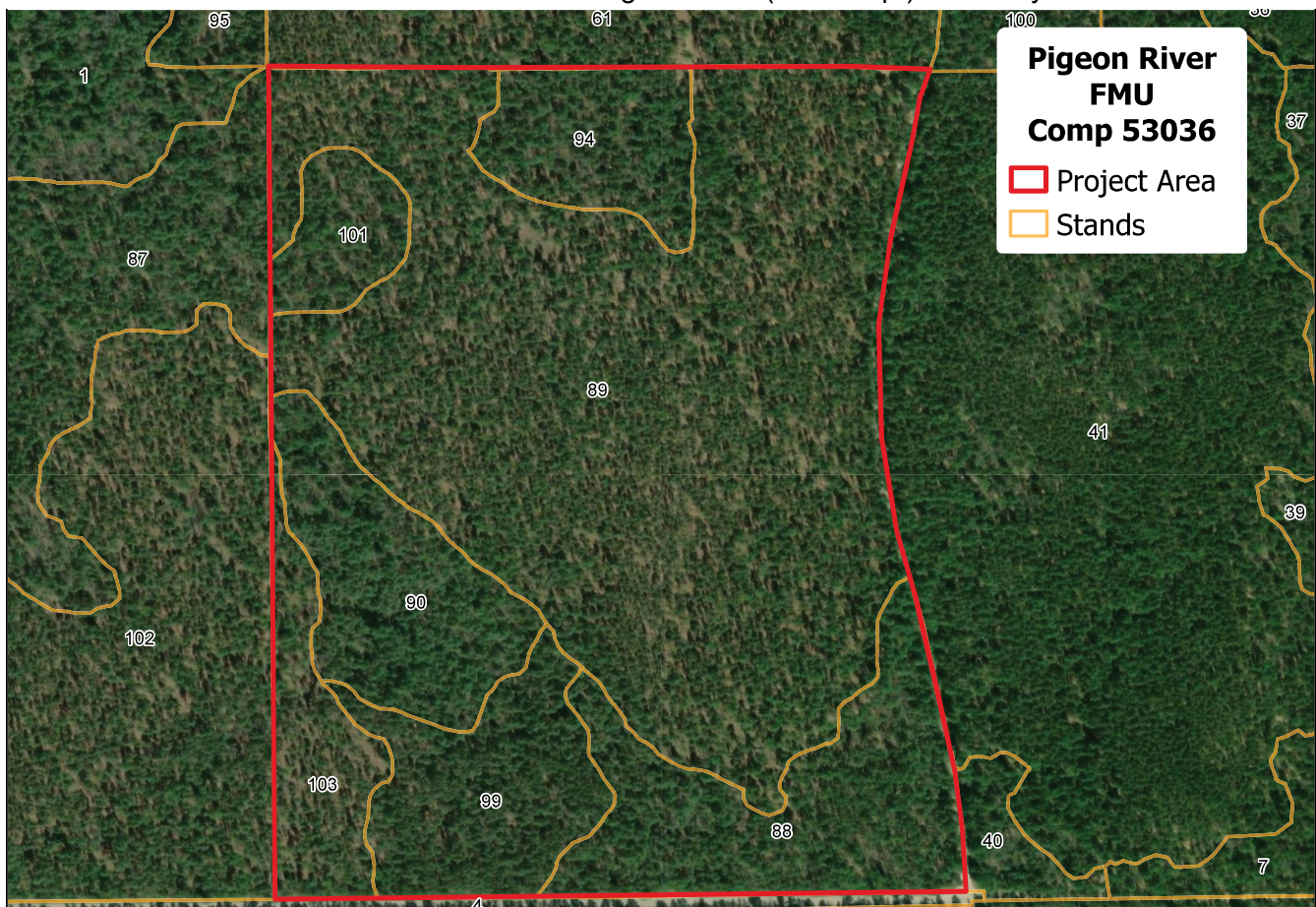
This is an ideal site for a Project Area because it includes red pine stands that previously burned in July of 2019. Because of the fire, mesophytic competition has already been successfully reduced, particularly white pine, red maple, and beech. However, red pine regeneration remains extremely limited and the site is dominated by bracken fern and white pine regeneration. Stand 89 is the primary treatment area with an average basal area of roughly 80-100 ft²/ac and evidence of low-intensity fire (2-5 ft char on bole). Localized red pine seedlings are present, often in areas that appear to be impacted by elk activity.

Select Stand-Level Information

- Stand 89: ~80-100 BA; reduced mesophyte competition from fire; very limited red pine regeneration; bracken fern dominant and white pine regeneration out competing red pine (10:1)



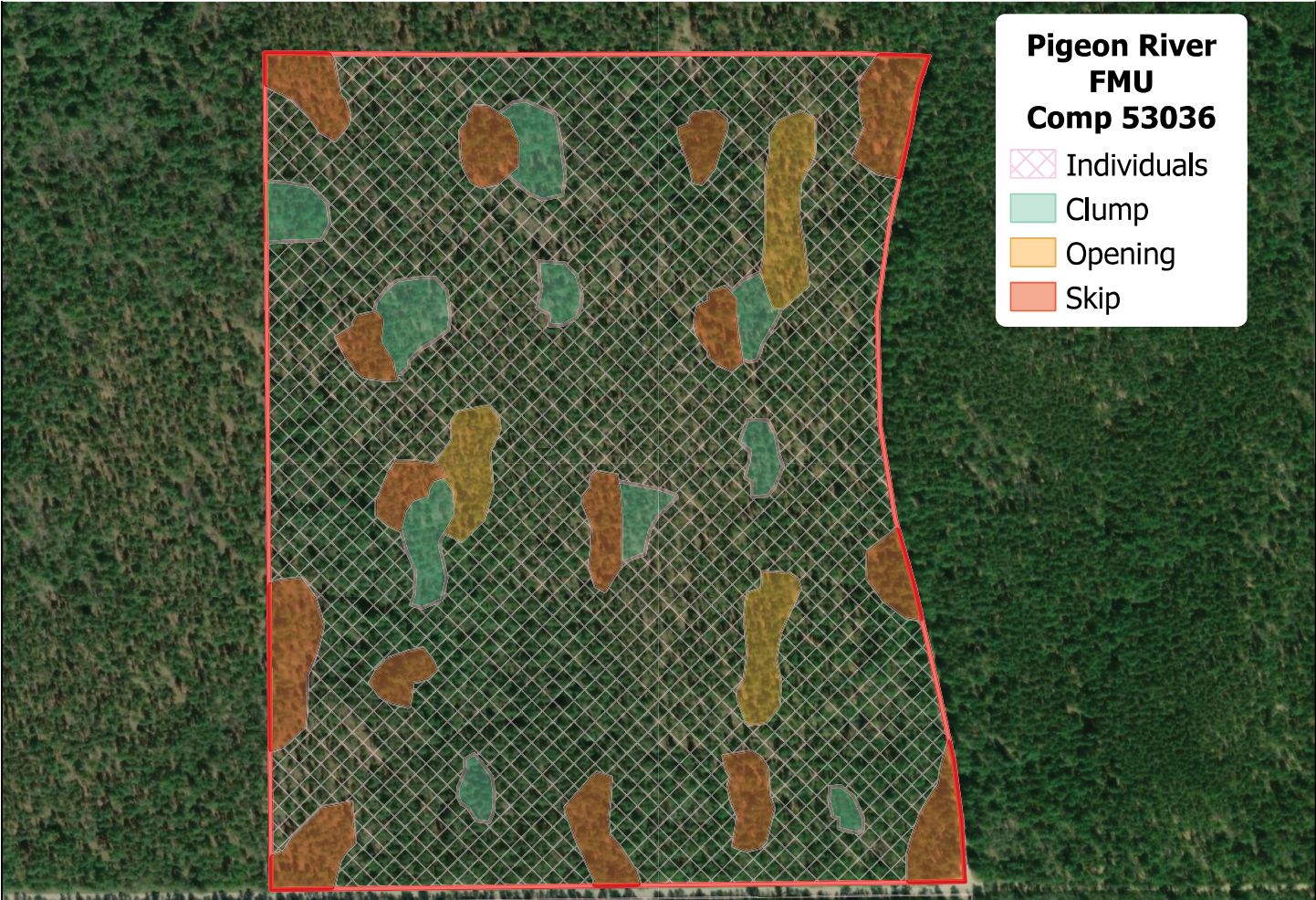
Stand 89 has been burned and thinned and the understory largely cleared of mesophytes. A second burn should be timed with a red pine mast year to promote red pine regeneration (June-Sept). Photo by J.M. Lincoln.



Locations of Pigeon River FMU Project Area (Compartment 53036). The Project Area boundaries are intended to serve as a burn break for the entire project area.



The boundary between unburned Stand 102 (Left) and Stand 103 (Right) which was burned July 10, 2019. The single fire dramatically reduced red maple and white pine in the understory, though red pine regeneration was still low abundance. Additionally, bracken fern height was substantially reduced following the burn, even 6 years after. A second burn should be timed with a red pine mast year to promote red pine regeneration (June-Sept). Photo by J.M. Lincoln.



ICO Management zones for Pigeon River FMU Project Area (Compartment 53036).

- Stand 90: Similar conditions but retains some subcanopy red pine
- Across site: Bracken fern dominant following fire, but much shorter than in adjacent unburned stands; limited but present red pine seedlings in disturbed soils; ice storm debris and declining canopy trees; possibly areas of localized plantation with a natural appearance
 - Focus on burning during red pine mast year and apply ahead of seed drop
- Second burn: 5-10 years post-harvest to reinforce red pine regeneration, mitigate disease risks, and reduce competition

Targeted timber harvest:

- Delay immediate timber harvests in natural stands until the first prescribed burn has been implemented and red pine regeneration is confirmed
 - Survey for red pine regeneration and implement Openings treatments around areas of regeneration releasing existing understory red pine
 - Thin Individuals by 1/3 basal area
 - Avoid Skips and Clumps

Additional considerations:

- Monitor for invasive species along roads and trails
- Monitor use by elk
- Include neighboring Stands 87 and 102 to the west in similar management approach

Management Recommendations

Site is already well-suited for a project area due to previous application of fire. A single, well-timed fire will likely promote red pine regeneration.

Prescribed fire:

- Establish a large burn unit, using existing roads/trails as burn breaks
- Apply a single prescribed burn across all stands prior to additional thinning
 - Timed for late growing season (June-Sept, prior to red pine seed drop), targeting reduction of mesophytic competition and preparing seedbed for red pine germination



Red pine regeneration was infrequent across the Project Area despite an application of fire and reduced competition from mesophytes. A second, well-timed burn is expected to improve regeneration. Photo by J.M. Lincoln.

9. Pigeon River FMU: C53038

Location: Compartment 53038 – Stands 20, 33, 34, and 35

Natural Community Type: Dry-mesic Northern Forest

Size: 194 acres

Site Summary

This Project Area consists of previously thinned mixed pine stands that have not yet received prescribed fire. As a result, the system is rapidly mesifying with dense red maple and white pine regeneration in the understory.

Stands 34 and 35 contain moderate basal area, increasing hardwood competition, and patchy but limited red pine regeneration. White pine regeneration strongly outnumbers red pine regeneration by approximately 100:1 in some areas. Ice storm damage and elk activity were noted throughout.

Despite current conditions and lack of recent fire applications, this is a project area with excellent potential for natural red pine management. Fuel conditions remain suitable and the system is well-positioned to respond to prescribed fire.

Select Stand-Level Information

- Stands 34 and 35: Thinned but unburned; dense red maple and white pine regeneration; minimal red pine regeneration; strong white pine dominance in sapling layer; dense understory and lack of herbaceous response (e.g., grasses) in unburned areas compared to stands to the north; localized damage from ice storm

Management Recommendations

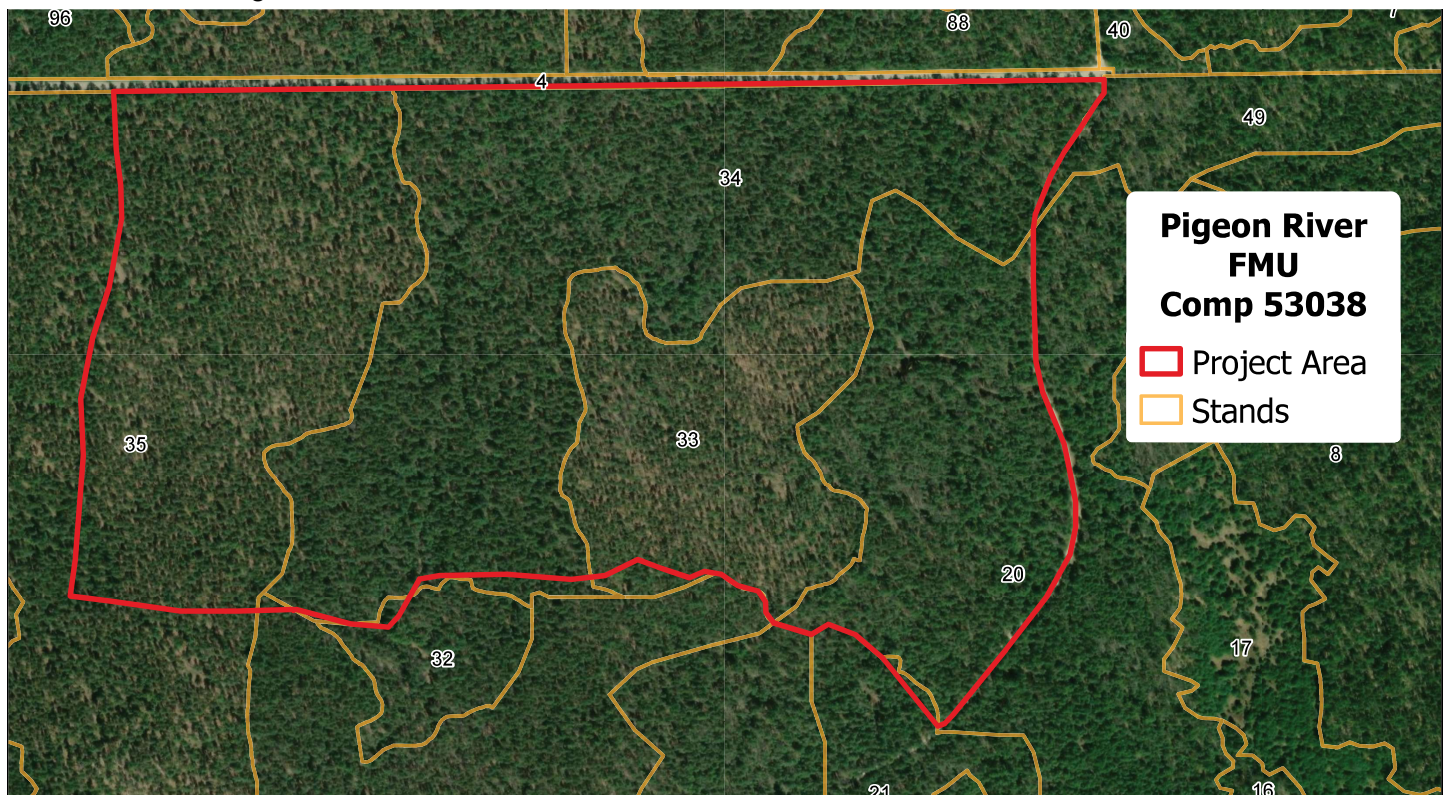
Recommendations were developed based on observations in the Project Area to the north (C53036). Apply prescribed fire to reduce understory white pine and red maple followed by a second burn and delayed thinning to promote red pine regeneration.

Prescribed fire:

- Establish a large burn unit, using existing roads/trails as burn breaks
- Apply two prescribed burns across all stands prior to additional thinning
 - Initial burn: low-intensity in dormant season, targeting surface fuels and partial reduction of understory density
 - Second burn: within 3-5 years, timed for late growing season (prior to red pine seed drop)
- Third burn: 5-10 years post-harvest to reinforce red pine regeneration, mitigate disease risks, and reduce competition

Targeted timber harvest:

- Delay immediate timber harvests in natural stands until two prescribed burns have been implemented



Location of Pigeon River FMU Project Area (Compartment 53038). The Project Area boundaries are intended to serve as a burn break for the entire project area.

- Execute a timber harvest after the second burn
 - Survey for red pine regeneration and implement Openings treatments around areas of regeneration releasing existing understory red pine
 - Avoid Skips and Clumps
 - Thin Individuals by 1/3 basal area

Additional considerations:

- Monitor for invasive species along roads and trails
- Monitor use by elk



The understory of most of the Project Area is dominated by white pine and red maple. The site will likely need at least two burns to reverse such extensive mesophication and promote red pine regeneration. Photo by J.M. Lincoln.



ICO Management zones for Pigeon River FMU Project Area (Compartment 53038).

10. Roscommon FMU: C71016

Location: Compartment 71016 – Stands 140-143, 145, 146, 148, 153-157, and 162-166

Natural Community Types: Dry and Dry-mesic Northern Forest, Intermittent Wetland, Bog

Size: 298 acres

Site Summary

This Project Area is organized around a wetland complex bordered by huckleberry and includes a mosaic of high-quality dry-mesic northern forest and pine barrens with areas for red pine management. The site contains areas of high conservation value including old-growth red pine (Stand 146), intermittent wetland (stands 142, 153, and 164), bog (stands 144 and 145), and potential pine barrens restoration in stand 157.

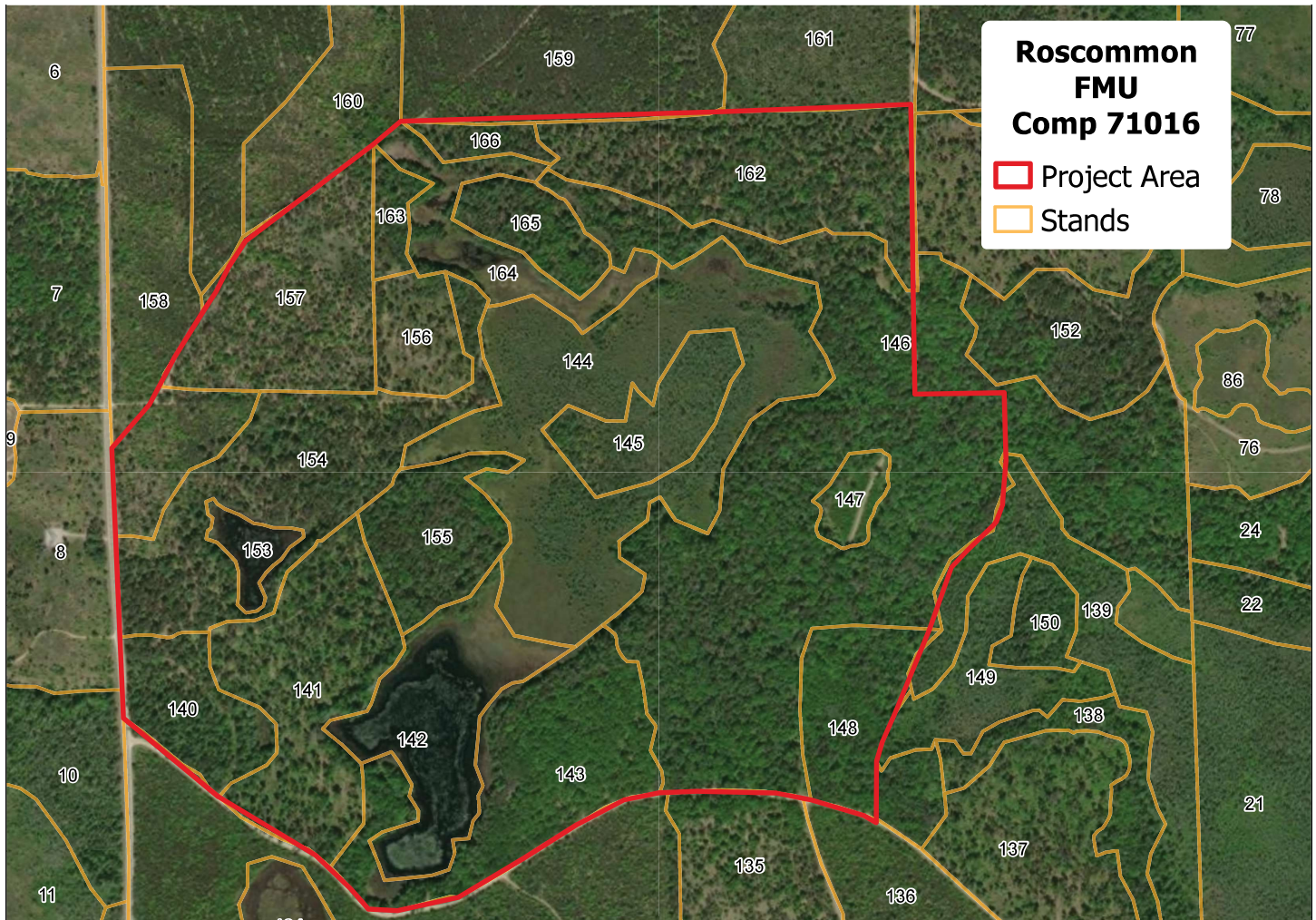
Structure and composition vary widely from pine barrens (Stand 157) to thinned red pine (Stand 162). White pine and other mesic species are prevalent in most upland stands but can be effectively reduced with fire.

This is an ideal landscape-scale burn opportunity with existing roads as fire breaks, numerous high-quality natural communities, natural red pine management targets, and pine barrens habitat management.

Ideally the high-quality wetlands would be included with prescribed fires and we urge no burn breaks be developed between the wetlands and adjacent uplands.

Select Stand-Level Information

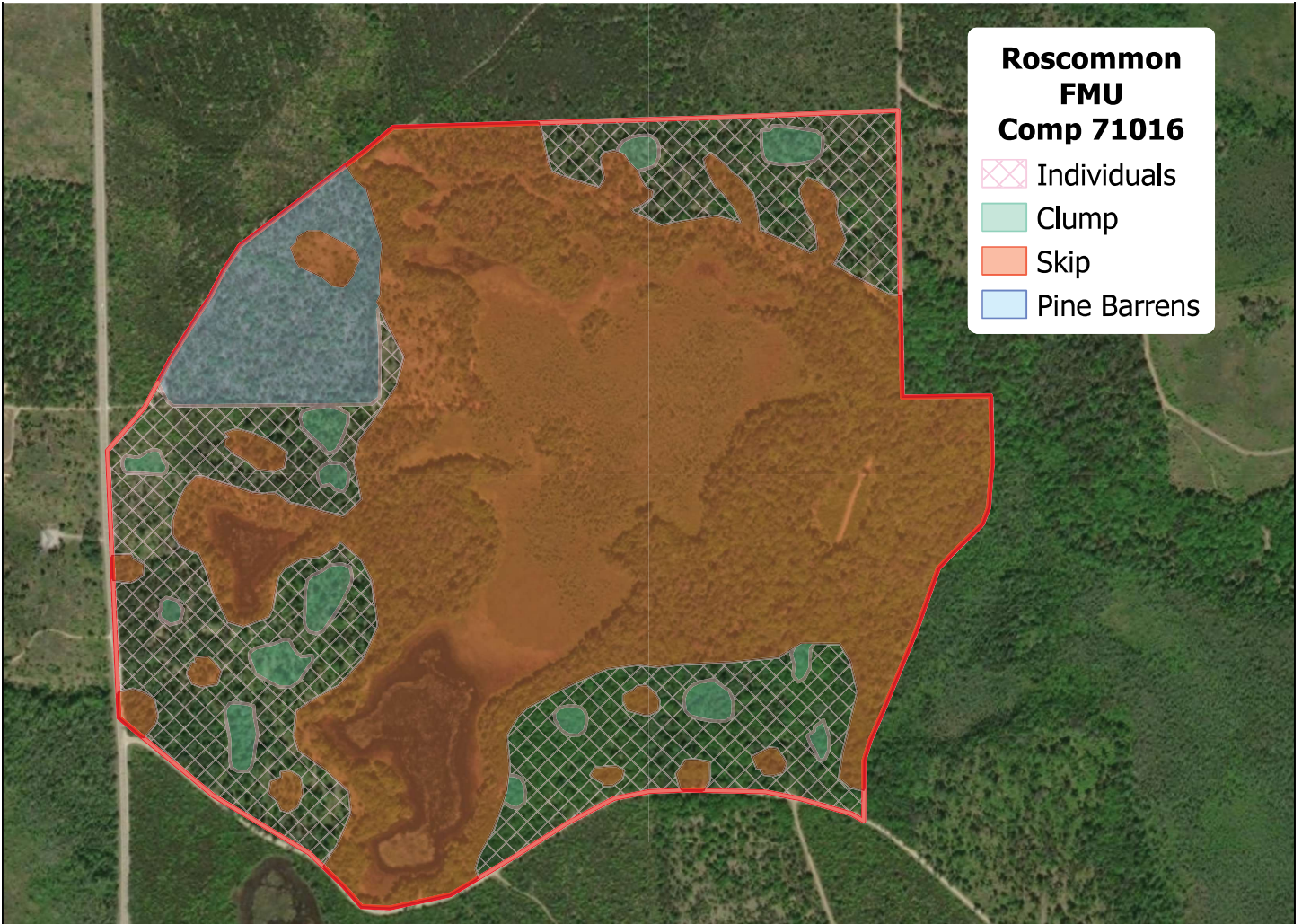
- Stands 146 and 155: High-quality dry-mesic northern forest with areas of old-growth red pine; 220-year-old cohorts throughout; we recommend no harvest and redirecting ORV trails away from these stands
- Stands 156, 165: Mature pine with wet inclusions, avoid timber harvests
- Stands 154, 143, 148, 141, 140: Stands suitable for fire and thinning sequence
- Stand 162: Thinned (~50% canopy); one large tree aged to 163 years, most in 70-80 year old cohort; good candidate for avoiding harvest in first round of thinnings; do not harvest older cohort in subsequent treatments



Location of Roscommon FMU Project Area (Compartment 71016). The Project Area boundaries are intended to serve as a burn break for the entire project area.



The wetlands within this Project Area are part of a fire-adapted landscape. We recommend incorporating these into the burn unit with no burn breaks between the wetland and adjacent uplands. Photo by J.M. Lincoln.



ICO Management zones for Roscommon FMU Project Area (Compartment 71016). This site has a high proportion of skips, particularly around wetlands and the high-quality dry-mesic northern forest in Stand 146.

- Stand 157: Pine barrens potential with sparse jack pine and oak; openings supporting barrens indicator species and minimal red pine; potential for Kirtland's warbler management

Management Recommendations

Implement landscape-scale prescribed fire across a burn unit with a large wetland complex at its center. Apply a combination of barrens and natural red pine management objectives while protecting stands of high conservation value.

Priority conservation targets:

- No timber harvest in Stands 146, 155, 156, and 165
- Maintain with prescribed fire only
- Protect old-growth red pine
- Consider eliminating trails within these areas
- Provide large forested buffer between wetlands and intensive forestry operations
- Remove ORV trails from these areas

Prescribed fire:

- Establish a large, continuous burn block across the project area, encircling the wetland complex and using the existing roads and trails as burn breaks
- Wetlands are part of a fire-adapted landscape and we recommend their inclusion in prescribed burns. Avoid equipment in areas of saturated soils.
- Apply an initial prescribed burn across all stands prior to additional thinning, including plantations and pine barrens habitat
 - Initial burn: apply a low-intensity spring burn immediately after snowmelt when wetlands are saturated to carry fire through uplands while protecting sensitive areas
- Second burn: 5-10 years post-harvest to reinforce red pine regeneration, mitigate disease risks, and reduce competition



Stands 146 and 155 feature a high-quality dry-mesic northern forest with areas of old-growth red pine and 220-year-old cohorts throughout. We recommend preventing timber harvests in these stands and redirecting ORV trails that bisect the forest. Photo by J.M. Lincoln.

Targeted timber harvest:

- Delay immediate timber harvests in natural stands until an initial prescribed burn has been implemented
- Thin stands 143, 148, 140, 141, 154 following initial burn
 - Avoid Skips and Clumps
 - Thin individuals by 1/3 basal area
 - Survey for red pine regeneration and implement treatments around releasing existing understory red pine

Barrens/Kirtland's Warbler Project Area:

- Stand 157; target canopy coverage of ~30%
- Could develop into separate burn unit from other stands
- Masticate young jack pine, pin oak (*Quercus palustris*), aspen, and cherry (*Prunus serotina*) ahead of burn

- Retain all red pine, white oak, and most large jack pine

- Apply low-severity/low-intensity burn just after snowmelt
- Apply fire at a frequency of 5 to 25 years to maintain barrens conditions
- Avoid soil disturbance in areas supporting barrens vegetation

Additional considerations:

- This is a mixed-condition burn unit. Focus on maintaining fire across a large area rather than achieving uniform outcomes
- Monitor for invasive species along roads and trails
- Evaluate stumps for determining fire history
- Monitor for Kirtland's warbler
- Redirect ORV trails away from wetland margins and high-quality forests



Stand 157 features several openings with characteristic pine barrens vegetation, including big and little bluestem. The site likely needs mastication prior to a prescribed fire. We recommend retaining all red pine, white oak, and mature jack pine during this process. Initial prescribed fires applied just after snow melt have shown dramatic improvements in similar sites in the region. Photo by J.M. Lincoln.

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APPENDIX

Appendix 1. Practitioner-informed considerations for prescribed fire implementation in natural red pine systems. These considerations are intended to provide general guidance for prescribed fire implementation in natural red pine systems based on practitioner experience and observed fire behavior across a range of site conditions. Appropriate conditions vary by site productivity, stand structure, fuel accumulation, prior fire history, management objectives, and weather conditions. These considerations are not intended as rigid prescriptions and should be adapted based on the judgment of experienced fire and forestry practitioners familiar with each site. Adapted with permission from communications with B.J. Stearns, J. McGowan-Stinski, and G. Cooper (2026).

Factors influencing Fire Behavior and Effects	General Guidance	Practitioner Notes
Days Since Measurable Precipitation	1–5 days	Xeric sites typically burn effectively within this range, though mesic sites may require longer drying periods. Sites burned within the previous 5–7 years may safely burn after longer dry periods because bole char can provide additional insulation to canopy trees.
Average Wind Speeds	3–12 mph	Appropriate wind speeds vary by stand density, fuel structure, and atmospheric conditions. Higher basal area stands may tolerate stronger winds. Under cloudy conditions with lower vapor pressure deficit (VPD), successful burns may occur with winds in the upper teens.
Relative Humidity (RH)	30–60% preferred; up to 65% where fuels remain receptive	Generally a safe operational range, though acceptable conditions depend on fuel structure and weather interactions. RH near the upper end may reduce fire spread and fuel consumption in shaded or fuel-heavy stands. RH alone may be less informative than VPD in some situations.
Temperature	Generally <60°F	Temperature thresholds are less important when VPD and fuel moisture are favorable. Stands with 30–40 BA can withstand higher temps (~75°F) but convective heat can kill mature red pine on hot days
Fine Fuel Moisture Code (FFMC)	<90*	Lower thresholds may not be necessary depending on management objectives and prior burn history.
Buildup Index (BUI)	<50	Initial dormant-season conditioning burns may be successful at substantially lower BUI values depending on fuels and desired fire effects.
Foliar Moisture Content	>110%	Lower foliar moisture may be acceptable in stands previously conditioned with fire. Initial entry burns generally benefit from higher foliar moisture to reduce overstory damage.
Flame length	0.5–2 ft	Flame lengths should reflect management objectives, fuel conditions, and tolerance for canopy scorch and bole injury.
Probability of Ignition % (Shaded)	<70%	Higher ignition probability may increase risk of excessive fuel consumption and overstory damage in fire-suppressed stands.
Initial Spread Index	<12	Acceptable spread rates vary by stand structure, fuel continuity, and desired fire effects.
Fire Weather Index (FWI)	<20**	Lower FWI values are generally preferred during initial conditioning burns in fire-suppressed stands.

* Fine fuels dry enough to carry fire without excessive intensity

** Low to moderate fire intensity and spread potential