Identifying Recoverable, Fire-Dependent Systems in the Newberry Forest Management Unit



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We collectively acknowledge that Michigan State University occupies the ancestral, traditional, and contemporary Lands of the Anishinaabeg – Three Fires Confederacy of Ojibwe, Odawa, and Potawatomi peoples. In particular, the University resides on Land ceded in the 1819 Treaty of Saginaw. We recognize, support, and advocate for the sovereignty of Michigan's twelve federally recognized Indian nations, for historic Indigenous communities in Michigan, for Indigenous individuals and communities who live here now, and for those who were forcibly removed from their Homelands. By offering this Land Acknowledgement, we affirm Indigenous sovereignty and will work to hold Michigan State University more accountable to the needs of American Indian and Indigenous Peoples.

We also acknowledge that Indigenous Peoples and their cultural practices were, and are, integral parts of Michigan's ecosystems.

Cover Photo: Ghost on the Shore dry northern forest. Photo by J.M. Lincoln.

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Field visit with Newberry Forest Resource Division staff to Ghost on the Shore dry northern forest. Photo by J.M. Lincoln.

EXECUTIVE SUMMARY

Michigan's eastern Upper Peninsula features extensive fire-adapted landscapes with pine forests, barrens, and vast peatland complexes that burned in conjunction with fire-dependent uplands. Many of these fire-dependent systems have been altered by decades of fire suppression, land conversion, and plantation forestry. As a result, many fire-suppressed natural communities are characterized by reduced biodiversity, regeneration failure of important canopy species, and mesophication, which leads to increased risk of severe wildfire. This report summarizes Michigan Natural Features Inventory's (MNFI) efforts in the first year of a three-year project funded by the Sustainable Forestry Initiative (SFI) to identify, evaluate, and guide stewardship of recoverable, fire-dependent systems within the Newberry Forest Management Unit (FMU).

The Newberry FMU encompasses approximately 356,000 acres in Luce and Chippewa Counties and contains the largest concentration of natural red pine and mixed pine forests within Michigan's State Forest system. While extensive logging and conversion to plantation have altered much of the landscape, significant natural cover of fire-adapted communities remains and provides an opportunity to restore ecological function while supporting sustainable forestry objectives.

MNFI's prescribed fire needs assessment model identified approximately 86,000 acres within the Newberry FMU as having a high or very high ecological need for fire. Following evaluation of model outputs, aerial imagery, Michigan Forest Inventory data, and discussions with Michigan Department of Natural Resources staff, survey targets for recoverable, fire-dependent natural communities were prioritized. Targeted surveys resulted in the documentation of eight previously undocumented natural communities, expansion of one existing element occurrence, and identification of Project Areas where prescribed fire and ecological silviculture can be applied to recover biodiversity, improve resilience, and promote natural regeneration.

This report emphasizes an alternative framework for managing natural red pine forests that integrates prescribed fire with ecological silviculture using the Individuals, Clumps, and Openings (ICO) approach. We developed 20 Project Areas where we recommend applying this approach to shift away from density-based and 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, lower wildfire risk, and maintain timber productivity. Importantly, it also aligns with Sustainable Forestry Initiative objectives related to biodiversity conservation, forest health, climate resilience, and fire management.

In addition to natural red pine Project Areas, we provide 2 pine barrens Project Areas where large-scale, repeated prescribed fire can improve composition and structure and promote habitat for species of conservation concern. The report also underscores the importance of monitoring prescribed fire and silvicultural treatments to inform adaptive management, stewarding existing Ecological Reference Areas, expanding the strategic use of Special Conservation Areas, and protecting shoreline forests, wetlands, and culturally significant landscapes. Finally, this report recommends improved growing season inventories, explicit recognition of old and fire-scarred trees, and consistent monitoring to support adaptive management and certification compliance.

Overall, this report provides a science-based and operationally feasible framework for prioritizing prescribed fire and ecological silviculture in the Newberry FMU. By focusing limited fire capacity on the most ecologically important landscapes, the approach outlined here offers a path to conserve rare fire-dependent systems, sustain natural red pine on the landscape, incorporate conservation partnerships, and meet the long-term objectives of sustainable forest management.

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INTRODUCTION

There are over four million acres of State Forest across Michigan's Upper and Northern Lower Peninsulas. State Forests are jointly managed by the Forest Resources Division (FRD) and Wildlife Division (WLD) of the Michigan Department of Natural Resources (DNR) for long-term forest health, sustainable forest products, wildlife habitat, recreational opportunities, and ecosystem services. The FRD and WLD are responsible for assuring that management activities do not harm threatened and endangered species and through dual forest certification, the DNR maintains a network of Ecological Reference Areas (ERAs) composed of high-quality and representative natural communities.

The Michigan Natural Features Inventory (MNFI) is Michigan's Natural Heritage Program and maintains a geospatial database of benchmark natural communities and populations of rare plants and animals. For more than four decades, MNFI has documented and monitored high-quality natural communities on State Forest land including numerous pine-dominated forests that are part of the State's network of ERAs (Cohen et al. 2009, Cohen, Multiple: 2014-2024, MNFI 2025). The maintenance and protection of these ERAs is part of the criteria for sustainable forest certification developed by the Sustainable Forestry Initiative (SFI) and Forest Stewardship Council (FSC). Through engagement with these certifying entities, the DNR strives to ensure sustainable forest management practices.

Through a three-year project from 2025 through 2027, the Sustainable Forestry Initiative has commissioned MNFI to identify examples of recoverable, fire-dependent systems (RFDS) within the Newberry, Atlanta, and Traverse City Forest Management Units (FMUs). We define RFDS as remnant patches of fire-dependent natural communities with the potential for recovery to a level of substantial conservation value with stewardship intervention. This potential is characterized in part by concentrations of plant species that are associated with high-quality remnants of fire-dependent communities, concentrations

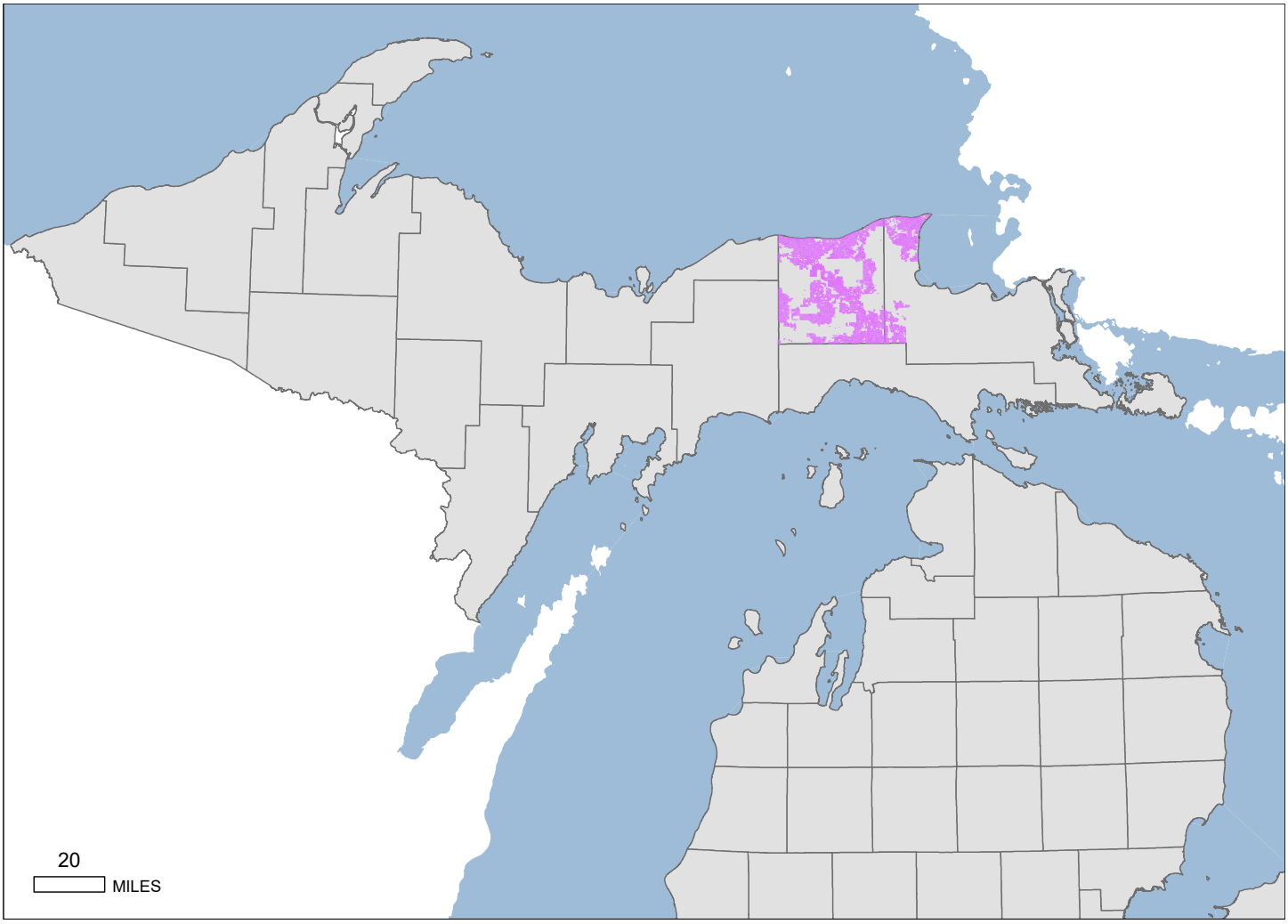


Figure 1. Location of Newberry Forest Management Unit in Michigan's Upper Peninsula.

of particularly old trees, and/or the prevalence of natural community indicator species. These natural communities and many of the species associated with them are considered fire-dependent, in that their long-term persistence is contingent on regular and recurring fire.

MNFI developed a prescribed fire needs assessment model for Department of Natural Resources (DNR) land in Michigan (Cohen et al. 2019, Cohen et al. 2021). The model uses a range of factors to identify the ecological need for prescribed fire. This report focuses on the first year of the project, which involved the evaluation of the Newberry FMU for RFDS. The Newberry FMU is in Luce and Chippewa Counties in the Eastern Upper Peninsula and consists of about 355,979 acres (Figure 1). The model was used to identify potential sites for field surveys. Model results were shared with Newberry FRD and WLD staff to focus targeted field surveys of potential RFDS. The goal of this project is to use MNFI's prescribed fire needs assessment model to identify and evaluate the best examples of fire-dependent natural communities in the Newberry FMU and foster their stewardship with fire.

Fire-dependent Systems

Numerous globally-rare fire-dependent natural communities occur in Michigan. This includes prairies, savannas, and barrens, as well as woodlands and forests dominated by pines (*Pinus* spp.) and oaks (*Quercus* spp.). These natural communities and many of the rare species that they support are threatened by fire suppression and habitat fragmentation. In the past, human- and lightning-set fires frequently spread over large areas of the landscape, influencing patterning of ecosystems, maintaining species composition, reducing colonization by trees and

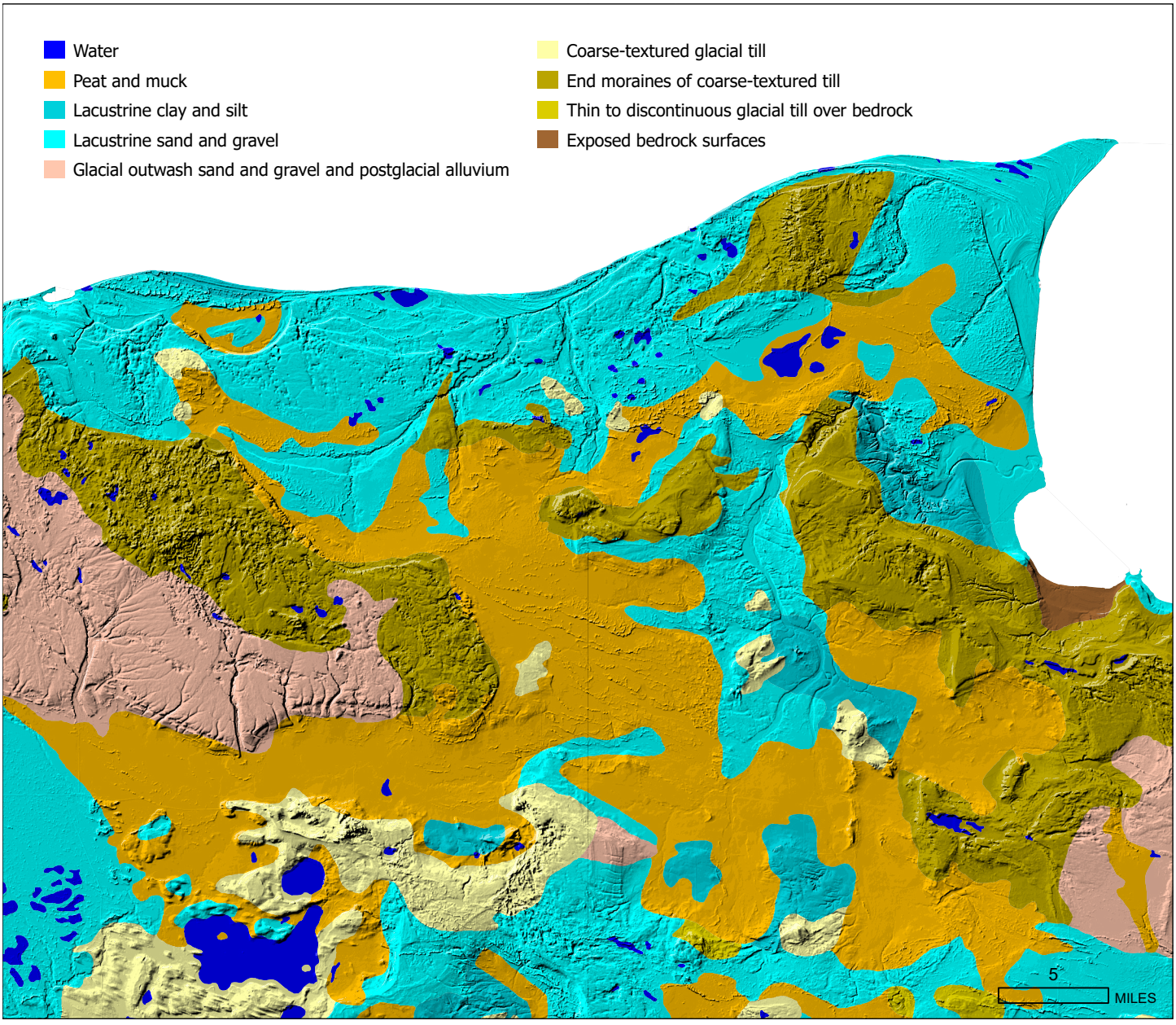


Figure 2. Surficial geology of Newberry Forest Management Unit.

shrubs, fostering regeneration of fire-dependent species, and sustaining the open structure of these fire-dependent ecosystems (Curtis 1959, Dorney 1981, Grimm 1984, Briggs et al. 2005, Bowman et al. 2009). A disproportionate number of rare species depend on fire-dependent ecosystems and over a third of Michigan's natural community types are fire dependent (MNFI 2025). In the absence of frequent fires, barrens have converted to closed-canopy forests dominated by shade-tolerant native and invasive species and cover only 0.02% of their historical extent (Comer et al. 1995, Cohen et al. 2021).

The eastern Upper Peninsula of Michigan was historically characterized by the prevalence of fire-dependent ecosystems. The interaction of landforms, vegetation, and Indigenous stewardship influenced the patterning of natural communities across this fire-influenced landscape. The region around Newberry FMU was strongly influenced by glacial activity which created landforms of lacustrine sand and gravel, glacial outwash sand and gravel, peatlands, and end moraines of coarse-textured till (Figure 2). Historic vegetation assemblages within Newberry FMU were approximated by MNFI ecologists using interpretations of the General Land Office (GLO) surveyor notes collected in the early 1800s (Comer et al. 1995; Figure 3). Circa-1800 vegetation of the Newberry FMU was predominantly forested, with an estimated 86% of the area supporting forested ecosystems. The predominant forested cover types included forested swamp (35%, 126,207 acres), upland pine forests (25%, 88,174 acres), mesic uplands (21%, 75,437 acres). Fire-dependent forests including jack pine-red pine forest (46,000 acres) and white pine-red pine forest (24,992 acres) covered 13% and 7% of the area respectively. A small percentage of area was described as early-successional aspen-birch forest (409 acres or 0.1%),



Extensive pine forest occurs along the Lake Superior shoreline. There are numerous fire-dependent natural communities in the Newberry FMU. Photo by J.M. Lincoln.

In addition, non-forested peatlands occupied 8% of the area (30,394 acres).

Indigenous peoples have been an integral part of the landscape of the upper Great Lakes. Pine-dominated landscape across the region have been shaped by cultural burning (Loope and Anderton 1998, Anderton 1999, Kimmerer and Lake 2001, Roos et al. 2014, Roos et al. 2021, Guyette et al. 2016, Swetnam et al. 2016, Lake et al. 2017, Larson et al. 2021).

The Newberry FMU was historically occupied and culturally stewarded by the Ojibwa and Odawa. who notably used natural pine forests along the shorelines for blueberry production (Loope and Anderton 1998, Anderton 1999). There is also increasing understanding that in addition to the prevalence of fire in these upland ecosystems, fire was a key component in peatlands (Meunier et al. 2019, Sutheimer et al. 2021) and coastal wetlands (Albert 2003). Fire or “Ishkode/Shkode” was used to promote culture, community, medicine, food, hunting, and pest control, facilitate travel, and attenuate wildfire risk (Kimmerer and Lake 2001, Huffman 2013, Hoffman et al. 2022, Parks et al. 2025). Prior to colonization, Indigenous fire stewardship shaped fire regimes across North American landscapes, providing safe living and foraging conditions and reduced wildfire (Hankins et al. 2025).

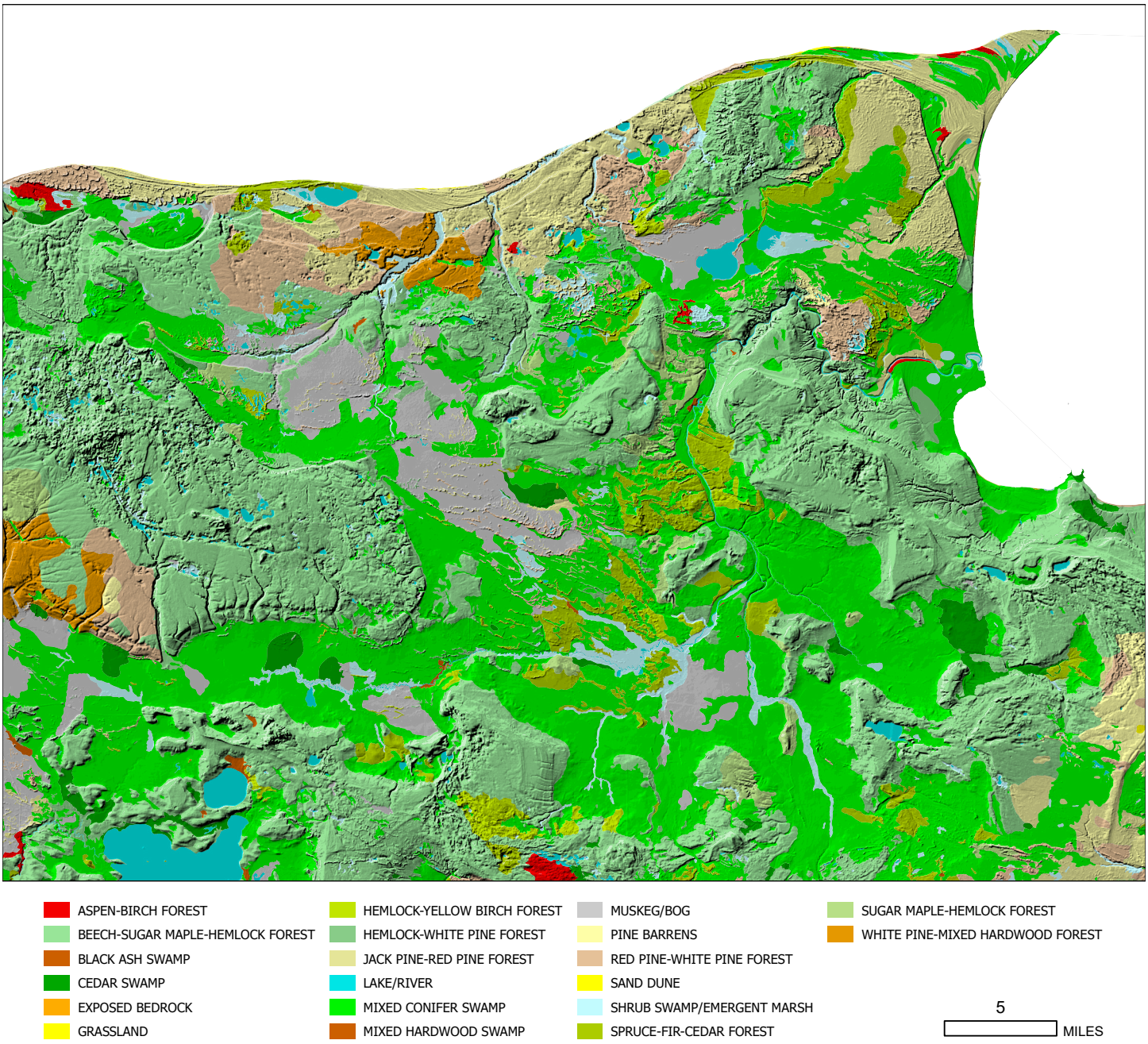
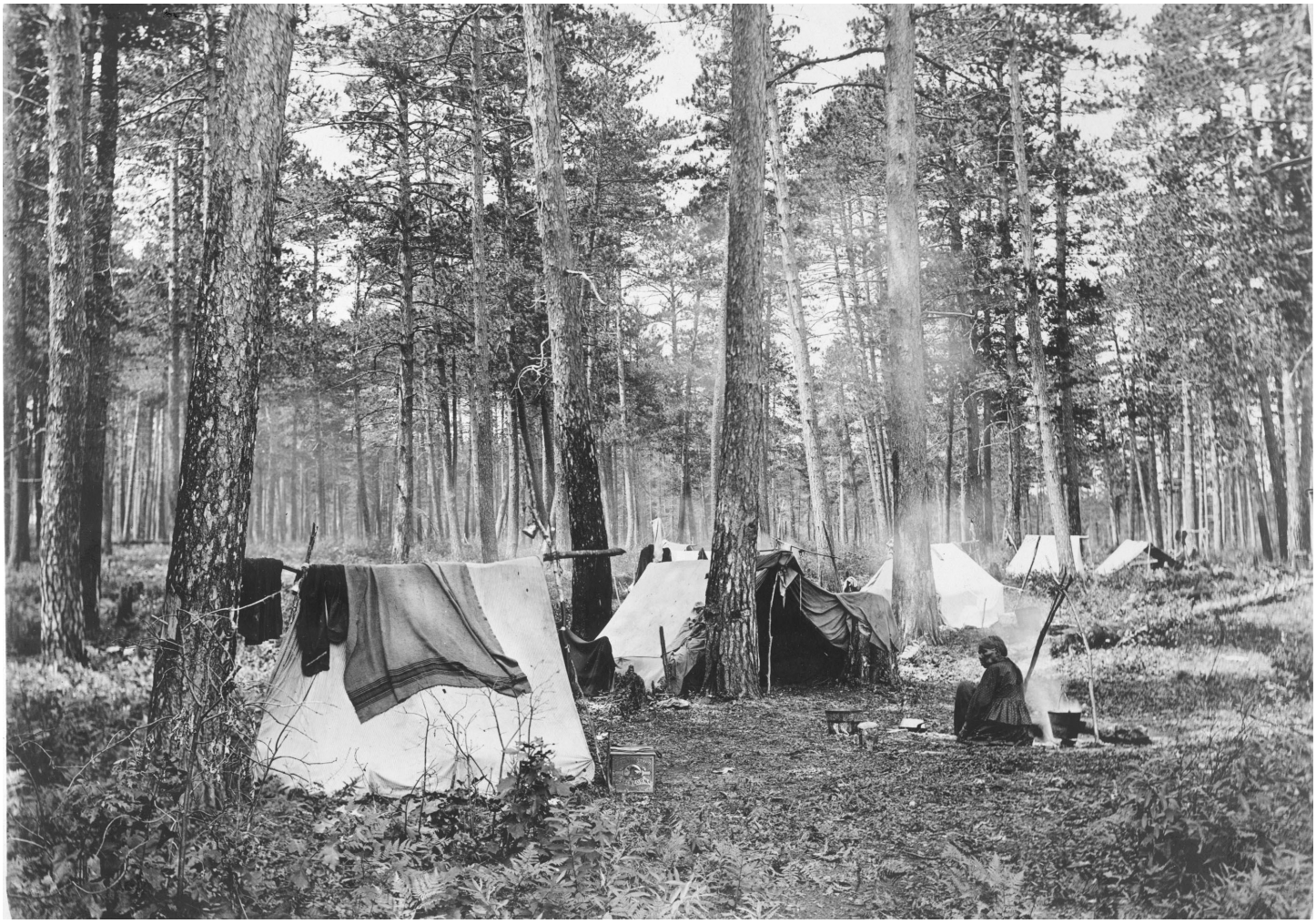


Figure 3. Vegetation of Newberry Forest Management Unit circa 1800 (Comer et al. 1995).



Charred trees remain after the 2007 Sleeper Lakes Fire burned through large peatlands. Fire was historically most prevalent in upland ecosystems but was likely a regular disturbance in peatlands, either through lightning strike, or fires deliberately set by Indigenous Peoples. Photo by J.M. Lincoln.



An Anishinaabeg camp in Northern Minnesota shows the historical structure of pine forests that were influenced by Indigenous cultural burning, likely for blueberry production. These forests have open understories with large, mature pine in the canopy. (Minnesota Historical Society).

Fire and the Modern Landscape

Following Eurocolonization of the Upper peninsula, displacement of Indigenous peoples and institutionalized fire suppression lead to dramatic shifts in the fire regime with widespread cultural burning likely stopping in the late 1800s. During the same period, large-scale timber removal and subsequent slash fires occurred. Pine plantations were established across large areas that remained unforested following the widespread logging and ensuing slash fires (Botti and Moore 2006).

The landcover within the Newberry FMU has changed significantly since the 1800s due to the displacement of Indigenous peoples, logging, fire suppression, and the establishment and sustained investment in pine plantations. Currently, forested wetlands remain the most predominant land cover type (26% of the FMU area; 92,896 acres). Upland pine forest and northern hardwoods are the next two most common cover types at 21% (74,633 acres) and 15% (53,963 acres), respectively. The most significant changes in forest cover type composition include the establishment of





Left, a red pine stump from the Newberry FMU with a fire scar indicating multiple fires (Photo by J.G. Cohen). Such samples are useful for developing an area's fire history. *Right*, a stump recovered from along the Shelldrake River shows evidence of at least six fires. These scars are annotated in the image on the right with the number of years between fires indicated (Photo by. J.M. Lincoln). This historic fire frequency provides managers with a target for fire return intervals of natural red pine stands. Based on this and other stumps from the area, we urge managers to apply low-severity/low-intensity prescribed burns at a rate of every 10 to 30 years.

plantations across the area and the increase in early-successional deciduous forest. Plantations make up approximately 8% of the FMU (28,106 acres), or 14.9% of the uplands, and early-successional forest dominated by aspen make up approximately 7% of the FMU (24,358 acres). Peatlands remain the most significant non-forested wetland cover type, occupying approximately 7% of the FMU (25,937 acres). Despite extensive logging and conversion to plantation, significant acreage of natural pine remains in the eastern Upper Peninsula. Based on the evaluation of current cover types across Michigan State Forest land, the Newberry FMU contains the largest coverage of natural red pine and natural mixed pine within the State Forest network. Natural red pine and mixed pine forest make up approximately 7% of the Newberry FMU (24,052 acres) (This estimation includes the summation of the following cover types within the Michigan Forest Inventory database: Natural Red Pine; Natural Red Pine, Mixed Deciduous; Natural Pine, Mixed Deciduous; and Natural Mixed Pine) (MDNR 2025). Throughout this report we emphasize the importance of the documentation and fire management of natural pine forests, especially those dominated by red pine.

Conservation Planning

Protecting and managing representative natural communities is critical to biodiversity conservation because native organisms are best adapted to environmental and biotic forces with which they have survived and evolved over millennia (Cohen et al. 2015). Biodiversity is most easily and effectively protected by preventing high-quality sites from degrading. This project is aimed at directing restoration efforts to the ecologically most important places.

Numerous high-quality fire-dependent natural community types were documented from the Newberry FMU prior to the 2025 surveys (Figure 4, MNFI 2025). However, there is a continued

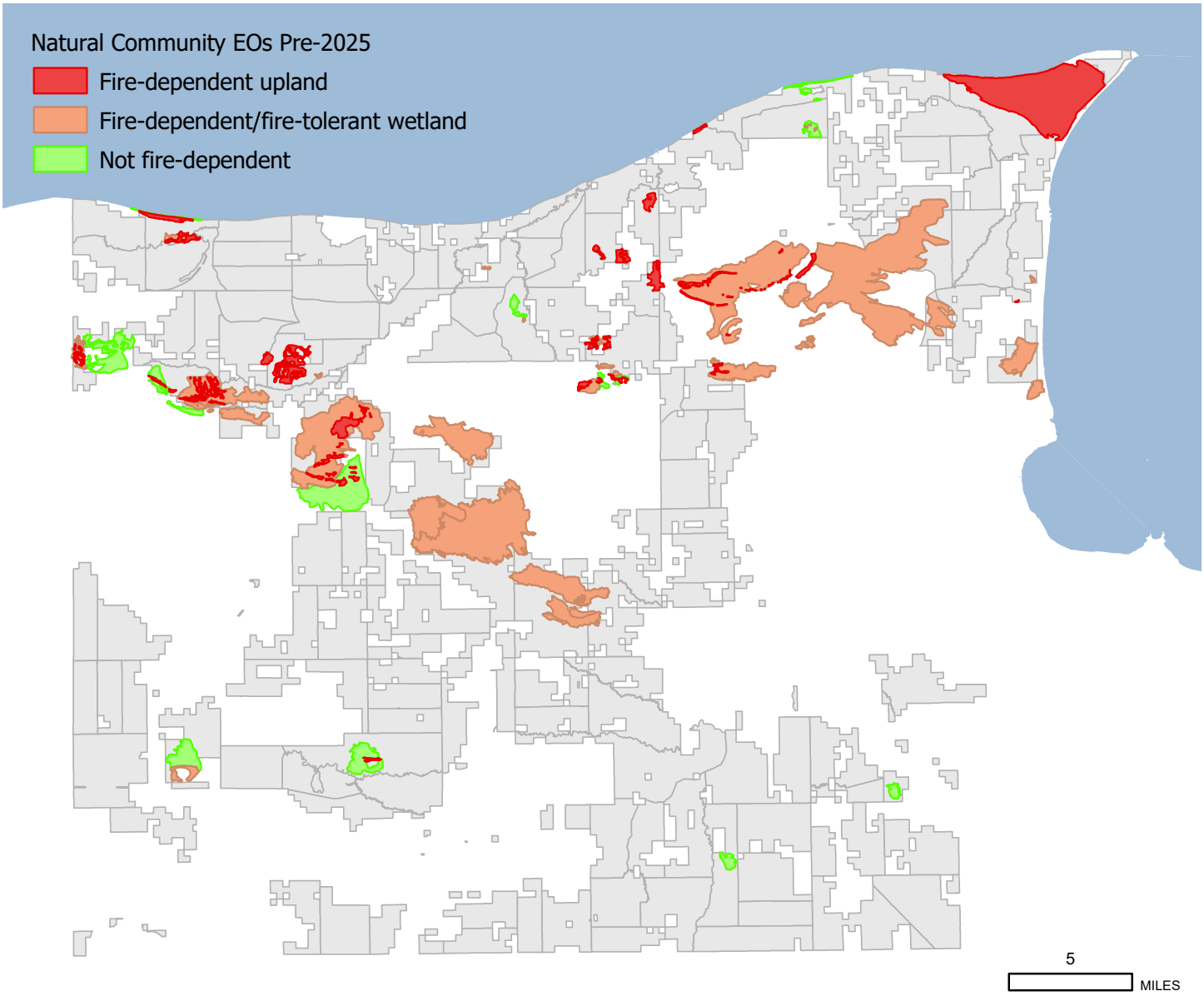


Figure 4. Previously documented high-quality natural communities in the Newberry FMU.

conversion of much of the region to plantation and early-succession forests. Within the Newberry FMU, many areas of RFDS, especially natural red pine forests, have either transitioned to a different forest type, or have been converted to pine plantation through clearing, trenching, herbiciding, and planting. Therefore, there is a need to assess what high-quality fire-dependent systems remain on the landscape to take steps to conserve them. There is also a pressing need to identify opportunities for holistic management of RFDS using prescribed fire in coordination with mechanical treatment. The primary focus of these surveys was on dry northern forest, especially those forests dominated by red pine, but other communities characteristic of a fire-adapted landscape were targeted for surveys including dry-mesic northern forest, pine barrens, poor fen, and muskeg.

The natural communities identified in the FMU were surveyed and specific stewardship recommendations were developed to help managers direct conservation efforts. This approach provides a timely opportunity to recognize, prioritize, and manage the remnants to increase diversity and resiliency in this landscape and prevent continuing loss and degradation of rare natural communities and loss of the species that rely on them. Fire-dependent remnants support high biodiversity, important cultural attributes, and are especially valuable targets for biodiversity conservation.



Swamp Lakes dry northern forest features red pine over 300 years old. Photo by J.G. Cohen.



The region features extensive peatlands with transverse dune ridges that support fire-dependent pine forests. Prison Camp Muskeg, Tahquamenon State Park. Photo by J.M. Lincoln.

Management Strategies for Natural Red Pine Forests

The mesophication of fire-adapted forests is increasingly degrading these systems. Mesophication increases shade and moisture levels in forest understories, limiting the recruitment of shade-intolerant pines and oaks and promotes fire-sensitive, shade-tolerant tree species such as maples, spruce, fir, and white pine (Nowacki and Abrams 2008). The result of mesophication in fire-suppressed forests is an understory with little advanced regeneration of the fire-dependent canopy cohort, shifts in understory and ground cover composition, reduced herbaceous cover overall, increased leaf litter density, and ultimately decreased plant species diversity (Cottam 1949, Curtis 1959, Chapman et al. 1993, Ratajczak et al. 2012). In contrast to the fire-suppressed forests of today, historic red pine forests were less dense, naturally regenerated, featured older trees, and were patterned by frequent, low-intensity burns, often initiated by Indigenous Peoples (Anderton 1999, Meunier et al. 2019, Kipfmueller et al 2021) (Figure 5). These ecosystems, and many species that depend upon them, are threatened both regionally and globally. Old-growth red pine is one of the rarest forest types in the Great Lakes Region with only 0.2% of the historic extent remaining (Frelich 1995). In many geographies, fire suppression has also resulted in increased risk of severe wildfire. Efforts to restore fire-dependent ecosystems in Michigan depend on the implementation of frequent prescribed fire and/or the mechanical treatment of vegetation.

This report emphasizes the identification of natural pine forest where we recommend incorporating the four principals of ecological silviculture (Palik et al. 2021). These principles include 1) maintaining continuity of structure, function, and composition; 2) maintaining structural complexity and species diversity; 3) applying silvicultural interventions at ecologically appropriate time intervals; and 4) implementing silvicultural interventions in the context

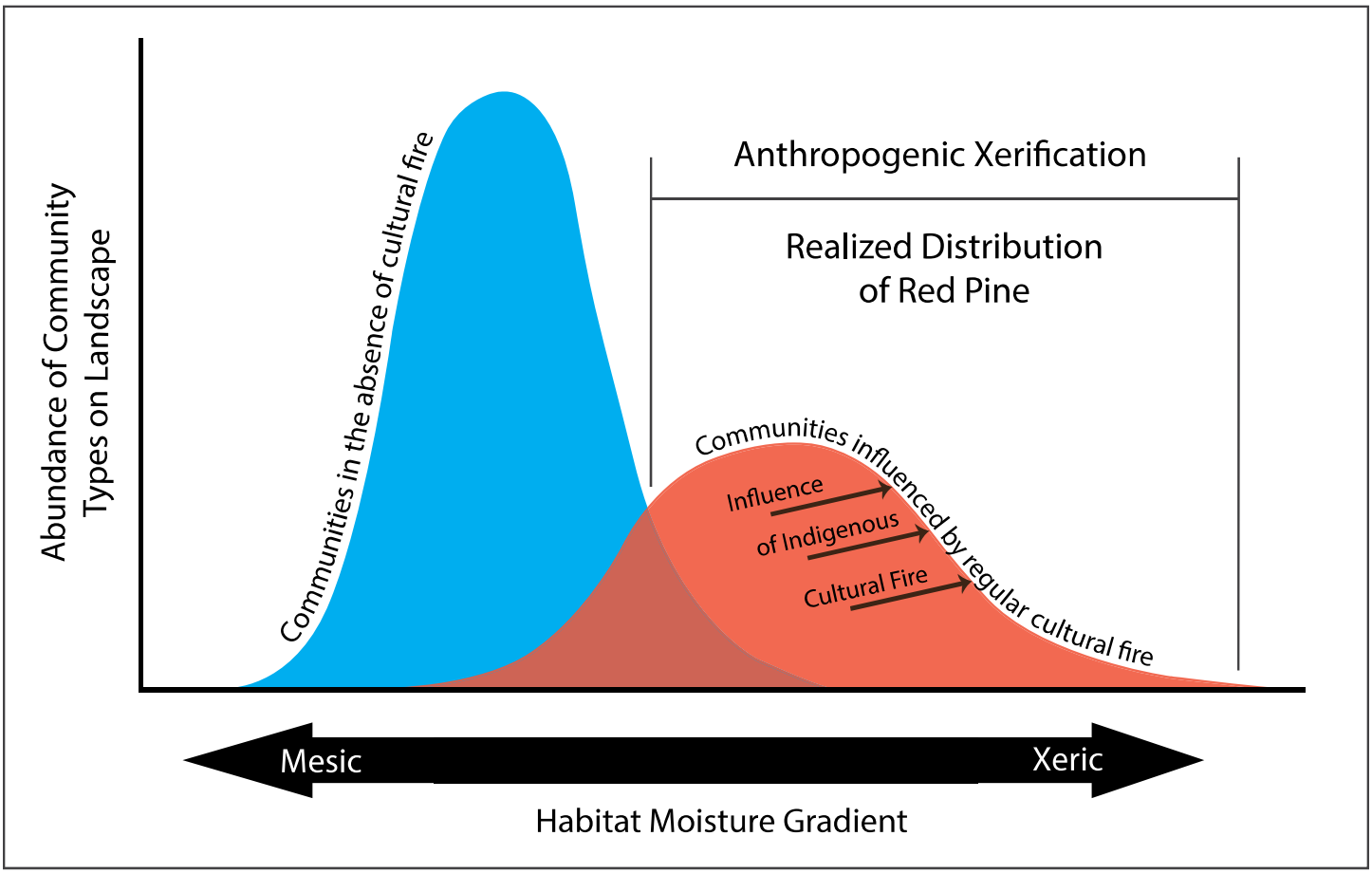


Figure 5. Anthropogenic xerification is the process by which the intentional use of Indigenous cultural fire promoted fire-tolerant species, such as red pine, in ecosystems in the Great Lakes Region. The use of fire by people may have increased xeric conditions and increased the competitive advantage of drought-adapted species in landscape positions they would not have occupied without regular cultural fire. Anthropogenic xerification caused by Indigenous cultural burning best explains the historic prevalence of red pine—dominated forests across much of Michigan's Upper Peninsula and partially accounts for the lack of natural red pine regeneration in the same areas where fire has not been recently applied. While red pine can persist in the driest of landscape positions without fire, it is rapidly being eliminated in mesic and dry-mesic conditions where white pine and other mesophytes have increased in dominance due to a lack of regular, low-severity/low-intensity fires. This figure was adapted with permission from Larson et al. (2021).



Two stands of natural pine, roughly the same age, showing the influence of fire on understory composition and natural regeneration of red pine. The forest in the top photo has been thinned but not burned and the understory is dominated by mesophytic species such as white spruce and white pine. The stand in the bottom photo is less than a mile away, has been thinned, was burned in the Duck Lake wildfire of 2012, and has natural red pine regeneration throughout. The application of prescribed fire throughout this landscape is fundamental to the natural regeneration of red pine. Photos by J.M. Lincoln.

of how these actions will influence landscape structure and function. Our project areas combine the application of fire and timber harvest to naturally regenerate red pine, promote a climate-resilient landscape, and protect regional biodiversity. The management of natural red pine stands is a priority for the 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 by conversion of natural forests to plantation. The historic application of Indigenous cultural fires increased the prevalence of red pine on the landscape through a process of anthropogenic xerification (Figure 5).The elimination of cultural fire and the lack of prescribed fire on the modern landscape has led to a widespread mesophication of red pine forests and is resulting in a lack of adequate regeneration of one of the most valuable timber resources in the Great Lakes region. This report highlights areas where the application of prescribed fire can be applied in concert with ecological silviculture.

We have developed an approach to the management of natural red pine that fosters a stand's potential for timber harvest and other goals such as controlling forest pathogens; enhancing resiliency to climate change and the ability to withstand wildfires; conserving biodiversity; and reducing costs associated with intensive management (Lincoln et al. 2025). As a counter to standard density-based management approaches, we are proposing a management framework based on the ICO approach (individuals, clumps, and openings) (Churchill et al. 2013). 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 even-aged management strategies. This method was developed for dry forests in the western states and is currently being applied in Wisconsin and Minnesota and is appropriate for many landscapes in Michigan (Razenkova 2025, Lincoln et al. 2025).

By combining the ICO approach with prescribed fire at return intervals that reflects historic disturbance cycles, we can develop a more ecologically based framework for managing red pine forests that considers spatial heterogeneity of forest composition and structure and promotes natural regeneration and landscape resilience. The Results and Appendices detail specific examples of high-quality natural communities (i.e., potential Ecological Reference Areas) and several proposed Project Areas. The Discussion section of this report provides specific management approaches to Project Areas where the ICO approach can be applied in the Newberry FMU. The primary objective of our recommendations is not to re-create pre-colonial forests within those Project Areas, but to provide an ecologically informed silvicultural framework for natural pine forests that enhances resilience and non-timber benefits.



In the absence of natural red pine regeneration, plantation management is favored over ecological silviculture across much of Michigan's State Forest system to ensure a supply of red pine. However, plantations are likely more vulnerable to extreme weather events and wildfires that are projected to increase with climate change. Photo by J.M. Lincoln.

METHODS

This Methods section provides details about our modeling approach for identifying Recoverable, Fire-Dependent Systems, our survey target selection process, and the survey approaches for natural communities and Project Areas. A natural community is defined as an assemblage of interacting plants, animals, and other organisms that repeatedly occur under similar environmental conditions across the landscape and is predominantly structured by natural processes rather than modern anthropogenic disturbances such as timber harvest, hydrological alteration, and fire suppression (Cohen et al. 2015, Cohen et al. 2025). Indigenous peoples have been integral to Michigan's landscapes, with many natural community types shaped by native land tending practices such as cultural burning, seeding, planting, and harvesting of plants, wildlife, and fish. This cultural stewardship has been responsibly implemented with sophistication and care at seasonally appropriate times (Kimmerer and Lake 2001, Stewart 2009). We define Project Areas as areas with significant conservation value that don't meet the criteria for a high-quality natural community or *Exceptional Conservation Value but* are natural pine systems that would benefit from holistic management including prescribed fire application and alternative silvicultural approaches.

Model Background and Natural Community Crosswalk

To identify survey areas of interest within the Newberry Forest Management, we utilized MNFI's prescribed fire needs assessment model to highlight stands and groups of stands in need of the ecological application of fire (Cohen et al. 2021) (Figure 6). We have used this modeling framework to identify recoverable fire-dependent ecosystems on both state (Lincoln et al. 2024, Schilke et al. 2024) and federal

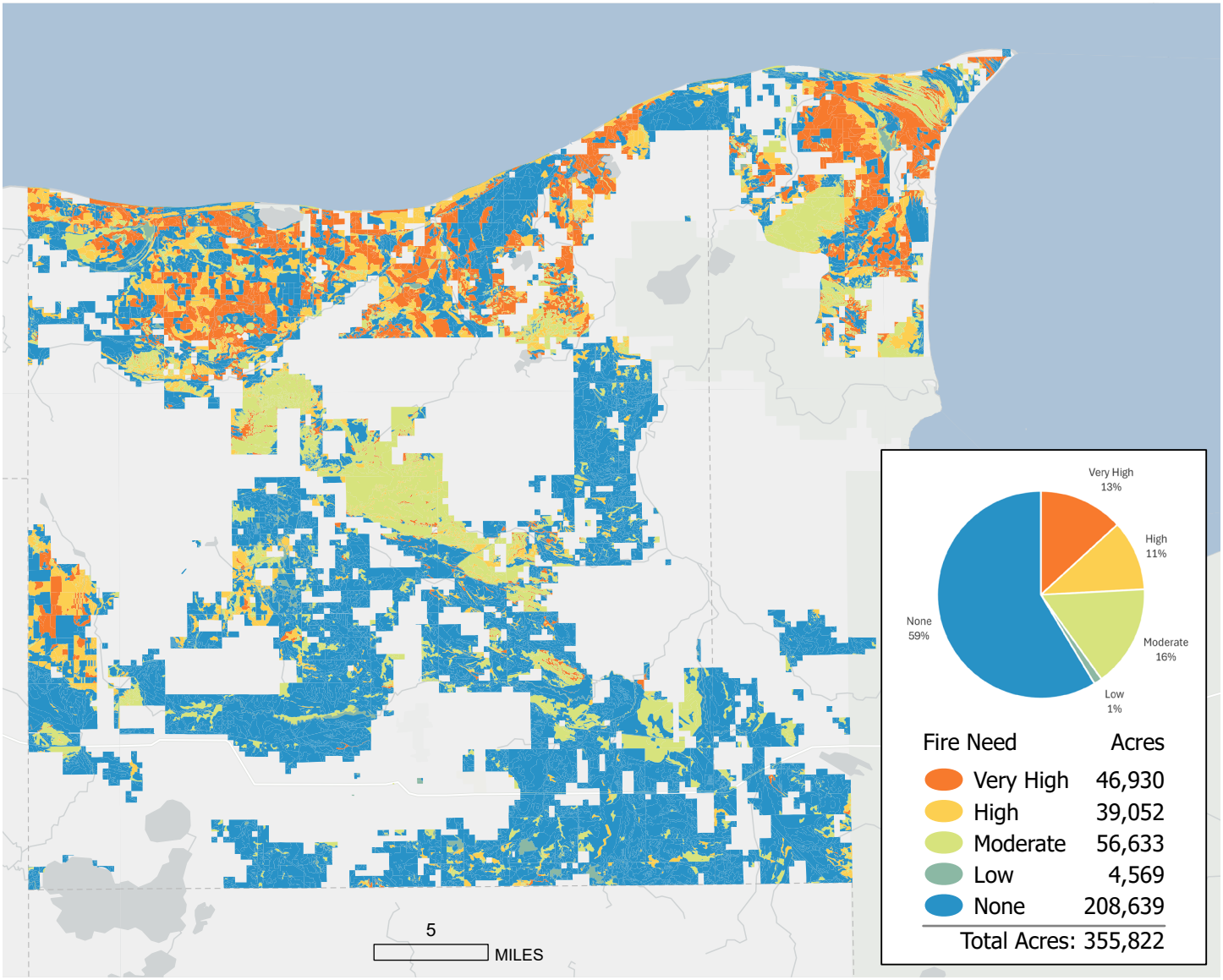


Figure 6. Output of the prescribed fire needs assessment model for the Newberry Forest Management Unit.

lands (Lincoln et al. 2022). MNFI originally developed the model for state lands in Michigan administered by Michigan's Department of Natural Resources (DNR) and we refined the model for the Newberry Forest Management Unit. A thorough description of the methods of this modeling framework is provided in Cohen et al. 2021 but here we provide a cursory overview in Appendix 1.

Survey Target Selection

Following implementation of the prescribed fire needs assessment model for the Newberry Forest Management Unit, we generated an ARC GIS geodatabase with the model output along with the footprint of wildfires within the last 20 years, MiFI data on stand age and concentrations of naturally regenerated pine, and the locations of historical Indigenous trails. We evaluated the entire Newberry Forest Management Unit (137 Compartments, 355,961 acres) through desktop analysis using a moving window approach. Compared to other Forest Management Units across the Upper Peninsula, the Newberry Forest Management Unit has substantial areas identified by our model as "High" or "Very High" fire needs concentrated in the northern half of the FMU near the Lake Superior shoreline (Figure 6). For each compartment, we identified concentrations of stands with high-fire scores, looked at multiple series of aerial imagery and topography, stand composition and age in the MiFI database, and proximity to existing natural community element occurrences. Through this process we identified a preliminary list of stands to focus survey efforts and consulted with Michigan Department of Natural Resources Forest Resources Division and Wildlife Division staff to further refine this list. Survey targets included potential fire-dependent natural community element occurrences, areas adjacent to existing fire-dependent natural community element occurrences, and potential Project Areas.

Potential targets for high-quality natural communities and Project Areas included a range of natural community types (e.g., dry northern forest, pine barrens, muskeg), different landscape positions (e.g., along the Lake Superior shoreline, within peatland complexes, along riparian corridors), and sites that are culturally significant to Indigenous communities (e.g., blueberry plains and encampments along the Lake Superior shoreline and/or rivers or inland lakes). We also included targets within areas impacted by different wildfires that burned at different intensities and for different durations. We targeted these areas as "Learning Landscapes" to help inform our understanding of how fire-dependent ecosystems respond to fire and gain insight in potential management strategies to promote both ecological and silvicultural objectives using the application of prescribed fire. We further focused on target Project Areas by using MiFI stand data and selecting stands and groupings of stands classified as red pine, jack pine, white pine, or mixed pine where at least 50



Field surveys were informed by the prescribed fire assessment model, aerial imagery interpretation, and input from the Newberry FMU staff, who often joined field visits. Photo by M.R. Parr.

percent of the canopy cover is composed of pine. We also selected stands that are classified as being of natural origin as opposed to stands that are classified as plantations. We selected natural pine because we expect that these stands are more likely to have exceptional characteristics in terms of vegetation structure, diversity, intact ecological processes, and higher ecosystem integrity. We further narrowed our survey targets to those with a dominant age of 100 years or greater. We expect that stands of this age will be more likely to have higher diversity, more natural structure such as old-growth characteristics, higher conservation value, and more potential to manage for old-growth structure. We further refined the selection of Project Areas to survey by evaluating the landscape context of the stands and groupings of stands. We prioritized larger stands and blocks of stands that are near water bodies or wetlands as we anticipate that these stands will have greater diversity and will be more conducive to fire management due to the natural breaks present.

Surveys

Ecological field surveys were conducted over 24 days in June, July, August, September, and November, 2025. We conducted targeted surveys for natural communities and Project Areas in portions of 20 compartments. Newberry FMU DNR staff joined MNFI ecologists several times throughout the season. In addition, MNFI ecologists were also joined by Tribal staff from the Sault Sainte Marie Tribe of Chippewa Indians and the Bay Mills Indian Community.

Natural Community Surveys

The targets for the natural community assessment were prioritized based on their rarity and estimated integrity using the Natural Heritage sampling prioritization principal. This prioritization principal emphasizes that natural community survey efforts should be focused on the rarest and highest quality natural communities (NatureServe 2002, Rocchio et al. 2018). Rarity is determined by evaluating a natural community's conservation status both at the state and global levels (i.e., S and G Ranks) (Appendix 2). Integrity is determined by employing Natural Heritage methodology, which considers three factors to assess a natural community's ecological integrity or quality: size, landscape context, and condition (Faber-Langendoen et al. 2008, Faber-Langendoen et al. 2016). If a site meets defined requirements for these three criteria (MNFI 1988), it is categorized as a high-quality example of that specific natural community type, entered into MNFI's database as an element occurrence, and given a rank of A to D – excellent to poor – based on how well it meets the above criteria. Throughout this report, a documented occurrence of a high-quality natural community at a specific location is referred to as an "element occurrence" (EO). The Michigan DNR designates natural community EOs with an EO Rank of A, B, C, or D as Ecological Reference Areas (ERAs) if they are critically imperiled (G1 and/or S1); imperiled (G2 and/or S2); or vulnerable (G3 and/or S3) and sensitive to typical forest management practices. In addition, more common natural community EOs with an EO Rank



Surveying with staff from the Sault Sainte Marie Tribe of Chippewa Indians and the Bay Mills Indian Community. Photo by J.G. Cohen.

of A or B can be designated as ERAs if they are vulnerable (G3 and/or S3) and not detrimentally impacted by typical forest management practices; apparently secure and uncommon (G4 and/or S4); or secure and common (G5 and/or S5) (Forest Certification Work Instruction 1.4).

Qualitative meander surveys were conducted to assess the natural community classification, ecological boundaries, and ranking of the communities. Vegetative structure and composition, soils, landscape and abiotic context, threats, management needs, and restoration opportunities were all assessed. Surveyors carefully documented and framed threats to ecological integrity of natural communities to develop management recommendations that will serve to protect the high-quality examples of natural communities on the landscape. Ecological evaluations are important for facilitating site level decisions about prioritizing management objectives to conserve native biodiversity, evaluating the success of restoration actions, and informing landscape-level planning efforts. Methods employed during this survey followed the methodology developed during the initial evaluation of Ecological Reference Areas on state forest land by MNFI ecologists (Cohen et al. 2008; Cohen et al. 2009).

Project Area Surveys

As noted above, we define Project Areas as concentrations of stands with significant conservation value that don't meet the criteria for a high-quality natural community but are fire-dependent forested ecosystems that are in need of integrated management approaches that incorporate the application of prescribed fire in concert with nontraditional silviculture. These Project Areas are restorable dry northern forest, dry-mesic northern forest, and pine barrens dominated by naturally regenerated pine. Ecological surveys within these Project Areas were less intensive than the natural community surveys in terms of cataloging biotic and abiotic components and were more focused on delineating restoration opportunities. Field surveys involved walking through Project Areas and gathering stand-level data on floristic composition and vegetation structure; evaluating age structure; documenting legacy trees (i.e., trees over 100 years in age); describing impacts of previous wildfire or prescribed fire (e.g., fire-scarred living trees and stumps); and recording information to inform the development of prescribed fire plans (e.g., data on fuel loading, ladder fuels, organic soil depth, basal area, and pine regeneration).



Determining tree ages using increment borers is important for evaluating natural pine stands. Photo by J.G. Cohen.

RESULTS

The prescribed fire needs assessment model identified 24% of the Newberry FMU's 355,961 acres as very high to high fire needs (Figure 6). Compared to the other five FMUs within the Upper Peninsula, the Newberry FMU has the highest proportion of very high to high fire needs. These areas of high concentrations of high fire need were the focus of targeted surveys for fire-dependent recoverable ecosystems including high-quality natural communities and potential Project Areas.

We documented 8 new natural communities and updated 1 previously documented natural community in 2025 (Table 1, Figure 7). New EOs were documented for 3 different natural community types, including dry northern forest (6), muskeg (1), and poor fen (1). We also updated 1 previously documented dry northern forest. In total we documented 790 acres (0.2% of Newberry FMU) of high-quality, fire-dependent natural communities within the Newberry FMU. These natural communities have been incorporated into MNFI's natural heritage database and qualify for consideration as Ecological Reference Areas.



MNFI Ecologist Mary Parr with a culturally modified tree in Ghost on the Shore dry northern forest. This tree displays scars consistent with bark peeling for Indigenous resin harvest. Photo by J.M. Lincoln.

Table 1. High-quality natural communities that were documented or updated during 2025 field surveys. Comprehensive site descriptions and management recommendations are provided for each site in Appendix 3.

Site Name	EO ID	EO Rank	EO Size (Acres)	Compartment	Primary Stands
Dry Northern Forest					
East Branch of the Two Hearted River	28174	AB	29	42028	34, 39, 45, 59, 77, and parts of 41 and 64
Ghost on the Shore	28184	B	105	42029	6
Sleeper Pines	28155	B	31	42084	55, 87, 91, 95, and parts of 51
Swamp Lakes	28171	BC	86.7	42042	158, parts of 29, and parts of 70
Barfield Lakes*	4328	C	71	42003	52, 56, and parts of 62
Murphy Creek	28175	C	27	42084	Parts of 24, 25, 159, 165, and 176
Deer Park Pines	28169	C	17	42023	32
Muskeg					
Swamp Lakes	28172	B		42042	89 and 126
Poor Fen					
East Branch of the Two Hearted River	28173	AB	427	42028	60

* updated and expanded existing EO

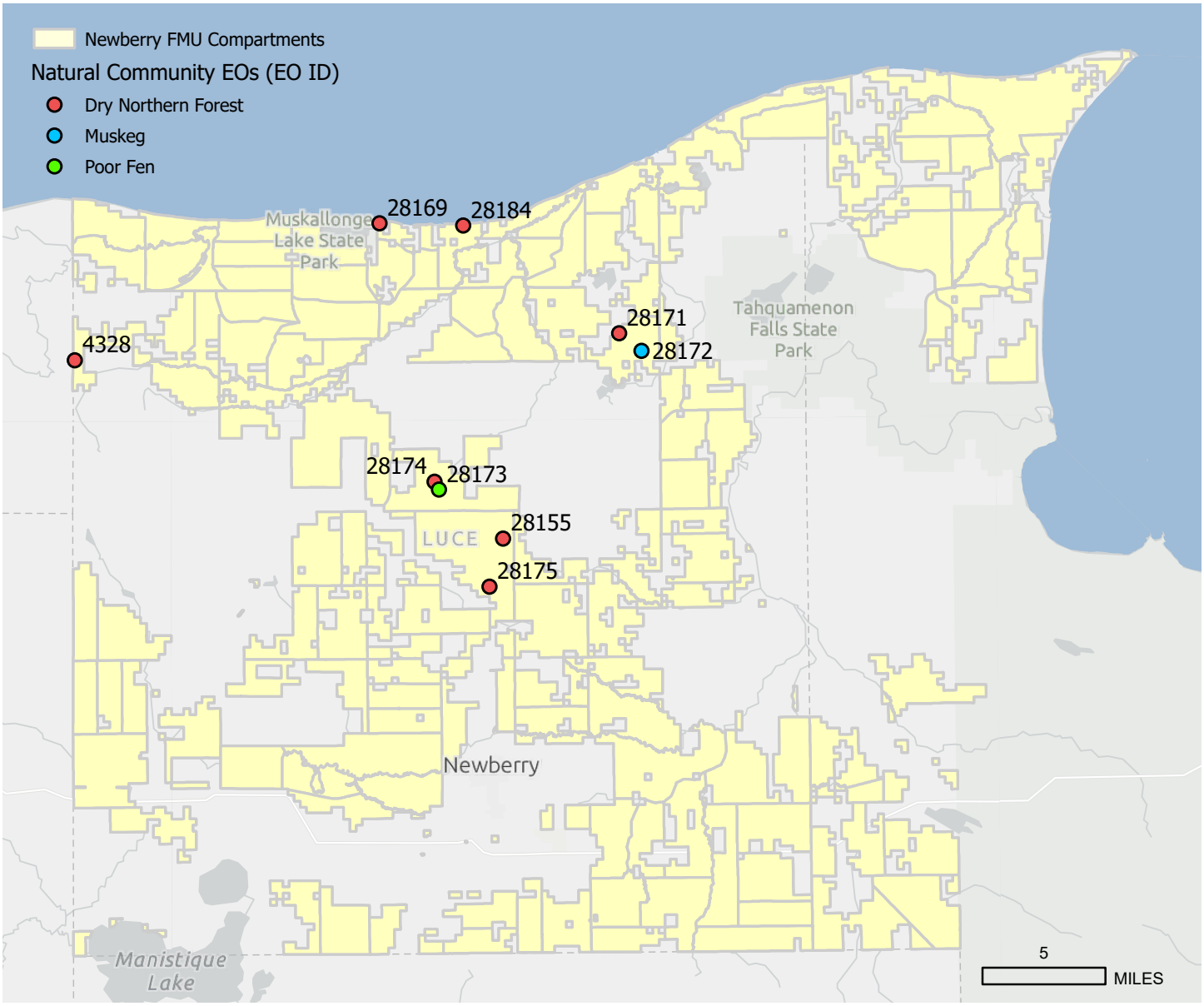


Figure 7. Location of high-quality natural communities in the Newberry Forest Management Unit surveyed in 2025.



Sleeper Pines (EO ID 28155) is nested within an extensive peatland complex. Photo by J.G. Cohen.

We also documented 20 potential Project Areas for the management of natural red pine, constituting 3,815 acres (1.0% of Newberry FMU) in 17 different compartments (Table 2). These Project Areas are sites of natural pine where we recommend the application of fire and implementation of timber management using the individuals, clumps, and openings framework to enhance forest resilience and ecological benefits along with timber harvest goals. Two additional pine barrens Project Areas were also developed for the Danaher Plains region of Newberry FMU. In total we evaluated 20 different forest compartments constituting 52,785 acres.

Detailed description of the vegetation, structure, and management considerations of each natural community EO are provided in Appendix 3 (pg 57 - 74). In addition, we provide brief descriptions for each priority Project Areas in the Appendix 4 (pg 75 - 118) along with specific management recommendations based on the management approach outlined in the *Project Area Management Recommendations* portion of the Discussion. Comprehensive management recommendations for the Project Areas are also detailed in the Discussion of this report.



The natural pine forests along Muskrat Lakes are recommended as a potential Project Area for management of natural red pine. We are proposing developing natural red pine Project Areas where there are stands of natural red pine and existing features such as roads and streams that could serve as burn breaks. In the case of Muskrat Lakes Project Area, we are recommending the application of prescribed fire and that the fire be allowed to naturally extinguish in the wetlands adjacent to the pine forest. Photo by J.M. Lincoln.

Table 2. Potential Project Areas identified during 2025 field surveys. Site descriptions and management recommendations are provided for each site in Appendix 4.

Priority	Site Name	Compartment	Primary Stands	Other Stands in Project Area	Project Size (Acres)	Community Type
	Forested Project Areas					
1	Muskrat Lakes North	42040	29, 19	26, 27, 45, 24, 44, 34, 22	416	Dry Northern Forest
2	Muskallonge/Deer Park	42023	32, 28	45, 17 ,23, 24, 25, 31, 22	125	Dry Northern Forest
3	Blind Sucker River	42011	44, 37, 28, 19, 43	18, 45	258	Dry to Dry-mesic Northern Forest
4	North Country Block	42017	3	4, 7, 8	153	Dry to Dry-mesic Northern Forest
5	Blind Sucker Flooding (The Hole)	42005	9, 15	21, 19, 4, 12, 5	223	Dry Northern Forest
6	Chris Brown Lake South	42031	58, 49, 59	47, 50, 32, 34, 29	369	Dry-mesic Northern Forest
7	Wabash Creek North	42031	10, 9, 12	98	166	Dry-mesic Northern Forest
8	Dry Lakes South	42044	69, 64, 57	81, 63, 71, 67	251	Dry-mesic Northern Forest
9	Dry Lakes North	42044	34, 21, 20, 28,29	34, 31; S53 in C42040	216	Dry to Dry-mesic Northern Forest
10	Andrus Lake	42067	65, 62	74, 58, 68, 38, 76, 59, 63	180	Dry to Dry-mesic Northern Forest
11	County Road 414	42031	103, 3	4,10, 6	153	Dry-mesic Northern Forest
12	Shelldrake River	42054	60, 62	3, 63, 64	114	Dry-mesic Northern Forest
13	Chris Brown Lake	42031	41, 42	39, 35, 43, 44, 1	199	Dry to Dry-mesic Northern Forest
14	South Branch Betsy	42062	8, 20	10, 9, 23	240	Dry to Dry-mesic Northern Forest
15	Bodi Lake West	42043	12, 4, 19	59, 10, 24	291	Dry Northern Forest
16	Muskrat Lakes South	42040	59, 49, 50	47, 60, 58, 20, 44	126	Dry Northern Forest
17	Wabash Creek South	42031	30, 31, 28	13	84	Dry to Dry-mesic Northern Forest
18	Bodi Lake East	42043	36, 72, 48	44, 26	90	Dry to Dry-mesic Northern Forest
19	Vermillion Point	42054	59, 58, 92	24, 20	81	Dry Northern Forest
20	Danaher Forest Zone	42093	26, 27	15	80	Dry-mesic Northern Forest
	Pine Barrens Project Areas					
1	Danaher West Barrens	42094	7, 8, 38, 4	39, 6, 5	510	Pine Barrens
2	Danaher South Barrens	42097/96	1, 2, 3, 4 (3 C96)		719	Pine Barrens

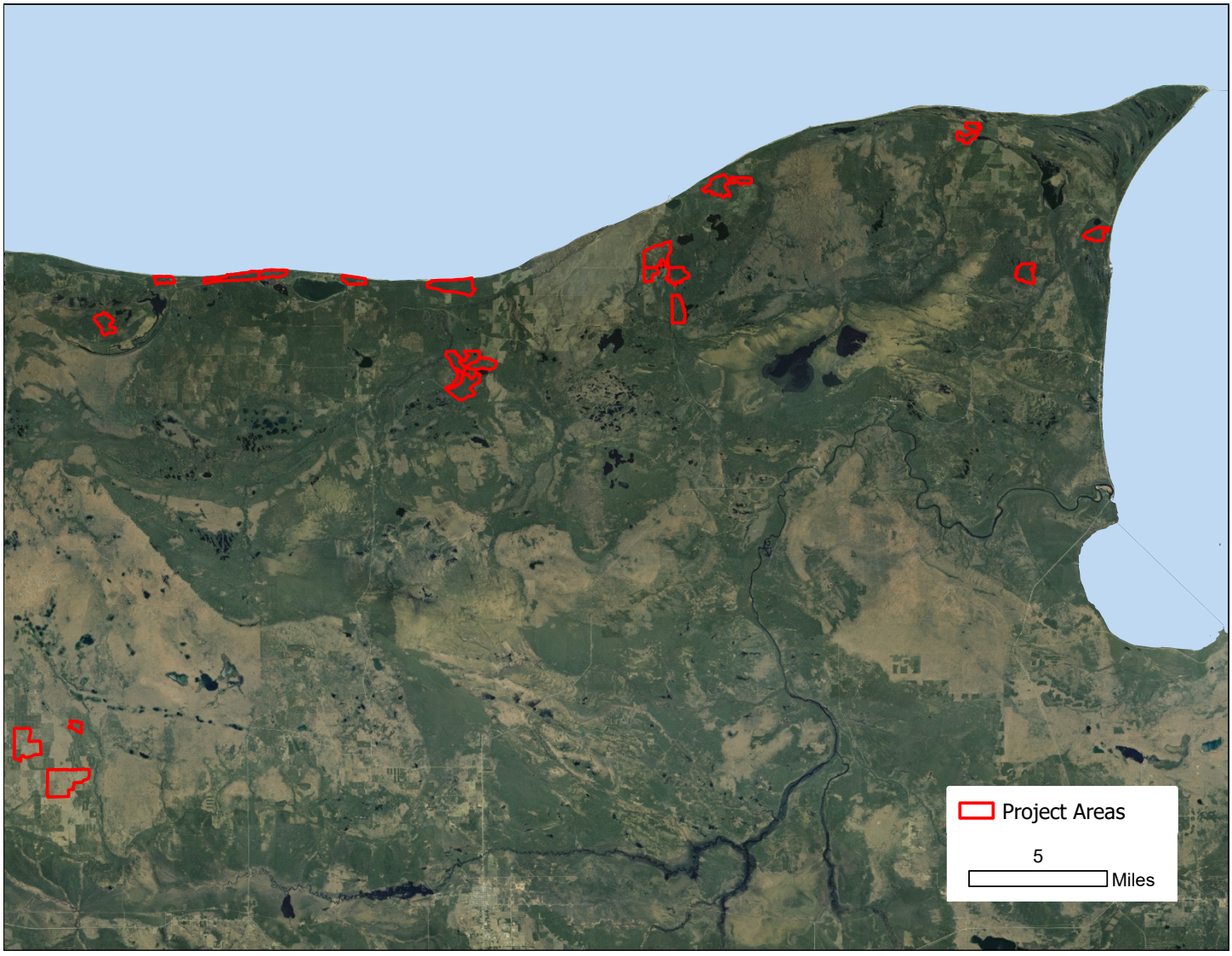


Figure 8. Locations of potential Project Areas in Newberry FMU.

DISCUSSION

The Sustainable Forestry Initiative commissioned Michigan Natural Features Inventory to document recoverable, fire-dependent systems within the Newberry Forest Management Unit. Using GIS-based multicriteria decision analysis, we developed a prescribed fire needs assessment model that identified approximately 86,000 acres of the Newberry FMU as having high or very high need for fire. Evaluating these model outputs and working in collaboration with the Michigan Department of Natural Resources, MNFI developed site leads for previously undocumented high-quality natural communities and recoverable, fire-dependent systems. Field evaluation of these sites led to the documentation of 8 new natural communities, expansion of an existing high-quality dry northern forest, and the identification of Project Areas where we recommend implementing prescribed fire as part of an ecological silviculture approach.

This Discussion provides recommendations for long-term management of the Project Areas that combine consistent application of prescribed fire and incorporates the four principals of ecological silviculture (Palik et al. 2021). These principles include 1) maintaining continuity of structure, function, and composition; 2) maintaining structural complexity and species diversity; 3) applying silvicultural interventions at ecologically appropriate time intervals; and 4) implementing silvicultural interventions in the context of how these actions will influence landscape structure and function.

In addition, we provide suggestions to resource managers and planners to continue concentrating efforts on the protection of native biodiversity by: 1) implementing stewardship activity within existing Ecological Reference Areas (ERAs) and benchmark natural communities; 2) increasing the use of Special Conservation Area (SCA) designations within the Newberry FMU to apply ecological silviculture techniques in areas that do not qualify as ERAs; and 3) expanding collaborative engagements with conservation partners. We also provide suggestions for improving inventory systems critical for informing management decisions and implementing monitoring to guide adaptive management of fire-dependent landscapes.



Ghost on the Shore is high-quality dry northern forest that was documented along Lake Superior during the 2025 survey efforts. The eastern half of this forest has several trees over 200-years-old and a few that were aged to around 350-years-old. Photo by J.M. Lincoln.

Project Area Management Recommendations

Management recommendations for the Project Areas are designed to enhance resilience and native biodiversity in areas where timber harvests will occur. More detailed recommendations for each Project Area are provided in the Appendices. We believe the outlined approach meets the expressed goals of SFI certification to conserve biological diversity (Objective 3), forest health and productivity (Objective 2), climate smart forestry (Objective 9), and fire resilience and awareness (Objective 10) (Sustainable Forestry Initiative 2022: pp 7, 8, 11,12). The following management recommendations are rooted in the understanding of natural disturbance processes that shape the highest-quality natural pine forests and pine barrens in the region.

The Project Areas we have identified in the Newberry FMU were developed around areas of degraded pine barrens and natural pine forests. Within the natural pine Project Areas, we recommend implementing prescribed fire with the ICO (Individuals, Clumps, and Openings) approach refined for natural red pine in the Great Lakes states (Churchill et al. 2013, Palik et al. 2021, Lincoln et al. 2025, Razenkova et al. 2025). Despite the extensive distribution of natural red pine forests in Michigan and clear evidence of fire in these systems, there are few places to visit in the State Forest system where ecological silviculture has been combined with application of prescribed fire. A reevaluation of the State's approach to red pine management is needed to maintain resilient red pine systems on the landscape, and intervention is needed to prevent stands of natural red and mixed pine to convert either to more mesic covertypes or pure jack pine stands. The Project Areas we have identified in Newberry FMU were developed around 1) areas of degraded pine barrens that support rare species and can be recovered to improved condition with the application of fire and careful management, and 2) areas of natural red pine that are suitable candidates for the ICO approach, which combines prescribed fire and thinning.



Proposed Project Area along Chris Brown Lake. We recommend using features such as lakes and streams as burn breaks. Photo by J.M. Lincoln




Left, a natural mixed pine forest with an understory dominated by white pine with no red pine regeneration. In the absence of fire, red pine is not regenerating at sufficient rates to meet silvicultural demand. Photo by W.O. Lincoln. The areas in Newberry FMU that consistently showed natural red pine regeneration had been impacted by recent wildfires. *Right*, This stand was burned in the Duck Lake Fire in May of 2012 and had patchy red pine regeneration throughout. Photo by J.M. Lincoln



Scarification is a tool that is often used to promote red pine regeneration on Michigan State Forest Lands. This site was scarified following a canopy thinning. However, despite adequate seed sources, mechanically prepared seedbeds, adequate light following the thinning, and reduced competition, scarification failed to produce results that are regularly achieved by fire. Similar results were observed across the FMU. Photo by J.M. Lincoln

Pine Barrens Project Areas

While the focus of this section is developing Project Areas for the management of natural red pine forests, we also identified two Project Areas where pine barrens management is an appropriate fit. These two proposed Project Areas, totaling 1,229 acres, occur in the Danaher Plains, in the western portion of the Newberry FMU (Appendix 4, pg 115-118). While these areas have been trenched and scarified and do not meet the qualifications of high-quality pine barrens, the rarity of the community type on the landscape, the presence of rare animal species, and the opportunity to recover the sites to an improved condition justify ongoing pine barrens stewardship. Kirtland's warbler (*Setophaga kirtlandii*, State Endangered and Focal Species within the State Wildlife Action Plan) and sharp-tailed grouse (*Tympanuchus phasianellus*, Special Concern) (Derosier et al. 2015, MNFI 2025), have been documented in the Danaher Plains.

The State Forest Management Plan recommends creating a Conservation Area Network for developing dedicated areas of at least 200 acres for Kirtland's warbler habitat management in the Upper Peninsula (MDNR 2024, p 249). The barrens Project Areas are appropriate locations for meeting this objective. Large-scale barrens management in these areas would also provide habitat for common nighthawks (*Chordeiles minor*, Special Concern and Focal Species within the State Wildlife Action Plan) and upland sandpipers *(Bartramia longicauda,* State Threatened).



A photograph from a pine barrens in northern lower Michigan before it was cleared. The picture reflects descriptions from the General Land Office surveyor's notes from Danaher Plains where red pine was prevalent and formed an uneven-aged supercanopy over jack pine thickets. The removal of red pine has facilitated the dominance of jack pine that characterizes pine barrens remnants today.

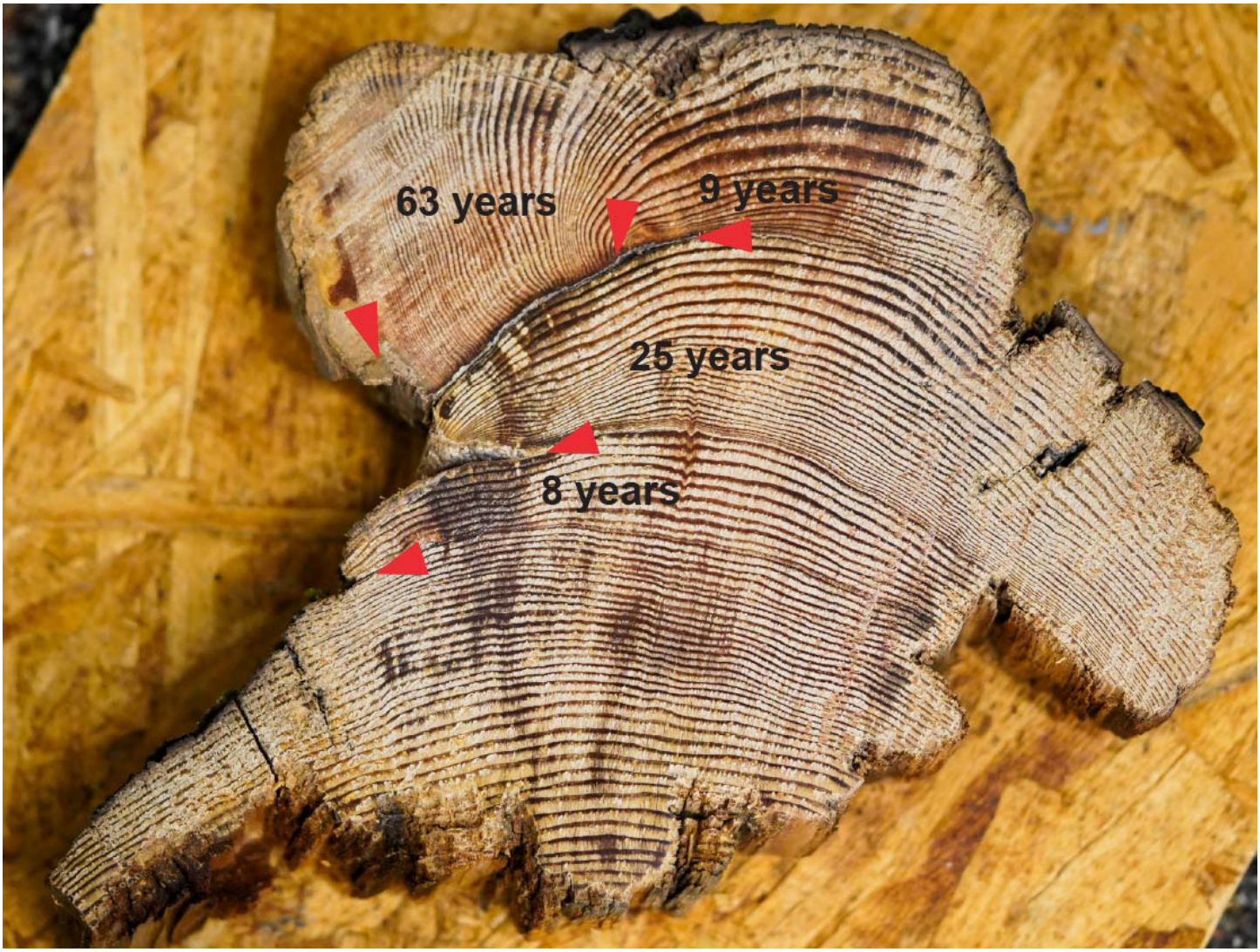


The pine barrens Project Areas in Danaher Plains feature characteristic pine barrens structure. We recommend applying low-severity fires at a frequency of every 5 to 25 years. Photo by J.M. Lincoln

The notes from the original surveys in 1851 for the Danaher Plains describe “white and red pine plains, gently rolling, third rate sandy soil” and “burnt lands, open pine plains, poor sandy soil” (Francis Coleman, 1851 GLO notes, Appendix 5). Broadly, we suggest managing large areas with the regular application of periodic, large-scale prescribed fire to recreate a mixed-pine plains featuring complex age structures and varying densities of jack pine. This would promote habitat for Kirtland’s warbler, sharp-tailed grouse, nighthawks, and upland sand pipers.

The two identified sites have a history of beneficial prescribed fire management by Newberry staff. Our recommendations are intended to build upon that work and include refined management approaches recently developed through ongoing evaluation of sites around the state (Lincoln et al. 2022, Lincoln et al. 2024, Cohen et al. 2025).

Specific recommendations for pine barrens Project Areas in Newberry FMU are to 1) avoid scarification; 2) capture a greater range of natural variation by establishing large Project Areas beyond areas historically managed as open barrens; 3) apply frequent, low-severity/low-intensity burns at intervals of 5 to 25 years (Figure 9); and 4) establish a monitoring program for rare bird species and vegetative response.



A cross-section of a red pine stump recovered from a dune ridge along the southern end of Danaher Plains. Such samples are useful for understanding historic burn frequencies. The stump shows evidence of at least at least five fires over a 100-year span. These scars are annotated by arrows with the number of years between fires indicated. Many lower severity fires likely occurred but were not recorded on this tree. Because a thorough fire history of Danaher Plains was not conducted, we are not able to elucidate a detailed fire history for the site. However, the fires recorded by this stump provide managerswith a target for fire return intervals for the pine barrens Project Areas in Danaher Plains. Based on this and other stumps from the area, we urge managers to apply low-severity prescribed burns at a rate of every 5 to 25 years with higher frequencies during initial stages of restoration and longer durations between fires after the site has been burned several times.
Photo by J.M. Lincoln.

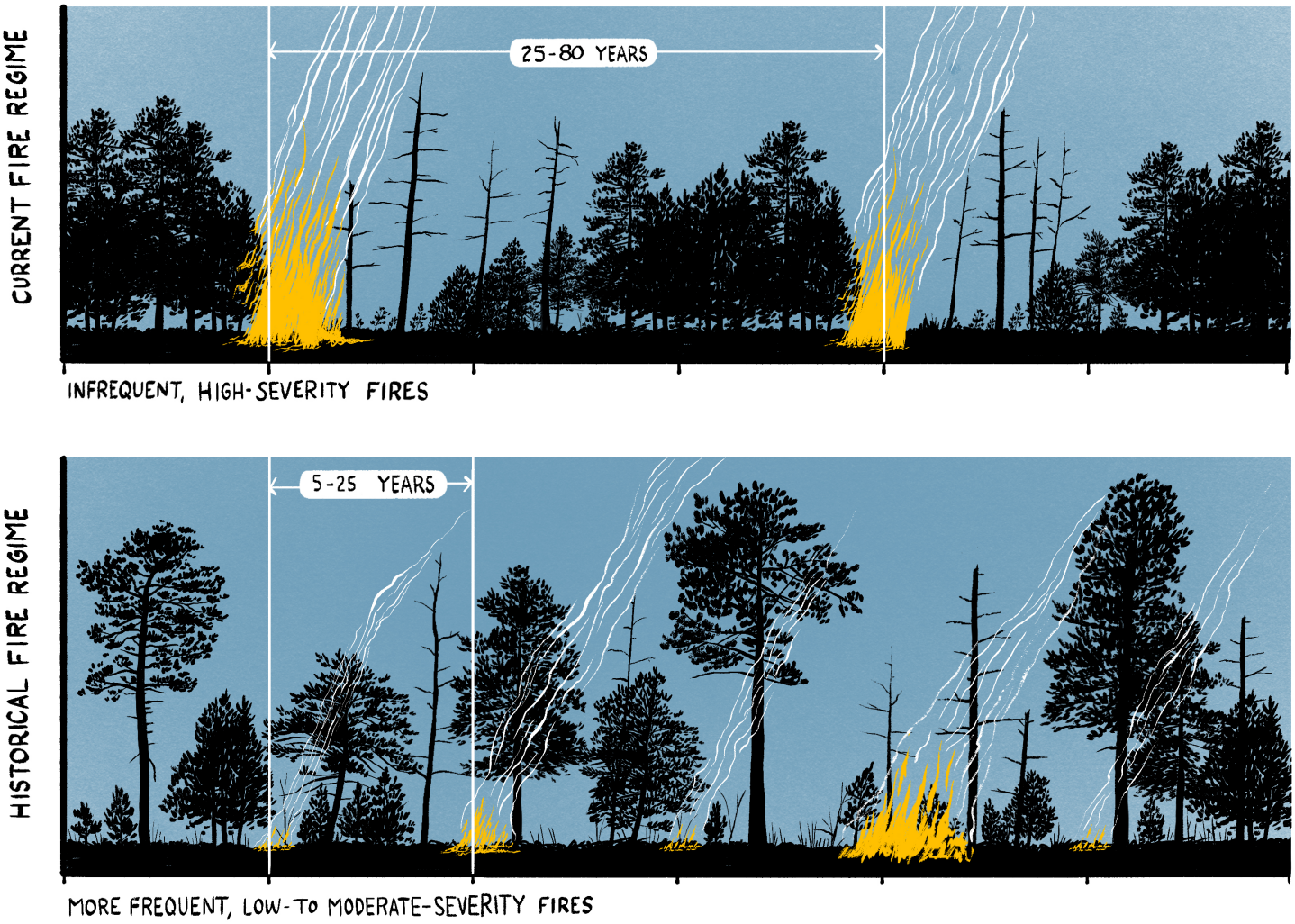


Figure 9. Pine barrens fire regimes. *Top panel*: The current paradigm around fire for much of the jack pine—dominated landscape. Here, irregular, catastrophic stand-replacing fire shapes the system. Under this paradigm, pine barrens are established in the wake of fires that kill nearly all trees. The serotinous cones open, and the next cohort slowly fills in on a successional trajectory towards a closed-canopy forested system. The system is reset through lightning strike or accidental, human-caused ignitions, typically on a frequency of every 25 to 80 years, as is observed on the landscape today. In this paradigm, barrens structure is brief, and species are at greater risk of local extirpation as greater portions of the landscape trend towards closed canopy. *Bottom panel*: The historic fire regime in many pine barrens. Historic descriptions of pine barrens often note red pine; a species consistently absent from many of our best remaining examples of pine barrens. This species is adapted to survive fire, and ongoing research shows that red pine trunks often scar during a fire, thereby recording the site's unique fire history. Stumps found at barrens sites in Michigan clearly and consistently indicate periods of fire return intervals between 5 and 25 years, which is also the age of jack pines required for by Kirtland's warblers for nesting. The fact that several stumps recovered from pine barrens display such scarring allows us to reconsider the current paradigm of intense, stand-replacing fire. Instead, we propose a return to the historic paradigm of more frequent but lower intensity fires and greater landscape stability. This approach creates longer periods of open savanna conditions over a larger area, a greater portion of the landscape in a natural condition, greater landscape resilience to wildfire and climate change, lower costs associated with maintaining Kirtland's warbler habitat, and more consistent habitat availability for a greater range of species. Illustration by Querkus Creative.

Natural Red Pine Project Areas

Natural red pine regeneration in many Michigan forests is insufficient to meet future timber harvest needs. As a result, natural pine forests are allowed to transition to different cover types or are being converted to red pine plantations by way of clearcutting, trenching, and herbicide application. The conversion of natural and semi-natural forests into plantation is not aligned with the SFI certification standards (SFI 2022 Forest Management Standard). Further, even-aged management does not replicate mixed-severity disturbances which historically shaped dry forest ecosystems, and clearcutting eliminates seed sources needed for natural pine regeneration (Nyamai et al. 2014, Palik and D'Amato 2019). Maintaining natural red pine on the landscape is an objective outlined in Michigan's State Forest Management Plan (MDNR 2024, p 234) and is of significant interest to conservation stakeholders. The Michigan DNR has expressed an interest in identifying alternative management to promote natural red pine regeneration through pathways that increase ecosystem resilience, protect native biodiversity, and provide for future timber needs. The following focuses on fire-adapted forests in the Newberry FMU where alternative silvicultural practices could be applied to manage stands of natural red pine.

We developed 20 potential natural pine Project Areas totaling 3,815 acres, across the Newberry FMU during the 2025 field season. Detailed descriptions for each site are provided in the Appendix 4 (pg 75-114). While this report is specific to the Newberry FMU within the Michigan State Forest network, this is a logical framework for a general approach that can be adapted and applied to natural and semi-natural red and mixed-pine forests across various ownerships in the Great Lakes region. Generally, we recommend combining prescribed fire and forestry treatments to enhance natural regeneration of red pine, make the landscape more resilient to wildfire, ensure a continuity of covertypes, and protect the economic viability of these areas.

Benchmark examples of natural pine forests are characterized by structural and compositional heterogeneity developed and maintained largely through frequent, low-severity fires (Binkley et al. 2007, Meunier et al. 2019, Razenkova et al. 2025). Integration of low-severity prescribed fire is central to managing ecosystem resilience in natural dry pine forests in the Great Lakes Region. Therefore, the general approach to the management of proposed Project Areas is to return fire and implement timber harvest treatments that will establish multi-age forests that mimic the natural model for frequent-fire forests. We recommend the ICO approach for achieving structural complexity (Figure 10) (Churchill et al. 2013, Razenkova et al. 2025, Lincoln et al. 2025). There are several names and similar approaches for this type of ecological silviculture, including "mixed-severity silvicultural system" (Palik et al. 2021), "variable harvest retention" (Palik and D'Amato 2019), or "variable density thinning" (Carey 1995, Palik et al. 2021). The ICO approach is intended to be an "intuitive, flexible, and efficient approach to restore the mosaic patterns" common in natural pine forests (Larson and Churchill 2012, Razenkova et al. 2025). The intended results are complex, uneven-aged forests that approximate historic structural heterogeneity characteristic of pre-colonial conditions for the benefit of natural regeneration and are resilient to disease, wildfire, and climate change.



New plantations are being established through clearcutting, trenching, and herbicide application. This site on State Forest land is not in Newberry FMU but is consistent with prescriptions across State Forest lands. Photo by J.M. Lincoln.

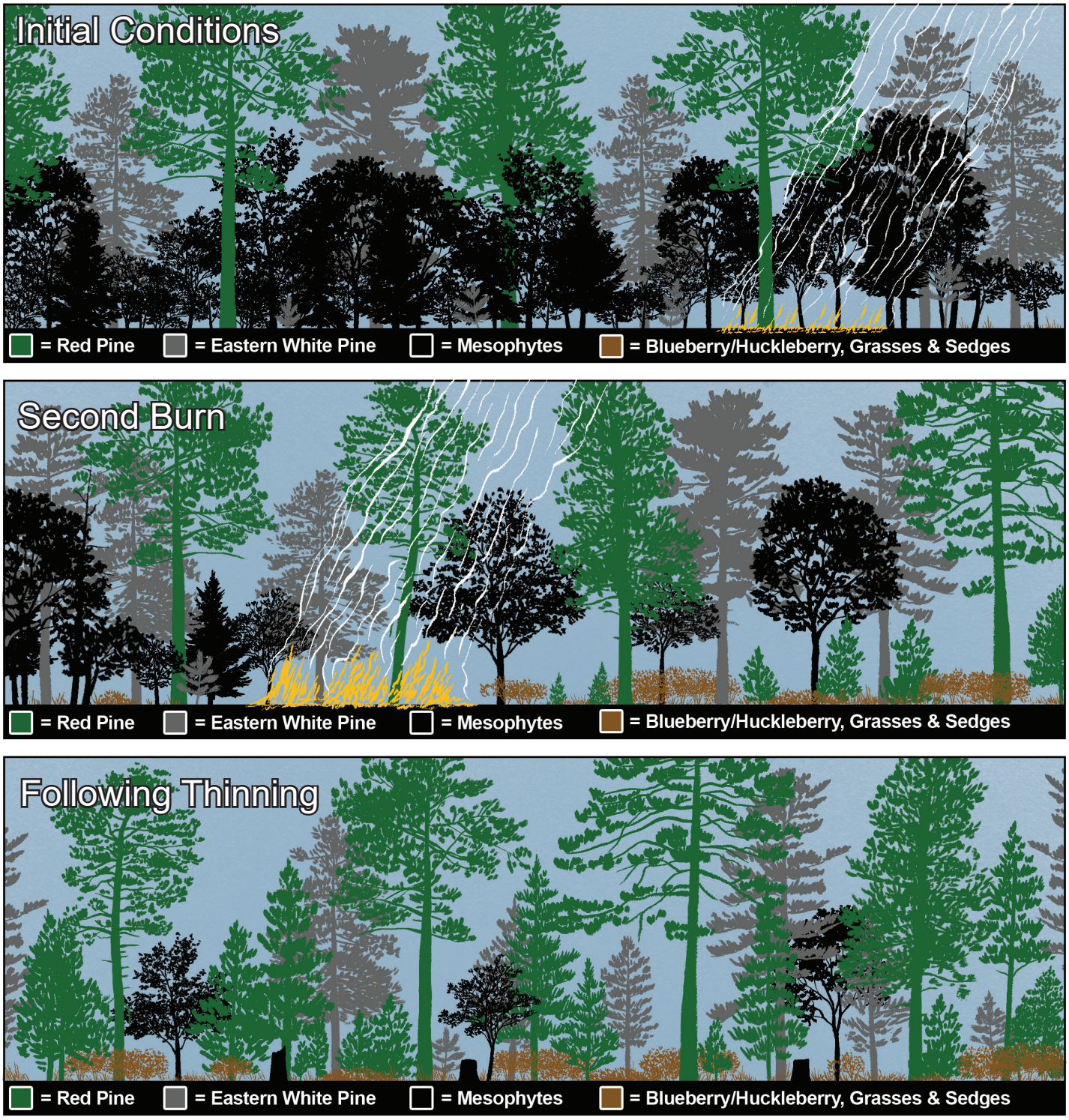


Figure 10. *Top panel:* Our natural red pine forests are often fire suppressed with a dense understory of balsam fir, spruce, red maple, and white pine. Due to a lack of adequate red pine regeneration, removal of the canopy will shift the trajectory towards a new composition. Ahead of forestry treatments, we recommend applying a low-severity/low-intensity prescribed fire to begin reduction of mesophytic competition and promote natural red pine regeneration. This will reduce ladder fuels, increase canopy base height, and condition the trees for future fires. *Middle panel:* After protracted fire suppression, a single burn will not have the impact necessary to condition the stand for improved red pine regeneration. We recommend the application of two fires before canopy reduction to better prepare the site for natural regeneration and long-term maintenance as a natural red pine forest. The second burn should be applied during a red pine mast year to help enhance natural red pine regeneration. The second burn will prepare the site for its next timber harvest. *Bottom panel:* Following the second burn, roughly 1/3 of the basal area will be harvested. Following the timber harvest, the site will be managed for the foreseeable future with alternating applications of prescribed fire and canopy reduction by 1/3 every 30 years. Illustration by Querkus Creative.

The boundaries of the Project Areas are intended to serve as maintained burn breaks for the repeated application of prescribed fire. We have provided approximate boundaries that will need to be examined, verified, installed, and maintained by local managers familiar with the sites. Existing roads were chosen for burn breaks, when possible, but wetlands and waterbodies were recommended in several instances. Burn break placement is intended to enable fire movement across ecotones and avoid constructing unnecessary burn breaks that may have negative long-term impacts on saturated soils and can be conduits for invasive species. Ecotones include transitional areas between uplands and wetlands; they are often very diverse and serve as critical habitat for many herptiles at different times of the year for thermoregulation and nesting. Further, larger Project Area sizes will contain several stands of multiple age classes, and consistent and carefully timed prescribed fire should provide acceptable levels of red pine regeneration.

Prescribed Fire and Sustainable Forestry Initiative Standards

SFI standards support the use of prescribed fire to limit susceptibility of forests to undesirable impacts of wildfire and to raise community awareness of fire benefits, risks, and minimization measures (Objective 10) (Sustainable Forestry Initiative 2022: p 12). Certified organizations are required to reduce wildfire impacts and raise community awareness for fire benefits through 1) the use of *stand* and *landscape* level management techniques; 2) actions and/or *policies* to promote *forest health* and resilience; and 3) mitigation of the likelihood of undesirable impacts of wildfire through the application of prescribed fire, cultural burning, thinning, and/or hazardous fuel reduction where appropriate based on risk. This includes participation in, or support of, local, state, provincial, federal, or Indigenous fire management wildfire prevention programs, and programs to promote benefits of fire management (Sustainable Forestry Initiative 2022: p 12).

The Need for Prescribed Fire

The fire deficit that has accrued in the upper Midwest has resulted in fuel accumulation, increased wildfire risk, unprecedented socioeconomic impacts, and increases in canopy density in natural red pine stands across the Great Lakes Region (Meunier et al. 2019, Razenkova et al. 2025, Parks et al. 2025). The absence of fire as an ecological process on the landscape has led to natural pine stands in the Newberry FMU generally characterized by a lack of advanced red pine regeneration, a thick needle/duff layer that hinders red pine establishment, and dense understories dominated by white pine, red maple, paper birch, white spruce, and balsam fir, particularly in more mesic areas. The regular application of prescribed fire is critical to promote natural regeneration of red pine, reduce mesophytic competitors, consume ladder fuel, and ensure that natural red pine systems remain resilient to wildfire. 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 (Larson et al. 2021).



We have proposed a Project Area along the Shelldrake River where the river could serve as a burn break and the fires could be allowed to naturally extinguish in the adjacent wetlands. Photo by J.M. Lincoln.

The natural red pine Project Areas are generally fire-suppressed with dense understories with mesophytes and therefore increasingly susceptible to severe wildfire risk. Large red pine boles are strongly resistant to mortality from low-severity surface fires, even with high fuel loads (Scherer et al. 2016) and planning initial fires to be low-severity/low-intensity will reduce mortality risk associated with wildfires in areas with a high density of understory trees such as spruce, white pine, and balsam fir. The application of repeated, low-severity/low-intensity surface fire in natural red pine stands can promote natural regeneration and increase resilience to wildfire (Scherer et al. 2016, 2018). However, managing expectations for the first burn entry is important. In areas that have had fire excluded for decades, the forest can exhibit low canopy base heights (height of lowest living branches), increased litter and coarse woody fuels, dense understories, and a heavy moss component. 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, initially applying low-severity fires lessens the risk of damage to the roots, particularly in areas where needle duff has accumulated from a prolonged absence of fire (Zeleznika and Dickmann 2004).



Dense red pine regeneration following the Duck Lake Fire. Red pine saplings can survive low-severity fires after they are 5 years old if the fire is applied prior to elongation of terminal buds, or prior to the growing season. Photo by J.M. Lincoln.



A low-severity/low-intensity prescribed fire being applied in a pine barrens. Photo by Steve Woods, Michigan DNR.

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.

Prescribed fire seasonality is an important consideration in achieving the intended low-severity/low-intensity fires to accomplish targeted ecological objectives. Historically, fires regularly occurred during the dormant season (late fall to early spring) based on fire scar positions relative to growth rings (Muzika et al. 2015, Sutheimer et al. 2021). Typically, conducting a first entry of fire during the dormant season consumes litter but not much of the duff layer. This allows for a nutrient flush in the soil without impacting the roots of the trees and may stimulate root growth or condition roots to better tolerate future fires (Mallik and Roberts 1994, Zeleznik and Dickmann 2004). Therefore, we stress the importance of repeated low-severity prescribed burns over single moderate-to high-severity burns to achieve fire effects. We recommend that initial applications of fire be low-severity/low-intensity with the initial two fires applied at each Project Area in relatively rapid succession (3 to 7 years apart).

Forecasting for red pine cone bumper crops and coordinating the second burn with increased cone production is fundamental for ensuring adequate regeneration. Red pine has a two-year cone cycle and cone crop forecasting can be done annually by monitoring to estimate when adequate crops will be present and allow sufficient lead time to plan burns. Red pine bumper crops occur every 5 to 10 years and cone crops often vary from one stand area to the next. Red pine cones typically mature in September with seed fall from mid-September through early October (Keith Konen, Silviculturist, United States Forest Service, personal communication).

We recommend conducting the second burn just prior to seed fall to reduce competition from deciduous species and avoid fire consuming freshly fallen cones. Foresters with the Menominee Tribal Enterprises have had success promoting red pine recruitment in natural pine stands by burning in July during a high cone production year (Ron Waukau, Forest Manager Menominee Tribal Enterprises, personal communication). If there is inadequate regeneration after two burns, we recommend



This natural red pine forest in the Huron Shores District of the Huron-Manistee National Forest was burned in 2018. As a result of the low-intensity fire, there is patchy but consistent natural regeneration throughout the forest, no observed canopy mortality, no seedlings affected by disease, and minimal bole char as of 2025. Photo by B.J Stearns, USFS.

continuing to synchronize burns with years of red pine bumper crops. There has been over a century of mesophication in most natural red pine forests, it will take patience and diligence to reverse it.

Fire and harvest are both stressors on the forest and events like drought and disease should be evaluated prior to burning or harvest activities to avoid compounding stress events. Following the second burn in a Project Area, we recommend delaying mechanical treatment by a season or two to help reduce tree mortality. After the initial timber harvest, we suggest applying fire within 3 to 5 years to reduce impacts of red pine cone beetles, decrease risks from disease, and promote red pine regeneration. Following the third fire, managers can apply fire at an interval of every 10 to 30 years, between subsequent timber harvests. Ideally, managers would vary the seasonality and adjust the severity/intensity to control understory mesophytes, continue to promote red pine regeneration, and avoid killing red pine seedlings, which can withstand low severity fires at five to eight years old. A proposed treatment schedule is provided (Table 3).

Within Michigan's State Forest lands, fire is rarely applied in the context of ecological silviculture and there is evidence that it is an effective means of reducing numerous pathogens and pests. Repeated burning has been shown to successfully decrease populations of multiple species of bark beetles (*Coleoptera* and *Scolytidae* species) and wood-borers (McCullough et al. 1998). Surface fires may also reduce multiple species of shoot blight (Koch et al. 2009, Palik et al. 2021). For example, a site in the Upper Peninsula exhibited significantly lower spore counts of *Sirococcus conigenus* in burned treatment areas than in harvest only and control plots (Koch et al. 2009). The accumulation of pine needles without fire creates an environment conducive to many tree diseases. Incidents of shoot blight on the landscape may be higher in general due to the removal of surface fires from the landscape and reintroduction of periodic burns could potentially decrease outbreaks of these species (Palik et al. 2021). A combination of less needle duff and more open conditions through frequent fire could reduce the incidence of contagion. If shoot blight spores are truly carried from stand-to-stand by cone insects as postulated by some foresters (Albers 2024), then prescribed fires may both directly and indirectly lessen shoot blight occurrences via spore count reduction and cone beetle mortality. In addition, reduction of needle duff and increased air flow created by low-intensity burning may reduce suitable substrate for pests and pathogens.

The suggested approach for the repeated application of prescribed fire is not the only approach that would work. We recognize that in some sites (e.g., dry-mesic sites or sites with high soil moisture capacity and high nutrient availability), mechanical treatment to reduce understory fuel loads may be necessary before the implementation of burning. We also recognize the need to apply prescriptions that are catered to the unique conditions of each site. A generic or formulaic approach is discouraged, and each site should be evaluated for its distinct attributes. We have provided an approach based on our ecological expertise and experience along with the expertise and experience of other professionals across the Great Lakes and extensive support in literature. We provide this framework to trained foresters to develop site-specific treatments for each Project Area. Further details and justification are available in two technical reports on natural red pine management that MNFI produced for the DNR (Schilke et al. 2024, Lincoln et al. 2025).

This approach is intended to allow the harvest of red pine for timber markets to continue in the central Upper Peninsula, where the prospect of fire in natural red pine receives substantial pushback from the timber industry. Char on the boles of trees can be undesirable in stands marked for timber sale. The suggested fire prescriptions aim to mitigate charring with the application of low-severity/low-intensity fires. In particular, the low flame lengths should greatly reduce char. Conducting the first entry during the dormant season and within 5 days of the last rain can help minimize the char on red pine boles and prevent the occurrence of fire climbing the boles of the trees. Even with high relative humidity, waiting longer than 7 days after rain can lead to increased bole char and greater risk of crown fires. These prescriptions are intended to limit char to the lower section of the trunk, and the flaky nature of red pine bark typically removes traces of char within 10 to 12 years for low-intensity fires.

We urge land managers to consider the application of fire to be a critical aspect of the proposed management approach. By combining prescribed fire with the ICO approach, we believe the approach we outline in this report will provide natural red pine regeneration and an improved resilience to climate change, wildfires, and disease for a more stable, biodiverse, and productive landscape. Increased forest structural complexity has been linked to greater resilience to catastrophic wildfire (Koontz et al. 2020) and to increased ecosystem productivity, carbon sequestration, and biodiversity (Gough et al. 2019).

Table 3. Example of a proposed treatment schedule.

Process	Year of Application	Goals	Burn Conditions
First Entry Burn	1	• Condition rhizosphere for future fires • Partial consumption of duff/leaf litter • No mortality of canopy pine • Consume lower ladder fuels • Set back understory mesophytes • Minimal char on boles	• Late dormant season, before terminal buds swell (often around mid-April) • Low flame lengths (below 12") over 60 to 80% of the site • Relative humidity over 30% • Wind speed below 15 mph • Within 5 days of last rain
Monitor		• Identify/treat invasive species • Evaluate understory response from first fire • Conduct red pine cone crop forecasting to time next burn • Determine intensity of next burn	
Second Entry Burn	3 to 7	• Burn just prior to seed release of bumper crop year • No mortality of canopy pine • Expose soils for red pine regeneration • Consume lower ladder fuels • Set back understory mesophytes • Canopy base height improvement	• Attempt burn just prior to red pine seed release (mid-Sept to early Oct) • Low flame lengths (below 12") over 60 to 80% of the site • Slightly increased intensity
Monitor		• Identify/treat invasive species • Evaluate understory response • Evaluate red pine regeneration • Develop timber harvest treatment boundaries (ICO) • Determine harvest levels	
First Harvest	5 to 15	• Skips - no harvest, avoid equipment • Individuals - remove 1/3 of BA • Clumps - no harvest this round • Openings - remove all canopy trees, avoid red pine regen	• Provision in timber sale that slash must be pulled several feet from base of leave trees to minimize risk of damage from slash/tops during subsequent fires
Monitor		• Identify/treat invasive species • Evaluate red pine regeneration • Conduct red pine cone crop forecasting to time next burn • Plan next burn based on regeneration and health of trees	
Third Entry Burn	8 to 10 years after previous burn	• Consume woody debris from harvest to limit bark beetle • Minimal mortality of pine regeneration and canopy trees • Continue to promote red pine regeneration • Continue to set back understory mesophytes • Limit disease risk to red pine seedlings	• Spring or late summer burn • Low to moderate intensity • Flame lengths under 2 ft
Monitor		• Evaluate invasive species • Evaluate understory response • Evaluate red pine regeneration • Determine need for additional fire before next thinning • Develop next treatment layout (clumps/openings) • Determine harvest level of next thinning, reduce BA by 1/3	
Second Harvest	20 to 40 years post thinning	• Skips - no harvest, avoid equipment • Individuals - thin by 1/3 BA • Clumps - identify which clumps will be removed and where new clumps will be established • Openings - establish new openings including some clumps saved in previous thinning; remove all canopy trees, avoid red pine saplings/seedlings	

Forestry Treatments

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 realize these benefits in a forest that incorporates timber harvest, we suggest implementing recommendations adapted from the ICO approach (Churchill et al. 2013, Churchill et al. 2016, Razenkova et al. 2025, Lincoln et al. 2025). For each Project Area, there are four distinct management zones: **Individuals**, **Clumps**, **Openings**, and **Skips** - all to be included with prescribed fire. The Project Areas we identified for the ICO approach often include several stands and cover types, with most of the area comprised of mature natural red pine or mixed pine forests. An example of a Project Area and proposed treatment areas is provided below (Figures 11 and 12).

While the placement of **Skips** is static to protect important features, the locations of **Individuals**, **Clumps**, and **Openings** were intended to serve as a guide for managers and can be adjusted within each area. **Skips** (or reserves) are zones that are intended never to be harvested and are generally placed along the margin with wetlands, steep slopes, pockets of older trees and/or concentrations of fire-scarred trees, and areas of high-quality forest. Additional **Skips** can be placed for wildlife retention areas, such as goshawk nests, to retain snags and patches of dead wood, and protect vernal pools. **Skips** can also be placed in areas of heightened herbaceous diversity that are often damaged with traditional forestry techniques. **Skips** are intended to be embedded throughout the Project Area to retain zones of low shrubs and herbaceous composition characteristic of natural red pine forests. By evenly placing **Skips**, there will be continual supplies of seed from the oldest trees throughout the Project Areas. These zones will be where the advanced age classes are allowed to develop and perpetuate.

The **Individuals** management zone comprises most of each Project Area and is essentially the matrix

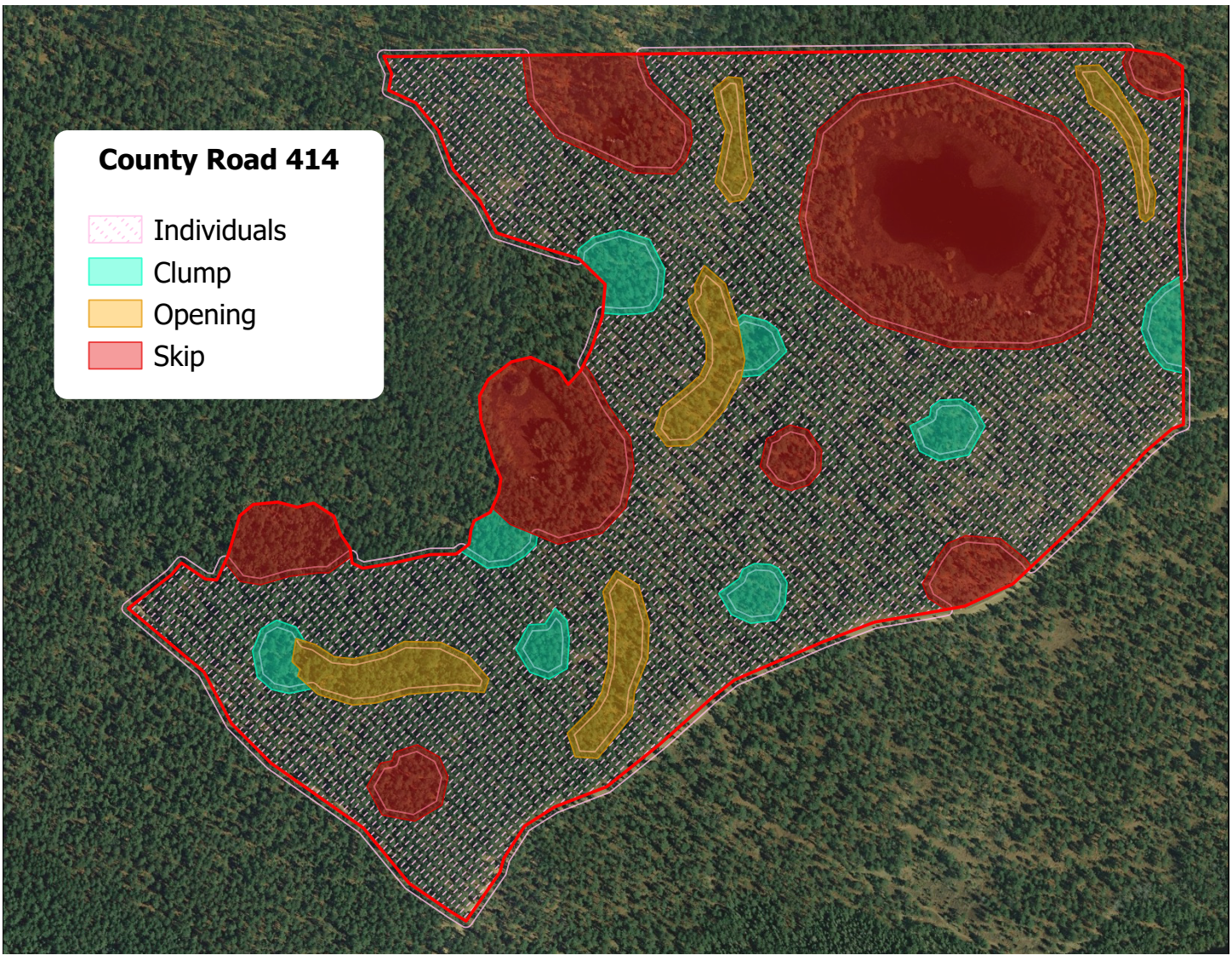


Figure 11. ICO Management zones for County Road 414 Project Area (Compartment 42031).

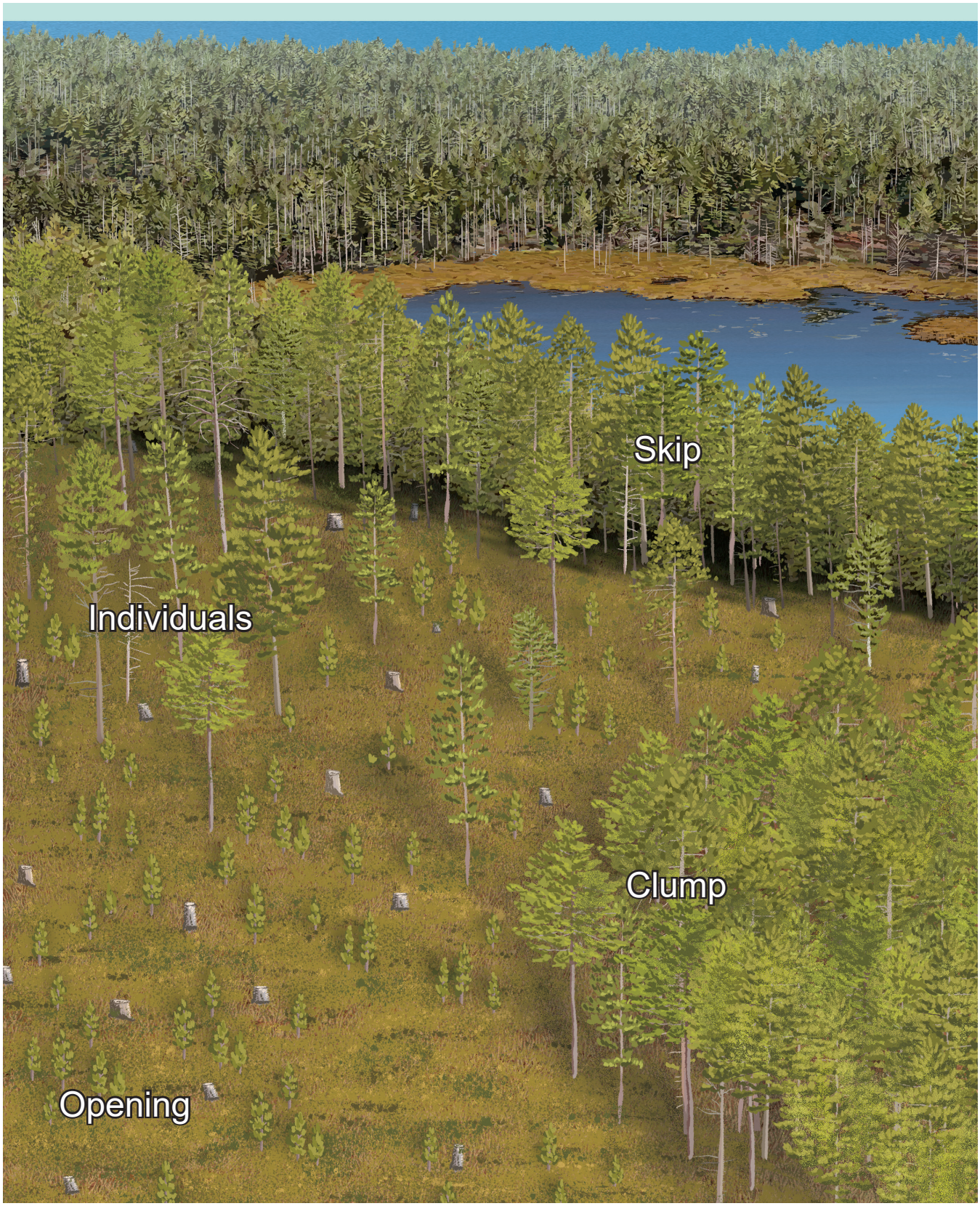


Figure 12. Diagram of a forest treated with the ICO approach. We recommend application of prescribed fire and uneven-aged silviculture following the Individuals, Clumps, and Openings (ICO) method. With this approach, much of a site will be thinned by 1/3 BA (Individuals), clumps of unharvested trees will be retained (Clumps), small areas will be harvested where the entire canopy is removed (Openings), and zones that will never be harvested will be designated where old-growth conditions are allowed to perpetuate (Skips). Wetlands and riparian areas should be protected by permanent buffers (Skips) ranging from 100 to 300 ft depending on slope. Illustration by Querkus Creative.

for the Project Area that will be thinned at the first harvest. Because each Project Area starts from a different condition, there is no rule for how much to thin during the first treatment. Ideally, there will be a range of tree densities following the treatment, but generally it will be thinned to 50 to 100 square feet basal area (BA) per acre with about a third of existing trees being removed. The goal of this approach is to periodically harvest much of the site through thinning, so it is important to leave enough trees for the next treatment to remain economically viable within 20 to 30 years.

Clumps are similar to **Skips** and function to retain various age classes and herbaceous composition across the site. Unlike **Skips**, **Clumps** are not intended to be permanently omitted from timber harvest, and some of the **Clumps** will be harvested in subsequent timber harvests. **Clumps** generally make up about 10% of a Project Area and are more variable in size than **Skips**, generally ranging from 0.25 to 1.5 acres (0.1 to 0.6 hectares), but flexibility in determining size is encouraged. It is difficult to predict each Project Area's response to the management approach, and retention of **Clumps** will provide options for future harvests. The evenly spaced distribution of **Skips** and **Clumps** is intended to assure natural regeneration of red pine and retention of culturally relevant shrubs and characteristic herbaceous species. The **Clumps** and **Skips** should therefore be distributed across project areas and not concentrated in one large retention area or along edges.

Because red pine regeneration responds positively to open conditions, we have included **Openings** where all canopy trees will be harvested. **Openings** comprise roughly 5 to 10% of a site and mimic various disturbances, including windthrow and severe fire. We provide the potential location of **Openings** for the initial harvest treatment, but these are suggestions and can be altered based on each site's response to fire, particularly red pine regeneration. The ICO implementation guidelines (Churchill et al. 2016) suggest small (<0.5 acre) and large (>0.5 acre) **Openings** and that these should be "sinuous and amorphous in shape" rather than circular gaps. This flexibility allows for the creation of openings where there are concentrations of natural regeneration. In stands at risk of infection by shoot blight, large **Openings** of over 0.75 acres have been shown to act as a natural barrier to spore spread (MN DNR 2025). We generally placed **Openings** in areas of flat topography away from wetlands and in areas with fewer old trees. We also provided 5-acre targets for implementing each **Opening** treatment with the intention that managers would operate within those areas to develop appropriate sizes and shapes based on the unpredictable distribution of natural red pine regeneration expected after the initial application of fire. In subsequent harvest treatments, we expect new **Openings** to 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**.

It is essential to implement the 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. 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 these Project Areas are typically large and contain multiple stands of varying age classes, it is difficult to prescribe specific targets regarding basal area 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 judgment of professionals familiar with each site and a commitment to adaptive management. Likewise, 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 and sometimes 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.

Future Work

Red pine is one of the most valuable timber resources in the state and if implemented, the approach we have outlined would be a dramatic shift in the management of natural red pine forests on Michigan DNR lands. Currently 14.9% of the uplands within Newberry FMU are managed with plantation forestry and ecological silviculture is not being applied to any fire-dependent forests. Although the approach proposed in this report is complex and untried within the Michigan State Forest system, many of these techniques have been implemented both within and outside of Michigan, and we believe the benefits outweigh the drawbacks. Implementation of these techniques offers a unique opportunity to gauge success and inform future application. We emphasize the need for sound inventory data and for monitoring throughout the management cycle to facilitate adaptive management. The objective is to learn from the trials to continue improving future management. To help facilitate this work, it may be possible to direct resources from cultivation projects towards funding prescribed fires in the Project Areas identified in this report the suggested approach is designed to promote regeneration.

Fire Needs and the Fire Deficit

A pervasive fire deficit persists across North American forests. As a result of increased fuel loading, contemporary wildfires are characterized by unprecedented severity and extent. Historic records of fires noted by the GLO surveys in the Newberry region from 1840 to 1850, documented 35 fire events that averaged 555 acres in size (Comer et al. 1995). In comparison, two wildfires in the region in the past two decades each impacted over 20,000 acres. By causing widespread tree mortality and recruitment failure at a landscape scale, contemporary wildfires can cause ecological transformation or vegetation type conversion and act as a destabilizing feedback (Parks et al. 2025). Implementation of fire stewardship or prescribed fire in the face of this fire deficit can function as stabilizing feedback with low-severity fire consuming live and dead fuels and reducing the risk of high-severity fire and reducing the extent of wildfires when they occur.

The prescribed fire needs assessment model can be used to roughly gauge fire deficit in Michigan at multiple scales. We can look at model outputs regionally and across the state to assess how much fire is needed on a yearly basis to burn areas classified as fire-dependent systems. We can determine target acreage to burn in the highest, very high, and high classes per year by evaluating the corresponding area for each class by its corresponding fire frequency range. For example, if there are 100,000 acres of a fire-dependent ecosystem that has a fire-return interval ranging between 10 and 20 years, then we can set our prescribed burn target for the extent of this ecosystem at 5,000 to 10,000 hectares per year. Using this same logic, we project that at a minimum 55,225 to 214,359 acres should be burned every year in Michigan to adequately burn the areas of highest, very high, and high need. Based on the prescribed fire needs assessment model, to adequately burn fire-dependent systems between 772 and 4,485 acres should be burned every year in Newberry FMU and between 6,952 and 37,294 acres should be treated



A forest near the mouth of the Two Hearted River that burned in the Duck Lake wildfire of 2012. In the absence of regular fire, fire-dependent forests develop dense understories and become more susceptible to high-severity wildfire. Photo by J.M. Lincoln.

with prescribed fire across all State Forest lands. Furthermore, as these are generally fire-suppressed ecosystems in fire-suppressed landscapes, this estimated range is conservative and should likely go up significantly since many sites on State Forest lands will need to burn more frequently than suggested by their assigned fire frequency range to overcome fire suppression.

To determine fire deficit, these projected acres per year can be compared to the actual acres burned per year. The following estimations of prescribed fire per year were provided by the Michigan DNR (GraceAnna Cooper and Glenn Palmgrenn, DNR FRD, personal communication). During a five-year period from 2019 to 2023, it is estimated that an average of just over 16,000 acres were burned across Michigan. To satisfy the fire return interval for all areas with highest, very high, and high fire needs, between 3.5 and 13.4 times more acres need to burn across Michigan. During a seven-year period from 2019 to 2025, it is estimated that an average of just under 6,000 acres were burned across all State lands in Michigan and just under 600 acres of prescribed fire occurred across Michigan's State Forest lands. We project that between 11.9 and 63.9 times more acres should be burned annually to adequately burn the areas of highest, very high, and high need on State Forest lands. From 2005 to 2025, 10 prescribed fires occurred within the Newberry FMU accounting for 476 acres. Over this 20-year period, on average, 24 acres were burned per year within the Newberry Forest Management Unit. Our model suggests 32.1 to 186.8 times more acres should be burned per year in the Newberry FMU. A significant fire deficit occurs across Michigan and is strikingly severe on State Forest lands and within the Newberry FMU.

Considering the limited ability to apply prescribed fire across the State Forest system, we suggest concentrating on the application of fire in documented natural communities and Project Areas identified in this report. There have been 30 fire-dependent natural communities documented in Newberry, averaging around 130 acres per site. To apply prescribed fire in these natural communities at the recommended frequency of every 10 to 30 years, roughly 200 to 400 acres of fire would need to be applied annually. Additionally, we identified 22 Project Areas with an average size of around 230 acres. To treat 1 natural community and 1/5th of the Project Areas for the next 5 years, approximately 1,000 acres of prescribed fire are needed annually. Assuming two prescribed fires are applied to each Project Areas in the first 10 years, the frequency of prescribed fires would be roughly half to one third of that rate after 10 years. Therefore, we are recommending, at a minimum, between 500 and 1,500 acres of prescribed fire are applied annually in the Newberry FMU for the foreseeable future with a priority of application in the highest quality natural communities and Project Areas.



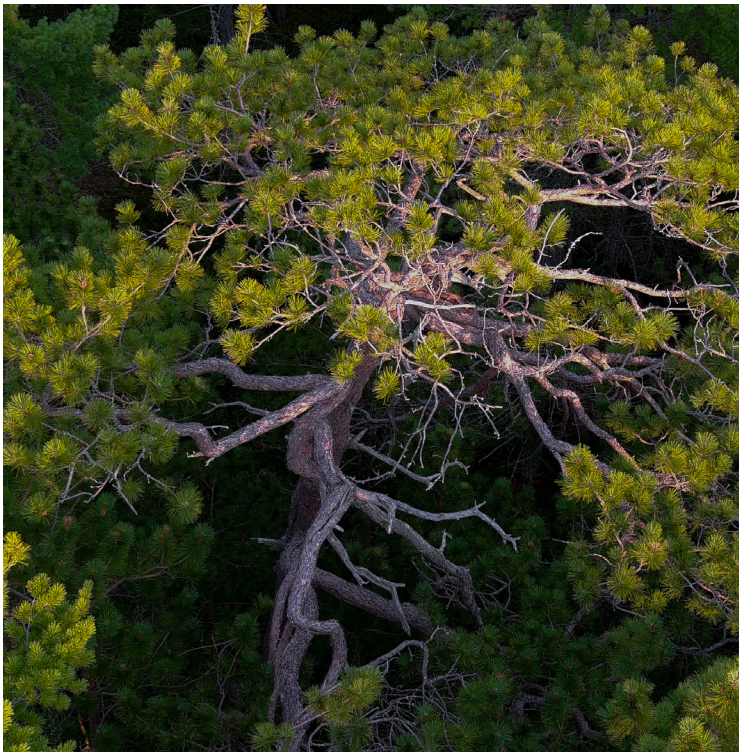
We suggest concentrating on the application of fire in documented natural communities and Project Areas identified in this report. In several cases, this involves including surrounding peatlands in the prescribed fires. Through the Ishkode Project, the Sault Tribe is currently collaborating with the Hiawatha National Forest to conduct fire stewardship in upland pine forests and adjacent peatlands. Photo by M.A. Anderson.

Inventory Process

Sound forest management requires a robust baseline of ecological data to inform decisions at multiple scales. Detailed and accurate stand inventory is fundamental to sustainable forestry and central to our ability to identify potential fire-dependent recoverable ecosystems. Because MiFI stand classifications are the foundational units used in our modeling, the accuracy of model outputs is directly dependent on the quality of these inputs. The SFI 2022 Forest Management Standard underscores this need, requiring pre-harvest surveys by trained resource professionals to identify tree and plant species, stand-level wildlife habitat elements, and other ecological attributes (Indicator 1.1.1; Sustainable Forestry Initiative 2022: p 5).

Field surveys conducted for this project revealed limitations of the current MiFI inventory process. Many stands typed as pine plantation were naturally regenerated or mixed natural–planted stands that qualify as Semi-Natural Planted Forests under SFI definitions. Numerous sites replanted in the 1920s had recovered a natural appearance, yet are still managed as plantations, often through trenching, spraying, and clearcutting that eliminate ground-layer diversity and degrade site quality. Because plantation management is perceived as economically efficient, there is an incentive to maintain plantation classifications. However, the SFI 2022 Forest Management Standard prohibits the conversion of natural and semi-natural stands into plantations. We also observed widespread misclassification of stand age structure. Many stands typed as even-aged natural pine were uneven-aged and contained a small percentage (<5%) of legacy red pine older than 150 years. These trees have distinctive morphological characteristics, including concave bark plates with deep fissures, large lateral branches, asymmetrical crowns, fire scars, cavities, and bear scratches. The presence of these legacy individuals is ecologically, genetically, and culturally significant, particularly given the near absence of natural red pine regeneration and the rarity of old red pine across the landscape. Their omission from inventory data, either through misclassification or the transfer of age estimates from prior records, results in stand prescriptions that fail to protect critical structural elements. The absence of older red pine on the landscape and the dearth of natural red pine regeneration necessitate protecting any remaining old trees from harvest to restore demographics that are closer to the range of natural variation and retain genetically, ecologically, and culturally significant legacy trees. Legacy trees should be explicitly documented during inventory, either in survey notes or as a separate age category.

Fire-scarred red pine stumps, snags, and living trees also provide essential site-specific information on historical fire regimes, including Indigenous fire stewardship. These natural features should be treated as cultural and ecological artifacts. Their destruction during harvesting or prescribed fire erases irreplaceable records of timing, frequency, and severity of past fire events. These trees, stumps,





Old red pines are characterized by irregular canopies, large-diameter lateral branching, canopy deadwood, cavities, and large bark plates. While large bole diameters are often indicative of older tree, old-growth red pine can be surprisingly small relative to expectations. Photos by J.M. Lincoln.

and snags hold the stories of past cultural burning practices that can help inform current management approaches. Areas with dense concentrations of fire-scarred material and culturally significant features identified by Tribal partners or dendrochronological researchers should be deferred from treatment until fire histories can be reconstructed.

Current timing of MiFI inventory further constrain data quality. State forest inventory is typically conducted by DNR foresters during winter, when only canopy and understory trees are identifiable. Winter surveys systematically underrepresent understory shrubs, herbaceous species, and culturally relevant plants, and they do not reliably detect invasive species. Given projected increases in invasive species under climate change and land fragmentation, winter-based surveys will not provide sufficient early detection capacity. Winter conditions also hinder tree coring, increasing reliance on outdated age records.

To address these limitations, we recommend transitioning to growing-season inventories conducted by surveyors with ecological and botanical expertise. These specialists could be either DNR staff dedicated to inventory or third-party professionals. This approach has been successfully implemented on Parks and Recreation Division and Wildlife Division lands and would enable more accurate identification of natural community types, legacy trees, understory composition, culturally significant plants, and early invasive species infestations. Independent, growing-season surveys would also strengthen SFI certification compliance by ensuring that pre-harvest assessments meet the intent of Indicator 1.1.1 (Sustainable Forestry Initiative 2022: p 5), improve stand-level decision-making, and reduce the risk of misclassification that can lead to inappropriate management practices.

Monitoring

Monitoring the impacts of prescribed fire treatments and wildfire is essential for developing adaptive management approaches and maximizing the ecological benefits and efficiency of fire management. Pine stands impacted by the Duck Lake Fire and Sleeper Lake Fire should be quantitatively monitored to see how these areas respond over time to the wildfire. These pine ridges can be used as a learning landscape to help discern how to best use fire to promote natural regeneration of pine within natural pine stands. Post-burn monitoring following wildfire and prescribed fire of plants and animals, particularly rare species, will be valuable to refine ideal burn size, intensity, timing, and frequency. Additionally, it is important to evaluate the fire weather parameters and metrics and how they affect ecological outcomes. Records should be kept of the drought code, days since rain, temperature, relative humidity, flame lengths, and fire behaviors for each unit.



Dense red pine regeneration is locally common within the Swamp Lakes dry northern forest, especially along the margins of the dune ridges and the peatlands. This forest and the surrounding peatlands burned in the Sleeper Lake fire of 2007. Pine ridges impacted by the Duck Lake and Sleeper Lake wildfires should be quantitatively monitored to help discern how to best use fire to promote natural pine regeneration. Photo by J.G. Cohen.

Frequency and timing of fire is particularly important for red pine regeneration as it must coincide with large red pine seed crops that occur only every 5 to 10 years (Horton and Bedell 1960, Kozlowski and Ahlgren 1974). The natural regeneration of red pine is a critical component of our proposed approach and forecasting of cone crops should be carefully monitored and used to inform the timing and intensity of burns. Red pine has a two-year cone cycle and cone crops can be monitored to estimate when adequate crops will be present. Managers should revisit sites at least once a year and monitor cone development with binoculars and assess any canopy mortality.

Consistently monitoring Project Areas will be critical for developing the most effective approach for each site. Natural red pine regeneration can be patchy and stocking surveys will be critical to ascertain how much regeneration there is, where it is, and if it is enough. Stocking surveys will help inform the timing and specific arrangement of ICO treatments. Stands should also be evaluated for shoot blight presence before treatments and response after harvests and prescribed fire. Following the initial fires, ICO treatment zones should be established to capitalize on areas of natural regeneration. The timing and intensity of the second burn can be adjusted based on pine regeneration, mesophyte response in the understory, and health of the residual trees. Monitoring should also incorporate consistently surveying for invasive species and treating problematic populations. As fire begins to be more commonly implemented across State Forests, we recommend the managers develop a spatial database where the application of fire across State Forest lands is tracked and consistently evaluated. Spatialized data of areas treated with prescribed fire should be documented and saved in a central database linked to stands.

The Michigan DNR lists 31 animals that are dependent on red pine and associated natural communities (Bielecki et al. 2004) and several rare animals in Michigan use pine forests as habitat, including American goshawk (*Accipiter gentilis*, State Threatened and Focal Species within the State Wildlife Action Plan), northern flying squirrel (*Glaucomys sabrinus*, Special Concern), Connecticut warbler (*Oporornis agilis*, Special Concern), smooth green snake (*Opheodrys vernalis*, Special Concern and Focal Species within the State Wildlife Action Plan) (Derosier et al. 2015), northern blue (*Plebejus idas nabokovi*, State Threatened and Focal Species within the State Wildlife Action Plan), black-backed woodpecker (*Picoides arcticus*, Special Concern), eastern whip-poor-will (*Antrostomus vociferus*, State Threatened), evening grosbeak (*Coccothraustes vespertinus*, State Threatened), and spruce grouse (*Canachites canadensis*, State Threatened). Continual monitoring of these species should be implemented where these management techniques are employed.



Populations of Kirtland's warbler have been documented from Danaher Plains and the application of fire outlined in this report would benefit this and other priority conservation species. Photo by A.P. Kortenhoven.

Biodiversity Stewardship of ERAs

The DNR maintains a network of Ecological Reference Areas (ERAs) composed of high-quality and representative natural communities, and the stewardship of these ERAs is part of the criteria for dual sustainable forest certification under SFI and Forest Stewardship Council (FSC). Roughly 3% of the Newberry FMU has been identified as high-quality, fire-adapted natural community. These include some of the largest benchmark examples of the community types in the state. Our recommended stewardship actions for dry and dry-mesic northern forest ERAs are to prevent commercial logging within forested ERAs; prioritize the application of low-severity prescribed fire in the highest quality fire-adapted forests; monitor the floristic and vegetative response of those ERAs that have burned in wildfires and will be burned with prescribed fire; reduce fragmentation by limiting trails and recreational development; and provide 150-foot-wide (45.7 meter-wide) buffers between ERAs and intensive forestry operations (i.e., clearcuts and herbicide application).

Protecting Priority Conservation Assets

The Newberry FMU is characterized by large, relatively intact landscapes with low road densities, few private inholdings, large wetland complexes, concentrations of fire-dependent natural communities, and extensive undeveloped shoreline along Lake Superior. In our field assessments, we identified significant tracts of land that do not meet the criteria for ERAs but maintain significant conservation features that are worthy of providing protection to support landscape level conservation opportunities. Sites designated as Special Conservation Areas (SCAs) within Michigan's State Forest have a broad range of conservation elements and management restrictions vary on the designation. The systematic documentation of potential SCAs was not an objective of this project but we recommend a future collaborative effort to identify additional SCAs within the Newberry FMU. We did not conduct a systematic overview of potential SCAs and a more thorough process is needed. Below we provide several examples of potential SCAs and additional





Left, a stump recovered from Ghost on the Shore dry northern forest had scars from at least 4 fires, with 7, 41, and 33 years between the fires. Fire was part of the highest quality, pine-dominated forests in the Newberry region and in the absence of regular, low-intensity fire, the forests are becoming denser and red pine fails to regenerate. Prioritizing the application of prescribed fire in ERAs is one of our top recommendations. Photos by J.M. Lincoln.

conservation designations for consideration based on our modeling and survey efforts. Other areas that merit this same type of designation occur throughout the Newberry FMU with additional examples including Beavertown Lakes, Barfield Lakes, and Pretty Lakes.

To protect sensitive and biodiverse areas observed during our surveys from degradation, we suggest establishing or expanding 4 SCAs across the Newberry FMU to ensure their protection. We suggest 1) recognizing the wooded dune and swale complex from Vermillion Point to Whitefish Point as a Coastal Environmental Area; 2) expanding the non-dedicated natural area around McMahon Lake Preserve to include more of the vast wetland complex around the East Branch of the Two Hearted River and working towards an official Natural Area Designation; 3) expanding the existing SCA around the Blind Sucker Flooding, and; 4) establishing an SCA Environmental Shorelands Protection (MDNR 2024, p 269) designation that covers all areas within ½ mile of the Lake Superior Shoreline.

“In terms of anything related to bird migration, Whitefish Point is the most significant site in Michigan and maybe the Great Lakes” (Steve Roels, American Bird Conservancy, personal communication). Whitefish Point and Vermillion Point have been designated as Important Bird Areas by the National Audubon Society. Since the early 1900s, Whitefish Point has been recognized as a continentally important area for bird observation and monitoring. The area acts as a funnel for migratory species due to its location within the Great Lakes flyway and should be afforded protection. Whitefish Point has long been recognized as an important area for migratory birds, starting in 1912 when Norman Wood first cataloged the birds of Whitefish Point as part of the Shiras Expeditions. Michigan Audubon and the Detroit Audubon Society started Whitefish Point Bird Observatory in 1979 to document the migration through Whitefish Point using standardized counts. Twenty-five species of raptors have been recorded at the raptor count. An average of 17,000 raptors migrate through Whitefish Point each year including 8,600 sharp-shinned hawks, 4,500 broad-winged hawks, and 1,600 red-tailed hawks. While most of the passerine information is anecdotal, a standardized count in the spring of 2025 documented 96 species and over 24,000 birds were recorded migrating between March 14 and May 30. This includes over 6,000 blue jays, 3,000 American robins, 2,000 redpolls, 2,700 common grackles, and nearly 1,000 yellow-rumped warblers. Whitefish Point Bird Observatory’s summer owl banding from 2015 through 2024 averaged just over 300 northern saw-whet owl captures annually. Over 80% of those captures were juvenile birds, suggesting that Whitefish Point is a very important post-nesting dispersal area for northern saw-whet owl. Taken together, these surveys show the importance of Whitefish Point as a migratory corridor for many species of birds (Max Henschell, Michigan Audubon, personal communication). Much of Whitefish Point is recognized as an ERA, but there are hundreds of acres near the eastern tip that are currently being managed with intensive forestry techniques. We recommend designating the entire area as a Coastal Environmental Area SCA and prohibiting clearing of mature forests in favor of the application of prescribed fire and ecological silviculture.



Vermilion Point is a critical migratory stopover. Thousands of birds concentrate along this stretch of the Lake Superior shoreline during spring and fall movements. This stretch of shoreline provides essential resting and foraging habitat after long over-water flights. Photo by J.M. Lincoln.

The McMahon Lake Preserve is owned by The Nature Conservancy adjacent to the Newberry FMU and is currently a Non-designated Natural Area. This preserve is part of a vast wetland complex with upland pine ridges that extends onto the Newberry FMU where there are large blocks of high-quality, culturally important wetlands with vast stretches of roadless area and old-growth pine forests on transverse dune ridges. We urge the expansion of the Non-designated Natural Area to include these benchmark natural communities in the Newberry FMU and the pursuit of the elevated status of Designated Natural Area for this complex to offer this area a higher degree of protection.

The Blind Sucker Flooding is currently an SCA for wildlife management based on the flooding. We suggest expanding the boundaries of the existing SCA; establishing buffers along the wetland margins; preventing logging near the top of steep slopes; applying prescribed fire and ecological silviculture techniques outlined in this report within the natural pine forest within the SCA; and prioritizing surveys for high-quality wetlands within the proposed expanded boundaries.

Within the Michigan State Forest system, the Newberry FMU supports some of the most extensive and highest quality forests along the Great Lakes. We recommend establishing an SCA Environmental Shorelands Protection (MDNR 2024, p 269) designation for State Forest land along the Lake Superior shoreline to direct holistic forestry in particularly sensitive areas (Figure 13). The Newberry FMU has 12,491 acres within ½ mile of the Lake Superior Shoreline and 72% (9,102 acres) of that area is composed of upland forest. These forests often have significant concentrations of red pine over 150 years old. In addition, the highest concentration of fire-scarred red pines, stumps, and snags were documented within shoreline compartments suggesting the importance of these areas for Indigenous communities and for future fire history research.

The four example areas we provide here for consideration for SCA designation constitute approximately 50,000 acres or 14% of the 355,822 acres of the Newberry FMU, though 17,500 acres are already protected ERAs. Within these recommended SCAs, we propose applying ecological silviculture



Blind Sucker Flooding contains extensive fire-dependent forest communities embedded within large, contiguous wetland complexes, making it a suitable landscape for ecological silviculture and prescribed fire. The natural wetland matrix functions as an effective fire break, which can allow fire to be reintroduced at the landscape scale while minimizing the risk of escape. Photo by J.M. Lincoln.

that incorporates the ICO approach outlined above. Additional conservative management approaches include larger buffers along wetlands and streams, no canopy reduction below a basal area of 50, elimination of scarification and herbicide application, minimizing road and trail development to limit disturbance to wildlife, prioritization of prescribed burns, and engaging with a management panel of stakeholders to approve stewardship actions. The current approach to natural pine forest management close to the shoreline incorporates even-aged silvicultural techniques that reduce forest health, resilience, and natural regeneration processes.

Simplifying natural pine forests via clearcutting and scarification or converting to plantations via clearcutting, trenching, and planting eliminates natural pine seed sources, accelerates the loss of old trees, and simplifies vegetative composition resulting in decreased value to wildlife and elimination of culturally significant resources utilized by local Indigenous communities. We recommend a conservative management approach for shoreline forests that will help maintain water quality, protect concentrations of native plant diversity, protect culturally significant sites, and allow these forests to better function as corridors for wildlife.

While ecological silvicultural techniques should not be restricted to areas recommended as SCAs within this FMU, these example areas that we identified have especially high conservation value with enormous wetland complexes; concentrations of high-quality natural communities; areas of high plant diversity and low levels of anthropogenic degradation; and/or high cultural value with a well-documented history of Indigenous management stretching back centuries (Loope and Anderton 1998, Anderton 1999). While these designations will reduce the total volume of timber harvest across the unit, we believe the value to biodiversity conservation, water quality protection, and climate resilience will offset those short-term reductions.



The Great Lakes shoreline is a highly dynamic ecological system. Establishing and maintaining a wide, forested buffer along the lakeshore sustains mature forest conditions, protects nearshore water quality and shoreline processes, and preserves landscape-scale connectivity that supports wildlife migration. Photo by J.M. Lincoln.



Following the Duck Lake wildfire of 2012, extensive areas along the Two Hearted River and Lake Superior shoreline were converted to plantation or scarified. Retaining structurally complex, mature forest cover near the lakeshore enhances shoreline stability, protects water quality, and sustains long-term ecological function and landscape connectivity. Photo by J.M. Lincoln.

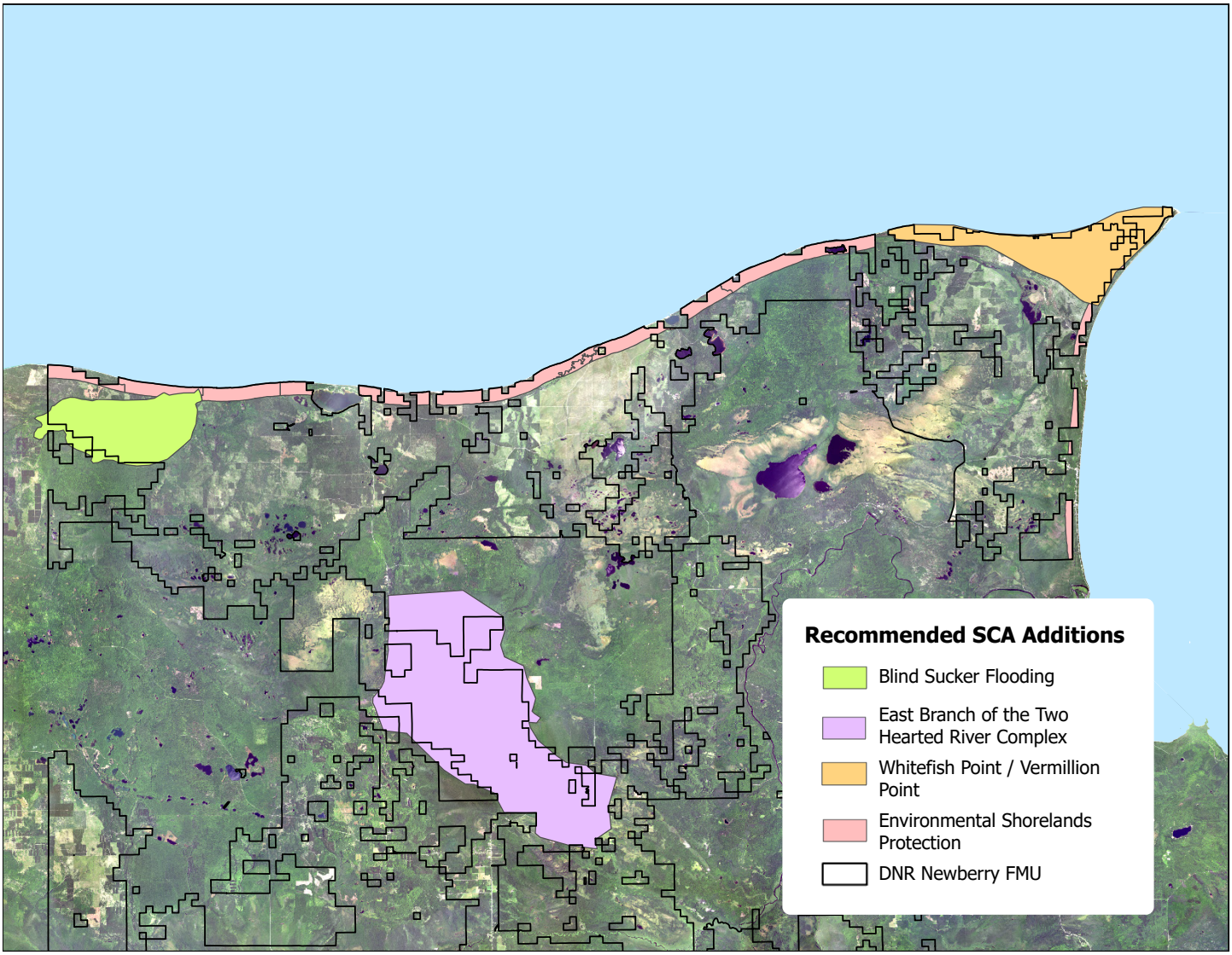


Figure 13. Proposed Special Conservation Areas in the Newberry FMU. We are recommending everything within a 1/2 mile of the Lake Superior Shoreline be designated as Environmental Shorelands Protection SCA.

Working With Conservation Partners

SFI standards require that certified organizations have programs to identify special sites containing natural heritage features and culturally significant sites to manage and protect them in a manner appropriate for their unique features (Objective 6 and 8, Sustainable Forestry Initiative 2022: p 10). As part of managing ERAs and SCAs, we recommend exploring collaborations and management oversight with various groups that are already operating in the region, including Audubon Society, The Nature Conservancy, Michigan Nature Association, Michigan State Parks, US Fish and Wildlife Service, MNFI, Bay Mills Indian Community, and the Sault Ste. Marie Tribe of Chippewa Indians. Ideally these groups would automatically be contacted for participation whenever ERAs and SCAs are evaluated during the compartment review process.

Engaging with local Tribal Government natural resources departments is an important component in ensuring forest management activities do not infringe on cultural activities, significant resources, or special areas. SFI recognizes Indigenous sovereignty and requires its certified organizations to recognize and respect Indigenous Peoples' rights and traditional knowledge, and supports relationship building and shared benefits from sustainably managed forests, especially in cases when management techniques may impact culturally important sites or resources (Objectives 8, Sustainable Forestry Initiative 2022: p 10).

Through the Treaty of 1836, Tribes retained their rights to hunt, fish, gather, and practice cultural stewardship, which includes a wide range of sophisticated land-tending practices. Cultural fire is one of these practices and was historically and continues to be a source of cultural expression and is a sovereign right of Anishinaabe Peoples throughout this region. Revitalization of Indigenous fire stewardship promotes climate resilience and Indigenous lifeways, reduces severe wildfire risk, and fosters biodiversity conservation (Hankins et al. 2025). The Anishinaabe historically used fire in coastal and inland red pine forests for blueberry production. Natural pine forests remain culturally significant sites across the region for community blueberry collection today. Working in collaboration with the Sault Ste. Marie Tribe of Chippewa Indians and the Bay Mills Indian Community, the US Forest Service is engaged in co-management efforts with the Tribal communities that blend shared stewardship goals to prioritize prescribed fire applications in specific locations to benefit culturally important resources.



MNFI ecologist Mary Parr surveying East Branch of the Two Hearted with Lori Gambardella of the Sault Tribe, and Jesse Bowens of the Bay Mills Indian Community. Photo by J.G. Cohen.

In 2019, the Sault Tribe initiated the Ishkode Project in collaboration with the Hiawatha National Forest and the Inter-Tribal Council of Michigan to develop an interagency fuels treatment plan. In 2023, this plan was codified in a Tribal Forest Protection Act agreement that takes a co-stewardship approach, drawing on Anishinaabe and western science to understand the impacts of fire management and evaluate new prescriptions in collaboration with community members. The Ishkode project involves developing plans to enhance fire safety, ecosystem resilience, and biodiversity through revitalizing and protecting ancestral forest relations. We recommend DNR staff to work closely with their DNR Tribal Liaison to facilitate engagement with Tribal natural resource department staff from the Sault Ste Marie Tribe of Chippewa Indians and the Bay Mills Indian Community.

Establishing relationships and frequent communications are important to facilitate co-stewardship efforts in culturally significant areas. We also recommend the collaborative evaluation of potential SCAs that qualify for enrollment as "Cultural and Customary Use Areas". This SCA designation is used by Tribes and/or the public for specific purposes, such as collecting sap for maple syrup, wild fruit, and other plant-gathering areas and habitats. Finally, we also recommend that Tribes be invited to participate in compartment reviews along with meetings related to landscape-scale forest management planning efforts. Through these interactions, it is important to recognize Tribal entities as rightsholders, not stakeholders (Hankins et al. 2025).

CONCLUSIONS

Through support from the Sustainable Forestry Initiative (SFI), Michigan Natural Features Inventory (MNFI) is engaged in a three-year effort to identify recoverable, fire-dependent systems on State Forest land using modeling and targeted field surveys to highlight opportunities for fire restoration. This report summarizes the efforts from the first year of the project focused on the Newberry Forest Management Unit (FMU). The goal of this project is to provide a framework to guide the application of fire on these landscapes to maintain ecological integrity, enhance resilience, and improve habitat for native biodiversity.

Fire-dependent ecosystems, such as natural red pine forests, have historically been shaped by Indigenous fire practices. Without periodic fire, these systems are being invaded by mesophytic species and becoming denser. At a landscape-scale, fire suppression of fire-dependent ecosystems is resulting in reductions in species and habitat diversity and increased risk of wildfire. Maintaining these systems with fire and uneven-aged silvicultural techniques supports SFI certification goals while ensuring forests continue to deliver ecological, economic, and societal benefits.

Applying a prescribed fire needs assessment model, we identified approximately 86,000 acres of the Newberry FMU that support cover types with a high or very high need for fire. The GIS-based multicriteria decision analysis modeling technique that we employed can be used to integrate spatial data, expert knowledge, and stakeholder input to identify fire needs across multiple scales, guide surveys, and inform actionable, site-specific recommendations for informed conservation decisions. While the base units of our model are stands from the Michigan Forest Inventory database and are specific to Michigan and state lands in Michigan, this modeling framework can be utilized to help inform multi-scale, spatially explicit conservation decisions and can be applied in different geographies and by different management agencies.

Through field-based surveys informed by the modeling efforts, aerial imagery interpretation, and engagement with Department of Natural Resources personnel, we identified previously undocumented high-quality natural communities and recoverable fire-dependent systems. Field evaluations led to the documentation of eight new natural communities and the expansion of an existing natural community. We also documented 22 Project Areas where we recommend the application of prescribed fire as part of an ecological silviculture approach for natural pine forests. While the results and management recommendations presented in this report are specific to Michigan, we believe the modeling, surveying, and management frameworks are broadly applicable.

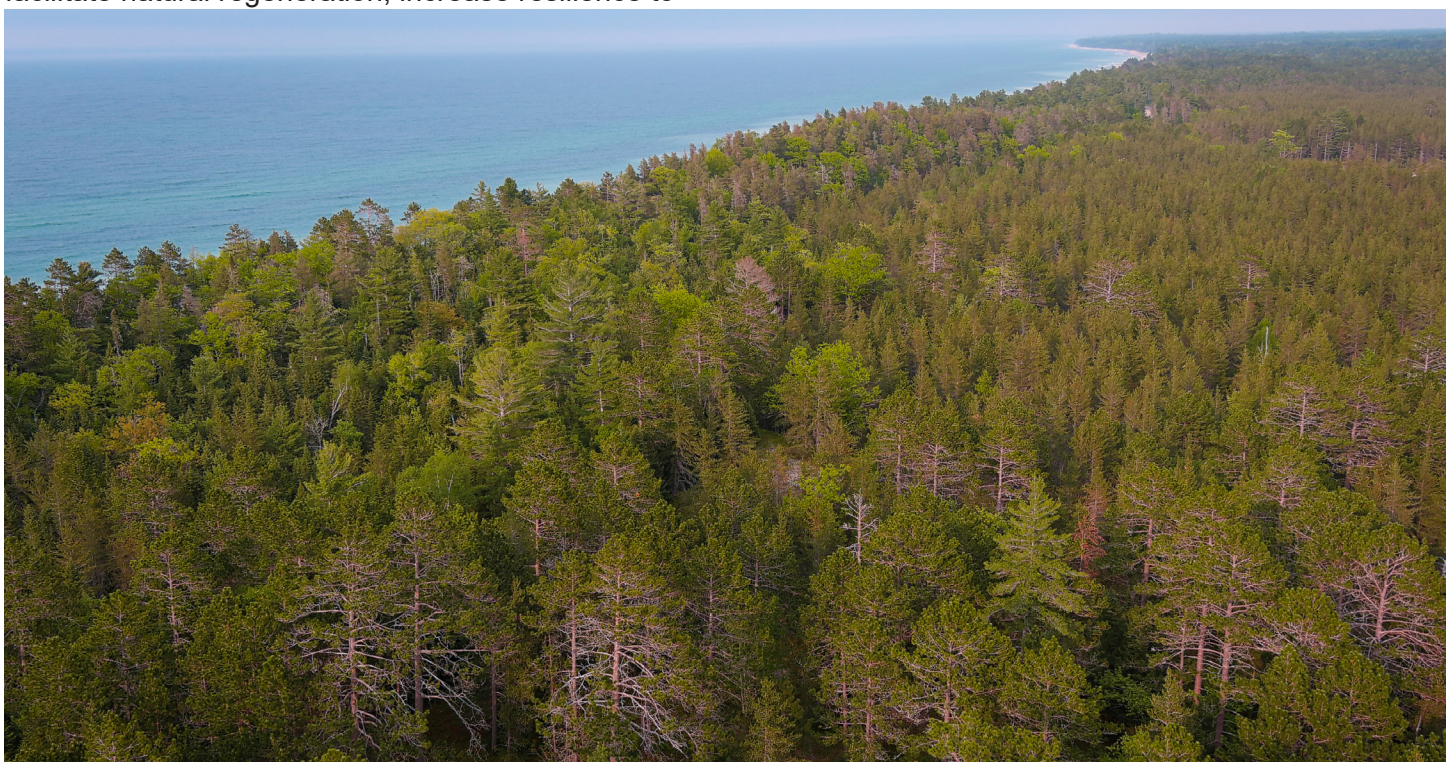


Newberry FMU features some of the largest wetland complexes in the state and several important examples of fire-dependent natural communities. Photo by J.M. Lincoln.

Managers are responsible for producing timber efficiently while protecting biodiversity, supporting climate resilience, and preserving the ecological and cultural character of Michigan's forests. Even-aged management, scarification, and herbicide use simplify forest structure, degrade ground-layer diversity, eliminate culturally significant species, and fail to achieve adequate rates of natural red pine regeneration. We emphasize that desired fire effects in natural pine systems are best achieved through repeated, low-severity prescribed burns, rather than single moderate- to high-severity fire events. We recommend that initial fire applications be low-intensity, with the first two prescribed burns at each Project Area implemented in relatively rapid succession (approximately 3–7 years apart). We recommend implementing an approach that integrates ecological silviculture into natural pine management. The Individuals, Clumps, and Openings (ICO) approach combined with prescribed fire fosters structural complexity of natural red pine systems and emulates historic disturbance patterns to achieve natural regeneration and continued productivity.

We developed 22 potential Project Areas constituting 5,044 acres (1.4% of Newberry FMU) where we recommend natural pine management. The majority of these Project Areas are sites of natural red pine where we recommend the application of fire and implementation of timber management using the ICO approach to enhance forest resilience and ecological benefits along with timber harvest goals. We believe that the ICO approach applied with prescribed fire will facilitate natural regeneration, increase resilience to wildfire and climate-related stressors, mitigate insect and disease outbreaks, and protect native biodiversity. This framework enables sustainable timber harvest while achieving ecological objectives that plantation-style and even-aged management cannot. Consistent application of prescribed fire is central to this approach, and we recommend implementing between 500 and 1,500 acres of prescribed fire annually in the Newberry FMU, focusing on the highest-quality natural communities and Project Areas identified in this report. Because the proposed approach within the Project Areas is designed to promote regeneration, it may be possible to direct resources from cultivation projects towards implementation of prescribed fire in Project Areas.

The sustainable management of natural red pine is a silvicultural challenge across the Great Lakes region. The recommendations in this report are based on universal principles of ecological silviculture and tailored to one of the most economically, ecologically, and culturally significant forest types in the region. This approach can be applied across ownerships throughout the Great Lakes region. By adopting the practices we have outlined, Michigan's State Forests can continue to provide timber, support ecological integrity, and serve as a model for responsible forest management in the Great Lakes region and beyond. With fire-based stewardship, Michigan can restore a more resilient, biodiverse, and culturally relevant forest landscape that honors the past, serves the present, and prepares for the uncertainties of the future.



Red pine is an iconic species that is economically valuable, culturally significant, and ecologically essential. The future of red pine forests in Michigan depends on the decisions we make today. Photo by J.M. Lincoln.

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APPENDIX 1 - MODEL DEVELOPMENT

MNFI has been working in collaboration with the Michigan's Department of Natural Resources (DNR) Wildlife Division to model the need for prescribed fire on state land since 2017 (Cohen et al. 2019, Cohen et al. 2021). The model presented in this report was refined for the Newberry Forest Management Unit. The foundational unit of the model is stand-level data within the Michigan Forest Inventory database (MiFI) that describes canopy and subcanopy species composition, stand age, and other ecological conditions. For each stand, we generated an intersection with numerous spatial data layers including datasets with information on physiographic region, landform, circa-1800 vegetation, slope, aspect, departure from historical fire regime, and occurrences of high-quality natural communities or ecosystems. We used information gleaned from this intersection as well as stand-level data to "crosswalk" or assign a natural community type to as many stands as possible. Anthropogenic systems (e.g., developed, cropland, plantations, roads, ruderal systems, and grassland plantings) were not crosswalked to a natural community type.

MNFI has developed a classification of natural community types in Michigan (Cohen et al. 2015, Cohen et al. 2025). This classification includes a detailed discussion of vegetative composition and structure, soil texture and soil moisture, hydrology, and natural disturbance regime for each natural community. In addition, the classification includes information on fire-dependence, fire return interval, and fire frequency range drawn from literature review and ecological inference. Fire return interval is the time between fire in a designated area and can be used to estimate fire frequency range which is the range of time between fire events irrespective of area.

Variable Selection and Data Preparation
Through literature review, evaluation of available spatial data layers, and discussion with natural resource managers and ecological experts, we identified variables that determine the prescribed fire need for each stand and used this needs assessment to identify potential fire-dependent ecosystems on the landscape. In selecting these variables, we tried to incorporate factors that contribute to the past, current, and future relationship of each stand with fire. Because multiple variables interact at different scales in determining the characteristics of a site's fire regime, we identified critical variables for our model at landscape-, stand-, and species-scales.

Landscape
Landscape-scale variables included physiographic region, surficial geology or landform, historic vegetation, and departure from historic disturbance regime. Physiographic regions are classified by large scale abiotic factors, such as climate and underlying bedrock, which, along with surficial geology, influence the patterning of ecosystems across landscapes. We used Schaetzl et al. (2013) for physiographic regions and Farrand and Bell (1982) for surficial geology. The data layer of surficial geology that we used includes descriptions of the glacial and post-glacial landforms as well as modifiers that convey information about soil texture properties of those landforms. Vegetation circa 1800 has been mapped in Michigan following interpretation of the original land surveyors' notes (Comer et al. 1995). This spatial database of historic land cover provides useful information about how fire-prone and fire-sensitive ecosystems were patterned across Michigan. The historical legacy of ecosystems and species influences current distribution of ecosystems and their need for fire disturbance. To incorporate departure from historic fire regime we used LANDFIRE's Vegetation Condition Class or VCC, which gauges how far removed an area is from its historic fire return interval (LANDFIRE 2008).

Stand
Stand-level variables included fire frequency range, fire dependence, aspect, slope, age, size, and presence of exemplary ecosystems or natural community element occurrences. For each stand crosswalked to a natural community type we determined the scale of fire dependence (i.e., extremely fire dependent, very fire dependent, fire dependent, fire neutral, fire sensitive, very fire sensitive, and extremely fire sensitive), fire frequency (i.e., extremely frequent, very frequent, somewhat frequent, frequent, infrequent, somewhat infrequent, very infrequent, extremely infrequent), and fire frequency range (e.g., 1-5 years, 10-20 years, 200-500 years, and >1000 years). We also assigned a level of certainty for the fire frequency range (i.e., low, medium, and high). Fire frequency ranges were derived from the literature, but in cases where there was no reference for a natural community type, we relied on expert inference and evaluated similar natural community types to assign a fire frequency range. For natural community types with broad fire frequency ranges, such as wetland ecosystems, we modified the fire frequency range depending on the landscape context of the natural community. For example, poor fens occurring in a fire-prone landscape were assigned a higher fire frequency range (e.g., 10-100 years) than poor fens nested in less combustible landscapes (e.g., 100-200 years). In terms of aspect, westerly and southerly aspects are more prone to fire than easterly and northern aspects. We used 30-meter digital elevation model (DEM)

data to incorporate slope and aspect into the model. In terms of slope, flatter areas are more fire prone than areas of rugged topography. The stand database was used to derive the age and size variables. For forested systems, stand age and size-class can be used as predictors of need for fire, since certain forest types such as oak and pine forests depend on fire disturbance to foster regeneration. Within fire-dependent forested systems, there is a greater need for fire in mature systems compared to regenerating ones. For the size-class variable, we assumed there is a greater need for fire in forested stands categorized as “sawtimber” compared to “poletimber” and “seedling/sapling”. Finally, stands that have higher ecological integrity have a higher need for fire from a conservation perspective and were therefore integrated into the model using documented examples of high-quality natural communities from MNFI’s Natural Heritage Database (i.e., natural community element occurrences).

Species

Species-level or within-stand variables included presence of fire-tolerant and fire-dependent species. Our model incorporates plant species occurrence data from the MiFI database and also rare animal and plant species element occurrence data from MNFI’s Natural Heritage Database. Within MiFI there are currently 411 plant species that can be entered via a pull-down menu. We conducted a literature search on the fire tolerance and fire dependence of each species. For each species, we assigned a classification for fire tolerance (i.e., tolerant or sensitive) and for fire dependence (i.e., dependent or not dependent). We then grouped species into five categories: (1) fire-sensitive, desirable natives; (2) fire-tolerant invasives; (3) fire-sensitive invasive or undesirable native species; (4) somewhat fire-sensitive invasive species that may require multiple fires to be controlled; and (5) fire-tolerant and/or fire dependent native species. We ran an intersection of MiFI stands with MNFI’s rare species element occurrences and generated a list of known rare species occurrences that intersect with stands. For each of these species we researched whether or not the species is fire tolerant or fire dependent, and if the habitat the species depends on is fire dependent. We evaluated a total of 461 rare animal and plant species.

Variable Scoring

The input variables included both categorical and numerical data. For example, classes within the surficial geology layer include “end moraines of fine-textured till” and “ice-contact outwash sand and gravel,” and classes attributed to the aspect variable include “south,” “southwest,” and “west.” The variables that have numerical data are attributed with different numbering systems with different ranges. For example, for the slope variable, the data is broken into mean slope classes (e.g., ≥ 0 and ≤ 6; ≥7 and ≤ 9; ≥21 and ≤ 30), and the fire frequency range variable included 14 different classes (e.g., 1-5 years; 5-20 years; 50-100 years; 500-100 years; > 1000 years). To combine the input variables into the same analysis, we reclassified each variable to the same relative evaluation scale to allow for comparison across variables. Scores for most variables were scaled equally within 6 integers and ranged between 0 and 5, in order of increasing ecological need for prescribed fire (i.e., 0 = No Fire Needs or None, 1 = Low, 2 = Moderate, 3 = High, 4 = Very High, 5 = Highest). We developed detailed scoring rules for each input variable. For example, for natural community types with a fire frequency range of 1 to 5 years, we developed the following rule: “IF Fire Frequency Range = 1-5 Years, THEN +5.” Additional examples of rules include: “IF Surficial Geology = Ice-contact outwash sand and gravel, THEN +5”; “IF Aspect = West, THEN +5”; and “IF stand is classified as ‘fire dependent’ and Mean Slope ≥ 0 AND ≤ 6, THEN +5”.

GIS-Based Multicriteria Decision Analysis

To synthesize the data contributed by our multiple input variables into one prescribed fire needs score, we used GIS-based multicriteria decision analysis, which combines spatially referenced data and multi-attribute criteria in a problem-solving environment. This integrated analysis allows users to apply weights to input variables and combine them into a single output. We assigned weights to variables to infer relative importance to prescribed fire needs. Weights were derived following discussions with natural resource managers and fire ecology experts and literature review on the factors that influence fire disturbance regimes and the response of landscapes, ecosystems, and species to fire. We multiplied each reclassified score by the assigned weighting factor. Assigned variable weights include x25 for Fire Frequency Range, x20 for VCC, x20 for Fire Dependence, x15 for Physiographic Region, x10 for Surficial Geology, x10 for Aspect, x10 for Slope, x10 for Size Class, x5 for Circa1800 Vegetation, and x5 for Natural Community Element Occurrence (Figure A1). The remaining variables received a weight of one (x1), which is equivalent to no weight. For each stand, the prescribed fire needs score was calculated by summing the weighted scores for each variable, and then rescaling the final score to a 0 to 5 range. Higher scores convey a higher level of ecological need for prescribed fire. See Figure 5 for a schematic of the model architecture. To visualize the scoring, the scores were assigned colors on a blue to red color gradient with higher scores corresponding to reds and displayed within GIS.

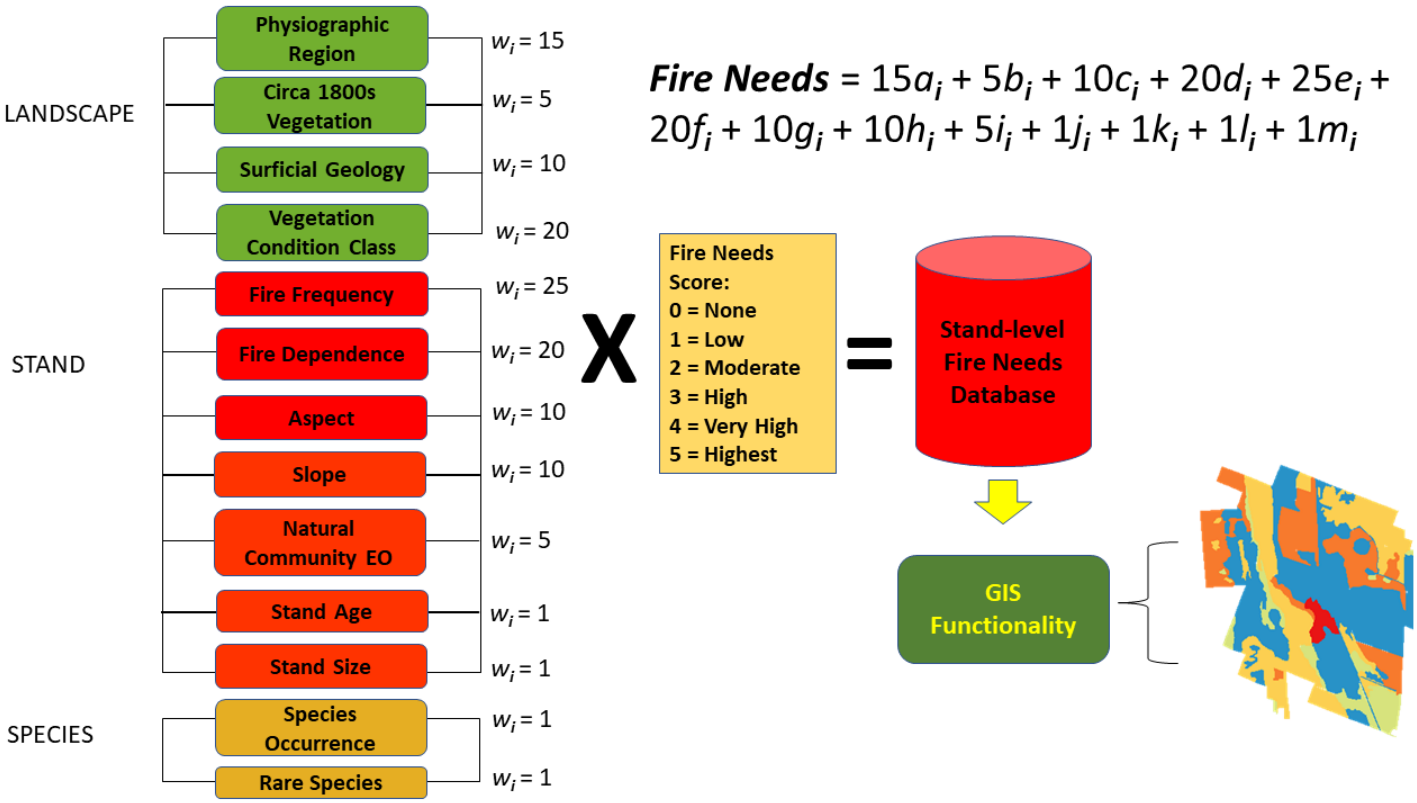


Figure A1. Overview of prescribed fire needs assessment model. This model gauges each stand's ecological need for prescribed fire based on an array of spatial variables and the presence of fire-dependent and fire-sensitive species. For each stand, multiple input variables at multiple scales were evaluated, scored, and weighted to generate an overall fire needs score. Each input variable was binned into one of three modules or submodels depending on the variable's scale (i.e., landscape, stand, and species).

APPENDIX 2 - GLOBAL AND STATE ELEMENT RANKING CRITERIA

GLOBAL RANKS

G1 = critically imperiled: at very high risk of extinction due to extreme rarity (often 5 or fewer occurrences), very steep declines, or other factors.

G2 = imperiled: at high risk of extinction due to very restricted range, very few occurrences (often 20 or fewer), steep declines, or other factors.

G3 = vulnerable: at moderate risk of extinction due to a restricted range, relatively few occurrences (often 80 or fewer), recent and widespread declines, or other factors.

G4 = apparently secure: uncommon but not rare; some cause for long-term concern due to declines or other factors.

G5 = secure: common; widespread.

GNR = Global rank not yet assessed. Unranked.

GU = currently unrankable due to lack of information or due to substantially conflicting information about status or trends.

GX = eliminated: eliminated throughout its range, with no restoration potential due to extinction of dominant or characteristic species.

G? = incomplete data.

STATE RANKS

S1 = critically imperiled in the state because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state.

S2 = imperiled in the state because of rarity due to very restricted range, very few occurrences (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the state.

S3 = vulnerable in the state due to a restricted range, relatively few occurrences (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.

S4 = uncommon but not rare; some cause for long-term concern due to declines or other factors.

S5 = common and widespread in the state.

SNR = State rank not yet assessed. Unranked.

SX = community is presumed to be extirpated from the state. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.

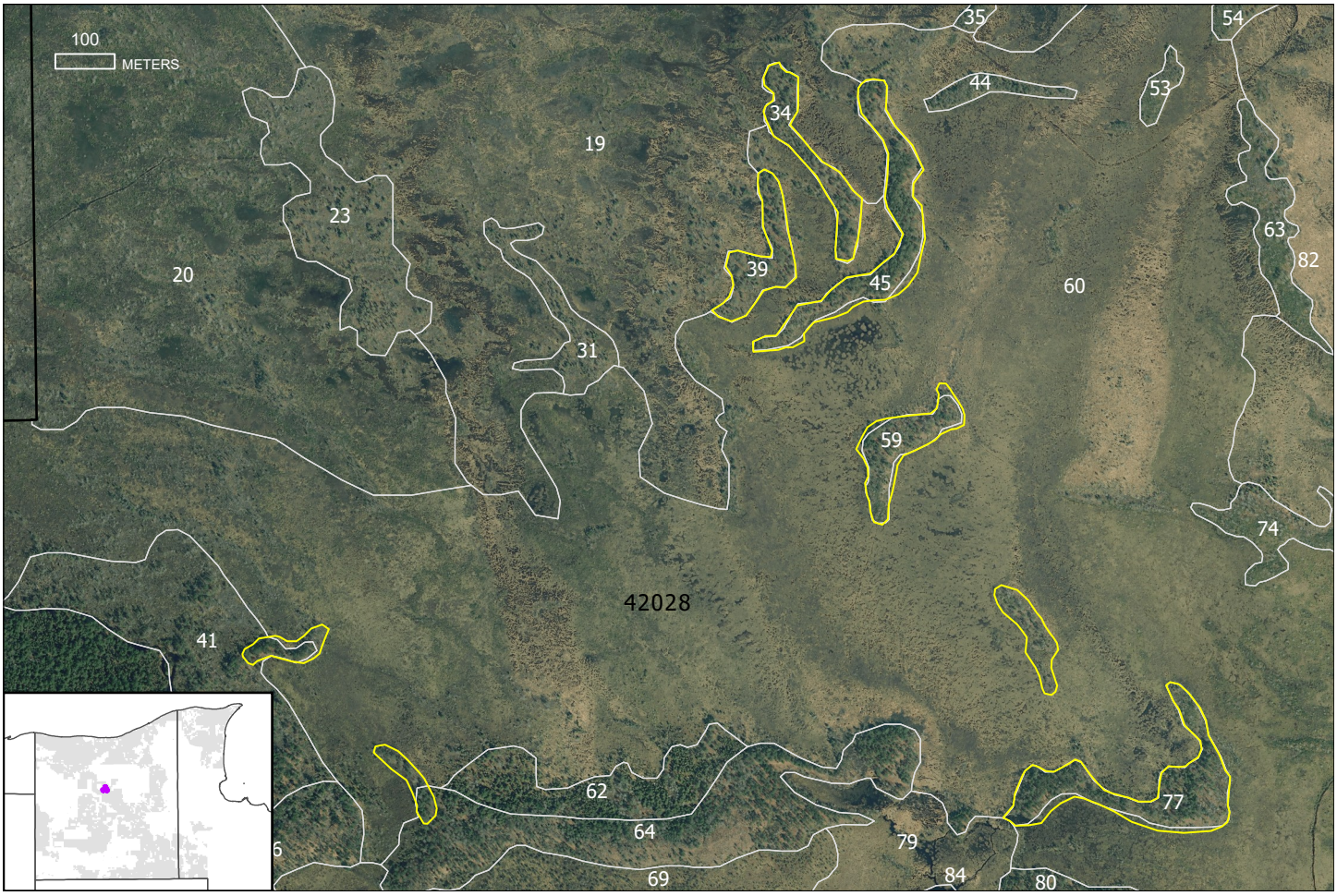
S? = incomplete data.

APPENDIX 3 - NATURAL COMMUNITIES

1. East Branch of the Two Hearted River
Natural Community Type: Dry Northern Forest
Location: Newberry Forest Management Unit; Compartment 42028, Stands 34, 39, 41, 45, 59, 64, and 77
Rank: G3? S3; likely vulnerable globally and vulnerable in Michigan
Element Occurrence Rank: AB, good to excellent
Size: 29 acres
Element Occurrence Identification Number: 28174 (new EO)

The East Branch of the Two Hearted River dry northern forest occurs on transverse dune ridges within a large peatland occupying a poorly drained lakeplain basin. The ridges and peatland burned during the Sleeper Lake Fire of 2007. The Sleeper Lake Fire was started by a lightning strike in the late summer of a drought year and burned an estimated 18,000 acres over three months (August-October). This fire was largely slow moving with low intensity and was allowed to safely burn out within existing natural burn breaks and roads (Personal communication with Keith Magnusson). The canopy of this dry northern forest is dominated by red pine (*Pinus resinosa*) and/or jack pine (*Pinus banksiana*) with white pine (*Pinus strobus*) occurring locally as canopy associates. Canopy coverage is variable, ranging from 60 to 75% depending on the local intensity of the wildfire on individual ridges. Many of the large-diameter red pine that survived have fire scars on their boles. Ring counts for cored red pine trees ranged from 135 to 290 years. Several dune ridges are characterized by moderate volumes of coarse woody debris from pine snags and downed logs that died during or following the fire.

Areas with more open canopy burned more intensively and tend to be dominated by overstory and understory jack pine. The understory is also variable (depending on the local intensity of the fire) with coverage ranging from 40 to 60% in areas that burned intensively and 10 to 25% in areas that burned less intensively. In addition to regenerating jack pine, characteristic understory species include white pine, red pine, black spruce (*Picea mariana*), trembling



Location of East Branch of the Two Hearted River dry northern forest (EO 28174).

aspen (*Populus tremuloides*), big-toothed aspen (*P. grandidentata*), and red maple (*Acer rubrum*). The low shrub layer is prevalent (40-60%) and is dominated by culturally significant shrubs including huckleberry (*Gaylussacia baccata*) and low sweet blueberry (*Vaccinium angustifolium*) with seedling jack pine and black spruce.

Management considerations

We recommend avoiding active timber or salvage harvests on dune ridges within this and other high-quality wetland complexes. Monitoring should be implemented to see how these stands respond over time to the wildfire. These pine ridges can be used as a learning landscape to help discern how to best use fire to promote natural regeneration of pine within natural pine stands. We recommend preventing alterations to the hydrology in the surrounding wetland complex, surveying for additional high-quality forests on the pine ridges within the wetland complex, and partnering with local Tribes to apply Indigenous cultural burns to the landscape. This forest occurs within an extensive wetland complex that we recommend for evaluating as a Designated Natural Area, Cultural and Customary Use Area, or another form of elevated protection.



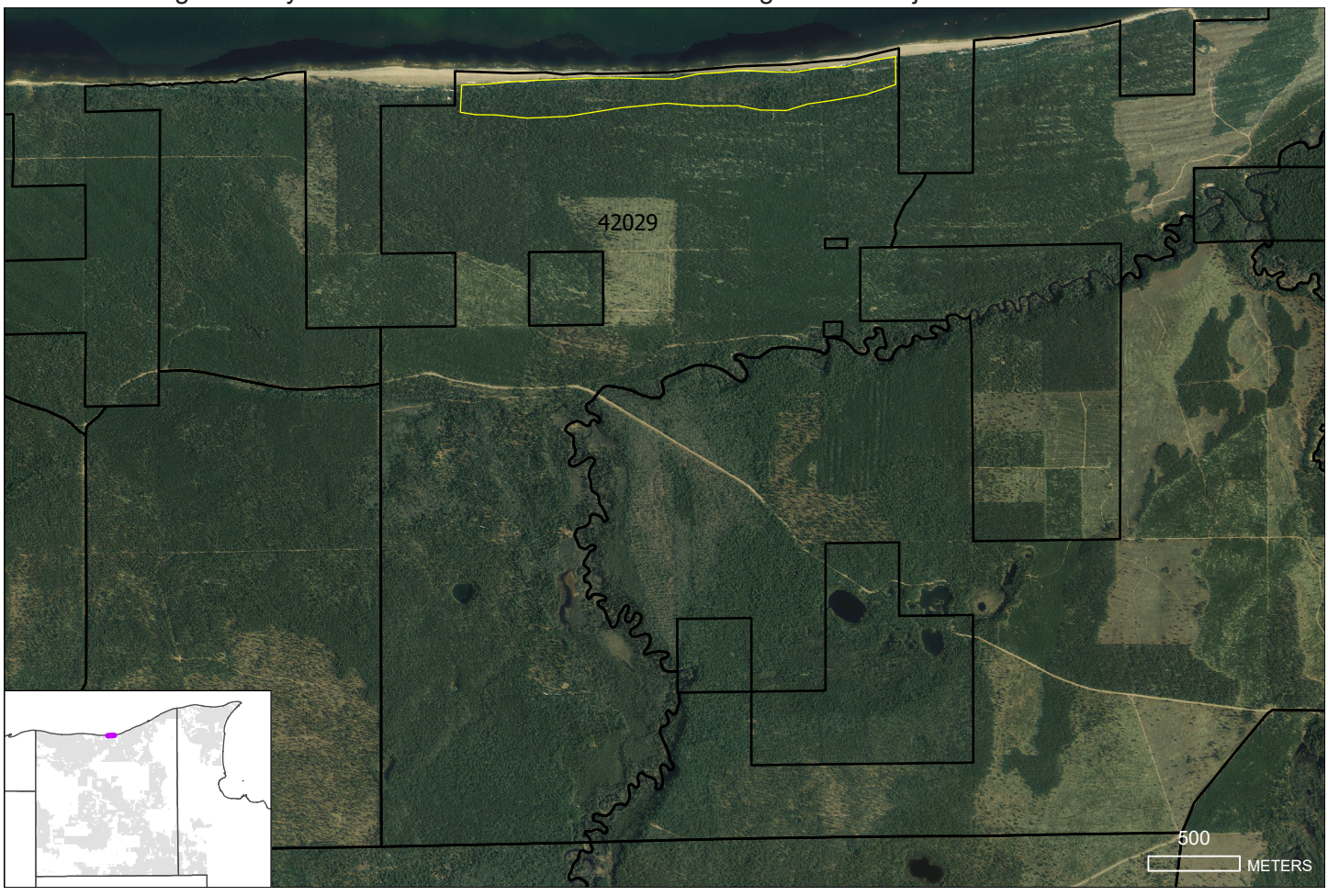
East Branch of the Two Hearted River dry northern forest. Photo by J.G. Cohen.

2. Ghost on the Shore
Natural Community Type: Dry Northern Forest
Location: Newberry Forest Management Unit; Compartment 42029, Stand 6.
Rank: G3? S3; likely vulnerable globally and vulnerable in Michigan
Element Occurrence Rank: B, good
Size: 105 acres
Element Occurrence Identification Number: 28184 (new)

This is a pine-dominated forest occurring on bands of dune ridges above a steep slope above the Lake Superior shoreline. Locally, the landscape features vast expanses of excessively drained sands with terraces associated with historic lake levels and forested dune ridges up to 40 ft tall. Structure and composition in the eastern half of the stand are consistent with old-growth conditions and influenced by fire suppression and proximity to Lake Superior. There are concentrations of red pines over 200 years old in the eastern half of the forest and two trees were aged to over 300 years old and some trees that we were unable to core are likely over 400. The oldest pines feature irregular canopies, large diameter lateral branching, numerous fire scars, and platy bark. Damage from storms and natural senescence is leading to irregular canopy coverage. Some standing snags appear to have been killed by lightning strike.

There were also fire scars on older red pine trees with some indicating as many as 6 burns. There was at least one tree with a bark peel scar and all of this is indicative of Indigenous cultural influences in the past 300 years, or more. This area was likely influenced by Indigenous populations that would have burned to improve berry crops. The influence of the lake and lack of fire is causing the system to trend towards dry-mesic northern forest. In the absence of fire, red pine is not regenerating and gaps caused by windthrow often are dominated by red oak and paper birch.

Management considerations
We recommend providing a large, forested buffer between this forest and logging activities to prevent additional fragmentation and to expand the portion of the landscape that is holistically managed. The adjacent stand to the south is scheduled to be cut and we recommend avoiding equipment on steep slopes, providing a no-cut buffer within 150 feet of this forest, not scarifying the soil, and not applying herbicide to the adjacent stand. In addition we recommend allowing this and adjacent forests to continue



Location of Ghost on the Shore dry northern forest (EO 28184).

maturing and including this stand and adjacent stand in prescribed burns. Protracted fire suppression has led to an accumulation of white spruce, fir, and white pine, in the subcanopy which would likely function as ladder fuels, jeopardizing canopy trees. Prior to the implementation of fire, it might be necessary to hand cut spruce and drag brush away from trees to prevent damage to the oldest red pine. Initial fires should be low-severity/low-intensity in order to consume ladder fuels without leading to crown fires and mortality of canopy individuals. Adjacent stands should be included in low-severity/low-intensity prescribed burns at intervals of every 10 to 30 years. Prior to implementation of management, we recommend engaging with Tribes and dendrochronologists to better understand the fire regime of this site. Finally, we recommend evaluating this forest and surrounding stands along the Lake Superior shoreline as a Cultural and Customary Use Area.

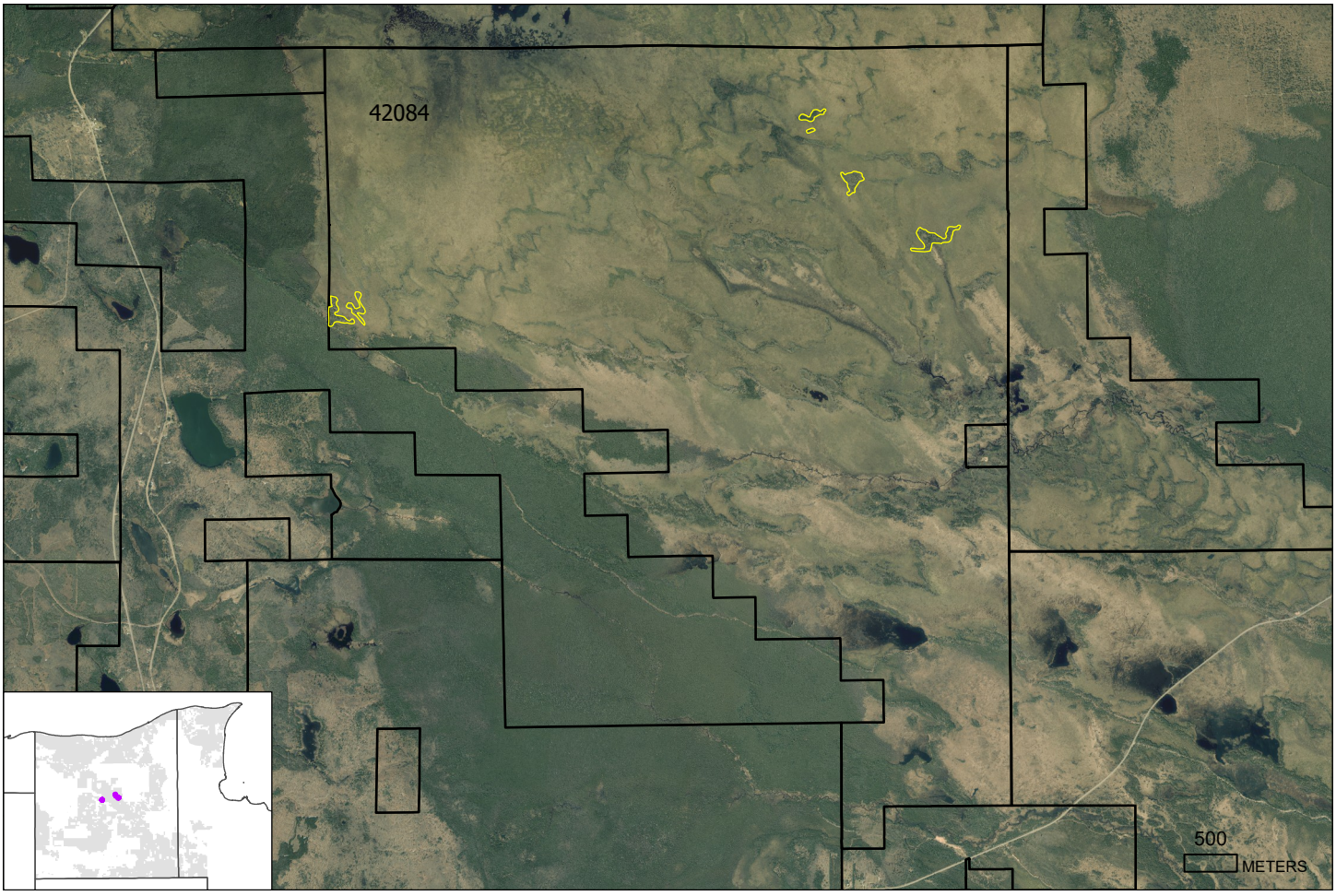


Ghost on the Shore dry northern forest. Photo by J.M. Lincoln.

3. Sleeper Pines
Natural Community Type: Dry Northern Forest
Location: Newberry Forest Management Unit; Compartment 42084, Stands 51, 55, 87, 91, and 95
Rank: G3? S3; likely vulnerable globally and vulnerable in Michigan
Element Occurrence Rank: B, good
Size: 31 acres
Element Occurrence Identification Number: 28155 (new EO)

The Sleeper Pines dry northern forest occurs on transverse dune ridges within a large muskeg occupying a poorly drained lakeplain basin. The ridges and peatland burned during the Sleeper Lake Fire of 2007. The Sleeper Lake fire was started by a lightning strike in the late summer of a drought year and burned an estimated 18,000 acres over three months (August-October). This fire was largely slow moving with low intensity and was allowed to safely burn out within existing natural burn breaks and roads (Personal communication with Keith Magnusson). Many of the large-diameter red pine that survived have fire scars on their boles. The largest red pine have bear scratches on their boles. The canopy is dominated by red pine (*Pinus resinosa*) and/or jack pine (*Pinus banksiana*) with canopy associates including white pine (*Pinus strobus*), and paper birch (*Betula papyrifera*). Canopy coverage is variable, ranging from ranging from 40 to 75% and depending on the local intensity of the wildfire on individual ridges. Areas with more open canopy burned more intensively and tend to be dominated by overstory and understory jack pine. Ring counts for cored red pine trees ranged from 122 to 334 years. Several dune ridges are characterized by moderate volumes of coarse woody debris from pine snags and downed logs that died as a result of the fire.

The understory is also variable (depending on the local intensity of the fire) with coverage ranging from 50 to 70% in areas that burned intensively and 10 to 25% in areas that burned less intensively. In addition to regenerating jack pine, characteristic understory species include white pine, red pine, black spruce, trembling aspen (*Populus tremuloides*), and balsam fir (*Abies balsamea*). The low shrub layer is prevalent (60-80%) and is dominated by culturally significant shrubs including huckleberry (*Gaylussacia*



Location of Sleeper Pines dry northern forest (EO 28155).

baccata) and low sweet blueberry (*Vaccinium angustifolium*) with bearberry (*Arctostaphylos uva-ursi*) and sweetfern (*Comptonia peregrina*). In addition, seedling jack pine, white pine, black spruce, and trembling aspen are abundant.

Management considerations

We recommend avoiding active timber or salvage harvests on dune ridges within this and other high-quality wetland complexes. Monitoring should be implemented to see how these stands respond over time to the wildfire. These pine ridges can be used as a learning landscape to help discern how to best use fire to promote natural regeneration of pine within natural pine stands. We also recommend preventing alterations to the hydrology in the surrounding wetland complex, surveying for additional high-quality forests on the pine ridges within the peatland, and partnering with local Tribes to apply Indigenous cultural burns to the landscape. This forest occurs within an extensive wetland complex that we recommend for evaluating as a Designated Natural Area, Cultural and Customary Use Areas, or another form of elevated protection.



Sleeper Pines dry northern forest. Photo by J.G. Cohen.

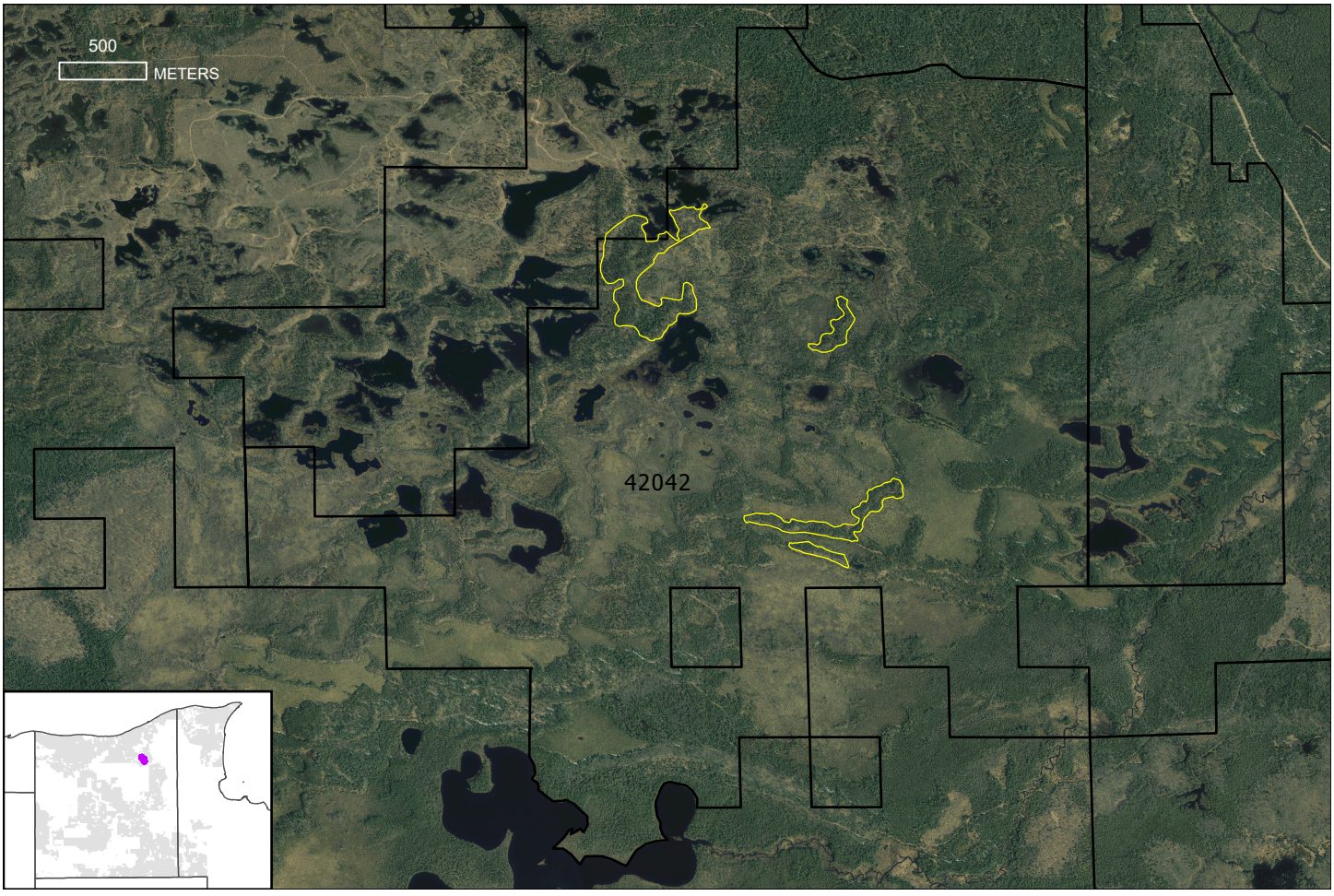


Sleeper Pines dry northern forest. Photo by J.G. Cohen.

4. Swamp Lakes
Location: Newberry Forest Management Unit; Compartment 42042, Stands 29, 70, and 158
Natural Community Type: Dry Northern Forest
Rank: G3? S3; likely vulnerable globally and vulnerable in Michigan
Element Occurrence Rank: BC, fair to good
Size: 87 acres
Element Occurrence Identification Number: 28171 (new EO)

The Swamp Lakes dry northern forest occurs on dune ridges within a large peatland occupying a poorly drained lakeplain basin. The Duck Lake Fire was the state's third largest fire on record and burned over 21,000 acres over the course of a few days in May of 2012. The fire started off slowly with low intensity and grew to a fast-moving crown fire as it approached the shores of Lake Superior (Personal communication with Keith Magnusson). The canopy of this Swamp Lakes dry northern forest is dominated by red pine (*Pinus resinosa*) with canopy associates including red oak (*Quercus rubra*), jack pine (*Pinus banksiana*), white pine (*Pinus strobus*), and paper birch (*Betula papyrifera*). Canopy coverage is variable, ranging from 50 to 65% and depending on the local intensity of the wildfire on individual ridges. The surviving cohort of red pines have char on their boles with several large red pines having fire scars on their boles. Ring counts for cored red pine trees ranged from 121 to 185 years. Canopy snags are scattered throughout the site with white pine being the most common snags. The understory is variable with coverage ranging from 10 to 30%, depending on the local intensity of the fire. Regenerating tree species include white pine, red pine, big-toothed aspen (*Populus grandidentata*), red maple (*Acer rubrum*), red oak, and paper birch. The low shrub layer is prevalent (40-60%) and is dominated by culturally significant shrubs including huckleberry (*Gaylussacia baccata*), low sweet blueberry (*Vaccinium angustifolium*), and Canada blueberry (*V. myrtilloides*).

Non-burned pine ridges are characterized by denser canopy with more overstory white pine and denser understories with a higher abundance of black spruce (*Picea mariana*) and white pine. The ground cover in the non-burned pine ridges is more homogenous in composition with bracken fern dominating and lichens being more prevalent.



Location of Swamp Lakes dry northern forest (EO 28184).

Management considerations
We recommend avoiding active timber or salvage harvests on dune ridges within this and other high-quality wetland complexes. Monitoring should be implemented to see how these stands respond over time to the wildfire. These pine ridges can be used as a learning landscape to help discern how to best use fire to promote natural regeneration of pine within natural pine stands. We also recommend preventing alterations to the hydrology in the surrounding wetland complex, surveying for additional high-quality forests on the pine ridges within the wetland complex, and partnering with local Tribes to apply Indigenous cultural burns to the landscape. This forest occurs within an extensive wetland complex that we recommend for evaluating as a Designated Natural Area or another form of elevated protection.



Swamp Lakes dry northern forest . Photo by J.G. Cohen.



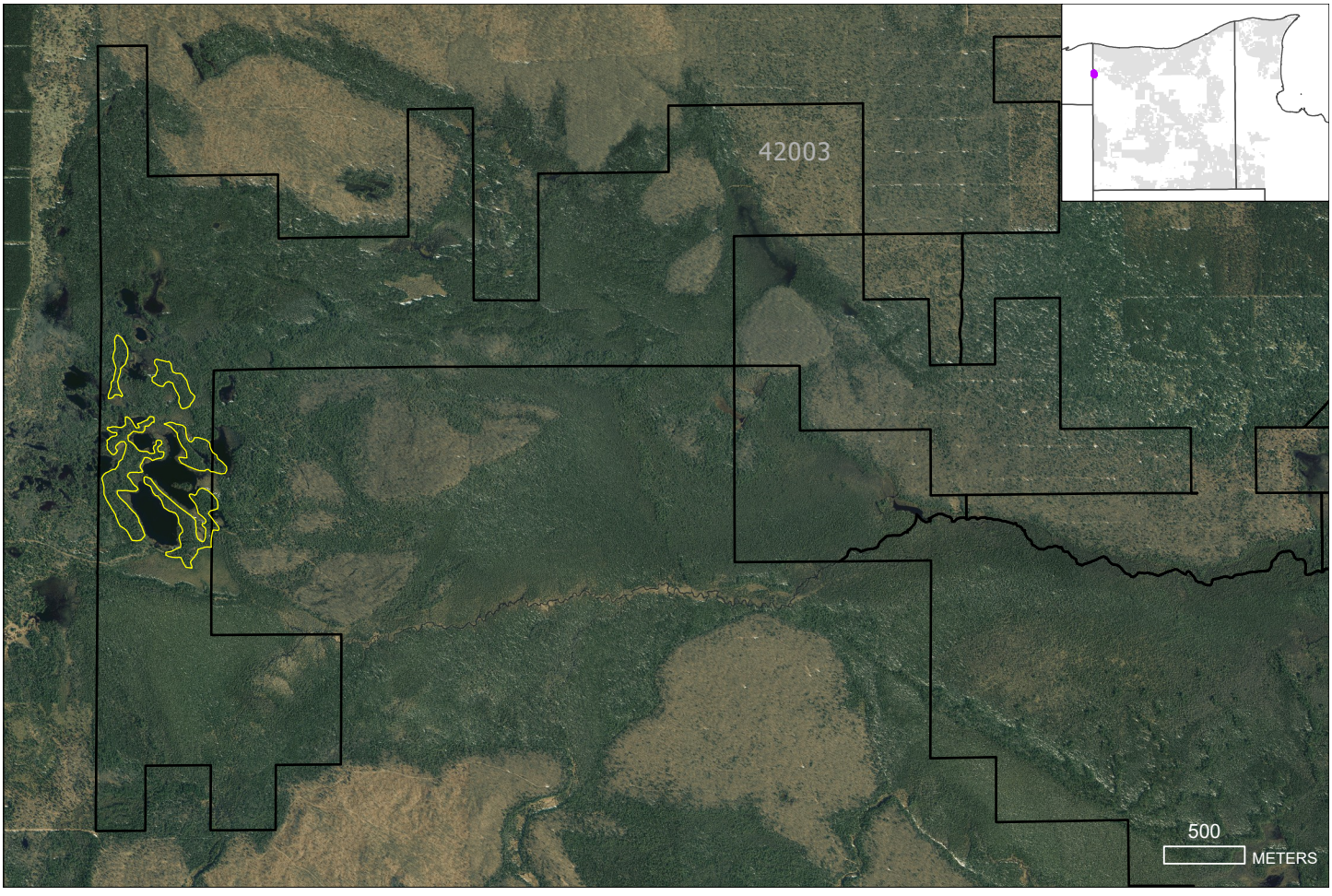
Swamp Lakes dry northern forest . Photo by J.G. Cohen.

5. Barfield Lakes
Location: Newberry Forest Management Unit; Compartment 42003, Stands 52, 56, and 62
Natural Community Type: Dry Northern Forest
Rank: G3? S3; likely vulnerable globally and vulnerable in Michigan
Element Occurrence Rank: C, fair
Size: 71 acres
Element Occurrence Identification Number: 4328 (update)

Barfield Lakes dry northern forest is a mature, naturally regenerated pine forest that occurs along sandy transverse dune ridges within an extensive peatland complex on poorly drained lakeplain. The canopy is variable (65-90%) and is dominated by large-diameter red pine (*Pinus resinosa*) and white pine (*P. strobus*) (45-65 cm DBH) with canopy associates including red oak (*Quercus rubra*), big-toothed aspen (*Populus grandidentata*), paper birch (*Betula papyrifera*), and northern white-cedar (*Thuja occidentalis*). Cored canopy red pines were estimated to be over 120 years old and the forest likely regenerated following a significant fire as indicated by numerous large diameter burnt white pine snags and charcoal within the soil profile.

Fire suppression has led to the increase in the subcanopy and understory layers of mesophytic species including white pine, red maple (*Acer rubrum*), black spruce (*Picea mariana*), and paper birch with little red pine regeneration. The low shrub layer is dense (40-60%) and dominated by culturally significant shrubs including low sweet blueberry (*Vaccinium angustifolium*), Canada blueberry (*V. myrtilloides*), and huckleberry (*Gaylussacia baccata*).

Management considerations
The primary management recommendation is to allow this forest to continue to mature and to include this forest and adjacent peatlands in prescribed burns. Initial fires should be low-severity/low-intensity and consume ladder fuels to reduce the risk of crown fires and mortality of canopy individuals. In the event of a wildfire or if prescribed fire is implemented, establishment of new fire lines should be avoided, and existing fire breaks (i.e., roads and wetlands) should be used. New fire breaks could allow for invasive species encroachment.



Location of Barfield Lakes dry northern forest (EO 4328).



Barfield Lakes dry northern forest. Photo by J.M. Lincoln



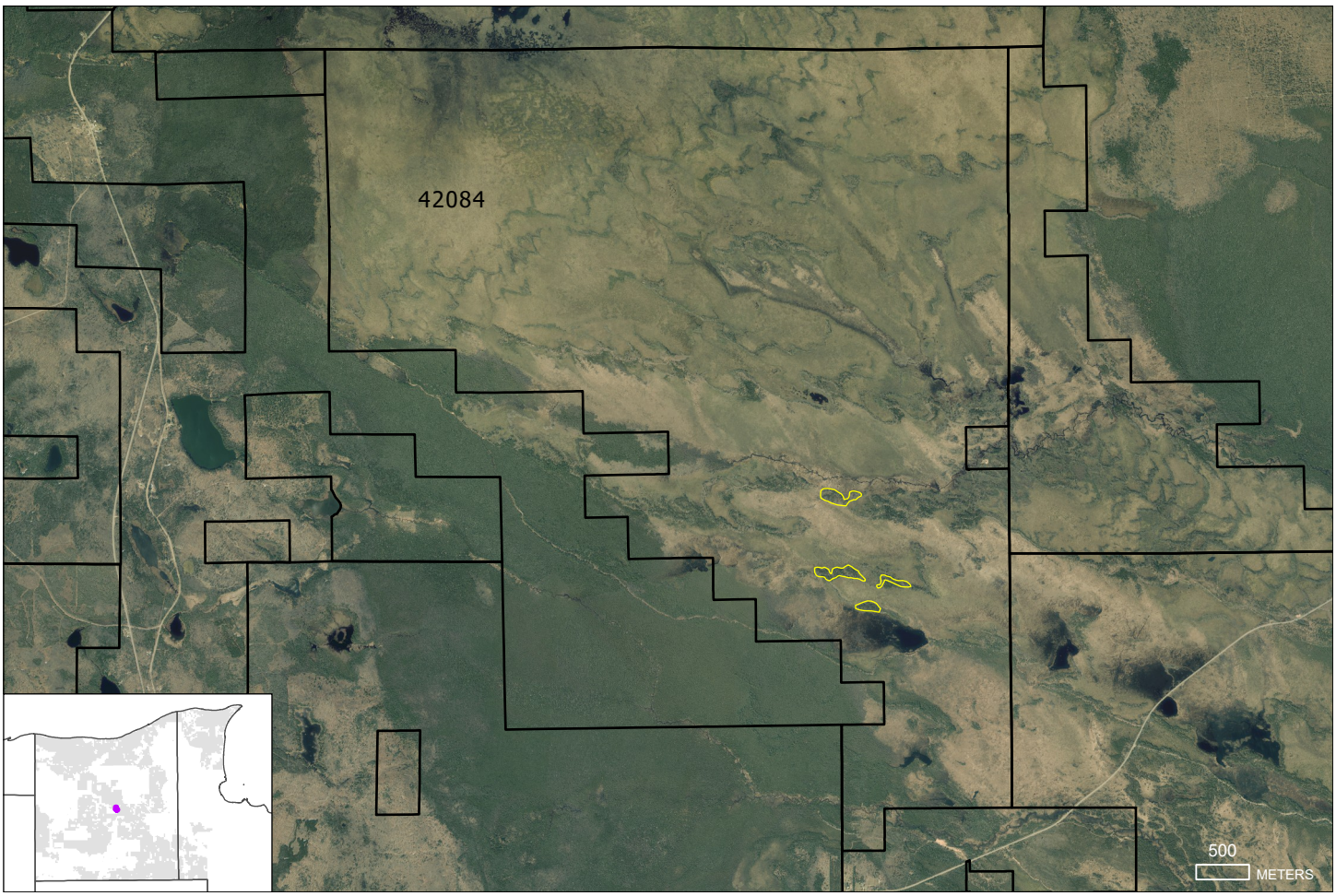
Barfield Lakes dry northern forest. Photo by J.G. Cohen.

6. Murphy Creek
Location: Newberry Forest Management Unit; Compartment 42084, Stands 24, 25, 159, 165, and 176
Natural Community Type: Dry Northern Forest
Rank: G3? S3; likely vulnerable globally and vulnerable in Michigan
Element Occurrence Rank: C, fair
Size: 27 acres
Element Occurrence Identification Number: 28175 (new EO)

The Murphy Creek dry northern forest occurs on transverse dune ridges within a large peatland occupying a poorly drained lakeplain basin south of Murphy Creek. The ridges and peatland burned during the Sleeper Lake Fire of 2007. The Sleeper Lake Fire was started by a lightning strike in the late summer of a drought year and burned an estimated 18,000 acres over three months (August-October). This fire was largely slow moving with low intensity and was allowed to safely burn out within existing natural burn breaks and roads (Personal communication with Keith Magnusson).

The canopy of the Murphy Creek dry northern forest is dominated by red pine (*Pinus resinosa*) with associates including white pine (*Pinus strobus*), jack pine (*Pinus banksiana*), trembling aspen (*Populus tremuloides*), big-toothed aspen (*P. grandidentata*), and paper birch (*Betula papyrifera*). Canopy coverage ranges from 65 to 75%. Many of the large-diameter red pine that survived have fire scars on their boles. The forest is uneven aged. Ring counts for cored red pine trees ranged from 137 to 179 years. Several dune ridges are characterized by moderate volumes of coarse woody debris from pine snags and downed logs that died during or following the fire.

The understory is variable (depending on the local intensity of the fire). Areas with more open canopy burned more intensively and tend to be characterized by dense jack pine regeneration. In addition to regenerating jack pine, characteristic understory species include big-toothed aspen, red maple (*Acer rubrum*), and black spruce (*Picea mariana*). The low shrub layer is prevalent with culturally significant shrubs including huckleberry (*Gaylussacia baccata*), low sweet blueberry (*Vaccinium angustifolium*), and Canada blueberry (*V. myrtilloides*).



Location of Murphy Creek dry northern forest (EO 28175).

Management considerations
We recommend avoiding active timber or salvage harvests on dune ridges within this and other high-quality wetland complexes. Monitoring should be implemented to see how these stands respond over time to the wildfire. These pine ridges can be used as a learning landscape to help discern how to best use fire to promote natural regeneration of pine within natural pine stands. We also recommend preventing alterations to the hydrology in surrounding wetland complex, surveying for additional high-quality forests on the pine ridges within the wetland complex, and partnering with local Tribes to apply Indigenous cultural burns to the landscape. This forest occurs within an extensive wetland complex that we recommend for evaluating as a Designated Natural Area, Cultural and Customary Use Area, or another form of elevated protection.



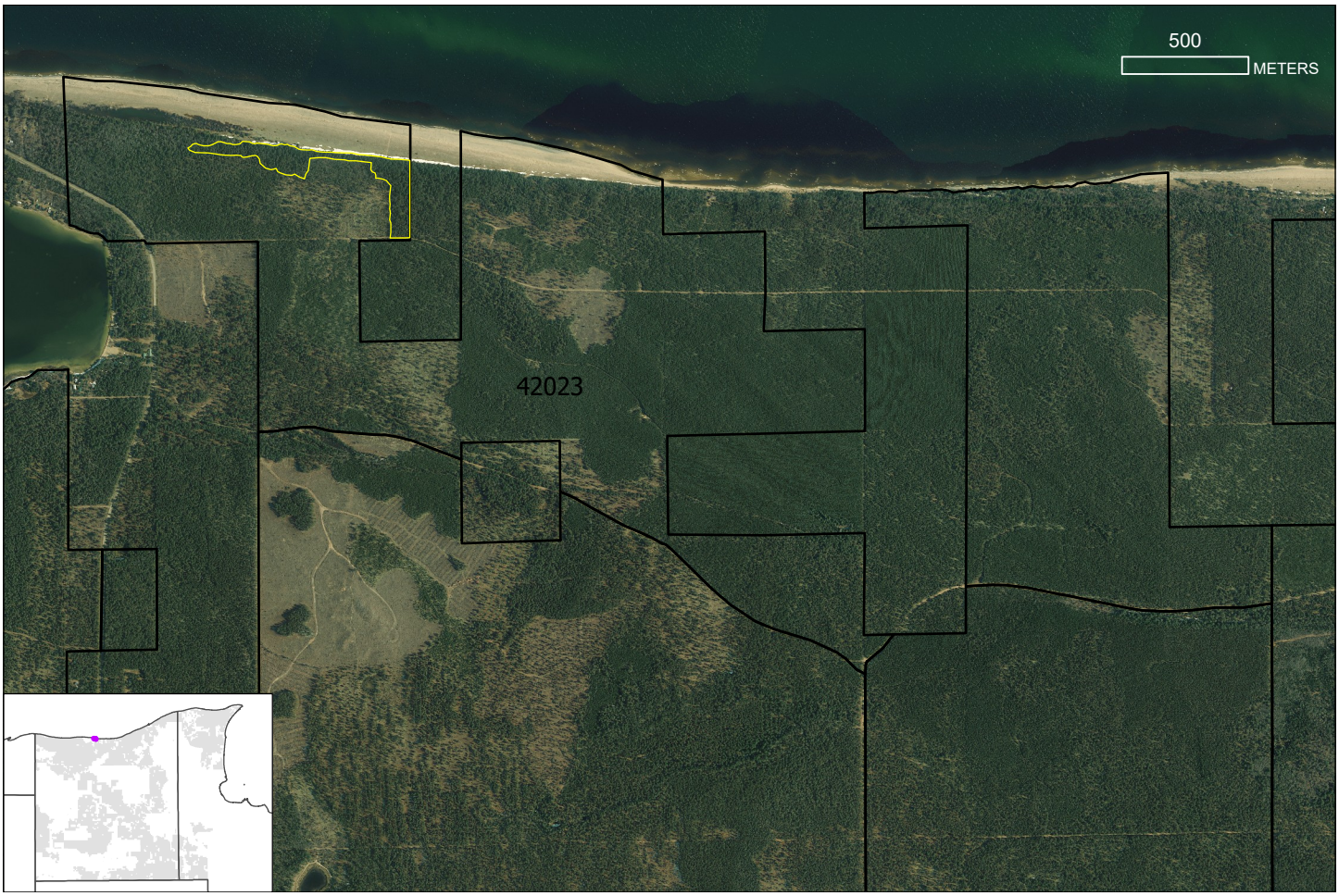
Murphy Creek dry northern forest. Photo by J.G. Cohen.

7. Deer Park Pines
Location: Newberry Forest Management Unit; Compartment 42023, Stand 32
Natural Community Type: Dry Northern Forest
Rank: G3? S3; likely vulnerable globally and vulnerable in Michigan
Element Occurrence Rank: C, fair
Size: 17 acres
Element Occurrence Identification Number: 28169 (new EO)

The Deer Park Pines dry northern forest occurs on a steep dune slope and flat terrace adjacent to sand and gravel beach along Lake Superior. The canopy is dominated by red pine (*Pinus resinosa*) with canopy associates including white pine (*Pinus strobus*), red oak (*Quercus rubra*), and jack pine (*Pinus banksiana*). Canopy closure ranges from 75 to 85% and overstory trees range in diameter from 30 to 60 cm. One cored canopy red pine was estimated to be over 170 years old. Fire scars on canopy red pine indicate that the forest was historically burned, likely by Indigenous peoples. Three scars were noted on one of the overstory red pines and several fire-scarred stumps exhibited three to four fire scars.

The prevalence of red maple (*Acer rubrum*), white pine, and balsam fir (*Abies balsamea*) in the understory and subcanopy indicate that the forest has been fire suppressed for several decades. The low shrub layer is prevalent (40-60%) and is dominated by low sweet blueberry (*Vaccinium angustifolium*) and huckleberry (*Gaylussacia baccata*) with addition culturally significant shrubs including bearberry (*Arctostaphylos uva-ursi*), Canada blueberry (*V. myrtilloides*), and serviceberries (*Amelanchier* spp.). Red oak seedling are common throughout.

Management considerations
We recommend implementing low-severity/low-intensity burning within this forest and establishing a no-cut buffer along the edges of this forest and the steep slopes along Lake Superior. We recommend incorporating the stands adjacent to this site as a Project Area. Numerous fire-scarred stumps occur



Location of Deer Park Pines dry northern forest (EO 28169).

within this forest and in adjacent stands. Prior to the implementation of prescribed fire, we encourage evaluation of the fire history of this site and adjacent areas of Lake Superior shoreline through dendrochronological research conducted in concert with Tribal communities. Existing features such as roads, trails, and the shoreline should be used as burn breaks to limit the spread of invasive species. We recommend evaluating this area as a Cultural and Customary Use Area.



Deer Park Pines dry northern forest. Photo by J.G. Cohen.



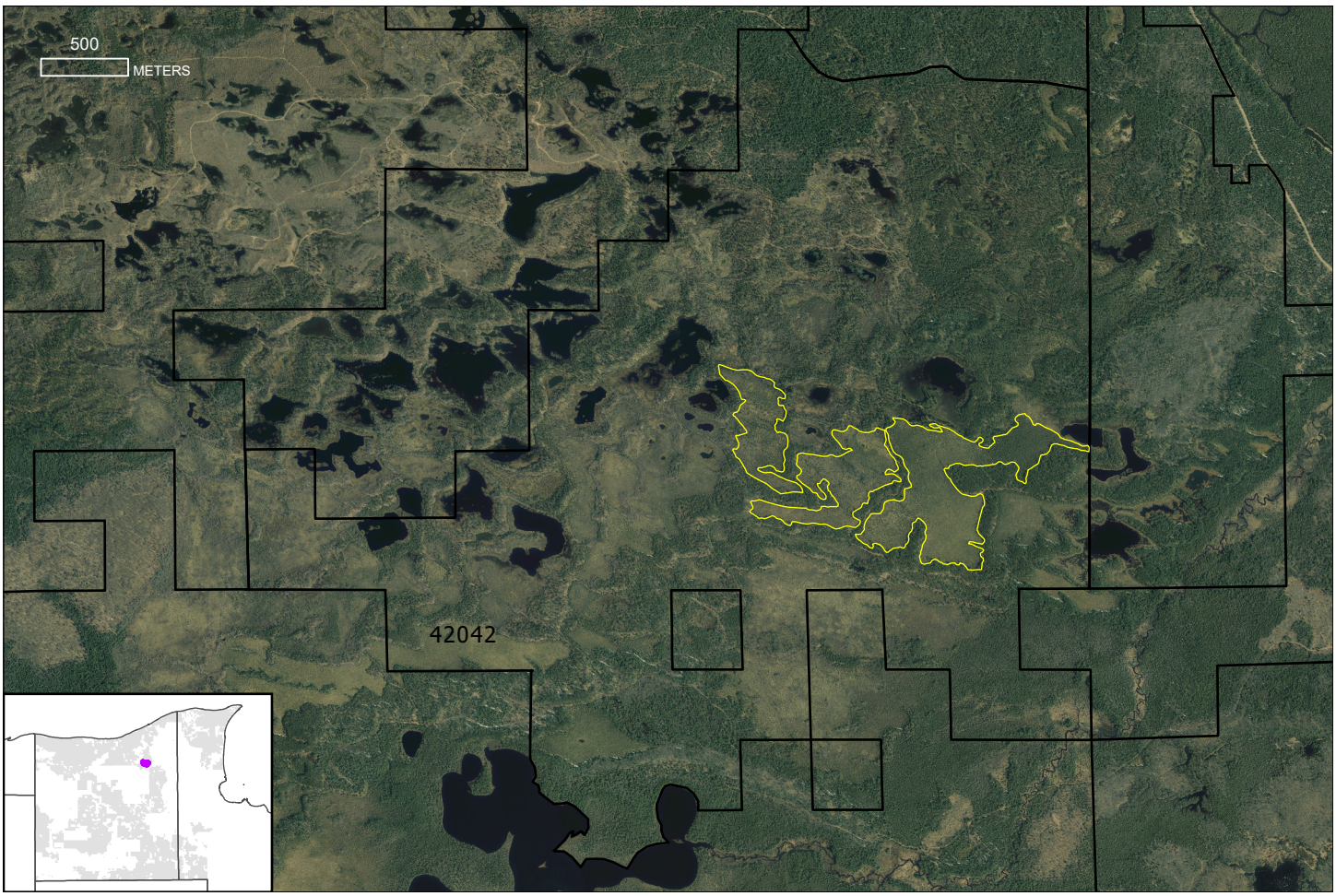
Deer Park Pines dry northern forest. Photo by J.G. Cohen.

8. Swamp Lakes
Location: Newberry Forest Management Unit; Compartment 42042, Stands 89 and 126
Natural Community Type: Muskeg
Rank: G4G5 S3; apparently secure to secure globally and vulnerable in Michigan
Element Occurrence Rank: B, good
Size: 204 acres
Element Occurrence Identification Number: 28172 (new EO)

The Swamp Lakes muskeg occurs on a broad expanse of poorly drained lakeplain with numerous intersecting pine ridges between lakes and surrounding peatlands. The muskeg is characterized by a scattered and stunted overstory ranging from 5 to 15% with black spruce (*Picea mariana*) and tamarack as dominates and associates including jack pine (*Pinus banksiana*), white pine (*Pinus strobus*), and less frequently red pine (*Pinus resinosa*). The majority of the muskeg and the intersecting pine ridges burned during the Duck Lake Fire. The Duck Lake Fire was the state's third largest fire on record and burned over 21,000 acres over the course of a few days in May of 2012. The fire started off slowly with low intensity and grew to a fast-moving crown fire as it approached the shores of Lake Superior (Personal communication with Keith Magnusson). The eastern portion of the muskeg did not burn and is characterized by dense conifers. A 12 cm tamarack (*Larix laricina*) was cored and estimated to be 75 years old.

Where the muskeg burned, the understory is sparse to patchy (10-20%) with black spruce, tamarack, mountain holly (*Ilex mucronata*), wild-raisin (*Viburnum cassinoides*), black chokeberry (*Aronia prunifolia*), jack pine, white pine, and paper birch (*Betula papyrifera*). Portions of the muskeg that did not burn are characterized by denser overstory and understory black spruce and tamarack. The low shrub layer is patchy to dense (40-60%) with leatherleaf (*Chamaedaphne calyculata*), Labrador-tea (*Rhododendron groenlandicum*), bog rosemary (*Andromeda glaucophylla*), bog laurel (*Kalmia polifolia*), and cranberry and blueberry species (*Vaccinium* spp).

Shrub diversity and density increase with proximity to the margins of upland ridges. The ground layer (40-60%) is dominated by Sphagnum mosses (*Sphagnum* spp.) with characteristic species including few-seed sedge (*Carex oligosperma*), pitcher-plant



Location of Swamp Lakes muskeg (EO 28172).

(*Sarracenia purpurea*), small cranberry (*Vaccinium oxycoccos*), cotton-grasses (*Eriophorum* spp.), round-leaved sundew (*Drosera rotundifolia*), wintergreen (*Gaultheria procumbens*), few-flower sedge (*Carex pauciflora*), pink lady-slipper (*Cypripedium acaule*), grass-pink (*Calopogon tuberosus*), three-way sedge (*Dulichium arundinaceum*), and creeping snowberry (*Gaultheria hispidula*). Floating mats occur locally along the margins of bog ponds and are characterized by large cranberry (*Vaccinium macrocarpon*), white beak-rush (*Rhynchospora alba*), round-leaved sundew, arrow-grass (*Scheuchzeria palustris*), and few-flower sedge.

Management considerations

We recommend avoiding active timber or salvage harvests within this peatland and on dune ridges within this and other high-quality wetland complexes. Monitoring should be implemented to evaluate community response to the wildfire. These peatlands can be used as a learning landscape to help discern how to best use fire to implement prescribed fire in peatlands. We also recommend preventing alterations to the hydrology in the peatland complex and partnering with local Tribes to apply Indigenous cultural burns to the landscape.

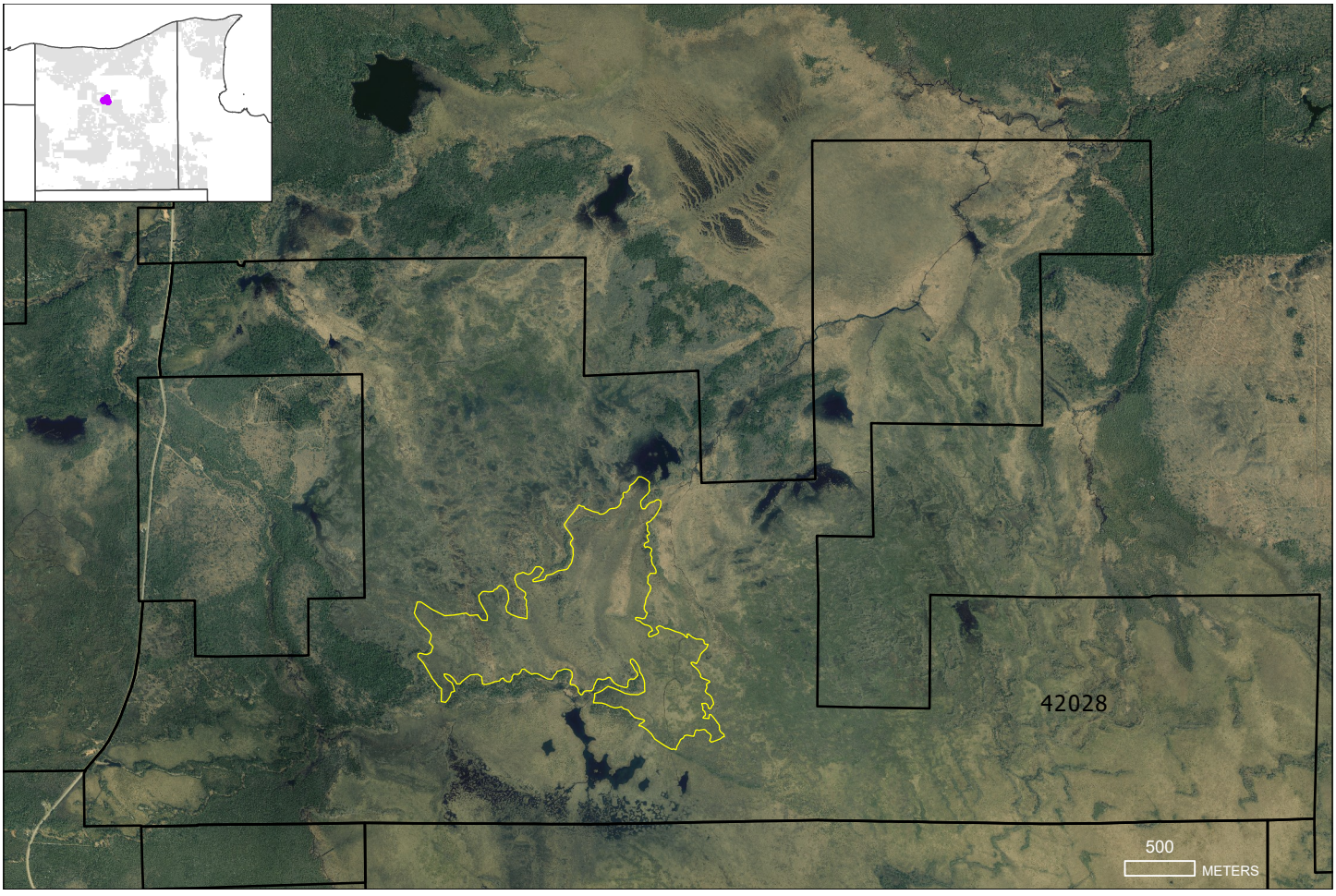


Swamp Lakes muskeg. Photo by J.G. Cohen.

9. East Branch of the Two Hearted River
Location: Newberry Forest Management Unit; Compartment 42028, Stand 60
Natural Community Type: Poor Fen
Rank: G4G5 S3; apparently secure to secure globally and vulnerable in Michigan
Element Occurrence Rank: B, good
Size: 204 acres
Element Occurrence Identification Number: 28173 (new EO)

This poor fen is an open peatland that occurs on flat poorly drained lakeplain near the East Branch of the Two Hearted River. Poor fen grades locally to muskeg in areas that trend towards more acidic. The majority of the peatland is characterized as shrubby poor fen with extensive zones of graminoid-dominated fen meadow throughout the complex. The peatland and surrounding pine-dominated transverse dune ridges burned during the Sleeper Lake Fire of 2007. The Sleeper Lake Fire was started by a lightning strike in the late summer of a drought year and burned an estimated 18,000 acres over three months (August-October). This fire was largely slow moving with low intensity and was allowed to safely burn out within existing natural burn breaks and roads (Personal communication with Keith Magnusson). This muskeg occurs within an extensive wetland complex that we recommend for evaluating as a Designated Natural Area, Cultural and Customary Use Area, or another form of elevated protection.

The open canopy of the poor fen is characterized by scattered and stunted black spruce (*Picea mariana*), tamarack (*Larix laricina*), white pine (*Pinus strobus*), and jack pine (*Pinus banksiana*). Canopy closure typically ranges from 5 to 25% and canopy trees range from 2 to 20 cm in diameter and 2 to 5 m in height. The understory is patchy to locally dense (10-25%) and is characterized by sapling black spruce, tamarack, and paper birch (*Betula papyrifera*) with tall shrub associates including bog birch (*Betula pumila*), wild-raisin (*Viburnum cassinoides*), black chokeberry (*Aronia prunifolia*), and mountain holly (*Ilex mucronata*). The low shrub layer is dense (40-60%) and is characterized by ericaceous shrubs including leatherleaf (*Chamaedaphne calyculata*), bog laurel (*Kalmia polifolia*), Labrador-tea (*Rhododendron groenlandicum*), bog rosemary (*Andromeda glaucophylla*), and low sweet blueberry (*Vaccinium angustifolium*) along with seedling black spruce,



Location of East Branch of the Two Hearted River poor fen (EO 28173).

tamarack, bog birch, wild-raisin, and black chokeberry. The ground cover (20-40%) is dominated by sedge species (i.e., *Carex lasiocarpa* and *C. oligosperma*) and Sphagnum mosses (*Sphagnum* spp.) with characteristic ground cover species including small cranberry (*Vaccinium oxycoccos*), cotton-grasses (*Eriophorum* spp.), pitcher-plant (*Sarracenia purpurea*), bog aster (*Oclemena nemoralis*), wild blue flag (*Iris versicolor*), false mayflower (*Maianthemum trifolium*), white beak-rush (*Rhynchospora alba*), blue-joint (*Calamagrostis canadensis*), and broad-leaved cat-tail (*Typha latifolia*).

Management considerations

We recommend avoiding active timber management within this peatland. Monitoring should be implemented to see how this peatland responds over time to the wildfire. These peatlands can be used as a learning landscape to help discern how to best use fire to implement prescribed fire in peatlands. We also recommend preventing alterations to the hydrology in the peatland complex and partnering with local Tribes to apply Indigenous cultural burns to the landscape. This fen occurs within an extensive wetland complex that we recommend for evaluating as a Designated Natural Area, Cultural and Customary Use Area, or another form of elevated protection.



East Branch of the Two Hearted River poor fen. Photo by J.G. Cohen.

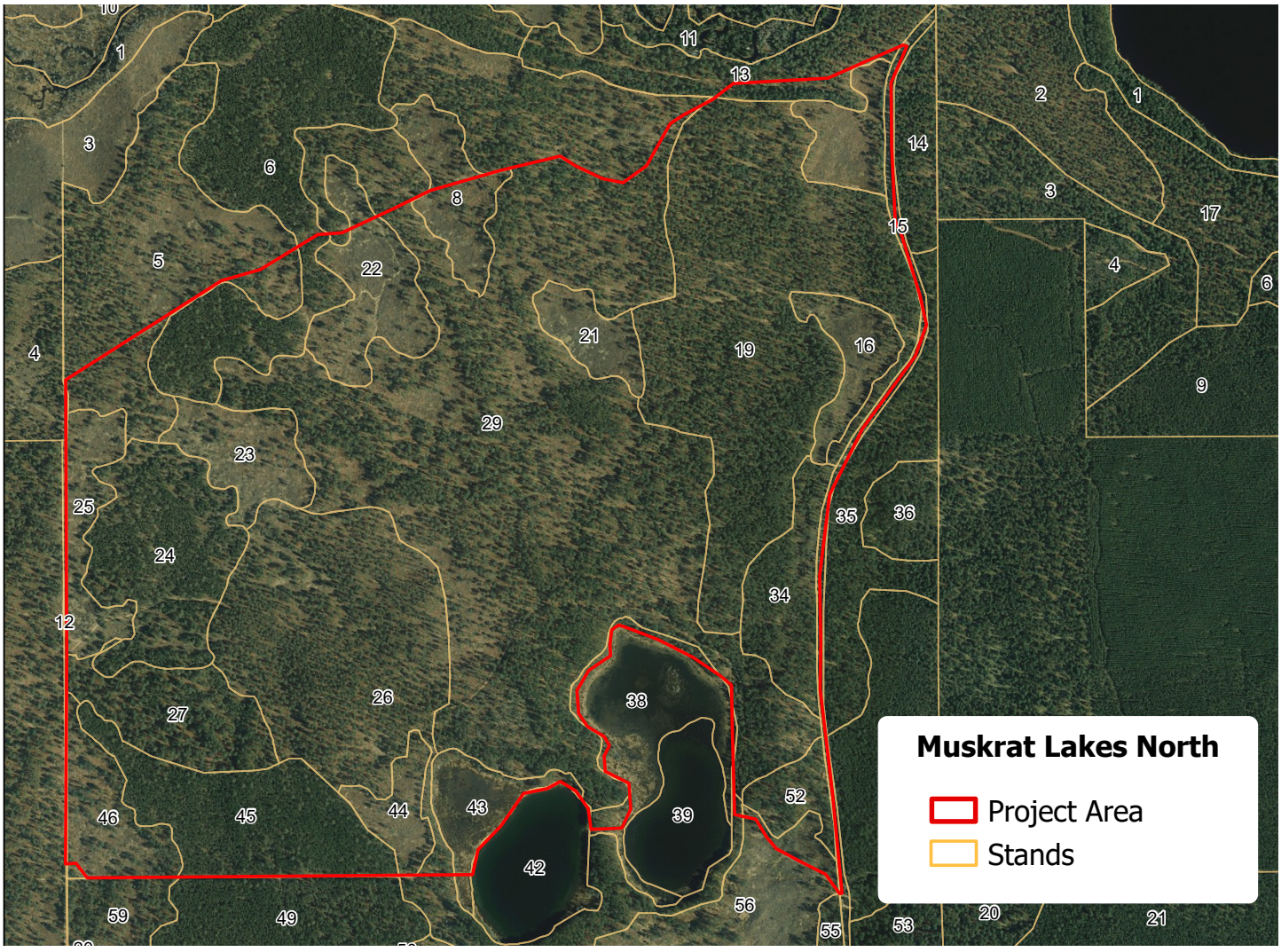
APPENDIX 4 - PROJECT AREAS

1. Muskrat Lakes North
Location: Compartment 42040, Stands 29, 19, 34
Size: 416 acres
Community type: dry northern forest

The Duck Lake Fire burned through this forest in late May of 2012. The forest was then then thinned in 2013, which reduced canopy cover by about 25%. The dry northern forest is maturing second growth with no old- growth individuals and low floristic diversity characteristic of dry northern forest. The canopy is sparse (40-70% canopy coverage) and dominated by red pine with white pine throughout and infrequent canopy jack pine. The low shrub layer is sparse to locally dense (20-60% cover) and features thickets of low sweet blueberry and huckleberry. Pine seedlings occur throughout the area with jack pine more abundant along Muskrat Lake where the fire appeared to be more intense. Following the fire, red pine seedlings established throughout the forest.

Management Recommendations

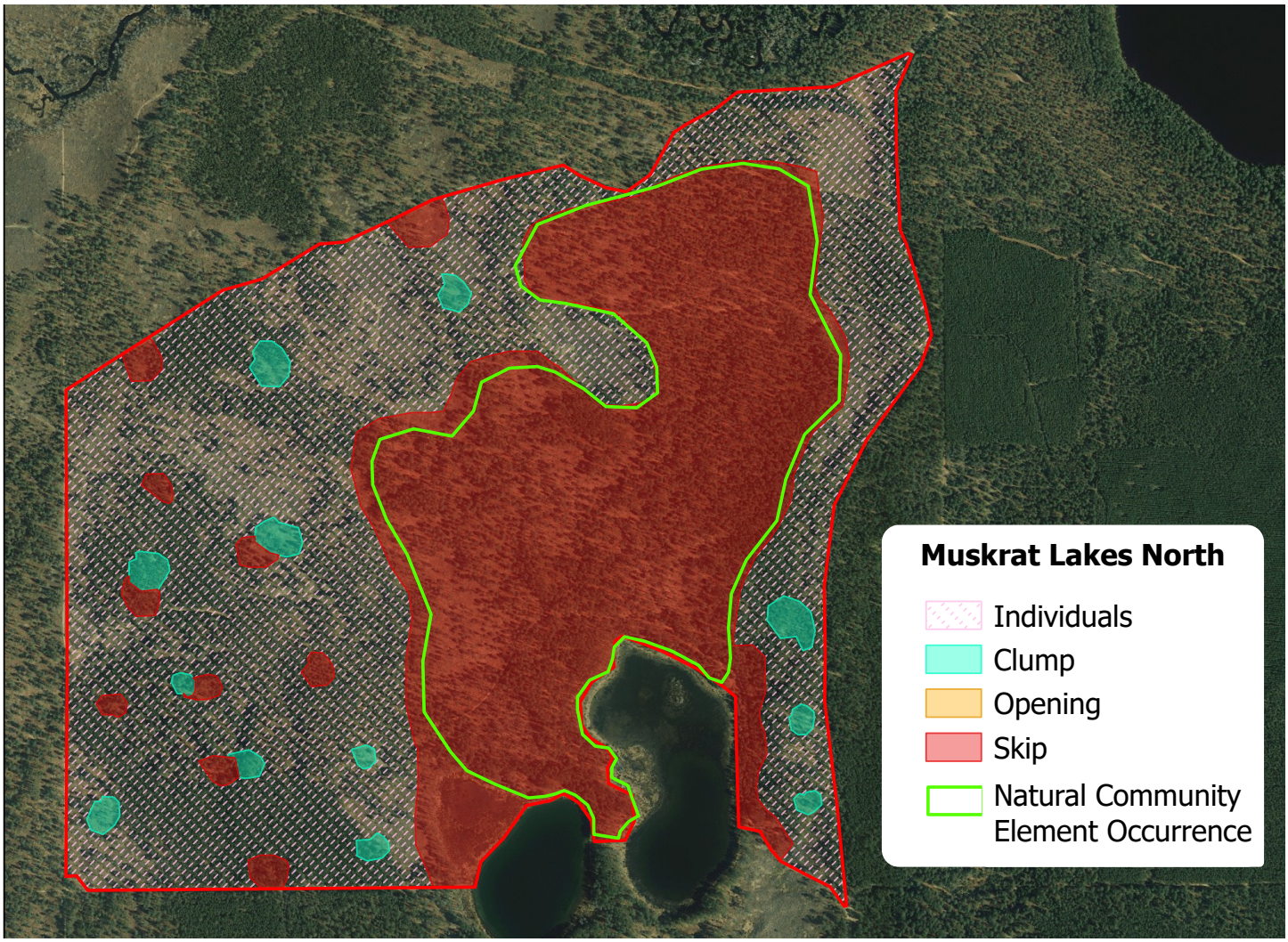
We recommend applying a low-severity/low-intensity fire across the entire Project Area. The burn should be applied during the late summer or fall to reduce leaf litter and mesophytic species in the understory and should be applied during a red pine mast year. Following implementation of a second fire, we recommend harvesting *Openings* zones and thinning the *Individuals* zone by 1/3 BA. Within 5 to 10 years of thinning, we recommend applying a low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. Retaining the oldest trees across the site and protecting fire-scarred living trees and stumps will facilitate the reconstruction of the site's fire history. Surveys for invasive species should be conducted along roads and trails.



Location of Muskrat Lakes North Project Area (Compartment 42040).



Muskrat Lakes North Project Area. Photo by J.M. Lincoln.

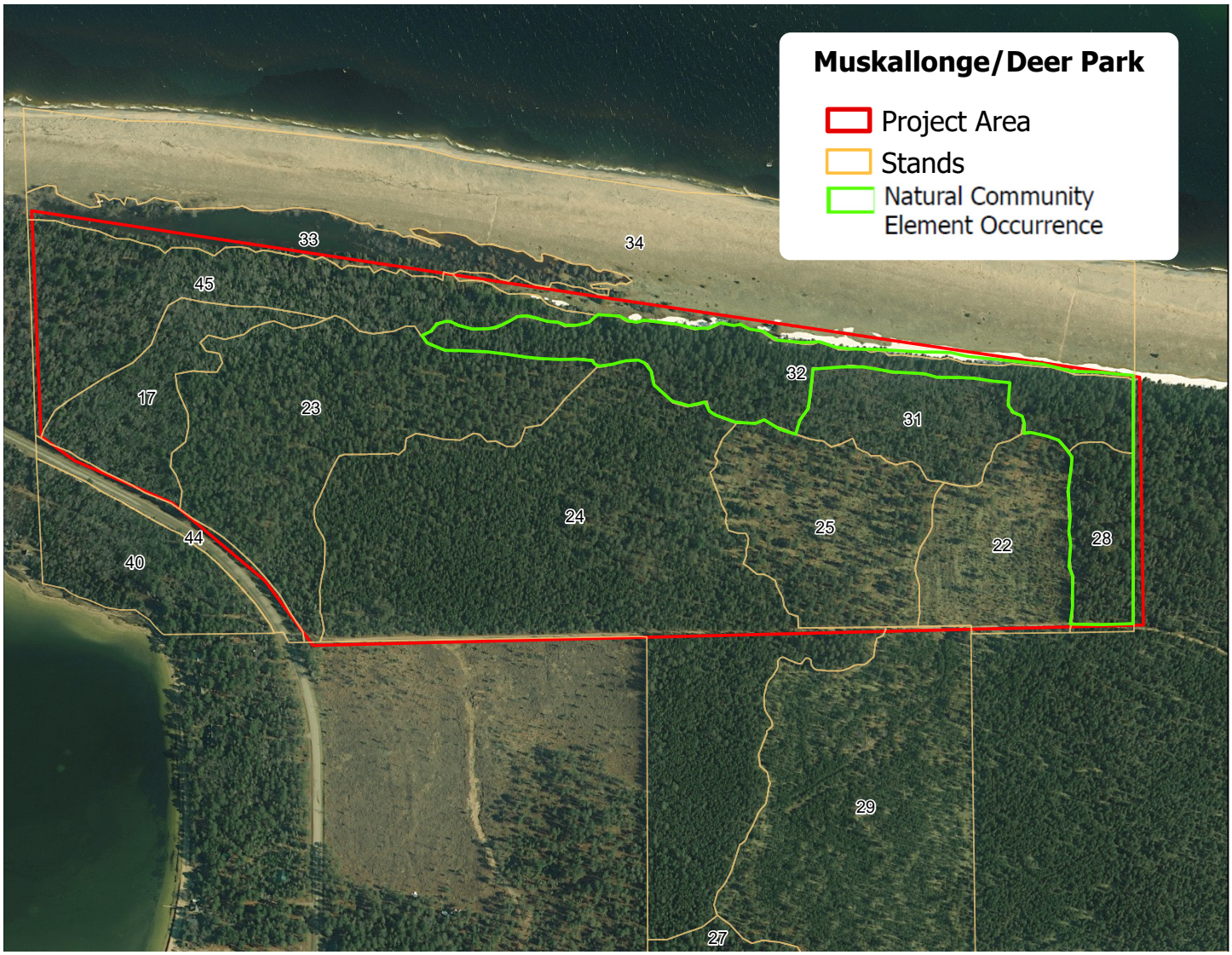


ICO Management zones for Muskrat Lakes North Project Area (Compartment 42040).

2. Muskallonge/Deer Park
Location: Compartment 42011, Stands 44, 43, 37, 19, 28, and 14
Size: 125 acres
Community type: dry northern forest

This Project Area consists of several stands along Lake Superior and includes Deer Park Pines dry northern forest (EO described on pg ##). The canopy is dominated by red pine with white pine, red oak, and jack pine. One cored canopy red pine was estimated to be over 170 years old. Three scars were noted on one of the overstory red pines and several fire-scarred stumps exhibited three to four fire scars. Adjacent stands are younger and have a history of forestry treatments, primarily thinning. The forest understories have a prevalence of red maple, white pine, and balsam fir. The low shrub layer is dominated by low sweet blueberry and huckleberry.

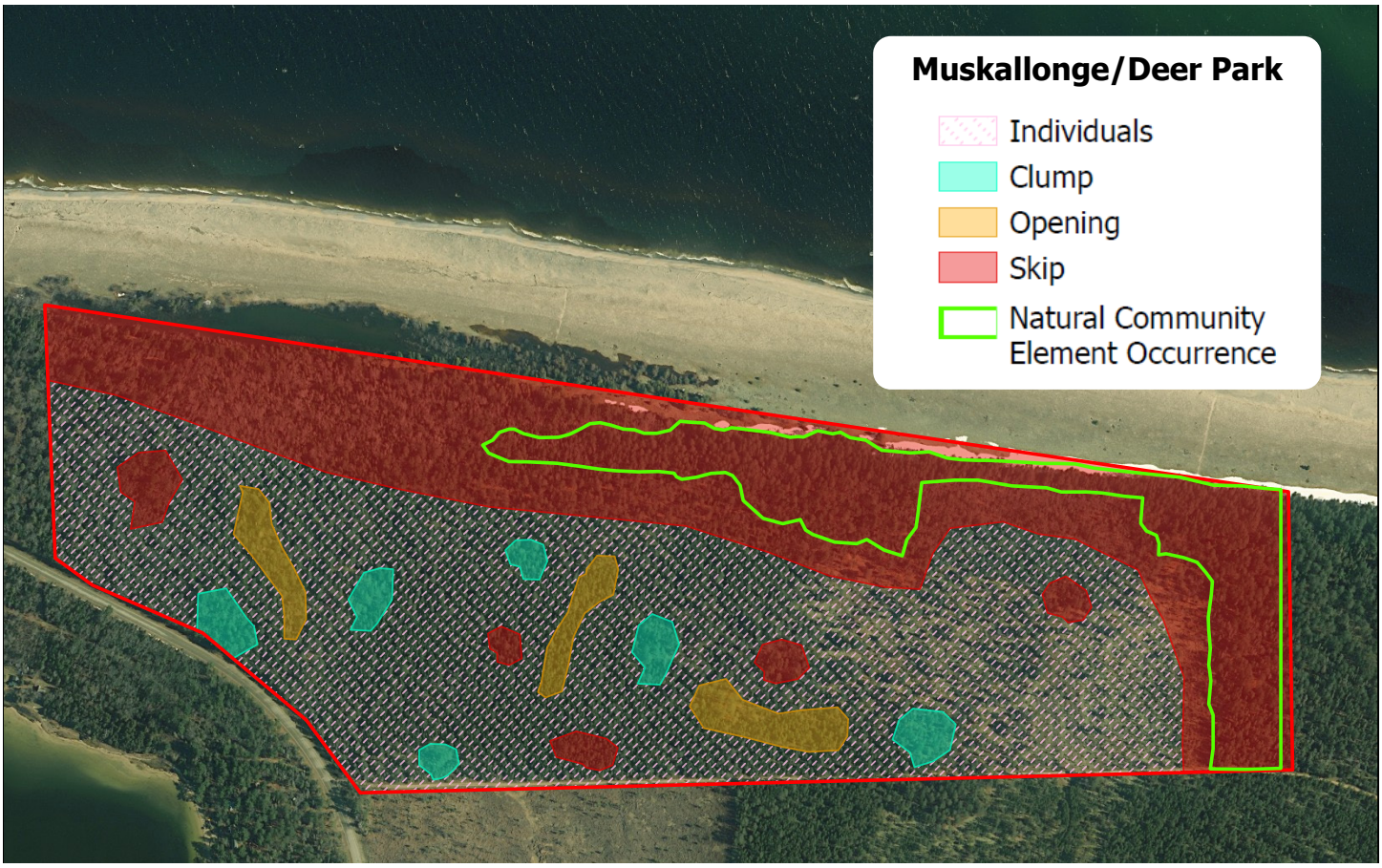
Management Recommendations
The site likely needs only a single fire to set back the mesophytes in the understory, and we recommend this be applied prior to a timber harvest. The burn should be low-severity to prevent damage to the existing red pine regeneration and applied during the late summer or fall during a red pine mast year with the goals of reducing leaf litter and mesophotic species in the understory. We recommend avoiding timber harvests within the mapped high-quality forest, developing *Opening* zones on away from Lake Superior and thinning the *Individuals* zone by 1/3 BA following the fire. Treatments should avoid steep slopes above the lakeshore where wide no-cut buffers should be established. Within 5 to 10 years of thinning, we recommend applying a low severity/ low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. Surveys for invasive species should be conducted along roads and trails.



Location of Muskallonge/Deer Park Project Area (Compartment 42011).



Muskallonge/Deer Park Project Area. Photo by J.G. Cohen.

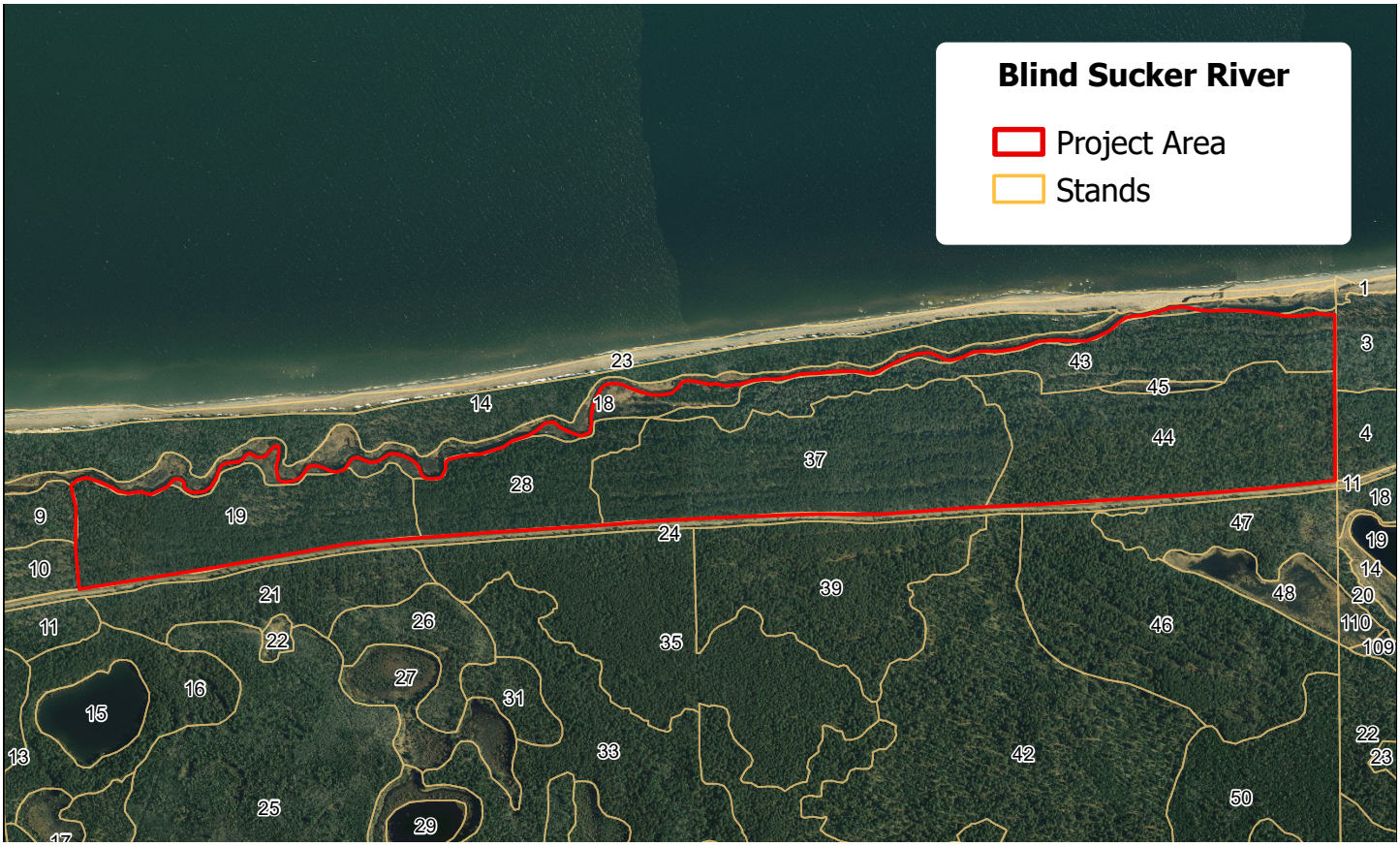


ICO Management zones for Muskallonge/Deer Park Project Area (Compartment 42011).

3. Blind Sucker River
Location: Compartment 42011, Stands 44, 43, 37, 19, 28, and 14
Size: 258 acres
Community type: dry to dry-mesic northern forest

This Project Area consists of several stands along the Blind Sucker River and Lake Superior. There were several small wetland inclusions and zones of relatively high-quality forest, particularly in Stand 43 and along the Blind Sucker River. These stands are dominated by natural red pine and occur on undulating dune ridges. There is generally very little natural red pine regeneration. There are concentrations of old trees along the river with some estimated to be over 300 years old. A 22-inch red pine in Stand 19 was cored and estimated to be over 210 years old. Stand 19 is classified as a plantation but there is also natural pine throughout, and an intact ground layer compared to other plantations. The North Country Trail occurs along the Lake Superior shoreline and the visibility of this Project Area, its proximity to Lake Superior, and the Blind Sucker River make this an ideal Project Area to attempt more holistic management approaches.

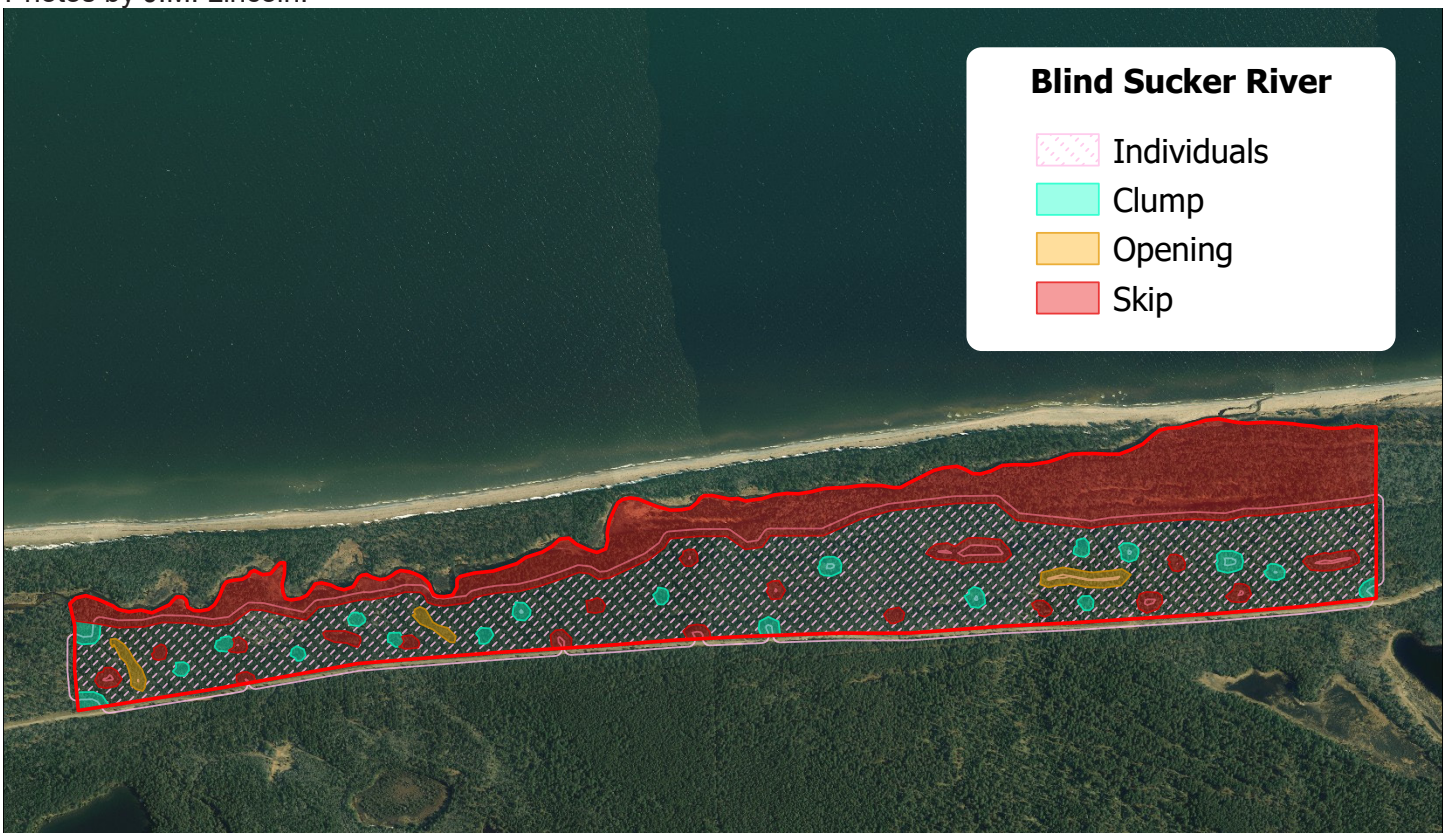
Management Recommendations
The site likely needs only a single fire to set back the mesophytes in the understory, and we recommend this be applied prior to a timber harvest. We recommend applying a low-severity/low-intensity burn across the entire Project Area, using existing features as burn breaks, particularly the Blind Sucker River. Allow fire to burn into the river and other wetlands. The burn should be applied during late summer or fall and applied during a red pine mast year. The goals of the burn are to reduce leaf litter, remove lower branches of understory trees, avoid mortality of canopy trees, and promote natural red pine regeneration. We recommend harvesting *Openings* zones and thinning the *Individuals* zone by 1/3 BA following the fire, though Stand 37 has already been thinned and additional thinning should take place in subsequent treatments. Treatments should avoid steep dune ridges and wetland inclusions and a wide no-cut buffer should be established along the Blind Sucker River. Within 5 to 10 years of thinning, we recommend applying a low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. Retaining the oldest trees across the site and protecting fire-scarred living trees and stumps will facilitate the reconstruction of the site's fire history. Surveys for invasive species should be conducted along roads and trails.



Location of Blind Sucker River Project Area (Compartment 42011).



Left, Stand 37 has already been thinned and most regeneration is red maple and white pine. Right, Stand 19 has been identified as a plantation but there was characteristic vegetation and natural pines throughout. Photos by J.M. Lincoln.

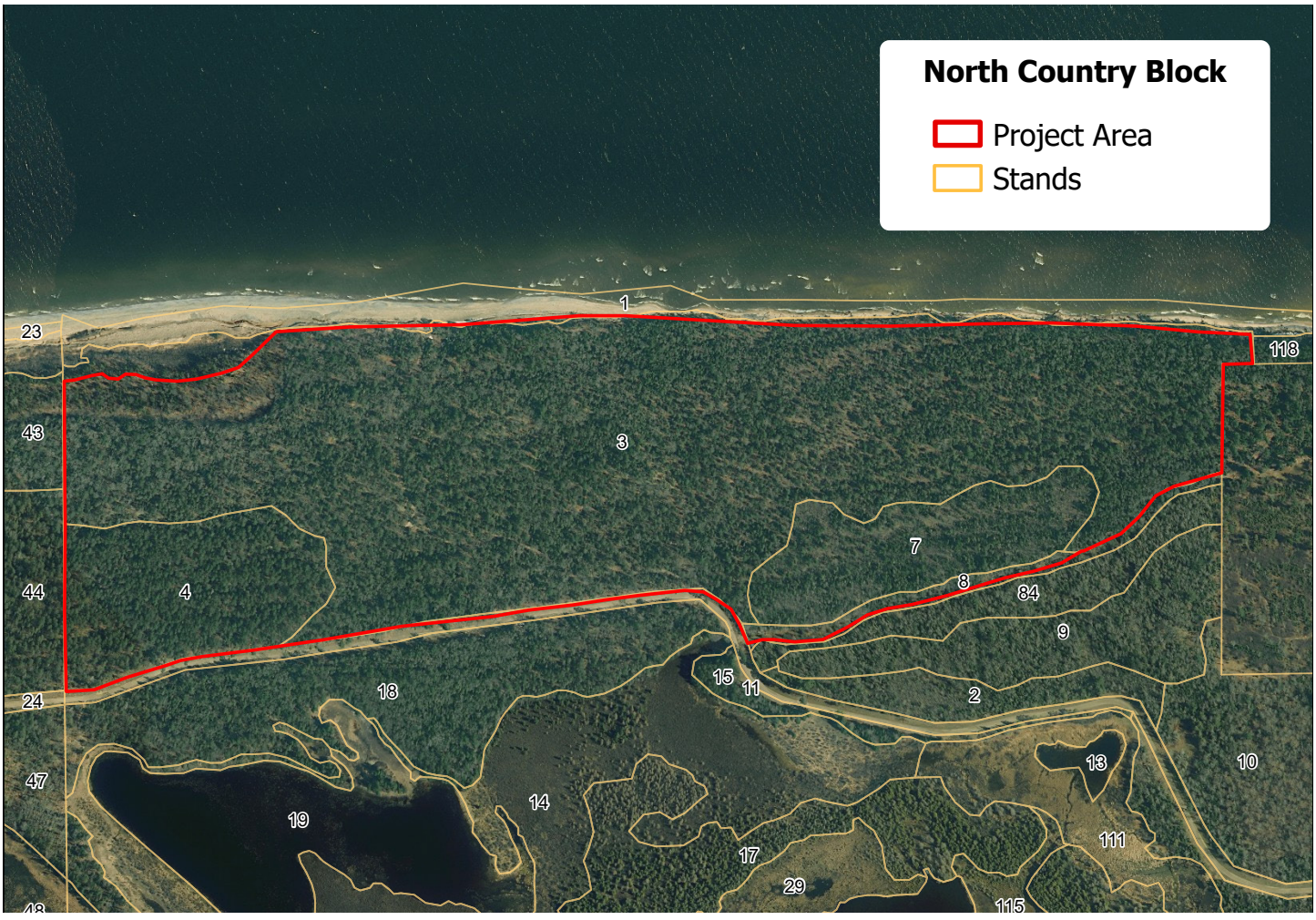


ICO Management zones for Blind Sucker River Project Area (Compartment 42011).

4. North Country Block
Location: Compartment 42017, Stands 3, 4, 7
Size: 153 acres
Community type: dry-mesic northern forest

This Project Area consists primarily of a large stand along Lake Superior. The site includes several parallel dune ridges and zones of high-quality forest, particularly near the lakeshore. The stand is a mix of natural red and white pine with red oak, birch and aspen throughout. This stand was thinned previously and there is a variable age structure with most red pine in the 60- to 90-year-old cohorts and a few trees along the shoreline around 120 years old. These stands are dominated by natural red pine and occur on undulating dune ridges. There is generally very little natural red pine regeneration. The North Country Trail occurs along the Lake Superior shoreline and the visibility of this Project Area along with its proximity to Lake Superior and steep topography make this an excellent Project Area for an ecological silviculture approach.

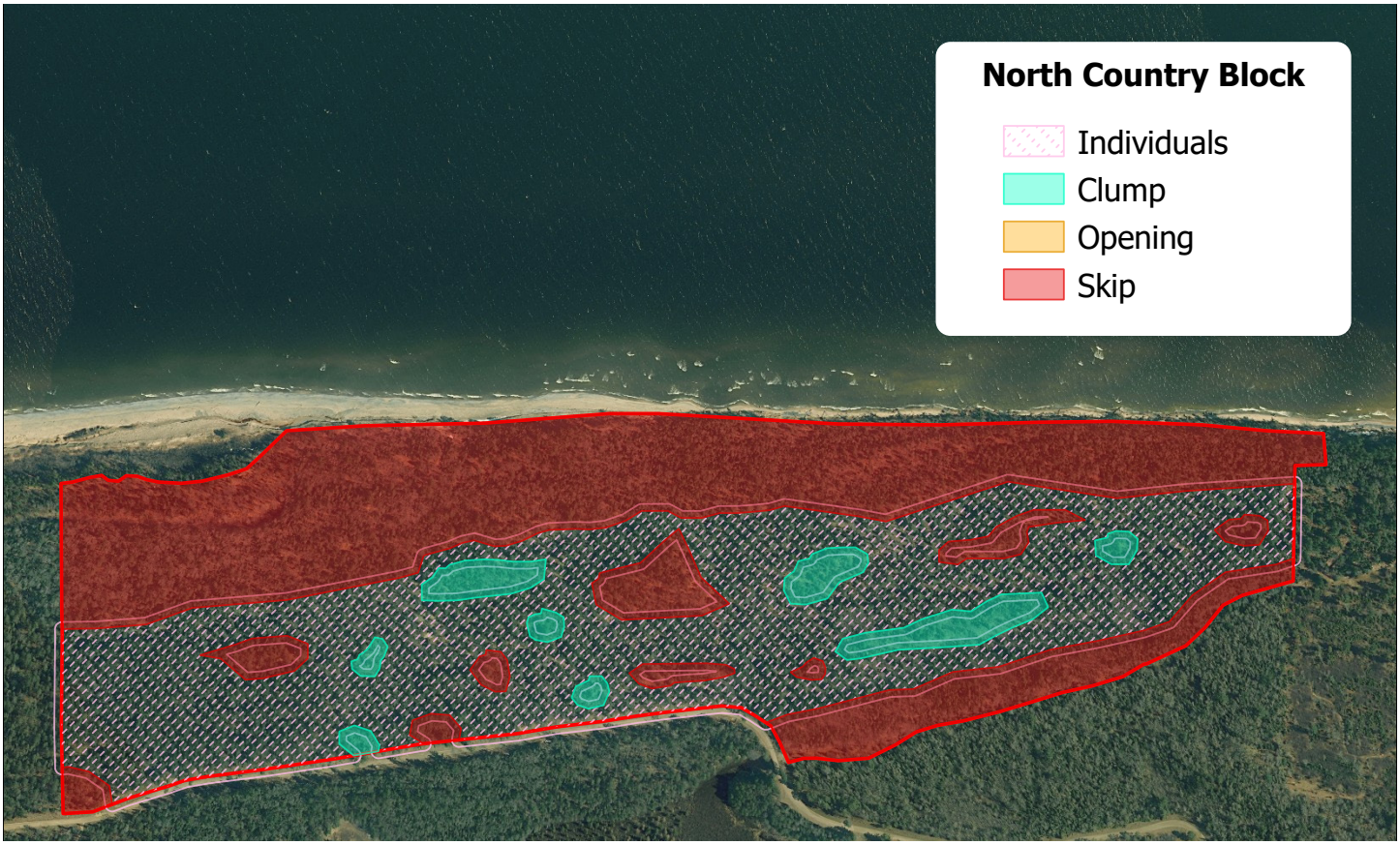
Management Recommendations
The understory is dense with mesophytes and we recommend applying two low-intensity fires across the entire Project Area, using existing features as burn breaks, particularly the Lake Superior shoreline, the road along the southern edge, and the North Country Trail along the eastern edge. The goals of the first burn are to reduce leaf litter, remove lower branches of understory trees, and avoid mortality of canopy trees. The second burn should be applied during the late summer or fall within 3 to 5 years of the first burn with the goals of further reducing leaf litter and mesophytic species in the understory. This second burn should be applied during a red pine mast year. We recommend thinning the *Individuals* zone by 1/3 BA following the second fire. Treatments should avoid steep dune ridges and provide a large no-cut buffer along wetland inclusions and Lake Superior. Within 5 to 10 years of thinning, we recommend applying a low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. Retaining the oldest trees across the site and protecting fire-scarred living trees and stumps will facilitate the reconstruction of the site's fire history. Surveys for invasive species should be conducted along roads and trails.



Location of North Country Block Project Area (Compartment 42017).



Stand 3 has natural red pine in the canopy but the understory is dominated by red oak, red maple, and white pine. Photo by J.M. Lincoln.

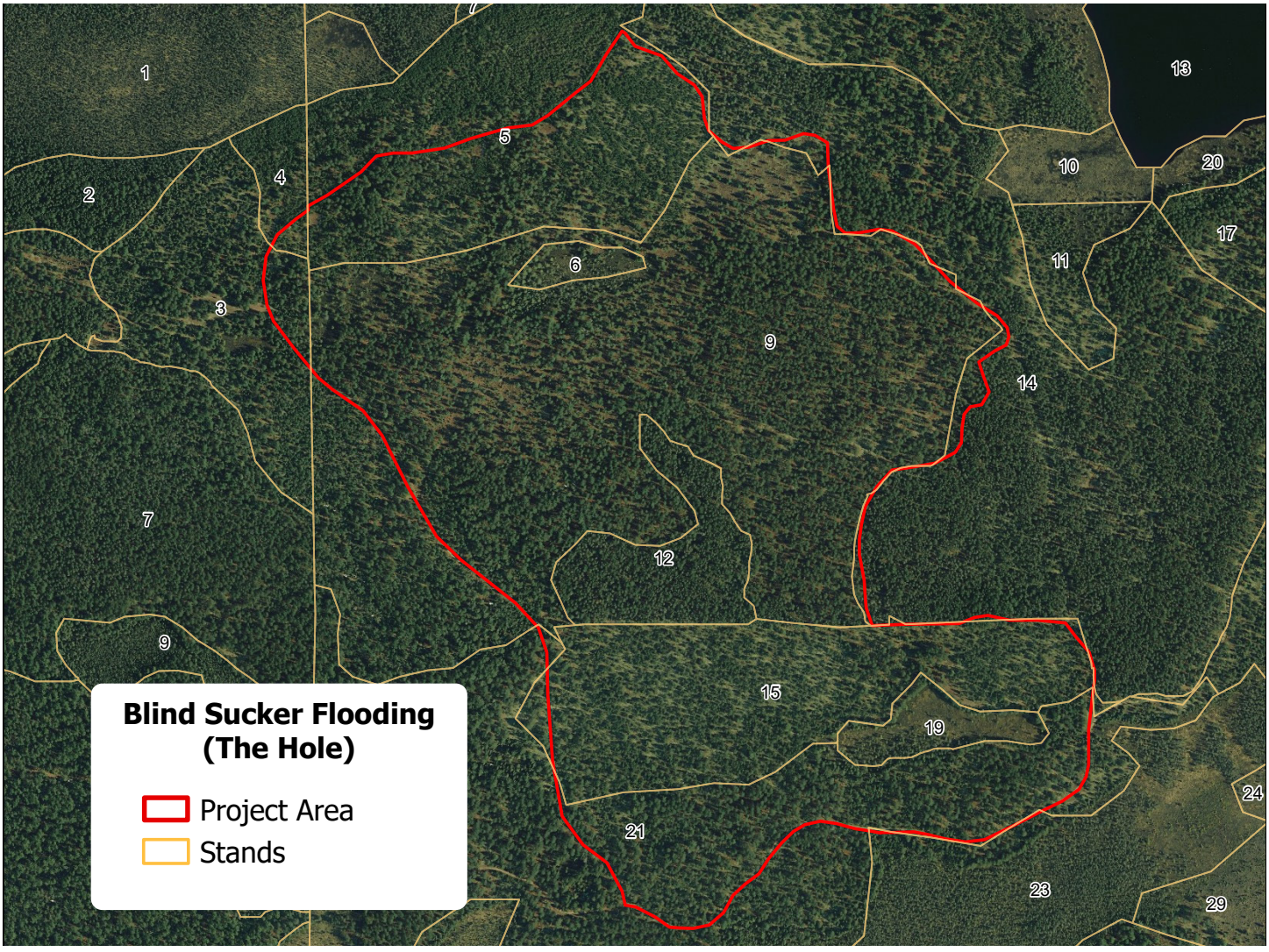


ICO Management zones for North Country Block Project Area (Compartment 42017).

5. Blind Sucker Flooding (The Hole)
Location: Compartment 42005, Stands 9, 21, 15, 5, 19, 12
Size: 223 acres
Community type: dry northern forest

Stand 9 is the primary focal area of this Project Area and encompasses a stand of natural red pine with multiple age classes. The canopy cohort is primarily 80 years old but about 2% of the canopy red pine are around 200 years old. White pine is local in the canopy and jack pine is infrequent. There is consistent natural red pine regeneration throughout with white pine, jack pine, and spruce occurring at medium to low density. Low bush blueberry and huckleberry are prevalent throughout. The site has been thinned but is of an ideal structure, age distribution, and landscape context to attempt the ICO approach.

Management Recommendations
The site likely needs only a single fire to set back the mesophytes in the understory, and we recommend this be applied prior to the next timber harvest. We recommend applying a low-severity/low-intensity burn across the entire Project Area, using existing roads as burn breaks and allowing fire to burn into wetlands. The burn should be applied during late summer or fall and applied during a red pine mast year. The goals of the burn are to reduce leaf litter, remove lower branches of understory trees, avoid mortality of canopy trees, minimize mortality of red pine saplings, and promote natural red pine regeneration. We recommend harvesting *Openings* zones and thinning the *Individuals* zone by 1/3 BA following the fire. Treatments should avoid wetland inclusions. Within 5 to 10 years of thinning, we recommend applying another low-severity/low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. Retaining the oldest trees across the site and protecting fire-scarred living trees and stumps will facilitate the reconstruction of the site's fire history. Surveys for invasive species should be conducted along roads and trails.

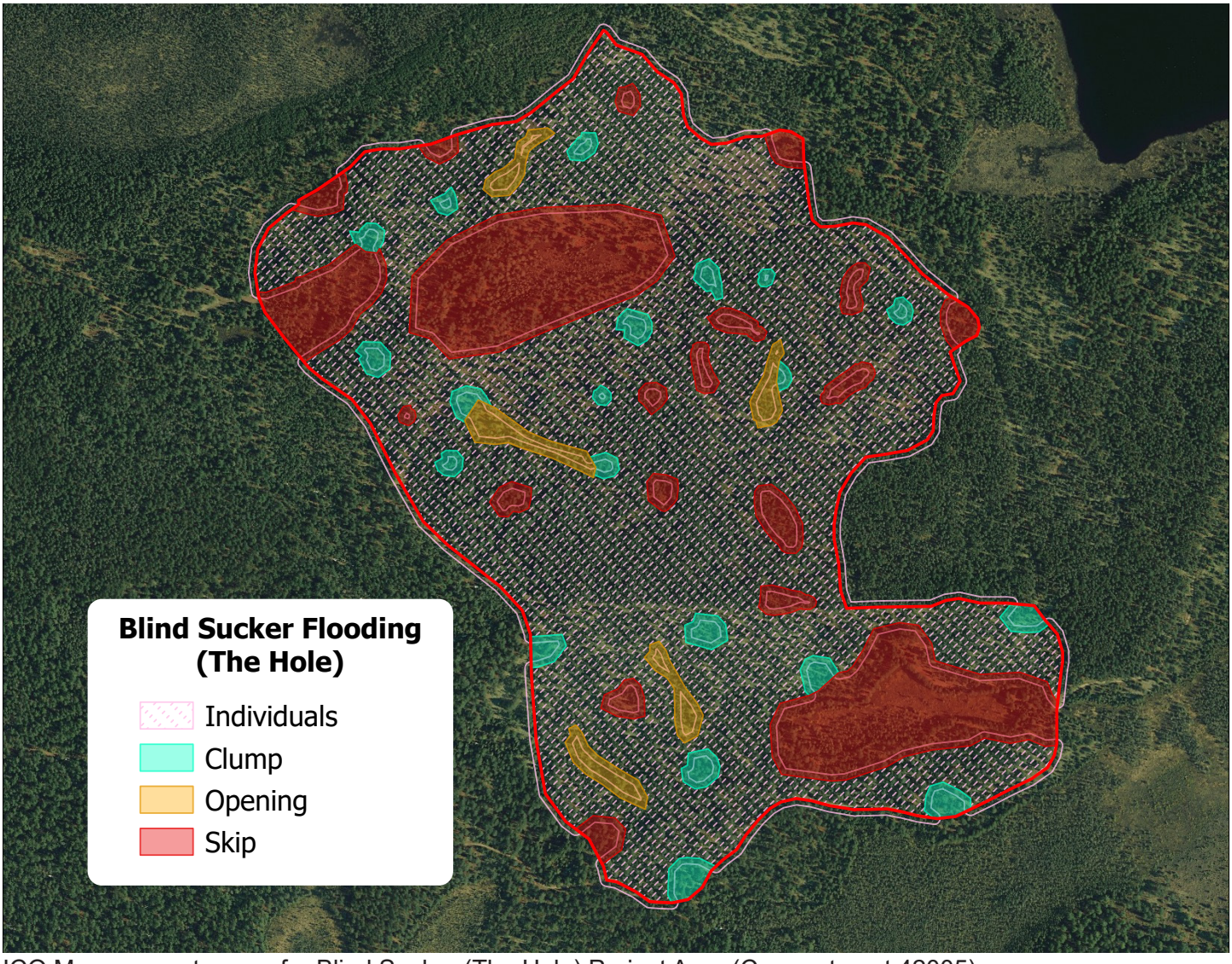


Location of Blind Sucker Flooding (The Hole) Project Area (Compartment 42005).





There were several trees in the 170 to 200 year old cohort throughout stand 9, many had fire scars indicating multiple burns. These should be retained during a timber harvest and a fire history should be conducted for this site. Photos by J.M. Lincoln.

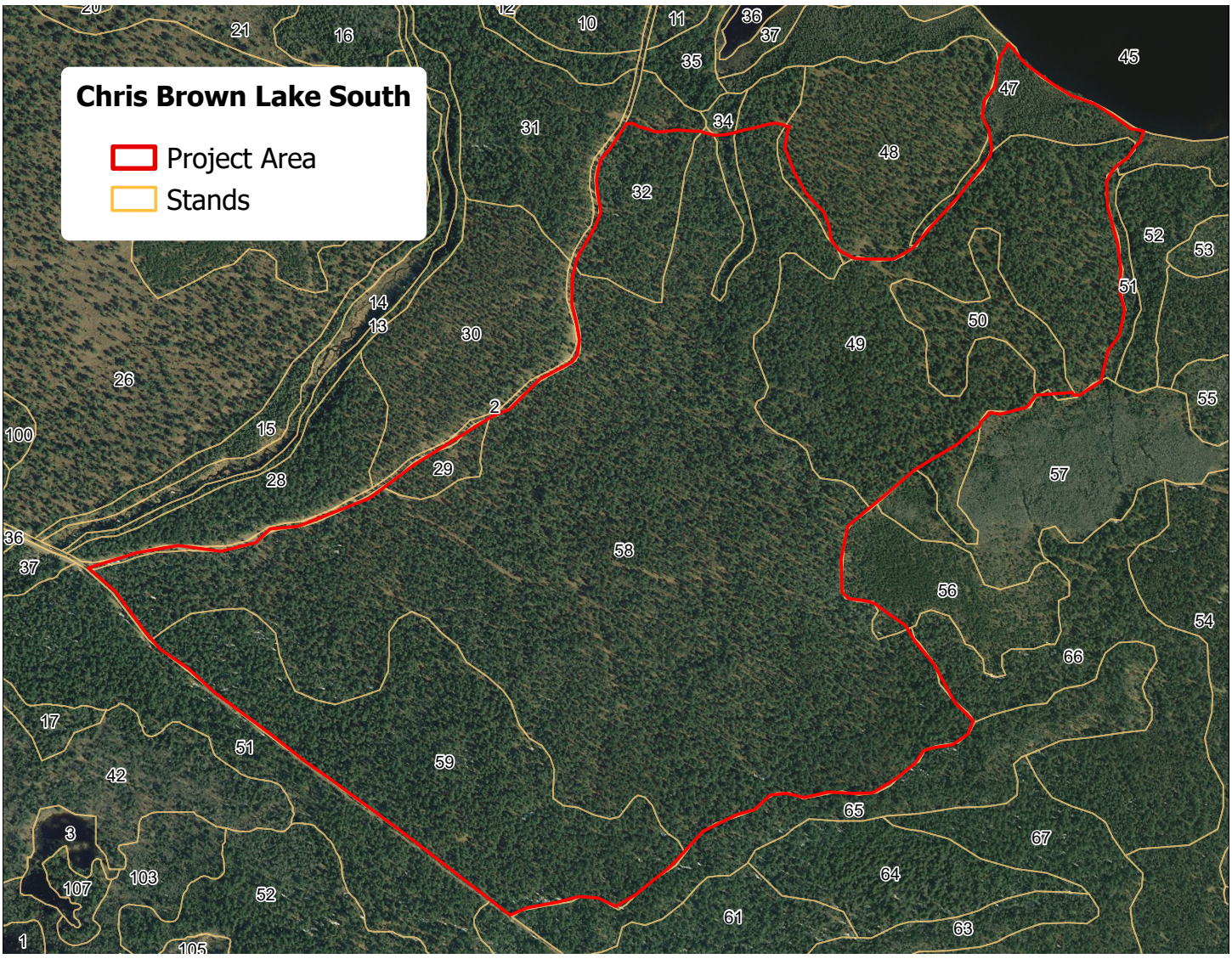


ICO Management zones for Blind Sucker (The Hole) Project Area (Compartment 42005).

6. Chris Brown Lake South
Location: Compartment 42031, Stands 58, 49, and 59.
Size: 369 acres
Community type: dry-mesic northern forest

This Project Area encompasses a large forest of natural white and red pine around 105 years old. One individual red pine was 22 inches in dbh and had 129 rings but most appear to be in a cohort around 100 years old. While white pine is the dominant canopy species, red pine is prevalent in the canopy (up to 40%). However, the understory is dominated by white spruce, balsam fir, red maple, and white pine. Low sweet blueberry (*Vaccinium angustifolium*) is prevalent throughout. Stand 58 was thinned in 2010 and the BA is around 80 to 100.

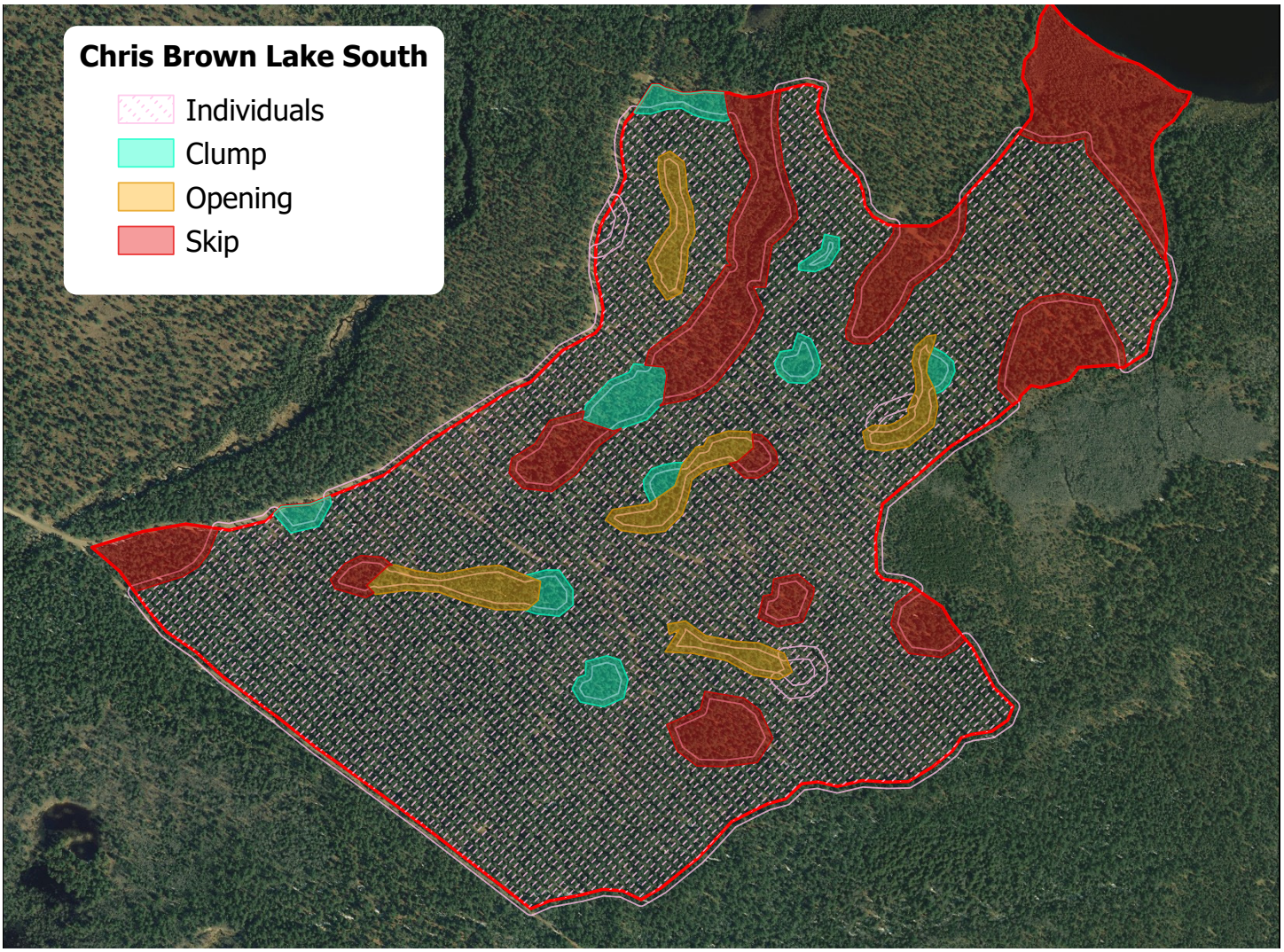
Management Recommendations
The site has been thinned in 2010 and there is patch red pine regeneration along old logging trails. A single, low-severity/low-intensity burn could likely be applied without additional mechanical intervention. We recommend using existing roads as burn breaks. The burn should be applied during the late summer or fall during a red pine mast year with the goals of reducing leaf litter, mesophytic species in the understory, and promoting red pine regeneration. A low-severity fire will have minimal impacts on the existing red pine regeneration. Following the fire, we recommend harvesting *Openings* zones and thinning the *Individuals* zone by 1/3 BA. Within 5 to 10 years of thinning, we recommend applying a low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. Surveys for invasive species should be conducted along roads and trails.



Location of Chris Brown Lake South Project Area (Compartment 42031).



The understory of Stand 58 is dominated by white pine and white spruce. Red pine regeneration occurs locally along old logging trails. Photos by J.M. Lincoln.



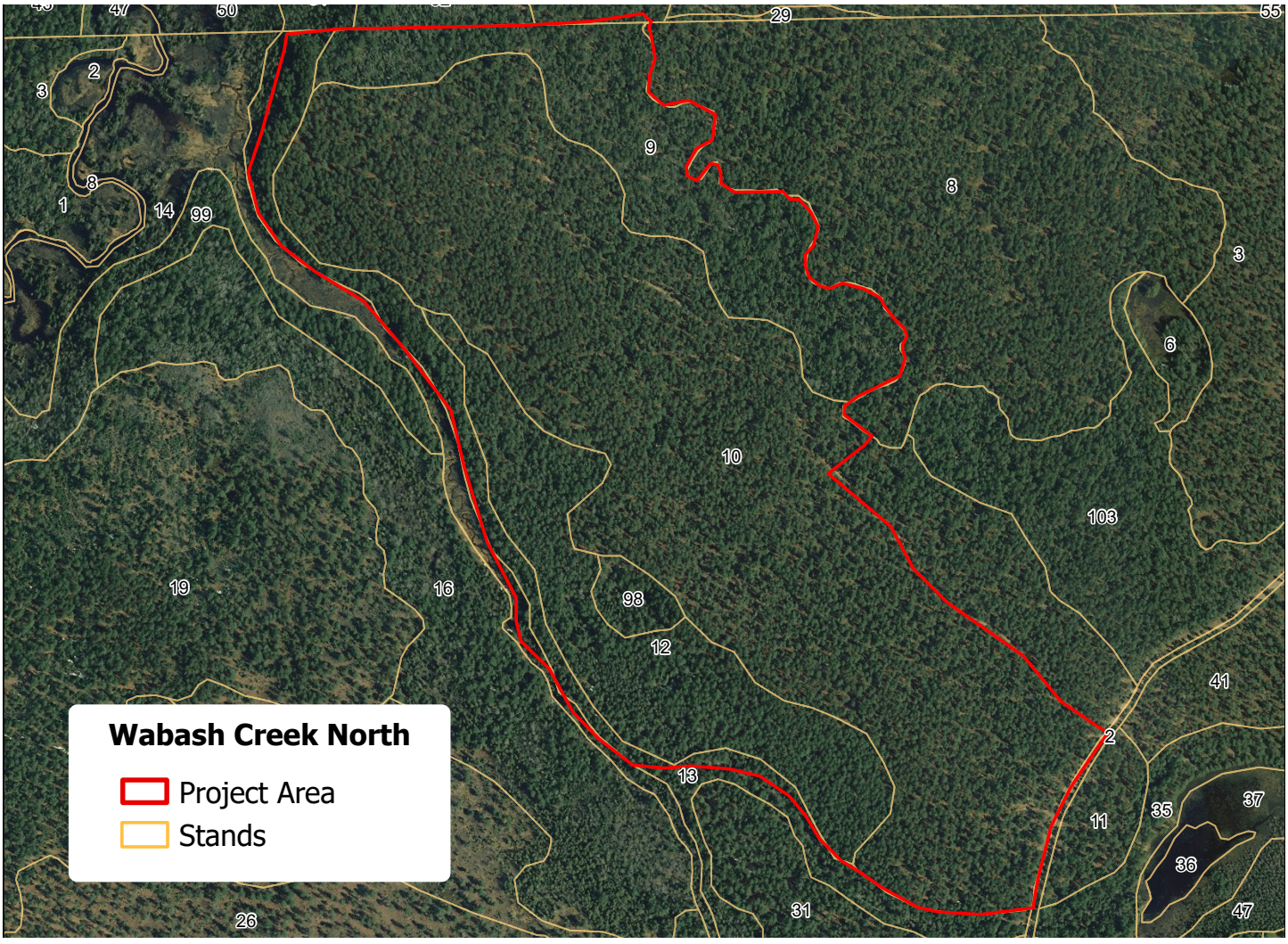
ICO Management zones for Chris Brown Lake South Project Area (Compartment 42031).

7. Wabash Creek North
Location: Compartment 42031, Stands 10, 9, 12
Size: 166 acres
Community type: dry-mesic northern forest

This Project Area consists of stands along the north side of Wabash Creek. Stands 10 and 9 are dominated by white pine with natural red pine occupying 15 to 25% of the canopy and red oak around 2% of the canopy. There is generally very little natural red pine regeneration across this proposed Project Area, with spruce, fir, red maple, and white pine dominating the understory. Huckleberry and low sweet blueberry also occur throughout the low shrub layer. The site was thinned in 2000 and there was between 100 and 120 BA. There are several zones of saturated soils in Stands 12 and 13 along Wabash Creek.

Management Recommendations
While it would be preferable to apply a prescribed fire prior to timber harvest, the dense canopy and understory will make it difficult to get fire to carry through the stand before a thinning. If a thinning takes place prior to the fire, we suggest leaving most red oaks and red pine to promote red pine regeneration.

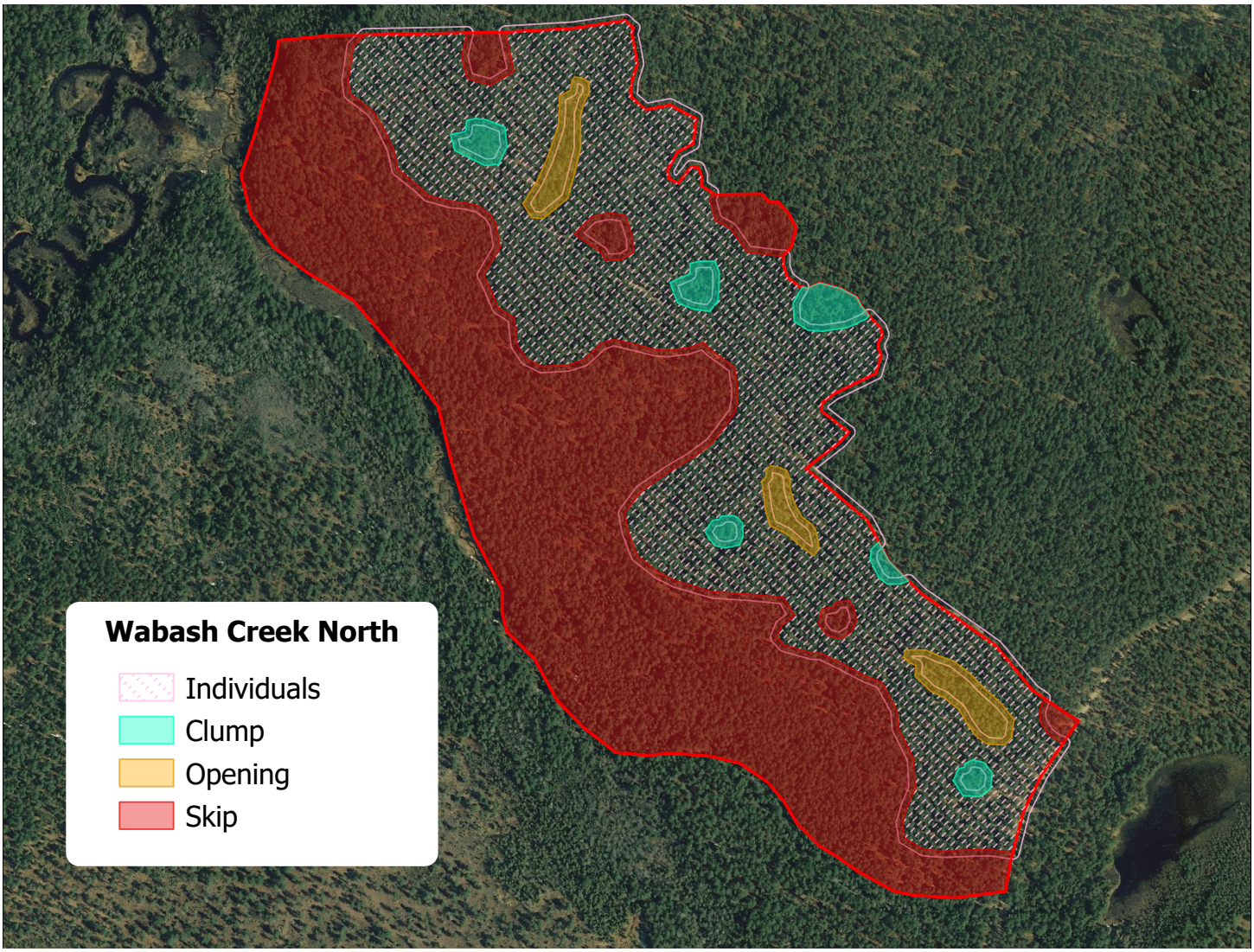
We recommend harvesting *Openings* zones and thinning the *Individuals* zone by 1/3 BA. Treatments should avoid steep slopes above the valley and wetland inclusions, and wide no-cut buffers should be established along the Wabash Creek and other wetland inclusions. Within 3 to 5 years of thinning, we recommend applying a low- severity/low-intensity fire using existing features as burn breaks, particularly Wabash Creek, a logging road that runs through Stand 10, and the stand boundary to the east along the road. The goal of the first burn is to condition the site by reducing leaf litter, removing lower branches of understory trees, avoiding mortality of canopy trees, and mitigating disease risks. We recommend applying a second low-severity/low-intensity fire, applied during the late summer or fall within 3 to 5 years of the first burn with the goals of further reducing leaf litter, duff, and mesophytic species in the understory. The second burn should be applied during a red pine mast year to promote red pine regeneration.



Location of Wabash Creek North Project Area (Compartment 42031).



The understory of Stand 10 is dominated by white pine, red maple, and white spruce. Photos by J.M. Lincoln.

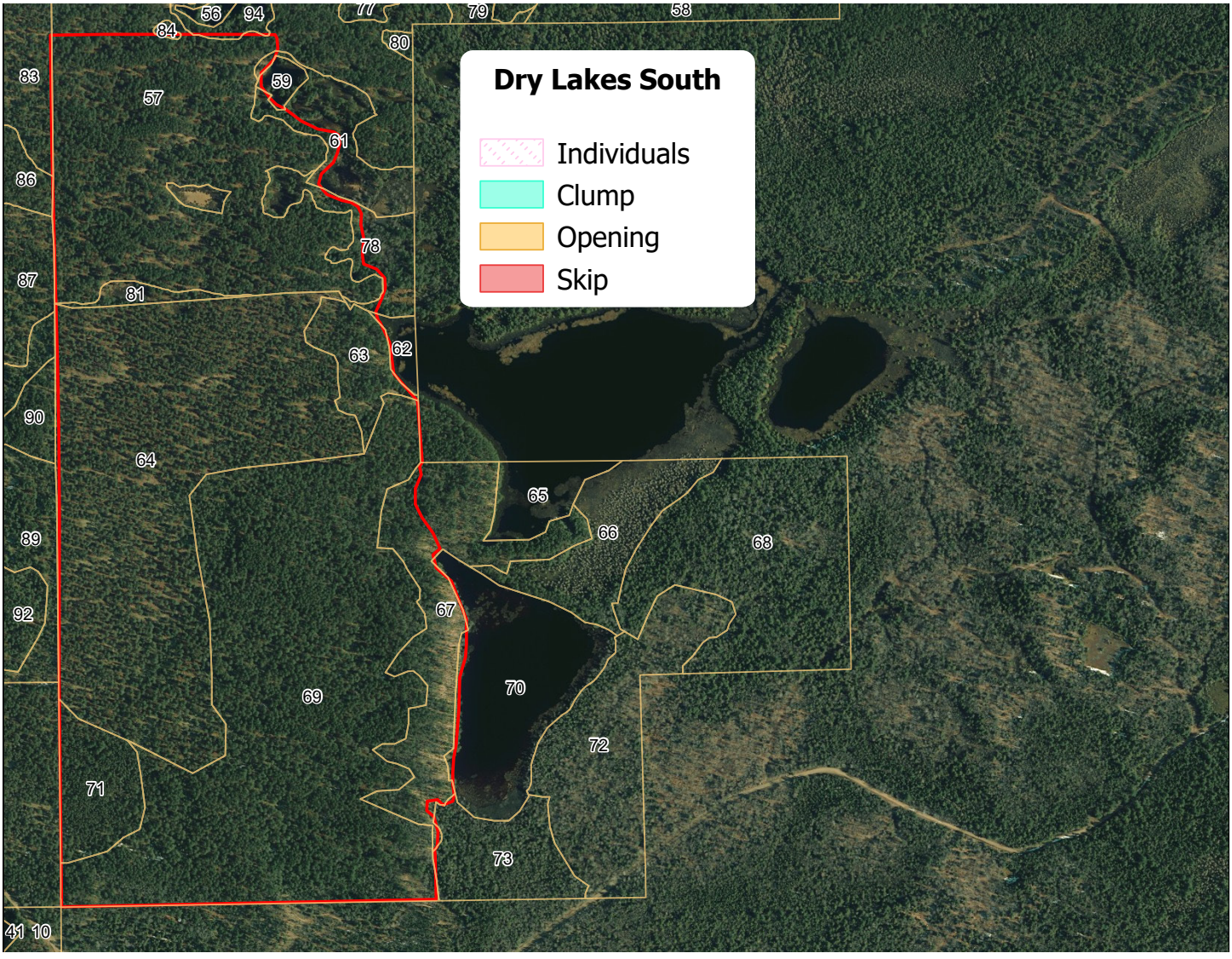


ICO Management zones for Wabash Creek North Project Area (Compartment 42031).

8. Dry Lakes South
Location: Compartment 42044, Stands 57, 63, 64, 67, and 69
Size: 251 acres
Community type: dry-mesic northern forest

This Project Area consists of several stands occurring south of the Dry Lakes recreational area and contains portions of the North Country Trail. The unit has a rolling landscape with sandy ridges and occasional shallow wetlands and has a park-like appearance of natural pine with little natural regeneration in the understory. The area was historically logged with the last harvest occurring in 1979. The canopy is red pine dominated with individuals consistently 15 to 20 inches in dbh and uneven aged. The oldest red pine recorded was estimated to be over 271 years old (19.5 in dbh). The canopy also had white pine, red oak, and the subcanopy density varied with the northern areas having little to no regeneration and southern areas having higher densities of seedlings and saplings of red oak, white pine, balsam fir, black spruce, jack pine, and red maple. The unit had evidence of historical fires visible as char on living red pine and stumps that had 2 to 3 fire scars. The unit is ideal for prescribed fire applications as the mature trees have been conditioned to fire and the unit is bordered by two-tracks and wetlands, and contains abundant historical logging trails, and single-track hiking trails.

Management Recommendations
We recommend applying two low-intensity fires across the entire Project Area. The goal of the first burn is to condition the site by reducing leaf litter, removing lower branches of understory trees, avoiding mortality of canopy trees, and mitigating disease risks. We recommend applying a second low-severity/low-intensity fire, applied during the late summer or fall within 3 to 5 years of the first burn with the goals of further reducing leaf litter, duff, and mesophytic species in the understory. The second burn should be timed to coincide with a red pine mast year to promote red pine regeneration. We recommend harvesting

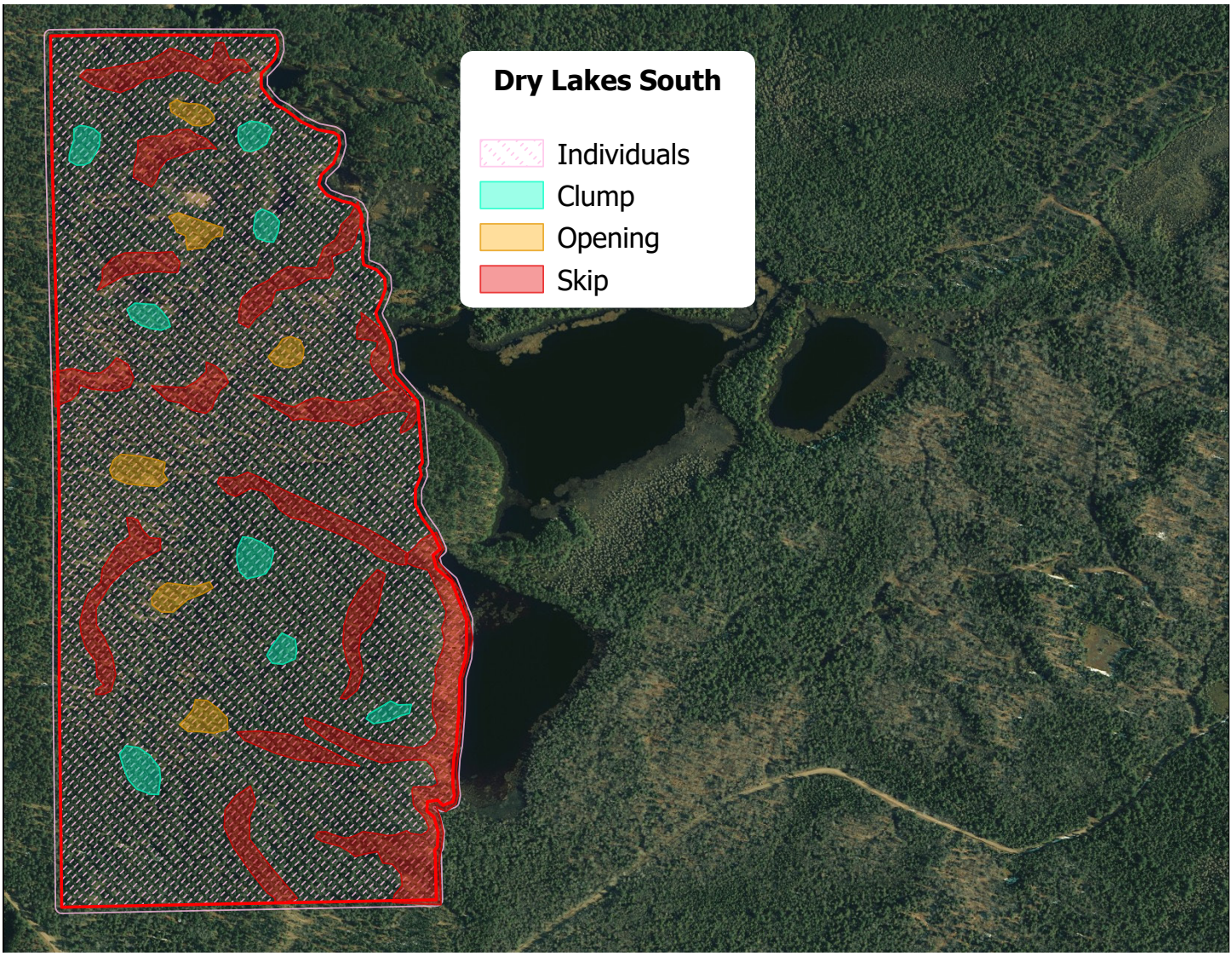


Location of Dry Lakes South Project Area (Compartment 42044).

Openings zones and thinning the *Individuals* zone by 1/3 BA following the second fire. Within 5 to 10 years of thinning, we recommend applying a low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. Retaining the oldest trees across the site and protecting fire-scarred living trees and stumps will facilitate the reconstruction of the site's fire history. Surveys for invasive species should be conducted along roads and trails.



Dry Lakes South Project Area. Photo by M.R. Parr.

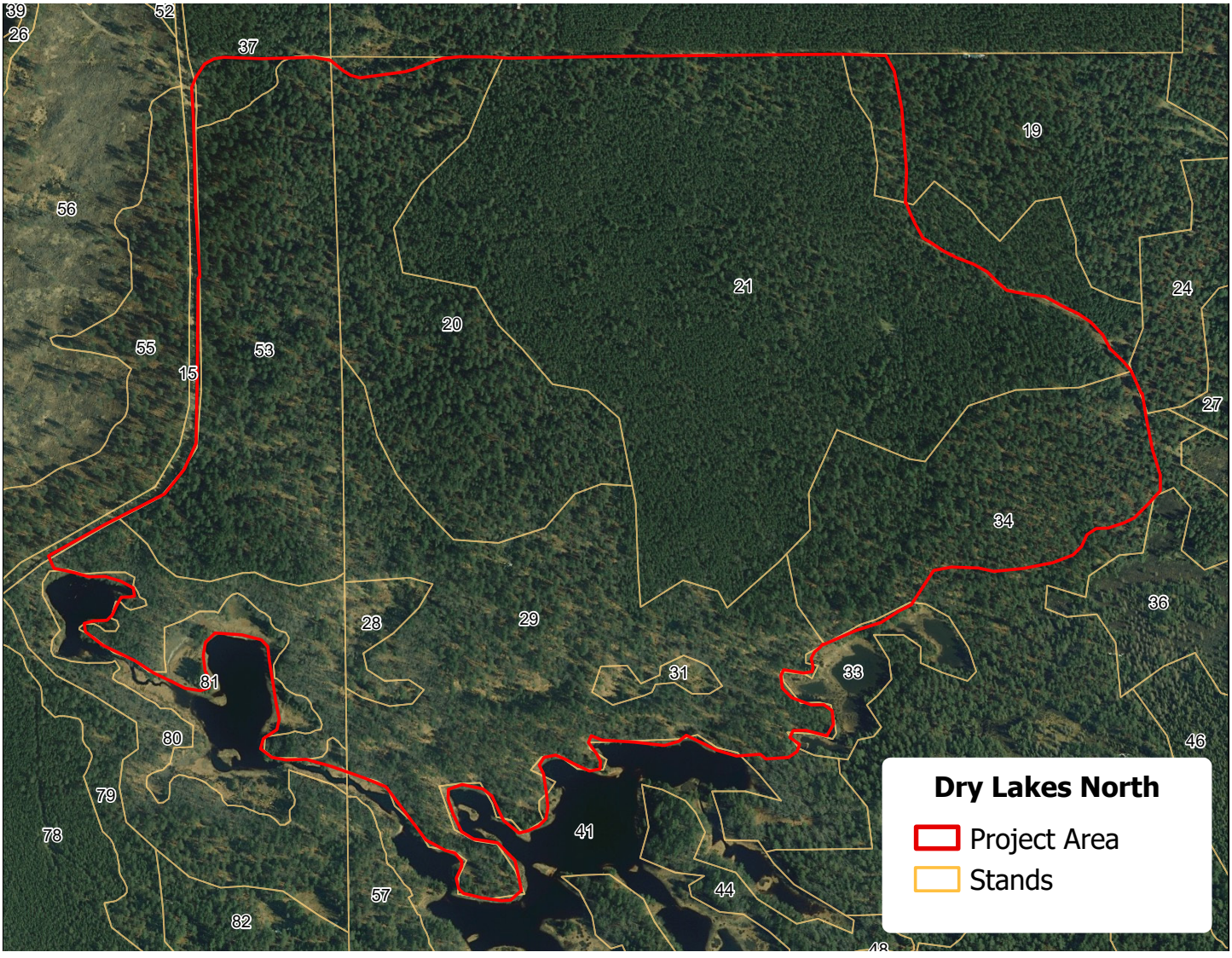


ICO Management zones for Dry Lakes South Project Area (Compartment 42044).

9. Dry Lakes North
Location: Compartment 42044, Stands 34, 21, 20, 28, 29, and S53 in C42040
Size: 216 acres
Community type: dry to dry-mesic northern forest

This Project Area consists of several stands occurring north of the Dry Lakes. The Project Area features sandy ridges and shallow wetlands with little natural red pine regeneration in the understory. Stand 53 in Compartment 42042 is a natural pine stand with approximately 75% red pine in the canopy, mostly in the 110- to 120-year-old age cohort. There is very little red pine regeneration, and the understory is dominated by white pine, beech and other mesophytic species. Nearby stands have been thinned and have ideal structure to implement ICO methodology. There are several zones of saturated soils, particularly along the wetlands known as Dry Lakes. The site is ideally situated for a natural pine project as there is extensive natural red pine, areas of sensitive habitat along wetlands and steep dunes, and the wetlands could serve as a natural burn break.

Management Recommendations
Some portions of the Project Area have already been thinned and it is possible that a single, low-severity/low-intensity burn could be applied to sufficiently promote red pine regeneration and reduce mesophytic competition. Stand 21 may need to have the jack pine harvested or mechanically treated prior to the first burn to decrease hazardous fuels. We recommend using existing features as burn breaks, especially existing roads and the margins of Dry Lakes. No-cut buffers should be established along the margins of the lake to protect the oldest cohort of red pine and prevent erosion on steep topography. The burn should be applied during the late summer or fall during a red pine mast year with the goals of reducing leaf litter, mesophytic species in the understory, and promoting red pine regeneration. Following

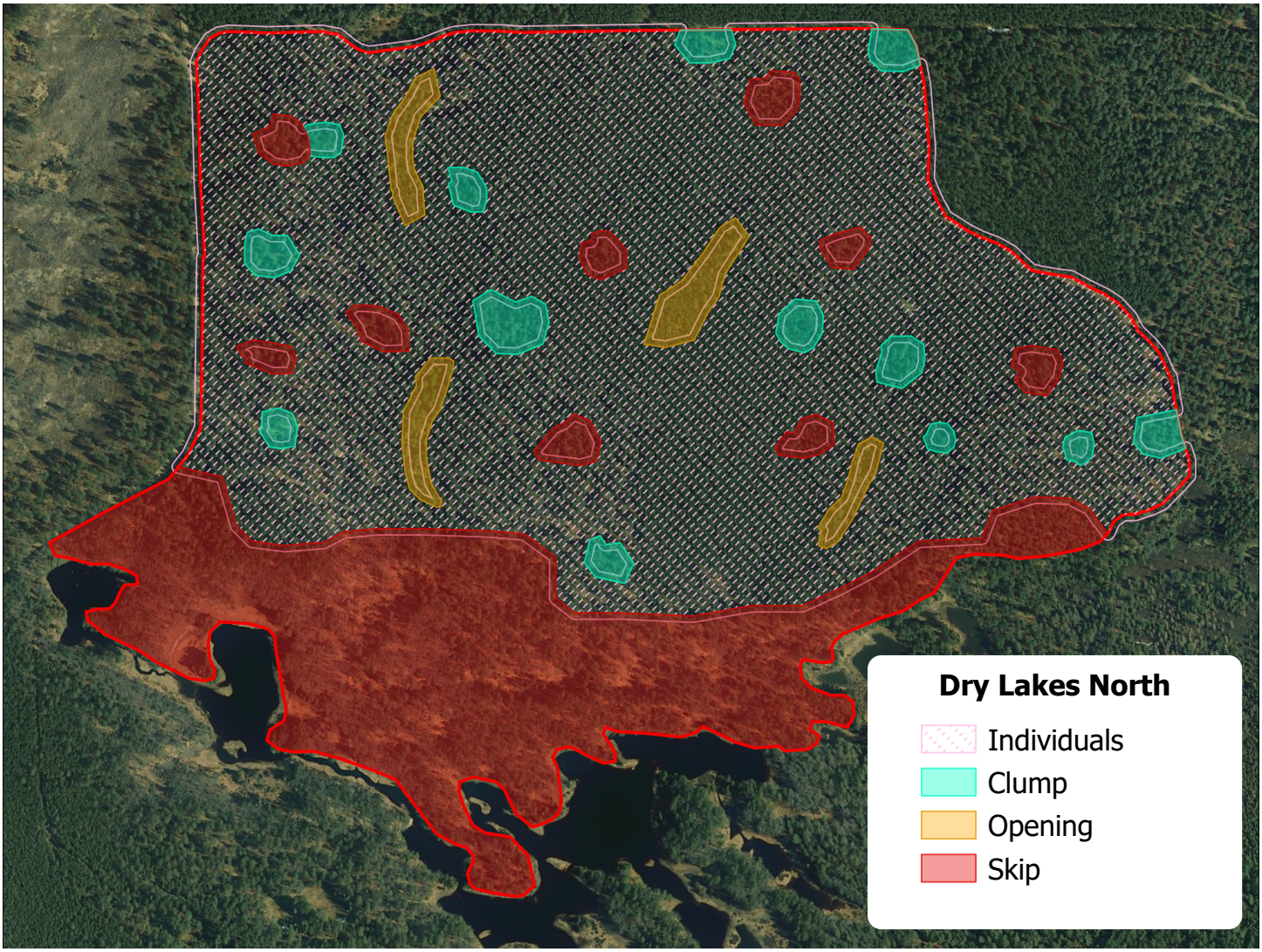


Location of Dry Lakes North Project Area (Compartment 42044).

the fire, We recommend harvesting *Openings* zones and thinning the *Individuals* zone by 1/3 BA. Within 5 to 10 years of thinning, we recommend applying a low-severity/low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. Retaining the oldest trees across the site and protecting fire-scarred living trees and stumps will facilitate the reconstruction of the site's fire history. Surveys for invasive species should be conducted along roads and trails. During low water years, ATVs are driving through the wetlands, and this dramatically increases the probability of introducing invasive species. We recommend closing off access to prevent further degradation of the wetlands.



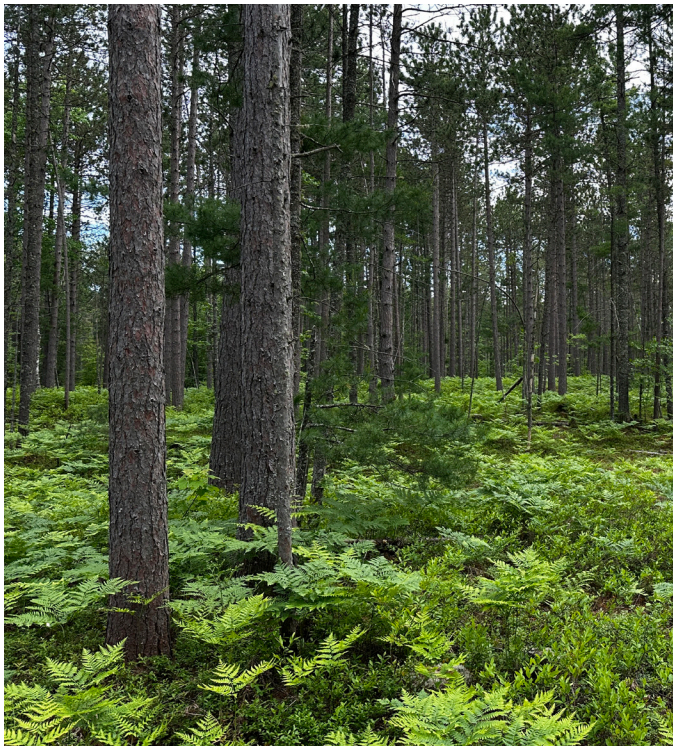
Dry Lakes North Project Area. Photo by J.M. Lincoln.



ICO Management zones for Dry Lakes North Project Area (Compartment 42044).

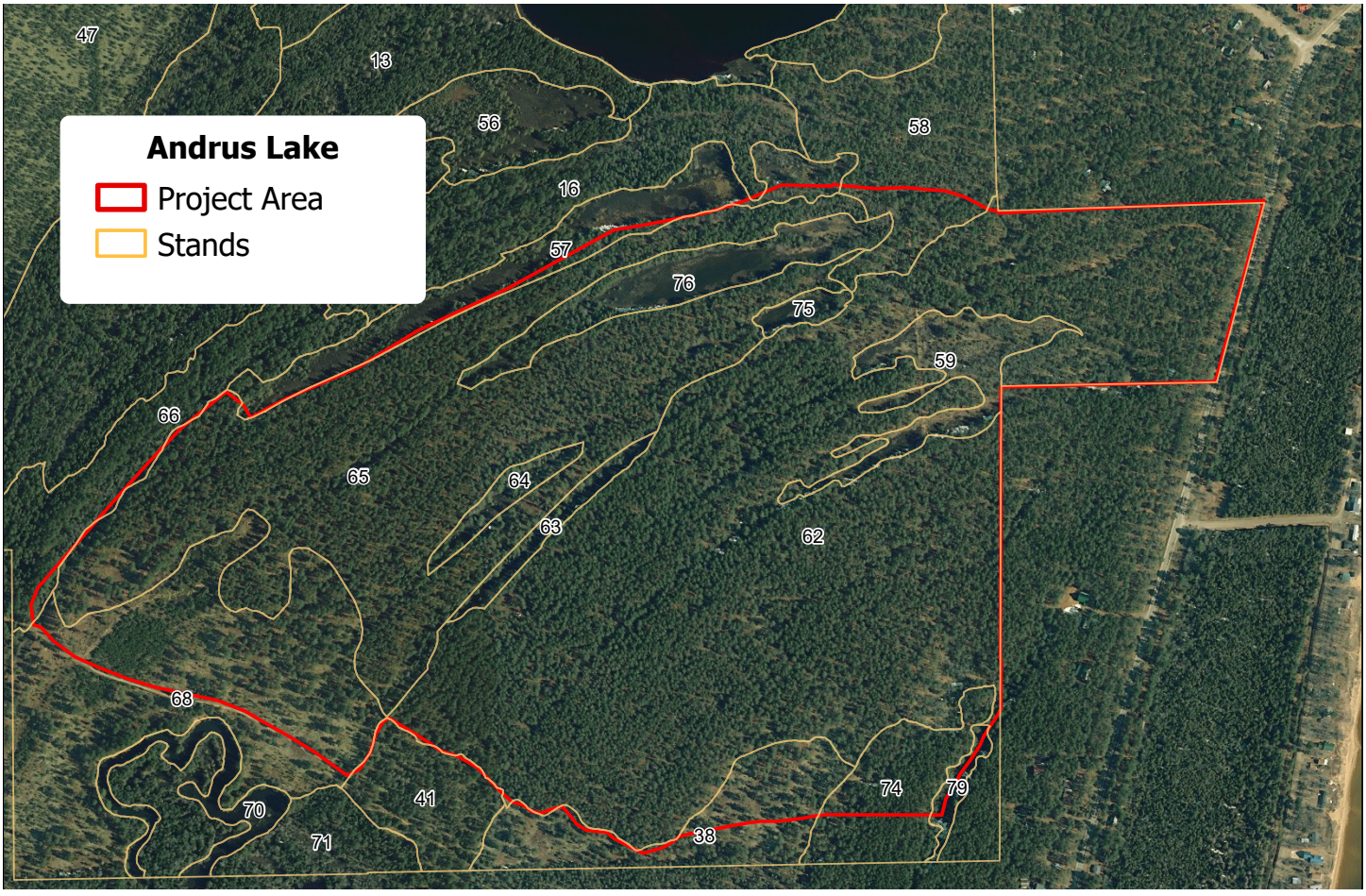
10. Andrus Lake
Location: Compartment 42067, Stands 62, 65
Size: 180 acres
Community type: dry-mesic northern forest

This Project Area is south of Andrus Lake and features stands dominated by natural red pine on subtle sandy ridges with bands of parallel wetlands between. Most of the canopy trees are in a cohort of 90- to 100-year-old trees. The site has already been thinned, the understory features white pine, red maple, and spruce at the margins of the wetlands. There is a dense undergrowth of huckleberry and low sweet blueberry and almost no red pine regeneration.



Andrus Lake Project Area. Photo by J.M. Lincoln.

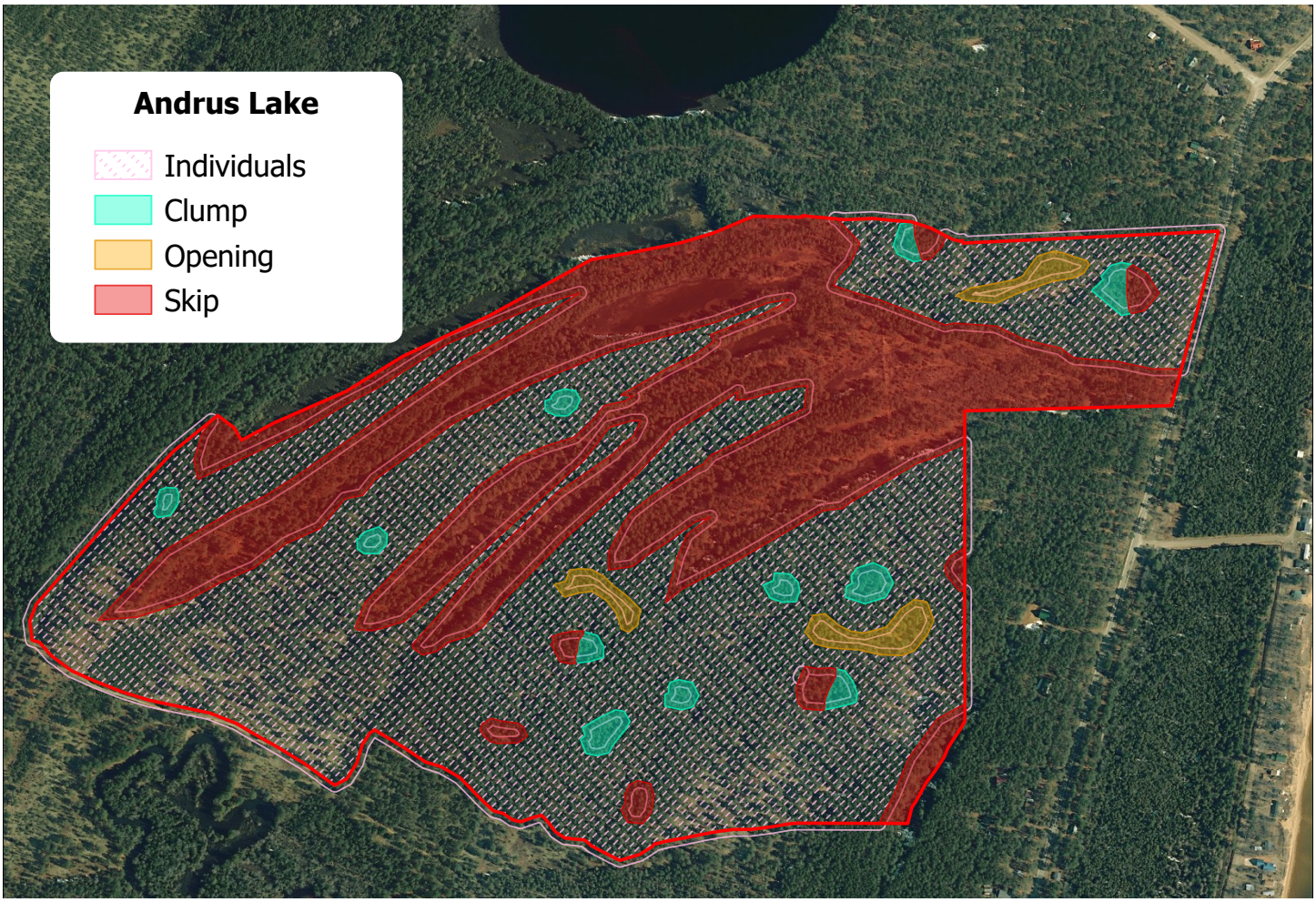
Management Recommendations
The understory is quite sparse and the site likely only would need a single burn to condition the site for red pine regeneration. The burn should be applied during the late summer or fall with the goals of reducing leaf litter and mesophotic species in the understory. This fire should be applied during a red pine mast year. We recommend developing *Opening* zones on ridges away from wetlands and thinning the *Individuals* zone by 1/3 BA following the fire. Within 5 to 10 years of thinning, we recommend applying a low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. We also recommend providing no-cut buffers along the wetlands and surveying for invasive species along roads and trails.



Location of Andrus Lake Project Area (Compartment 42067).



Andrus Lake Project Area. Photo by J.M. Lincoln.

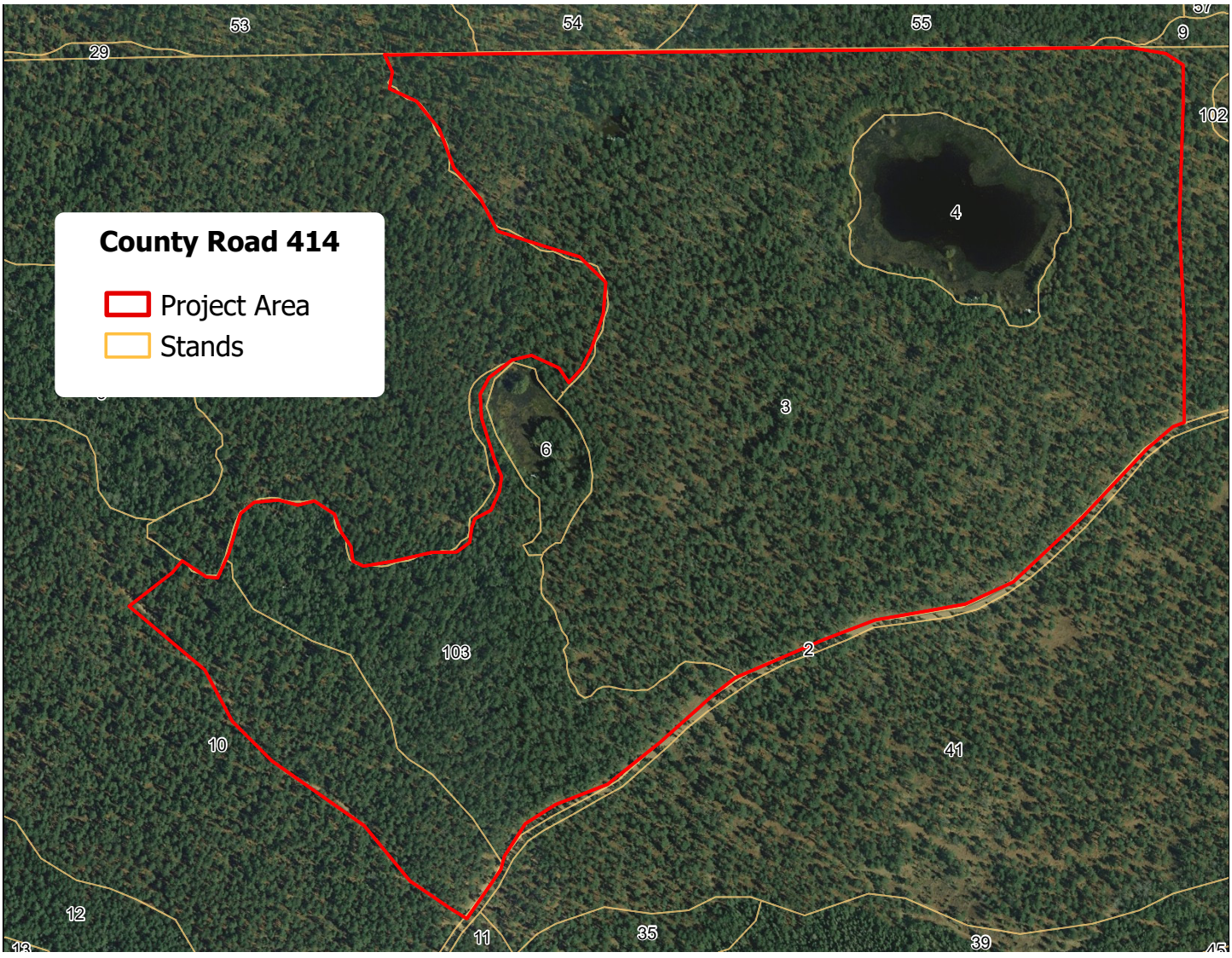


ICO Management zones for Andrus Lake Project Area (Compartment 42067).

11. County Road 414
Location: Compartment 42031, Stands 103, 3, and part of 10.
Size: 153 acres
Community type: dry-mesic northern forest

Stand 3 is dominated by red pine that are around 110 years old. The site has been thinned and scarified and there is almost no red pine regeneration. Stand 3 surrounds a small wetland in Stand 4 with relatively high-quality bog along its margins. Stand 103 has 100 BA and is predominantly white pine with red pine comprising approximately 25% of the canopy. It has been thinned but the understory is dominated by white spruce, balsam fir, red maple, and white pine and very little red pine.

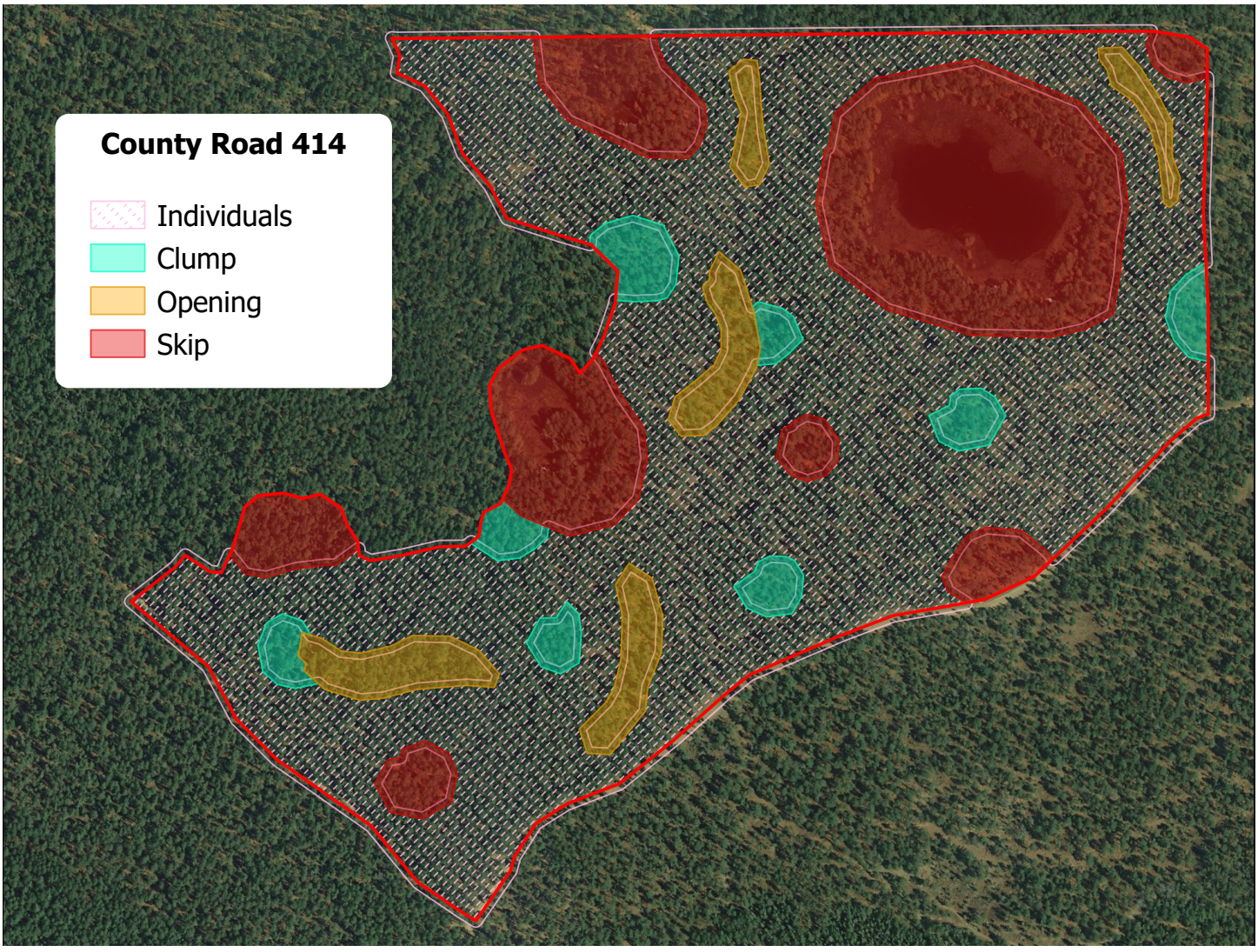
Management Recommendations
We recommend applying a single low-intensity fire across the entire Project Area, using existing features as burn breaks, especially existing roads and trails. The fire should be allowed to burn to the margins of the wetland in Stands 4 and 6 and no-cut buffers should be established along the margin of the wetland in Stand 4. The burn should be applied during the late summer or fall during a red pine mast year with the goals of reducing leaf litter, mesophytic species in the understory, and promoting red pine regeneration. If there is sufficient red pine regeneration following the initial burn, we recommend harvesting *Openings* zones and thinning the *Individuals* zone in Stands 10 and 103 by 1/3 BA, Stand 3 has been recently thinned and the Openings zones are likely the only areas in that Stand that warrant harvesting in the next harvest treatment. Within 5 to 10 years of thinning, we recommend applying a second low-intensity fire to mitigate disease risks and reduce mesophytic competition. Surveys for invasive species should be conducted along roads and trails.



Appendix 31. Location of County Road 414 Project Area (Compartment 42031).



County Road 414 Project Area. Photo by J.M. Lincoln.

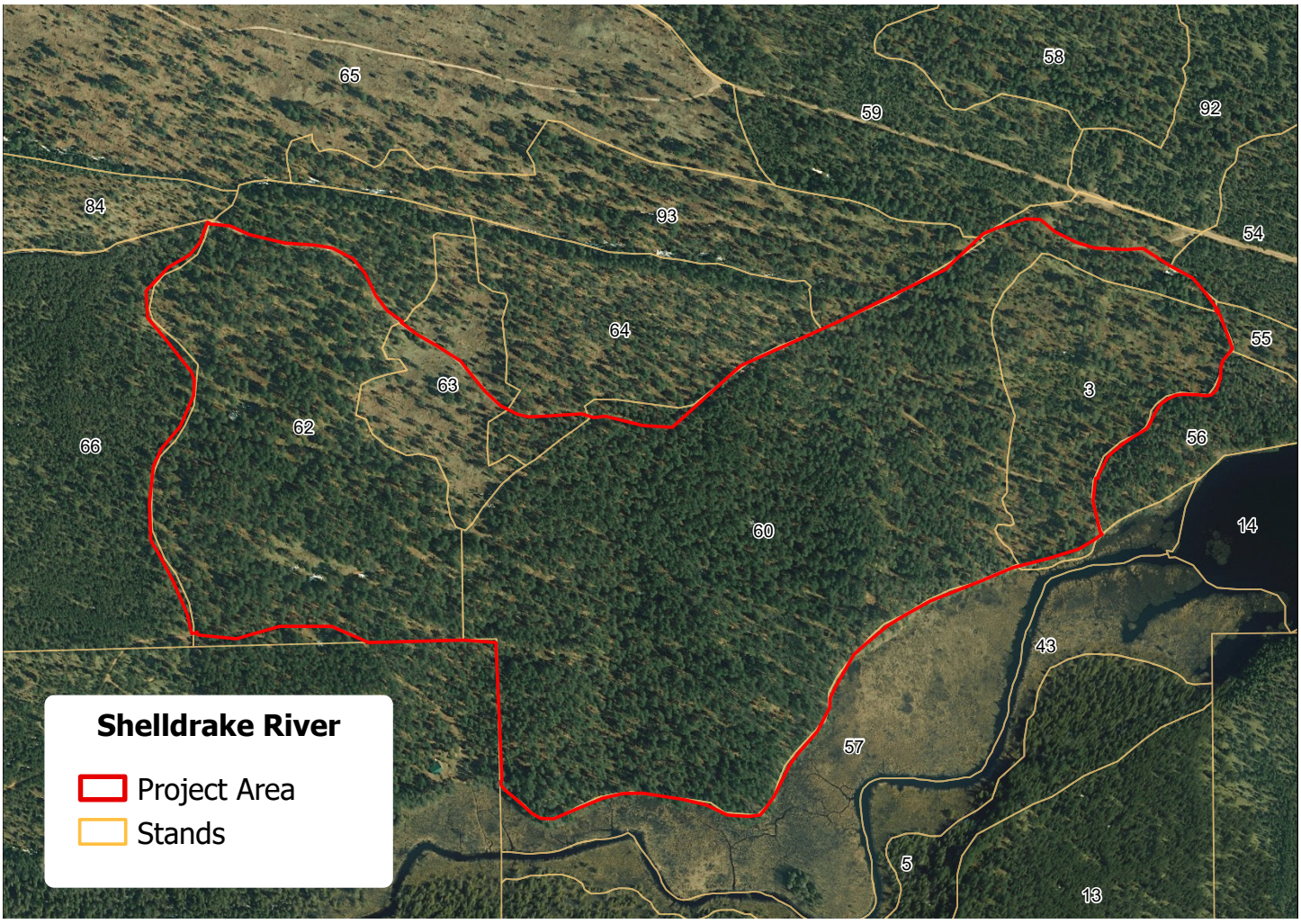


ICO Management zones for County Road 414 Project Area (Compartment 42031).

12. Sheldrake River
Location: Compartment 42054, Stands 60, 62, and 3
Size: 114 acres
Community type: dry-mesic northern forest

This Project Area consists of several stands occurring along the Shelldrake River and Vermillion Road. The stand consists of a red pine–dominated canopy with trees consistently 85 to100 years old (12-16 in dbh) with occasional old trees. One 20-inch red pine was estimated to be over 195 years old. Other canopy associates include white pine and red oak with white spruce, white pine, paper birch, red maple, and occasional red pine in the understory. The site contains abundant logging trails, perimeter roads, and wetlands that can function as burn breaks.

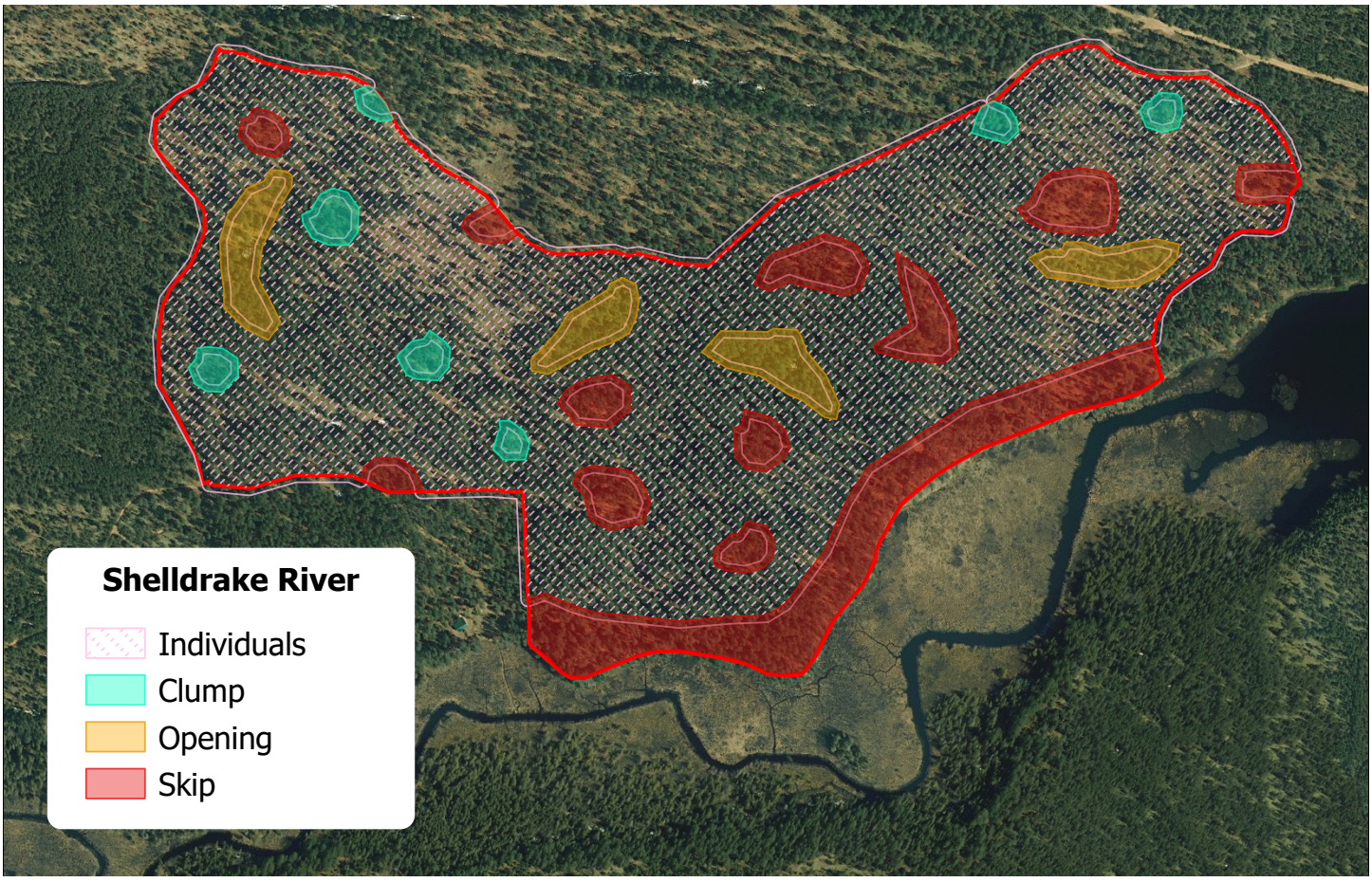
Management Recommendations
Some portions of the Project Area have already been thinned and it is possible that a single, low-severity/low-intensity burn could be applied to sufficiently promote red pine regeneration and reduce mesophytic competition. Stand 62 may need to have the jack pine harvested or mechanically treated prior to the first burn to decrease hazardous fuels. We recommend using existing features as burn breaks, especially existing roads and the Shelldrake River. No-cut buffers should be established along the slopes above the river and on the steepest dunes to protect the oldest cohort of red pine and prevent erosion on steep topography. The burn should be applied during the late summer or fall during a red pine mast year with the goals of reducing leaf litter, reducing mesophytic species in the understory, and promoting red pine regeneration. Following the fire, We recommend harvesting *Openings* zones and thinning the *Individuals* zone by 1/3 BA. Within 5 to 10 years of thinning, we recommend applying a low-severity/ low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. There were several stumps with fire scars and we suggest retaining the oldest trees collecting stumps to facilitate the reconstruction of the site's fire history. Surveys for invasive species should be conducted along roads and trails.



Location of Shelldrake River Project Area (Compartment 42054).



Shelldrake River Project Area. Photos by J.M. Lincoln.



ICO Management zones for Shelldrake River Project Area (Compartment 42054).

13. Chris Brown Lake
Location: Compartment 42031, Stands 41, 39, 44, 42, portions of 1
Size: 199 acres
Community type: dry-mesic northern forest

This Project Area encompasses a natural pine stand on the north side of Chris Brown Lake. The canopy is white and red pine and has already been thinned, though the regeneration is primarily white pine and red maple. Most canopy trees appear to be in a cohort around 80 years old but there were several old, fire-scarred red pine in Stand 39 on subtle ridges above wetland inclusions. A 24" dbh red pine had 285 rings and another had a fire scar with evidence of 3 fires. While white pine is the dominant canopy species, red pine is relatively abundant in the canopy (up to 25%).



The understory of Stand 41 is dominated by white pine and white spruce. Photo by J.M. Lincoln.

Management Recommendations
A single, low-severity/low-intensity burn could likely be applied without additional mechanical intervention. We recommend using existing features as burn breaks, especially existing roads and the margins of Chris Brown Lake. No-cut buffers should be established along the margins of the lake to protect the oldest cohort of red pine. The burn should be applied during the late summer or fall during a red pine mast year with the goals of reducing leaf litter and mesophytes in the understory, and promoting red pine regeneration. Following the fire, we recommend harvesting *Openings* zones and thinning the *Individuals* zone by 1/3 BA. Within 5 to 10 years of thinning, we recommend applying a low-severity/ low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration.



Location of Little Chris Brown Lake Project Area (Compartment 42031).



Little Chris Brown Lake Project Area. We recommend using features such as lakes and streams as burn breaks. Photo by J.M. Lincoln.

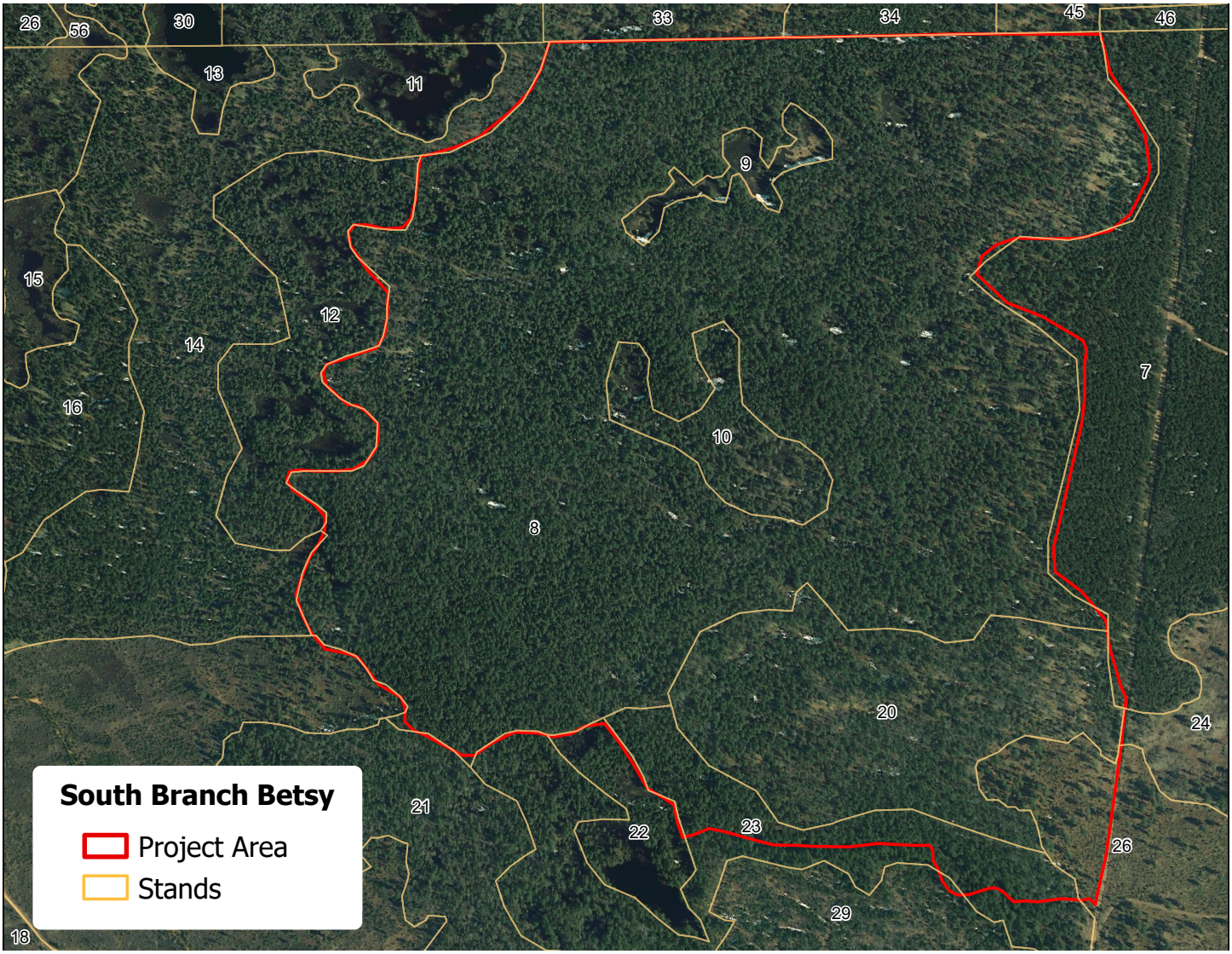


ICO Management zones for Little Chris Brown Lake Project Area (Compartment 42031).

14. South Branch Betsy
Location: Compartment 42062, Stands 8, 20, 10, 9, 23
Size: 240 acres
Community type: dry-mesic northern forest

This Project Area consists of several stands of natural pine with dune ridges and numerous small intermittent wetlands and vernal pools. The area features sandy ridges with natural red pine comprising about 10 to 25% of the canopy and shallow wetlands with little natural red pine regeneration in the understory. The canopy cohort is mostly between 80 to 100 years old and the canopy is variable across the site with an average of 110 BA. The understory is dense with paper birch, white pine, red maple, red oak, and balsam fir. There are several zones of saturated soils, and these often have leatherleaf. The site is ideally situated for a natural pine project as there are extensive natural red pine, areas of sensitive habitat along wetlands, and steep dunes.

Management Recommendations
Because of the dense understory, we recommend applying two low-severity/low-intensity fires across the entire Project Area. The goals of the first burn are to reduce leaf litter, remove lower branches of understory trees, and avoid mortality of canopy trees. The second burn should be applied during the late summer or fall within 3 to 5 years of the first burn with the goals of further reducing leaf litter and mesophotic species in the understory. The second burn should be applied during a red pine mast year. We recommend harvesting *Openings* zones and thinning the *Individuals* zone by 1/3 BA following the second fire., Harvesting should be avoided on steep ridges and saturated soils. Within 5 to 10 years of thinning, we recommend applying a low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. Surveys for invasive species should be conducted along roads and trails.

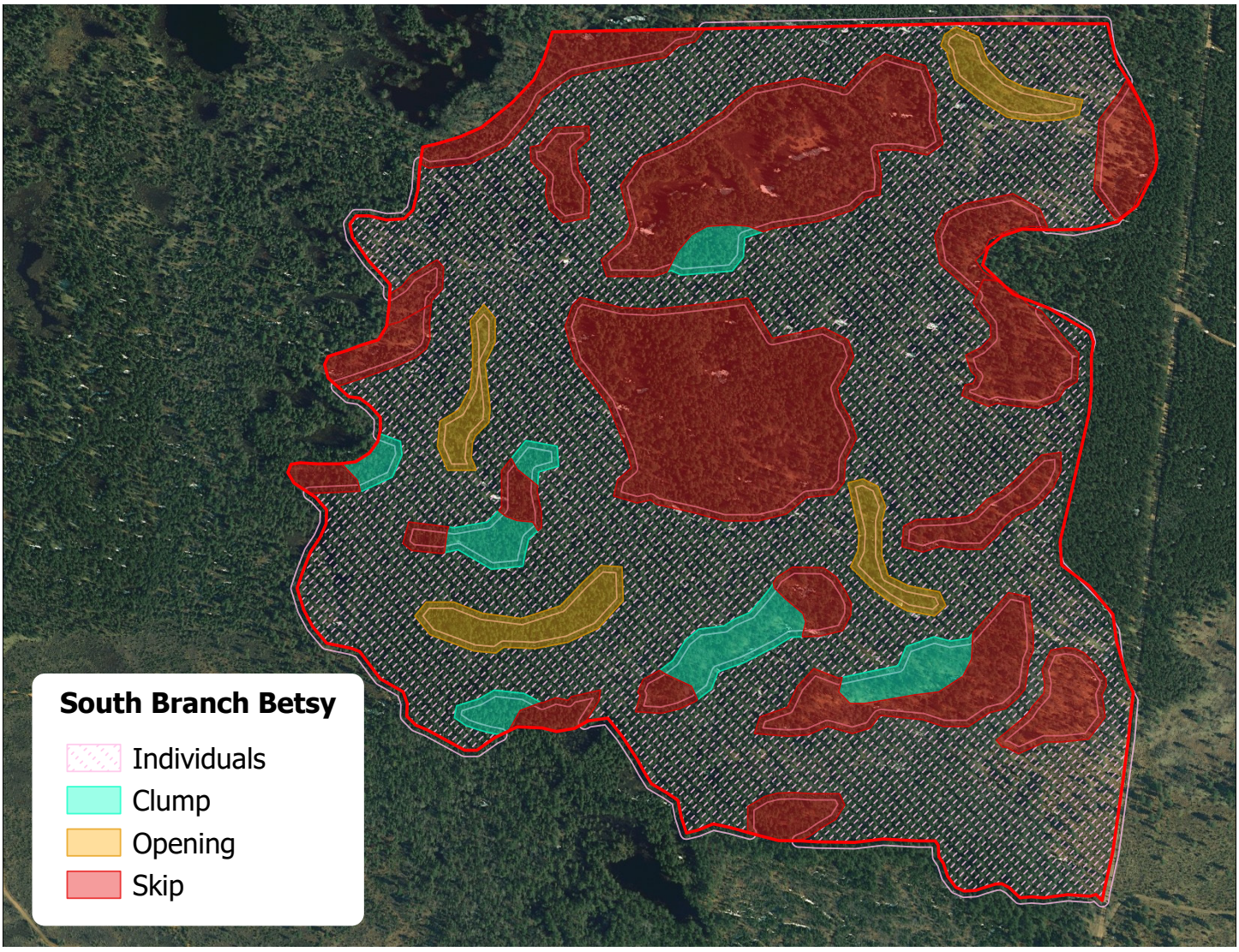


Location of South Branch Betsy Project Area (Compartment 42062).





The understory of Stand 8 is dominated by white pine, red maple, and white spruce. There are also numerous wetland inclusions throughout this Project Area. Photos by J.M. Lincoln.

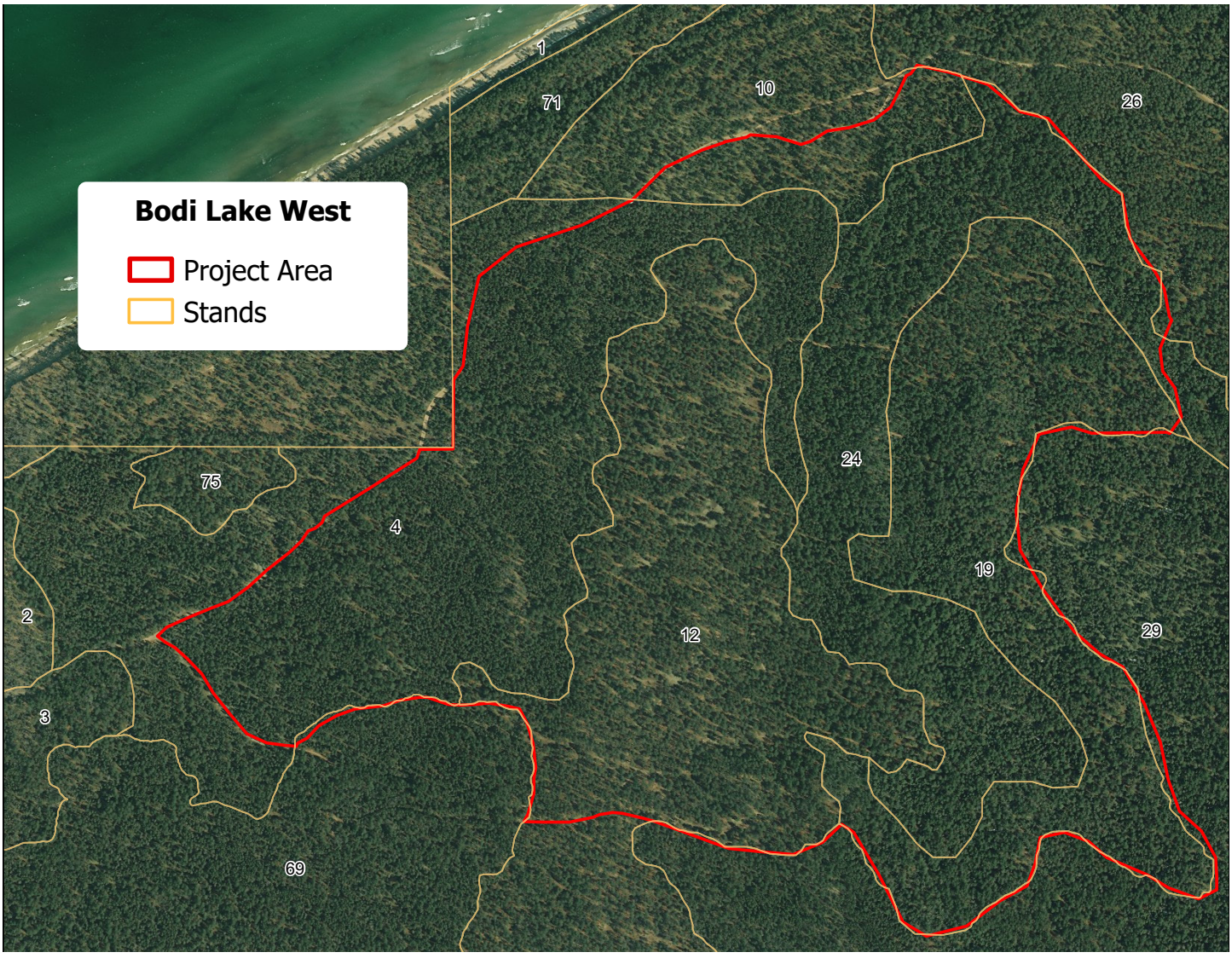


ICO Management zones for South Branch Betsy Project Area (Compartment 42062).

15. Bodi Lake West
Location: Compartment 42043, Stands 12, 4, 24, 59, 19, 10
Size: 291 acres
Community type: dry northern forest

This Project Area consists of several stands of natural pine on dune ridges near Lake Superior. The forests are a mix of red, white, and jack pine with natural red pine comprising about 40% of the canopy. The canopy cohort is mostly between 80 to 100 years old and the canopy is variable across the site with an average of 100 BA. The understory composition is primarily mesophytic species such as white pine, red maple, white spruce, and balsam fir with minimal red pine regeneration. The site is ideally situated for a natural pine project as the site is accessible, close to Lake Superior, characterized by extensive natural red pine with little natural regeneration, and contains roads that can function as burn breaks.

Management Recommendations
We recommend applying at least one low-intensity fire across the entire Project Area prior to timber harvest. The goals of the first burn are to reduce leaf litter, remove lower branches of understory trees, and avoid mortality of canopy trees. The burn should be applied burn should be applied during the late summer or fall during a red pine mast year to encourage natural regeneration. We recommend harvesting *Openings* zones and thinning the *Individuals* zone by 1/3 BA following the second fire Timber treatments should be avoided on steep ridges. Within 5 to 10 years of thinning, we recommend applying a low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. Surveys for invasive species should be conducted along roads and trails.

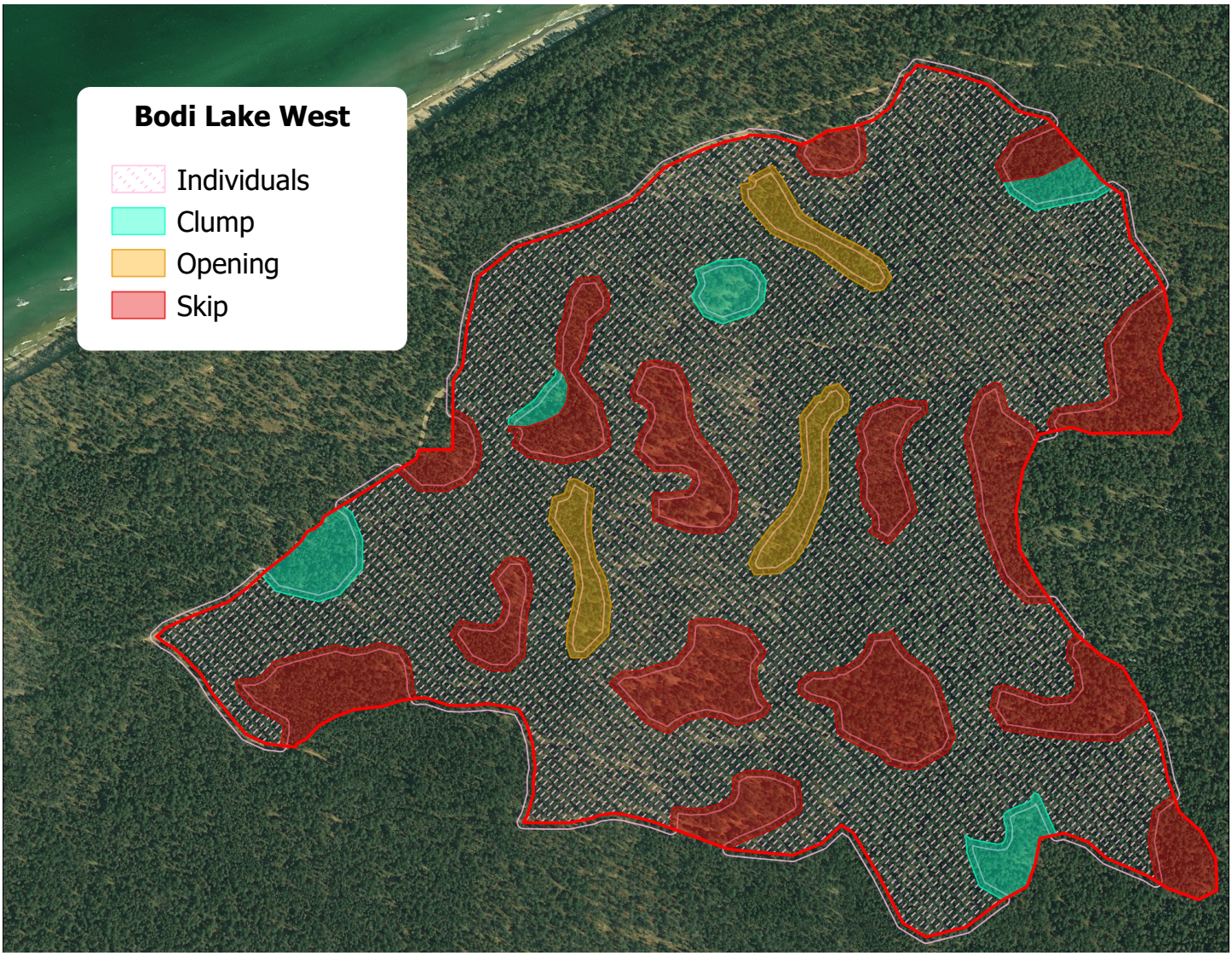


Location of Bodi Lake West Project Area (Compartment 42043).





Bodi Lake West Project Area. Photos by J.M. Lincoln.

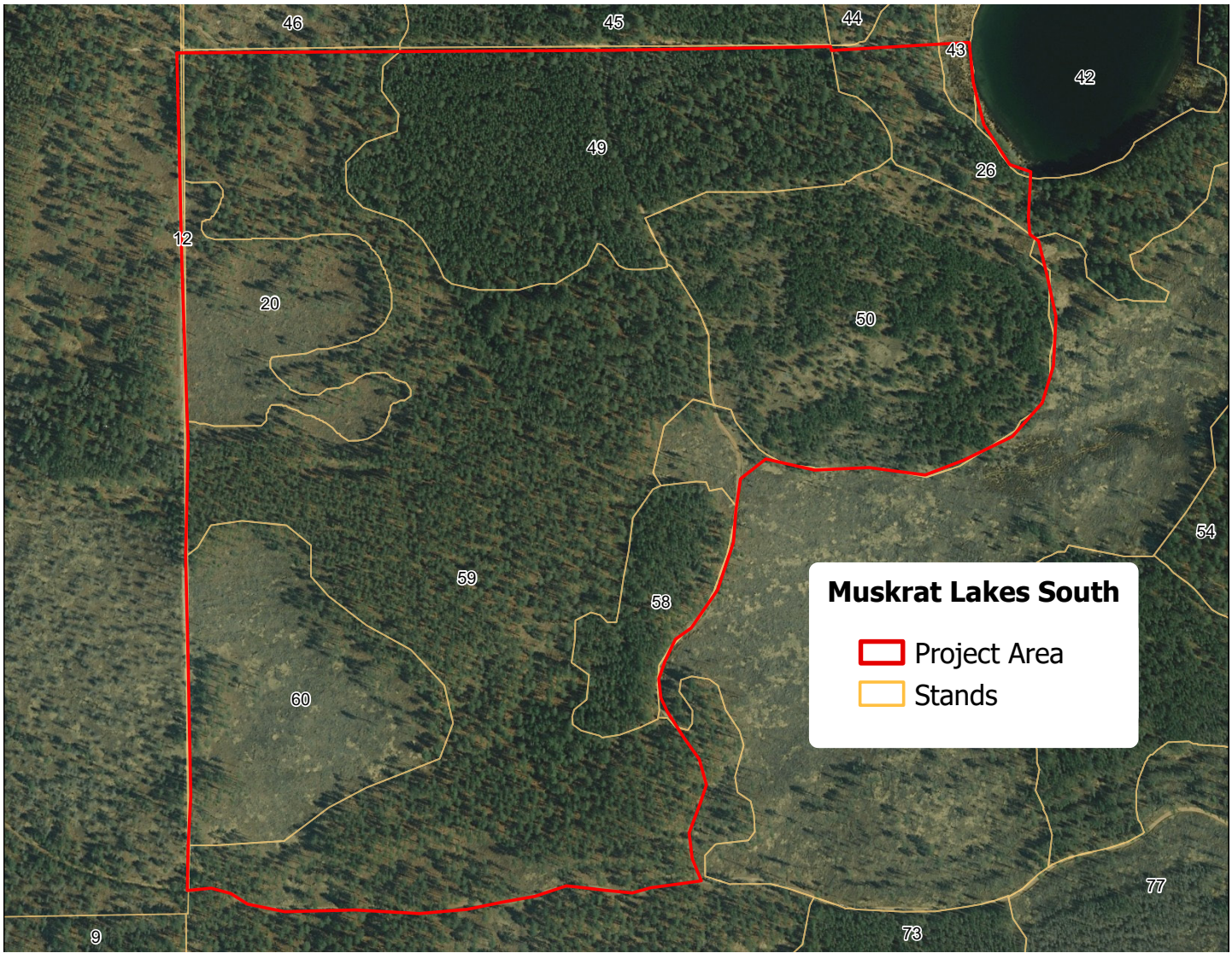


ICO Management zones for Bodi Lake West Project Area (Compartment 42043).

16. Muskrat Lakes South
Location: Compartment 42040, Stands 59, 49, 47, 50, 58
Size: 126 acres
Community type: dry northern forest

The Duck Lake Fire burned through this forest in late May of 2012. Stand 59 is a stand of natural red pine with multiple cohorts. Most trees are between 100 and 120 years old, but some are around 200 years old. Jack pine and white pine occur throughout the canopy but total less than 10% of the canopy. The stand BA is between 50 and 80 and has likely been thinned. There is abundant but patchy natural red pine regeneration throughout, but these are primarily seedlings and the site should not be burned for another 5 years to allow them to grow large enough to withstand a low-severity/low-intensity fire.

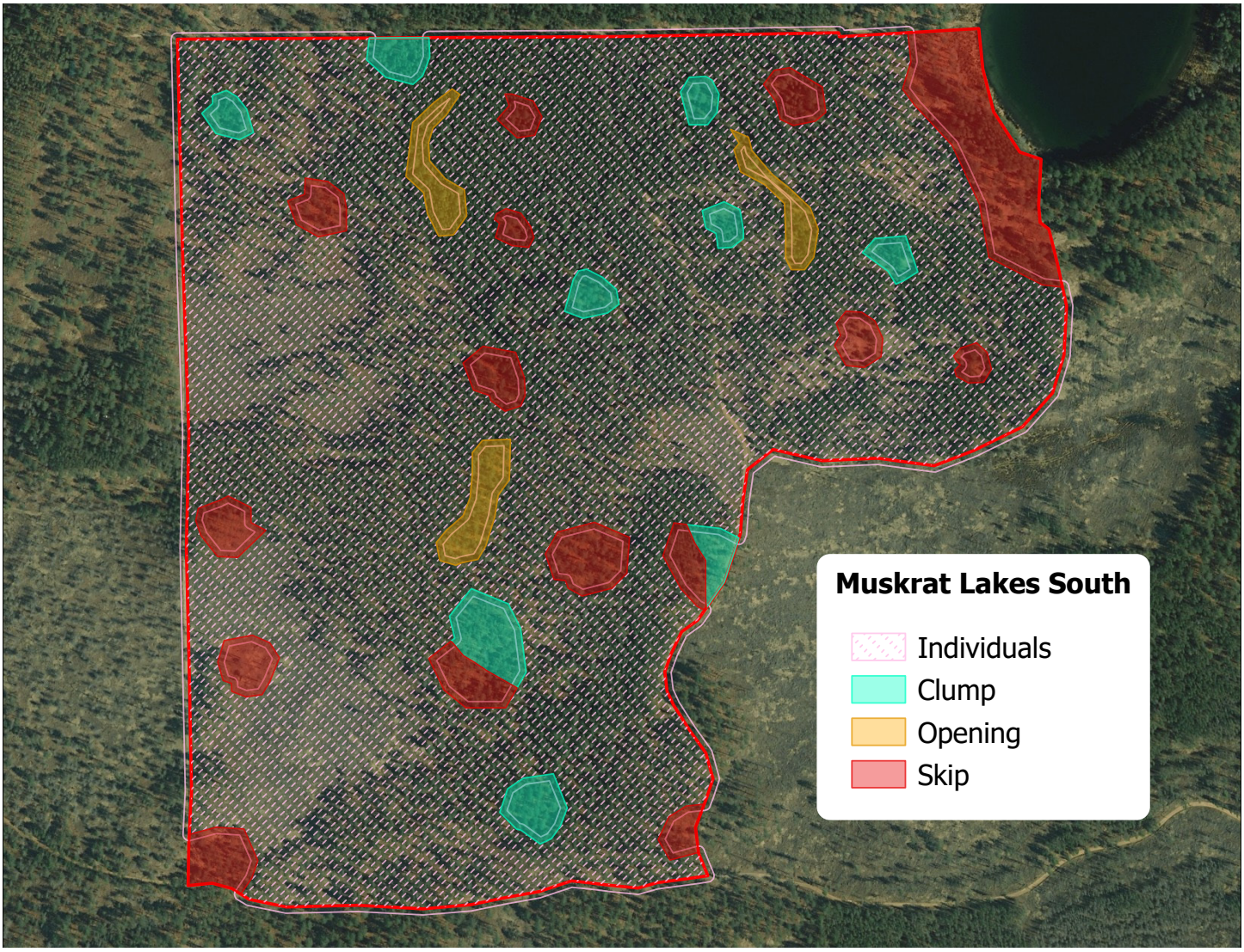
Management Recommendations
We recommend harvesting *Openings* zones around the greatest concentrations of red pine and thinning the *Individuals* zone by 1/3 BA and taking care to prevent damage to the concentrations of red pine regeneration already present throughout the site. Within 5 to 10 years of thinning, we recommend applying a low-severity/low-intensity fire across the entire Project Area to mitigate disease risks and encourage more red pine regeneration. The burn should be applied during the late summer or fall during a red pine mast year. We also recommend retaining the oldest trees across the site and surveying for invasive species along roads and trails.



Location of Muskrat Lakes South Project Area (Compartment 42040).



Muskrat Lakes South Project Area was burned in the Duck Lake wildfire of 2012 and has natural regeneration throughout. Photos by J.M. Lincoln.

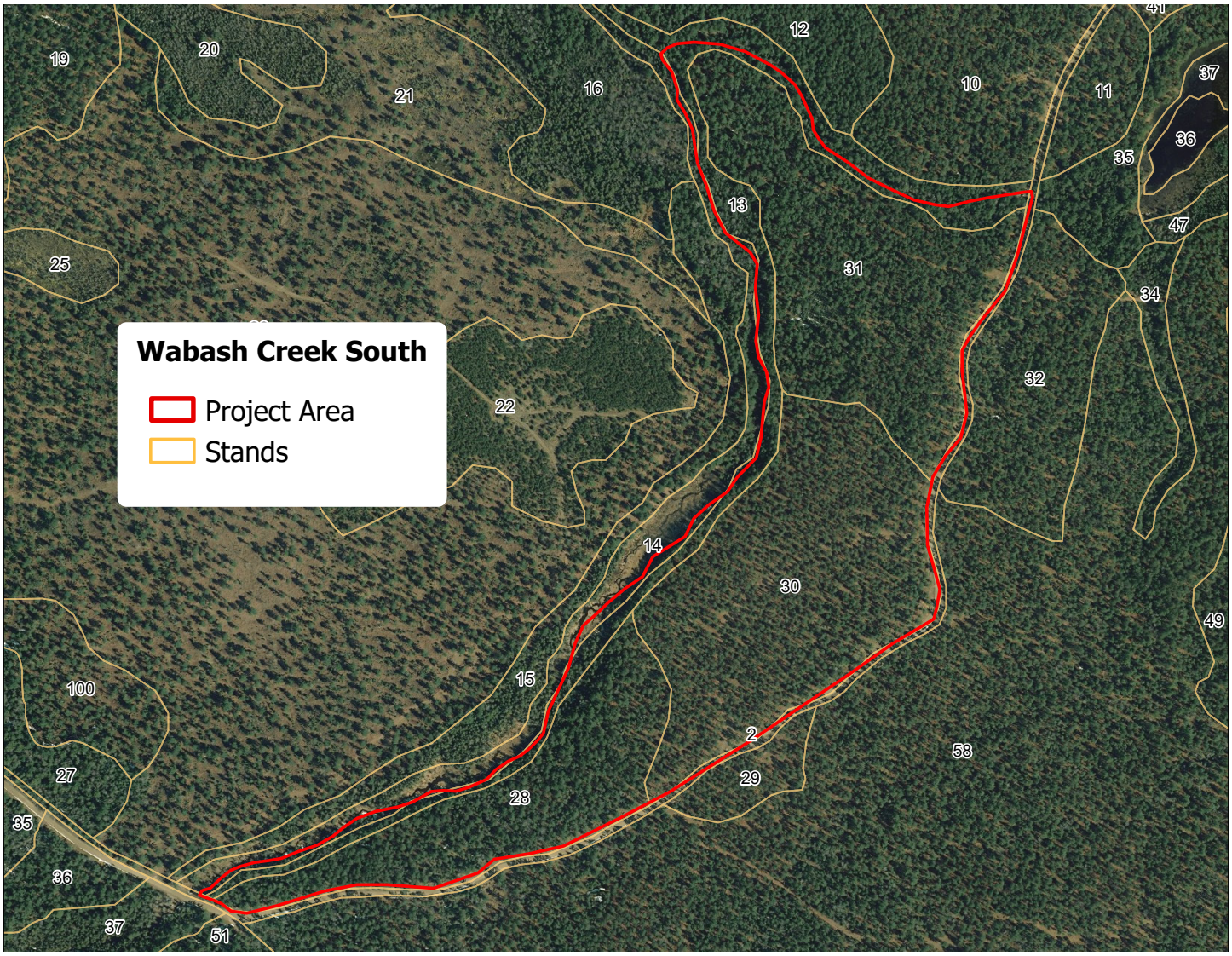


ICO Management zones for Muskrat Lakes South Project Area (Compartment 42040).

17. Wabash Creek South
Location: Compartment 42031, Stands 30, 31, 28
Size: 84 acres
Community type: dry-mesic northern forest

This Project Area consists of stands along the east side of Wabash Creek, between the creek and Pike Lake Rd. There are steep slopes along Wabash Creek. Stands 10 and 9 are dominated by white pine with natural red pine comprising 15 and 25% of the canopy and red oak around 2% of the canopy. There is generally very little natural red pine regeneration across this proposed Project Area, with spruce, balsam fir, red maple, and white pine dominating the understory. Lowbush blueberry and huckleberry also occur throughout in the low shrub layer. The site was thinned in 2000 and the BA is generally between 100 and 120 ft^2 per ac.

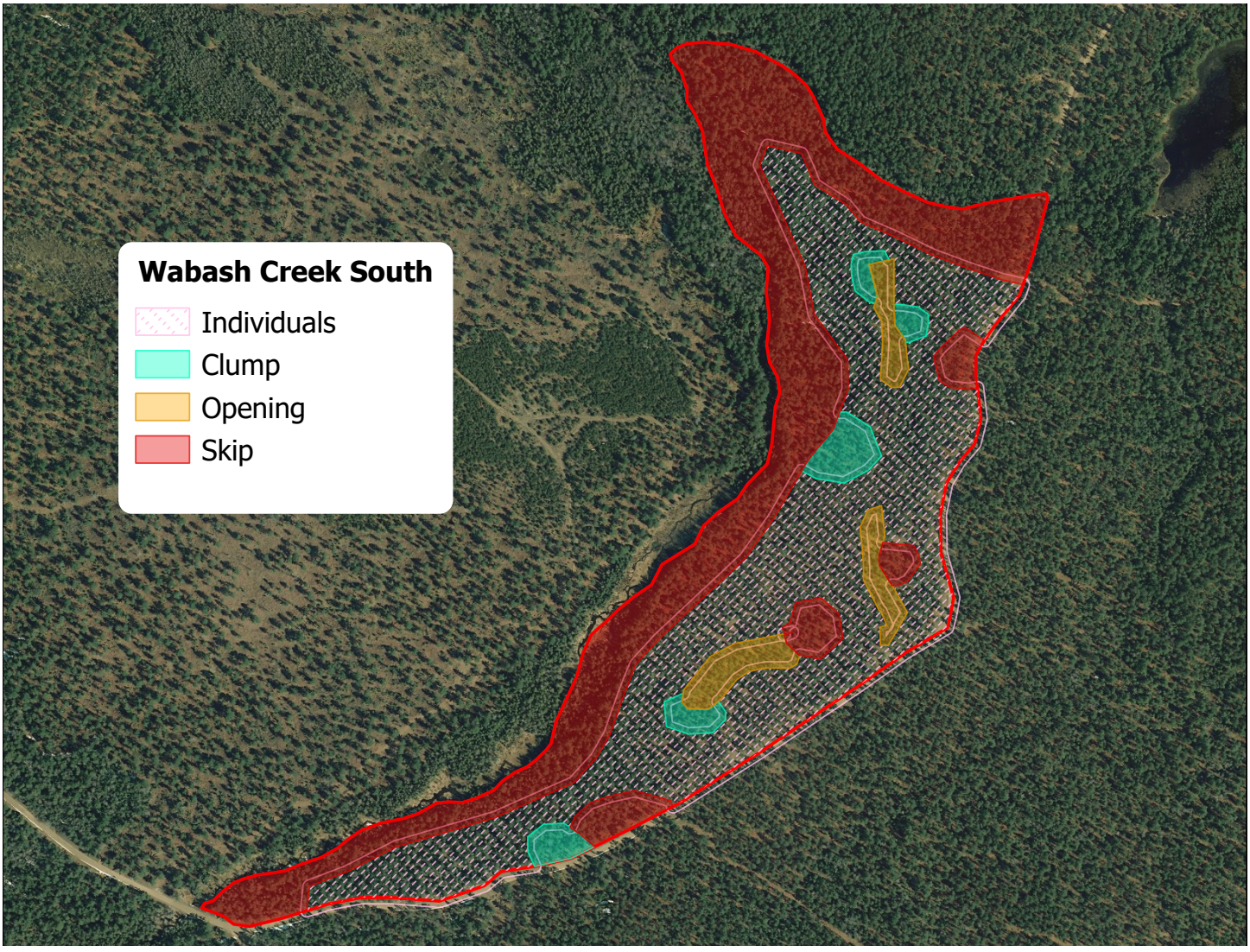
Management Recommendations
The site has already been thinned once and there is patchy red pine regeneration, but white spruce and white pine will outcompete the red pine. The site likely needs only a single fire to set back white spruce and white pine. The burn should be low-severity to prevent damage to the existing red pine regeneration and applied during the late summer or fall during a red pine mast year with the goals of reducing leaf litter and mesophotic species in the understory. We recommend developing *Opening* zones on ridges away from wetlands and thinning the *Individuals* zone by 1/3 BA following the fire. Treatments should avoid steep slopes above the valley and wetland inclusions, and wide no-cut buffers should be established along the Wabash Creek and wetlands. Within 5 to 10 years of thinning, we recommend applying a low severity/ low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. Surveys for invasive species should be conducted along roads and trails.



Location of Wabash Creek South Project Area (Compartment 42031).



The understory of Stand 30 is dominated by white pine and white spruce. Photo by J.M. Lincoln.

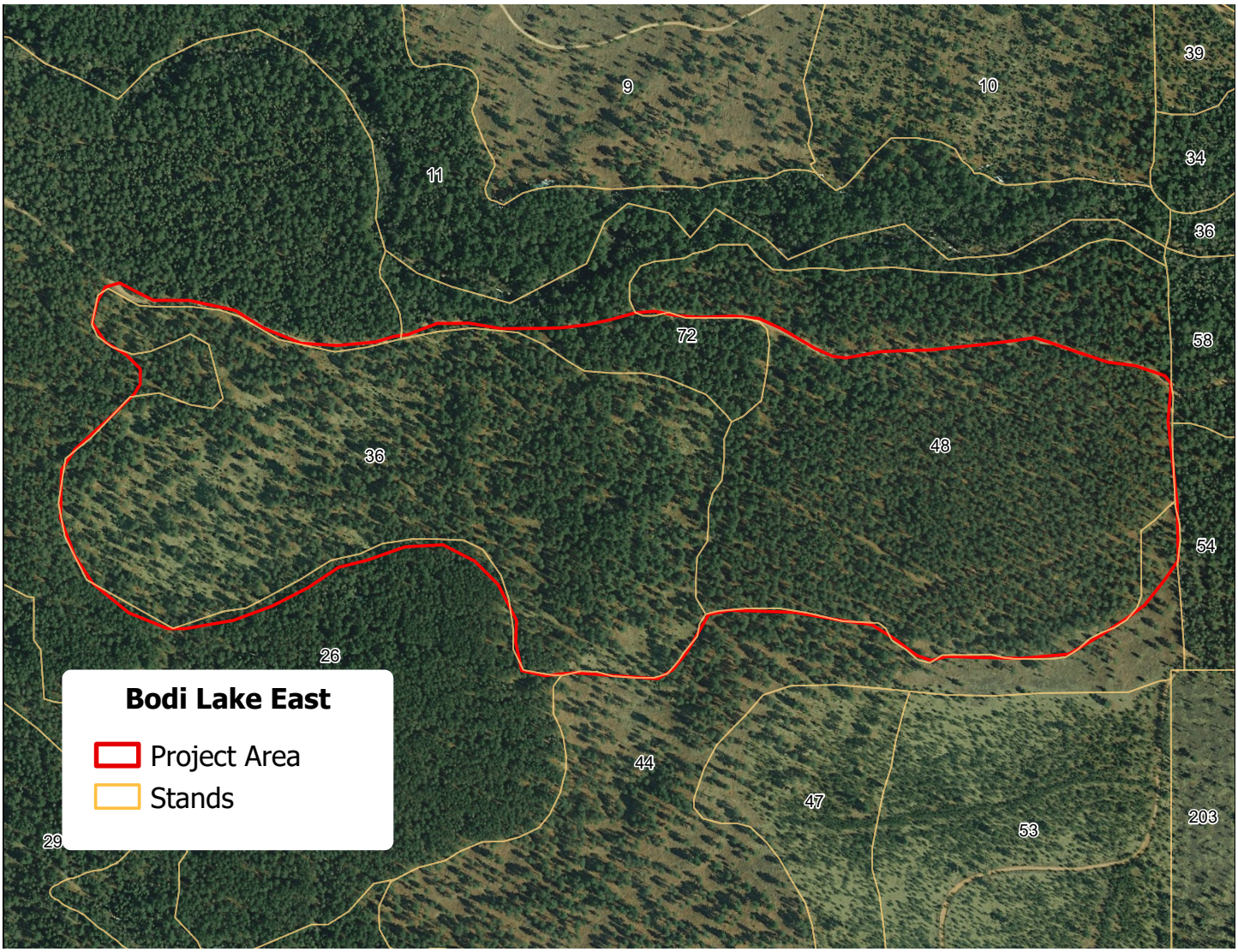


ICO Management zones for Wabash Creek South Project Area (Compartment 42031).

18. Bodi Lake East
Location: Compartment 42043, Stands 36, 72, 48
Size: 90 acres
Community type: dry to dry-mesic northern forest

This project area consists of several stands of natural pine near Lake Superior. The forests are a mix of red and white pine with natural red pine comprising about 60% of the canopy. The canopy cohort is mostly between 80 to 100 years old. The understory composition is primarily mesophytic species such as white spruce and white pine with minimal red pine regeneration. The site is ideally situated for a natural pine project as the site is accessible, close to Lake Superior, characterized by extensive natural red pine in the canopy with little regeneration, and contains roads that can function as burn breaks.

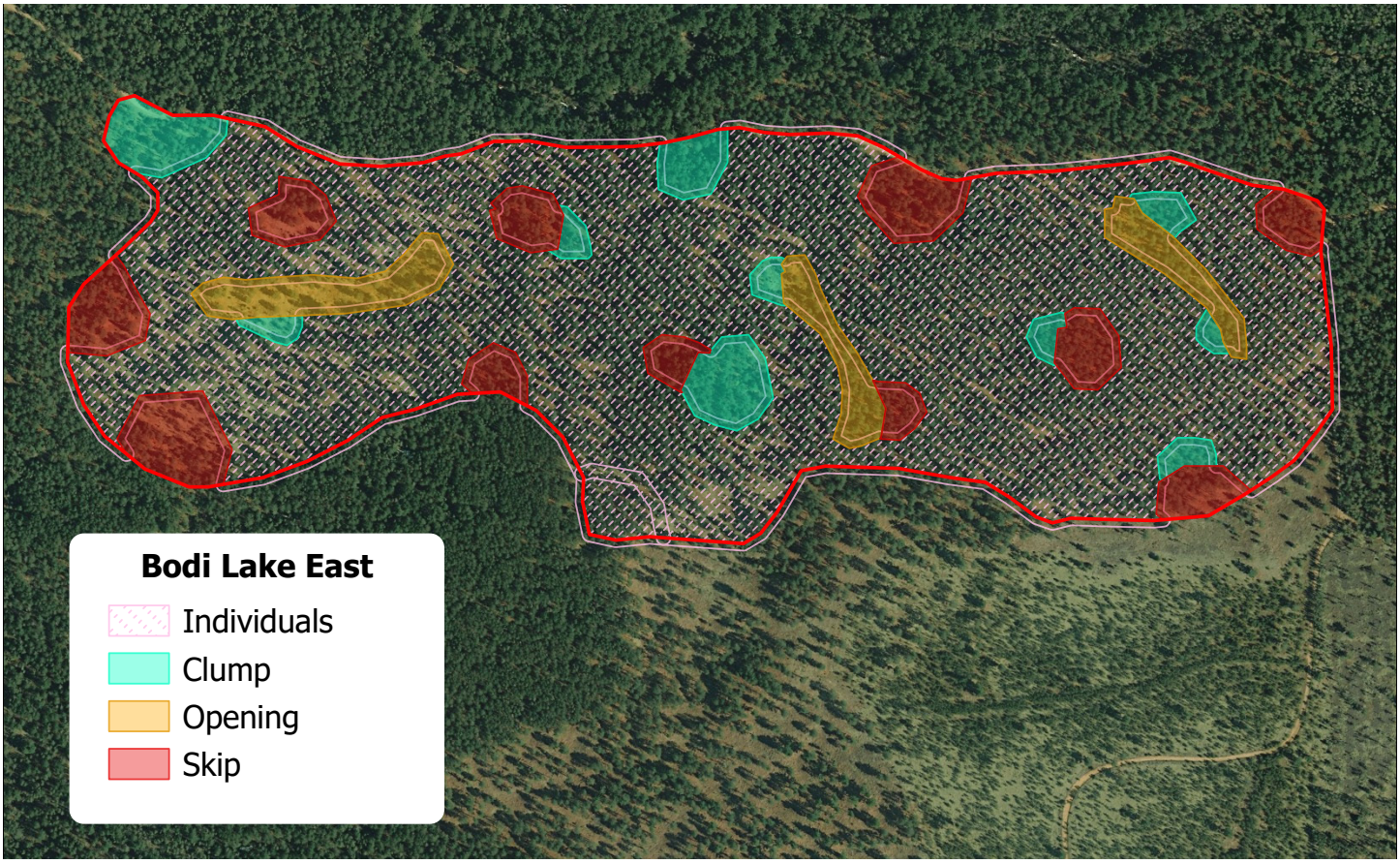
Management Recommendations
We recommend applying at least one low-severity/ low-intensity fire across the entire Project Area prior to timber harvest. The goals of the first burn are to reduce leaf litter, remove lower branches of understory trees, and avoid mortality of canopy trees. The burn should be applied during the late summer or fall during a red pine mast year to encourage natural regeneration. We recommend harvesting *Openings* zones and thinning the *Individuals* zone by 1/3 BA following the second fire Timber treatments should be avoided on steep ridges. Within 5 to 10 years of thinning, we recommend applying a low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. Surveys for invasive species should be conducted along roads and trails.



Location of Bodi Lake East Project Area (Compartment 42043).



The understory of Stand 48 is dominated by white pine and white spruce. Photo by W.O. Lincoln.

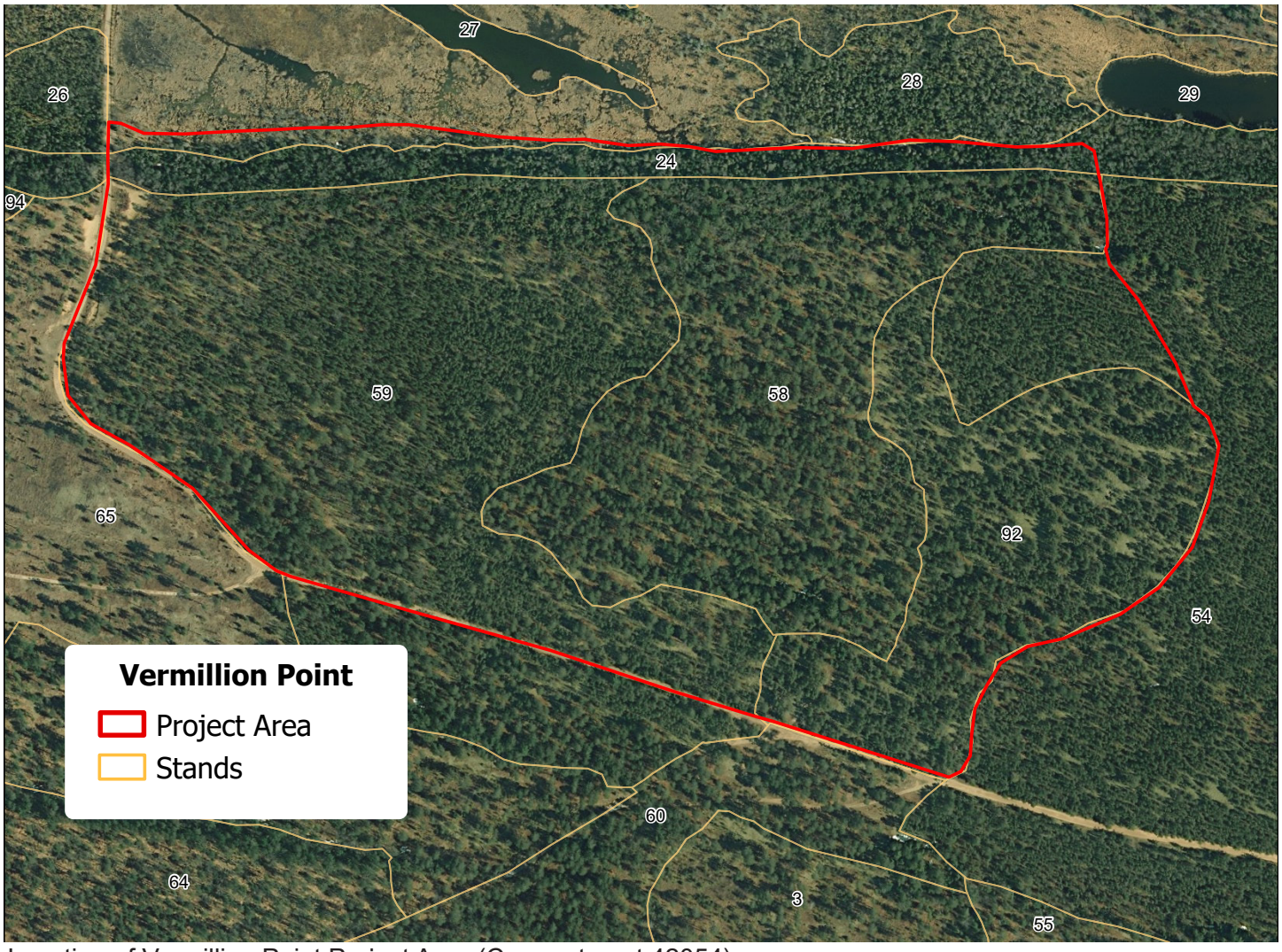


ICO Management zones for Bodi Lake East Project Area (Compartment 42043).

19. Vermillion Point
Location: Compartment 42054, Stands 59, 58, 92
Size: 81 acres
Community type: dry northern forest

This Project Area consists of stands above the steep ridge along Vermillion Point. The forest is a mix of natural white, red, and jack pine. The area features sandy ridges and shallow wetlands with little natural red pine regeneration in the understory. Vermillion Point is a major migratory bird hotspot, and this is a site ideally situated for application of a holistic ecological forestry approach. There is extensive natural red pine, areas of sensitive habitat along wetlands and steep dunes, and the wetlands could serve as a natural burn break. Most of the surrounding stands have been converted to planted jack pine and the forests have been dramatically simplified as a result.

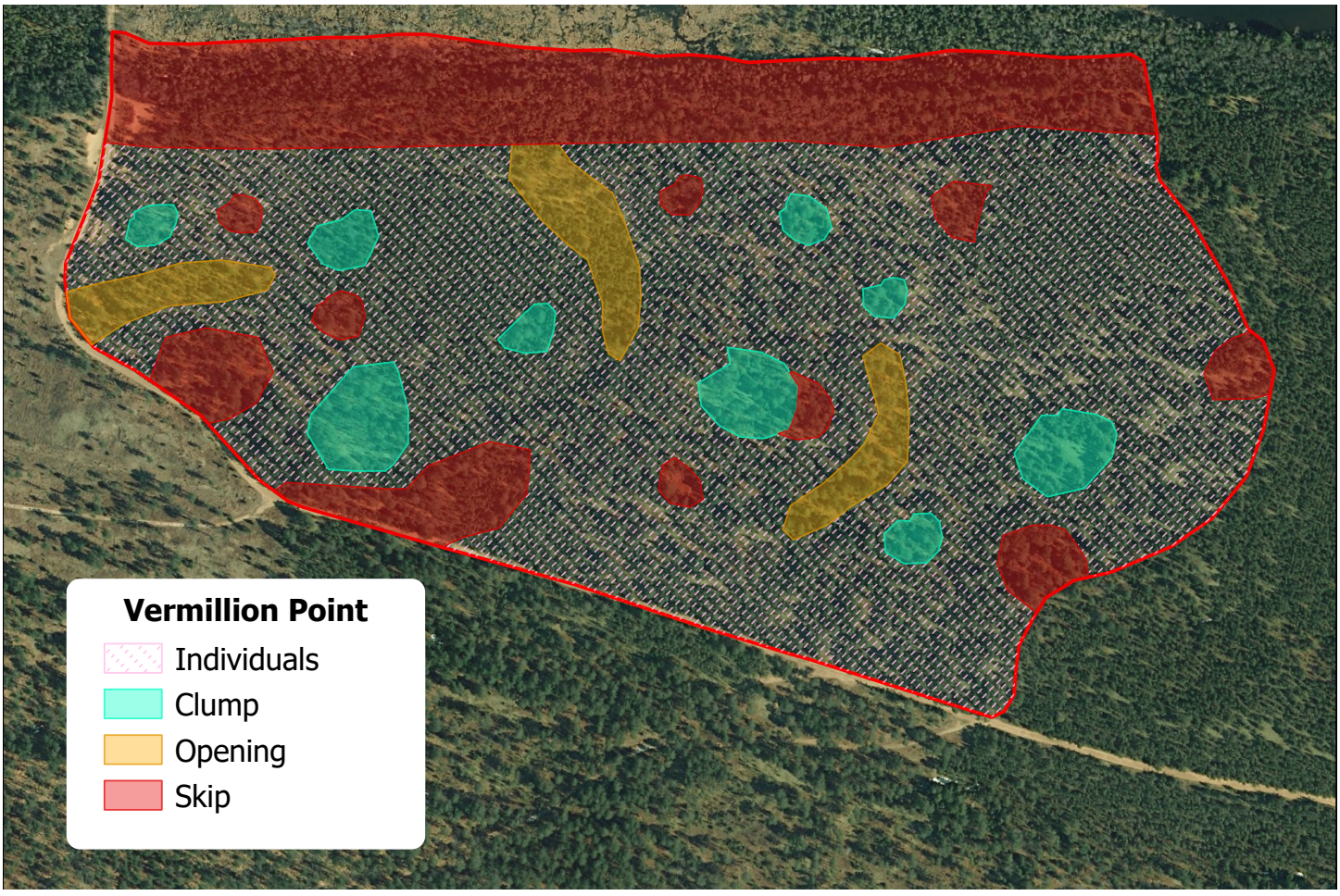
Management Recommendations
The site may need to have some of the jack pine harvested or mechanically treated prior to the first burn to decrease hazardous fuels. We recommend applying at least one low-severity/low-intensity fire across the entire Project Area prior to timber harvest. The goals of the first burn are to reduce leaf litter, remove lower branches of understory trees, and avoid mortality of canopy trees. The burn should be applied during the late summer or fall during a red pine mast year to encourage natural regeneration. We recommend harvesting *Openings* zones and thinning the *Individuals* zone by 1/3 BA following the fire, once patterns of red pine regeneration have been determined. Timber treatments should be avoided on steep ridges. Within 5 to 10 years of thinning, we recommend applying a low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. Retaining the oldest trees across the site and protecting fire-scarred living trees and stumps will facilitate the reconstruction of the site's fire history. Surveys for invasive species should be conducted along roads and trails.



Location of Vermillion Point Project Area (Compartment 42054).



Vermillion Point Project Area. Photo by J.M. Lincoln.

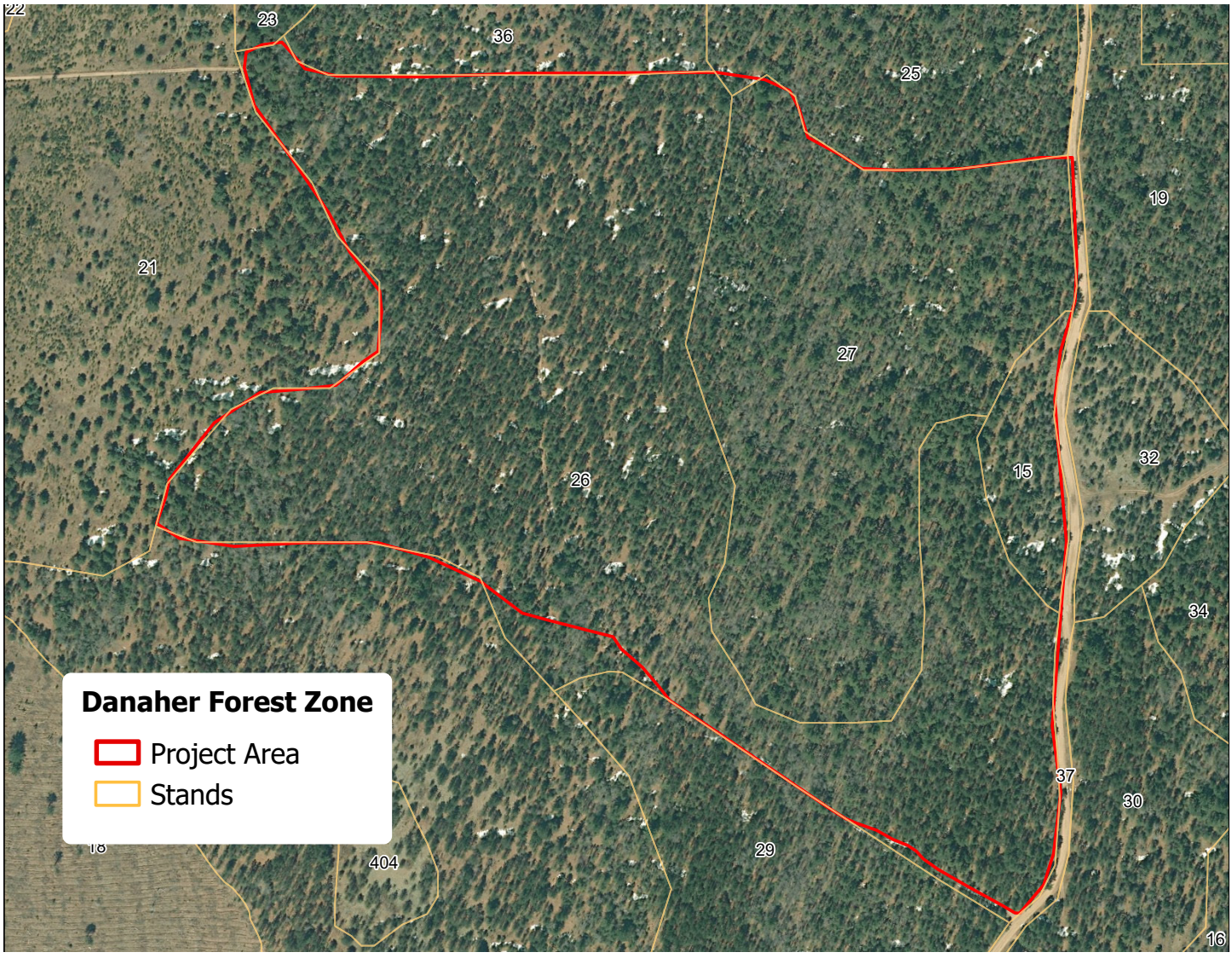


Appendix 47. ICO Management zones for Vermillion Point Project Area (Compartment 42054).

20. Danaher Forest Zone
Location: Compartment 42093, Stands 26, 27, 15
Size: 80 acres
Community type: dry-mesic northern forest

This Project Area contains several stands of mixed natural white and red pine around 90 years old. The understory is dominated by red maple, white pine, and some beech. Lowbush blueberry occurs throughout.

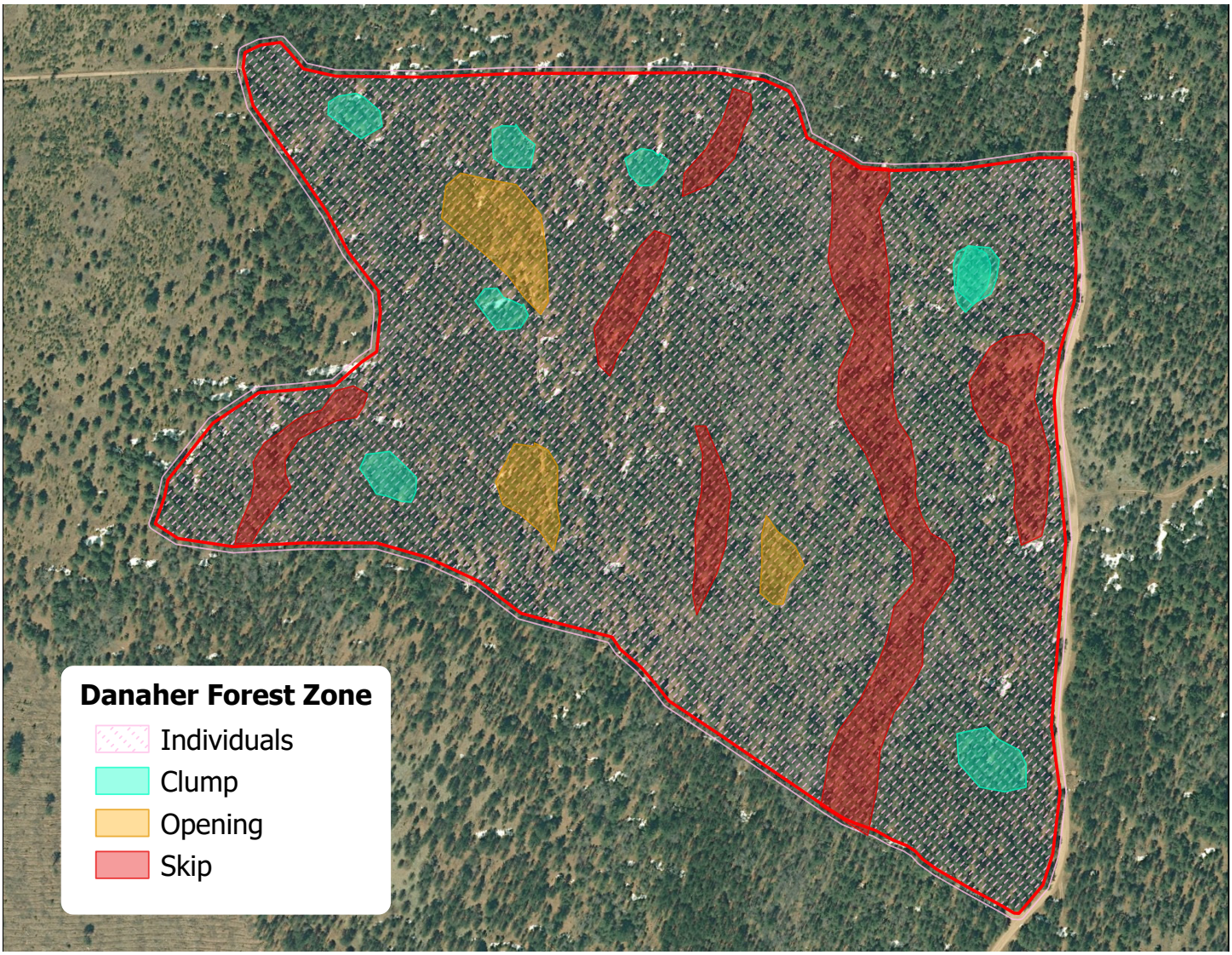
Management Recommendations
The understory of this Project Area is especially dense with mesophytes and we recommend applying two low-intensity fires across the entire Project Area. The goals of the first burn are to reduce leaf litter, remove lower branches of understory trees, and avoid mortality of canopy trees. The second burn should be applied during the late summer or fall within 3 to 5 years of the first burn with the goals of further reducing leaf litter and mesophytic species in the understory. The second burn should be applied during a red pine mast year to facilitate red pine regeneration. We recommend harvesting *Openings* zones and thinning the *Individuals* zone by 1/3 BA following the second fire. Within 5 to 10 years of thinning, we recommend applying a low-intensity fire to mitigate disease risks, reduce mesophytic competition, and continue to promote red pine regeneration. Surveys for invasive species should be conducted along roads and trails.



Appendix 48. Location of Danaher Forest Zone Project Area (Compartment 42093).



Danaher Forest Zone Project Area. Photo by J.M. Lincoln.



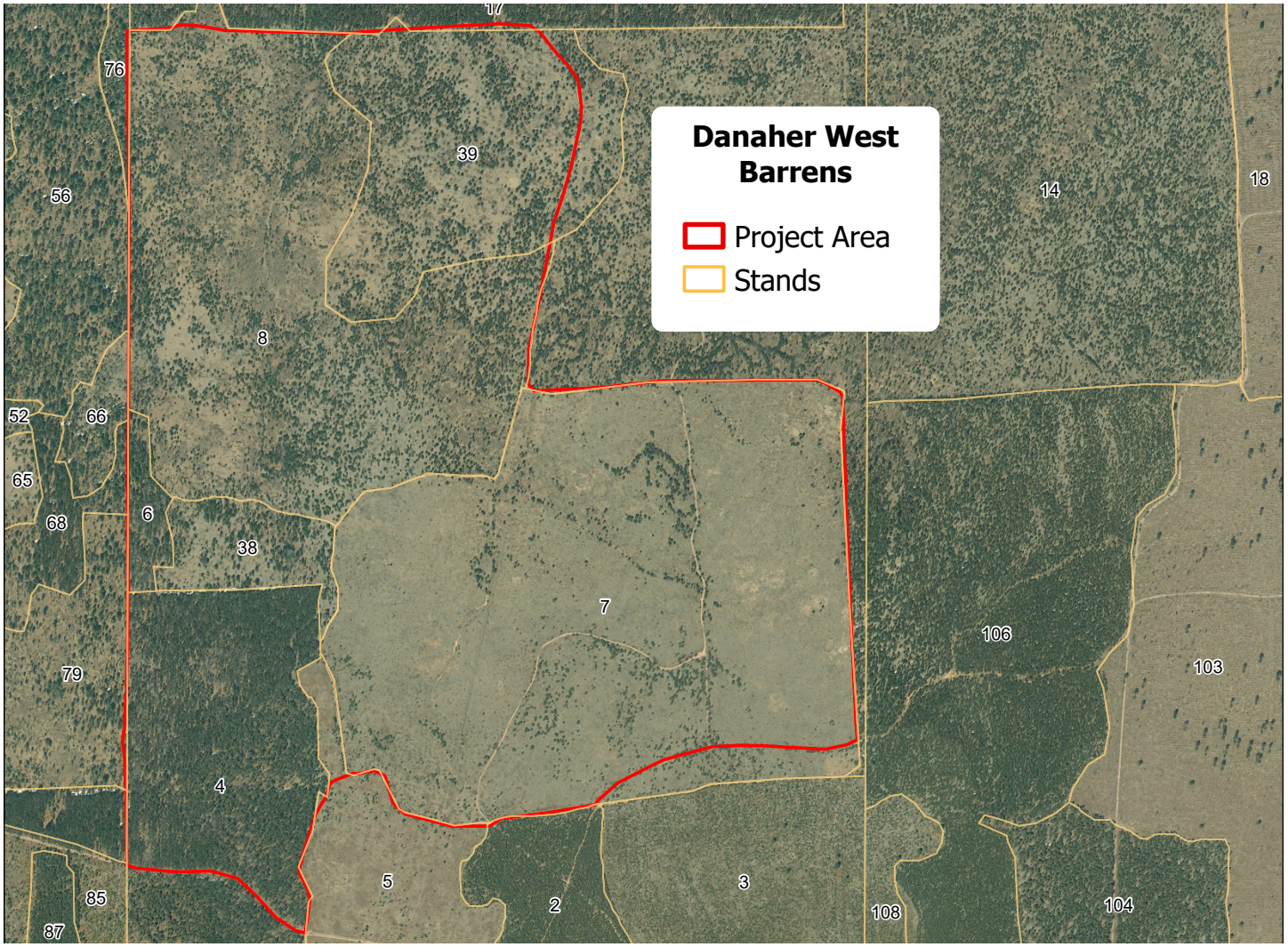
ICO Management zones for Danaher Forest Zone Project Area (Compartment 42093).

PINE BARRENS PROJECT AREAS

1. Danaher West Barrens
Location: Compartment 42094, Stands 7, 8, 38, 4, 39, 6
Size: 510 acres
Community type: pine barrens

This Project Area consists of stands dominated by sparse, stunted jack pine. The site has been burned and scarified and the ground layer is predominantly reindeer moss with few other pine barrens indicators. Historic descriptions depict a “burnt over pine plains” with a sparse canopy of white pine, red pine, and jack pine. There are no pine barrens indicator species such as little bluestem, big bluestem, or Indian grass at the site and historically it was probably more of a pine woodland than a true pine barrens. The site has been managed for sharp-tailed grouse and Kirtland’s warbler has been documented nearby.

Management Recommendations
We recommend including more of the surrounding landscape in prescribed fire to capture a fuller range of natural variation of pine barrens. The site was likely a shifting mosaic of pine woodlands and more open areas with typical pine barrens structure of a sparse canopy. The ideal structure would be semi-forested with various age classes of white pine, red pine, and jack pine. Relatively frequent, low-severity/low-intensity burns would provide a mosaic of habitat for Kirtland’s warbler, sharp-tailed grouse, upland sandpiper, and nighthawks. A stump from the southern end of Danaher Plains was recovered showing a range multiple fires with 9, 26, and 70 years between fires. We suggest applying low-severity/low-intensity fires at a frequency of every 10 to 30 years to promote habitat for Kirtland’s warbler. Ideally a frequent burn schedule would increase the abundance of fine fuels to allow greater ease in the application of prescribed fire. After the first fire, we recommend hand planting red pine at a rate of 10 to 20 trees per acre to return compositional and structural diversity across the site. Scarification should be avoided to allow native vegetation to establish and proliferate.



Location of Danaher West Barrens Project Area (Compartment 42094).



Danaher West Barrens Project Area. Photo by J.M. Lincoln.

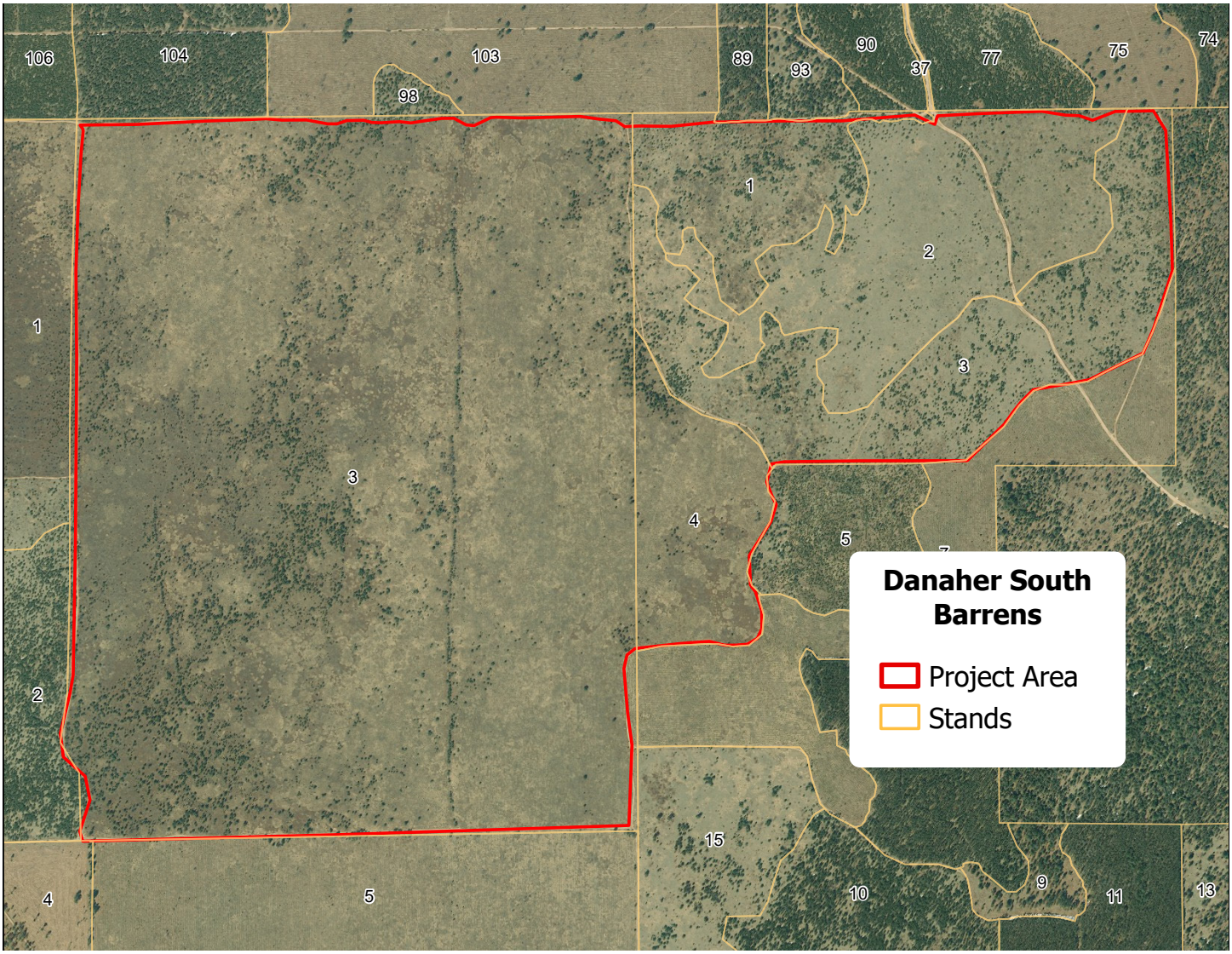


We recommend including more of the surrounding landscape in prescribed fire to capture a fuller range of natural variation of pine barrens that includes old cohorts of red and white pine throughout the site. The site was likely a shifting mosaic of pine woodlands and more open areas with typical pine barrens structure of a sparse canopy. Photo by J.M. Lincoln.

2. Danaher South Barrens
Location: Compartments 42097 and 42096, Stands 1, 2, 3, 4, and portions of S3 in Compartment 42096
Size:
Community type: pine barrens

This Project Area consists of stands dominated by sparse, stunted jack pine. The site has been burned and scarified and the ground layer is predominantly reindeer moss with few other pine barrens indicators. Historic descriptions depict a "burnt pine plains" with a sparse canopy of white pine, red pine, and jack pine. The site has been managed for sharp-tailed grouse and Kirtland's warbler has been documented nearby.

Management Recommendations
We recommend including more of the surrounding landscape in prescribed fire to capture a fuller range of natural variation of pine barrens. The site was likely a shifting mosaic of pine woodlands and more open areas with typical pine barrens structure of a sparse canopy. The ideal structure would be semi-forested with various age classes of white pine, red pine, and jack pine. Relatively frequent, low-severity/ low-intensity burns would provide a mosaic of habitat for Kirtland's warbler, sharp-tailed grouse, upland sandpiper, and nighthawks. A stump from the southern end of Danaher Plains was recovered showing a range multiple fires with 9, 26, and 70 years between fires. We suggest applying low-severity/low-intensity fires at a frequency of every 10 to 30 years to promote habitat for Kirtland's warbler. Ideally a frequent burn schedule would increase the abundance of fine fuels to allow greater ease in the application of prescribed fire. After the first fire, we recommend hand planting red pine at a rate of 10 to 20 trees per acre to return compositional and structural diversity across the site. Scarification should be avoided to allow native vegetation to establish and proliferate.



Location of Danaher South Barrens Project Area (Compartment 42094).



Danaher South Barrens Project Area. Photo by J.M. Lincoln.



Because of a history of scarification, neither site qualifies as a high-quality pine barrens. Photo by J.M. Lincoln.

APPENDIX 5 - GLO SURVEYOR NOTES



Two hand-drawn maps of Danaher Plains by General Land Office surveyor Francis Coleman after his 1851 survey of the region. The notes from the original surveys in 1851 for the Danaher Plains describe “W & Y Pine Plains, gently rolling, third rate sandy soil” and “burnt lands, open pine plains, poor sandy soil” (Francis Coleman, 1851 GLO notes). Red pine was referred to as “yellow pine” or “Y. pine” and jack pine was referred to as “spruce pine” or “sp.” White pine is often designated by “W. Pine.”