Natural Features Surveys and Monitoring of The Nature Conservancy's Two-Hearted River Forest Reserve




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Michigan Natural Features Inventory
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For:
The Nature Conservancy of Michigan

January 31, 2009

Report Number 2009-01

Michigan DNR

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan Natural Features Inventory

Suggested Citation: Cohen, J.G., R.P. O'Connor, M.J. Monfils, D.L. Cuthrell, and H.D. Enander. 2009. Natural Features Surveys and Monitoring of The Nature Conservancy's Two-Hearted River Reserve. Michigan Natural Features Inventory, Report Number 2009-01, Lansing, MI. 62 pp.

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Cover photos: top left, old-growth white pine within the Two-Hearted Lakes Dry-mesic Northern Forest; top right, young merlin discovered within the Dawson Creek Muskeg; lower left, floating bog mat adjacent to Stuart Lake; and lower right, forest structure and vegetation monitoring within the West of Pine Stump prescribed stand (Photos by Joshua G. Cohen).

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

INTRODUCTION

During the summer of 2008, The Nature Conservancy of Michigan (TNC) commissioned Michigan Natural Features Inventory (MNFI) to begin work on TNC's Two-Hearted River Forest Reserve (THRFR). The reserve is a commercial forest property managed as a center of conservation research aimed at addressing questions of watershed management for forest and aquatic resources on lands that are actively managed for sustainable timber harvesting. Research questions examined in the reserve will guide future forest management activities in this and other watersheds across the Great Lakes region. As stated in the management plan for the reserve (Nelson et al. 2007), "the goal…is to reach a balance of enhancing the quality of water resources, forest communities, and wildlife resources with responsible forest management to ensure protection of plant and animal habitat and a sustainable harvest of forest products." Critical to reaching this balance is the development of a thorough understanding of the current biological resources of the THRFR. To help TNC achieve this balance, MNFI developed and implemented monitoring protocols in managed areas of the reserve, conducted a natural features survey in lands proposed for timber harvest, began a natural features survey across the reserve, and developed a prioritization of survey targets and a plan for future natural features surveys across the reserve.

MNFI conducted monitoring in northern hardwood stands scheduled for harvest, as well as in unmanaged control stands on THRFR lands and nearby state lands. Four aspects of forest ecological integrity were measured: coarse woody debris and forest structure; forest-interior bird presence and diversity; floristic composition; and deer herbivory pressure. Monitoring techniques developed during this project can be applied throughout managed upland forests and can be used as indices of ecological integrity. MNFI scientists conducted surveys for rare species and high-quality natural communities in areas of northern hardwood forest currently proposed for management and also conducted focused natural features surveys across the reserve. This report describes the landscape setting of the THRFR, outlines the developed monitoring techniques, summarizes the findings of MNFI's surveys, and highlights priorities for future survey work within the THRFR.

Landscape Setting

Regional Landscape Ecosystems

Regional landscape ecosystems of Michigan have been classified and mapped based on an integration of climate, physiography (topographic form and geologic parent material), soil, and natural vegetation (Albert 1995). The regional classification describes broad patterns of natural community and species occurrences and natural disturbance regimes across the state. Understanding these patterns is useful for integrated resource management and planning, and for biological conservation. The classification is hierarchically structured with three levels in a nested series, from broad landscape regions called sections, down to smaller subsections and sub-subsections.

The Two-Hearted River Forest Reserve falls within Section VIII, Northern Lacustrine-Influence Upper Michigan, and Subsection VIII.2, the Luce Subsection, which consists of poorly drained sand lakeplain, sandy end moraine, shoreline, and outwash plain. The subsection is characterized by sandy soils and high lake-effect snowfall. Sub-subsections VIII.2.1, the Seney Sand Lake Plain, and VIII.2.2, the Grand Marais Sandy End Moraine and Outwash, both occur within the THRFR, but the majority of the reserve falls within Sub-subsection VIII.2.1 (Figure 1). This sub-subsection of poorly drained sand lakeplain contains the largest expanses of wetlands in the state. Numerous meandering rivers originate in the wetlands. Former transverse beach ridges occur throughout the areas of poorly drained lakeplain. Soils include peats and poorly drained sands within areas of flat lakeplain and well-drained sands along the dune ridges, lakeplain, and outwash plain. Circa 1800, marshes, peatlands, and low productivity swamps were the predominant vegetation noted by the surveyors on the very poorly drained topography (Comer et al. 1995) (Figure 2). Many of the broad wetlands occupy embayments of Glacial Lake Algonquin (10,000 years B.P), but it was only during the moister, cooler climatic conditions of the last 3,000-4,000 years that peat began to accumulate. Pine forests were prevalent along dune ridges and dry sand areas of outwash and lakeplain. Jack pine (*Pinus banksiana*) dominated the droughtiest outwash plains, but red pine (*P. resinosa*), white pine (*P. strobus*), and bigtooth aspen (*Populus grandidentata*) occupied the seasonally moist lakeplains and the transverse dunes (Figure 2). Based on the surveyors' notes, fires occurred regularly on both the extensive peatlands and

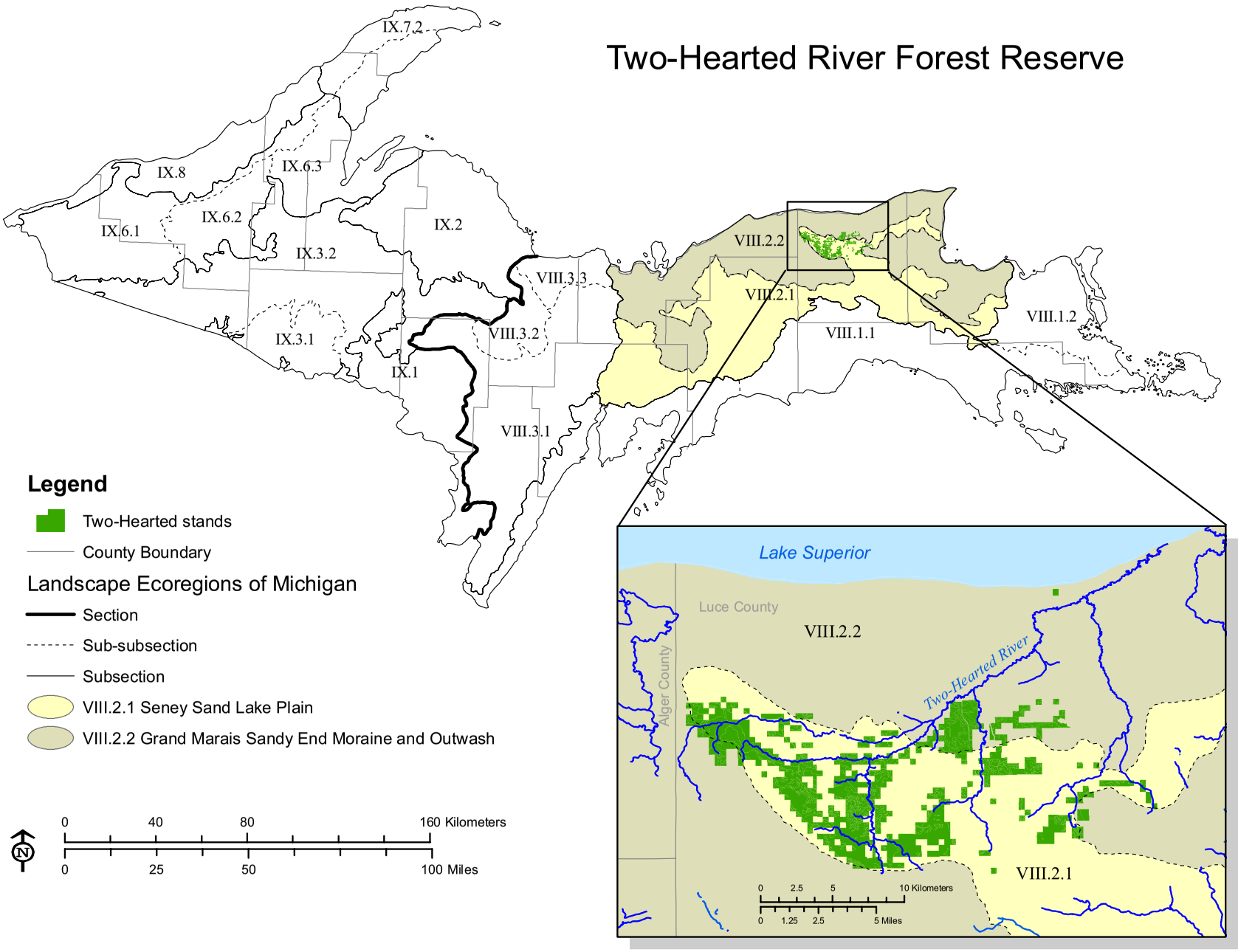

Figure 1. Ecoregions of Upper Michigan (Albert 1995). The Two-Hearted River Forest Reserve occurs within Sub-subsection VIII.2.1 (Seney Sand Lake Plain) and Sub-subsection VIII.2.2 (Grand Marais Sandy End Moraine and Outwash).

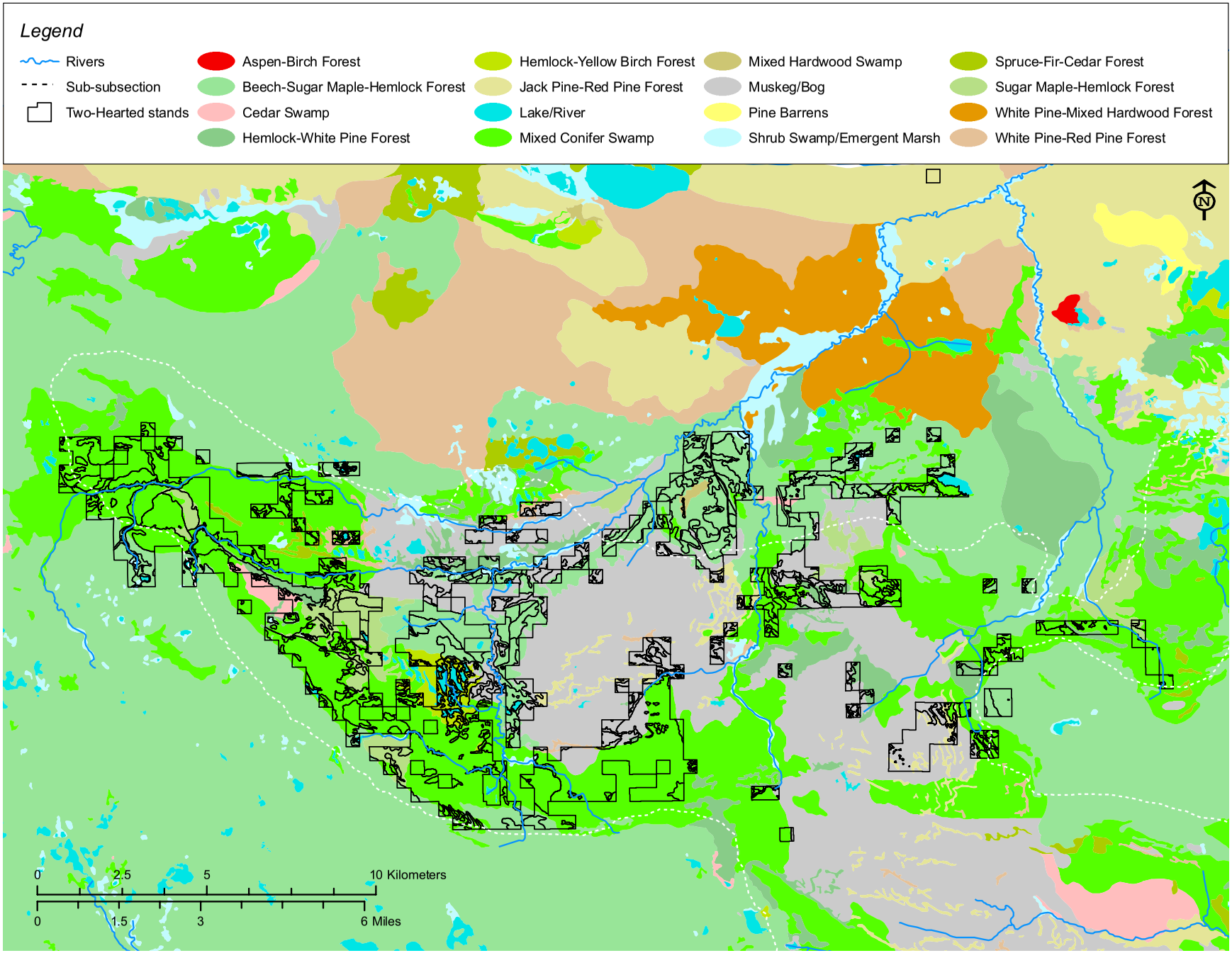

Figure 2. Vegetation circa 1800 of the Two-Hearted River Forest Reserve and surrounding area (Comer et al. 1995).

the transverse dunes within the peatlands. In addition, beaver floodings were quite common. The sub-subsection remains unfragmented with vast stretches of unperturbed wetlands and moderately logged upland forest. The peatlands of the sub-subsection are among the largest and least developed wetlands of the state. For much of the area, the original logging occurred shortly after 1900; white pine and red pine were harvested from the uplands and northern white-cedar (*Thuja occidentalis*) was logged from margins of the wetlands (Albert 1995).

Sub-subsection VIII.2.1, the Grand Marais Sandy End Moraine and Outwash, occurs in the northeastern corner of the THRFR and along the western and eastern edges (Figure 1). This sub-subsection is characterized by sandy end moraine ridges and pitted outwash with localized occurrences of transverse dunes, Lake Superior shoreline features, and poorly drained lacustrine deposits. Most of the moraine ridges and pitted outwash have well drained sandy soils. Circa 1800, coarse-textured moraines supported northern hardwoods, often with significant amounts of hemlock (*Tsuga canadensis*). Forests of red pine and white pine and red pine "openings" were also common on these moraines, and small swamps dominated by northern white-cedar, tamarack (*Larix laricina*), and spruce (*Picea* spp.) were also found in depressions on these moraines. On somewhat poorly drained tills, where bedrock is near the surface, hemlock and white pine were dominant species. Well-drained outwash supported northern hardwood forests. Moderately poorly drained outwash near the edges of wetlands often supported hemlock forest. Droughty, flat outwash plains supported open jack pine barrens or, where conditions were not quite so fire prone, forests of jack pine, red pine, and, occasionally, white pine (Figure 2). The dominant use of this sub-subsection has been commercial timber production. The upland forests were greatly affected by logging-era activities. Although most of the wetlands in this region persist, they were probably altered by logging and post-logging fires. Roads and small dams have had the most significant impact on wetland hydrology in this sub-subsection (Albert 1995).

Forest Change

As noted by Nelson et al. (2007), the forests of the THRFR have changed significantly within the past 100 years following widespread timber harvesting in the early 1900s. Forest change within this region has been characterized by decreases in structural and composition diversity of the forests and not dramatic forest conversion. In their assessment of the historical changes in the forests of the Luce District of the eastern Upper Peninsula, Zhang et al. (2000) found that the diameter distribution of long-lived species was truncated; circa 1800, there were fewer but larger trees, especially hemlock and white pine. The shift in the diameter distribution to smaller size classes was accompanied by a decrease in mean diameter and also in variance of diameters. These forests have increased in density but decreased in basal area due to the current prevalence of short-lived, early-successional species such as aspens and paper birch (*Betula papyrifera*). Decreases in large-diameter trees and conifers and increases in early-successional composition have resulted in a drastic decrease in volume and heterogeneity of coarse woody debris loads within managed forests (Tyrell and Crow 1994). In addition, logging and subsequent wildfires greatly diminished the role of conifers (white pine and hemlock) as a widespread component of the canopy (Zhang et al. 2000). Within this region, hemlock and white pine regeneration has diminished within managed stands because of the drastic reduction in seed source, and also due to the paucity of suitable establishment substrate such as decaying wood (nurse logs), moss beds, and large tip-up mounds, features associated with old-growth and late-successional stands and also necessary for yellow birch (*Betula alleghaniensis*) establishment (Curtis 1959, Rooney et al. 2000).

METHODS

The following discussion of methods is separated into two sections. The first section provides detailed description of the monitoring techniques developed to measure ecological integrity of managed upland forests. The second section outlines the methods employed by MNFI scientists to conduct rare species and natural community surveys.

MONITORING METHODS

In the summer of 2008, with the help of TNC, MNFI developed and implemented a long-term monitoring protocol to assess impacts of experimental timber management on the THRFR. The monitoring forms that were developed are included as Appendices 1 and 2. Monitoring was conducted in three different areas: northern hardwoods within the reserve scheduled for harvest in 2009 ("West of Pine Stump/South" and "East

of Pine Stump"); northern hardwoods within the reserve potentially held as experimental controls ("West of Pine Stump/North" and "Stuart Lake"); and reference areas (old-growth or late-successional forest) on nearby state lands (Tahquamenon Falls State Park and Newberry Forest Management Unit). For each stand sampled, qualitative information was noted regarding soils, site condition, threats, and management needs. Soil pits were dug to examine the soil profile and facilitate description of the depth to organics, depth to mineral soil, texture of mineral soil, and the pH of the soil. A comprehensive plant species list was compiled for each stand. At least one canopy dominant was aged using an increment borer. Threats (i.e., invasive species) and management recommendations were noted and element occurrence ranks (where appropriate) were assigned. In addition to the collected qualitative information, quantitative measures were acquired through sampling for four different aspects of forest ecological integrity: 1) forest structure, 2) forest-interior bird presence and diversity, 3) floristic quality, and 4) deer browse pressure. A detailed description of the methods for estimating the quantitative measures for each of the four aspects of forest ecological integrity is presented below.

1. Coarse woody debris and forest structure assessment.

A randomized line intercept method was utilized to gauge levels of coarse woody debris and plot sampling was employed to characterize overstory and understory structure and microtopography (De Vries 1973, Siitonen et al. 2000, Bate et al. 2004, Weber et al. 2007).

Coarse woody debris (CWD)

For the randomized line intercept method, transects of 20 meters (66 ft or a chain) were randomly arrayed in the stand of interest. Twenty transects were established per stand. Distance between the transects was greater than or equal to 10 meters (33 ft or one-half chain). The number and length of coarse woody debris intersecting the planar transect that stretches from ground to sky was recorded. For each piece that intersected the transect, surveyors determined species (if discernable), measured the diameter at the transect intersection, the diameter at the small and large ends of the piece, and piece length, and also assigned a decay class (Photo 1). Diameters were measured by holding a measuring tape against the log at a position perpendicular to the length. For logs that were not round, the diameter was estimated from the widest portion visible. Every log sampled was given a decay class ranging from I to V (Tyrell and Crow 1994, Weber et al. 2007). The five decay classes were: I – recent CWD, leaves present, solid wood, and round shape; II – solid CWD, leaves absent, solid wood, and round shape; III – solid or decayed CWD, leaves absent, solid or punky wood, and round or oval shape; IV – decayed CWD, leaves absent, punky wood, and oval shape; and V – very decayed CWD, leaves absent, punky wood, and oval or collapsed shape (Tyrell and Crow 1994).

Forest Structure

Twenty overstory and understory plots were established along the coarse woody debris transects at the 10 meter mark on the left side of the transect. The overstory plot was 10 x 15 meters and all tree species > 10 cm in diameter at breast height (DBH) were identified and their DBHs were measured (Photo 2). Both live and dead species were measured. Snags (dead, standing trees over two meters or six feet tall) were identified to genus or species (when possible) and given a decay class ranging from I to IV. The four snag classes assigned were: I – bark intact, small branches present; II – bark loose or sloughing, no sapwood degradation; III – little to no bark, sapwood degradation; and IV – no bark, extensive sapwood degradation. Snag height was estimated using a clinometer. For each stand, at least one canopy dominant within the overstory plot was aged using an increment borer. Within the 10 x 15 meter plot, pit and mound topography was assigned to one of four classes: I (none), II (< 10%), III (10-50%), or IV (> 50%). A 5 x 5 meter understory plot was nested within the overstory plot with a shared plot corner along the transect at the 10 meter mark (Photo 3). Within this plot, the stems of all understory species greater than or equal to 1 meter in height and greater than or equal to 1 cm DBH and < 10 cm DBH were recorded. In addition, data for calculating a deer browse index was collected within these plots. Within the understory plots the number of browsed and unbrowsed twigs for shrubs, saplings, and seedlings were recorded (see Deer Herbivory Index below).

2. Forest-interior bird presence and diversity.

Point-count sampling was employed to gather baseline information about forest-interior bird populations including relative abundance, species richness, and bird diversity. Methods similar to those recommended in Reynolds et al. (1980), Ralph et al. (1995), and Huff et

Forest vegetation and structure monitoring included measuring coarse woody debris (Photo 1, top left), and composition of the overstory (Photo 2, top right), understory (Photo 3, lower left), and ground cover (Photo 4, lower right) (Photo 1 by Ryan P. O'Connor and Photos 2-4 by Joshua G. Cohen).

al. (2000) were used. Point-count stations were randomly placed within each stand at least 75 meters from stand boundaries and dirt/paved roads (i.e., larger than two-tracks or old forest roads) and a minimum of 150 meters from other stations. Monitoring was conducted in early June from sunrise to 10:00 a.m. All birds seen and heard during ten-minute point counts were recorded. The species and number of individuals observed were recorded in three consecutive periods lasting 3 minutes and 20 seconds each. The three periods were treated as independent surveys and data collection was restarted at the beginning of each period. This method will permit estimation of detection probabilities. Each bird observation was assigned to one of four distance categories (0-25 m, 25-50 m, 50-100 m, and >100 m) based on the estimated distance from the observer to facilitate future distance analyses and refinement of density and population estimates. Qualitative information on the available songbird habitat (e.g., dominant overstory species, presence/absence of understory) was gathered at each point.

3. Floristic quality assessment.
Stand, transect, and plot-based surveys were utilized to assess native and non-native floristic diversity and composition by establishing baseline and benchmark floristic quality indices and plot-based estimations of native plant richness (Herman et al. 1997, Herman et al. 2001, Lopez and Siobhan Fennessy 2002, Edgin et al. 2005, Taft et al. 2006). For each stand, an overall species list was recorded, which was used to generate a stand level floristic quality list and index. Five 1 m^2 ground cover plots were established along the right side of the coarse woody debris transect and these plots were separated by four meters (Photo 4). Within each stand, a total of 100 plots were established (five plots per transect). Within the ground cover plots all herbaceous species and woody species < 1 meter in height were identified and the percentage cover for each species was estimated using the following seven cover classes: I (0-1%), II (2-5%), III (6-25%), IV (26-50%), V (51-75%), VI (76-95%), and VII (96-100%) (Duabenmire 1959 as modified by Bailey and Poulton 1968). Floristic plot data can be aggregated along each transect.

4. Deer herbivory index.
Plot-based assessments of deer browse on understory woody species were conducted within the understory plots (Frelich and Lorimer 1985, Balgooyen and Waller 1995, Rooney et al. 2002). Within the 5 m^2 understory plots, the number of browsed and unbrowsed twigs for shrubs, saplings, and seedlings was recorded. Browsed twigs that appear rough and jagged with a straight bite pattern were recorded as browsed by deer. This data can be utilized to calculate a deer herbivory index using the ratio of browsed to unbrowsed twigs.

SURVEY METHODS

MNFI scientists conducted surveys for rare species and high-quality natural communities in areas of northern hardwood forest currently proposed for management and also conducted focused natural features surveys across the reserve.

Rare Species Surveys within the Prescribed Northern Hardwoods

MNFI ecologists, botanists, and zoologists analyzed aerial photographs and MNFI's spatial database of rare species (MNFI 2008) to determine which rare plant and animal species could potentially occur within the northern hardwoods of the THRFR (Tables 1 and 2). Surveys for rare plants associated with the prescribed northern hardwoods were conducted in August, during the middle of the growing season, and coincided with the intensive vegetative sampling effort described above. Surveys focused on goblin moonwort (*Botrychium mormo*, state threatened, federal species of concern), bedstraw (*Galium kamtschaticum,* state threatened), and New England sedge (*Carex novae-angliae*, state threatened). Rare plant surveys involved intensive plot sampling (described above) in conjunction with meander surveys, during which comprehensive species lists were compiled and microhabitats were systematically searched.

Rare animal surveys within the prescribed northern hardwoods were conducted in May, June, July, and August 2008 and focused on rare raptors, including red-shouldered hawk (*Buteo lineatus*, state threatened) and northern goshawk (*Accipiter gentilis,* state special concern). Raptor surveys involved broadcasting conspecific calls at stations positioned throughout northern hardwood stands (Mosher et al. 1990, Anderson 2007). Station locations were identified on aerial photos and stand maps in ArcView, and points were uploaded to Garmin 12XL GPS units that were used to navigate to the appropriate station locations during field surveys. While walking and driving between station locations, trees were visually inspected for stick

Table 1. Rare plant survey targets, 2008.

Community	Scientific Name	Common Name	State Status
Bog and muskeg			
	Carex wiegandii	Wiegand's sedge	T
	Empetrum nigrum	Black crowberry	T
	Rubus acaulis	Dwarf raspberry	E
	Sarracenia purpurea f. *heterophylla*	Yellow pitcher-plant	T
Emergent marsh and submergent marsh			
	Armoracia lacustris	Lake cress	T
	Callitriche hermaphroditica	Autumnal water-starwort	SC
	Littorella uniflora	American shore-grass	SC
	Myriophyllum alterniflorum	Alternate-leaved water-milfoil	SC
	Myriophyllum farwellii	Farwell's water-milfoil	T
	Nuphar pumila	Small yellow pond-lily	E
	Potamogeton confervoides	Alga pondweed	SC
	Potamogeton hillii	Hill's pondweed	T
	Ruppia maritima	Widgeon-grass	T
	Subularia aquatica	Awlwort	E
Intermittentent wetland			
	Bartonia paniculata	Panicled screw-stem	T
	Carex wiegandii	Wiegand's sedge	T
	Huperzia selago	Fir clubmoss	SC
	Juncus vaseyi	Vasey's rush	T
	Lycopodiella margueriteae	Northern prostrate clubmoss	T
	Lycopodiella subappressa	Northern appressed clubmoss	SC
	Scirpus clintonii	Clinton's bulrush	SC
	Scirpus torreyi	Torrey's bulrush	SC
Patterned fen			
	Bartonia paniculata	Panicled screw-stem	T
	Drosera anglica	English sundew	SC
	Juncus stygius	Moor rush	T
	Petasites sagittatus	Sweet coltsfoot	T
Mesic northern forest			
	Botrychium mormo	Goblin moonwort	T
	Carex novae-angliae	New England sedge	T
	Galium kamtschaticum	Kamtschat's bedstraw	T

nests. In addition, visual surveys were conducted in July and August for territorial raptors and stick nests. Rare bird surveys were also conducted during the point-count sampling described above. Both rare plant and rare animal surveys relied on coverage of as much of the prescribed northern hardwoods as possible.

Ecological Surveys within the Prescribed Northern Hardwoods

When applying Natural Heritage and MNFI methodologies, three factors are considered when assessing a natural community's ecological integrity or quality: size, landscape context, and condition (Faber-Langendoen et al. 2008). If a site meets defined requirements (MNFI 1988) for these three criteria it is categorized as a high-quality example of a specific natural community type, entered into MNFI's statewide biodiversity conservation database (MNFI 2008) as an element occurrence, and given a ranking based on the consideration of its size, landscape context, and condition. Growing season surveys were conducted in July and August to assess the condition of the prescribed northern hardwood stands. Ecological surveys conducted in August coincided with the intensive vegetative sampling (described above). The quantitative vegetative sampling facilitated the evaluation of canopy, understory, and ground cover composition and structure, coarse woody debris levels, and deer browse pressure. Surveys involved compiling comprehensive plant species lists, describing the site's structural attributes and ecological processes, aging canopy dominants, analyzing the soils, noting current anthropogenic disturbances, evaluating potential threats, ground-truthing aerial photographic interpretation using Global Positioning Systems (both Garmin and HP iPAQ units were utilized), taking digital photos and GPS points, evaluating adjacent lands to assess landscape context, assigning element occurrence ranks, and noting management needs and restoration opportunities.

Targeted Rare Animal Surveys

During early June, rare animal surveys focused on insects associated with open peatland systems, including ebony boghaunter (*Williamsoni fletcheri*, state special concern dragonfly), red-disked alpine (*Erebia discoidalis*, state special concern butterfly), frigga fritillary (*Boloria frigga*, state special concern butterfly), and freija fritillary (*Boloria freija*, state special concern butterfly). Meander surveys through appropriate habitat occurred from 9:00 a.m. to 5:00 p.m. When a rare insect was encountered, an MNFI special animal form was completed, selected habitat photos were taken, and when necessary a voucher specimen was collected for later confirmation.

Targeted Rare Plant Surveys

Rare plant species were targeted for survey based on the natural communities found in the reserve and known historical and current rare plant distribution patterns within the region. Table 1 lists the rare plant species survey targets by associated natural community. Rare plant surveys focused on more than two dozen species associated with open wetlands, such as bog, muskeg, intermittent wetland, emergent marsh, and submergent marsh (Table 1). Rare plant inventories were performed by meander survey of appropriate habitat during periods when the plants are most recognizable (Elzinga et al. 1998). Surveys for rare plants within open wetlands were conducted during July, August, and early September. When a rare plant was encountered, an MNFI special plant form was filled out, selected photos were taken, and when necessary a voucher specimen was collected for later confirmation.

Targeted Ecological Surveys

Natural community surveys assessed the current ecological condition of high-quality areas and detailed the vegetative structure and composition, landscape and abiotic context, threats, management needs, and restoration opportunities. As noted above, Natural Heritage and MNFI methodologies consider three factors to assess a natural community's ecological integrity or quality: size, landscape context, and condition (Faber-Langendoen et al. 2008). If a site meets defined requirements (MNFI 1988) for these three criteria it is categorized as a high-quality example of that specific natural community type, entered into MNFI's statewide biodiversity conservation database (MNFI 2008) as an element occurrence, and given a rank based on the consideration of its size, landscape context, and condition. Growing season surveys were conducted to assess the condition and classification of the sites, while a combination of ground surveys, aerial photographic interpretation, and Geographic Information System (GIS) analysis was employed to determine the size and the landscape context of the sites. Targeted surveys focused on muskeg, bog, hardwood-conifer swamp, and dry-mesic northern forest. Ecological surveys were conducted in July 2008 during which MNFI ecologists visited seven high-quality sites.

Table 2. Potential survey targets and survey prioritization scoring.

NATURAL COMMUNITY	G/S Rank	State Status	Stand Types	Rarity	Threat	Estimated Probability	SCORE	Acreage	Estimated Survey Effort
Rich Conifer Swamp (RCS)	G4S3		SC	4	2	5	11	11214	2-3 weeks (RCS & HCS)
Hardwood-Conifer Swamp (HCS)	G4S3		SC	4	2	5	11	11214	2-3 weeks (RCS & HCS)
Dry Northern Forest	G3?S3		P (within SC or M)	4	1	5	10	226	1-2 days
Muskeg	G4G5S3		M	4	1	5	10	2260	2-3 days
Bog	G3G5S3		M	4	1	4	9	2260	3-5 days
Dry-mesic Northern Forest	G4S3		P (within SC or M)	4	2	3	9	226	1-2 days
Intermittent Wetland	G2S3		M	5	1	3	9	2260	3- 5 days
Mesic Northern Forest	G4S3		NH and HH	4	3	1	8	9131	2-3 weeks
Northern Shrub Thicket	G4S5		M	2	1	5	8	2260	3- 5 days
Northern Wet Meadow	G45S4		M	2	1	5	8	2260	3- 5 days
Poor Conifer Swamp	G4S4		SC	2	1	5	8	11214	3-5 days
ANIMALS (grouped by habitat)	**G/S Rank**	**State Status**	**Stand Types**	**Rarity**	**Threat**	**Estimated Probability**	**SCORE**	**Acreage**	**Estimated Survey Effort**
Hemlock/Hardwood Diurnal Raptors			HH	3	3	4	10	4642	2-3 weeks
Northern Goshawk	G5S1S2	SC							
Red-shouldered Hawk	G5S3S4	T							
Broad-winged Hawk	G5S5								
Cooper's Hawk	G5S3S4	SC							
Sharp-shinned Hawk	G5S4								
Red-tailed Hawk	G5S5								
Northern Hardwood Diurnal Raptors			NH	3	3	2	8	4490	2-3 weeks
Northern Goshawk	G5S1S2	SC							
Red-shouldered Hawk	G5S3S4	T							
Broad-winged Hawk	G5S5								
Cooper's Hawk	G5S3S4	SC							
Sharp-shinned Hawk	G5S4								
Red-tailed Hawk	G5S5								
Wetland dragonflies			M	4	1	5	10	2260	2 weeks
Ebony Boghaunter	G3G4S1S2	SC							
Incurvate Emerald	G4S1S2	SC							
Bog butterflies			M	4	1	4	9	2260	2-3 weeks
Freija Fritillary	G5S3S4	SC							
Frigga Fritillary	G5S3S4	SC							
Red-disked Alpine	G5S2S3	SC							

Table 2, continued. Potential survey targets and survey prioritization scoring.

ANIMALS (grouped by habitat)	G/S Rank	State Status	Stand Types	Rarity	Threat	Estimated Probability	SCORE	Acreage	Estimated Survey Effort
Wetland birds			M	4	1	4	9	2260	2-3 weeks
Yellow Rail	G4S1S2	T							
American Bittern	G4S3S4	SC							
Short-eared Owl	G5S1S2	E							
Northern Harrier	G5S3	SC							
Common Loon	G5S3S4	T	(ponds and lakes)						
Conifer birds									
Merlin	G5S1S2	T	P (within SC or M)	4	2	5	11	226	1 week
Black-backed Woodpecker	G5S2	SC	P (within SC or M)	3	2	4	9	226	1 week
Northern Goshawk	G5S3	SC	P	3	3	3	9	226	1-2 days
Spruce Grouse	G5S2S3	SC	SC	2	1	5	8	11214	2 weeks
Generalist herptiles			All types associated with drainages						
Blanding's Turtle	G4S3	SC		3	1	4	8		1 week
Wood Turtle	G4S2S3	SC		3	1	3	7		1 week

PLANTS (grouped by habitat type)	G/S Rank	State Status	Stand Types	Rarity	Threat	Estimated Probability	SCORE	Acreage	Estimated Survey Effort
Graminoid-dominated Wetlands			M				8.6	2260	2-3 weeks
Auricled Twayblade	G3S2S3	SC		4	1	5	10		
Dwarf Raspberry	G5S1	E		4	1	3	8		
English Sundew	G5S3	SC		3	1	5	9		
Fir Clubmoss	G5S3	SC		3	1	5	9		
Fleshy Stitchwort	G5S1S2	T		3	1	3	7		
Hudson Bay Sedge	G4S1	E		4	1	3	8		
Moor Rush	G5S1S2	T		3	1	3	7		
Northern Appressed Clubmoss	G2S2	SC		5	1	4	10		
Northern Prostrate Clubmoss	G2S2	T		5	1	4	10		
Panicled Screw-stem	G5S2	T		4	1	5	10		
Sweet Coltsfoot	G5S1S2	T		4	1	2	7		
Dry-mesic Northern Forest			P				8.5	226	1 week
False-violet	G5S1S2	T		4	2	2	8		
Pine-drops	G5S2	T		4	2	3	9		

Table 2, continued. Potential survey targets and survey prioritization scoring.

PLANTS (grouped by habitat type)	G/S Rank	State Status	Stand Types	Rarity	Threat	Estimated Probability	SCORE	Acreage	Estimated Survey Effort
Rich Conifer Swamp			SC				8.6	11214	2-3 weeks
Calypso or Fairy-slipper	G5S2	T		3	2	4	9		
Lapland Buttercup	G5S1S2	T		3	2	4	9		
Limestone Oak Fern	G5S2	T		3	2	3	8		
Ram's Head Lady's-slipper	G3S3	SC		4	2	3	9		
Round-leaved Orchis	G5S1	E		4	2	2	8		
Bog and Muskeg			M				8.3	2260	2 weeks
Black Crowberry	G5S2	T		3	1	3	7		
Wiegand's Sedge	G3S2	T		4	1	5	10		
Yellow Pitcher-plant	G5S1	T		4	1	3	8		
Mesic Northern Forest			NH and HH				8	9131	2 weeks
Bedstraw	G5S1	T		4	3	1	8		
Goblin Moonwort	G3S2	T		4	3	1	8		
New England Sedge	G5S1	T		4	3	1	8		
Ponds and Streams			W				7.5	480	2 weeks
Alga Pondweed	G4S3	SC		3	1	5	9		
Alternate-leaved Water-milfoil	G5S2S3	SC		3	1	3	7		
American Shore-grass	G5S2S3	SC		3	1	3	7		
Autumnal Water-starwort	G5S2	SC		3	1	3	7		
Farwell's Water-milfoil	G5S2	T		3	1	3	7		
Hill's Pondweed	G3S2	T		4	1	3	8		
Lake Cress	G4S2	T		4	1	3	8		
Satiny Willow	G5S2	SC		3	1	3	7		

Typically, a minimum of a day was spent at each site. Many sites occur on multiple ownerships; however, surveys were restricted to TNC property and areas of public ownership. Where possible, MNFI ecologists targeted lands adjacent to existing Ecological Reference Areas on State Forest lands. For each site visited, an Ecological Community Field Survey Form was completed. Surveys involved:

a) compiling comprehensive plant species lists
b) describing site-specific structural attributes and ecological processes
c) measuring tree diameter at breast height (DBH) of representative canopy trees and aging canopy dominants (where appropriate)
d) analyzing soils and hydrology
e) noting current anthropogenic disturbances
f) evaluating potential threats
g) ground-truthing aerial photographic interpretation using Global Positioning Systems (both Garmin and HP iPAQ units were utilized)
h) taking digital photos and GPS points
i) surveying adjacent lands when possible to assess landscape context
j) assigning a natural community classification
k) assigning element occurrence ranks
l) noting management needs and restoration opportunities

Following completion of the field surveys, the collected data were analyzed and transcribed to generate element occurrence records in MNFI's statewide biodiversity conservation database (MNFI 2008). Information from these surveys and from surveys conducted prior to this project was used to produce site descriptions, threat assessments, and conservation and management recommendations for each documented high-quality natural community occurrence, which appear within the following Survey Results and Site Discussion section.

MONITORING RESULTS

The vegetative sampling was conducted by MNFI ecologists and botanists during August 2008. Twenty transects were established within five different sites or stands. Two of the stands are prescribed northern hardwoods on the THRFR: West of Pine Stump/South and East of Pine Stump (Figures 3 and 4). Two sampled stands on the THRFR are prescribed northern hardwood stands that will likely be held as experimental controls (West of Pine Stump/North and Stuart Lake) (Figures 3 and 5). The final stand sampled was an old-growth mesic northern forest that occurs within the Tahquamenon Falls State Park (Figure 6).

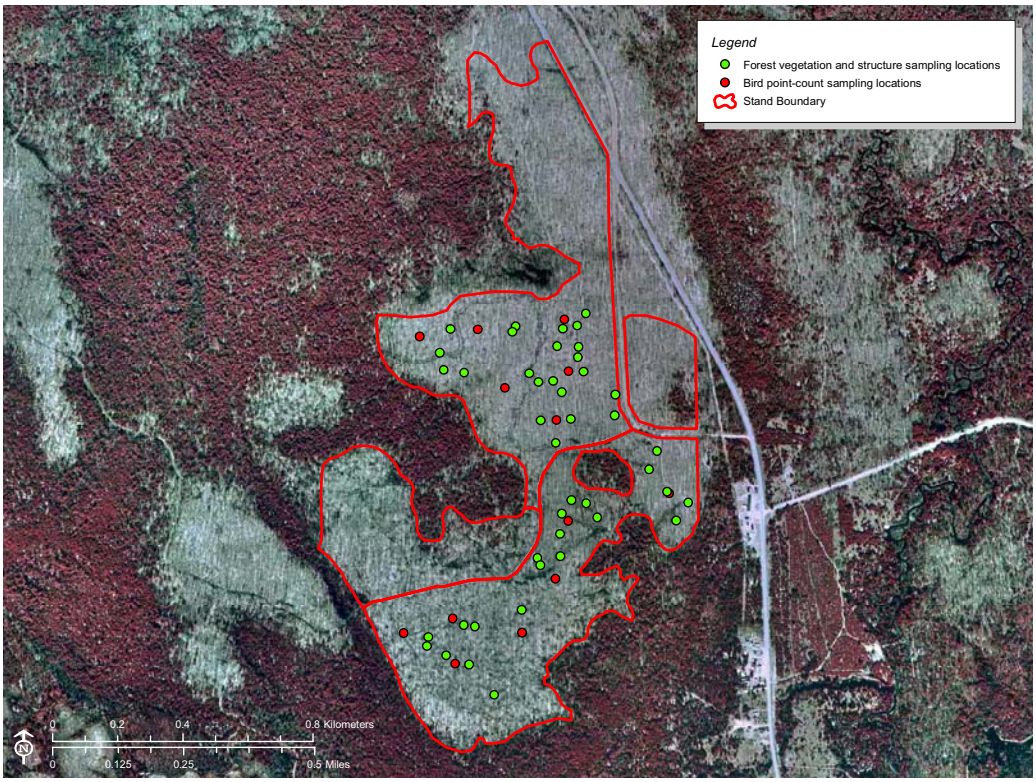

Figure 3. Monitoring locations within West of Pine Stump stands. The southern polygon is prescribed for harvest and the northern polygon will likely be held as an expiremental control.

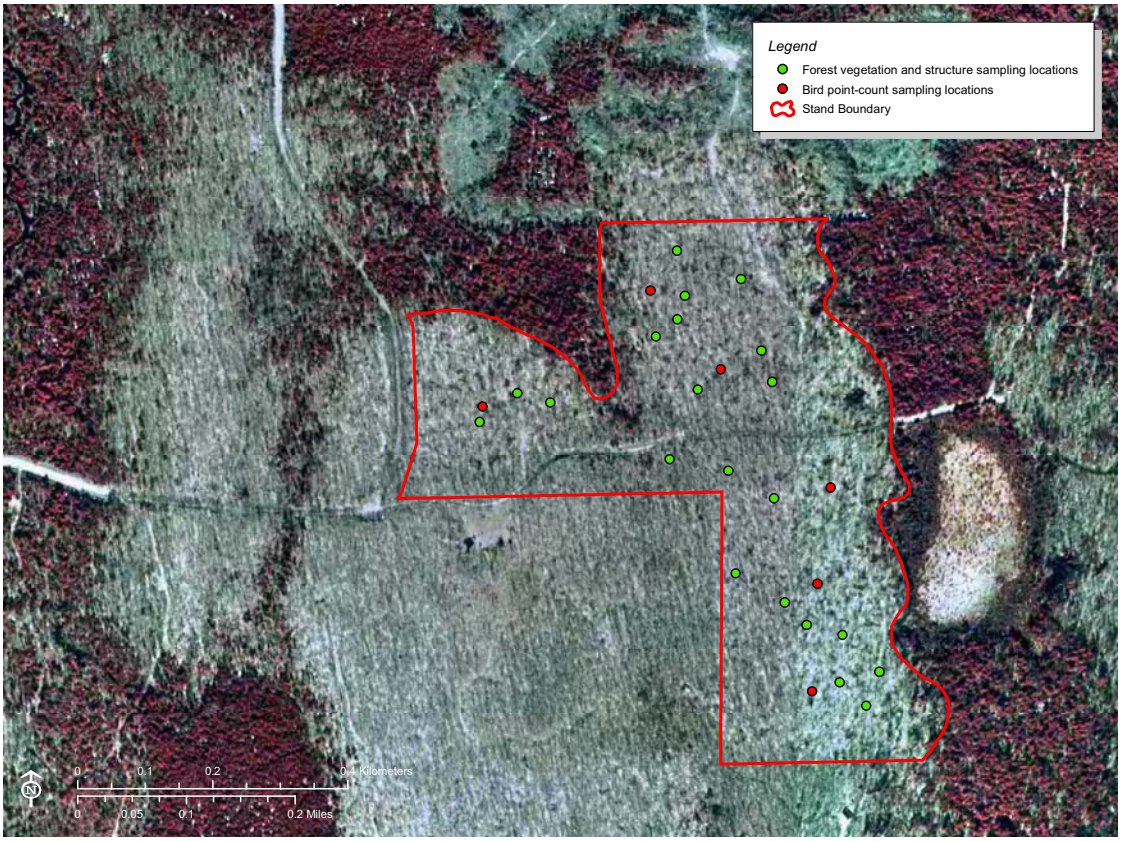

Figure 4. Monitoring locations within East of Pine Stump stand.

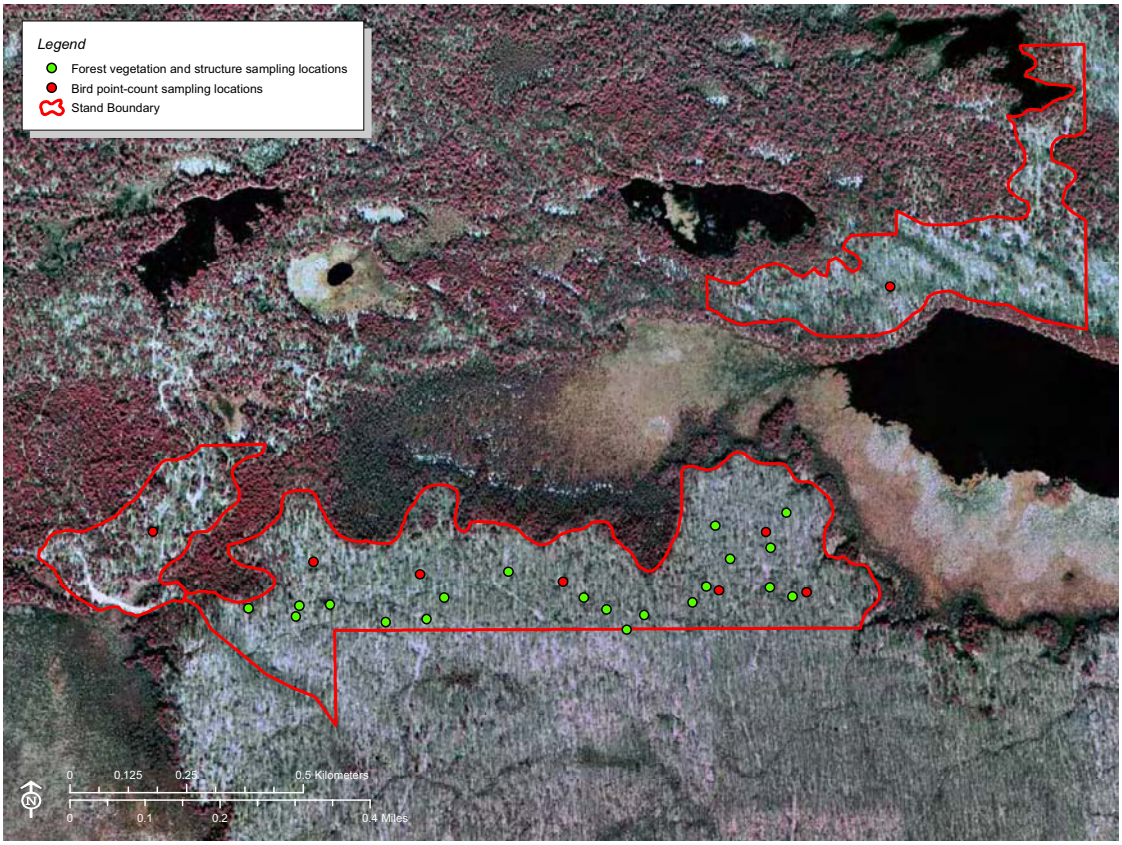

Figure 5. Monitoring locations within Stuart Lake stands.

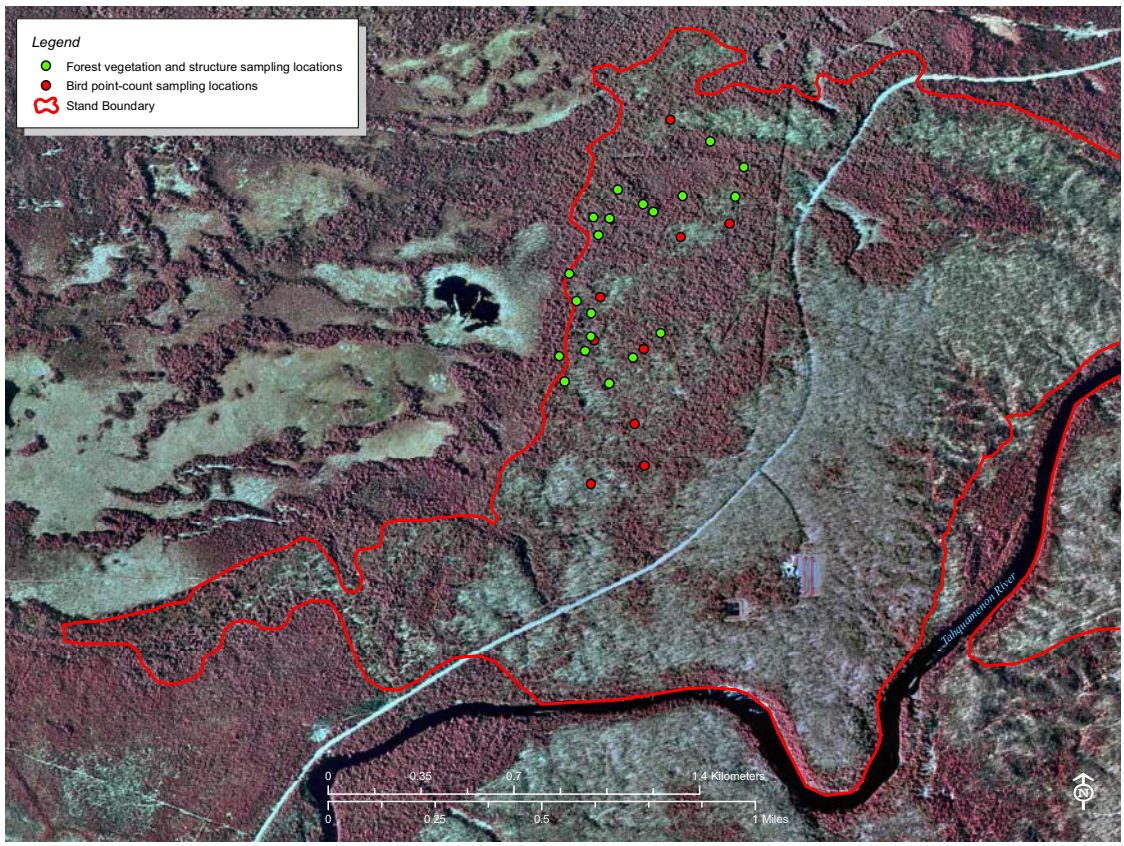

Figure 6. Monitoring locations within old-growth forest in Tahquamenon Falls State Park.

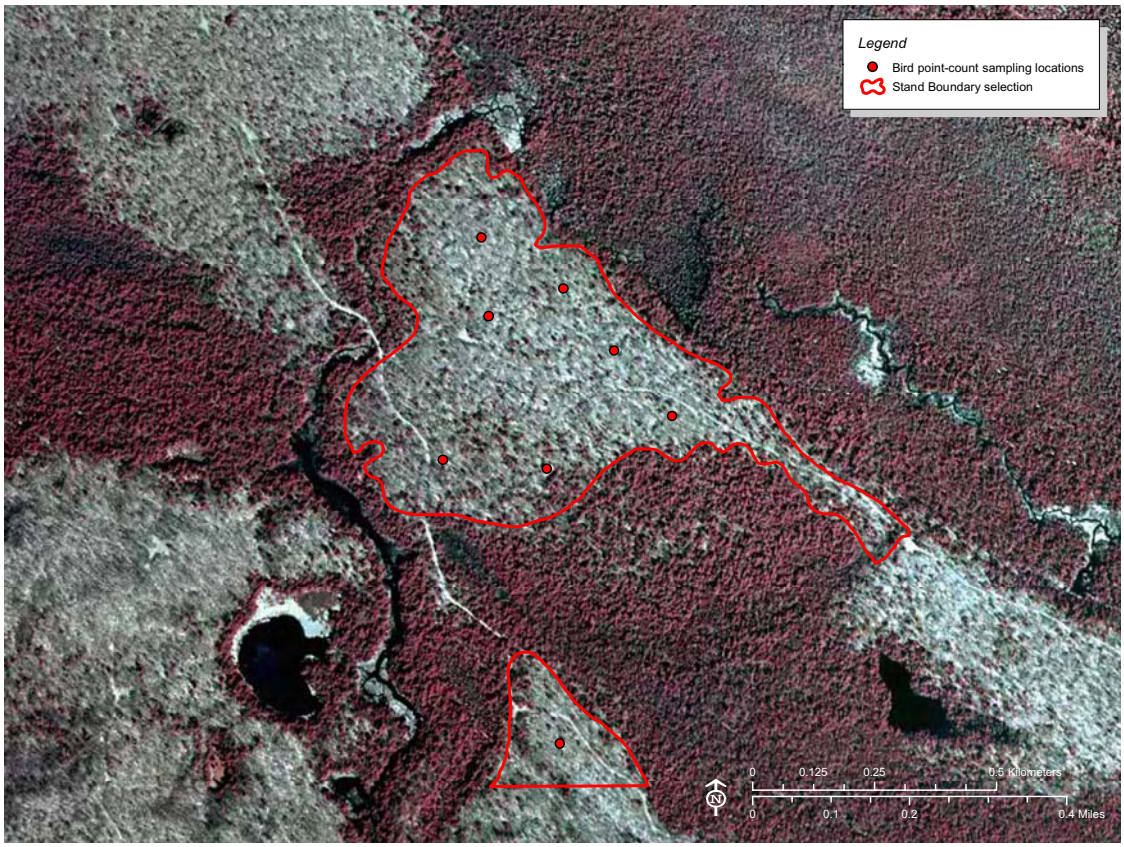

Figure 7. Monitoring locations within Martindary Lake stands.

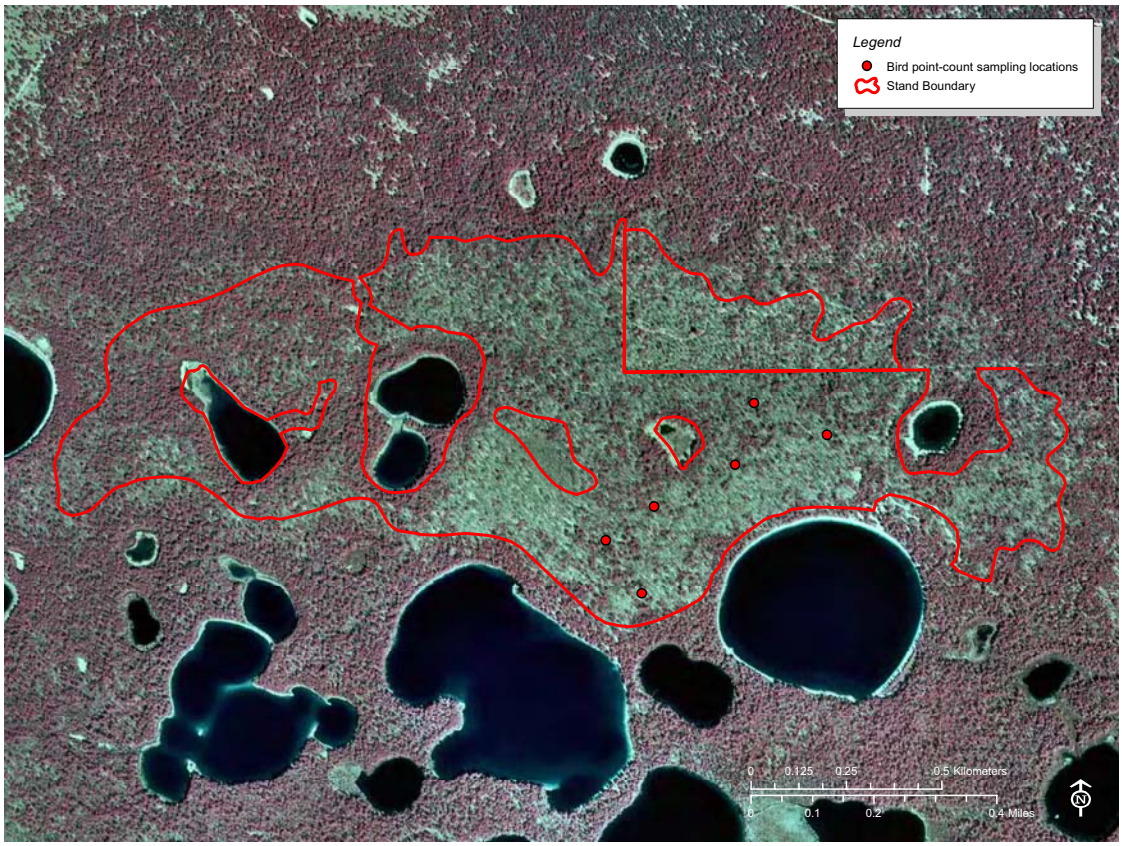

Figure 8. Monitoring locations within Pretty Lakes State Forest stand.

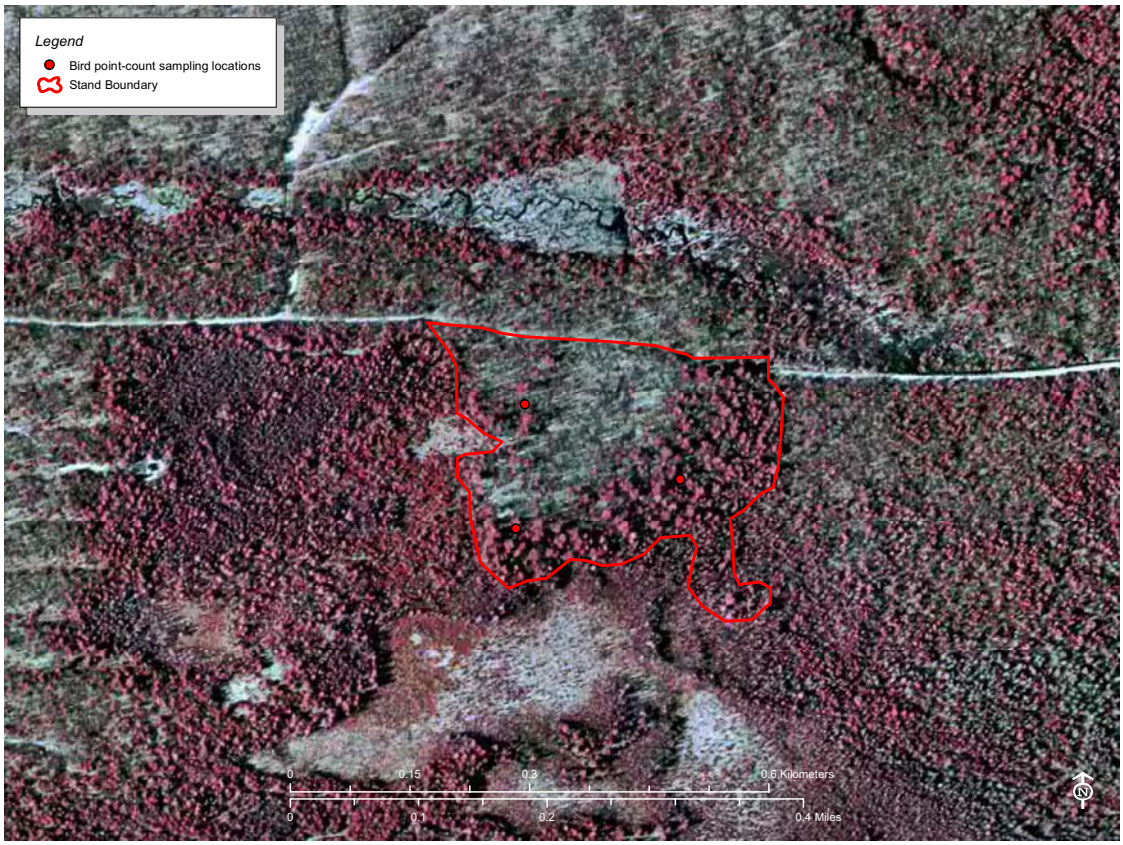

Figure 9. Monitoring locations within Parcell Lakes old-growth forest.

Figure 10. Monitoring locations within Little Two-Hearted Lakes old-growth forest.

MNFI zoologists completed point-count sampling for forest-interior bird presence and diversity in early June. Fifty-seven point counts were conducted at a total of eight sites. Four of these sites and 35 point counts were within northern hardwoods of the THRFR that were managed within the past fifty years: West of Pine Stump (13 points), East of Pine Stump (6 points), Stuart Lake (8 points), and Martindary Lake (8 points) (Figures 3, 4, 5, and 7). Two of these sampled stands on the THRFR are prescribed northern hardwood stands that will likely be held as experimental controls (West of Pine Stump/North and Stuart Lake). The remaining four sites and 22 point counts were reference stands within mature to old-growth forest on nearby State lands: Pretty Lakes (State Forest, 6 points) (Figure 8), Parcell Lake (State Forest, 3 points) (Figure 9), Little Two-Hearted Lakes (State Forest, 4 points) (Figure 10), and Tahquamenon Falls (State Park, 9 points) (Figure 6). Field forms from the monitoring were delivered to TNC for analysis in October 2008.

SURVEY RESULTS AND SITE DISCUSSION

Rare Species Surveys and Ecological Surveys within Prescribed Northern Hardwoods

No rare species or high-quality natural communities were found within the prescribed northern hardwood stands. Given that these prescribed northern hardwood stands have been recently managed (within the last several decades) and lack the structural and compositional complexity of late seral mesic northern forest, these results were expected.

Targeted Rare Animal Surveys

New records for ebony boghaunter, spruce grouse (*Falcipennis canadensis*, state special concern), and merlin (*Falco columbarius*, state threatened) were discovered on the reserve this past summer within peatland systems. New element occurrence records for merlin and spruce grouse were observed opportunistically by MNFI ecologists and botanists conducting botanical and ecological surveys. Targeted surveys for these species within the THRFR will likely result in additional documentation.

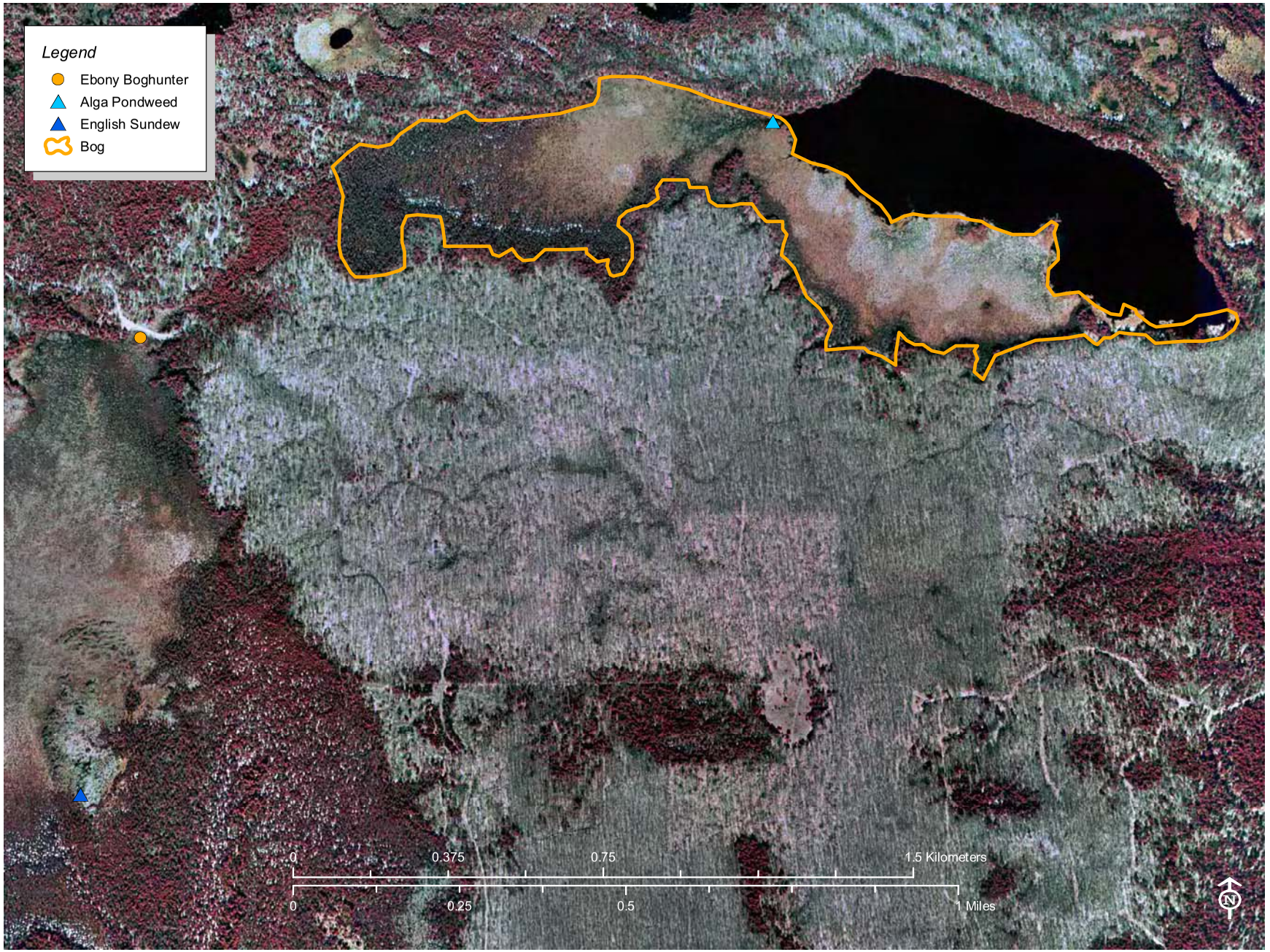

Figure 11. Stuart Lake Bog. The high-quality bog adjacent to Stuart Lake supports a population of alga pondweed. To the west, within a previously documented high-quality patterned fen, are populations of ebony boghaunter and English sundew.

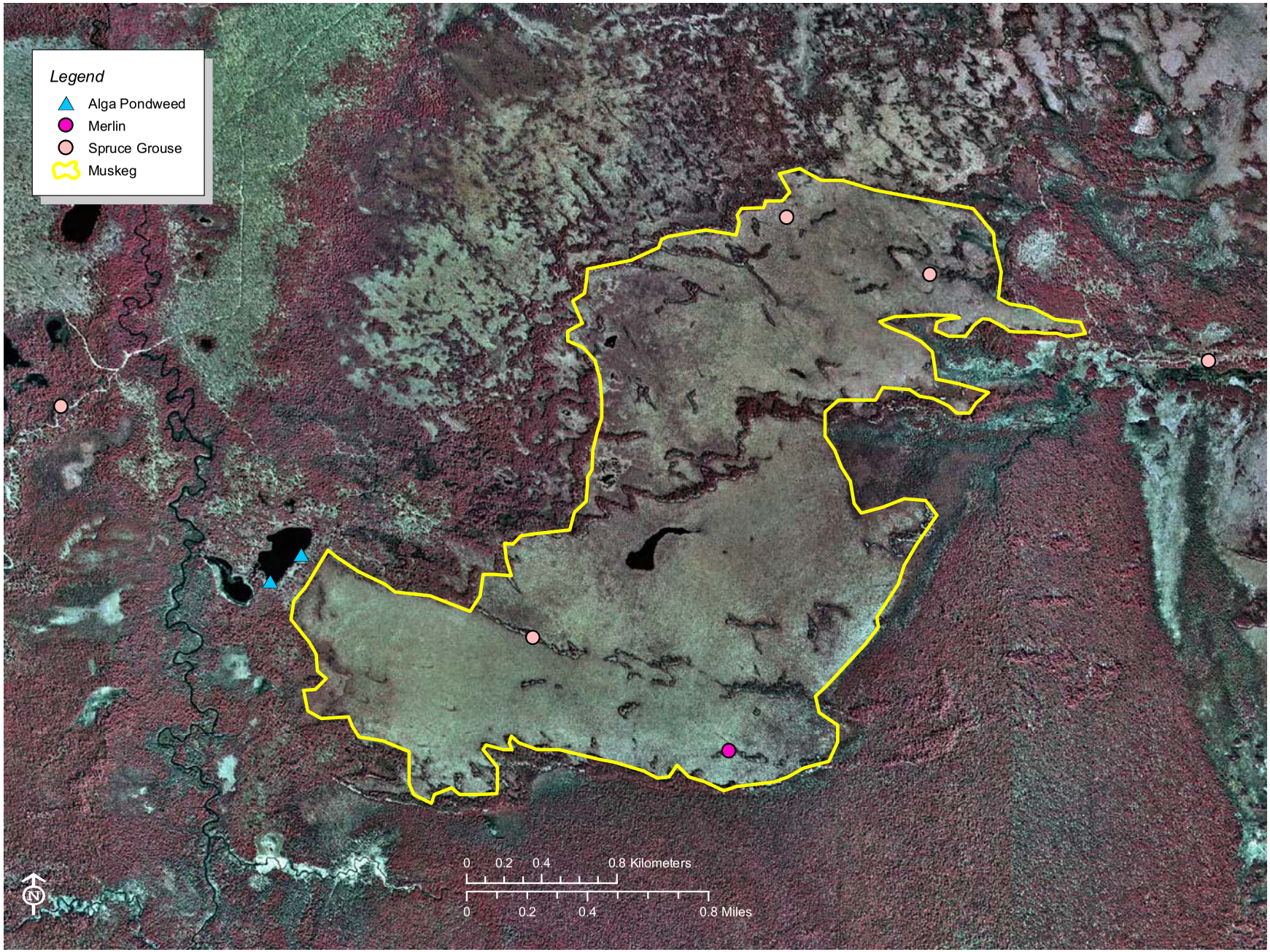

Figure 12. Dawson Creek Muskeg. Spruce grouse and merlin were documented within this extensive peatland complex. In addition, spruce grouse were also observed in the vicinity and alga pondweed was found nearby along the shores of Beaver Lake.

Species: Ebony boghaunter (*Williamsoni fletcheri*)
Rank: G3G4 S1S2, apparently secure globally and uncertain in MI, ranging from critically imperiled to imperiled
Status: special concern
Element Occurrence Rank: AB
Location: Captain Jenk's Patterned Fen

The ebony boghaunter specimen was collected in the previously documented Captain Jenk's Patterned Fen, and while only one specimen was observed, this high-quality patterned fen contains abundant habitat (i.e., bog pools) (Photo 5 and Figure 11). This represents the fifteenth location for the ebony boghaunter in Michigan and the first location from Luce County. The nearest location to the THRFR is in Tahquamenon Falls State Park in the Betsy Lake peatland complex.

Photo 5. Captain Jenk's Patterned Fen contains numerous bog pools that provide habitat for ebony boghaunter (Photo by Joshua G Cohen).

Species: Merlin (*Falco columbarius*)
Rank: G5 S1S2, secure globally and uncertain in MI, ranging from critically imperiled to imperiled
Status: special concern
Element Occurrence Rank: BC
Location: Dawson Creek Muskeg

A young merlin was found on the ground along the margin of dry northern forest within the Dawson Creek Muskeg (Figure 12). Tree species in the area included jack pine (*Pinus banksiana*), red pine (*P. resinosa*), and black spruce (*Picea mariana*). Ground cover consisted of blueberry (*Vaccinium* spp.), wintergreen (*Gaultheria procumbens*), bracken ferns (*Pteridium aquilinum*), and lichens. Two agitated adult merlin were in the immediate vicinity and although no nest could be located the young bird was incapable of flight and likely had fallen out of the nest (Photo 6). This represents only the second nesting location for merlin in Luce County and the seventh in the MNFI database for the state (MNFI 2008). The first Michigan Breeding Bird Atlas documented 16 confirmed and 14 probable nesting records in seven Upper Peninsula counties (Binford 1991).

Species: Spruce grouse (*Falcipennis canadensis*)
Rank: G5 S2S3, secure globally and uncertain in MI, ranging from imperiled to vulnerable
Status: special concern
Element Occurrence Rank: AB
Location: Dawson Creek Muskeg

At least a dozen individuals were observed, mostly in the Dawson Creek Muskeg, a peatland dominated by scattered and stunted conifers and bisected by narrow sandy upland ridges dominated by pines (Figure 12 and Photo 7). Birds were also found in cover along adjacent sandy ridges traversed by the Dawson Creek trail, and a single male was observed in second-growth northern hardwoods upslope from the Two-Hearted Lakes Intermittent Wetland (Figure 13). This record represents the third spruce grouse element occurrence in Luce County. In Michigan, spruce grouse occur in scattered locations throughout the Upper Peninsula, although they appear to be more common in the eastern Upper Peninsula (Monfils 2007).

Photo 6. A young merlin was found in the Dawson Creek Muskeg (Photo by Joshua G. Cohen).

Photo 7. Numerous spruce grouse were observed along the low dune ridges within the Dawson Creek Muskeg (Photo by Joshua G. Cohen).

Table 3. Rare plants documented during 2008 surveys.

Species	Site Name	State Status	Year First Observed	Year Last Observed
Bartonia paniculata Panicled screw-stem	Beavertown Lakes Muskeg	T	2008	2008
Drosera anglica English sundew	Captain Jenk's Patterned Fen	SC	1984	2008
Potamogeton confervoides Alga pondweed	Stuart Lake Bog	SC	1983	2008
Potamogeton confervoides Alga pondweed	Beavertown Lakes Muskeg	SC	2008	2008
Potamogeton confervoides Alga pondweed	Beaver Lake	SC	2008	2008

Targeted Rare Plant Surveys

Three new plant element occurrences were found, and two previously documented plant populations were reconfirmed (Table 3). All of theses rare plant occurrences were found in open wetland communities. Panicled screw-stem (*Bartonia paniculata*, state threatened) was found just south of Beavertown Lakes, and two new records for alga pondweed (*Potamogeton confervoides*, state special concern) were found at Beavertown Lakes and Beaver Lake. In addition, two previously known records were reconfirmed, including alga pondweed at Stuart Lake and English sundew (*Drosera anglica*, state special concern) at Captain Jenk's Patterned Fen.

Species: Panicled screw-stem (*Bartonia paniculata*)
Rank: G5 S2, secure globally and imperiled in the state
Status: threatened
Element Occurrence Rank: C
Location: Beavertown Lakes Muskeg (south of Beavertown Lakes)

Panicled screw-stem was the most significant new plant occurrence, representing only the seventh record for the species in the state (Photo 8). It occurs within the expansive Beavertown Lakes Muskeg complex just south of Beavertown Lakes on the margin of an intermittent wetland with minerotrophic influence (Figure 14). Only sixteen plants were found, despite an apparent abundance of suitable habitat. Compared to other occurrences for the species, the population is small, although the habitat is of exceptional quality with no disturbance noted. This occurrence is only the second locality for the species in Luce County.

Photo 8. Panicled screw-stem, documented within an intermittent wetland south of Beavertown Lakes (Photo by Ryan P. O'Connor).

Species: Alga pondweed (*Potomogeton confervoides*)
Rank: G4 S3, apparently secure globally and vulnerable in the state
Status: special concern
Element Occurrence Rank: A
Location: Beavertown Lakes Muskeg (Beavertown Lakes)

Alga pondweed, an aquatic species, was found in 10 to 20 cm of water within 1 to 2 meters of the shore, often in proximity to upland sand ridges. Although usually rooted in peat substrate, broken stems of alga pondweed were frequently observed floating on the surface of the water near large colonies (Photo 9). More than a dozen indivual colonies were found across five different lakes within the Beavertown Lakes Muskeg, totaling an area of several hundred square meters (Figure 14). An exceptionally large metapopulation for this normally uncommon species, this site ranks as one of only two A-ranked occurrences out of the 19 records for this species in the state.

Photo 9. Alga pondweed documented in the Beavertown Lakes (Photo by Ryan P. O'Connor).

Species: Alga pondweed (*Potomogeton confervoides*)
Rank: G4 S3, apparently secure globally and vulnerable in the state
Status: special concern
Element Occurrence Rank: C
Location: Beaver Lake

A second new occurrence of alga pondweed was found in a small lake east of the Two-Hearted River and west of the Dawson Creek Muskeg in Beaver Lake (Figure 12). A small colony was located in an inlet shaded by a large white pine (*Pinus strobus*) on the east side of the lake, and a second small colony was documented to the south along the shoreline. Although occupying an area of just a few square meters, the habitat quality was excellent with potential for additional colonies to be found elsewhere on the lake. This new occurrence and the occurrence at Beavertown Lakes bring the total alga pondweed records in Luce County to six, the most in any county in the state.

Species: Alga pondweed (*Potomogeton confervoides*)
Rank: G4 S3, apparently secure globally and vulnerable in the state
Status: special concern
Element Occurrence Rank: C
Location: Stuart Lake Bog (Stuart Lake)

A previously known occurrence of alga pondweed was reconfirmed at Stuart Lake within the Stuart Lake Bog complex (Photo 10 and Figure 11). Originally documented in 1983, better locational information, habitat data, and a list of associated species were collected for this occurrence. Found in a narrow inlet on the northwest corner of the lake (Photo 11), the species occupied approximately 20 square meters of habitat.

Species: English sundew (*Drosera anglica*)
Rank: G5 S3, secure globally and vulnerable in the state
Status: special concern
Element Occurrence Rank: B
Location: Captain Jenk's Patterned Fen

English sundew occurs in the large peatland known as Captain Jenk's Patterned Fen, located approximately 2.5 miles east of Pine Stump Junction (Figure 11). English sundew is most abundant in flarks, or wet swales, in the southeastern portion of the patterned fen (Photo 12). One of several sundew species present in

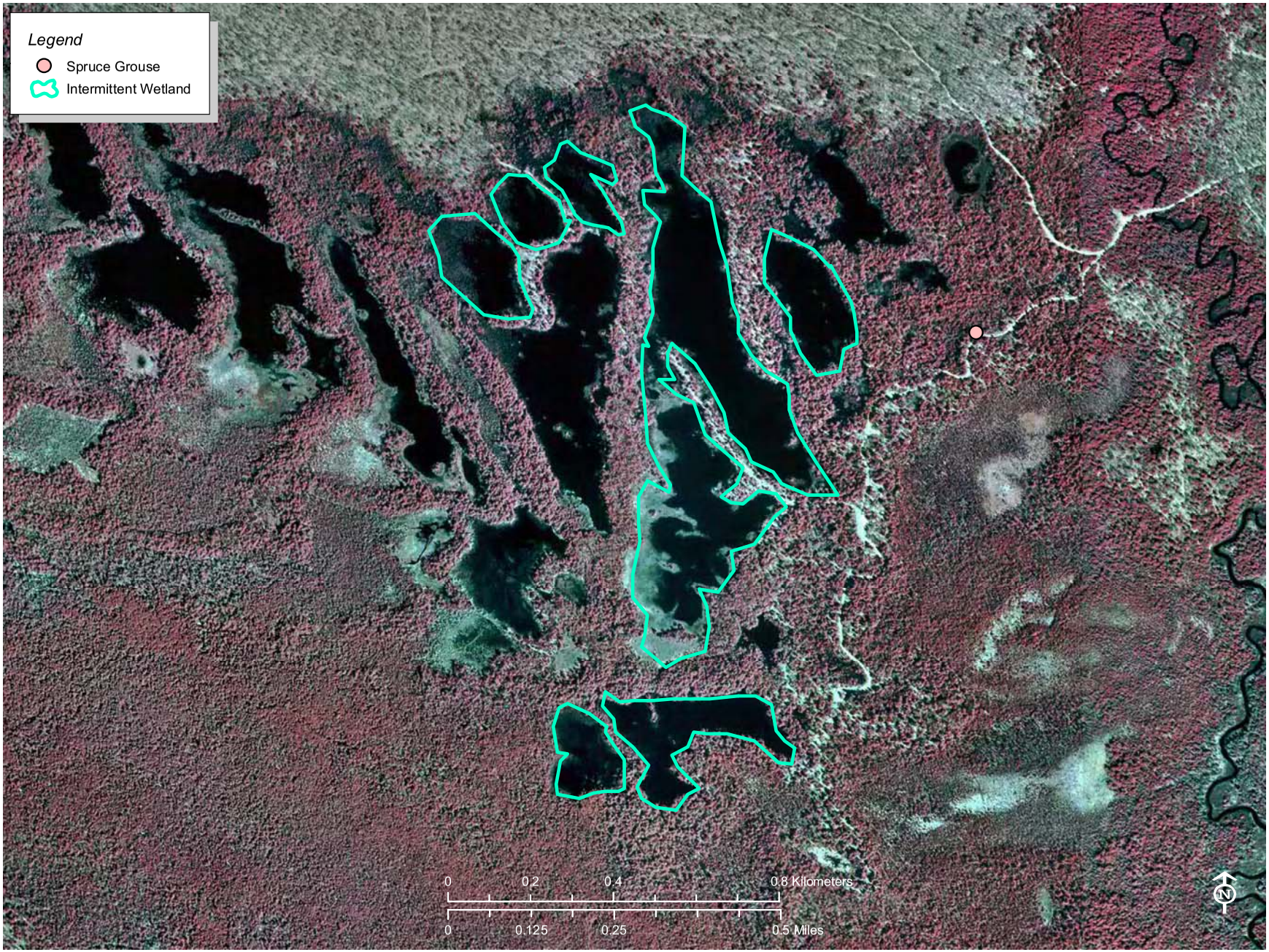

Figure 13. Two-Hearted Lakes Intermittent Wetland. Spruce grouse were documented to the east in the surrounding uplands.

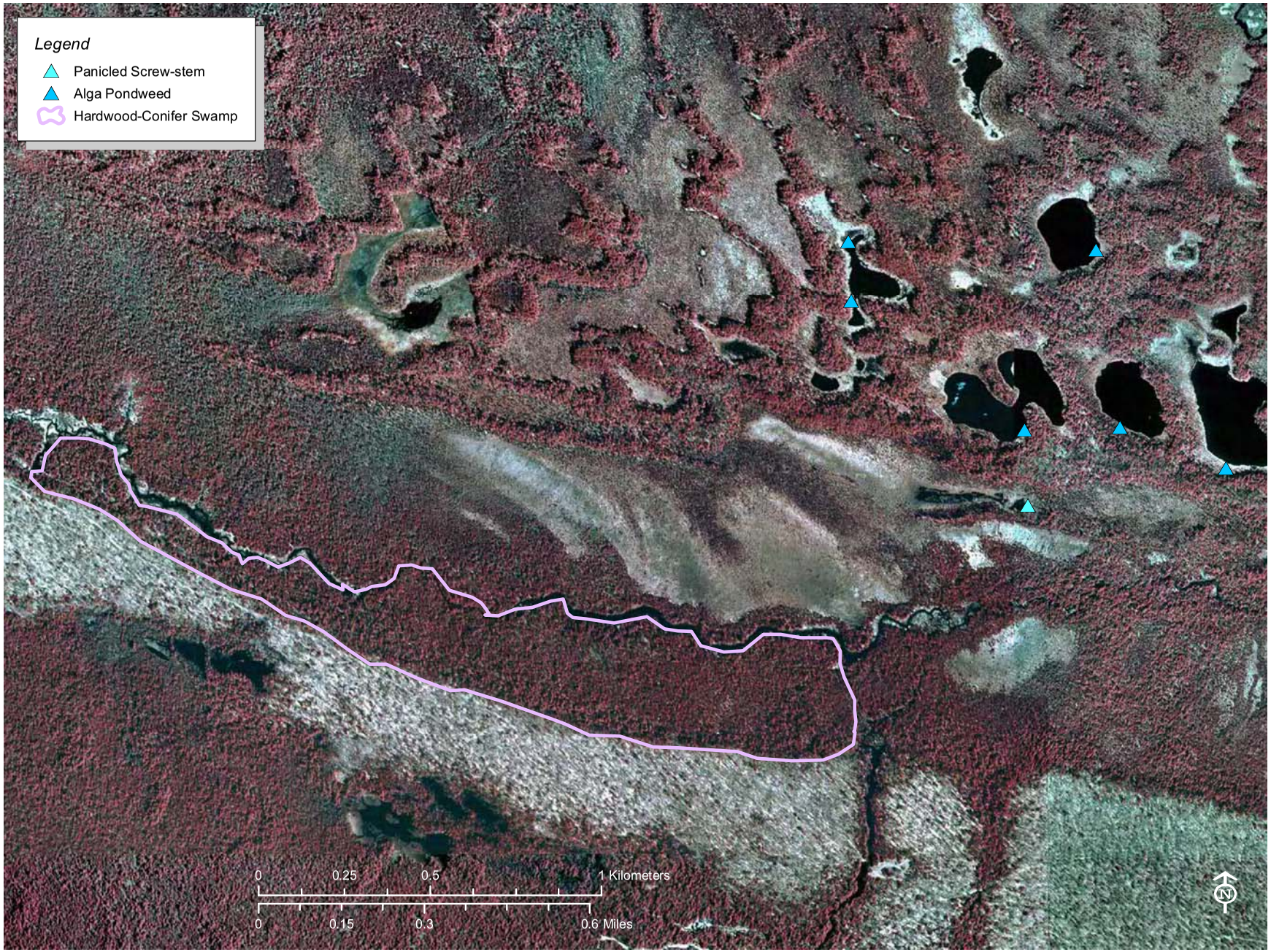

Figure 14. Beavertown Lakes Hardwood-Conifer Swamp. Populations of panicled screw-stem and alga pondweed were discovered to the northeast of this swamp complex.

Photo 10. Broken stem of alga pondweed within the Stuart Lake site (Photo by Ryan P. O'Connor).

Photo 11. Alga pondweed occurs in a narrow inlet of the northwest corner of Stuart Lake (Photo by Ryan P. O'Connor).

the patterned fen, it is easily confused with spoonleaf sundew (*Drosera intermedia*). While both species have spoon-shaped leaves, the sticky hairs of English sundew extend from the blade at least sparingly onto the petiole, while the sticky hairs of spoonleaf sundew are absent from the petiole. These plants can also be differentiated by examination of the scape, the part of the plant that bears the flowers and fruits. The scape of English sundew is strictly erect, whereas the scape of spoonleaf sundew arises laterally from the base of the plant and curves upward. Although there are a total of 22 occurrences of English sundew known in the state, nearly half have not been observed in the past 40 years, and this is one of only five English sundew records with an element occurrence rank of B or higher.

Photo 12. English sundew is prevalent in the flarks or minerotrophic swales of Captain Jenk's Patterned Fen (Photo by Joshua G. Cohen).

Targeted Ecological Surveys

Six new occurrences of high-quality natural communities were documented including bog, two dry-mesic northern forests, intermittent wetland, muskeg, and rich conifer swamp. Some of these occurrences are found on both TNC and neighboring State lands. According to the Michigan Department of Natural Resources' forest certification standards, as high-quality natural communities, they qualify for consideration as Ecological Reference Areas (MDNR 2005). Where possible, MNFI ecologists targeted lands adjacent to existing Ecological Reference Areas on State Forest lands and were able to expand the existing boundaries of a high-quality hardwood-conifer swamp Ecological Reference Area and increase baseline information on this community. Information gathered from this survey effort will help the DNR prioritize restoration management and selection of areas of high conservation value and designation of Biodiversity Stewardship Areas. The following Site Summaries contain a detailed discussion for each of these seven natural communities organized alphabetically by community type and then by element occurrence. At the beginning of each grouping of communities there is an overview of the natural community type, which was adapted from MNFI's natural community classification (Kost et al. 2007). For each site summary, the following information is provided:

a) site name
b) natural community type
c) crosswalk to TNC/NatureServe association (NatureServe 2008)
d) global and state rank
e) current element occurrence rank
f) size
g) locational information
h) digital photographs
i) detailed site description
j) threat assessment
k) management recommendations
l) discussion of the regional and statewide conservation context

Photo 13. Numerous pools occur on the floating bog mat adjacent to Stuart Lake (Photo by Joshua G. Cohen).

SITE SUMMARIES

BOG

Overview: Bog is a nutrient-poor peatland type that is characterized by acidic, saturated peat and the prevalence of sphagnum mosses and ericaceous shrubs. Bogs occur in depressions in glacial outwash and sandy glacial lakeplains and in kettles on pitted outwash and moraines. Bogs frequently occur as a floating mat on the margins of lakes and ponds. Fire and flooding are the main natural disturbance factors (Kost et al. 2007).

1. Stuart Lake Bog

Natural Community Type: Bog
TNC/NatureServe Association: Open Graminoid / Sphagnum Bog
Rank: G3G5 S4, vulnerable to secure globally and apparently secure within the state
Element Occurrence Rank: AB
Size: 139 acres
Location: T48N R10W Sections 1, 2, and 3

Site Description: This bog complex is a diverse peatland occupying the poorly drained lakeplain adjacent to Stuart Lake (Figure 11). The peatland has formed after thousands of years of lake-filling or terristrialization. Deep inundated to saturated acidic (4.5-5.0 pH) sphagnum peats have well-defined fibric/hemic/sapric structure, and sphagnum hummock and hollow microtopography is well-developed with hollows adjacent to the lake being filled with water. Pools of water also occur adjacent to Stuart Lake where the peat mat is encroaching on the lake margin (Photo 13). The peats tend to be more consolidated with increasing distance from the lake, while closer to the lake the fibric peats are deep and unconsolidated or loose. The sphagnum hummock and hollow microtopography and areas of minerotrophic flow generate microsite heterogeneity due to fine-scale gradients of soil moisture and soil chemistry. Minertrophic influence is concentrated near the margins of the upland and in the northwestern and southeastern portions of Stuart Lake.

Diverse ecological zonation characterizes this site with a floating bog mat occurring adjacent to Stuart Lake (Photo 14) and grounded bog mat concentrated in the western and southern portions of the peatland. Well-developed sphagnum hummock and hollow microtopography increases the species diversity throughout the site because of the noted fine-scale gradients of soil moisture and soil chemistry. Plants characteristic of the hollows include white beak-rush (*Rhynchospora alba*), yellow-eyed grass (*Xyris montana*), three-way sedge (*Dulichium arundinaceum*), arrow-grass (*Scheuchzeria palustris*), and wild blue flag (*Iris versicolor*). These species, along with pitcher-plant (*Sarracenia purpurea*), grass pink (*Calopogon tuberosus*), round-leaved sundew (*Drosera rotundifolia*), large cranberry (*Vaccinium macrocarpon*), bog aster (*Aster nemoralis*), and bladderwort (*Utricularia vulgaris*) are prevalent in areas of floating bog mat (Photo 15). Characteristic species of the hummocks include starflower (*Trientalis borealis*), creeping snowberry (*Gaultheria hispidula*), scattered and stunted conifers, namely black spruce (*Picea mariana*) and tamarack (*Larix laricina*), and ericaceous shrubs including leatherleaf (*Chamaedaphne calyculata*), bog laurel (*Kalmia polifolia*), bog rosemary (*Andromeda glaucophylla*), and small cranberry (*Vaccinium oxycoccos*). Additional shrubs include mountain holly (*Nemopanthus mucronata*), black chokeberry (*Aronia prunifolia*), and Labrador tea (*Ledum groenlandicum*), which is typically most prevalent along the margins of the surrounding dune ridges. Tall shrubs such as mountain holly, black chokeberry, and tag alder (*Alnus rugosa*) are concentrated along the edge of the peatland and at the base of dune ridges in areas of slight minerotrophic influence. Throughout the peatland, graminoids and sphagnum species dominate the ground cover (Photo 16). Characteristic graminoids include white beak-rush, few-seed sedge (*Carex oligosperma*), and cotton-grasses (*Eriophorum* spp.). The diverse array of sphagnum species are stratified along soil moisture and chemical gradients that characterize the hummock and hollow microtopography. With increasing distance from the lake, conifer and ericaceous shrub cover increases in importance as the peats become more consolidated and less inundated. Forty-five native, vascular plant species were noted during the survey. As noted above, alga pondweed (*Potamogeton confervoides*, state special concern) was reconfirmed in a narrow inlet on the northwest corner of Stuart Lake.

Threats: Logging of the pine ridges adjacent to the complex is a potential threat and could locally increase surface flow and sedimentation. Fire suppression in the general landscape has likely increased the fire rotation of these peatlands.

Management Recommendations: The main management recommendation is to allow natural processes to operate unhindered. Wildfires should be allowed to burn the bog as well as the surrounding uplands. Maintaining a forested buffer surrounding the bog will help ensure the stability of the bog's hydrologic regime. Forested inclusions (pine dune ridges) intersecting the bog and adjacent uplands should be left uncut. Monitoring for non-native invasive species should be implemented to ensure that they do not spread into the bog.

Discussion: The AB-ranked Stuart Lake Bog is one of eighty-nine documented bogs in Michigan. Within the state there are twelve bog element occurrences that are ranked AB or higher. Three other AB-ranked bog element occurrences have been documented within the Upper Peninsula. The Stuart Lake Bog falls within Sub-subsection VIII.2.2 of the regional landscape ecosystems of Michigan hierarchical landscape classification (Albert 1995) (Figures 1 and 15). Within Section VIII and across the Upper Peninsula there are eight other bog element occurrences. Stuart Lake represents the third bog occurrence within the Luce Subsection (VIII.2) and within the Grand Marais Sandy End Moraine and Outwash (Sub-subsection VIII.2.2).

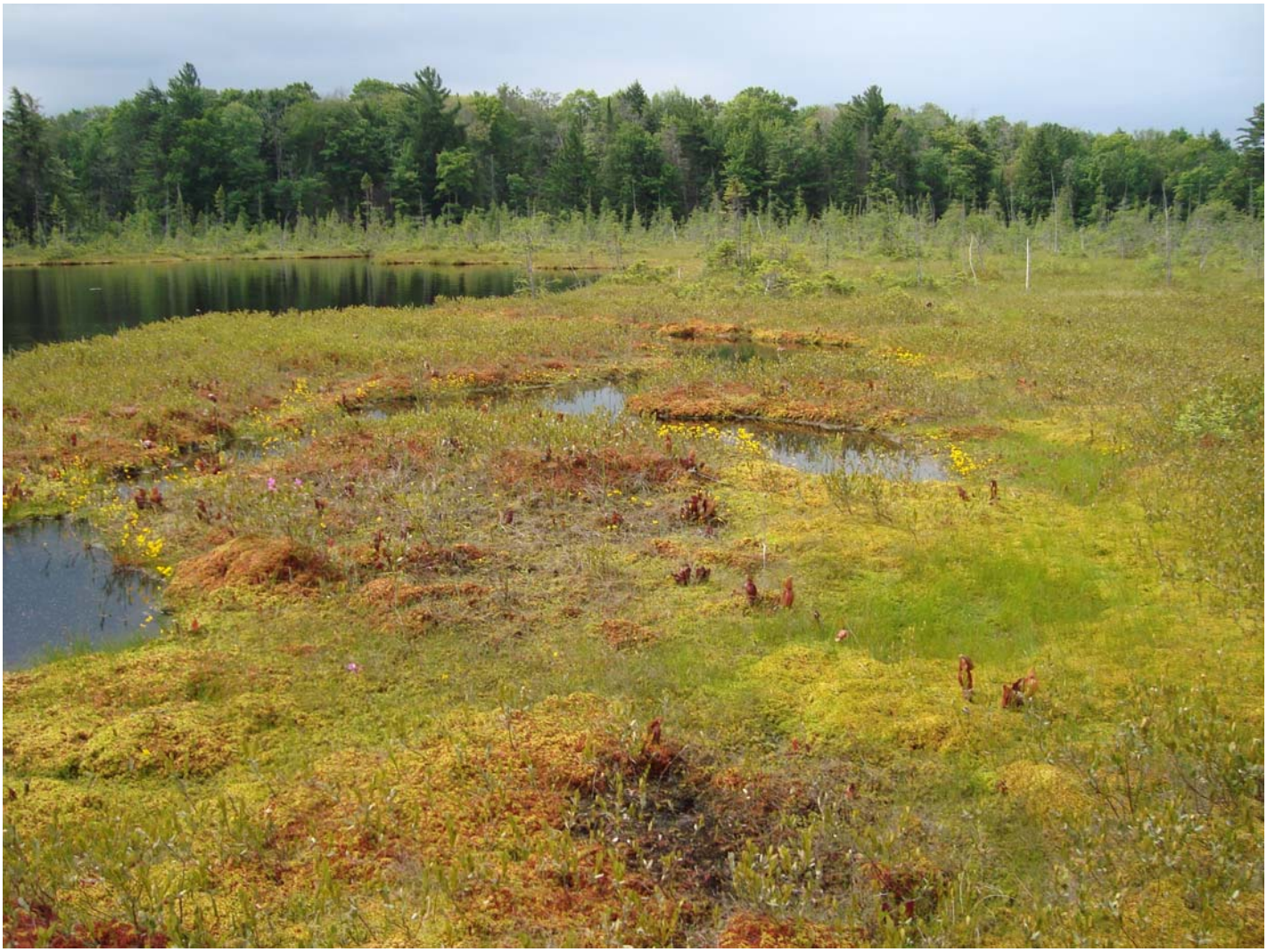

Photo 14. An extensive floating bog mat occurs adjacent to Stuart Lake (Photo by Joshua G. Cohen).

Photo 15. Pitcher-plant and grass pink are prevalent in the Stuart Lake Bog (Photo by Joshua G. Cohen).

Photo 16. Stuart Lake Bog is characterized by scattered and stunted conifers, clumps of ericaceous shrubs, and a ground layer dominated by graminoids and sphagnum mosses (Photo by Joshua G. Cohen).

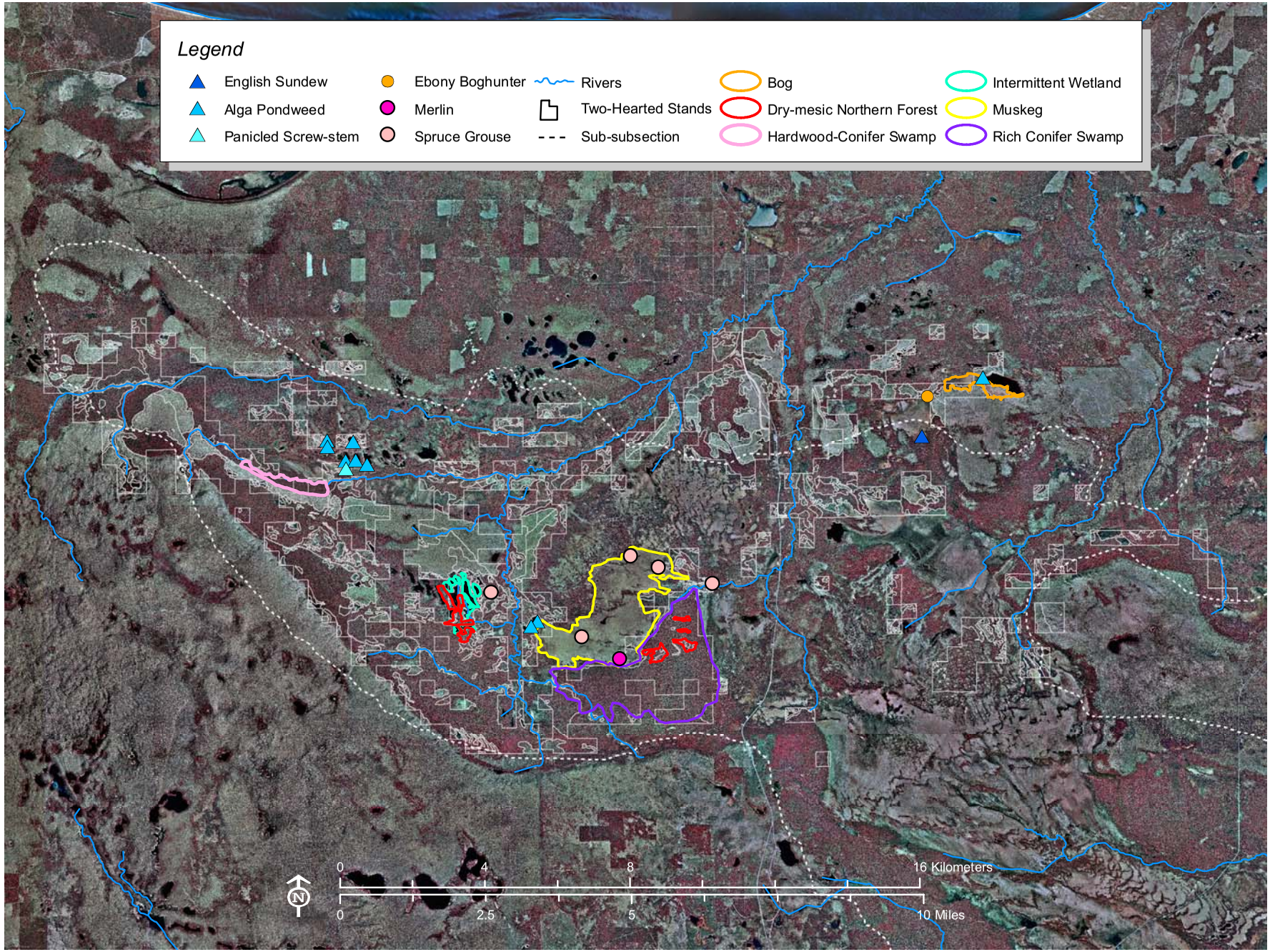

Figure 15. Element occurrences documented or reconfirmed in 2008 within the Two-Hearted River Forest Reserve.

DRY-MESIC NORTHERN FOREST

Overview: Dry-mesic northern forest is a pine or pine-hardwood forest type of generally dry-mesic sites located mostly north of the transition zone. Dry-mesic northern forest is characterized by acidic, coarse- to medium-textured sand or loamy sand and occurs principally on sandy glacial outwash, sandy glacial lakeplains, and less often on inland dune ridges, coarse-textured moraines, and thin glacial drift over bedrock. The community historically originated in the wake of catastrophic fire and was maintained by frequent, low-intensity ground fires (Kost et al. 2007).

2. Dawson Creek Dry-mesic Northern Forest

Natural Community Type: Dry-mesic Northern Forest
TNC/NatureServe Association: Great Lakes White Pine – Hemlock Forest
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: B
Size: 77 acres
Location: T48N R11W Sections 25 and 26

Site Description: Pockets of uneven-aged, mature to old-growth hemlock (*Tsuga canadensis*) and white pine (*Pinus strobus*) forest characterize the sandy dune ridges that occur within a poorly drained sand lakeplain dominated by high-quality rich conifer swamp[1] (Figures 16 and 17 and Photo 17). Diameters of canopy hemlock range from 60 to 85 cm, while canopy white pines are between 60 and 100 cm. A 68 cm hemlock was estimated to be over 170 years old. Areas of old-growth are characterized by well-developed pit and mound topography, large-diameter canopy and supercanopy hemlock and white pine, and high volumes of coarse woody debris with diverse species composition, size classes (including 60+ cm logs), and decay classes (including numerous nurse logs) (Photo 18). The overall site is characterized by moderate amounts of coarse woody debris, which is beginning to accumulate as the canopy hemlock and white pine begin to senesce. Occasional canopy snags occur throughout the forest. Several of the ridges supporting old-growth forest were selectively cut during the turn-of-the-century logging as indicated by the scattered stumps.

The dune ridges are of variable orientation and shape, with most running east to west and rising 6 to 12 meters above the adjacent wetlands. These forested dune ridges likely regenerated following a catastrophic fire event some 180 years ago. Following the fire, gap-phase dynamics have determined species composition, structure, and succession. There are numerous small windthrow gaps along the dune ridges. The forest is characterized by high densities of shade-tolerant regeneration, including hemlock and northern white-cedar (*Thuja occidentalis*). As noted, the dune ridges rise from a poorly drained lakeplain that is dominated by high-quality rich conifer swamp. The ecotone between the rich conifer swamp and the dry-mesic northen forest is characterized by moderate levels of groundwater seepage and higher species diversity and vegetative density due to the more favorable moisture and nutrient conditions. The soils along the dune ridges are fine- to medium-textured sands underlying a deep organic layer or mor hummus. The organic layer ranges from 20 to 40 cm deep and overlies a zone of leached grey sands (10 to 20 cm deep, pH 5.0), which in turn overlies red sands (pH 4.0- 5.0).

The closed canopy (85-95%) is dominated by large-diameter hemlock and white pine. Canopy associates include northern white-cedar, red maple (*Acer rubrum*), and paper birch (*Betula papyrifera*). Northern white-cedar is especially prevalent along the margins of the dune ridges and along the lower and narrower dune ridges. Lower dune ridges are characterized by more diverse canopy composition and denser understory and overstory structure. The subcanopy and tall shrub layer contain balsam fir (*Abies balsamea*), hemlock, red maple, northern white-cedar, and spruce species (*Picea* spp.), with black spruce (*Picea mariana*) and northern white-cedar most prevalent along the dune margins. The abundance of hemlock and northern white-cedar regeneration is notable and suggests that the site is characterized by low winter densities of deer. The low shrub layer of the dune ridges is sparse and is dominated by blueberries, including low sweet blueberry (*Vaccinium angustifolium*) and Canada blueberry (*V. myrtilloides*). In addition to Labrador tea (*Ledum groenlandicum*), hemlock, northern white-cedar, and red maple seedlings are also prevalent in the low shrub layer. Common species in the ground layer include goldthread (*Coptis trifolia*), Canada mayflower (*Maianthemum canadense*), bracken fern (*Pteridium aquilinum*), wintergreen (*Gaultheria procumbens*), bunchberry (*Cornus canadensis*), stiff clubmoss (*Lycopodium annotinum*), and wild sarsaparilla (*Aralia nudicaulis*). Thirty native, vascular plant species were noted during the survey.

1. Dawson Creek Rich Conifer Swamp

Threats: Increased deer herbivory could result in the failure of white pine, hemlock, and northern white-cedar to regenerate.

Management Recommendations: The primary management recommendation is to allow natural processes to operate unhindered (i.e., permit wildfires to burn through this site and the surrounding wetlands). In the event of a wildfire, 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. Long-term monitoring for deer herbivory of white pine, hemlock, and northern white-cedar regeneration will allow for determining whether or not deer browse pressure is negatively impacting the forest.

Discussion: The B-ranked Dawson Creek Dry-mesic Northern Forest and the B-ranked Two-Hearted Lakes Dry-mesic Northern Forest are two of thirty-six documented dry-mesic northern forests in Michigan. Within the state there are fifteen dry-mesic northern forest occurrences that are ranked B or higher. In addition, fifteen other dry-mesic northern forests have been documented in the Upper Peninsula with three in the western Upper Peninsula and twelve in the eastern Upper Peninsula. These two dry-mesic northern forests fall within Sub-subsection VIII.2.1 of the regional landscape ecosystems of Michigan hierarchical landscape classification (Albert 1995) (Figures 1 and 15). There are seven other dry-mesic northern forests within the Luce Subsection (VIII.2) and five other element occurrences within the Seney Sand Lake Plain (Sub-subsection VIII.2.1).

Photo 17. The Dawson Creek Dry-mesic Northern Forest is dominated by hemlock and white pine and occurs on sandy dune ridges surrounded by rich conifer swamp on a poorly drained lakeplain (Photo by Joshua G. Cohen).

Photo 18. Areas of old-growth within the Dawson Creek Dry-mesic Northern Forest contain high volumes of large coarse woody debris (Photo by Joshua G. Cohen).

Photo 19. The Two-Hearted Lakes Dry-mesic Northern Forest surrounds high-quality intermittent wetlands (Photo by Joshua G. Cohen).

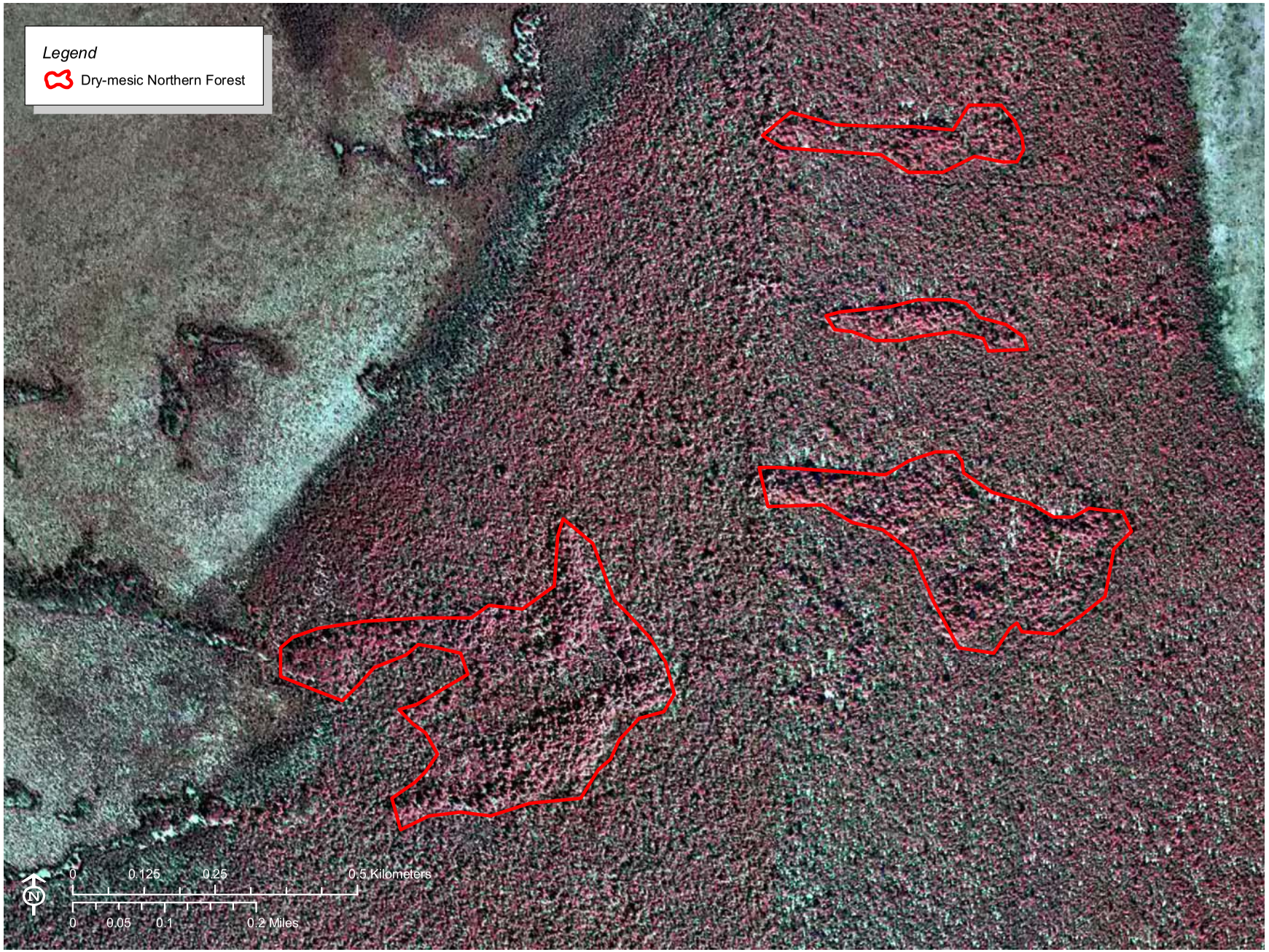

Figure 16. The Dawson Creek Dry-mesic Northern Forest occurs on sandy dune ridges rising above the surrounding poorly drained lakeplain.

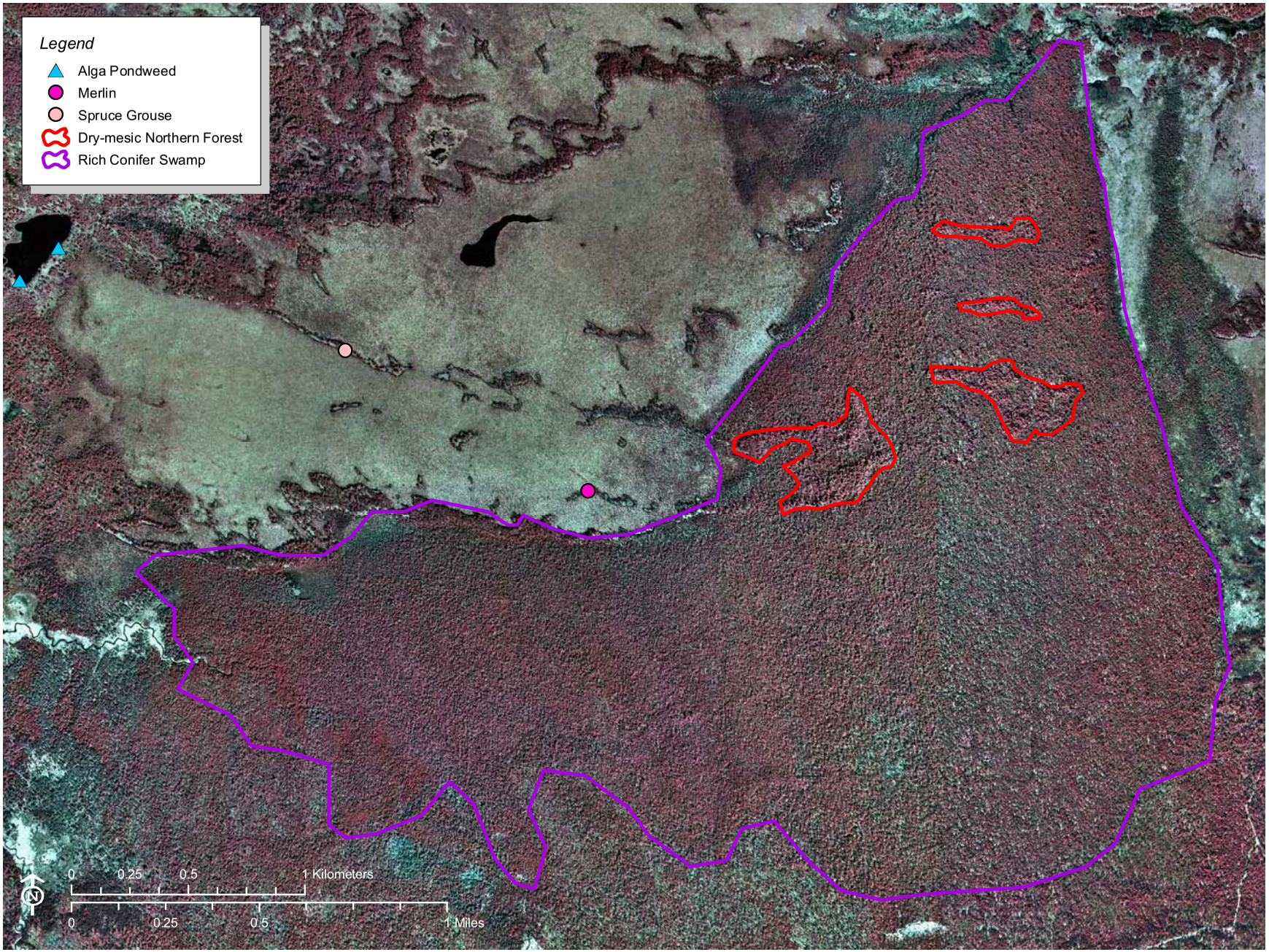

Figure 17. The Dawson Creek Rich Conifer Swamp, which surrounds the Dawson Creek Dry-mesic Northern Forest, occurs on poorly drained lakeplain with saturated to inundated peats overlying wet sands.

3. Two-Hearted Lakes Dry-mesic Northern Forest

Natural Community Type: Dry-mesic Northern Forest
TNC/NatureServe Association: Great Lakes White Pine – Hemlock Forest
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: B
Size: 97 acres
Location: T48N R11W Sections 20 and 29

Site Description: Pockets of uneven-aged, old-growth hemlock (*Tsuga canadensis*) and white pine (*Pinus strobus*) forest characterize the sandy dune ridges occuring within a poorly drained sand lakeplain that supports high-quality intermittent wetland[2] associated with the Two-Hearted Lakes (Figures 13 and 18 and Photo 19). Diameters of canopy hemlock range from 50 to 85 cm, while canopy white pines are typically between 60 and 90 cm with the largest measured white pine measuring 140 cm (Photo 20). A 65.5 cm hemlock was estimated to be more than 283 years old. Areas of old-growth are characterized by well-developed pit and mound topography, large-diameter canopy and supercanopy hemlock and white pine, and high volumes of coarse woody debris of diverse species composition, size classes (including 60+ cm logs), and decay classes (including numerous nurse logs). Numerous canopy snags occur throughout the forest and include many white pine snags over 100 cm. Portions of the old-growth were selectively cut during the turn-of-the-century logging as indicated by the scattered stumps. In addition, there are several areas of younger forest dominated by early-successional species including paper birch (*Betula papyrifera*) and balsam fir (*Abies balsamea*). These areas likely burned, as indicated by the burnt pine snags and even-aged structure of these pockets. Gap-phase dynamics and fire disturbance have determined species composition, structure, and succession. In areas that did not burn, the forest is uneven-aged old-growth with high densities of shade-tolerant regeneration, including hemlock and northern white-cedar (*Thuja occidentalis*).

The dune ridges are of variable orientation and shape, with many occurring as long fingers wrapping around the adjacent high-quality intermittent wetlands. The dune ridges are typically 15 to 30 meters taller than the adjacent wetlands. The soils along the dune ridges are medium-textured sands underlying a deep organic layer or mor hummus. The organic layer ranges from 10 to 14 cm deep and overlies a 10 cm zone of leached grey sands of medium texture, which in turn overlies red sands of medium texture. The organic soils are strongly acidic (pH 4.8-5.0), while the sands are very strongly acidic (pH 4.5) to acidic (pH 5.5). Areas along the margins of the dunes are characterized by increased moisture availability as indicated by the increase in species diversity and density in these ecotonal areas.

The closed canopy (85-95%) is dominated by large-diameter hemlock and white pine. Canopy associates include northern white-cedar and red maple (*Acer rubrum*) with paper birch prevalent in areas that burned. The subcanopy and tall shrub layer contain hemlock, red maple, paper birch, balsam fir, spruces (*Picea* spp.), and northern white-cedar, with black spruce (*Picea mariana*) and northern white-cedar most prevalent along the dune margins, particularly in narrow dune fingers. The abundance of hemlock and northern white-cedar regeneration is notable and occurs due to the abundance of nurse logs and the low winter densities of deer. The tall shrubs wild-raisin (*Viburnum cassinoides*), mountain holly (*Nemopanthus mucronata*), tag alder (*Alnus rugosa*), and winterberry (*Ilex verticillata*) are concentrated along the wetland margins where moisture levels are higher. In addition, Labrador tea (*Ledum groenlandicum*) is most common in these ecotonal areas. The low shrub layer of the dune ridges is sparse and is dominated by blueberries, including low sweet blueberry (*Vaccinium angustifolium*), Canada blueberry (*V. myrtilloides*), and Canada bilberry (*V. membranaceum*). In addition to American fly honeysuckle (*Lonicera canadensis*), seedlings of hemlock, northern white-cedar, and red maple are also prevalent in the low shrub layer. Characteristic species of the ground cover include goldthread (*Coptis trifolia*), Canada mayflower (*Maianthemum canadense*), bracken fern (*Pteridium aquilinum*), wintergreen (*Gaultheria procumbens*), bunchberry (*Cornus canadensis*), stiff clubmoss (*Lycopodium annotinum*), starflower (*Trientalis borealis*), pipsissewa (*Chimaphila umbellata*), Indian cucumber root (*Medeola virginiana*), and partridge berry (*Mitchella repens*). Thirty native, vascular plant species were noted during the survey.

Threats: Increased deer herbivory could result in the failure of white pine, hemlock, and northern white-cedar to regenerate. Adjacent forest on state lands could be harvested. Fire suppression could result in the failure of pine to regenerate.

2. Two-Hearted Lakes Intermittent Wetland

Management Recommendations: The primary management recommendation is to allow natural processes to operate unhindered (i.e., allow wildfires to burn through this site and the surrounding wetlands). Monitoring for pine regeneration over time would facilitate the assessment of whether prescribed fire is needed as a management tool. If no fire occurs in 20 to 40 years and pine regeneration is lacking, then a prescribed fire could be employed to promote regeneration. Prescribed burning of the dry-mesic northern forest should be orchestrated in concert with burning the adjacent high-quality intermittent wetlands. If prescribed fire or wildfire occurs within the site, existing fire breaks (i.e., roads and wetlands) should be utilized and the establishment of new fire breaks should be avoided. New fire breaks could allow for invasive species encroachment. Long-term monitoring for deer herbivory of white pine, hemlock, and northern white-cedar regeneration will allow for determining whether or not deer browse pressure is negatively impacting the forest. Avoiding management within the adjacent hemlock stands to the east would provide a beneficial buffer and seed source. Finally, portions of the dry-mesic northern forest occurring on state lands could be protected through designation as an Ecological Reference Area and as a part of a Biodiversity Stewardship Area.

Discussion: See above discussion within the Dawson Creek Dry-mesic Northern Forest site summary.

Photo 20. Supercanopy, large-diameter white pine, like this 140 cm DBH tree, occur scattered throughout the Two-Hearted Lakes Dry-mesic Northern Forest (Photo by Joshua G. Cohen).

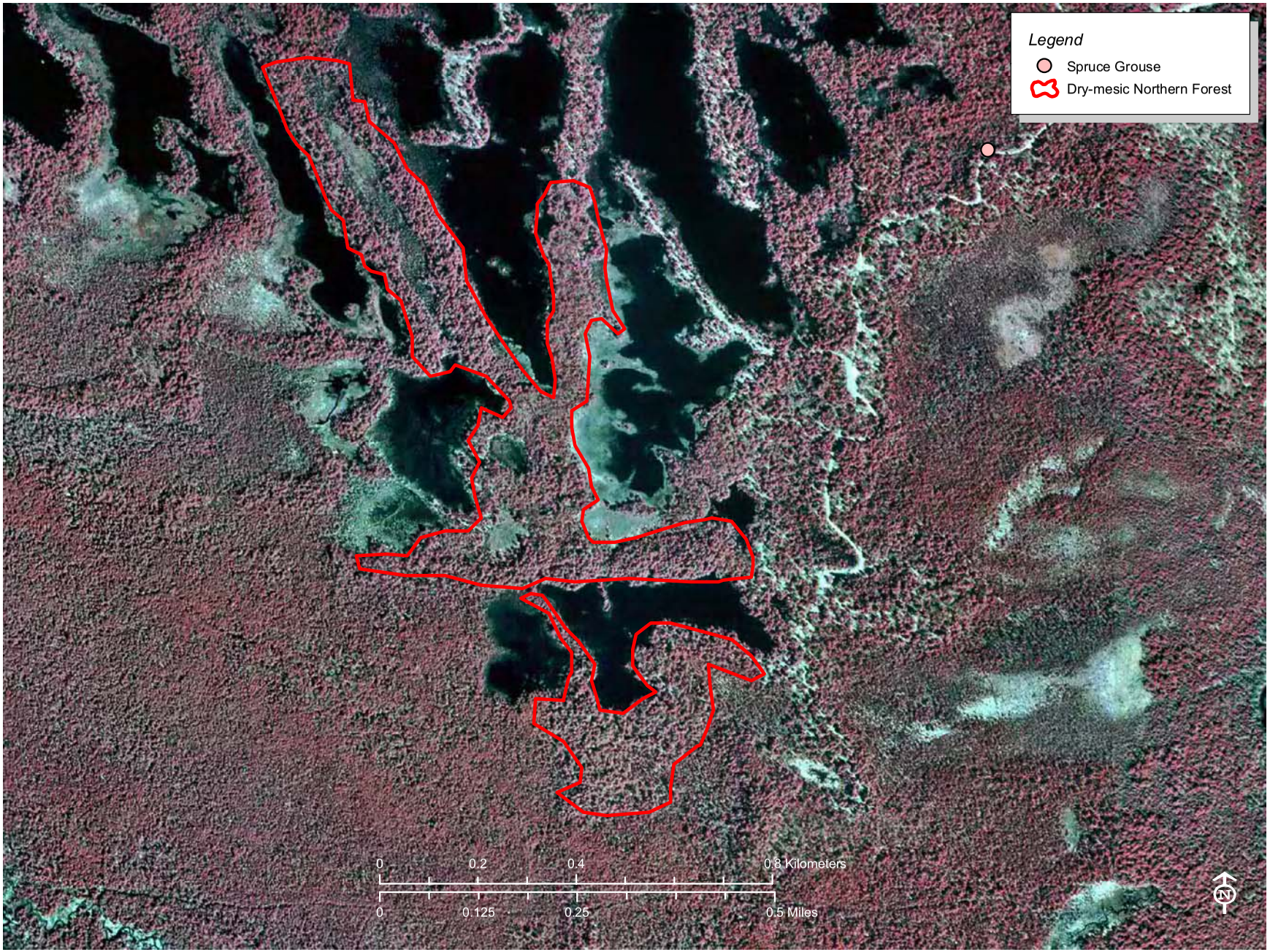

Figure 18. The Two-Hearted Lakes Dry-mesic Northern Forest occurs adjacent to high-quality intermittent wetlands and lakes. Spruce grouse were observed to the east of the Two-Hearted Lakes area.

HARDWOOD-CONIFER SWAMP

Overview: Hardwood-conifer swamp is a minerotrophic forested wetland dominated by a mixture of lowland hardwoods and conifers, occurring on organic (i.e., peat) and poorly drained mineral soils throughout Michigan. The community occurs on a variety of landforms, often associated with headwater streams and areas of groundwater discharge. Species composition and dominance patterns can vary regionally. Windthrow and fluctuating water levels are the primary natural disturbances that structure hardwood-conifer swamp (Kost et al. 2007).

4. Beavertown Lakes (Hardwood-Conifer Swamp)

Natural Community Type: Hardwood-Conifer Swamp
TNC/NatureServe Association: Hemlock – Hardwood Swamp
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: AB
Size: 113 acres
Location: T48N R12W Sections 10-14

Site Description: This uneven-aged block of hardwood-conifer swamp occurs on poorly drained lakeplain adjacent to a steep sandy end moraine (Figure 14 and Photo 21). Areas close to the slope are characterized by seeps and a water table near the surface. Soils are deep (> 1 m), saturated peats that are slightly acidic (pH 5.5-6.0) in areas dominated by hemlock (*Tsuga canadensis*) to circumneutral (pH 6.5-7.0) in areas dominated by northern white-cedar (*Thuja occidentalis*) and tamarack (*Larix laricina*). Groundwater seepage generates minerotrophic conditions and saturated peats, especially along the upland margin. The West Branch of the Two Hearted River borders the site. Windthrow is prevalent throughout the swamp (both single gaps and multiple treefall gaps) generating structural diversity at multiple scales (tip-up mounds and even-aged patches) (Photo 22). This hardwood-conifer swamp is characterized by a high volume of coarse woody debris of diverse species composition, decay classes, and diameter ranges.

A narrow (30-60 m) band of old-growth (more than 275 years old) hardwood-conifer swamp occurs along the upland margin and is dominated by northern white-cedar, hemlock, yellow birch (*Betula alleghaniensis*), and red maple (*Acer rubrum*), with scattered white pine (*Pinus strobus*), white spruce (*Picea glauca*), and tamarack. Areas closer to the river are more even-aged and more conifer-dominated, with northern white-cedar and tamarack as co-dominants and canopy and subcanopy associates including red maple, black ash (*Fraxinus nigra*), and balsam fir (*Abies balsamea*). The understory is dominated by tag alder (*Alnus rugosa*) and northern white-cedar (locally). Additional understory species include striped maple (*Acer pensylvanicum*), red maple, and sugar maple (*A. saccharum*) and, locally, hemlock. Northern white-cedar and tag alder are locally dense in windthrow gaps. In addition, tag alder is locally dominant along the river, especially in areas with flooding from beaver dams. Species of the low shrub layer include American fly honeysuckle (*Lonicera canadensis*), northern white-cedar, maples, balsam fir, and Labrador tea (*Ledum groenlandicum*). Coarse woody debris provides an important substrate for tree seedlings and saplings. Hemlock and northern white-cedar are prevalent along nurse logs. In the ground cover, royal fern (*Osmunda regalis*) is dominant in the tamarack and northern white-cedar–dominated swamp, while hairy sweet cicely (*Osmorhiza claytonii*) dominates in the hardwood-conifer swamp. Characteristic ground cover species throughout the swamp include lake sedge (*Carex lacustris*), tussock sedge (*C. stricta*), three-seeded sedge (*C. trisperma*), dwarf raspberry (*Rubus pubescens*), sensitive fern (*Onoclea sensibilis*), starflower (*Trientalis borealis*), goldthread (*Coptis trifolia*), bunchberry (*Cornus canadensis*), Canada mayflower (*Maianthemum canadense*), fowl manna grass (*Glyceria striata*), common skullcap (*Scutellaria galericulata*), and northern wood sorrel (*Oxalis*

Photo 21. This hardwood-conifer swamp is characterized by diverse canopy composition (Photo by Joshua G. Cohen).

acetosella). Sphagnum carpets are locally prevalent, especially in areas where northern white-cedar and tamarack are dominant. Seventy-six native, vascular plant species were noted during the survey.

Threats: Currently there is excellent northern white-cedar and hemlock regeneration, but a series of mild winters could result in increased deer herbivory of these browse-sensitive species.

Management Recommendations: The main management recommendation is to allow natural processes (i.e., windthrow, flooding, and fire) to operate unhindered (i.e., prohibit salvage logging and allow lightning strike fires to burn). Monitoring deer densities and deer herbivory will allow for the assessment of whether deer herbivory threatens northern white-cedar and hemlock regeneration. Maintaining large-diameter northern white-cedar and hemlock in surrounding upland forests is recommended to provide an ample seed source of conifers for swamp systems throughout the landscape. Aerial photographic interpretation indicates that additional high-quality hardwood-conifer swamp occurs to the northwest. Finally, portions of the swamp occurring on state lands should be managed as an Ecological Reference Area and as a part of a Biodiversity Stewardship Area.

Discussion: The AB-ranked Beavertown Lakes Hardwood-Conifer Swamp is one of twenty-nine documented high-quality hardwood-conifer swamps in Michigan. Within the state there are only three hardwood-conifer swamp element occurrences that are ranked AB or higher. No other AB or higher ranked hardwood-conifer swamp element occurrence has been documented within the Upper Peninsula. The Beavertown Lakes hardwood-conifer swamp falls within Sub-subsection VIII.2.1 of the regional landscape ecosystems of Michigan hierarchical landscape classification (Albert 1995) (Figures 1 and 15). Within the Upper Peninsula there are three other hardwood-conifer swamp element occurrences; two of these swamps occur in the eastern Upper Peninsula. Beavertown Lakes represents the sole occurrence within the Luce Subsection (VIII.2) and the Seney Sand Lake Plain (Sub-subsection VIII.2.1). As noted above, this hardwood-conifer swamp occurs on both TNC and state forest lands.

Photo 22. Numerous windthrow gaps characterize the Beavertown Lakes Hardwood-Conifer Swamp (Photo by Joshua G. Cohen).

INTERMITTENT WETLAND

Overview: Intermittent wetland is a graminoid- and herb-dominated wetland found along lakeshores or in depressions and characterized by fluctuating water levels, both seasonally and from year to year. Intermittent wetlands occur in depressions in glacial outwash and sandy glacial lakeplains and in kettles on pitted outwash. Soils range from loamy sand and peaty sand to peaty muck and are very strongly acid to strongly acid. Intermittent wetlands exhibit traits of both peatlands and marshes, with characteristic vegetation including sedges (*Carex* spp.), rushes (*Juncus* spp.), sphagnum mosses, and ericaceous shrubs. The community occurs statewide (Kost et al. 2007).

5. Two-Hearted Lakes Intermittent Wetland

Natural Community Type: Intermittent Wetland
TNC/NatureServe Association: Great Lakes Intermittent Wetland
Rank: G3 S3, vulnerable throughout range
Element Occurrence Rank: AB
Size: 121 acres
Location: T48N R11W Sections 20, 21, and 29

Site Description: This site is characterized by several intermittent wetlands in variable stages of drawdown occurring on level, poorly drained lakeplain surrounded by low dune ridges supporting high-quality dry-mesic northern forest[3] (Figures 13 and 18 and Photo 19). Well-developed ecological zonation characterizes the intermittent wetlands and is patterned by hydrologic fluctuation. The wetlands were inundated during the mid to early growing season of 2008 (still inundated on July 22) and had drawn down by September (Photos 23 and 24). Water depth in July ranged from 20 to 70 cm. The soils are characterized by a thin layer of muck over slightly acidic (pH 6.5-6.8) wet sands. The organic soil layer ranges from 2 to 10 cm, with shallower depths indicating more drastic areas of drawdown and subsequent soil decomposition.

Species composition is variable from wetland to wetland and during different stages of the growing season due to the variable water depth. Graminoids dominate and include golden-seeded spike-rush (*Eleocharis elliptica*), three-way sedge (*Dulichium arundinaceum*), twig-rush (*Cladium marisicoides*), and sedges (*Carex* spp.). Inundated areas support yellow pond-lily (*Nuphar variegata*), sweet-scented water-lily (*Nymphaea odorata*), northern manna grass (*Glyceria borealis*), rushes (*Junucs* spp.), and bulrushes (*Schoenoplectus* spp.). The upland margins of the wetlands are shrub-dominated with leatherleaf (*Chamaedaphne calyculata*), sweet gale (*Myrica gale*), bog rosemary (*Andromeda glaucophylla*), shrubby cinquefoil (*Potentilla fruticosa*), tag alder (*Alnus rugosa*), and winterberry (*Ilex verticillata*). Few-seed sedge (*Carex oligosperma*) is important within this zone as well as within slightly more acidic portions of the wetlands. Characteristic species within the intermittent wetlands include pipewort (*Eriocaulon septangulare*), northern St. John's-wort (*Hypericum boreale*), and grass-leaved goldenrod (*Euthamia graminifolia*).

Threats: There is a limited threat from off-road vehicles and invasive plant species due to the skid trail passing through the dune ridge adjacent to one of the intermittent wetlands.

Management Recommendations: The primary management recommendation is to allow natural processes to operate unhindered (i.e., allow wildfires to burn across these wetlands). Due to the potential for invasive species encroachment, periodic monitoring should be implemented to ascertain if there are any invasive species threatening native species composition and structure.

Discussion: The AB-ranked Two-Hearted Lakes Intermittent Wetland is one of thirty-three documented intermittent wetlands in Michigan. Within the state there are ten intermittent wetland element occurrences that are ranked AB or higher. Six other intermittent wetland element occurrences ranked AB or higher have been documented within the Upper Peninsula, where there are a total of twelve occurrences, all within the eastern Upper Peninsula. The Two-Hearted Lakes Intermittent Wetland falls within Sub-subsection VIII.2.1 of the regional landscape ecosystems of Michigan hierarchical landscape classification (Albert 1995) (Figures 1 and 15). Two-Hearted Lakes represents the sixth intermittent wetland occurrence within the Luce Subsection (VIII.2) and the third occurrence within the Seney Sand Lake Plain (Sub-subsection VIII.2.1).

Photo 23. Two-Hearted Lakes Intermittent Wetland in July (Photo by Joshua G. Cohen).

Photo 24. Two-Hearted Lakes Intermittent Wetland in September (Photo by Ryan P. O'Connor).

MUSKEG

Overview: Muskeg is a nutrient-poor peatland characterized by acidic, saturated peat, and scattered or clumped, stunted conifer trees set in a matrix of sphagnum mosses and ericaceous shrubs. Black spruce (*Picea mariana*) and tamarack (*Larix laricina*) are typically the most prevalent tree species. The community primarily occurs in large depressions on glacial outwash and sandy glacial lakeplains. Fire occurs naturally during periods of drought and can alter the hydrology, mat surface, and floristic composition of muskegs. Windthrow, beaver flooding, and insect defoliation are also important disturbance factors that influence species composition and structure (Kost et al. 2007).

6. Dawson Creek Muskeg

Natural Community Type: Muskeg
TNC/NatureServe Association: Black Spruce / Leatherleaf Semi-treed Bog
Rank: G4G5 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: A
Size: 1591 acres
Location: T48N R11W Sections 14, 22-28, 34, and 35

Site Description: This extensive muskeg occurs on deep, saturated peats on a vast expanse of poorly drained sand lakeplain, with fingers of sandy dune ridges dominated by pine forest extending into the peatland. High-quality rich conifer swamp[4]occurs to the east and south of the muskeg (Figures 12 and 17). The soils are characterized by deep (70 to 100+ cm) saturated to inundated, acidic (4.5-4.8 pH) sphagnum peats with well-developed fibric/hemic/sapric structure overlying wet sands. Peats tend to be shallower (30-60 cm) and less acidic (pH 5.0) in areas near dune margins and slightly more acidic on hummocks. Sphagnum hummock and hollow microtopography is well-developed, with some hummocks being over a meter in height and in circumference (Photo 25). Floating bog mats have formed along the margins of several scattered lakes and ponds. Seasonally wet pockets of muskeg occur throughout the complex. Lake-filling (terrestrialization) and paludification have resulted in the development of this extensive muskeg complex (Photo 26). Well-developed sphagnum hummock and hollow microtopography generates microsite heterogeneity due to fine-scale gradients of soil moisture and soil chemistry. In addition, the site is characterized by diverse patterning of natural communities due to different stages of lake-filling, with more recent areas of peatland development supporting bog and areas of shallow peat over sands supporting denser muskeg and pockets of poor conifer swamp. Surrounding uplands burned approximately 100 years ago, and portions of muskeg and surrounding wetlands were likely also burnt by this wildfire.

This extensive muskeg is characterized by four primary vegetative strata. The canopy is dominated by scattered and stunted tamarack (*Larix laricina*) and black spruce (*Picea mariana*) (3-15 cm in DBH, 1-6 m tall, canopy closure typically ranging from 2-25%) (Photo 27). White pine (*Pinus strobus*) and jack pine (*P. banksiana*) are common associates and are most prevalent near dune ridges where the density and diversity of species in all strata tend to be greatest. Trees and shrubs also tend to be concentrated or clumped on sphagnum hummocks. Black spruce, tamarack, and white pine are prevalent in the tall shrub layer, with black spruce and tamarack also common in the low shrub layer. The tall shrub zone is most developed along edges of the muskeg and at the base of dune ridges in areas of slight minerotrophic influence. Wild-raisin (*Viburnum cassinoides*), mountain holly (*Nemopanthus mucronata*), and black chokeberry (*Aronia prunifolia*) are typical tall shrubs. The low shrub layer (75-95% closure) is overwhelmingly dominated by leatherleaf (*Chamaedaphne calyculata*) with other ericaceous shrub associates including bog laurel (*Kalmia polifolia*), bog rosemary (*Andromeda glaucophylla*), low sweet blueberry (*Vaccinium angustifolium*), and Labrador tea (*Ledum groenlandicum*), which is typically most prevalent along the margins of the dune ridges. Ericaceous shrubs are often concentrated on the sphagnum hummocks. The ground cover is dominated by sphagnum species and graminoids, especially few-seed sedge (*Carex oligosperma*). Characteristic ground cover species include small cranberry (*Vaccinium oxycoccos*), pitcher-plant (*Sarracenia purpurea*), and cotton-grasses (*Eriophorum* spp.). Species that are common on hummocks include wintergreen (*Gaultheria procumbens*), creeping snowberry (*G. hispidula*), and cow-wheat (*Melampyrum lineare*). These species, along with false mayflower (*Smilacina trifolia*) and wild blue flag (*Iris versicolor*), are also common in areas of muskeg near the dune ridges. The diverse array of sphagnum species is stratified along soil moisture and chemical gradients that characterize the hummock and hollow microtopography.

4. Dawson Creek Rich Conifer Swamp

Bog-dominated areas, which occur along many of the lake and pond margins, are dominated by graminoids, such as few-seeded sedge, few-flower sedge (*C. pauciflora*), and white beak-rush (*Rhynchospora alba*), and ericaceous shrubs (i.e., leatherleaf and bog rosemary). Characteristic species of these bog inclusions are pitcher-plant, cotton-grasses, yellow-eyed grass (*Xyris montana*), round-leaved sundew (*Drosera rotundifolia*), large cranberry (*Vaccinium macrocarpon*), bog buckbean (*Menyanthes trifoliata*), and bladderwort (*Utricularia vulgaris*). Small pockets of submergent marsh in bog ponds support arrow-grass (*Scheuchzeria palustris*), yellow pond-lily (*Nuphar variegata*), sweet-scented water-lily (*Nymphaea odorata*), bladderwort, and three-way sedge (*Dulichium arundinaceum*). Patches of poor conifer swamp, which occur in areas where the peats are shallower over the sands, are characterized by denser canopy of greater coverage with larger and taller trees. Canopy dominants include black spruce, tamarack, and white pine. In addition, the understory is denser and more diverse than areas of muskeg with conifer saplings, mountain holly, wild-raisin, and black chokeberry prevalent. The sandy dune ridges that occur as narrow fingers within the peatland are dominated by pines, with black spruce occurring along the lower dune margins.

Threats: Fire suppression in the overall landscape may reduce the fire frequency within the muskeg. Logging of the pine ridges within the complex on state forest lands is a potential threat.

Management Recommendations: The main management recommendation is to allow natural processes to operate unhindered. Wildfires should be allowed to burn the muskeg as well as the surrounding uplands. In the event of a wildfire, 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. Vehicular traffic should be avoided through this peatland. Forested communities (i.e., dry-mesic northern forest and dry northern forest on dune ridges, rich conifer swamp, and poor conifer swamp) adjacent to and intersecting the muskeg should be left uncut. State lands within and adjacent to the site should be promoted for designation as an Ecological Reference Area and as part of a Biodiversity Stewardship Area.

Discussion: The A-ranked Dawson Creek Muskeg is one of thirteen documented muskegs in Michigan. Within the state there are six A-ranked muskeg element occurrences and all occur within the eastern Upper Peninsula, where there are a total of twelve muskeg occurrences. The Dawson Creek Muskeg falls within Sub-subsection VIII.2.1 of the regional landscape ecosystems of Michigan hierarchical landscape classification (Albert 1995) (Figures 1 and 15). This muskeg represents the ninth muskeg occurrence documented within the Luce Subsection (VIII.2) and the sixth occurrence recorded within the Seney Sand Lake Plain (Sub-subsection VIII.2.1); one of the six occurrences is ranked AB, and the remainder are A-ranked.

Photo 25. Sphagnum hummocks generate microsite heterogeneity within the Dawson Creek Muskeg (Photo by Joshua G. Cohen).

Photo 26. The Dawson Creek Muskeg spans across an extensive poorly drained lakeplain (Photo by Joshua G. Cohen).

Photo 27. Scattered and stunted conifers characterize the Dawson Creek Muskeg (Photo by Joshua G. Cohen).

RICH CONIFER SWAMP

Overview: Rich conifer swamp is a groundwater-influenced, minerotrophic, forested wetland dominated by northern white-cedar (*Thuja occidentalis*) that occurs on organic soils (i.e., peat) primarily north of the climatic tension zone in the northern Lower and Upper Peninsulas. Rich conifer swamp occurs in outwash channels, outwash plains, glacial lakeplains, and in depressions on coarse- to medium-textured ground moraines. It is common in outwash channels of drumlin fields and where groundwater seeps occur at the bases of moraines. Rich conifer swamp typically occurs in association with lakes and cold, groundwater-fed streams. It also occurs along the Great Lakes shoreline in abandoned embayments and in swales between former beach ridges, where it may be part of a wooded dune and swale complex. Windthrow is common, especially on broad, poorly drained sites. Fire was historically infrequent. Rich conifer swamp is characterized by diverse microtopography and ground cover. The community is also referred to as cedar swamp (Kost et al. 2007).

7. Dawson Creek Rich Conifer Swamp

Natural Community Type: Rich Conifer Swamp
TNC/NatureServe Association: White-cedar – (Mixed Conifer) / Alder Swamp
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: AB
Size: 2,045 acres
Location: T48N R10W Sections 30 and 31
T48N R11W Sections 24-27 and 34-36

Site Description: This extensive rich conifer swamp occurs on flat, poorly drained lakeplain south of Dawson Creek in a predominantly unfragmented landscape with no roads in the immediate vicinity and low road densities in the overall landscape (Figure 17). The organic soils overlying wet sands are saturated to inundated peats (pH 5.0-6.5) that range from shallow (10-30 cm) to deep (> 1 m). High-quality dry-mesic northern forest[5] occurs within the rich conifer swamp, and high-quality muskeg[6] occurs to the west and north of the swamp (Figures 12 and 16). Well-developed ecological zonation is patterned by windthrow and groundwater influence, which interact to determine species composition, structure, and succession. The site is characterized by high native species diversity (over 70 species were noted during a single survey) that is driven by large-scale ecological zonation (influenced by windthrow and groundwater influence) and microscale variability controlled by sphagnum hummock and hollow microtopography. High levels of structural diversity occur with numerous patches of blowdown, scattered snags, and coarse woody debris of diverse species composition, size classes, and decay classes. Several large areas of blowdown occur throughout the swamp and generate age-class diversity. In addition, small-scale windthrow gaps promote uneven-aged canopy conditions (Photo 28). Multiple-tree blowdowns have generated multi-root mat tip-ups and large areas of pooling in the root footprints. Groundwater influence is most prevalent along the margins of the dune ridges that are embedded within the swamp complex. High levels of advanced northern white-cedar (*Thuja occidentalis*) regeneration were observed throughout the swamp, with cedar reproducing through layering as well as sexually. The numerous nurse logs throughout the swamp are providing suitable substrate for cedar regeneration. The ample cedar regeneration suggests that wintering deer densities and associated deer

Photo 28. Multiple-tree blowdown in the Dawson Creek Rich Conifer Swamp (Photo by Joshua G. Cohen).

5. Dawson Creek Dry-mesic Northern Forest
6. Dawson Creek Muskeg

browse pressure are low. Moose (*Alces alces*, state special concern) scat was observed within the swamp.

The closed canopy (85-95%) is dominated by northern white-cedar (15-45 cm DBH) with canopy associates including red maple (*Acer rubrum*), paper birch (*Betula papyrifera*), spruces (*Picea* spp.), black ash (*Fraxinus nigra*), and scattered white pine (*Pinus strobus*) (Photo 29). Canopy trees become larger along the margins of the numerous dune ridges that are embedded within the swamp complex. In addition, the canopy is more open and the understory is denser in wetter microsites. As noted above, northern white-cedar is dominant in the understory layer with dense regeneration throughout the swamp. Also abundant in the understory are tag alder (*Alnus rugosa*) and balsam fir (*Abies balsamea*), and to a lesser degree, mountain holly (*Nemopanthus mucronata*) and winterberry (*Ilex verticillata*). Northern white-cedar and red maple seedlings are also prevalent in the low shrub layer with associates including alder-leaved buckthorn (*Rhamnus alnifolia*), Labrador tea (*Ledum groenlandicum*), and blueberries (*Vaccinium* spp.). Species dominant in the ground cover include sphagnum mosses, three-seeded sedge (*Carex trisperma*), dwarf raspberry (*Rubus pubescens*), goldthread (*Coptis trifolia*), creeping snowberry (*Gaultheria hispidula*), bluebead lily (*Clintonia borealis*), starflower (*Trientalis borealis*), and royal fern (*Osmunda regalis*). Additional characteristic ground cover species include mad-dog skullcap (*Scutellaria lateriflora*), common skullcap (*Scutellaria galericulata*), northern bugleweed (*Lycopus uniflorus*), wild blue flag (*Iris versicolor*), cinnamon fern (*Osmunda cinnamomea*), and false mayflower (*Smilacina trifolia*).

Threats: A string of mild winters could result in high deer densities, which could jeopardize the cedar advanced regeneration.

Management Recommendations: The main management recommendations are to allow natural processes (i.e., windthrow, flooding, and fire) to operate unhindered. Periodic monitoring for deer herbivory and cedar regeneration could be conducted to asses browsing impacts.

Discussion: The AB-ranked Dawson Creek Rich Conifer Swamp is one of 57 documented rich conifer swamps in Michigan. Within the state there are twelve rich conifer swamp element occurrences that are ranked AB or higher. Eight other rich conifer swamp element occurrences ranked AB or higher have been documented within the Upper Peninsula, where there are a total of twenty-five (twenty-two in the eastern Upper Peninsula and three in the western Upper Peninsula). The Dawson Creek Rich Conifer Swamp falls within Sub-subsection VIII.2.1 of the regional landscape ecosystems of Michigan hierarchical landscape classification (Albert 1995) (Figures 1 and 15). This rich conifer swamp represents the eleventh rich conifer swamp occurrence within the Luce Subsection (VIII.2) and the sixth occurrence within the Seney Sand Lake Plain (Sub-subsection VIII.2.1), where there are three other swamp occurrences ranked AB or higher.

Photo 29. Northern white-cedar dominates the canopy of this extensive rich conifer swamp (Photo by Joshua G. Cohen).

MONITORING DISCUSSION

This past year's project focused on development of a forest monitoring protocol and the collection of baseline data. Since no data have been analyzed, the subsequent discussion focuses on limitations of the monitoring methods and means for improving the methodology. Time limitations forced vegetative and point-count songbird sampling to be focused during single time periods. For the point-count sampling, two or three visits per season would better capture songbird diversity due to variable breeding phenologies. For the vegetative sampling, greater floristic diversity could be captured by conducting the floristic monitoring in two time periods, early growing season (late May to June) and late growing season (late July to August). The structural data can be collected any time during the growing season. MNFI scientists recommend including additional measurement to better assess canopy structure, such as canopy height and canopy closure.

Pervasive management in the uplands within the reserve and in the surrounding landscape made selection of reference areas challenging. State lands within the region were selected for sampling, including extensive old-growth forest in Tahquamenon Falls State Park for the vegetative and songbird monitoring and small patches of old-growth and late-successional state forest lands within the Newberry Forest Management Unit for the songbird monitoring. Tahquamenon Falls State Park provides an adequate but not perfect reference due to its distance from the THRFR and fundamental differences in soils, slope, landscape context, and landform compared to the THRFR. The reference stands on State Forest land tend to be small in acreage, so their value as avian community reference sites may be limited. Stand size and nearby adjacent habitat may limit use by forest-interior bird species and affect diversity and species richness. Due to the small size of these reference areas, survey point locations had to be purposefully selected rather than randomly selected to meet distance requirements from the stand edge. Because many of the reference stands were small, the sample size of reference points was also limited. Standardized bird survey protocols, such as Ralph et al. (1995) and Huff et al. (2000) recommend that point-count stations are situated at least 125 m from stand edges and at least 200-250 m apart. We deviated from these recommendations due to the small size of many stands, presence of roads, and the mix of forest types within and adjacent to stands, which limited the number of points that could fit within a given forest stand. As noted above in the methods section, point-count stations were situated at least 75 meters from stand boundaries and roads and a minimum of 150 meters from other stations, so we could achieve an adequate sample size of points. A final limitation to note regarding the point-count sampling is that stand boundaries are being used to track changes in avian community associated with management. These anthropogenically derived boundaries may not represent biological units from a bird species perspective, since each species perceives potential breeding habitat on the landscape differently.

The utility of these metrics can be most accurately gauged through data analysis over time. One measure of ecological integrity that may not be useful currently for the THRFR is the deer herbivory index. The reserve occurs within an area of high winter snowfall (Albert et al. 1995), and subsequently wintering deer populations and deer browse pressure are low. However, data collected for this metric is gathered rapidly within the existing understory plot, and with changes in climate due to global warming and management within the adjacent landscape, deer browse pressure may increase within the THRFR over time.

Despite the potential limitations of the monitoring methods, the implementation of this long-term monitoring protocol will facilitate the evaluation of the impacts of experimental timber management conducted by TNC on the THRFR in comparison to controls and reference areas. The periodic estimation of the four measures of forest ecological integrity (forest structure, forest-interior bird presence and diversity, floristic quality, and deer browse pressure) will allow TNC to evaluate whether or not the prescribed forest management is adhering to the stated goals of promoting levels of standing and down coarse woody debris, age-class diversity, and structural heterogeneity representative of late seral stage forest and increasing species composition of forests appropriate for site characteristics.

SURVEY DISCUSSION

General Discussion of Survey Results

MNFI devoted a total of five weeks to conducting surveys on the THRFR for rare species and high-quality natural communities. Two weeks were spent surveying areas of northern hardwood forest currently proposed for management, and three weeks were dedicated to focused natural features surveys across the reserve. No high-quality natural communities or rare species were found during surveys of the prescribed northern hardwoods. As noted above, this result is not unexpected given that these prescribed northern hardwood stands have been recently managed and lack the structural and compositional diversity of late-seral mesic northern forest (Photos 30, 31, 32, and 33). In contrast, focused surveys in targeted areas yielded twelve new element occurrences (six high-quality natural communities, three rare animals, and three rare plants) and three element occurrence updates (one high-quality natural community and two rare plants). These contrasting results stress the importance of managing the northern hardwoods for increased structural and compositional complexity, the prevalence of high-quality habitat and natural communities within the wetlands and unmanaged uplands of the THRFR, and the high probability of identifying additional high-quality natural communities and rare species following additional targeted surveys. Site specific discussion about the statewide and regional conservation context of each element occurrence is located in the Survey Results and Site Discussion section.

NEXT STEPS: SETTING INVENTORY PRIORITIES

Potential Survey Targets

Through aerial photographic interpretation, analysis of MNFI's statewide biodiversity conservation database (MNFI 2008), assessment of state and global ranking criteria, evaluation of stand-level maps, and on-the-ground experience gained from 2008 activities and prior surveys on adjacent State Forest lands (Cohen et al. 2008), MNFI scientists determined the potential survey targets within the reserve (Table 2). Undocumented high-quality natural communities that are likely to occur within the THRFR include bog, dry-mesic northern forest, dry northern forest, hardwood-conifer swamp, intermittent wetland, muskeg, northern shrub thicket, northern wet meadow, poor conifer swamp, and rich conifer swamp. Due to pervasive management within upland hardwoods within this region, documentation of high-quality mesic northern forest is unlikely. Because of the historic anthropogenic disturbance within uplands hardwoods, potential for rare species within the northern hardwood and hemlock hardwood stand on the THRFR is limited. Rare plants that could persist within these upland hardwoods include goblin moonwort, bedstraw (*Galium kamtschaticum*), and New England sedge. Northern hardwood and hemlock hardwood stands harbor potential for rare diurnal raptor species including red-shouldered hawk, Cooper's hawk (*Accipiter cooperii*, state special concern), and northern goshawk.

Northern goshawk can also occur within the natural pine stands along with merlin and black-backed woodpecker (*Picoides arctius*, state special concern). Merlin are especially likely in pine stands that are embedded within wetlands, such as swamp conifers and non-forested wetlands (e.g., muskeg). Black-backed woodpecker occurrence is typically correlated with recent fire disturbance, and this species has been noted on the reserve recently in areas that burned during the Sleeper Lake fire of 2007. As noted above, merlin were opportunistically encountered during ecological surveys of a muskeg with pine and spruce conifer inclusions. Targeted survey efforts for this species across the reserve will likely document additional merlin breeding territories. Rare plants that could potentially occur within the natural pine stands include pine-drops (*Pterospora andromeda*, state threatened) and false violet (*Dalibarda repens*, state threatened).

Forested conifer swamps, which constitute a significant portion of the THRFR, harbor potential for additional spruce grouse populations and the following rare plants: calypso (*Calypso bulbosa*, sate threatened), round-leaved orchis (*Amerorchis rotundifolia*, state endangered), ram's head lady-slipper (*Cypripedium arietinum*, state special concern), limestone oak fern (*Gymnocarpium robertianum*, state threatened), and Lapland buttercup (*Ranunculus lapponicus*, state threatened). As noted above, spruce grouse were opportunistically encountered during ecological and botanical surveys of a muskeg with pine and spruce conifer inclusions. Targeted survey efforts for this species across the reserve will likely document additional spruce grouse populations.

Photo 30. Old-growth mesic northern forest from Tahquamenon Falls State Park (Photo by Joshua G. Cohen).

Photo 31. Deep organic soils characterize this old-growth forest (Photo by Joshua G. Cohen).

Photo 32. Compared to old-growth forest, the managed forests of the Two-Hearted River Forest Reserve have simplified composition and structure (Photo by Joshua G. Cohen from the prescribed southern portion of the West of Pine Stump stand).

Photo 33. Managed northern hardwoods have shallow organic soils compared to the deep organics of old-growth systems (Photo by Joshua G. Cohen from the northern portion of the West of Pine Stump stand).

Non-forested wetlands, particularly peatlands, within this region have experienced little to no anthropogenic disturbance. A wide array of rare plants and animals could occur within these open wetlands. Large expanses of open wetlands harbor potential for the following rare birds: American bittern (*Botaurus lentiginosus*, state special concern), yellow rail (*Coturnicops noveboracensis*, state threatened), short-eared owl (*Asio flammeus*, state endangered), and northern harrier (*Circus cyaneus*, state special concern). Numerous rare insects could occur within the THRFR's non-forested wetlands, including incurvate emerald (*Somatochlora incurvata*, state special concern dragonfly), ebony boghaunter (*Williamsoni fletcheri*, state special concern dragonfly), frigga fritillary (*Boloria frigga*, state special concern butterfly), and freija fritillary (*Boloria freija*, state special concern butterfly). Rare plants associated with bog and muskeg that could be found within the THRFR include Wiegand's sedge (*Carex wiegandii*, state threatened), black crowberry (*Empetrum nigrum*, state threatened), and yellow pitcher-plant (*Sarracenia purpurea* f. *heterophylla*, state threatened). Rare plant survey targets for graminoid-dominated wetlands are numerous and include English sundew (*Drosera anglica*, state special concern plant), panicled screw-stem (*Bartonia paniculata*, state threatened), moor rush (*Juncus stygius*, state threatened), fir clubmoss (*Huperzia selago*, state special concern), sweet coltsfoot (*Petasites sagittatus*, state threatened), northern appressed clubmoss (*Lycopodiella subappressa*, state threatened), northern prostrate clubmoss (*Lycopodiella margueriteae*, state special concern), auricled twayblade (*Listera auriculata*, state special concern), fleshy stichwort (*Stellaria crassifolia*, state threatened), Hudson Bay sedge (*Carex heleonastes*, state endangered), and dwarf raspberry (*Rubus acaulis*, state endangered).

There is potential for wood turtle (*Glyptemys insculpta*, state special concern) and Blanding's turtle to occur across the reserve in stands associated with drainages. Streams and/or ponds also harbor potential for the following rare plants: satiny willow (*Salix pellita*, state special concern), alga pondweed (*Potamogeton confervoides*, state special concern), lake cress (*Armoracia lacustris*, state threatened), alternate-leaved water-milfoil (*Myriophyllum alternifolium*, state special concern), Farwell's water-milfoil (*Myriophyllum farwellii*, state special concern), autumnal water-starwort (*Callitriche hermaphroditica*, state special concern), American shore grass (*Littorella uniflora*, state special concern), and Hill's pondweed (*Potamogeton hillii*, state threatened plant). Finally, inland lakes could support breeding common loon (*Gavia immer*, state threatened) and osprey (*Pandion haliaetus*), which nest in near shore areas.

Prioritization of Survey Targets

For each potential survey target or group of survey targets, a score for rarity, threat from management, and estimated probability of occurrence within the THRFR was assigned on a scale of one to five. For rarity, a ranking of one corresponded to very common and five corresponds to very rare. Global and state ranks (Appendix 3) and state status (special concern, threatened, or endangered) were used to assign this rarity score. For the threat category, one was assigned to targets that are not threatened by management and five was assigned to targets that are highly threatened by management. Finally, for the probability of occurrence category, one corresponded to a low probability of occurrence and five corresponded to a high probability of occurrence. Each ranking was summed to generate a total score for each survey target or group of survey targets (Table 2). Species that share habitat and survey windows were grouped since they can be surveyed for simultaneously. This scoring exercise facilitated the identification of survey priorities for natural communities, rare animals, and rare plants.

High priority natural community survey targets include rich conifer swamp, hardwood-conifer swamp, muskeg, and dry northern forest. High priority rare animal survey targets and groups of survey targets include diurnal raptors (red-shouldered hawk, northern goshawk, and Cooper's hawk), wetland dragonflies (ebony boghaunter and incurvate emerald), and merlin. For rare plants, groups of rare plants associated with non-forested wetlands, rich conifer swamp, and dry-mesic northern forest are the highest priority survey targets (Table 2).

Plan for Future Natural Features Surveys

Based upon this prioritization of survey targets, we propose the following multi-phase plan for future natural features surveys across the THRFR. The first phase of systematic surveys should involve the highest priority targets, including rich conifer swamp, hardwood-conifer

swamp, muskeg, dry northern forest, diurnal raptors, merlin, wetland dragonflies, and rare plants associated with graminoid-dominated wetlands and rich conifer swamp. Concurrent to this phase and subsequent phases, surveys for rare plants and high-quality mesic northern forest should be conducted in those stands prescribed for forest management during that particular phase. The second phase should focus on intermittent wetland, dry-mesic northern forest, bog, bog butterflies, wetland birds, a subset of the conifer birds (black-backed woodpecker and northern goshawk), and rare plants associated with bog, muskeg, and dry-mesic northern forest. The final phase of the natural features surveys across the reserve should focus on northern shrub thicket, northern wet meadow, poor conifer swamp, remaining mesic northern forest, spruce grouse, wood turtle, Blanding's turtle, and rare plants associated with mesic northern forest and ponds and streams. Additional surveys on the THRFR will lead to the refinement of this natural features survey plan as scientists gain increased knowledge of the landscape and its associated species and will continue to inform conservation and management within the THRFR and across the region.

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ACKNOWLEDGMENTS

We thank The Nature Conservancy of Michigan for funding this effort to survey high-quality natural communities on Michigan's State Forest lands. Special thanks are due to Patrick Doran and Brian Carlson for overseeing this project. Patrick Doran, Brian Carlson, Doug Pearsall, Christina Hall, and Matt Herbert provided assistance in developing the workplan, refining the methodology, and selecting sites for sampling. In addition, we are grateful to TNC staff for the sharing of maps, TNC's cabin, and insights about the reserve. Doug Pearsall generously assisted with the sampling effort. Gratitude is also due to many people in MNFI who participated in the development of the workplan and the methodology, including Mike Penskar, Yu Man Lee, Michael Kost, and Joelle Gehring. Helpful editorial support and insightful comments were provided by Martha Gove. Rebecca Rogers was instrumental in processing the survey data for this project. Kraig Korroch assisted with report formatting, and much appreciated administrative support was provided by Sue Ridge, Connie Brinson, Nancy Toben, and Yu Man Lee. No thanks to the mosquitoes, black flies, deer flies, ground bees, and bald-faced hornets.

Photos by Joshua G. Cohen.

Appendix 1. Forest vegetation and structure monitoring form.

The Nature Conservancy — Saving the Last Great Places on Earth

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan Natural Features Inventory

TWO-HEARTED RIVER MONITORING FIELD FORM

SURVEY INFORMATION

Survey date:	Time: from _____ am pm to _____ am pm	Site Name:
Surveyors (principal surveyor first, include first & last name):		

LOCATION INFORMATION

GPS location: _____ Transect Number: _____

RANDOM LINE INTERCEPT COARSE WOODY DEBRIS

Decay Classes: I - recent, leaves present, solid, and round; II – solid, leaves absent, and round; III – solid or decayed, leaves absent, solid or punky wood, round or oval; IV – decayed, leaves absent, punky wood, oval; and V – very decayed, leaves absent, punky wood, oval or collapsed shape (Tyrell and Crow 1994).

Piece # and Species (if discernible)	Total Length	Intersection Diameter	Large End Diameter	Small End Diameter	Decay Class*

Appendix 1, continued. Forest vegetation and structure monitoring form.

STRUCTURE: OVERSTORY SPECIES
In a 10X15 meter plot, measure DBH of all live trees over 10 cm. Make note if the tree has a cavity. Estimate age of 1 canopy dominant.

TREE SPECIES	DBH FOR EACH TREE, SEPARATED BY A COMMA

STRUCTURE: SNAGS In a 10X15 meter plot, measure DBH and height of all snags or dead trees over 10 cm and 2 meters tall. Make note if the tree has a cavity. Decay classes: I - bark intact, small branches present; II - bark loose or sloughing, no sapwood degradation; III - little to no bark, sapwood degradation; and IV – no bark, extensive sapwood degradation.

TREE SPECIES	DBH	Height	Decay Class	TREE SPECIES	DBH	Height	Decay Class

STRUCTURE: MICROTOPOGRAPHY
10X15 m plot

Pit & mound topography development	None	Minor < 10%	Moderate 10-50%	Major > 50%	Comments
Mark observation ☑					

Appendix 1, continued. Forest vegetation and structure monitoring form.

STRUCTURE: UNDERSTORY SPECIES ABUNDANCE

In a 5X5 meter sub-plot, record number of woody stems of all species ≥ 1 meter in height and 1cm DBH.

SPECIES	PLACE A TALLY MARK FOR EACH WOODY STEM THAT IS ≥ 1 M IN HEIGHT AND 1 CM DBH

DEER HERBIVORY INDEX

Within the 5X5 meter sub-plot, record the number of browsed and unbrowsed twigs per woody stem by species.

SPECIES	Browsed	Unbrowsed	SPECIES	Browsed	Unbrowsed	SPECIES	Browsed	Unbrowsed

Appendix 1, continued. Forest vegetation and structure monitoring form.

GROUND COVER SPECIES ABUNDANCE
Using a relevé approach on 1x1 meter subplots, make a species list and estimate percentage cover by class for each species. Include woody species < 1 meter in height. The five cover classes include:

SPECIES	COVER CLASS	SPECIES	COVER CLASS
PLOT 1		**PLOT 2**	
PLOT 3		**PLOT 4**	
PLOT 5		**PLOT 5**	

Appendix 1, continued. Forest vegetation and structure monitoring form.

MISCELLANEOUS DATA

What EO Rank would this forest receive and why? _____

_____

_____

_____

_____

_____

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_____

Additional Comments: _____

_____

_____

_____

_____

Appendix 2. Forest-interior bird point-count monitoring form.

SITE:	DATE:	VISIT:	OBSERVER:
Station ID:	[ ] Random Point [ ] Selected Point	Start Time:	Temp.: [ ]°F [ ]°C
Cloud Cover (%):	Wind Speed: [ ]km/h [ ]mph [ ]Beaufort	Precip: [ ]none [ ]light [ ]mod	Noise: [ ]1 [ ]2 [ ]3 [ ]4
Notes:			

	Period 1				Period 2				Period 3			
SPECIES	≤25 m	25-50 m	50-100 m	>100 m	≤25 m	25-50 m	50-100 m	>100 m	≤25 m	25-50 m	50-100 m	>100 m

Basal Area (10X prism)		Coarse woody debris (Class 1-3)	
Canopy Height (tallest tree per quarter quadrat 11.3 m)			
NW	NE	SW	SE

Dominant Species (use Daubenmire rank 1: 0-5%, 2: 5-25%, 3: 25-50%, 4: 50-75%, 5: 75-95%, 6: 95-100%)

Canopy (≥9 cm):	Subcanopy (<9 cm and/or ≥5 m tall):	Shrubs (≥1 m and <5 m):

Ground cover plot (total % cover within 1 m^2 or 56 cm diameter)

NORTH-SOUTH					EAST-WEST				
1	2	3	4	5	1	2	3	4	5

Canopy Closure (use + or – for presence or absence of canopy)

NORTH		SOUTH		EAST		WEST	
1	6	1	6	1	6	1	6
2	7	2	7	2	7	2	7
3	8	3	8	3	8	3	8
4	9	4	9	4	9	4	9
5	10	5	10	5	10	5	10

Appendix 3. Global and state 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.

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.

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.