Baseline Natural Features Inventory for Saginaw Chippewa Indian Tribal Lands

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Cover: Transition from submergent to emergent marsh on the north edge of Tawas Lake, Iosco County with wild rice (*Zizania aquatica and Z. palustris*) and tussock sedge (*Carex stricta*).
Above: Ellipse mussel (*Venustaconcha ellipsiformis*) found at Jordon Creek, Isabella County.

Acknowledgements

We thank the Saginaw Band of Chippewa Indian Tribe for prioritizing and funding this effort to survey lands in Michigan. Special thanks are due to Chase Stevens for providing information to guide this project and for assisting in property access. We also thank the Michigan Department of Natural Resources for use of their Michigan Forest Inventory protocol and database, which allowed for the collection of baseline vegetation mapping data, and in particular to Nathan Poley for his technical support. Editorial support and insightful comments were provided by Jesse Lincoln and Josh Cohen. Finally, we thank the following colleagues: Helen Enander offered cartography advice for the creation of maps and figures, and Ashley Adkins, Nancy Toben, and Brian Klatt provided administrative support.

Sora is a secretive marsh bird species documented during 2019 surveys.

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Executive Summary

The Saginaw Chippewa Indian Tribe (SCIT) of Michigan is a federally recognized Indian Tribe headquartered on the Isabella Reservation, in Isabella County. This report summarizes the results of natural features inventories conducted on diverse properties across three counties in Michigan's Lower Peninsula. We begin by placing prioritized properties surveyed in context by discussing historic land cover. In the methods we describe digital delineation of natural and urban areas on prioritized lands as identified by SCIT land managers using vegetation circa 1800 land cover maps, mosaic imagery from 1938, and best-available satellite imagery. The outcome of these delineations are stands - polygons representing a relatively homogeneous area of a similar cover type. In the field we verified stand delineations and collected vegetation data by documenting canopy, subcanopy, and understory vegetation, including species composition and relative abundance. Each stand was assigned a natural community according to the Michigan Natural Features Inventory (MNFI) Natural Community Classification (Cohen et al. 2015). In this report we present summary results for all stands, highlight high-quality stands, and provide georeferenced files to be used for future planning and conservation.

We completed targeted rare species surveys for mussels, insects, secretive marsh birds, amphibians, and reptiles. Additionally, using culturally important species lists provided by the Tribe, we documented culturally important plants. These culturally important plant sightings were incidentally recorded when encountered during vegetation mapping surveys. We documented 13 occurrences of rare species, and 137 occurrences of culturally important plants during 2019 surveys.

Notably, we documented four rare species of mussels in Jordon Creek, Isabella County: slippershell (state threatened), rainbow (state special concern), creek hillsplitter (state special concern), and ellipse (state special concern). During secretive marsh bird surveys, we documented 10 of the 14 target species, including: least bittern (state threatened), Forster's tern (state threatened), common gallinule (state threatened), and marsh wren (state special concern).

We conclude with a discussion providing insights on leading threats facing natural areas, recommendations for restoration and management priorities, as well as suggestions for future surveys, and data-driven research opportunities. The primary threats affecting SCIT lands are invasive species, ecosystem fragmentation, deer herbivory, and lack of fire. We address these threats in the context of inventory results and provide recommendations for managing threats, and also suggestions for future land management endeavors. There are many potential avenues for future research and monitoring, and we offer our suggestions based on 2019 rare species inventory results. We conclude with a discussion of next steps for conservation planning, informed by the results of baseline inventory results as a necessary first step. We hope the results from this project provide critical information for making well-informed decisions on the management of natural resources.

Introduction

The Saginaw Chippewa Indian Tribe (hereafter referred to as SCIT) of Michigan is a federally recognized Tribe headquartered on the Isabella Reservation, Isabella County, Michigan. SCIT is currently developing a wildlife conservation program and expressed a desire to reconnect with trust resources through conservation, restoration, and protection of its properties comprising various forests and wetlands throughout its service area in three counties: Isabella, Iosco, and Arenac (Figure 1). These lands are diverse, and subsequently face unique natural resource challenges. The development of priorities for management and conservation planning can be informed and enhanced with baseline natural features data. We worked to address this by meeting the following objectives: 1) provide information critical to making well-informed conservation decisions by providing stand-level vegetation data and information on biodiversity, 2) make the information collected through this project available through Michigan Natural Features Inventory's (MNFI) Natural Heritage Database and georeferenced natural community, vegetation, and rare species data available for download through ArcGIS Online (ESRI 2020), and 3) identify opportunities for research, monitoring, ecological restoration, and conservation planning based on the results of this inventory. Evaluating existing ecosystem quality is integral to setting wildlife monitoring goals, restoration needs, and management goals. Baseline data will help land managers make informed conservation and resource management decisions. In this report we present results from these vegetation mapping inventories and rare species surveys on priority parcels, which comprise 2,882 acres of the SCIT lands (Figure 1). This integrated inventory approach identifies areas that harbor high potential for biodiversity, rare species, areas in need of management, and cultural resources in need of protection. These data represent a starting point for the development of a conservation plan, of which we offer a suggested outline in the final section of this report.

Landscape Context

Our understanding of the ecological context of contemporary natural areas can be enhanced by examining the historical setting of natural communities and natural features. European colonization has had a devastating impact on the extensive wetlands and forests that once comprised Michigan and subsequently land cover has changed significantly since the early 1800s due to urban and suburban development, logging, agriculture, deer herbivory, fire suppression, invasive species, and hydrologic alteration. We examined Vegetation of Michigan circa 1800 land cover maps (Comer et al. 1995) to inform our survey efforts. Between 1816 and 1856, Michigan was systematically surveyed by the General Land Office (GLO), surveyors noted the location, species, and diameter of each tree used to mark section lines and section corners. Surveyors commented on the locations of rivers, lakes, wetlands, the agricultural potential of soils, cultural featues (including trails, farms and villages used by indigenous peoples), and the quality of timber along each section line. Resulting digital maps were constructed through exhaustive analysis of the GLO surveyor notes, and are available for use by researchers, land managers, and the general public (Comer et al. 1995). We generated circa 1800s land cover maps for all SCIT properties to aid in baseline inventories.

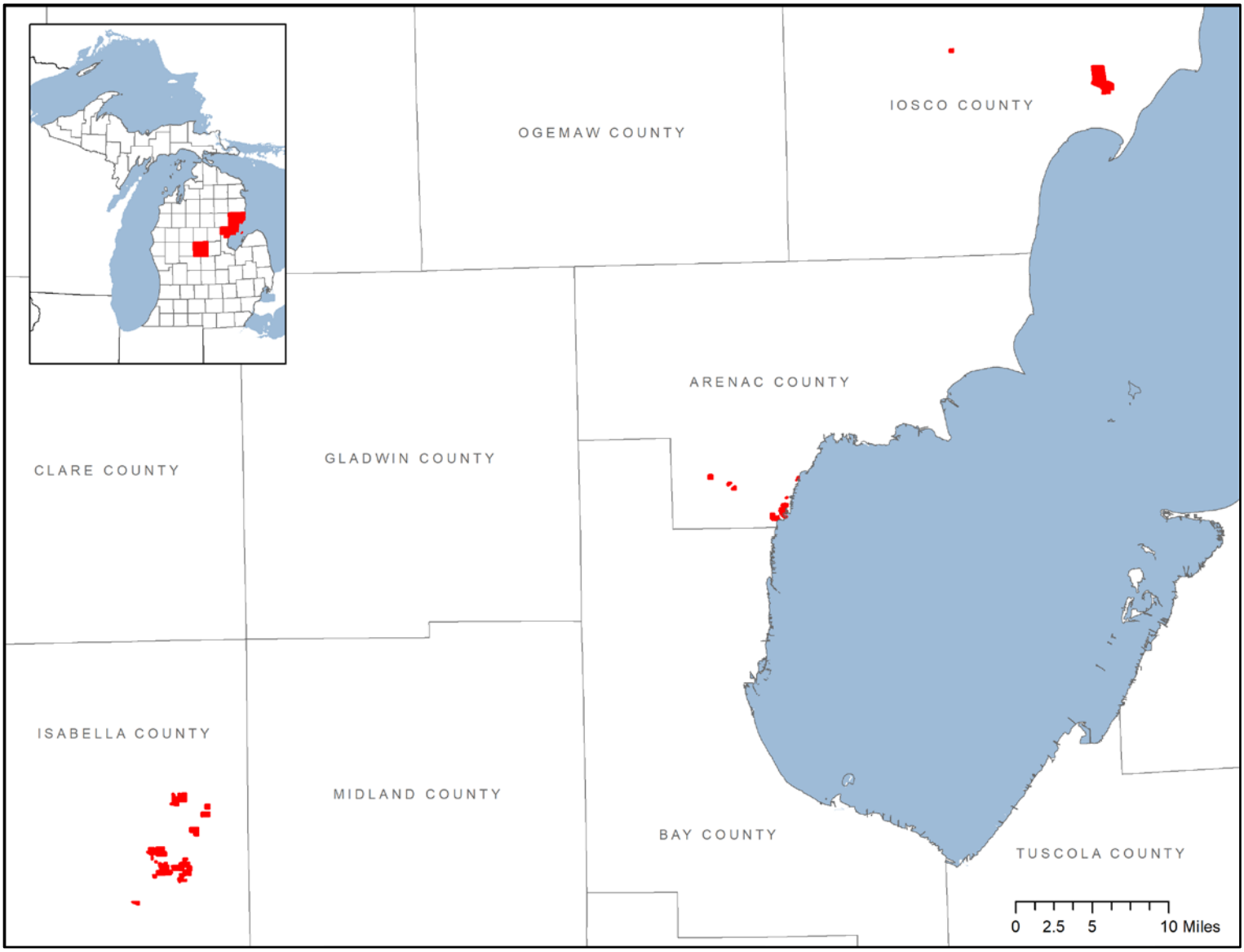

Figure 1. Saginaw Chippewa Indian Tribe properties surveyed by Michigan Natural Features Inventory.

While natural areas in Michigan incurred significant alterations throughout the 1800s and early 1900s, these systems were further altered, and in many cases decimated, in subsequent decades as managed forests, agriculture, and human settlements replaced natural communities at an increasing rate. The oldest aerial imagery available for Michigan is from flights taken in 1938. Mosaics created from this imagery are an invaluable tool in determining where intact natural areas may still occur. A key assumption is that if an area experienced anthropogenic disturbance in 1938, it is likely ecologically degraded in present day. These disturbances often manifest in low native plant species diversity and a high abundance of non-native invasive plant species. Conversely, areas that were historically forested, remained forested in the 1930s, and have not been logged in the intervening years tend to have comparatively fewer invasive species and a greater diversity of native species, including those of high conservation value. The mosaic of aerial photographs from 1938

show how logging and the expansion of agriculture heavily impacted the landscape in Michigan (Figures 3, 5, and 7).

Throughout this report we classify vegetation communities by assigning them a natural community, which we define as an assemblage of interacting plants, animals, and other organisms that repeatedly occur under similar environmental conditions across the landscape and is predominantly structured by natural processes rather than modern anthropogenic disturbances, such as timber harvest, alterations to hydrology, and fire suppression. Throughout history, indigenous peoples have been an integral part of Michigan's natural communities, aiding in the management of prescribed fire and the movement of native plants across the landscape. In this report, we often refer to MNFI's natural community classification, which recognizes 77 natural community types in Michigan (Kost et al. 2007, Cohen et al. 2020). These communities are described in detail on MNFI's website (Cohen et al. 2020) and in an associated field guide (Cohen et al. 2015). Protecting and managing representative natural communities is critical to biodiversity conservation because native organisms are best adapted to environmental and biotic forces with which they have survived and evolved over the millennia (Kost et al. 2007). The circa 1800s maps refer to land cover types that are often more broad, or have different nomenclature from the natural community classification. Below we describe natural communities synonymous with these land cover types when applicable.

Comprising two peninsulas, Michigan is uniquely situated among the Great Lakes and strongly influenced by their presence. An east to west "tension zone" bisects the Lower Peninsula of Michigan marking a relatively abrupt shift between southern and northern vegetation. In southern Michigan, hardwoods dominate with a diverse understory of more southern herbaceous plants. Moving northward, conifers, ferns, orchids and other more northerly plant species begin increasing in dominance. This tension zone is influenced by climate and soil types, influencing shifts in floristic composition. Although the precise delineation of the tension zone in Michigan is difficult, a useful interpretation is to draw a line from Bay City to Muskegon, then apply a generous buffer. Many northern range limits of southern plants are concentrated around this tension zone, whereas southern range limits of northern plants are not as consistent or well defined. The tension zone is often where northern and southern variants of several natural communities (e.g., mesic southern forest vs. mesic northern forest) are delineated. Therefore, as we explore natural communities found on SCIT lands, this occasionally results in the lack of a clear definition of which natural community is present, particularly when anthropogenic disturbances have eliminated much of the natural characteristics of that stand.

Properties in all three counties are mostly located in the Saginaw Lowlands of Michigan. These plains are associated with Glacial Lake Saginaw, an area that was glaciated between 13,000 and 14,000 years ago. Comprising classic low relief lake plain, this region contains a mix of poorly to somewhat poorly drained loamy and sandy sediment with scattered sandy dune ridges, and several streams with incised valleys cross the landscape.

Isabella County

The circa 1800 land cover maps characterize much of this area as beech-sugar maple forest, or mesic southern forest, which is an American beech (*Fagus grandifolia*) and sugar maple (*Acer saccharum*)–dominated forest primarily distributed south of the tension zone (Figure 2). These forests occur on a variety of soil types and are characteristic of well-drained lake plains, till plains, and moraine ridges. Mesic forests are unique in their high diversity of spring ephemeral wildflowers, such as bloodroot (Meskojiibikak, *Sanguinaria canadensis*) and Jack-in-the-pulpit (Zhaashaagomin, *Arisaema triphyllum*), which form a carpet of color in the spring before leaf out.

Hemlock-white pine forests (a variant of mesic northern forest) were historically co-dominant in what is now Isabella County. Disturbances in this forest system were limited, with infrequent burning, and regeneration of species occurring via windthrow. This upland forested community is dominated by a variety of species, including eastern hemlock (*Tsuga canadensis*), yellow birch (*Betula alleghaniensis*), sugar maple, American beech, red oak (*Quercus rubra*), and white pine (*Pinus strobus*). Often found on coarse-textured ground and end moraines and loamy sands to sandy loam soils, these forests are sustained by frequent, small windthrow events that create canopy gaps and allow shade-tolerant canopy seedlings to regenerate. These forests were multigenerational and occurred as a matrix community, historically covering over 12 million acres in Michigan (Comer et al. 1995, Cohen 2000).

Mixed conifer swamp was mapped in the northwestern portion of the Isabella parcel and was composed of either hardwood-conifer swamp or rich conifer swamp. Much of the natural component of this community has been lost due to logging, so today these communities are primarily hardwood-dominated wetland forests, lacking the conifer component. Rich conifer swamp, a groundwater-influenced, minerotrophic, forested wetland, is dominated by northern white-cedar (Giizhikaatig, *Thuja occidentalis*). It typically occurs in association with lakes and cold, groundwater-fed streams, and is influenced by groundwater seepage, seasonal water-level fluctuations, windthrow, flooding by beaver, hummock and hollow development, and occasionally catastrophic fire. Hardwood-conifer swamp is typically associated with headwater streams or shallow kettle depressions in outwash channels where it is influenced by fluctuations in groundwater levels, windthrow, and beaver flooding. The canopy varies, comprising red maple (*Acer rubrum*), yellow birch, white pine, quaking aspen (*Populus tremuloides*), northern white-cedar, and eastern hemlock. Also present to a lesser extent, northern hardwood swamps are forested wetlands occurring primarily in poorly drained depressions and high order stream drainages on a variety of landforms with a canopy dominated by green ash (*Fraxinus pennsylvanica*), black ash (*F. nigra*), silver maple (*Acer saccharinum*), and red maple. Historically, regular fluctuation of water levels led to windthrow of shallowly rooted trees, creating canopy gaps that promoted a diverse overstory. Due to the nutrient rich soils associated with the forests in this region, by the early 1900s much of the forest cover had been removed and converted to agricultural production. As indicated by the 1938 imagery mosaic, few areas remain forested (Figure 3). There are a small number of stands with fragmented tree cover in 1938, which were likely selectively harvested for building and fuel sources.

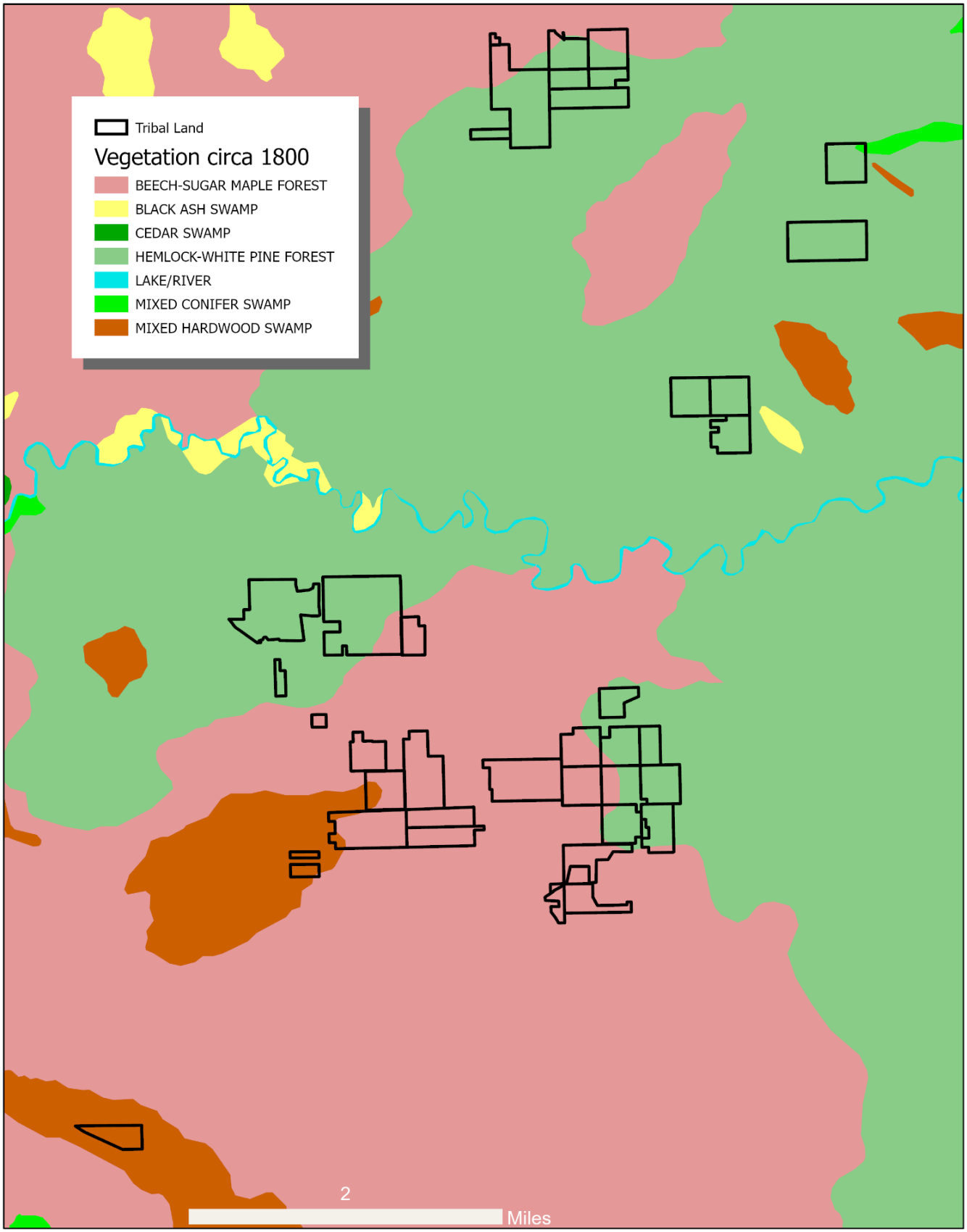

Figure 2. Circa 1800s land cover map for Isabella County.

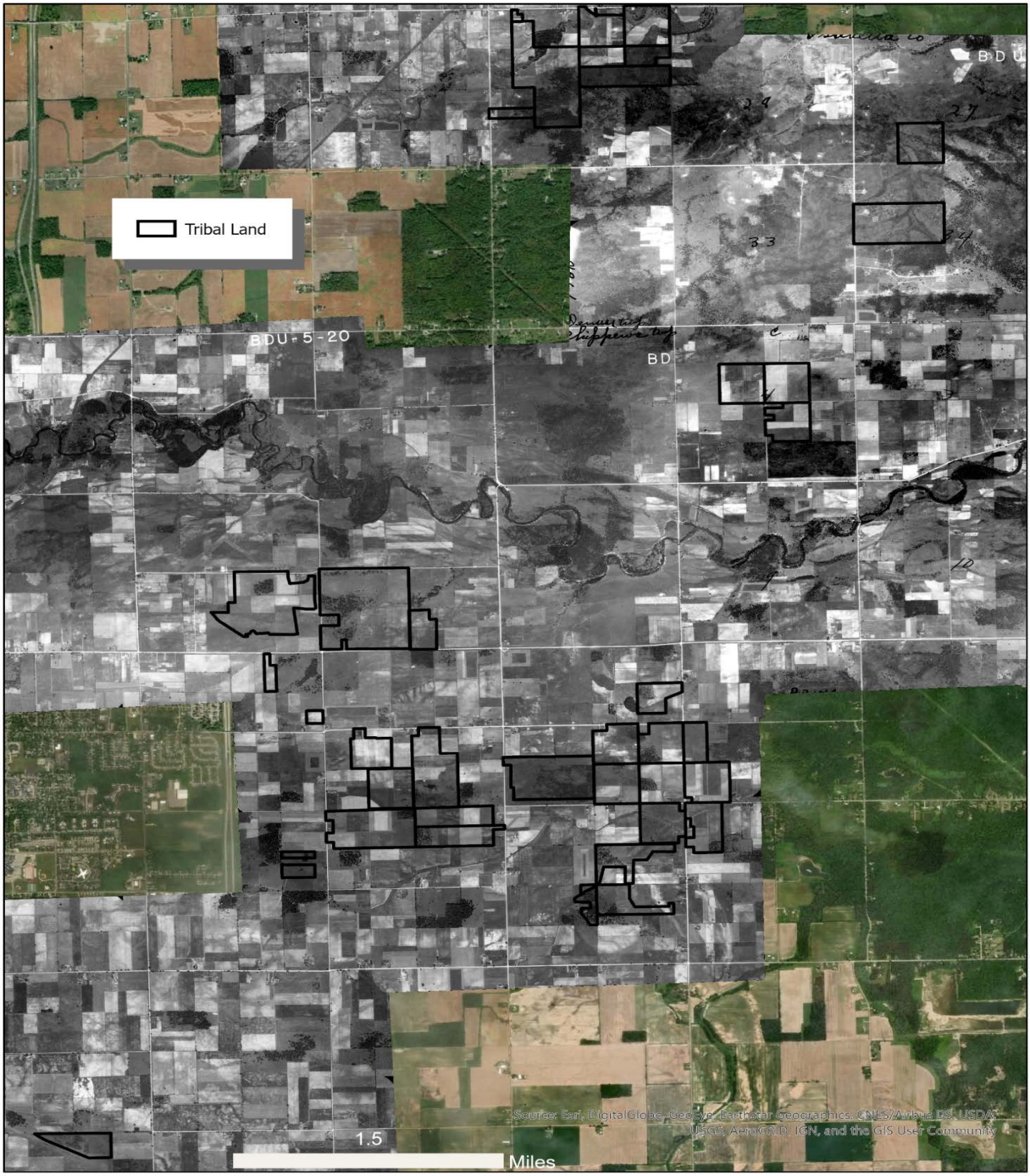

Figure 3. 1938 imagery mosaics for Isabella County.

Iosco County

Two recent land acquisitions expanded SCIT properties to Iosco County. The Goedecke property was acquired in 2008 and is a 29-acre inholding surrounded by the Huron National Forest. This property is located north of Indian Lake and throughout this report we refer to it as “Indian Lake“. This area was primarily classified as red pine-white pine on the circa 1800s map, synonymous with the MNFI natural community of dry-mesic northern forest (Figure 4). Dry-mesic northern forest typically occurs on well-drained sandy, acidic soil where they are dominated by white pine and red pine (*P. resinosa*), with red oak and eastern hemlock. The ground layer is often dominated by bracken fern (*Pteridium aquilinum*), along with a diversity of shrubs, sedges, grasses, and forbs. This natural community type historically originated in the wake of catastrophic fire with return intervals estimated to range from 120 to 300 years, and was maintained by frequent, low-intensity fires, with return intervals estimated from 5 to 20 years. This was among the most sought forest types by early Europeans in the Great Lakes region, who harvested extensive tracts of forests to provide lumber for the construction of rapidly developing cities. Examination of the 1938 imagery from Indian Lake show evidence of logging (Figure 5). Extensive rich conifer swamp was mapped throughout Iosco County, however, this natural community type is not shown on the circa 1800s, likely because it was too small to be noted by land surveyors. Rich conifer swamp is currently found throughout the central portion of the property, evident as one examines the stand in the field or through modern satellite imagery. Limited access to the lowlands likely resulted in limited harvesting for timber in this forested wetland.

Located along Tawas Lake, the Amesbury property (902 acres, hereafter referred to as the Tawas property) was acquired in 2017. Historically, this site contained a mix of jack pine-red pine forest, cedar swamp, and shrub swamp-emergent marsh (Figure 6). These three community types define the transitional gradient from the jack pine-red pine upland forests to the shores of Tawas Lake. Furthest upland, jack pine-red pine forests are synonymous with dry northern forest. Dry northern forest is a fire-dependent community that occurs on dry, sandy outwash plains. In the 1930s the jack pine-red pine forests and cedar swamps were still largely forested (Figure 7). As the land slopes towards Tawas Lake, lowland cedar swamps (rich conifer swamp) and hardwood-conifer swamps become the primary land cover type (Figure 8)**.** Mesic northern forest was likely interspersed with the hardwood-conifer swamp across the landscape.

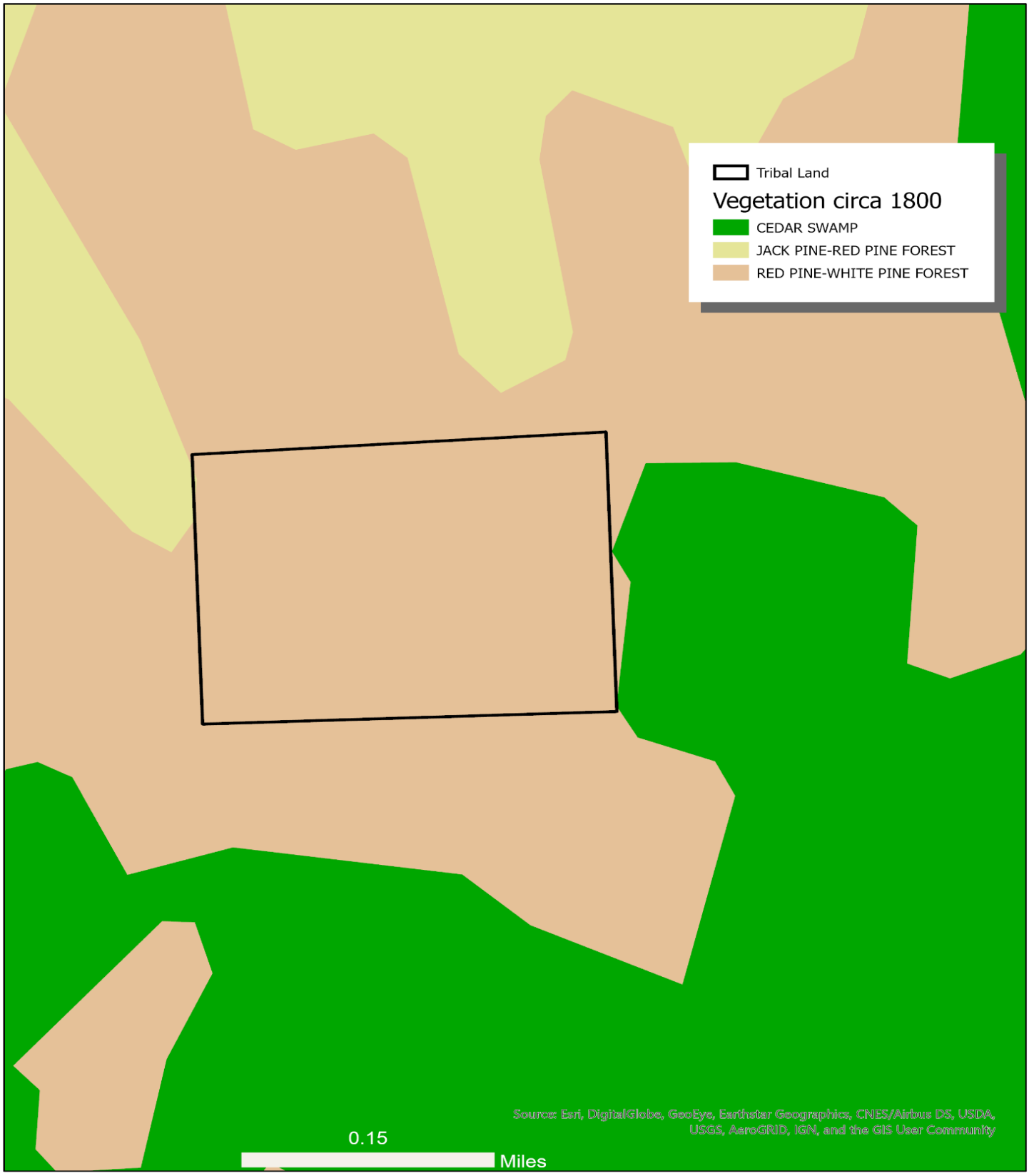

Figure 4. Circa 1800s land cover map for Indian Lake, Iosco County.

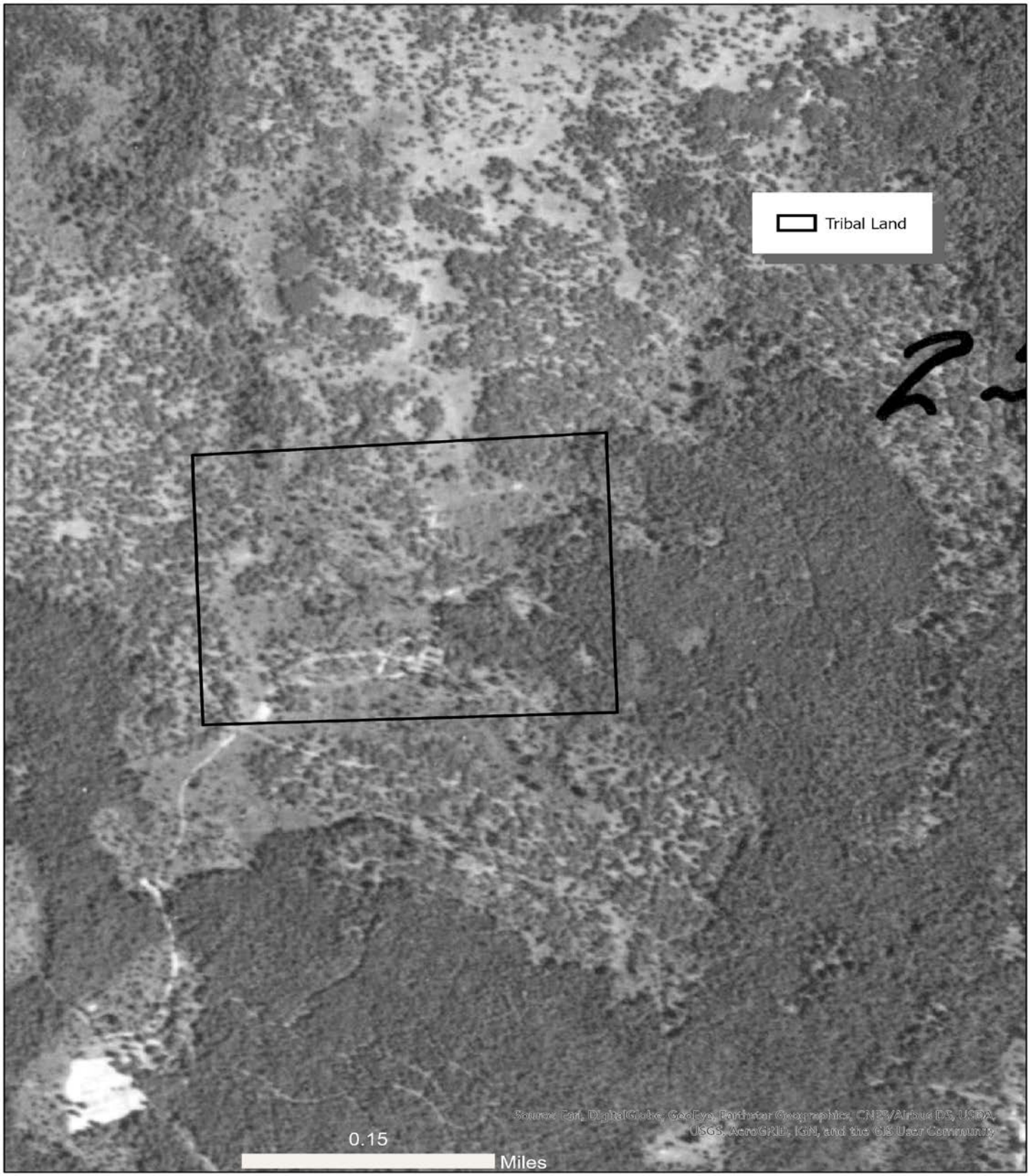

Figure 5. 1938 imagery mosaics for Indian Lake, Iosco County.

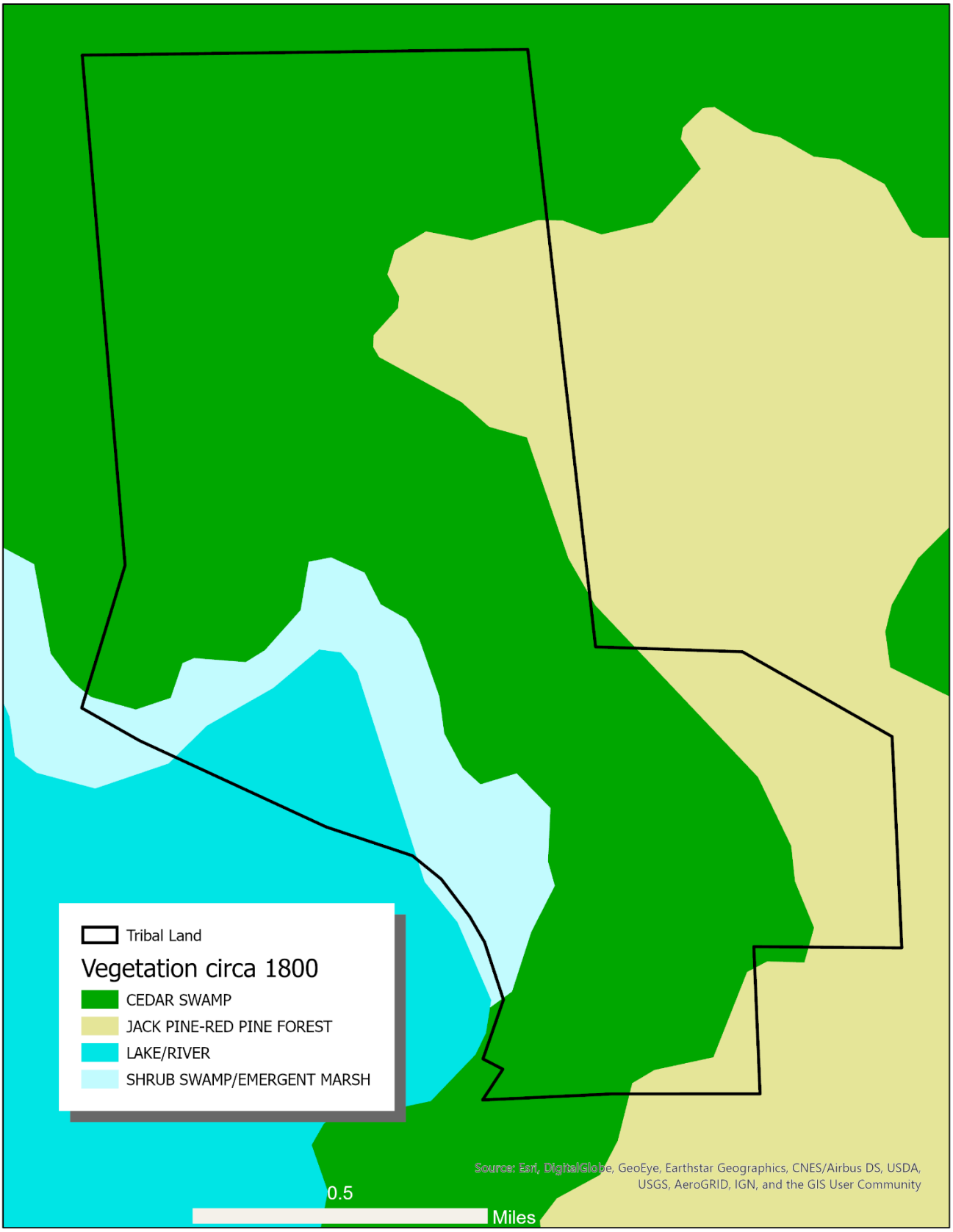

Figure 6. Circa 1800s land cover map for Tawas, Iosco County.

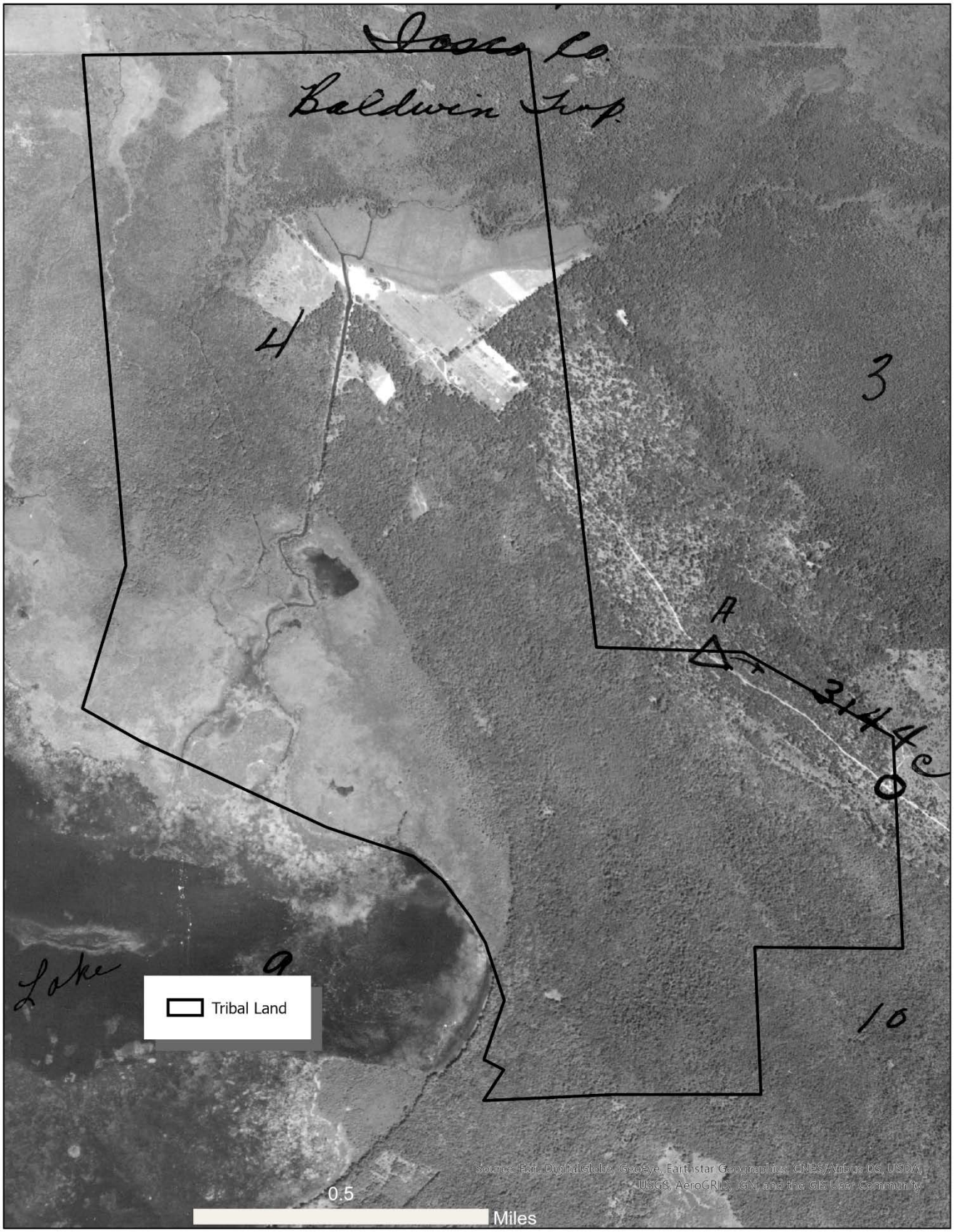

Figure 7. 1938 imagery mosaics for Tawas, Iosco County.

MNFI's open wetland classification from the circa 1800 map is broad because the GLO surveyors gathered limited information that did not allow for current ecologists to more specifically classify these communities. The circa 1800s maps assign much of the land adjacent to Tawas Lake as shrub swamp-emergent marsh, we refer to this as northern shrub thicket and emergent marsh (Figure 6). Northern shrub thicket is a shrub-dominated wetland that typically occurs along streams, adjacent to lakes, or adjacent to beaver flooding. Sites are overwhelmingly flat and can range from small pockets to extensive acreages, usually existing as a narrow band or zone of 20 - 30 m within a larger wetland complex. The soils of northern shrub thicket are wet to moist, nutrient-rich, and can range from poorly drained to well drained, with most sites remaining saturated throughout the growing season. The community is dominated by tag alder (*Alnus incana*), but dogwoods (*Cornus* spp.) and willows (*Salix* spp.) are regularly common. Northern shrub thickets can form following severe disturbances such as flooding, fire, beaver activity, and windthrow, which result in significant losses to the swamp canopy and the expansion of alder through establishment of seedlings or stump sprouting. Once established, northern shrub thicket can persist if disturbance factors prevent tree establishment and growth. Emergent marsh is characterized by herbaceous vegetation that is emergent above the surface of the water and comprising narrow-leaved species including bulrushes (*Scirpus* spp. and *Schoenoplectus* spp.), spike-rushes (*Eleocharis* spp.), rushes (*Juncus* spp.), and cattails (*Typha* spp.). Grasses and sedges (*Carex spp.*) typically dominant the wet meadow zone, along with numerous other herbaceous plants. Emergent marshes are particularly vulnerable to invasive species and are threatened by non-native Phragmites (*Phragmites australis*), narrow-leaved cattail (*Typha angustifolia*), reed canary grass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicaria*), and European frog's-bit (*Hydrocharis morsus-ranae*). This system is where wild rice (Manoomin, *Zizania aquatica* and *Z. palustris*) can often be found. In Michigan, wild rice grows in muck soils with shallow, flowing water, needs stable water levels, and is most successful when it has little competition. Threats to this species include hydrological alterations, pollution, herbicides, heavy boat traffic, and invasive species.

Rich conifer swamp located on Tawas, Iosco County. Dominated primarily by northern white cedar, a significant ash component has been lost from the canopy in recent years.

Arenac County

Situated along the shoreline of Lake Huron, SCIT properties in Arenac County were historically wet prairie along the lakeshore, transitioning into swamp forests dominated by a mix of conifers and hardwoods further inland (Figure 8). Wet prairies are dynamic, as they are heavily influenced by lake levels. This community contains a mix of prairie and shoreline plant species, and is influenced by seasonal and long-term fluctuation in water levels, which prevents shrubs and trees from replacing prairie species along the shoreline. During high lake levels, these communities may transition into Great Lakes marsh - an herbaceous wetland community occurring along Great Lakes' shorelines and major connecting rivers. These marshes contain diverse vegetative zones including submergent marsh, emergent marsh, wet meadow, and shrub swamp. As the Great Lakes water levels fluctuate, these zones shift inland or lakeward, however with ecosystem fragmentation and lakeshore hardening, these shifts are often not possible.

Tribal property situated along the Lake Huron shoreline in Arenac County was historically classified as wet prairie. Recent surveys have classified these shoreline stands as open water and marsh.

Further inland, swamp forests historically contained a mix of conifer and hardwood species (Figure 8). Situated near the tension zone, these forests contained species associated with both southern and northern systems. By the 1930s, nearly all of the western portion of this property had been converted to agricultural production (Figure 9). The lakeplain praire was likely harvested for "marsh hay" to feed livestock or altered for crop production. Drainage ditches can be seen in the 1938 imagery, which was historically common practice due to the fertile soils associated with lakeplain prairies.

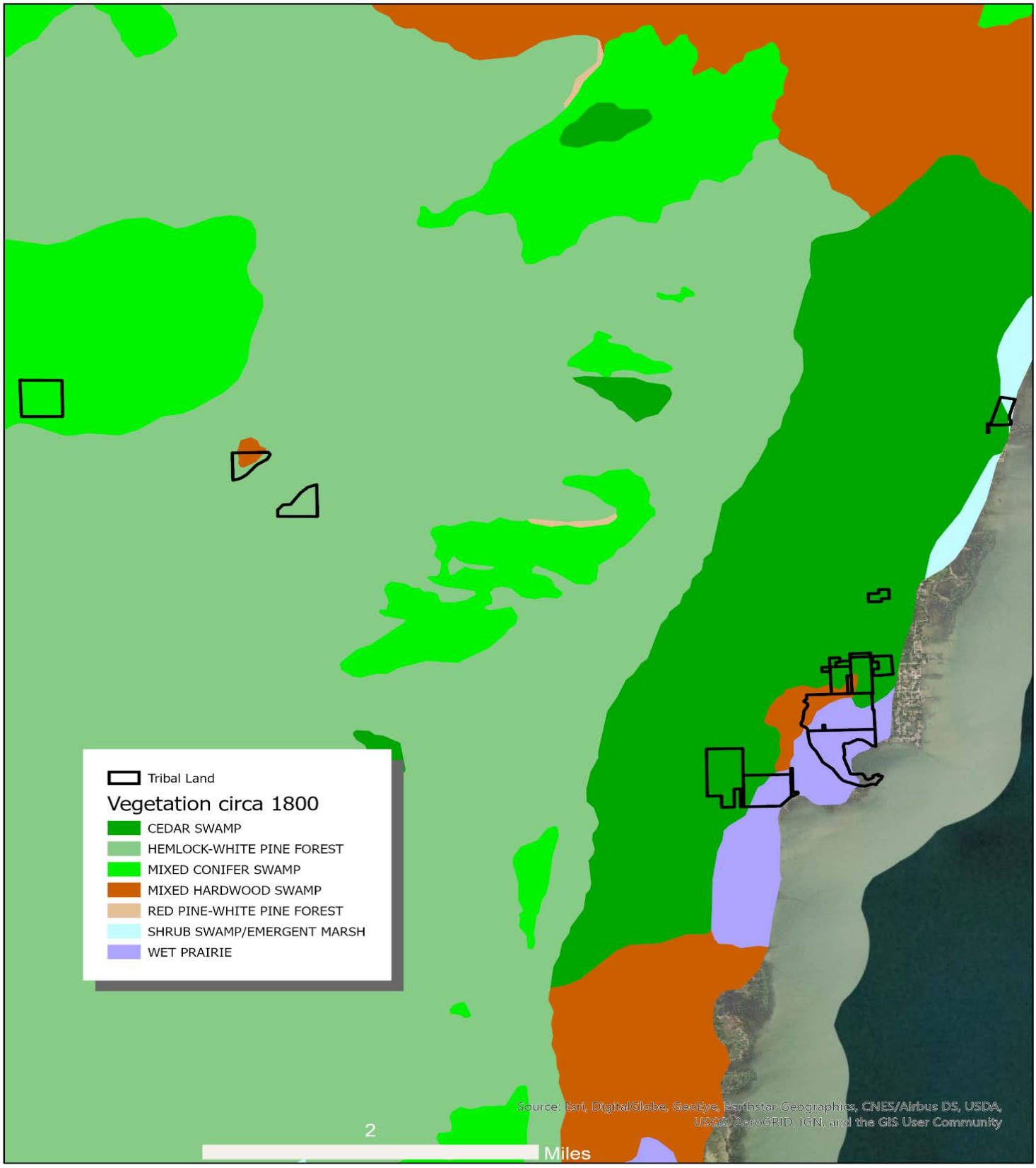

Figure 8. Circa 1800s land cover map for Arenac County.

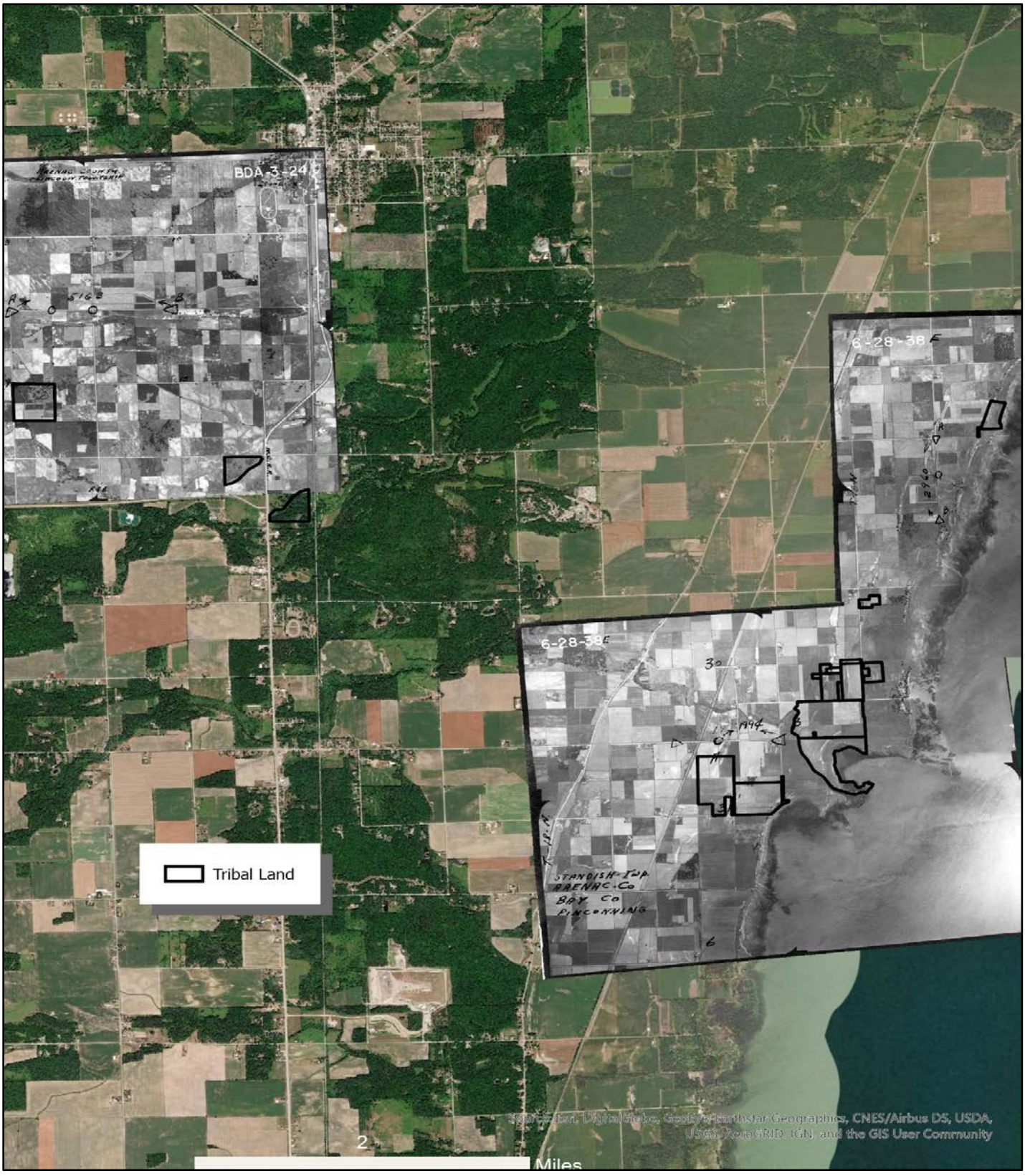

Figure 9. 1938 imagery mosaics for Arenac County.

Methods – Vegetation Mapping

We used best-available aerial imagery, Vegetation of Michigan circa 1800 land cover maps (Comer et al. 1995), and 1938 imagery mosaics to delineate prioritized properties into stands. Stands are discrete polygons representing a relatively homogeneous area of a similar cover type, natural community, and land use history. These stands are located in one of six property boundaries called 'compartments' and provide the framework for subsequent field vegetation and natural community surveys (Table 1).

Table 1. Summary of properties selected for vegetation mapping surveys.

Parcel	Compartment	County	Acres
Isabella (Mount Pleasant)	1, 2, 3	Isabella County	1605.8
Indian Lake (Goedecke Property)	6	Iosco County	29.0
Tawas (Amesbury property)	5	Iosco County	902.1
Saganing Bay	4	Arenac County	345.5
Total			2882.4

Each stand was surveyed in the field by walking a representative transect to gather data on vegetation composition using the Michigan Forest Inventory (MiFI) data collection framework. This framework offers a standardized approach for collecting stand level data and is consistent with similar surveys MNFI regularly conducts on state lands throughout Michigan. Data collection differs slightly for forested (>25% canopy cover) and non-forested (<25% canopy cover) stands. For each forested stand, we recorded percent cover and diameter at breast height (DBH) for all canopy species and used an increment borer to estimate the age of the stand, using a representative, dominant tree. In all stands we recorded percent cover of all species encountered in the herbaceous/shrub layer. Using this information, the MiFI framework assigns a cover type (e.g., herbaceous openland, cropland, mixed upland deciduous). We then assigned each stand with a MNFI natural community classification, except for highly degraded or planted (e.g., row crops or lawn grass) cover types, for which no natural community could be assigned. Each stand was given an ecoscore, ranging from 1 to 5, to develop a relative ranking system of stand quality (Table 2). This ranking system allows for the identification of high-quality stands and facilitates prioritization of stewardship.

MNFI botanist using an incremental tree corer to determine tree age.

Table 2. Descriptions of ecoscores assigned to natural communities during baseline inventories.

Ecoscore	Description
1	*Very heavily modified by past human activity*. Essentially destroyed from a natural plant community perspective. Most native vegetation or community assemblage is gone. Invasive species likely dominant. Examples: Weedy tree groves on spoil areas, former farm fields now containing non-native cover, and marshes with rampant non-native Phragmites.
2	*Heavily modified by past human activity*. Native vegetation or community assemblage is reduced to an altered state but still recognizable as having once been some type of a natural community (the original type of community may not be obvious). Examples: early seral scrub areas grown after clearcutting, "ponds" formed after meadows are impounded, marshes with growing populations of cattail, or old upland fields with a mix of native and non-native grassland species.
3	*Moderately to heavily altered by past human activity.* Native vegetation or community assemblage is altered but somewhat recognizable as a type of a natural community (the original type of community may still be present, but it is not a very high-quality example). Examples: early to mid-seral forest areas grown after logging 10 to 60 years prior, wet meadows with some hydrologic impact, prior ditching, or some invasive species, marshes with low species diversity and scattered purple loosestrife, or old upland fields with several prairie species mixed with non-native grassland species.
4	*Lightly to moderately altered by past human activity*. Native vegetation or community assemblage is apparently altered but quickly recognizable as a type of a natural community (the original nature of the natural community type is not entirely certain due to a history of factors like fire suppression or past tree removal, but the site has a fairly natural level of plant diversity and is more or less sustainable). Examples: maturing native forest areas grown after logging 60 years-or-more prior, or native forest recovering from selective tree removal, or wet meadows with increasing brush but covered almost entirely by native species.
5	*Unaltered to lightly altered by past human activity*. Native vegetation or community assemblage may be a bit altered but is clearly a natural community (the original nature of the natural community type could be debated due to history of factors like fire suppression or past selective tree removal, but the site has a natural level of plant diversity, many conservative species, and if correctly managed is sustainable). Examples: Mature native forest with no indications of human modification, mature native forest which may have been selectively logged 50 or more years prior, mature native forest which may have been heavily logged in the 1800s, wet meadows with little brush and covered by native species, or marshes with diverse native species composition.

Methods – Rare Species

Rare species survey targets were informed by current and historical ranges, habitat requirements, and vegetation mapping (Table 3). Project leads also consulted MNFI zoologists and botanists to provide input on surveys, which were prioritized in sites most suitable for supporting target species. Below we discuss methods for each taxon. In the case of bird surveys, secondary species were selected to serve as wetland indicators and represent a range of bird species, from common to rare as well as habitat specialist to generalist.

Table 3. List of species, by taxa, targeted for rare species surveys on SCIT lands. State statuses are listed as: SC = special concern, T = threatened, E = endangered. Federal listings are added with *.

Taxa	Target Species	State Status	Common Name	SCIT Properties Surveyed
Mussels				
	Alasmidonta viridis	T	Slippershell	Isabella County
	Cambarunio iris (=Villosa iris)	SC	Rainbow	Isabella County
	Lasmigona compressa	SC	Creek heelsplitter	Isabella County
	Venustconcha ellipsiformis	SC	Ellipse	Isabella County
Insects				
	Papaipema speciosissima	SC	Regal fern borer moth	Isabella, Iosco Counties
	Appalachian arcana	SC	Secretive locust	Iosco County
Birds				
	Botaurus lentiginosus	SC	American bittern	Arenac, Iosco Counties
	Ixobrychus exilis	T	Least bittern	Arenac, Iosco Counties
	Rallus elegans	E	King rail	Arenac, Iosco Counties
	Rallus limicola		Virginia rail	Arenac, Iosco Counties
	Porzana carolina		Sora	Arenac, Iosco Counties
	Gallinula galeata	T	Common gallinule	Arenac, Iosco Counties
	Fulica americana		American coot	Arenac, Iosco Counties
	Grus canadensis		Sandhill crane	Arenac, Iosco Counties
	Gallinago delicata		Wilson's snipe	Arenac, Iosco Counties
	Chlidonias niger	SC	Black tern	Arenac, Iosco Counties
	Cistothorus palustris	SC	Marsh wren	Arenac, Iosco Counties
	Sterna forsteri	T	Forster's tern	Arenac, Iosco Counties
	Cistothorus platensis		Sedge wren	Arenac, Iosco Counties
	Podilymbus podiceps		Pied billed grebe	Arenac, Iosco Counties
	Melospiza georgiana		Swamp sparrow	Arenac, Iosco Counties
Herpetofauna				
	Lithobates [Rana] palustris	SC	Pickerel frog	Arenac, Iosco, Isabella Counties
	Glyptemys insculpta	SC	Wood turtle	Arenac, Iosco, Isabella Counties
	Emydoidea blandingii	SC	Blanding's turtle	Arenac, Iosco, Isabella Counties
	Regina septemvittata	SC	Queen snake	Arenac, Iosco Counties
	Thamnophis butleri		Butler's garter snake	Arenac, Iosco Counties
	Opheodrys vernalis		Smooth green snake	Arenac, Iosco, Isabella Counties
	Sistrurus catenatus	*SC	Eastern massasauga	Iosco County
Plants				
	Zizania aquatica	T	Wild rice	Iosco County
	*Federally threatened			

Mussels

We completed aquatic surveys to determine the occurrence and abundance of native mussels (Unionidae, Table 3). We recorded incidental observations of additional taxa, such as aquatic snails, fish, crayfish, and fingernail clams, as well as any occurrences of non-native mollusk species (e.g., zebra mussel [*Dreissena polymorpha*], Asian clam [*Corbicula fluminea*]). We conducted surveys in wadable habitats (less than 70 cm deep) in stand 16 (compartment 1) in Jordon Creek, Isabella County and stand 30 (compartment 4) in the Saganing River, Arenac County. We characterized sites by documenting stream water chemistry and physical habitat characteristics. We measured the search area at each site to standardize sampling effort and to estimate unionid mussel density. The search area extended from bank to bank to include the widest range of microhabitats. We located live mussels (and snails) and shells with a combination of visual and tactile means. We used both glass bottom buckets for visual detection and tactile searches through the substrate to ensure that buried individuals were detected, including smaller-sized unionid mussels like the slippershell mussel. We identified live individuals to species and placed them back into the substrate anterior end down (siphon end up) in the immediate vicinity of where they were found. Mussel shells were also identified to species. Gastropod shells were collected by hand.

We documented stream conditions at the time of the surveys by recording habitat data. Substrate within each search area was characterized by visually estimating percent composition of each of the following six particle size classes (diameter): boulder (>256 mm), cobble (256-64 mm), pebble (64-16 mm), gravel (16-2 mm), sand (2-0.0625 mm), and silt/clay (<0.0625 mm, Hynes 1970). We noted woody debris, aquatic vegetation, exposed solid clay substrate, and eroded banks if present. We estimated percentage of the search area with pool, riffle, and run habitat, and characterized current speed by timing floating debris over a measured distance. We recorded conductivity and pH with an Oakton handheld meter and alkalinity and hardness with LaMotte kits (models 4491-DR-01 and 4824-DR-LT-01).

Rainbow was one rare mussel species we targeted in 2019 surveys.

Insects

We completed rare insect surveys for the regal fern borer moth and the secretive locust. While conducting these surveys, we also documented other insect species of interest. The regal fern borer moth occupies swamp forests where its known larval host plants, regal fern (*Osmunda regalis*) and/or cinnamon fern (*O. cinnamomea*), are present. We identified four locations with high abundance of ferns for blacklight surveys in Tawas (compartment 5, stands 8, 33, 44) and Isabella (compartment 1, stand 3). Surveys were conducted at night using standard mercury-vapor and UV lights powered by a portable generator. A 2-m^2 metal conduit frame supporting a large white sheet was used as a collecting surface. Moths attracted to the lights were collected directly off the sheet or the ground near the sheet. The setup was placed in the field with larval host plants on all sides to maximize the likelihood of attracting adults.

Secretive locust generally occurs in open leatherleaf-dominated sphagnum bogs surrounded by jack pine (*Pinus banksiana*). Males are usually found sunning at the tips of branches of leatherleaf (*Chamaedaphne calyculata*) or on trunks and branches of jack pine and tamarack (*Larix laricina*). Females are more secretive, usually remaining hidden lower in trees and shrubs. At Tawas (compartment 5), we identified suitable habitat in the southeast section of the property (stands 31 and 32). We conducted secretive locust surveys by slowly walking throughout potentially suitable habitat. Surveys were focused in areas where there was a mix of jack pine, tamarack, reindeer moss (*Cladonia rangiferina*), and huckleberry (*Gaylussacia baccata*). We used binoculars to scan sunning locations at the base of jack pine and the tops of leatherleaf. Binoculars provide a non-invasive method of surveying to minimize impact on potential populations.

Papaipema survey set-up using a white cloth and standard mercury-vapor and UV lights along the shores of Tawas Lake in Iosco County.

Secretive Marsh Birds

We focused avian surveys on rare, secretive marsh birds in emergent, submergent, and shrub wetlands in Arenac County along Lake Huron and the Saganing River, and Tawas, Iosco County. Surveys followed the Standardized North American Marsh Bird Monitoring Protocols described by Conway (2011) and further refined for Michigan (MiBCI 2015). Target species for these protocols were selected based on concern about apparent long-term declines, special status, and/or because they serve as indicators of specific wetland types. Primary target species consisted of all secretive marsh birds (i.e., grebes, bitterns, and rails) with potential to breed in the survey area and Wilson's snipe (Table 3). In addition, we recorded observations of the following secondary target species: sandhill crane, black tern, Forster's tern, sedge wren, marsh wren, and swamp sparrow. We randomly generated 13 points with a minimum separation distance of 400m. Point count stations were uploaded to a tablet, which was used for navigation in the field and data collection. Each point was surveyed at least once between May 22 and June 30. Surveys took place between one half hour before to three hours after sunrise. At each point, we conducted a ten-minute point count, consisting of a five-minute passive listening period followed by one-minute broadcast periods for American bittern, least bittern, king rail, Virginia rail, and sora. The locations of rare species were estimated using distance and azimuth from the point count station.

We surveyed for secretive marsh birds (marsh wren, Cistothorus palustris) along Tawas Lake and Lake Huron.

Herpetofauna

We identified seven rare reptile and amphibian (herpetofauna or herps) target species for surveys (Table 3). We conducted surveys for these species in areas with suitable habitat in all three counties. Visual encounter, basking, and aquatic funnel trapping surveys were conducted in September 2019 in areas with suitable or potential habitat for target species using standard methods for surveying amphibians and reptiles (Campbell and Christman 1982, Corn and Bury 1990, Crump and Scott 1994, Graeter et al. 2013). Visual encounter and basking surveys were conducted at all sites. Visual encounter surveys consisted of walking slowly through areas with suitable habitat, overturning cover objects (e.g., logs/woody debris, rocks, etc.), inspecting retreats, and looking for target species on the surface or under cover objects (Campbell and Christman 1982, Corn and Bury 1990, Crump and Scott 1994, Glaudus 2013). Basking surveys consisted of walking slowly along open wetlands and waterbodies and scanning the habitat with binoculars to look for reptiles and amphibians basking on logs, vegetation, and/or other structures in the water and along the shoreline (Buhlmann 2013). Additionally, we conducted aquatic funnel trapping, using minnow traps, primarily for turtles, snakes, and amphibians along the edge of wetlands and open waterbodies in Tawas (Willson 2013). We deployed 17 Promar minnow traps along the edge of emergent marsh, northern wet meadow, and northern shrub thicket stands (compartment 5, stands 9, 11, 12, and 24), resulting in 34 trap nights. Surveys were conducted under appropriate weather conditions when target species were expected to be active and/or visible (e.g., 60-80°F [16-27°C], wind <15 mph [24 km/h], no or light precipitation).

Painted turtle (Chrysemys picta) was one of the herpetofauna species observed during field surveys in 2019.

Methods – Vernal Pools

Vernal pools are small, isolated, temporary pools of water or wetlands that form in shallow depressions primarily in forested landscapes throughout Michigan (Colburn 2004, Calhoun and deMaynadier 2008, Thomas et al. 2010). These wetlands typically fill with water in spring and dry up by late summer or early fall, which prevents fish populations from establishing. Because vernal pools lack predatory fish, they provide critical breeding habitats for myriad amphibians and invertebrates. Vernal pool indicator species include the blue-spotted salamander (*Ambystoma laterale*), spotted salamander (*A. maculatum*), wood frog (*Rana sylvatica*), and fairy shrimp (*Eubranchipus* spp., Colburn 2004, Calhoun and deMaynadier 2008). Many animal species use vernal pools for food and water throughout the growing season, as breeding and nursery areas for development of their young, and as resting areas and steppingstones to travel to other areas with suitable habitat (Gibbs 1998, Semlitsch and Bodie 1998, Gibbs 2000, Mitchell et al. 2008). Several rare species in Michigan use vernal pools, and these systems provide important ecosystem services, including nutrient cycling, water storage, and groundwater recharge, and help maintain healthy forest ecosystems (Colburn 2004, Calhoun and deMaynadier 2008). Because vernal pools are small and dry for part of the year, they are easily overlooked and unintentionally damaged or destroyed.

We identified and mapped potential vernal pools (PVPs) based on aerial imagery interpretation, topographic maps, and field sampling. PVPs were digitized and mapped as polygons, and this geospatial data is provided along with all other georeferenced materials in this report. PVPs encountered incidentally during herp surveys in September 2019 were mapped in the field using a GPS unit. PVPs were also incorporated into the Michigan Vernal Pool Database (MNFI 2020b), a statewide vernal pool geodatabase with locational information as well as ecological data about potential and field-verified vernal pools across the state.

Methods – Culturally Important Plants

A list of 19 culturally important plant species was provided by SCIT Natural Resources Specialist, Chase Stevens (Table 4). While conducting vegetation mapping, we opportunistically documented these culturally important plant species either at the stand level, or by recording a point location. These surveys were intended as an initial effort to map presence of culturally important beings, rather than as a comprehensive effort to catalog all occurrences of these species. In addition to the species in Table 4, MNFI tracks occurrences of wild rice, which are species of fundamental cultural importance and documented in Michigan's Natural Heritage Database. Therefore, we conducted targeted surveys for this plant in Tawas Lake in 2019 to update this information in the database.

Table 4. List of culturally important plant species recorded during vegetation mapping.

Anishinaabemowin	**Common name**	**Scientific name**
Wiikenzh	Angelica	*Angelica atropurpurea L.*
Wiigobaatig	Basswood	*Tilia americana*
Aagimaak	Black ash	*Fraxinus nigra*
Meskojiibikak	Bloodroot	*Sanguinaria canadensis*
Bibigwemin	Elderberry	*Sambucus canadensis*
Sesabiins	Indian hemp	*Apocynum cannabinum*
Opin	Indian potato	*Apios americana*
Maananoons	Ironwood	*Ostrya virginiana*
Zhaashaagomin	Jack-in-the-pulpit	*Arisaema triphyllum*
Waabashkikiibag	Labrador tea	*Ledum groenlandicum*
Zhigaagawanzh	Wild Leek	*Allium tricoccum*
Miinagaawanzh	Lowbush blueberry	*Vaccinium angustifolium*
Giizhikaatig	Northern white cedar	*Thuja occidentalis*
Wiigwasaatig	Paper birch	*Betula papyrifera*
Miskwaabiimizh	Red osier dogwood	*Cornus sericea*
Wiikenh	Sweetflag	*Acorus americanus*
Kba'agne-mins	Sweetfern	*Comptonia peregrina*
Wiingashk	Sweetgrass	*Hierochloe odorata*
Animoshi'min	Winterberry	*Ilex verticillata*

Results & Discussion – Vegetation Mapping

In the introduction we provided historical context for the SCIT priority properties, and here we provide an overview of current land-use and cover types documented during baseline vegetation surveys. Summary data for invasive species most affecting SCIT lands is shown in tables for each compartment. These tables show invasive species that cover 75% or more of a given stand. We also provide descriptions for selected high-quality stands for each natural community type, discuss the current species composition, and briefly describe the conservation actions necessary to protect high-quality habitat. For the purposes of this project, a high-quality stand is one that received an ecoscore of 4 or higher. In this section we briefly discuss site-specific management issues when relevant, however, more general suggestions are addressed in the concluding sections. In the discussion we holistically address threats, management recommendations, future research needs, and suggestions for future conservation planning endeavors.

Isabella County

While a small portion of the Isabella Reservation retains components of natural communities, much of the land has experienced human-mediated disturbances, notably the conversion of forested land to agricultural and rural development. Surveys conducted in 2019 documented 16 cover types (Table 5, Figures 10-13). Of the 1605 acres surveyed in Isabella County, half had been converted to either cropland (404 acres), or herbaceous openlands (404 acres). These herbaceous openlands, or old fields, were overwhelmingly dominated by invasive and ruderal species. The remaining forested stands fit into two broad cover types: lowland deciduous such as southern hardwood swamp and mixed upland deciduous, or mesic southern forest. These remaining forested areas serve as an important reservoir of biodiversity for the region.

Table 5. The 16 cover types and associated acreage documented during vegetation mapping surveys in Isabella County.

Cover Type	Acres
Aspen	53.2
Cropland	403.7
Herbaceous Openland	404.2
Low-Density Trees	61.1
Lowland Aspen/Balsam Poplar	14.9
Lowland Deciduous	216.8
Lowland Shrub	44.9
Marsh	3.7
Mixed Upland Deciduous	185.8
Northern Hardwood	5.7
Oak	13.4
Paper Birch	2.2
Upland Mixed Forest	8.6
Upland Shrub	69.6
Urban	63.1
Water	54.9

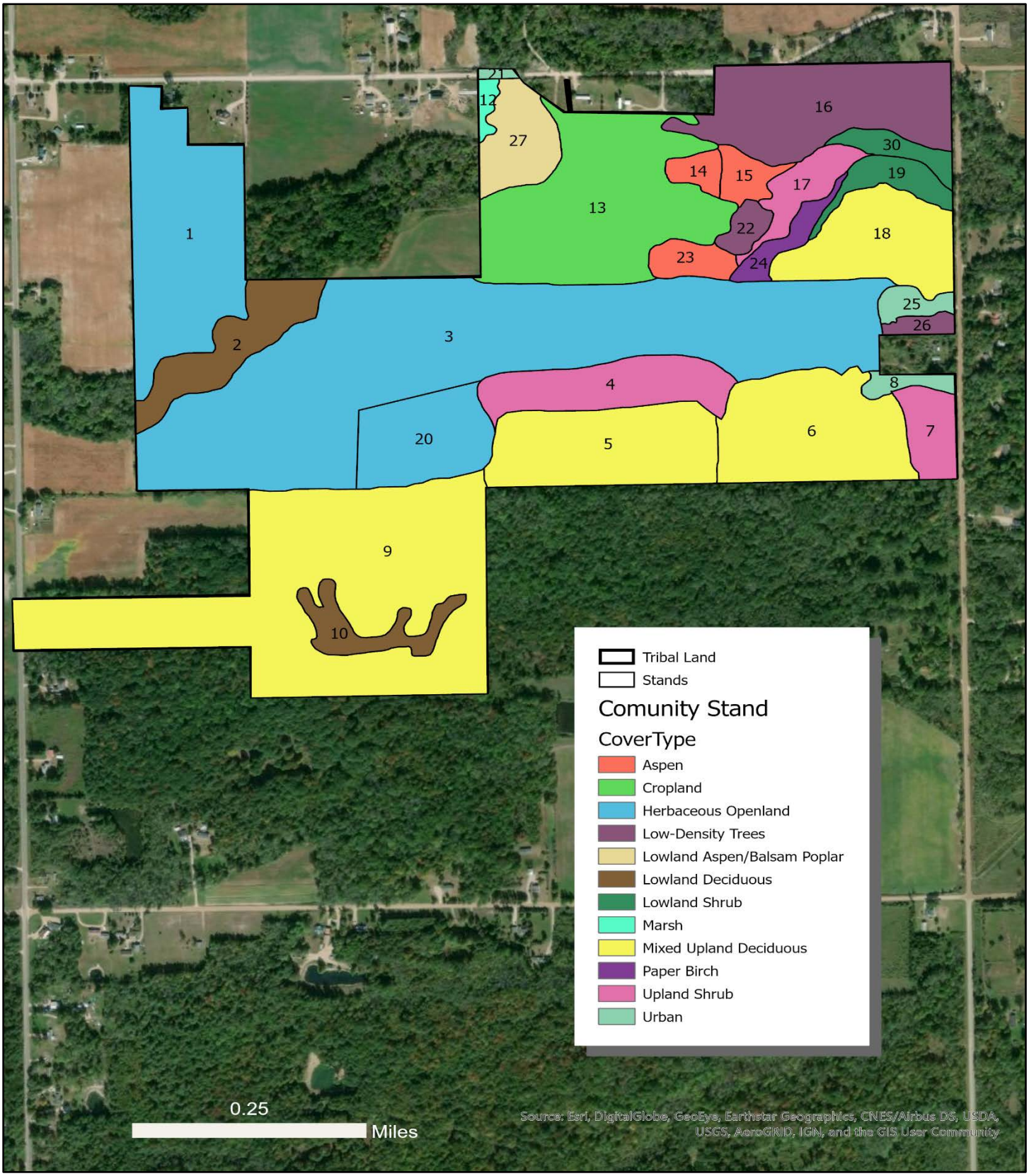

Figure 10. Stand-level cover types in compartment 1 in Isabella County.

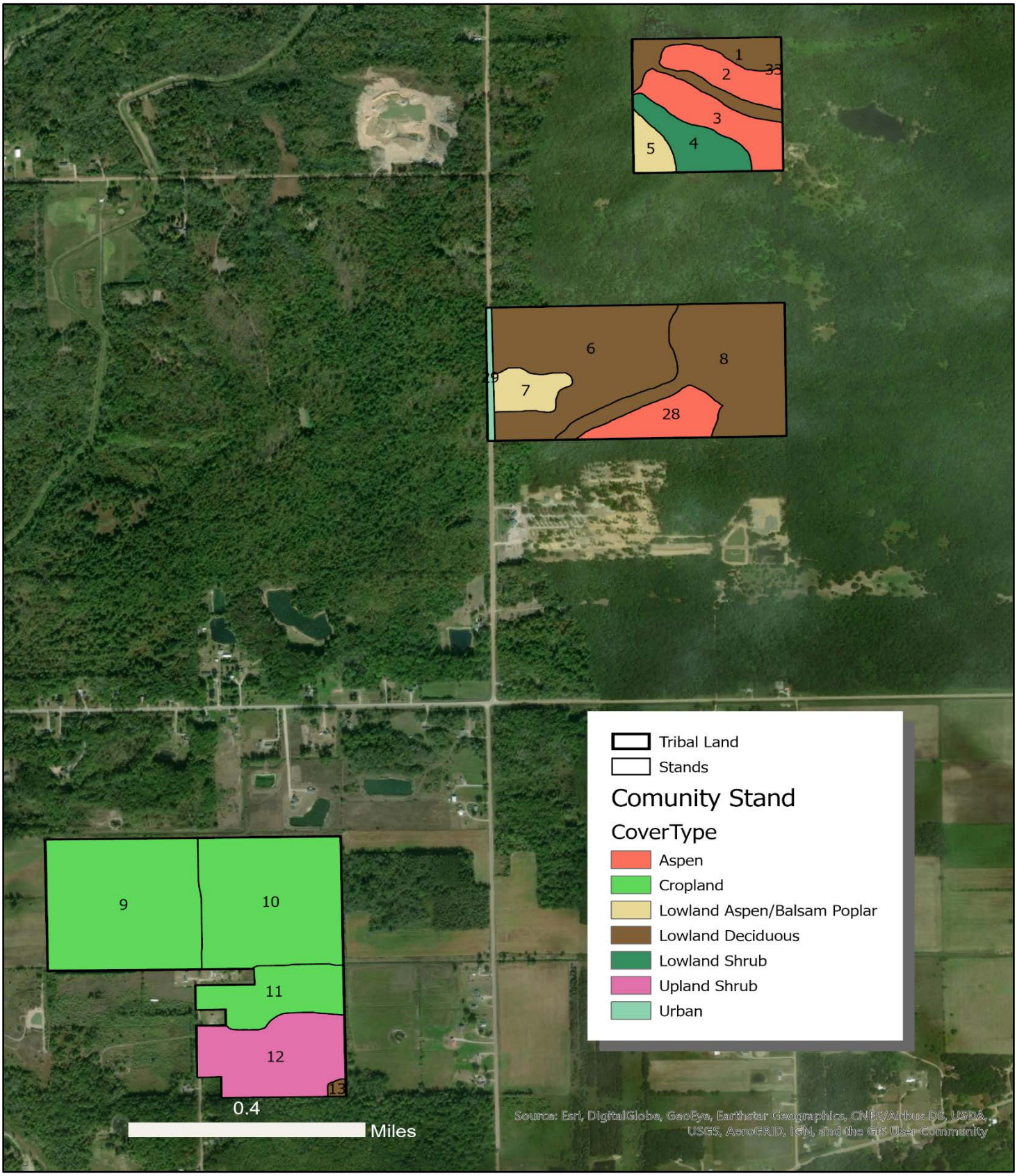

Figure 11. Stand-level cover types in compartment 2 in Isabella County.

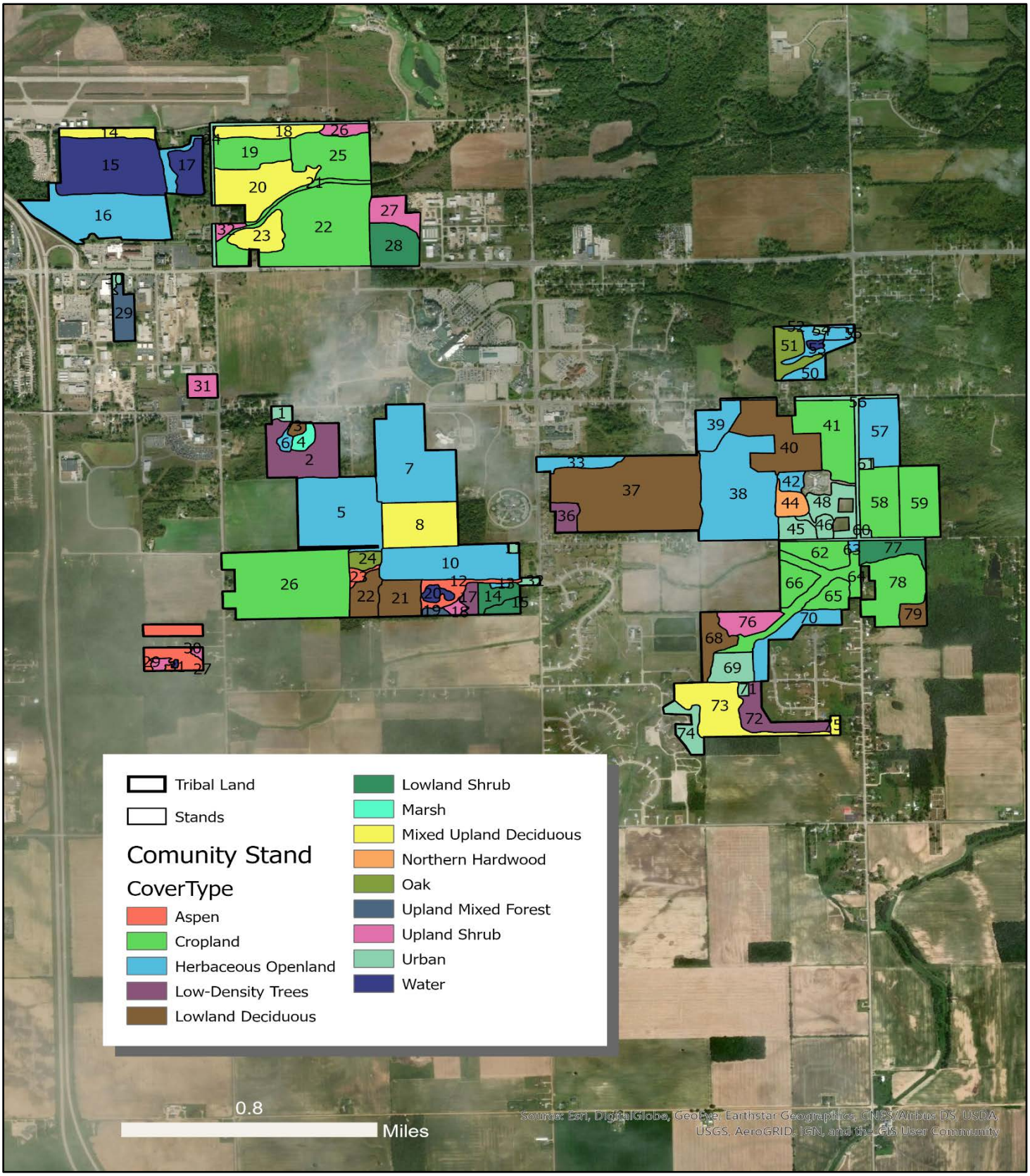

Figure 12. Stand-level cover types in compartment 3 in Isabella County.

Figure 13. Stand-level cover types in compartment 3 in Isabella County.

Invasive species posing the greatest threat in Isabella County are autumn olive and honeysuckle, each of which were found in 25 stands. We documented multiflora rose in 21 stands, and spotted knapweed in 17. Table 6 shows stands where these invasive species were in high abundance (75% or more cover). We address suggested prioritization, treatment, and data tools for addressing these species in later sections.

Table 6. A list of stands in Isabella County with high abundance of invasive species (most invaded sites by % cover).

County	Compartment	Common Name	Scientific Name	Stand
Isabella	1	Autumn olive	*Elaeagnus umbellata*	7
Isabella	1	Autumn olive	*Elaeagnus umbellata*	4
Isabella	1	Autumn olive, multiflora rose	*Elaeagnus umbellata, Rosa multiflora*	23
Isabella	1	Autumn olive	*Elaeagnus umbellata*	26
Isabella	1	Multiflora rose	*Rosa multiflora*	24
Isabella	2	Autumn olive	*Elaeagnus umbellata*	31
Isabella	2	Autumn olive	*Elaeagnus umbellata*	14
Isabella	2	Autumn olive	*Elaeagnus umbellata*	18
Isabella	2	Autumn olive	*Elaeagnus umbellata*	26
Isabella	2	Honeysuckle	*Lonicera spp.*	29
Isabella	2	Honeysuckle	*Lonicera spp.*	18
Isabella	2	Honeysuckle	*Lonicera spp.*	13
Isabella	2	Honeysuckle	*Lonicera spp.*	23
Isabella	2	Honeysuckle	*Lonicera spp.*	27
Isabella	3	Spotted knapweed	*Centaurea stoebe*	52
Isabella	3	Autumn olive	*Elaeagnus umbellata*	20
Isabella	3	Autumn olive	*Elaeagnus umbellata*	2
Isabella	3	Autumn olive, honeysuckle	*Elaeagnus umbellata, Lonicera spp.*	3
Isabella	3	Autumn olive, honeysuckle	*Elaeagnus umbellata, Lonicera spp.*	12
Isabella	3	Honeysuckle	*Lonicera spp.*	19
Isabella	3	Honeysuckle	*Lonicera spp.*	14
Isabella	3	Honeysuckle	*Lonicera spp.*	75
Isabella	3	Honeysuckle	*Lonicera spp.*	21
Isabella	3	Honeysuckle	*Lonicera spp.*	15

We identified seven high-quality natural communities (Table 7), of which we highlight three below. Several other stands, which received ecoscores lower than 4, would benefit from management, subsequently elevating them to high-quality forests. The primary natural disturbance in these forested communities is the infrequent creation of canopy gaps via windfall of trees.

Compartment: 3
Stand: 73
Community Classification: Mesic Southern Forest
MiFI Cover Type: Mixed Upland Deciduous
Ecoscore: 4.5/5

This 22-acre stand has a diversity of canopy tree species, including beech (20%), sugar maple (20%), black maple (*Acer nigrum*, 10%), and black oak (*Quercus nigra*, 10%), occurring with basswood (*Tilia Americana*), white oak (*Quercus alba*), bigtooth aspen *(Populus grandidentata*), red oak, bitternut hickory (*Carya cordiformis*), black cherry (*Prunus serotina*), cottonwood (*Populus deltoides*), and shagbark hickory (*Carya ovata*) in smaller numbers. The dominant understory species include ironwood (*Ostrya virginiana*), spicebush (*Lindera benzoin*), and sugar maple, with black cherry, black maple, shagbark hickory, and beech present in smaller numbers. This stand is surrounded by urban landscapes, and subsequently we observed multiflora rose on the perimeter, which will likely become more abundant if not treated. Vernal pools occur in depressions throughout the stand. This site has not been tilled or aggressively grazed and this has allowed for spring ephemerals (e.g. bloodroot and wild geranium) to persist in high abundance. Invasive species along the perimeter are a high priority for treatment.

Table 7. High-quality stands found in Isabella County during vegetation mapping surveys.

Natural Community Association	MiFI Cover Type	Compartment	Stand ID	Acres	Ecoscore
Mesic Southern Forest	Lowland Deciduous	1	2	7.7	4/5
Mesic Southern Forest	Lowland Deciduous	2	6	35.0	4/5
Mesic Southern Forest	Lowland Deciduous	3	37	68.6	4/5
Mesic Southern Forest	Mixed Upland Deciduous	3	73	22.0	4.5/5
Mesic Southern Forest	Lowland Deciduous	3	79	4.4	4/5
Dry-Mesic Southern Forest	Mixed Upland Deciduous	1	9	47.1	4/5
Southern Hardwood Swamp	Lowland Deciduous	2	8	29.9	4/5

Compartment: 2
Stand: 8
Community Classification: Southern Hardwood Swamp
MiFI Cover Type: Lowland Deciduous
Ecoscore: 4/5
This stand is approximately 30 acres with a canopy that has numerous gaps (50-75% closure), characteristic of a mature southern hardwood swamp. The canopy comprises cottonwood (50%), red maple (28%), bigtooth aspen (10%), white oak (10%), and ash (2%). Historically, there was a higher abundance of green ash throughout the canopy but die off from the emerald ash borer (*Agrilus planipennis*) has noticeably reduced this species' presence. Cottonwoods are by far the largest trees in the canopy with one having a DBH of 34 cm and aged at 79 years old. The subcanopy of this stand has a high density of sedges, and red maple, white ash (*Fraxinus Americana*), musclewood (*Carpinus caroliniana*), red oak, and white oak. Multiple fern species are also present, including maidenhair fern (*Adiantum spp.*), sensitive fern (*Onoclea sensibilis*), and royal fern. Witch hazel (*Hamamelis spp.*) was also found scattered throughout the stand. Red-shouldered hawk (*Buteo lineatus,* state threatened) calls were heard while surveying this stand.

Compartment: 1
Stand: 9
Community Classification: Dry-mesic Southern Forest
MiFI Cover Type: Mixed Upland Deciduous
Ecoscore: 4/5

This 47-acre stand is dominated by black oak (30%), red maple (25%), white oak (15%), and red oak (15%). Less abundant species in the canopy include silver maple, beech, paper birch (*Betula papyrifera*), and white pine. Many of the oaks and maples that make up the canopy are of similar age (65-85 years), and variable sizes. Overall, the understory is relatively low in invasive species abundance, and contains a diversity of native seedlings and shrubs. We documented a diversity of species in the understory: black oak, red oak, white oak, red maple, silver maple, bigtooth aspen, cottonwood, black ash, American elm (*Ulmus americana*), beech, musclewood, blackberry (*Rubus* spp.), and witch hazel. Within the interior of this stand is a small wetland depression with a mix of sedges and fern species along the edges, and potential vernal pools. Multiple patches of royal fern can be found throughout the site. Surrounding this stand is a mix of forested and open habitats. Invasive species threaten this site along the perimeter.

Iosco County

Tawas (Compartment 5)

The 902-acre Tawas property contains the most high-quality stands surveyed in the scope of this project. Our surveys documented 14 cover types (Table 8, Figure 14). The primary cover types include lowland shrub, natural mixed pines, and low-density trees. Much of this property was historically lowland cedar swamp, and approximately 51 acres remain as cedar swamp, with an additional 185 acres comprising lowland forests with various dominant and co-dominant tree species. Much of the land adjacent to Tawas Lake remains as it was in the 1800s: a mix of lowland shrub (303 acres, including many stands on the northern portion of the property) and emergent marsh (61 acres).

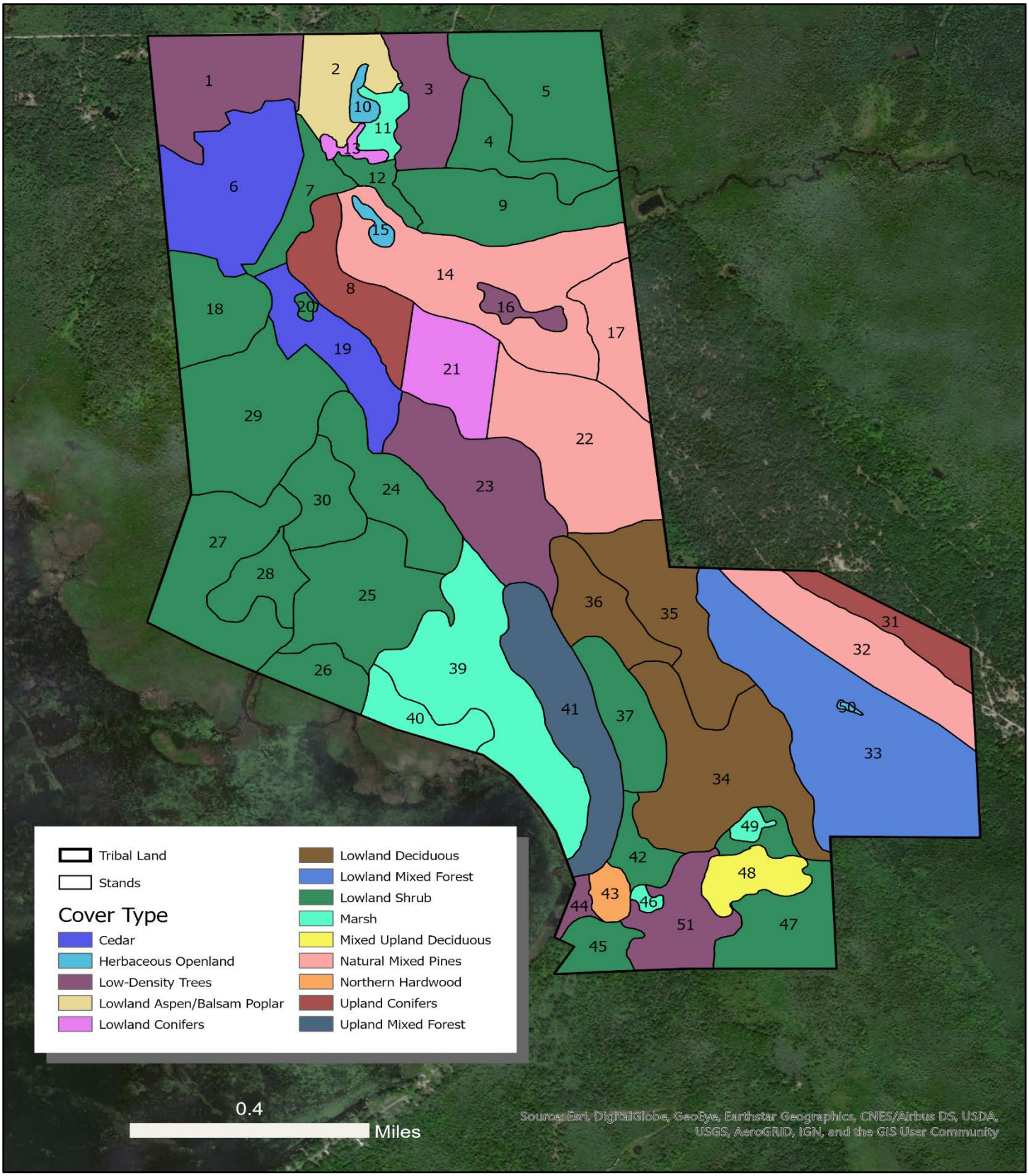

Figure 14. Stand-level cover types at compartment 5 at Tawas in Iosco County.

Table 8. The 14 cover types identified during vegetation mapping surveys at Tawas.

Cover Type	Acres
Cedar	51.5
Herbaceous Openland	4.0
Low-Density Trees	100.9
Lowland Aspen/Balsam Poplar	14.5
Lowland Conifers	19.4
Lowland Deciduous	83.8
Lowland Mixed Forest	67.2
Lowland Shrub	302.9
Marsh	61
Mixed Upland Deciduous	9.3
Natural Mixed Pines	127.2
Northern Hardwood	3.9
Upland Conifers	28.1
Upland Mixed Forest	28.4

Four invasive species were recorded in high abundance in three stands at Tawas (Table 9). Additionally, non-native Phragmites was documented in 21 out of 51 stands and is perhaps the biggest threat to wetlands in Tawas and is actively being addressed by land managers (personal communication, Chase Stevens 2019).

Table 9. Stands at Tawas with high abundance of invasive species (most invaded sites by % cover).

Site	Compartment	Common Name	Scientific Name	Stand
Tawas	5	Honeysuckle, Phragmites	*Lonicera spp., Phragmites australis*	47
Tawas	5	Honeysuckle, Phragmites	*Lonicera spp., Phragmites australis*	45
Tawas	5	Honeysuckle, Phragmites	*Lonicera spp., Phragmites australis*	43
Tawas	5	Phragmites, cattail	*Phragmites australis, Typha angustifolia*	49
Tawas	5	Cattail	*Typha angustifolia.*	39
Tawas	5	Cattail	*Typha angustifolia.*	40

We documented nine high-quality stands in Tawas that had an ecoscore of 4 or higher (Table 10), of which we highlight five below. These stands represent a quarter of the land comprising compartment, making it the highest-quality compartment we surveyed. There were several other stands that would have had a higher ecoscore, but the presence of invasive species, history of logging, and ash die-off warranted a lower score.

Compartment: 5
Stand: 32
Community Classification: Dry Northern Forest
MiFI Cover Type: Natural Mixed Pines
Ecoscore: 4/5
Stand 32 is approximately 26 acres and has a patchy canopy (50-75% closure) with trees of various ages and sizes, including red pines that we aged to be 125 years old. The canopy comprises red pine (35%), black oak

(30%), white pine (27%), jack pine (6%), and bigtooth aspen (2%). The ground is characterized by acidic sandy soils and a surface layer of mor humus, which is created by an accumulation of pine needles. The subcanopy includes species commonly associated with dry northern forests, including huckleberry and lowbush blueberry (*Vaccinium angustifolium*). Additional species in the subcanopy include jack pine, black oak, and reindeer moss (*Cladonia rangiferina*). No invasive plant species were observed in this stand.

Table 10. High-quality stands found in Tawas during vegetation mapping surveys.

Natural Community Association	MiFI Cover Type	Compartment	Stand ID	Acres	Ecoscore
Dry-Mesic Northern Forest	Natural Mixed Pines	5	14	48.7	4/5
Dry-Mesic Northern Forest	Natural Mixed Pines	5	22	39.5	4/5
Dry-Mesic Northern Forest	Upland Conifers	5	31	10.5	4/5
Dry Northern Forest	Natural Mixed Pines	5	32	25.7	4/5
Northern Shrub Thicket	Lowland Shrub	5	24	20.7	4/5
Mesic Northern Forest	Mixed Upland Deciduous	5	48	9.3	4/5
Hardwood-Conifer Swamp	Upland Conifers	5	8	17.6	4/5
Rich Conifer Swamp	Cedar	5	6	34.0	4.5/5
Rich Conifer Swamp	Cedar	5	19	17.5	4/5

Compartment: 5
Stand: 48
Community Classification: Mesic Northern Forest
MiFI Cover Type: Mixed Upland Deciduous
Ecoscore: 4/5
This relatively small stand (9.3 acres) has a patchy canopy (50-75% closure) and a mix of tree species that fall into two broad age groups. Northern white cedar (25%) and red maple (25%) are the primary dominant species in the canopy, however, the cedars are substantially older (one individual aged at 127 years) compared to the red maples that are closer to 50 years old. Additional species that make up the canopy include yellow birch (15%), eastern hemlock (15%), American elm (10%), and paper birch (10%). This stand contains small pockets of non-native phragmites along the outer portions. The understory is made up of white pine, northern white cedar, black oak, hemlock, white ash, musclewood, bracken fern, blackberries, and a few pockets of sedges.

Compartment: 5
Stand: 8
Community Classification: Hardwood-Conifer Swamp
MiFI Cover Type: Upland Conifers
Ecoscore: 4/5
This stand is approximately 18 acres with a dense canopy of white pine (40%), red maple (35%), northern white cedar (20%), and tamarack (5%). This hardwood-conifer swamp is embedded in a larger lowland swamp.

The swamp has lost much of the northern white cedar component. The understory is dominated by a mix of upland and lowland species including red oak, green ash, white pine, blueberries, tag alder, blackberries, bracken fern, sensitive fern, and royal fern. Overall, the understory shows a similar trend with upland species becoming increasingly abundant, particularly along the eastern-northeastern border of the stand.

Dry northern forest in Tawas (compartment 5, stand 32), Iosco County.

Compartment: 5
Stand: 6
Community Classification: Rich Conifer Swamp
MiFI Cover Type: Cedar
Ecoscore: 4.5/5
Stand 6 comprises 34 acres, with a canopy almost entirely dominated by northern white cedar (90%) with numerous gaps from ash die off. Additional canopy species include paper birch (4%), white pine (3%), red maple (2%), and silver maple (1%). Although there is limited diversity, the trees that make up the canopy are relatively old and include northern white cedars aged to 154 years, a red maple of 151 years, and a white pine

of 106 years. Numerous small sedge meadows occur in sunlit pockets created by fallen ash trees. However, deer herbivory appears to be heavy, as suggested by the numerous trails running through the stand and the limited subcanopy diversity. In particular, northern white cedar is missing from the subcanopy. We noted a trace amount (less than 15 plants) of Japanese barberry (*Berberis thunbergii*) in this high-quality stand and recommend immediate treatment.

High quality rich conifer swamp (compartment 5, stand 6) at Tawas.

Compartment: 5
Stand: 24
Community Classification: Northern Shrub Thicket
MiFI Cover Type: Lowland Shrub
Ecoscore: 4/5

This stand is approximately 21 acres, located west of the vast cedar-hardwood swamps that make up the interior of this compartment. It is a characteristic shrub thicket with a dominance of tag alder, which is evenly distributed throughout. Also present are open patches of mixed sedges and grasses, swamp rose (*Rosa palustris*), sweet gale (*Myrica gale*), and multiple species of willows. We noted a small stand of medium-sized green ash growing along the river running through the stand north to south. Overall, the stand seems to have

little, if any, signs of invasion by non-natives, despite a high abundance of non-native phragmites and cattail closer to Tawas Lake.

A*sh die-off, caused by the emerald ash borer, has had a devastating effect on natural communities.*

Indian Lake (Compartment 6)

The 29-acre Indian Lake (Goedecke) Property is an inholding surrounded by the Huron National Forest located near Indian Lake with an old homestead located in the center. Although circa 1800s land cover show this site supporting a mix of pine forests, 2019 surveys identified four main cover types (Table 11, Figure 15) including white pine, upland mixed forest, mixed upland deciduous, and cedar. These cover types comprise dry-mesic northern forest and rich conifer swamp. White pine remains a dominant canopy species in the upland, but canopy thinning likely provided opportunity for other species to become established. Because of the small size of this property and the scale at which the circa 1800s land cover maps were made, these historical maps did not show the lowland areas present in the center of this parcel. Three of the four stands at Indian Lake were classified as high-quality (Table 12). Below we highlight two of the three high-quality stands in this site. This is the only compartment that did not contain invasive species (therefore no invasive species table).

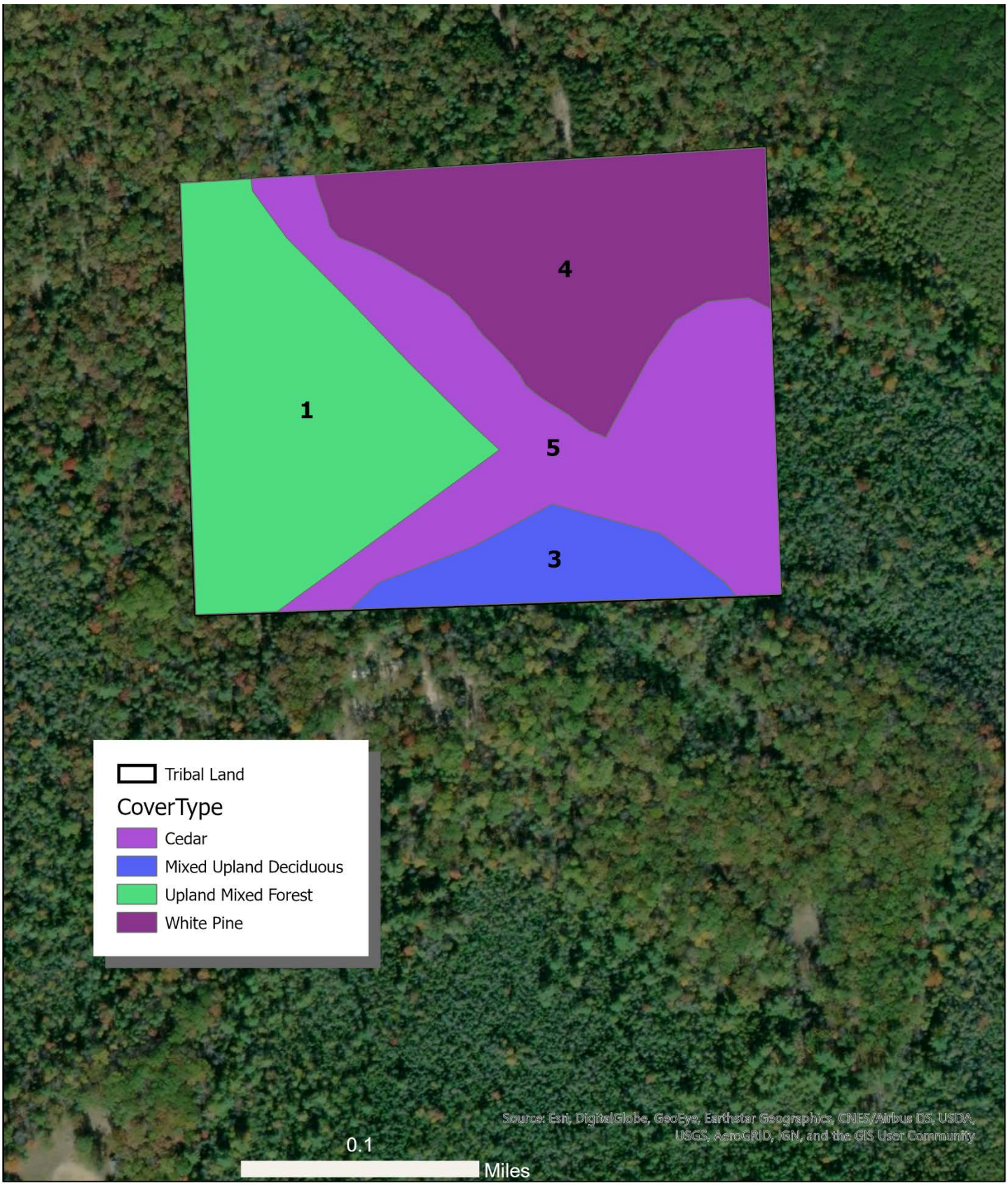

Figure 15. Stand-level cover types at the Indian lake parcel (compartment 6) in Iosco County.

Table 11. Vegetation mapping surveys identified 4 cover types at Indian Lake.

Cover Type	Acres
Cedar	9.1
Mixed Upland Deciduous	2.5
Upland Mixed Forest	9
White Pine	8.4

While conducting vegetation mapping surveys at this site, we documented evidence of American black bears (*Ursus americanus*) via fresh scat and a single adult female. Black bears are wide-ranging carnivores and have among the largest home ranges of any large mammal in the region (Carter et al. 2010). Black bears occur throughout most of Michigan, with the most recent statewide population survey estimating about 19,000 bears occupying about 90,650 km^2 of suitable bear habitat throughout the state (MI DNR 2008), with an estimated 1500 (1180–1950) bears occurring in the northern Lower Peninsula (NLP) of Michigan in 2009 (MI DNR, unpublished data, as cited in Waples et al. 2018).

Table 12. High-quality stands found in Indian Lake during vegetation mapping surveys.

Natural Community Association	MiFI Cover Type	Compartment	Stand ID	Acres	Ecoscore
Dry-Mesic Northern Forest	Mixed Upland Deciduous	6	3	2.5	4/5
Dry-Mesic Northern Forest	White Pine	6	4	8.4	4/5
Rich Conifer Swamp	Cedar	6	5	9.1	4/5

Compartment: 6
Stand: 3
Community Classification: Dry-mesic Northern Forest
MiFI Cover Type: Mixed Upland Deciduous
Ecoscore: 4/5
This stand is relatively small at 2.5 acres but contains a relatively dense canopy full of mixed aged tree species characteristic of dry-mesic northern forest. The dominant canopy species in this stand include white oak (29%), white pine (22%), and red maple (20%). Additional species in the canopy include black oak, red pine, spruce, bigtooth aspen, paper birch, and hemlock. We aged a white oak to 130 years old. The understory contains several shrub species as well as reindeer moss and common bracken fern. The subcanopy contains few tree species, but white pine and hemlock are regularly common as saplings. We observed no evidence of invasion by non-native plant species.

Compartment: 6
Stand: 5
Community Classification: Rich Conifer Swamp
MiFI Cover Type: Cedar
Ecoscore: 4/5

This 9.1-acre stand has a dense canopy with trees of mixed ages. Northern white cedar accounts for approximately 55% of the canopy with balsam fir, balsam poplar (*Populus balsamifera*), white pine, white spruce (*Picea glauca*), and paper birch in smaller numbers. The understory contains a high abundance of sphagnum moss (*Sphagnum spp*.) and eastern hemlock. In wetter areas tag alder and sedges are prevalent. Bordering the stand is an abundance of huckleberry, which continues into adjacent stands. The varied microtopography reveals that this lowland forest is maturing, due to apparent windthrows creating a matrix of hummocks and hollows. This was one of the few stands we surveyed that was free from invasive species, and as it ages it will qualify for an ecoscore of 5.

Rich conifer swamp located on the Indian Lake property in Iosco County.

Arenac County

Comprising 345.5 acres, the properties in Arenac County are primarily located along the Saganing River and Lake Huron. In addition, several disjunct parcels are located further inland. During 2019, surveys documented 13 land cover types (Table 13, Figure 16). The primary cover types included herbaceous openland, low-density trees, and marsh. Over 150 acres surveyed in Arenac County were a combination of herbaceous openland, low density trees, and upland shrub.

We did not survey any stands in Arenac Co. that met the criteria to be considered “high-quality” under current conditions. Several stands (e.g., 19, 10) received eco-scores of 3, because of the few invasive species present,

but they did not receive a higher score due to the young age (48 years old) of the trees. However, this does not mean that these natural areas are not valuable. They are recovering from human-mediated disturbances, such as the legacy of agriculture and logging, as well as natural disturbances. This property is logically divided into two areas, including wetlands adjacent to Lake Huron, and inland sites that are not connected to the lake. Below we discuss them separately. Table 14 shows the invasive species most prevalent in surveys in Arenac County.

Table 13. vegetation mapping surveys identified 13 cover types in Arenac County.

Cover Type	**Acres**
Aspen	30.9
Herbaceous Openland	88.6
Low-Density Trees	51.9
Lowland Aspen/Balsam Poplar	8.1
Lowland Deciduous	28.7
Lowland Shrub	29
Marsh	48.3
Mixed Upland Deciduous	11.4
Oak	3.8
Upland Shrub	9.9
Urban	4.1
Water	17.6
White Pine	13.2

Inland Sites

The properties located further inland were historically forested wetlands. However, these lands are currently a mix of low-density trees, young wood lots, and herbaceous/shrub dominated old fields with abundant early-succession and invasive species. Invasive species threatening these sites include autumn olive (in 15 stands) and honeysuckle species (in 18 stands). Moreover, these parcels are disjunct from one another and suffer from edge effects. However, there are also opportunities for management and restoration in degraded stands, which we detail in later sectioins.

Table 14. A list of stands in Arenac County with high cover of invasive species (most invaded sites by % cover).

County	Compartment	Common Name	Scientific Name	Stand
Arenac	4	Honeysuckle	*Lonicera spp.*	28
Arenac	4	Honeysuckle	*Lonicera spp.*	26
Arenac	4	Honeysuckle	*Lonicera spp.*	33
Arenac	4	Honeysuckle	*Lonicera spp.*	53
Arenac	4	Non-native Phragmites	*Phragmites australis*	38
Arenac	4	Non-native Phragmites, cattail	*Phragmites australis, Typha angustifolia*	35

Arenac	4	Cattail	*Typha angustifolia*	39
Arenac	4	Non-native Phragmites, cattail	*Phragmites australis, Typha angustifolia*	37
Arenac	4	Cattail	*Typha angustifolia*	45

Shoreline sites

Much of the property (17.6 acres) was completely underwater with little-to-no submergent vegetation (stands 40, 46, 47) due to high water levels of Lake Huron. Adjacent to the open water, we documented 48.3 acres of marsh, interspersed with shrub-dominated wetlands. Historically much of the of the shoreline was Great Lakes marsh. However, due to high lake levels much of the land cannot be classified as such in its current state. Great Lakes marsh is an herbaceous wetland community restricted to the shoreline of the Great Lakes and their major connecting rivers. The primary natural process that influences this community's composition and structure is water level fluctuation, which shifts seasonally due to the annual hydrological cycle in the Great Lakes basin, and interannually due to variable precipitation events. Periodically extreme lake level changes have tremendous impacts on the wetlands along Lake Huron. In general, as water levels rise and fall, vegetation communities shift landward during high-water years and lakeward during low-water years. However, fluctuating lake levels effect not only a change in water depth, but a broad range of associated stresses to which plants must respond, including changes in water current, wave action, turbidity (clarity or light penetration), nutrient content or availability, alkalinity, and temperature, as well as ice scour and sediment displacement (Albert 2001). Because species display different tolerance limits along one or more of these dimensions, species composition can also change dramatically within a zone (Albert 2001). These communities are of great importance to the culture and economy of the Great Lakes, with many species of game fish and wildlife using these habitats. Stands along the lakeshore are currently under pressure from invasive species, most notably non-native Phragmites and cattail. Phragmites was found in 16 stands and was high in abundance in three stands. Cattail was found in 13 stands, four of which had high abundance (Table 14).

Historically documented as Great Lakes marsh and lakeplain prairie, much of the Lake Huron shoreline in Arenac County is currently flooded and classified as a mix of open water and marsh.

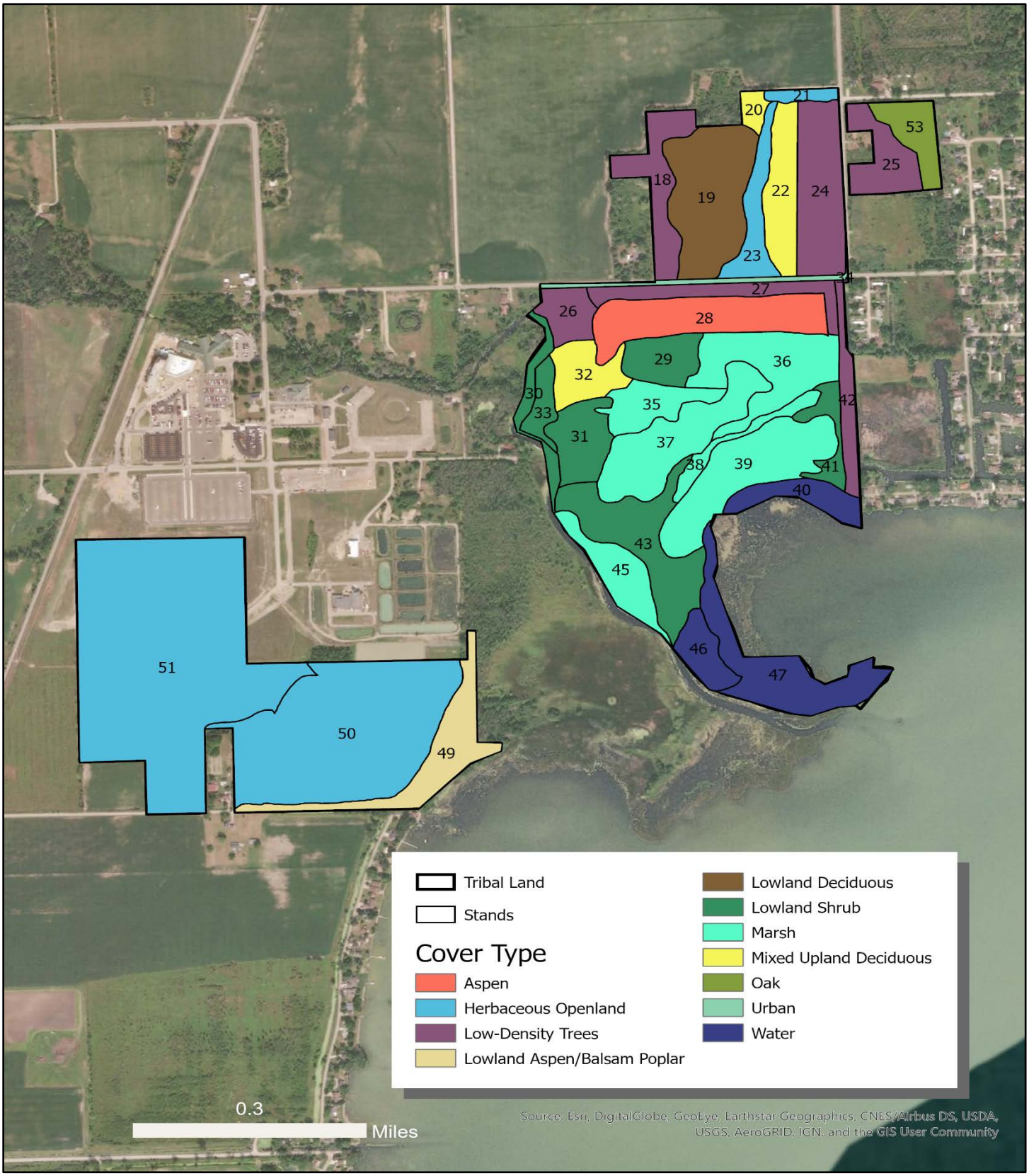

Figure 16. Stand-level cover types for Arenac County (compartment 4).

Results & Discussion – Rare Species

Below we present the results of rare species surveys. The writing of this report and the second field season for follow-up surveys occurred during the COVID-19 global pandemic. The subsequent shelter in place executive orders and MSU travel bans prevented us from completing follow-up surveys. Scheduled follow-up surveys for the spring of 2020 included verifying potential vernal pools and revisiting herpetofauna survey sites. In the discussion, we detail recommendations for carrying out these surveys, as well as additional monitoring and research that was outside of the scope of this project.

Mussels

We completed surveys for native unionid mussels at four sites in Arenac and Isabella Counties (Table 15). We identified eight species of mussels (Table 16), including the state threatened slippershell (*Alasmidonta viridis*), and two species of special concern, rainbow (*Cambarunio iris* =*Villosa iris*) and ellipse (*Venustaconcha ellipsiformis*).

Table 15. Locations of unionid mussel survey sites.

Site	Waterbody	Access	County	Stand Number	Compartment Number	Latitude (N)	Longitude (W)
1	Saganing River	Worth Rd.	Arenac	30	3	43.92435	-83.90255
2	Jordon Creek	E. Beal City Rd.	Isabella	16	1	43.66922	-84.68317
3	Jordon Creek	E. Beal City Rd.	Isabella	16	1	43.66895	-84.69171
4	Jordon Creek	N. Shepard Rd.	Isabella	16	1	43.66858	-84.68773

In addition to the sites listed in Table 15, we also qualitatively assessed the potential for mussels to occur in Kunze Creek at Tawas and did not find any live mussels or shells. The stream substrate was almost entirely sand, which appeared to be too unstable to support native unionid mussels. Site 1 is located along the Saganing River in Arenac County. We visited this site for surveys, but found that it was flooded due to high Great Lakes water levels. The water current was near zero, and possibly even “upstream” due to the wind direction at the time. The river channel and banks were underwater, and this section of river was too deep to survey without a dive team. We observed a thick mat of European frog’s-bit at this site.

In Jordon Creek, we documented live mussels and shells at all three sites. Most notably, we observed the threatened slippershell. This mussel was present in 36 of Michigan’s 58 major watersheds historically, and at least 22 watersheds since 1989. Although records are relatively widespread in Michigan, most recent records for this species are of empty shells. The state conservation rank of slippershell in Michigan is S2S3, “imperiled/vulnerable” (Badra et al. 2014). The slippershell occurs in creeks and headwaters of rivers in sand or gravel substrates and requires clear, clean water for survival. The slippershell uses fish, including johnny darter (*Etheostoma nigrum*) as a host. Therefore, protection of fishes in the Jordon Creek is important for the continued survival of this rare mussel.

Table 16. Numbers of live unionid mussels (#) recorded at each aquatic survey site. The number shells of rare species are given in parentheses (S(#)) if only shells were found at a site. Presence/absence of non-native bivalves is noted. (T= state threatened, SC= state special concern).

		Number Detected			
Common name	Species	Site 1	Site 2	Site 3	Site 4
Slippershell (T)	*Alasmidonta viridis*		S(1)	S(1)	S(3)
Cylindrical papershell	*Anodontoides ferussacianus*		S(2)	2	6
Rainbow (SC)	*Cambarunio iris (=Villosa iris)*		6	S(1)	S(1)
Plain pocketbook	*Lampsilis cardium*				1
Fatmucket	*Lampsilis siliquoidea*		S(1)	S(5)	3
White heelsplitter	*Lasmigona complanata*				S(1)
Giant floater	*Pyganodon grandis*			1	4
Ellipse (SC)	*Venustaconcha ellipsiformis*				13
	Total # individuals and density	0	6	3	27
	# species live	0	1	2	5
	# species live or shell	0	4	5	8
	Area searched (m^2)	*	105	108	183
Asian clams	*Corbicula fluminea*				
Zebra mussels	*Dreissena polymorpha*				

* A thick mat of European frog's-bit covering the water's surface and unusually deep water due to high Lake Huron water levels prohibited surveys for mussels and snails.

Maintaining riparian buffers along streams is a commonly used and important practice to mitigate impacts to aquatic species and ecosystems (Olson et al. 2007). The impacts of erosion, sedimentation, and increased water temperature are all exacerbated by loss of natural vegetation in land adjacent to rivers. Conservation easements and the USDA Conservation Reserve Program may provide opportunities to expand the amount of naturally vegetated riparian buffers around Jordan Creek and the surrounding watershed.

Excessive sedimentation can impact native mussel populations directly (Brim-Box and Mossa 1999), and indirectly by impacting fish hosts they rely on for reproduction. Eggs are fertilized within the female in the summer months and develop into larvae, called glochidia. These glochidia are brooded within marsupial gills of female mussels until they are ready to be released. When they are released, glochidia must attach to the gills or fins of a fish host in order to survive and develop into the adult mussel form. The fish host provides a stable environment for the glochidia to grow and they do not harm fish hosts. Without the proper species of fish co-occurring with the unionid mussel population, glochidia do not survive and reproduction cannot occur. Some species of mussel are specialists and only have a few species of fish known to act as hosts. Others are generalists and are known to utilize a dozen or more different host species. Glochidia are transported with their host fish until they transform into the adult form and drop off the fish. This allows unionid mussels, which are otherwise mostly sedentary, to migrate to new habitats and exchange genes among populations. Fish species known to be suitable hosts for slippershell are mottled sculpin (*Cottus bairdi*), banded sculpin (*Cottus carolinae*), and Johnny darter (*Etheostoma nigrum*). Known fish hosts for snuffbox are black sculpin

(*Cottus baileyi*), mottled sculpin (*Cottus bairdi*), banded sculpin (*Cottus carolinae*), Ozark sculpin (*Cottus carolinae*), blackspotted topminnow (*Fundulus olivaceous*), log perch (*Percina caprodes*), blackside darter (*Percina maculata*), and Roanoke darter (*Percina roanoka*).

Thick bed of European frog's-bit found along the Saganing River in Arenac County. This invasive species can threaten native biodiversity by growing dense populations as it colonizes new waterways.

A management action that could potentially improve the viability of slippershell, and other aquatic species within Jordon Creek, is to improve connectivity within the Creek and within the larger watershed. Removing barriers to allow for migration to new habitats and transportation of mussels between populations via host fish movement would benefit native mussels. Gene flow among populations prevents negative impacts from inbreeding and genetic isolation of populations (Watters et al. 1996, Haag 2012).

Finally, we documented the rusty crayfish (*Faxonius rusticus*) during surveys in Jordon Creek (Table 17). This large aggressive crayfish is native to the southern United States but is invasive in Michigan, where they can harm native fish populations.

Table 17. Incidental finds at aquatic survey sites, including aquatic snails (Gastropoda), fingernail clams (Sphaeriidae), crayfish, and fish.

Common Name	Species/Taxa	1	2	3	4
Snails	Gastropoda	X	X	X	X
Limpets	Gastropoda			X	
Fingernail clams	Sphaeriidae		X	X	X
Crayfish	Decapoda		X		X
Rusty crayfish	*Faxonius rusticus*				x
Fish	Osteichthyes		X	X	
Johnny darter	*Etheostoma nigrum*		X		

The open shell of the state threatened slippershell was observed in Jordon Creek in Isabella County at three survey locations.

Insects

We did not locate any regal fern borer moths during surveys. However, we did document four other *Papaipema* moth species including sensitive fern borer (*Papaipema inquaesita)*, bracken fern borer (*P. pterisii)*, turtle head borer (*P. nepheleptena*), and Joe-pye weed borer (*P. eupatorii*, Table 18). While we did not find target moths, we did locate populations of regal fern within multiple areas on SCIT properties. We also identified several other moths. Maintaining host plant populations is crucial for supporting populations of the regal fern borer moth. It is recommended to prevent any action that reduces the abundance of regal fern in areas where it is found on SCIT property.

Despite the presence of secretive locust habitat, we did not find this species during 2019 surveys. However, suitable habitat extends south on to private property, and it is possible that secretive locusts are present on SCIT properties. Maintaining this adjacent habitat (particularly in the stands along Kunze Road) composed primarily of jack pine, reindeer moss, and black huckleberry will provide the greatest likelihood of supporting habitat for secretive locust.

Table 18. Survey locations for regal fern borer moth (*Papaipema speciosissima*) and other species of *Papaipema* collected during these surveys at each site.

Compartment	Stand #	Latitude	Longitude	Survey Date	*P. inquaesita*	*P. pterisii*	*P. nepheleptena*	*P. eupatorii*
5	8	44.33239	-83.47274	09/16/2019	22	12	1	0
5	33	44.31738	-83.45539	09/17/2019	5	2	0	0
5	44	44.31440	-83.46447	09/17/2019	14	0	0	1
2	3	43.65540	-84.65809	10/03/2019	0	0	0	0

Dense populations of royal fern were identified during baseline surveys. Blacklight surveys were always conducted close to populations of this species.

We did not document occurrences of the regal fern borer moth. However, we did document additional species of Papaipema moths, as well as other moths such as this Eupsilia spp.

Secretive Marsh Birds

In 2019 we surveyed for marsh birds at 13 points along Lake Huron in Arenac County (compartment 4) and in Tawas, Iosco County (compartment 5). All points were surveyed at least once, and seven points were visited twice during the breeding season. Across all survey points, we detected 10 of the 14 target bird species. Eight species, pied-billed grebe, least bittern (state threatened), Forster's tern (state threatened), sandhill crane, sora, common gallinule (state threatened), marsh wren (state special concern), and swamp sparrow, were observed at the four Saginaw Bay points (Table 19). Marsh wren was detected at one of the survey points near the Saganing River mouth. Least bittern, common gallinule, and Forster's tern, all state-threatened species, were observed at the survey point adjacent to SCIT property to the north of Whites Beach. Although these species were detected during surveys, they were observed using coastal marsh to the north within Wigwam Bay State Wildlife Area. Pied-billed grebe was detected at three points and swamp sparrow at two of the four surveys points, whereas sandhill crane and sora were each detected at only one of the four survey points.

Table 19. Total number of detections and proportion of survey points having detections during marsh bird surveys conducted at Saginaw Bay and Tawas SCIT properties in 2019.

		Saginaw Bay (Arenac County)		Tawas (Iosco County)	
Common Name	**Scientific Name**	**Total No. Detections**	**Proportion of Points**	**Total No. Detections**	**Proportion of Points**
American bittern	*Botaurus lentiginosus*	0	0.00	6	0.56
Common gallinule	*Gallinula galeata*	1	0.25	0	0.00
Forster's tern	*Sterna forsteri*	4	0.25	0	0.00
Least bittern	*Ixobrychus exilis*	1	0.25	0	0.00
Marsh wren	*Cistothorus palustris*	1	0.25	2	0.22
Pied-billed grebe	*Podilymbus podiceps*	9	0.75	0	0.00
Sandhill crane	*Grus canadensis*	1	0.25	5	0.33
Sora	*Porzana carolina*	1	0.25	0	0.00
Swamp sparrow	*Melospiza georgiana*	6	0.50	11	0.44
Virginia rail	*Rallus limicola*	0	0.00	4	0.33

At the nine Tawas survey points, we detected five species: American bittern (state special concern), sandhill crane, Virginia rail, marsh wren (state special concern), and swamp sparrow (Table 19). American bittern was observed at five of the nine points surveyed at Tawas, with most observations coming from wetlands connected to Tawas Lake. A single American bittern was heard on the north end of the property in emergent/shrub-scrub wetlands near Kunze Creek. Marsh wren was recorded at two points in emergent marsh at the edge of Tawas Lake. Swamp sparrow was detected at four of the Tawas survey points and Virginia rail and sandhill crane were each observed at three of the nine points. During vegetation mapping, we also opportunistically documented a new occurrence of the common loon (*Gavia immer*, state threatened), which was nesting on Tawas Lake.

In addition to the target species observed during marsh bird surveys, we also recorded the following bird species at Tawas while conducting field work in 2019: bufflehead (*Bucephala albeola*), wild turkey (*Meleagris gallopavo*), common tern (*Sterna hirundo*), red-bellied woodpecker (*Melanerpes carolinus*), blue jay (*Cyanocitta cristata*), tree swallow (*Tachycineta bicolor*), black-capped chickadee (*Poecile atricapillus*), tufted titmouse (*Baeolophus bicolor*), veery (*Catharus fuscescens*), wood thrush (*Hylocichla mustelina*), yellow warbler (*Setophaga petechia*), common yellowthroat (*Geothlypis trichas*), song sparrow (*Melospiza melodia*), red-winged blackbird (*Agelaius phoeniceus*), northern cardinal (*Cardinalis cardinalis*), rose-breasted grosbeak (*Pheucticus ludovicianus*), American redstart (*Setophaga ruticilla*), and scarlet tanager (*Piranga olivacea*).

The wetlands we surveyed provide important breeding habitats for several rare and common species of marsh birds. Three waterbird species detected during field sampling, common tern, American bittern, and sora, are focal species for regional habitat conservation planning for the Joint Venture within the Waterbird Habitat Conservation Strategy (Soulliere et al. 2018). Although these wetland systems are under threat by cattail, non-

native Phragmites, and European frog's-bit, the marsh habitats hold extreme value for wildlife. The greatest priority to maintain habitats for marsh birds would be to control the invasive species populations present within these wetlands before they expand further and become more difficult to manage. Management to reduce the impacts of invasive species would help maintain and improve habitats for marsh bird species using these wetland complexes. In following sections we offer a summary of recommendations for future research and monitoring, including establishing a secretive marsh bird survey.

Marsh bird habitat located along Tawas Lake in Iosco County.

Other Avian Rare Species

We documented an active nest for red-shouldered hawk at Indian Lake, where large blocks of intact forest are providing valuable nesting habitat. Human disturbance, including road construction and cutting should be limited in these areas, specifically, within the period between February 15 and July 1. Red-shouldered hawks require large blocks of forest with adjacent wetlands. The extensive forested wetlands both on SCIT and neighboring land provide valuable habitat for this species. During vegetation mapping north of Mount Pleasant (stands 1, 2, 3, 6, 8 in compartment 2) we observed red-shouldered hawks calling. We subsequently searched for the characteristically large stick nests in tree crotches in the area, however it was after leaf-out

and we did not locate a nest. It is very likely that these hawks are nesting and reproducing either on SCIT land or adjacent forests. The southern hardwood swamp comprising this area is ideal habitat for this forest-dependent species. We also documented a new bald eagle nest in Saganing Bay in Arenac County (stand 47 in compartment 4) during natural community surveys. We observed two adults in the nest during surveys.

We documented a new occurrence of the red-shouldered hawk at Indian Lake.

Herpetofauna

During amphibian and reptile surveys in 2019, we did not document any target species, however, we observed common amphibian and reptile species. We recorded wood frog (*Lithobates sylvaticus*), northern leopard frog (*Lithobates pipiens*), green frog (*Lithobates clamitans*), eastern American toad (*Anaxyrus americanus americanus*), western chorus frog (*Pseudacris triseriata triseriata*), painted turtle (*Chrysemys picta*), and northern red-bellied snake (*Storeria occipitomaculata occipitomaculata*). Perhaps our failure to find rare species during 2019 surveys was due to the limited nature and timing of the surveys (i.e., fall surveys rather than spring) and limited habitat availability at some sites. Additionally, many of the target species are cryptic and challenging to find in the field. Several rare species have been documented within and/or near survey sites in all three counties based on information in the Natural Heritage Database and Michigan Herp Atlas. (Michigan Herp Atlas 2019, MNFI 2020a). These include recent and/or historical observations of eastern massasaugas, Blanding's turtles, wood turtles, Butler's garter snakes, queen snakes, smooth green snakes, pickerel frogs, and mudpuppies (Michigan Herp Atlas 2019, MNFI 2020a). Potential exists for these target species to occur on SCIT properties and future spring surveys may prove successful at documenting rare herptofauna.

To manage for diverse and resilient amphibian and reptile communities and rare species, it is critical to maintain and/or restore suitable and sufficient wetland and upland habitats that meet the needs of all the life history stages of these species. Almost all amphibian species in Michigan require wetlands, and about two-

thirds of the reptile species in the state use wetlands as one of their primary habitats. Maintaining a diversity of wetland habitats including open or early-successional wetlands as well as shrubby and/or forested wetlands, particularly those with canopy gaps or openings for herps to access sunlight for thermoregulation, provides habitat for diverse amphibian and reptile species. Increasing the amount or density of wetland habitats and providing wetland habitats with varying hydrology or water levels (e.g., permanent wetlands and ephemeral or seasonal wetlands, wetlands with shallow water and deeper water) also would likely benefit amphibian and reptile communities (Brodman 2010).

Maintaining and protecting vernal pools would provide important breeding and/or foraging habitats for herp species including the wood frog, Blanding's turtle and wood turtle. Maintaining or enhancing connectivity between wetland habitats is critical for herp species that utilize and move between different habitats. For example, Blanding's turtles use vernal pools in the spring and move to permanent and/or deeper wetlands or waterbodies in the summer. Restoring and/or creating additional habitat to facilitate connectivity and dispersal is particularly important in fragmented landscapes, such as those around the Isabella and Arenac County sites. Amphibians and reptiles also are sensitive to temperature and moisture regimes. Changes in the environment or habitat that result in dramatic or sudden changes in temperature and/or moisture conditions can significantly impact amphibians and reptiles and habitat quality and suitability. Maintaining open or semi-open vegetative structure or canopy gaps, encouraging more structural diversity (e.g., shrubs, hummocks, downed or floating logs/woody debris), and providing structures for basking within wetlands and waterbodies would benefit amphibian and reptile species. Monitoring and controlling vegetative succession and invasive species can help maintain suitable temperature regimes and habitat for basking and thermoregulation for herps. Invasive species such as non-native Phragmites can form tall, dense monocultures in wetlands and may result in increased shading, reduced basking opportunities, lower air and water temperatures, and reduced herp abundance/use, development and/or survival of turtle eggs , and movements/dispersal ability (Rice et al. 2000, Bolton and Brooks 2010, Mifsud 2014).

Maintaining and/or restoring a diversity of upland habitats that contain canopy gaps or openings, provide habitat for amphibian and reptile species. Reptiles and amphibians utilize uplands for foraging, mating, thermoregulating, nesting, gestating, giving birth to young, aestivating and/or overwintering (Harding and Mifsud 2017). Wood frogs, spotted salamanders, and blue-spotted salamanders breed in vernal pools for a couple of weeks in the spring but spend the rest of the year in the surrounding upland and lowland forests (Colburn 2004, Calhoun and deMaynadier 2008). Blanding's turtles, wood turtles, and other turtle species move from wetland/aquatic habitats to nest in open, sunny, sparsely vegetated areas with moist but well-drained, sandy, loamy, and/or gravelly substrates (Harding and Mifsud 2017). Suitable nesting habitats for turtles, especially those that are safe from nest predators, may be limited on the landscape. Maintaining open, sandy areas near wetlands and away from roads provide suitable turtle nesting habitat that is potentially safe from predators. Downed woody debris (e.g., hollow logs, rotting stumps), brush piles, decaying leaf litter/piles, compost piles, and/or sawdust or wood chip piles provide microhabitats in which snakes could deposit their eggs or give birth to their young (Ernst and Ernst 2003, Harding and Mifsud 2017). Maintaining

connectivity between wetland and upland habitats also is essential. Development (e.g., residential, agricultural), roads, invasive species and other factors can result in habitat loss, degradation and fragmentation that prevent amphibians and reptiles from accessing adjacent uplands and other habitats they need to meet their life history requirements. Maintaining and restoring habitat and installing ecopassages or culverts under roads can facilitate safe passage across roads and/or access to upland and other wetland habitats where needed.

Amphibian and reptile species/populations face additional threats that may need to be managed. Roads can serve as barriers to movement and dispersal and a source of direct mortality or injury to amphibians and reptiles. Monitoring wildlife road mortality along roads can help determine if this is a significant issue and where management might be needed to address this threat. Installing barrier fencing along roads and/or ecopassages or culverts under roads can help mitigate this issue where needed. Turtle nest predation rates can be very high (up to 100%) in highly fragmented landscapes and anthropogenically disturbed habitats (Garber and Burger 1995, Mitchell and Klemens 2000, Lee and Monfils 2008, Geller 2012). Control of meso-predators (e.g., raccoons) in turtle nesting areas, particularly during the nesting season, and/or predator exclosures/nest protection cages could help reduce predation of turtle nests and enhance reproductive success and population recruitment. Inappropriate habitat management, disease, illegal collection, persecution, and climate change are additional potential threats to herp species and populations. Kingsbury and Gibson (2012) and Mifsud (2014b) provide management recommendations and best management practices for conserving amphibian and reptile populations and habitat.

Results & Discussion – Vernal Pools

A total of seventeen PVPs were identified and mapped on SCIT lands (Table 20), fourteen of which are located in Isabella County, and three in Arenac County. These PVPs were mapped primarily in upland deciduous or mixed upland deciduous forest stands (i.e., dry-mesic southern, dry-mesic northern forests, and mesic southern forest) as well as lowland shrub stands (northern shrub thicket) and along the edge of an old field and a marsh. Of the 17 PVPs, fifteen were identified and mapped based on aerial photograph interpretation. Two PVPs were encountered incidentally in Isabella County during herp surveys. These appeared to be dry vernal pools based on the presence of small, shallow depressions with black matted leaves/leaf litter and fingernail clams which are commonly found in vernal pools. These are likely vernal pools but need to be surveyed in the spring to verify these depressions are wet and hold water for at least two months in the spring to confirm they are vernal pools. These two PVPs were not observed on available aerial imagery because they are so small and shallow. Future work is needed to survey these PVPs as well as surveys for additional vernal pools to occur on SCIT lands that were not identified and mapped by aerial photo interpretation (e.g., small and shallow vernal pools, pools in conifer-dominated areas).

Despite their small size and temporary nature, vernal pools can be incredibly diverse and productive wetlands, and are important for maintaining healthy forest ecosystems. Identifying and mapping vernal pools and understanding their ecological values are critical for effective planning, management, and conservation of these important wetlands not only on SCIT lands but statewide. Management of vernal pools should focus on protecting the pool's physical basin and water quality, and the integrity of the surrounding forest to maintain habitat for associated species, particularly pond-breeding amphibians (Calhoun and deMaynadier 2008). Activities that disturb soils or tree canopies within and immediately adjacent to vernal pools should be avoided or minimized, particularly during critical time periods for most amphibians (i.e., March/April through July/August, Thomas et al. 2010). Rutting and scarification of the forest floor also may create barriers and prevent salamanders from travelling to breeding pools (Means et al. 1996). The State of Michigan's sustainable soil and water quality practices for forest lands recommend no disturbance within the vernal pool depression, limiting use of heavy equipment within 30 m (100 ft) or at least one tree length of the pool to when the soil is dry or frozen to avoid or minimize creating deep ruts, and maintaining at least 70% canopy closure within the 30 m (100 ft or 1.4 ac) buffer (MDNR & MDEQ 2018). Maintaining an additional buffer from 31-122 m (100-400 ft or 13 ac) with at least 50% canopy cover around vernal pools and providing abundant cover on the forest floor (i.e., leaf litter and coarse woody debris) would protect terrestrial habitat for vernal pool-dependent amphibians and invertebrates (Semlitsch 1998, Calhoun and deMaynadier 2004 and 2008). Construction of roads and landings and applications of chemicals (e.g., herbicides and/or pesticides) should be avoided within the 30 m (100 ft) buffer around a vernal pool and minimized within the adjacent landscape (Calhoun and deMaynadier 2008).

Table 20. Potential Vernal Pools (PVPs), their Michigan Forest Inventory cover type and MNFI natural community.

PVP ID	Latitude	Longitude	Acres	County	Compartment	Stand	MiFI Cover Type	Natural Community
SCIT1-1	43.5989	-84.7056	0.47	Isabella	2	36	Low-Density Trees	Mixed upland/lowland with aspen regeneration
SCIT1-2	43.6128	-84.7178	0.44	Isabella	3	28	Mixed Lowland Shrub	Autumn olive dominated
SCIT1-3	43.5996	-84.7155	0.06	Isabella	3	7	Herbaceous Openland	Unmanaged opening
SCIT1-4	43.6003	-84.7153	2.02	Isabella	3	7	Herbaceous Openland	Unmanaged opening
SCIT1-5	43.6638	-84.6929	0.34	Isabella	1	4, 6	Upland Shrub, Mixed Upland Deciduous	Unmanaged opening, young dry-mesic southern forest
SCIT1-6	43.6644	-84.6911	0.14	Isabella	1	6	Mixed Upland Deciduous	Dry-mesic southern forest - young
SCIT1-7	43.6609	-84.7015	0.14	Isabella	1	10	Lowland Maple	Northern hardwood swamp
SCIT1-8	43.66	-84.7003	1.29	Isabella	1	10	Lowland Maple	Northern hardwood swamp
SCIT1-9	43.6592	-84.6984	0.22	Isabella	1	9	Mixed Upland Deciduous	Dry-mesic southern forest
SCIT1-10	43.6605	-84.7075	0.12	Isabella	1	9	Mixed Upland Deciduous	Dry-mesic southern forest
SCIT1-11	43.6503	-84.663	1.22	Isabella	2	6	Lowland Maple	Mesic southern forest
SCIT1-12	43.9267	-83.903	0.14	Arenac	4	32	Mixed Upland Deciduous	Mesic northern forest, Great Lakes marsh
SCIT1-13	43.926	-83.9023	0.12	Arenac	4	32, 35	Mixed Upland Deciduous, Phragmites	Mesic northern forest, Great Lakes marsh
SCIT1-14	43.96	-83.9935	0.22	Arenac	4	2	Lowland Deciduous, Mixed Coniferous	Dry-mesic northern forest
SCIT1-15	43.6496	-84.6656	0.02	Isabella	2	7	Lowland Aspen/Balsam Poplar	Dry-mesic southern forest
SCIT1-16	43.6499	-84.665	0.02	Isabella	2	6	Lowland Maple	Mesic southern forest
SCIT1-17	43.6621	-84.7007	0.66	Isabella	1	9	Mixed Upland Deciduous	Dry-mesic southern forest

Results & Discussion – Culturally Important Plants

During vegetation mapping surveys we documented 137 stand-level occurrences of culturally important plant species. These data are intended as an initial effort to map these plants rather than as a comprehensive effort to catalog all occurrences. Georeferenced locations of these species will be shared with SCIT and can be used to inform further mapping efforts.

Jack in the pulpit (left) and bloodroot (right) are two culturally important plant species documented during vegetation mapping surveys.

Several species were widespread on SCIT properties and recorded in multiple stands in multiple compartments, including Jack-in-the-pulpit, paper birch, red-osier dogwood (*Cornus sericea*), ironwood, basswood, and black ash. Other species were relatively common but more localized in distribution, including wild leek (*Allium tricoccum*), dogbane (*Apocynum cannabinum*), sweet fern, and northern white cedar. Other species were rather rare, occurring within a single compartment – groundnut (*Apios americana*), winterberry (*Ilex verticillata*), bloodroot, and lowbush blueberry. The apparent rarity of some of these species may be due to changes in detectability through the seasons. For instance, bloodroot is a spring ephemeral plant that completes its entire life cycle before trees leaf out, therefore stands we surveyed in mid- or late-summer may

have likely contained this plant, but it was not detectable at the time. Others were likely not detected due to the protocol of walking a transect through a stand to survey, which results in missing microhabitats or small populations of plants. We observed no occurrences of sweetflag (*Acorus americanus*), angelica (*Angelica atropurpurea*), sweetgrass (*Hierochloe odorata*), Labrador tea (*Rhododendron groenlandicum*), and elderberry (*Sambucus canadensis*). Habitat for all unobserved species-of-interest occurs in the survey area, although generally to a limited extent. Elderberry and sweetflag occur in a variety of marshes, whereas angelica and sweetgrass are limited to sedge-dominated wetlands, such as northern fen, and Labrador tea typically grows in acidic peatlands such as bogs and conifer swamps. Future surveys are warranted to document additional occurrences and to characterize the condition, distribution, and accessibility of these species.

We conducted focused surveys for wild rice in Tawas Lake. This is one of the largest extant rice beds in Michigan, which may cover as much as 700 acres, or most of the surface of Tawas Lake, in low-water years (MNFI 2020a). Our survey focused on a small proportion of this rice bed, in the far northeastern portions of Tawas Lake and within the marshes in and adjacent to stands 25-28, 39 and 40 (compartment 5, Figure 17). We mapped the distribution of wild rice in the areas we surveyed, and recorded notes on density and condition, and associated plant species. Two species of wild rice occur in Michigan, the southern *Zizania aquatica* (state threatened) and the more widespread *Zizania palustris*. Both occur intermixed at this site. During the 2019 surveys, water levels were very high in Tawas Lake, deeper than is ideal for wild rice. Wild rice can thrive in depths of approximately 0.3 – 1 m (1-3 ft, David 2019). Many patches of wild rice were growing in water up to 2 m (6 ft) deep. Reduced fitness, e.g., tillering (lateral vegetative growth) and flower production, have been seen at these depths (Stevenson and Lee 1987). Many individuals produced only floating leaves and occasional individuals were uprooted and floating. Wild rice was just beginning to flower mostly with staminate flowers showing, precluding differentiation between the two species. Wild rice was generally sparse, with occasional small dense patches, in near-shore areas dense with floating vegetation. Associates in near-shore areas included sweet-scented waterlily (*Nymphaea odorata*), yellow pond-lily (*Nuphar advena*), water-shield (*Brasenia schreberi*), and hard-stem bulrush. Associates in deeper waters included pondweed (*Potamogeton natans*), watermilfoil (*Myriophyllum verticillatum*), various-leaved watermilfoil (*Myriophyllum heterophyllum*), and common waterweed (*Elodea canadensis*). Wild rice was also found sporadically up Kunze Creek, associated with American bur-reed (*Sparganium americanum*), and sweet gale (*Myrica gale*). Wild rice is affected by human land use changes, which limit its dispersal ability.

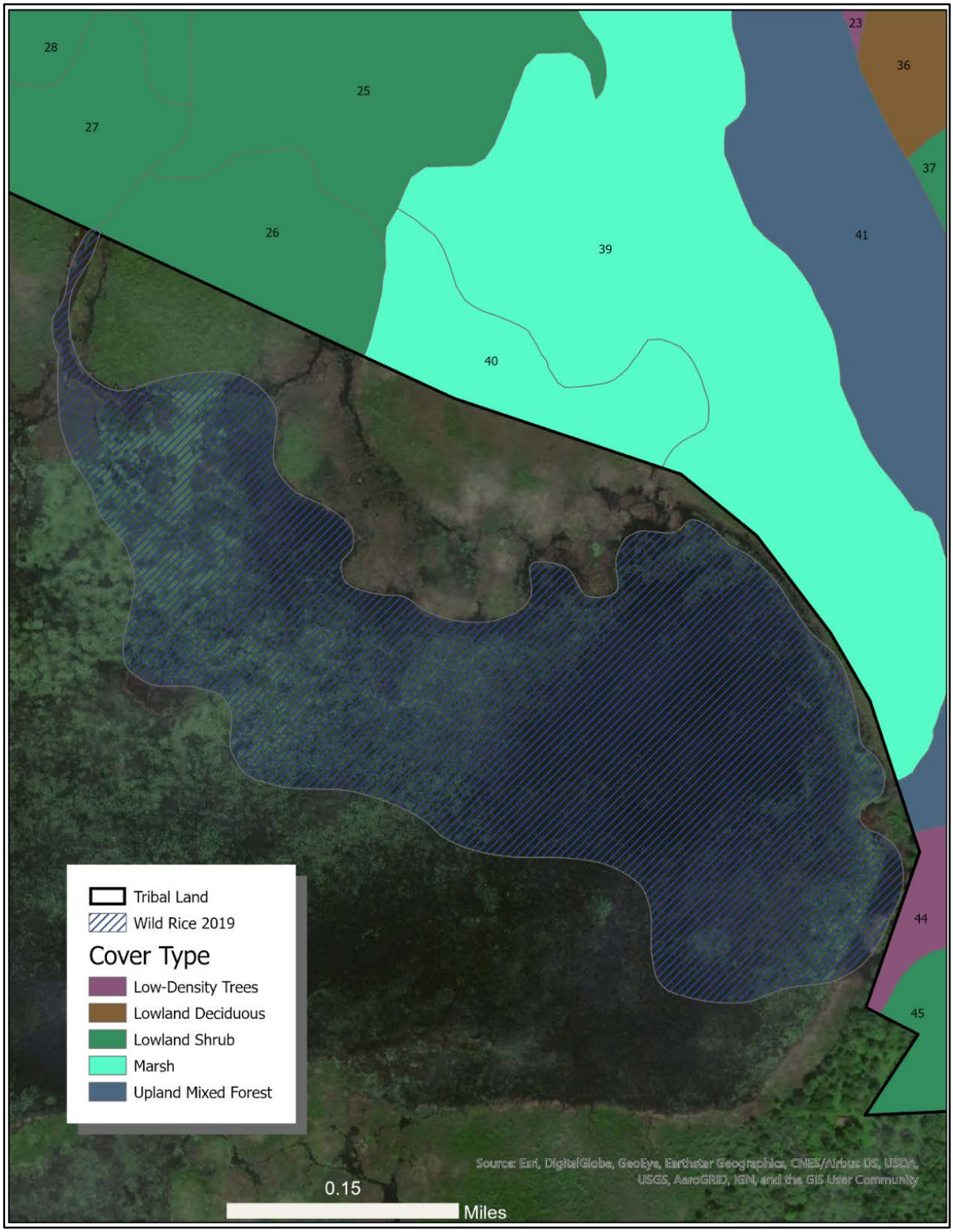

Figure 17. Wild rice on Tawas Lake as mapped during 2019 surveys during high water levels.

Natural Heritage Database

MNFI is a member of the Natural Heritage Program Network, a program of NatureServe. As a member of this program, we have the responsibility for collecting information about Michigan's elements of biological diversity. Each occurrence of these elements is referred to as an "Element Occurrence" or "EO." In this database we track 304 animal species, 420 plant species, and 77 natural communities in Michigan. These data comprise over 20,000 EOs and are used to guide conservation and management in Michigan (MNFI 2020a). The database is proprietary and the most comprehensive source of existing information on Michigan's endangered, threatened, or significant plant and animal species, as well as natural communities, and other natural features.

Ellipse was one of the rare species we recorded in Jordon Creek in 2019.

Results from our baseline inventories provided data to create or update 13 EOs (Table 21), indicating the importance of these lands to several rare species. No natural community EOs were added as part of this project, however, the forests and wetlands we surveyed cover significant acreage, and harbor significant biological diversity and wildlife habitat. While some of the natural communities were ranked as high-quality, they lacked attributes to qualify as EOs according to natural heritage methodology. For instance, in Tawas the cedar swamp (compartment 5, stand 6) is in most respects a representative example of a rich conifer swamp natural community. However, due to its small size and lack of diagnostic structural features, such as coarse woody debris and lack of cedar regeneration, the stand did not meet the requirements to qualify as an EO. With management and time, several of the high-quality sites would eventually qualify as natural community EOs. Although we did not conduct targeted surveys for raptors or eagles, we investigated and documented any potential when incidentally encountered. In this manner we documented a new active bald eagle nest, as well as a new red-shouldered hawk nest.

Table 21. Summary of Element Occurrences on SCIT lands from the Natural Heritage Database.

Common Name	Scientific Name	Last year observed	EO Number	County	Status
Birds					
Red-shouldered hawk	*Buteo lineatus*	2019	23688	Iosco	State threatened
Bald eagle	*Haliaeetus leucocephalus*	2017	11330	Iosco	State special concern
American bittern	*Botaurus lentiginosus*	2019	18569	Iosco	State special concern
Common loon	*Gavia immer*	2019	23318	Iosco	State threatened
Marsh wren	*Cistothorus palustris*	2019	23317	Iosco	State special concern
Bald eagle	*Haliaeetus leucocephalus*	2019	23067	Arenac	State special concern
Mussels					
Black sandshell	*Ligumia recta*	1932	17673	Arenac	State endangered
Slippershell	*Alasmidonta viridis*	2019	23690	Isabella	State threatened
Slippershell	*Alasmidonta viridis*	2019	23689	Isabella	State threatened
Slippershell	*Alasmidonta viridis*	2019	23691	Isabella	State threatened
Rainbow	*Cambarunio iris (=Villosa iris)*	2019	23694	Isabella	State special concern
Rainbow	*Cambarunio iris (=Villosa iris)*	2019	23693	Isabella	State special concern
Rainbow	*Cambarunio iris (=Villosa iris)*	2019	23692	Isabella	State special concern
Ellipse	*Venustaconcha ellipsiformis*	2019	23695	Isabella	State special concern
Herpetofauna					
Eastern massasauga	*Sistrurus catenatus*	1933	14202	Iosco	Federally threatened, state special concern
Blanding's turtle	*Emydoidea blandingii*	1935	6156	Iosco	State special concern
Blanding's turtle	*Emydoidea blandingii*	2017	23697	Arenac	State special concern
Butler's garter snake	*Thamnophis butleri*	2013	23698	Arenac	State special concern
Plants					
Wild rice	*Zizania aquatica*	2019	20646	Iosco	State threatened

Next Steps: Recommendations for Management and Research

We hope the following recommendations will provide resource managers with insight as SCIT continues to manage and protect natural areas. Results from vegetation mapping can inform management, restoration, and conservation planning in a way that is data-driven and quantifiable. Applying resources where they will have the most ecologically and culturally significant impact across a diverse service area requires strategic prioritization of stewardship efforts. Results from surveys can help target and prioritize ecological monitoring and research needs as well as management and restoration efforts. The rare species and stand-level vegetation data are available for download and use for staff through ArcGIS Online (ESRI 2020). In the vegetation mapping section of this report, we discussed each parcel with focused attention on high-quality stands, but these data are also available for all stands in ArcGIS Online. Below we provide insight and recommendations from baseline data in four themes: 1) leading threats, 2) restoration and management recommendations, 3) monitoring and research recommendations, and 4) conservation planning.

Leading Threats

The greatest threats to natural areas we surveyed were invasive species, ecosystem fragmentation, deer herbivory, and lack of fire.

Invasive Species

Invasive plant species present natural resource management challenges that are as diverse as the natural areas themselves. In general, invasive plants are non-native plant species that spread, largely unchecked by ecological processes, and outcompete native species. These aggressive species are a leading threat to species diversity and ecological integrity across the lands we surveyed, and their impact is exacerbated by the additive effects of other pressures such as deer herbivory, hydrological changes, habitat fragmentation, disease, and fire suppression. Invasive plants degrade native biodiversity by displacing native species, interrupting food webs, compromising pollination services, changing microclimates, and altering soils, hydrology, and disturbance regimes. These species often have no natural predators.

Newly established invasive species should be removed as rapidly as possible, following EDRR (Early Detection Rapid Response) guidelines. Treating these populations before they become well-established and infest additional areas is more effective and cost efficient than attempting to treat after the species are well established. Invasive species abstracts, which include detailed management guidelines, can be obtained at the following website: http://mnfi.anr.msu.edu/invasivespecies/best-control-practice-guides.cfm. When presented with difficult decisions to make in managing natural resources, models can help visualize data and inform decision-making. MNFI has recently provided data-driven models to inform land management for the Michigan Department of Natural Resources (MDNR). These models were constructed with data collected using MiFI, the same framework used for the baseline inventories presented in this report. Using data from baseline vegetation mapping surveys on state lands, MNFI developed an invasive species treatment priority model in 2019 that identifies areas where land management should be directed (Cohen et al. 2019a). We suggest

creating a similar invasive species prioritization model for SCIT using baseline vegetation mapping data, in conjunction with information on physiographic region, geology, landforms, circa 1800 land cover, slope, and aspect.

Indian Lake (compartment 6) is the only site in which we did not document invasive species. This is the smallest compartment, buffered by Huron National Forest with no primary roads near the site, so it does not suffer from edge effects or habitat fragmentation, despite its small size. Prioritizing treatment in high-quality sites that have low abundance of invasive species is warranted, as biodiversity is most easily and effectively protected by preventing high-quality sites from degrading. In Table 22 we provide a summary of stands that had trace (<5%) invasive species. Stands that have trace amounts of invasive species and are ranked as high quality are ideal targets for treatment.

Table 22. A list of stands that had trace (<5%) cover of invasive species.

Site	Compartment	Stand	Common Name	Scientific Name
Isabella	2	2	Japanese barberry	*Berberis thunbergii*
Isabella	2	33	Japanese barberry	*Berberis thunbergii*
Isabella	3	37	Multiflora rose	*Rosa multiflora*
Isabella	3	73	Multiflora rose	*Rosa multiflora*
Isabella	3	79	Honeysuckle	*Lonicera spp.*
Arenac	4	5	Purple loosestrife	*Lythrum salicaria*
Arenac	4	40	Cattail	*Typha angustifolia*
Arenac	4	46	Honeysuckle	*Lonicera spp.*
Arenac	4	47	Non-native phragmites	*Phragmites australis*
Arenac	4	50	Purple loosestrife	*Lythrum salicaria*
Arenac	4	51	Reed canary grass	*Phalaris arundinacea*
Tawas	5	2	Honeysuckle	*Lonicera maackii*
Tawas	5	6	Japanese barberry	*Berberis thunbergii*
Tawas	5	19	Reed canary grass	*Phalaris arundinacea*
Tawas	5	28	Non-native phragmites	*Phragmites australis*

There are several species of non-native honeysuckle threatening Michigan's natural areas, so we refer to them as *Lonicera* spp., which we documented in 50 stands (Table 23). This group of invasive species are readily identified by their opposite branching and conspicuous berries. Honeysuckles readily invade open / disturbed forests, as they are relatively shade tolerant. Autumn olive (*Elaeagnus umbellata*) is present in 51 stands. This non-native shrub invades disturbed areas, where it increases nitrogen levels and forms impenetrable thickets and changes the structure of the invaded system. This species was widely recommended for conservation planting until invasive traits became apparent (MISIN 2020). Because this species is difficult to control, we recommend monitoring sunny sites for new infestations that can be removed by hand pulling seedlings (MISIN 2020). Cutting, girdling, and burning of established shrubs (for both honeysuckle and autumn olive) must be done in conjunction with herbicide application.

We documented non-native Phragmites in 40 stands (Table 23). The treatment of this species in degraded Great Lakes marsh is complicated, as these communities also contain habitat for rare and declining marsh

birds. However, without management intervention, it is likely that it will become more dominant. Potential treatment options include herbicide application, prescribed fire, and managing flooding when possible. A framework for management was developed by experienced practitioners and presented in *A Guide to the Control and Management of Invasive Phragmites* (Michigan DEQ 2014). A long-term approach is required for this species and whatever management strategy is implemented needs to be monitored to gauge the success of control, assess impacts to the ecosystem and species that depend on it, and facilitate adaptive management. We found narrow-leaved cattail in 26 stands across three compartments (Table 23). If cattail appear to spread following prescribed fire management, control methods that involve using herbicides approved for open water use likely will be needed.

The impact of invasive species was most evident in degraded old fields and forest edges in Isabella and Arenac Counties, and along shorelines of Lake Huron and Tawas Lake. In Table 23 we identify the top four invasive species that affected the lands we surveyed.

Table 23. The four invasive plant species most commonly found during 2019 surveys and the number of stands where they were documented in each compartment.

		Autumn olive	Honeysuckle	Non-native phragmites	Cattail
County	**Compartment**	***Elaeagnus umbellata***	***Lonicera* spp.**	***Phragmites australis***	***Typha angustifolia***
Isabella	1	13	1	0	0
Isabella	2	7	8	0	0
Isabella	3	15	16	3	3
Arenac	4	16	18	16	13
Tawas	5	0	7	21	10
Indian Lake	6	0	0	0	0
Total number of stands		51	50	40	26

Invasive species that were seen in low numbers during vegetation mapping surveys, such as Oriental bittersweet (*Celastrus orbiculate*), can be treated with minimal effort before invasions become too difficult and expensive to control. Purple loosestrife (*Lythrum salicaria*) was only recorded in wetlands in eight stands. The purple loosestrife beetle is a biocontrol agent that can be deployed in these sites for minimal cost. We recommend employing this biocontrol agent in wetlands affected by the invasive plant.

European frog's-bit is listed as a prohibited noxious weed by the Michigan Department of Agriculture and was found on the Saganing River. Manual removal (e.g., hand removal) and chemical treatments have been used to treat European frog's-bit in Michigan. Management actions are most successful if conducted prior to the development of turions (late summer) and seeds (fall, Cahill et al. 2018). Reptiles and amphibians, particularly turtles and frogs/toads, may be negatively impacted by this aquatic invasive species.

Ecosystem Fragmentation

The natural areas on SCIT lands comprise reservoirs of biodiversity amidst a highly fragmented landscape. Roads, suburban development, forestry, and agriculture all cumulatively drive habitat fragmentation, reducing

the area supporting natural communities, as well as the sensitive or rare species that rely on them. Habitat fragmentation is greatest in Isabella County, where many habitat fragments are also of low ecological quality, for instance upland old fields dominated by non-native shrubs and grasses. These challenges also create opportunities for restoration, as discussed in the following sections. However, to specifically address habitat fragmentation we recommend the following actions to minimize fragmentation: 1) use logging practices, such as thinning, with restraint in forests that received an ecoscore of three or higher, 2) establish buffers along high-quality sites and actively manage these habitats, 3) buffer any slopes, water bodies, and wetlands from forestry or construction projects, and 4) reduce impacts to small order streams and vernal pools by expanding existing forests to provide increased buffering from surrounding developed lands.

Deer Herbivory

A native species of interest that tends to benefit from the artificial landscape created by the Anthropocene is the white-tailed deer (*Odocoileus virginianus*). We observed excessive deer browsing across the three counties, and as a result, the regeneration of important tree species (e.g., cedars and oaks) is negatively impacted. Although some forested stands may seem healthy, as they have various large, old tree specimens, without regeneration diversity will decline once the older trees begin dying off. Installation of deer exclosures in high-quality communities can help with seedling and sapling survivorship. We recommend including signs educating the public about what the deer exclosures are and why they were erected. Organized deer hunts can provide recreational opportunities for Tribal members as well as ecological benefit. We recommend monitoring deer densities and deer herbivory to allow for future assessment of the impact of deer herbivory and to set goals for sustainable deer populations.

Fire Suppression

Some natural communities we documented, such as dry-mesic northern, dry-mesic southern forests, and dry northern forest are fire-dependent ecosystems. In the past, lightning- and human-set fires frequently spread over large areas of Michigan, helping to reduce colonization by trees and shrubs, fostering regeneration of fire-dependent species, and maintaining the open structure of many of these fire-dependent ecosystems. The fire-dependent forests we surveyed are negatively impacted by fire suppression, manifested by the strong regeneration of thin-barked, shade-tolerant or mesophytic trees, such as red maple and beech, as well as the invasion of non-native shrubs like honeysuckle, multiflora rose, autumn olive, and Japanese barberry. These species outcompete oaks and white pine, contributing to a lack of regeneration in these species.

Ecosystems benefit from prescribed fire in several ways: they can decrease the cover of invasive woody species, increase the cover of native grasses and forbs, promote regeneration of desired tree species, such as oaks and pines, reduce litter levels, and can help express and rejuvenate seed banks.Knowing where and when to apply prescribed fire is a difficult and daunting task as land managers juggle priorities on diverse landscapes. To assist in this decision-making, MNFI has developed a data-driven, quantitative prescribed fire needs assessment model for the MDNR (Cohen et al. 2019b). The strength of this model is tied to the abundance of data, particularly MiFI data, to build and calibrate this model. With the vegetation mapping data

collected during this study, this model can also be used to prioritize fire management for the Tribe. Stands will be classified on a scale of fire dependence, and assigned a fire frequency range.

Restoration & Management Recommendations

Here we suggest opportunities for restoration and creation in three broad ecological systems: forests, non-forested uplands, and wetlands. Careful prioritization of sites for management is a challenge. Perhaps the best use of limited natural resource management funds is to keep high-quality natural areas intact and creating corridors among these intact systems. Restoration is sometimes more of an art than a science, however, we offer suggestions informed by our field observations and baseline data. SCIT land managers will also have stand-level vegetation data for use in selecting sites, as well as monitoring how they change over time. Our ecosystem management and restoration recommendations primarily fall into one of three broad categories: 1) improve or maintain condition of high- or medium-quality sites, 2) restore extremely degraded sites by using them as a 'blank slate', or 3) expand high-quality sites by restoring adjacent stands to buffer and reduce edge effects.

Forested Sites

Actions to maintain and improve forests include the return of fire to the landscape, removal of invasive species, and the expansion of existing forests by restoration. Selective logging (e.g., thinning) can be used sparingly for young forests, especially when prescribed fire is not an option. We recommend focusing these restoration and improvement efforts adjacent to existing high-quality stands (ecoscore of 4-5), and then in those stands that received a medium (e.g., 3) ecoscore. With thoughtful management and time, we can allow succession to proceed while managing for threats. Some of these moderately scored forest stands could become exemplary natural communities with the passage of time. Restoration of these ecosystems can be beneficial to providing habitat for culturally important plants and game species, such as wild turkey.

Reforesting areas is a tremendous task, but a worthwhile endeavor. However, planting trees does not necessarily create functioning forests, so it is necessary to put thought into planting a suite of species that will closely resemble the native assemblage of species that promotes structural heterogeneity and wildlife diversity. Using guidelines for climate resilient species can help create communities that will have the most success in the future. Forest restoration efforts can also be initiated on degraded sites adjacent to high-quality sites. During baseline vegetation mapping inventories these were often classified as low-density trees or aspen stands. By focusing on, and thus expanding existing forests, and creating corridors, the impact of edge effects and therefore pressure from invasive species can also be reduced. When forested remnants are small, nearly all of the parcel is impacted by edge effects, such as increased sunlight/heat, invasive species, insecticides, impacts from mesopredators, and pesticides.

When prescribed fire is not an option, which is often the case in the urban-wildland interface, selective logging and/or thinning of shade-tolerant species from the canopy can help improve forests. These projects can have the added value of providing income or timber for buildings and other projects. Planning for forestry projects

should take sensitive communities and species into account to ensure that they are not irrevocably harmed. Selective cutting can potentially be a valuable step to the restoration of oak and pine dominated forests and allows for the preservation of large trees. It is important to note that careful thought should be put into examining soil types to ensure that plantings and restoration efforts are done where plants will be the most successful.

Non-forested Sites

Vegetation mapping show substantial acreage of non-forested, non-wetland sites, especially in Isabella County. These degraded old fields are most likely the result of the clearing of forests for logging and agriculture, rather than previously existing as herbaceous-dominated natural communities that occur in Michigan, such as prairies, oak openings, or oak-pine barrens. Focusing restoration efforts solely on re-creating the primeval forests of northern Michigan would take generations, but strategic decisions to create herbaceous-dominated open and partially open habitats can promote valuable ecosystem functions that are not provided in the current fragmented landscape, with the advantage of creating diverse ecosystems in less than five years. These degraded old fields can provide a 'blank slate' for habitat creation. Although Isabella County is north of the historic range of prairies, there are opportunities to convert some land within this urban context to promote open or semi-open ecosystems (Comer et al. 1995, Chapman and Brewer 2008). Prairie and savannas have complex structures that include forb-rich grasslands and interspersed large trees, which can provide habitat for diverse pollinator assemblages and create corridors for declining butterflies, such as monarchs, and bees. This management option has the advantage of retaining large trees to create structure. Pursuing targeted creation of prairie and savanna communities at these ecologically degraded sites can create aesthetically appealing greenspace for the community. These sites can provide opportunities for beekeeping, thus creating revenue and food sources, outdoor learning, native seed collection, establishment of culturally important species, and recreation, such as snow shoeing, running, and cross-country skiing. By creating these ecosystems adjacent to high-quality forests, resilient communities can be created that can withstand the anthropogenic pressures and threats. Depending on available funds, prairie or savanna constructions can have either low-diversity mixes of cool-season grasses, or highly diverse plantings with a variety of native forbs and grasses.

New development opportunities, such as the establishment of new cultural or educational centers, or planting of crops, orchards, or permaculture projects, may necessitate development of SCIT of land. When selecting sites for development or agriculture, we recommend stands that received an ecoscore of 0 or 1. By focusing development on these sites, land managers can avoid losses of valuable natural resources and minimize negative impacts to biodiversity.

An old field in Isabella County, which was historically forested, could be used as a 'blank slate' for habitat creation.

Great Lakes Wetlands

The extensive wetlands present along Lake Huron and Tawas Lake are primarily under threat from invasive species. The non-native Phragmites, narrow-leaved cattail, and European frog's-bit are the most pernicious species warranting treatment. Aside from current management of invasive species, the primary stewardship need is to allow water level fluctuations to drive changes in species composition and structure, while monitoring the vegetative response to allow for rapid response to new invasive species populations. These parcels are also threatened by industrial agriculture through drainage, sedimentation, and nutrient loading, the latter of which causes algal blooms and facilitates invasive infestations.

Changes in Great Lakes water levels are one of the most important influences on these wetlands and the species that rely upon them. We recommend our baseline inventory surveys be followed up in the future, as these sites are likely to appear quite different in later years as lake levels recede. Lake levels have a profound impact on these communities and Lake Huron is currently at its highest levels since 1986. As of May 2020, Lake Huron was at 177 m (582 ft), 1 m (36 in) higher than long-term monthly average for May (USACE 2020).

The main management recommendations are to continue to manage for invasive species, and to allow natural processes (e.g., lake level changes) to operate unhindered and to retain an intact buffer of natural communities surrounding the wetlands to minimize the threat of hydrological alteration and facilitate spatial

and temporal shifts in these dynamic ecosystems. Monitoring ecosystem responses to lake level changes may help treat new infestations of non-native invasive species before they begin to dominate new areas.

Research & Monitoring Recommendations

In this study, we conducted targeted rare species surveys, however, complete inventories of all potential rare species were not feasible in the scope of this project, and many of the rare species are cryptic by nature and difficult to document in a single field season. Baseline vegetation mapping inventories identified stands with high potential for harboring biodiversity, and, some rare species, such as butterflies and moths, have obligate relationships to their host plants, and baseline vegetation data can inform where to target future surveys. There is potential to document several groups of rare species on SCIT properties and below we provide recommendations on where to direct future research and monitoring based on the knowledge we compiled during this study (Table 24). Overall, our recommendation is to focus future rare species surveys in Iosco County, continue surveys and monitoring of secretive marsh birds in Iosco and Arenac Counties, and monitor Jordon Creek for rare mussel species.

Birds

Bird monitoring can be a valuable tool in assessing the success of conservation actions, such as invasive species control efforts in wetlands or forest management practices. We recommend future surveys of secretive marsh birds follow the North American Marsh Bird Monitoring Protocols (Conway 2011, MiBCI 2015). Additionally, we documented a red-shouldered hawk nest directly adjacent to the Indian lake property, so we recommend that this territory be regularly monitored. These birds tend to have high fidelity to nesting sites and will re-use nests, rather than rebuilding each year, and we recommend future surveys for this raptor in both Isabella and Iosco Counties. There is ample habitat for both the red-shouldered hawk and the goshawk at Tawas and Indian Lake, so surveys are warranted for both species, especially given that these site occur within a largely forested landscape and these species tend to utilize large forest blocks for nesting. Bald eagle nests in both Arenac and Iosco Counties should continue to be monitored.

Insects

We documented habitat for the royal fern borer moth and additional surveys could help determine if this species occurs on Tribal properties, specifically in compartments 1. The southeast portion of Tawas contains suitable jack pine-red pine habitat for the secretive locust, and although we did not find it during our surveys, this species may be extant. Much of the required habitat for this locust extends southeast along Kunze Road. Therefore, management along the Tawas property boundary is likely to increase habitat suitability, potentially drawing in populations of secretive locust that extend beyond the border. There is opportunity to survey for multiple species of rare species of bumble bees on SCIT lands, including the rusty-patched bumble bee (*Bombus affinis,* federally endangered), yellow-banded bumble bee (*B. terricola*, state special concern), and the black and gold bumble bee (*B. auricomus*, state special concern). SCIT lands are within the historic ranges of these species. Surveys to determine habitat use, including nesting and foraging resources, would provide invaluable data necessary to the long-term conservation of these species.

Table 24. We provide a variety of recommendations for future surveys, research, and monitoring. Natural resource management goals and results of conservation planning goals can help inform the prioritization of these endeavors.

Survey area	Taxa	Details / Species
		Fauna
Iosco	Mammals	American marten, badger, bobcat, northern long-eared bat
All	Mammals	Woodland vole
Tawas, Arenac	Marsh birds	Annual monitoring for secretive marsh bird species
Isabella, Iosco	Raptors	Northern goshawk, red-shouldered hawk, bald eagle
Isabella, Iosco	Insects	Rusty patched bumble bee, Yellow-banded bumble bee, Black and Gold bumble bee
Tawas	Insects	Royal fern borer moth, secretive locust, Lake Huron locust
Iosco	Herps	Eastern massasauga, Blanding's turtle, wood turtle, pickerel frog, Butler's garter snake, smooth green snake, queen snake
Arenac	Herps	Blanding's turtle, Butler's garter snake and pickerel frog, smooth green snake, queen snake
Isabella	Herps	Blanding's turtle, wood turtle, Butler's garter snake, smooth green snake
Isabella, Arenac	Mussels	Slippershell, black sandshell, snuffbox
		Flora
All	Cultural plants	Complete mapping effort of culturally important plants
Iosco	Rare plants	Calypso, ram's-head lady-slipper, and broad-leaved twayblade
		Study Systems / Modeling Efforts
All	Vernal pools	Surveys to verify potential vernal pools, their locations, and presence of indicator or obligate species (e.g. fairy shrimp, wood frogs, spotted salamanders)
All	Modeling	Prescribed fire needs assessment
All	Modeling	Invasive species prioritization model, monitoring efficacy of treatment in high-quality and lakeshore habitats
All	Camera trapping	Camera trap arrays can be deployed in areas where mammal density and species richness estimates are needed
All	Deer monitoring	Monitor deer densities via aerial surveys or camera traps, monitor herbivory via enclosures

For more information on these species' life history status, and range, see the MNFI Rare Species Explorer at: https://mnfi.anr.msu.edu/species

Mammals

We did not conduct mammal surveys as part of this project, however, some mammals (e.g., bears, muskrats) were documented incidentally while conducting other inventories. Estimates of species distribution, abundance, and habitat use of mammals can be important guiding metrics for wildlife management and conservation. Large carnivores throughout North America are of high management or conservation priority because they are often disproportionately vulnerable to extinction or extirpation, regulated by harvest, indicators of ecosystem integrity, and convey top-down regulation of ecosystem structure and function (Ripple et al. 2014, Terbogh et al. 1999, Etter and Mayhew 2008). A better understanding of mammal use can be accomplished with grid-based camera trap surveys and/or small mammal trapping to investigate various population level metrics, including mammalian community richness, species-specific distributions, occupancy, and/or habitat use. MNFI is currently developing and testing machine learning technologies to automatically classify species in camera trap images, which allow us to rapidly ingest, process, and manage large amounts of data from camera traps (Wilton 2020). We specifically recommend targeting mammal surveys for American marten (*Martes americana*). Once thought to be extirpated from Michigan, this species of conservation concern has repopulated Michigan's Upper Peninsula and may occur at Indian Lake and Tawas. Other mammal targets for surveys in Tawas and Indian Lake include American badger (*Taxidea taxus*), bobcat (*Lynx rufus*), and northern long-eared bat (*Myotis septentrionalis*). Additionally, the woodland vole (*Microtus pinetorum*, state special concern) is a small rodent that uses deciduous woodlands in Michigan, and it is possible for this species to occur in all three counties.

Array of images from a project MNFI recently completed using grid-based camera trap surveys (Wilton 2020).

Mussels

In addition to monitoring populations of the rare slippershell, mussel surveys in Jordon Creek are warranted for the federally endangered snuffbox mussel (*Epioblasma triquetra*). Snuffbox was documented in the Salt River at the West Saginaw Road crossing in 1934, in the Chippewa River in 2009, and in the Wixom Lake reservoir on the Tittabawassee River in 2019. An assessment to identify potential point-source impacts, such as concentrated animal feeding operations, could identify potential sources for excessive nutrient loadings into Jordon Creek and the larger Salt River watershed, and opportunities to improve water quality. An assessment of stream/road intersections in Jordon Creek and the surrounding watershed could be made to identify opportunities to improve fish passage, and in turn improve the long-term viability of mussel populations. Culverts that are too small in diameter or perched above the water's surface can impede or prevent the movement of fish through a river. Inefficient culverts can contribute to erosion and create flooding hazards as well. Replacement of deficient culverts with improved culvert designs can allow for fish passage, improve mussel population viability, and reduce impacts to the river and the roadway from erosion.

Plants

Hardwood-conifer and rich conifer swamps, dry northern forest, and dry-mesic northern forests located in Iosco County have the potential to support rare plant species associated with these natural communities. We recommend early field season surveys in this area for rare orchids, such as calypso (*Calypso bulbosa*), ram's-head lady-slipper (*Cypripedium arietinum*), and broad-leaved twayblade (*Listera convallarioides*). Additional rare plants may be suitable targets for future surveys in these and other high-quality natural communities. Ongoing programs (e.g., drone flights) that monitor wild rice is prudent as climate change and fluctuating water levels can affect this species, as it is adapted to cool environments, has particular hydrological requirements and a lack of genetic variation, and is also susceptible to disturbance, competition, and pathogens. Continued involvement in existing partnerships, such as the Michigan Wild Rice Initiative, can provide additional guidance for managing and monitoring wild rice.

Herpetofauna

We recommend additional surveys for rare amphibians and reptiles in all three counties, given the presence of potential habitats and the cryptic nature of herpetofauna. Priority species and sites for future surveys include the following: 1) eastern massasauga, Blanding's turtle, wood turtle, pickerel frog, and Butler's garter snake at Tawas; 2) Blanding's turtle, Butler's garter snake and pickerel frog in the shoreline stands in Arenac County; and 3) Blanding's turtle, wood turtle, Butler's garter snake, and smooth green snake in Isabella County (Table 24). Visual encounter surveys, aquatic funnel trapping, and artificial cover or coverboard surveys are recommended for these species. These surveys can be conducted anytime during the species' active season (typically from April-October), but spring surveys (April-June) are generally recommended.

Vernal Pools

The next step of this work is to ground truth potential vernal pools (PVPs) to verify if they represent vernal pools in the field. This includes recording physical and hydrological characteristics, vegetative cover, surrounding habitat, disturbances, and presence of vernal pool indicator species and other animals in the pools. Vernal pools can be classified into the following six general types based on vegetation within the pools: open/sparsely vegetated pools, shrubby pools, forested pools, marsh pools, and other (e.g., half open and half shrubby). Field sampling data can be incorporated into the Michigan Vernal Pool Database (MNFI 2020b). Surveys to ground truth PVPs are recommended primarily in Isabella and Arenac Counties.

Conservation Planning

The primary goal of conservation planning is to support actions to achieve explicitly defined objectives through documented, structured, and socially engaged processes (Groves and Game 2015). To facilitate the process, several conservation planning frameworks are available including strategic foresight, systematic conservation planning, structured decision making, Open Standards for the Practice of Conservation (i.e., Conservation Standards), and evidenced-based practice (CMP 2013, Schwartz et. al. 2018). Of these, we suggest SCIT consider adopting Conservation Standards (CS), because of the biodiversity conservation focus of this framework (CMP 2020; Figure 18). This process should be highly participatory and Tribal engagement is necessary to ensure that goals are constructed to meet the needs of the group and individuals.

Figure 18. Conservation Standards (CMP 2020) Diagram

CS is a systematic process divided into five-steps, and requires both analytical and creativity skills (Figure 18). Baseline natural features data can be used to inform the process. Summaries of vegetation mapping inventories, occurrences of rare and culturally important species, and recommendations for restoration, management, monitoring, and research can all be used in the conservation planning process. Based on results from baseline inventories, there is clear evidence SCIT land holdings have much potential, but work remains to maintain and improve the health of these natural resources. We have developed a suggested outline for moving forward with a long-term conservation plan in Table 25.

This report represents much of the information needed to assess the status of natural resources to develop a conservation vision, identify key conservation targets, and determine the critical threats to those targets (Step 1, Table 25). During the second step of the planning process, SCIT would develop a series of goals, objectives, and strategies to guide the conservation of its critical natural resources. In the Recommendations for Management and Research section, we provide several opportunities to improve biodiversity on SCIT properties, which could form the basis of several conservation strategies. The planning phase (Step 2) also involves developing monitoring and operational plans. In this report we have highlighted several remaining information gaps and mechanisms to assess the effects of conservation actions, which could be incorporated into a monitoring plan. An operational plan identifies the funding and other resources (e.g., human capacity, skills) needed to achieve the goals. Step 3 is the implementation phase, during which specific work plans, budgets, and timelines are created and made operational. Data collected under the monitoring plan are analyzed in Step 4 and that information is used to adapt the plan's strategies, objectives, and goals, as needed. The final step (5) involves documenting the information learned through the planning process and sharing these lessons, along with the outcomes and products produced, with the community and partners. One of MNFI's scientists is trained in CS and could help guide SCIT through the planning process. The process of developing a conservation plan must demand involvement from various stakeholders to ensure that the plan is driven by the needs and desires of the Tribe. We hope that these recommendations can help as you begin this process.

Table 25. A suggested conservation planning outline using the Conservation Standards process (CMP 2020).

1. Assess	a. Define planning purpose and project team b. Define scope, vision, targets c. Identify critical threats d. Analyze the conservation situation
• Create a team of SCIT staff, community members, and partners responsible for overseeing the planning process. • Assess the status of the natural resources using the biological inventory results and other data sources. • Identify the critical threats to the natural resources using the biological inventory results and other data sources. • Based on the biological inventory, community engagement, and team discussion, define the plan's scope (e.g., natural and cultural resources), develop a vision, and identify the conservation targets. o Select the species and natural communities that are the greatest conservation priorities to the community. o Identify the key threats to these conservation targets.	
2. Plan	a. Develop goals, objectives, strategies, and assumptions b. Develop monitoring plan c. Develop operational plan
• Using the scope, vision, and conservation targets created in Step 1, the team will develop a series of goals, strategies, and objectives and record the assumptions made in their development. Here the path for conserving the targets (species, communities) is clearly defined. o Incorporate the restoration and management recommendations of this report into the strategies and objectives for the conservation targets. • Create a plan for monitoring the results of the conservation actions to be implemented. The monitoring plan identifies the metrics and methods to be used to assess the success of the implemented actions. o Use the research and monitoring recommendations of this report to help develop the monitoring plan. • Develop an operational plan that identifies the necessary steps to begin implementing actions.	
3. Implement	a. Develop work plan and timeline b. Develop and refine budget c. Implement plans
• Develop work plans to implement conservation strategies and objectives and follow-up monitoring, which will include timelines and estimated budgets.	
4. Analyze and Adapt	a. Prepare data for analysis b. Analyze results c. Adapt plan based on new information
• Use the data from monitoring and research to assess if goals and objectives are being met. • Adapt the conservation plan to better achieve goals as needed and continue regular monitoring and assessment.	
5. Share	a. Document learning b. Share learning c. Create learning environment
• Document the knowledge gained through iterative process of planning, implementation, assessment, and adaptation. • Share the what is learned with the community and partners. • Use the iterative process to identify key areas of uncertainty limiting achievement of conservation goals and strive to develop monitoring and research plans to address the knowledge gaps. • Research and monitoring recommendations of this report could help identify these key information gaps.	

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