

Natural Community Surveys of the Keweenaw Heartlands



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Cover Photo: Looking north over Bete Grise towards Mt. Houghton and the Keweenaw Peninsula.
Photo by J. M. Lincoln.

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Doug Pearsall during ecological surveys in the Montreal River Boreal Forest.
Photo by J.M. Lincoln.

EXECUTIVE SUMMARY

The Keweenaw Peninsula in Michigan's Upper Peninsula is a unique geologic formation with exposed volcanic (basaltic and conglomerate) bedrock that is over one billion years old. Cliffs, glades, and balds occur along parallel bedrock ridges that run the length of the peninsula, in a matrix of maple, oak, pine, and cedar forests. In 2023, the Nature Conservancy (TNC) contracted Michigan Natural Features Inventory (MNFI) to complete natural community surveys in their recently purchased 32,451-acre Keweenaw Heartlands Project Area (KHPA), as the second phase of a three-phase process including natural community mapping (Phase I) and forest canopy structural and condition assessment (Phase III). Natural community surveys primarily focused on documenting high-quality natural community occurrences to assist with conservation planning, and also included documenting rare plant occurrences and ground-truthing the natural community mapping conducted in Phase I.

We utilized a combination of desktop analysis and field surveys to identify, delineate, and assess natural communities. First, we prioritized field surveys by analyzing spatial data, targeting bedrock communities (e.g. glades, cliffs, and balds), large blocks of mature upland and swamp forest, and open wetlands with minimal hydrologic disruptions. Within each priority survey area we surveyed, we classified natural communities following the Michigan Natural Community Classification. While conducting surveys, we delineated boundaries and assessed the ecological integrity of natural communities following Natural Heritage methodology, which considers three factors: size, landscape context, and condition.

We conducted surveys in 47 of the 106 site leads identified as priority survey areas. Through these surveys we documented or updated 38 natural community occurrences representing 12 natural community types, including 1 bog, 1 boreal forest, 1 dry northern forest, 3 dry-mesic northern forests, 5 mesic northern forests, 1 northern bald, 2 northern fens, 2 northern wet meadows, 2 poor conifer swamps, 1 poor fen, 5 rich conifer swamps, 3 volcanic bedrock glades, and 11 volcanic cliffs. These high-quality natural communities cover 597 hectares (1,476 acres) or 4.5 % of the KHPA. We provide detailed descriptions of each of these 38 natural communities. For sites we surveyed that were not delineated as high-quality natural communities, we provide general habitat descriptions. We also provide recommendations for future surveys in additional sites with the potential to support high-quality natural communities.

Finally, we documented 17 occurrences of eight rare plant species, including green spleenwort (*Asplenium viride*, Special Concern; one update), Ross' sedge (*Carex rossii*, State Threatened; five new), blue-lips (*Collinsia parviflora*, Special Concern; one update, one new), Douglas' hawthorn (*Crataegus douglasii*, Special Concern; one update), male fern (*Dryopteris filix-mas*, Special Concern; one new), fragrant fern (*Dryopteris fragrans*, Special Concern; two new), blue rye (*Elymus glaucus*, Special Concern; two new), and woodland cudweed (*Omalotheca sylvatica*, State Threatened; three new).

The Keweenaw Peninsula is a region of considerable conservation value supporting numerous globally rare bedrock community types, large tracts of high-quality forest and wetlands, and high concentrations of rare plant and animal populations. The protection of the KHPA more than doubles Keweenaw County conservation lands from 22,780 to 55,230 acres. Moving forward, conservation planning in the KHPA will occur in the context of continuing forestry and diverse recreational activities in the region, and we hope that conservation planning also provides the highest levels of protection for biodiversity as possible. The conservation of the unique concentration of imperiled and vulnerable natural communities represents a once in a generation conservation opportunity.

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Tyler Bassett (Michigan Natural Features Inventory), Erin Johnston (Keweenaw Bay Indian Community), and Stephanie Kyriakakis (The Nature Conservancy), after surveying mesic northern forest, volcanic bedrock glade, and volcanic cliff at East Bluff. Photo by S. Kyriakakis.

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INTRODUCTION

The Keweenaw Peninsula features ancient volcanic rocks, cascading streams, scenic Lake Superior coastlines and lush forests that harbor globally rare plants and wildlife, as well as a wide variety of historic and culturally significant features and artifacts. In October 2022, The Nature Conservancy (TNC) purchased 32,541 acres in the Keweenaw Peninsula known as the Keweenaw Heartlands, over four parcels (The Point, Harbor View, Keweenaw Alpine, and Little Betsy Shoreline) (Figure 1). The Keweenaw Heartlands Project Area (KHPA) represents a largely intact forested landscape punctuated with ecosystems from open peatlands to ridgetop bedrock glades. As such, these lands are vital for conserving unique biodiversity alongside several millennia of cultural history, and safeguarding ecosystem services by protecting water quality in the Great Lakes, sequestering atmospheric carbon, and countless additional ways.

TNC sees the KPHA as “an opportunity to model an approach that balances the use and management of natural lands for people AND nature, to acknowledge a region’s cultural history and address future community needs” (TNC 2023). TNC contracted Michigan Natural Features Inventory (MNFI) to complete Focal Community Surveys. These surveys are Phase II of a three-phase approach for establishing a baseline data set to guide management of the KPHA, including Natural Community Mapping (Phase I) and Forest Canopy Structural and Condition Assessment (Phase III). These Focal Community Surveys involve applying Natural Heritage Methodology to assess the ecological integrity of the KPHA. These surveys focused on documenting high-quality natural community and rare plant occurrences, in addition to ground-truthing of the Natural Community Mapping conducted in Phase I.

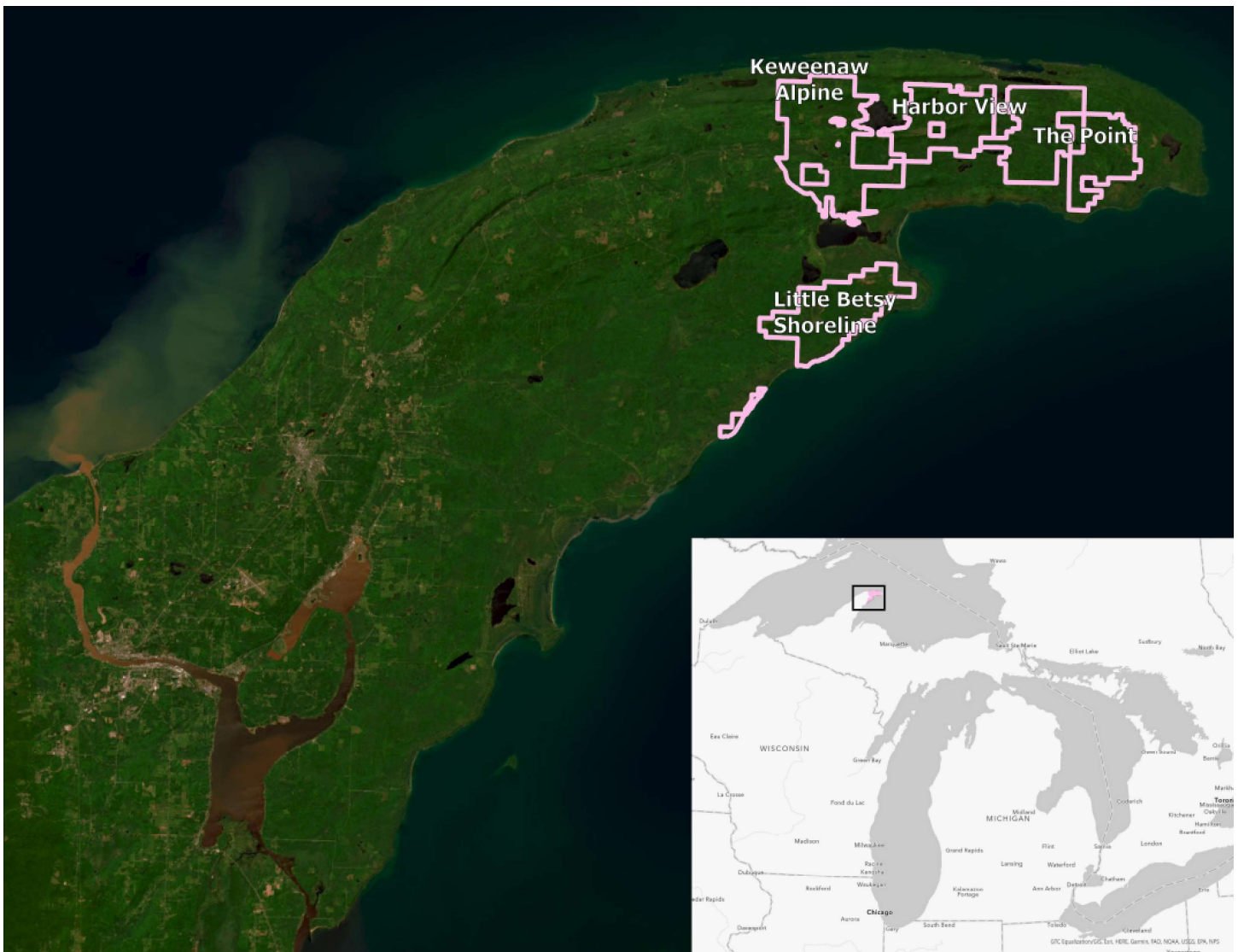


Figure 1. Four parcels of the Keweenaw Heartlands Project Area.

Landscape context

The Keweenaw Peninsula in Michigan's Upper Peninsula is a unique formation with exposed volcanic (basaltic and conglomerate) bedrock that is over one billion years old (Davis and Paces 1990). Parallel bedrock ridges run the length of the peninsula. A high concentration of primary natural community types is associated with these geologic features, including volcanic bedrock lakeshore, volcanic cobble shore, volcanic lakeshore cliff, volcanic bedrock glade, volcanic cliff, and northern bald (MNFI 2023). Other natural community types include boreal forest, dry-mesic northern forest, mesic northern forest, northern fen, northern wet meadow, rich conifer swamp, bog, poor conifer swamp, and wooded dune and swale complex, among others. Populations of black bear (*Ursus americanus*), gray wolf (*Canis lupus*), North American river otter (*Lontra canadensis*), moose (*Alces alces*), and beaver (*Castor canadensis*) persist in this landscape due to the concentration of high-quality natural communities and the extensive natural cover.

The Precambrian bedrock is primarily Keweenaw basalt and conglomerates (Copper Harbor Conglomerate), but also includes sedimentary bedrock, such as including Freda sandstone and Nonesuch shale (Dorr and Eschman 1984, Reed and Daniels 1987). Erosion-resistant conglomerates and amygdaloidal basalt form the steep ridges of

the sub-subsection, between which veins of more easily eroded volcanic bedrock supports lakes and wetlands (Albert 1995). The Lake Superior shoreline also consists of erosion-resistant volcanic bedrock. Copper-rich lava flows, common on the Keweenaw Peninsula, were extensively mined. The Nonesuch shale also contains copper, but often in concentrations too low for profitable mining. The volcanic ridges of the Keweenaw Peninsula are part of the Lake Superior syncline, a series of folds resulting from compression of bedrock. The southern end of the Lake Superior syncline extends from tip of the Keweenaw Peninsula of Michigan to northern Wisconsin, while Isle Royale is located at the northern end (Reed and Daniels 1987).

Historically, these ridges and associated slopes primarily supported mesic northern forest (sugar maple-yellow birch), as well as pockets of pine-dominated dry-mesic or dry northern forest generally with southern exposure and boreal forest (spruce-fire-cedar) with northern exposure (Comer et al. 1995). Proximity to the Great Lakes results in climatic conditions characterized by low summer temperatures and high levels of humidity, snowfall, and summer fog and mist (Cohen 2010). As a result, white cedar, balsam fir, and white spruce, typical dominants in boreal forest, were consistent components of most upland forests. Black spruce, white-cedar, and



Moss-covered chunk of conglomerate bedrock. Photo by T.J. Bassett.

tamarack-dominated swamps occurred in localized depressions between bedrock ridges, and along the northern shoreline where soils are poorly drained till over bedrock. White cedar, hemlock, and balsam fir also dominated poorly drained parts of the sand lake plain west of Eagle Harbor, where jack pine grew on excessively drained sand dunes.

The unique geologic conditions have also led to a high concentration of copper near the earth's surface. Copper was mined for millennia by indigenous cultures which seasonally occupied the Keweenaw but apparently did not have permanent, year-round settlements in the area (Martin 1999). European cultures extracted copper at an industrial scale beginning in the mid-1800s (Albert 1995). This corresponded with timber clearing largely for building the underground mines, in particular white and red pine. Stumps from this primary clearing event are evident across the landscape, as pine stumps resist decay. Char from fires that followed widespread land clearing is evident on many of these ancient white pine stumps. These fires may have contributed to preserving the stumps. The oldest remaining forests are mature second growth and are largely restricted to the steepest topography. The exception is Estivant Pines, an old-growth dry-mesic northern forest along a prominent ridgeline that runs through the center of the KHPA.

Focused natural community surveys

In summer 2023, we conducted Focused Natural Community Surveys and other biodiversity-focused surveys, to identify the most vital conservation areas in the KHPA. Identifying, conserving, and managing

representative natural communities is critical to biodiversity conservation because native organisms are best adapted to environmental and biotic forces with which they have survived and evolved over millennia (Cohen et al. 2015). Ecological evaluations are also important for facilitating site-level decisions about prioritizing management objectives to conserve native biodiversity, evaluating the success of restoration actions, and informing landscape-level planning efforts. MNFI's natural community classification recognizes 77 natural community types in Michigan (Kost et al. 2007, Cohen et al. 2015). A natural community is defined as an assemblage of interacting plants, animals, and other organisms that repeatedly occurs 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. Historically, Indigenous Peoples were an integral part of natural communities throughout the Great Lakes region with many natural communities being maintained by native management practices such as cultural fire, wildlife management, and planting and harvesting plants. The interactions between Indigenous cultures and their landscape were widespread, sophisticated, and central to maintaining historical abundances of biodiversity (Stewart 2009). Biodiversity is most easily and effectively protected by preventing sites that support high-quality natural communities from degrading. This ecological evaluation is aimed at protecting the diverse and unique landscape and to prevent degradation of the most important habitats and the rare species that occupy them.



A large white pine stump from 1800s. Note fire char in lower right. Photo by J.M. Lincoln.

METHODS

We conducted field surveys of the KHPA from June 21-July 1 and August 2-10, 2023. The primary priority was to document high-quality natural communities to facilitate setting conservation priorities for the KHPA. A secondary priority was to collect additional data to more fully describe ecological conditions within the KHPA, in particular by opportunistically documenting rare plant species when encountered, and to ground-truth a cover type classification map provided by TNC.

Natural community surveys

We utilized a combination of desktop analysis and field surveys to identify, delineate, and assess natural communities. First, we prioritized field surveys by analyzing spatial data. We identified sites with the potential to support high-quality natural communities by interpreting vegetation signatures in current and historical aerial imagery and topographical signatures in digital elevation models (Figure 2). We refined these interpretations using existing biodiversity and vegetation data, including rare species and natural community data in Michigan's

Natural Heritage Database (MNFI 2023), and forest stand descriptions provided by TNC. Specifically, we delineated sites with the potential to support primary bedrock communities (e.g. glades, cliffs, and balds), large blocks of mature upland and swamp forest, and open wetlands with minimal road crossings and beaver dams. We then assigned each site to high, medium and low priority for surveys based on the conservation value of each potential natural community, favoring sites adjacent to other known and potential high-quality areas (Table A1: Figures A1-8). To assess the conservation value, we used the global and subnational (i.e., state-level) conservation rank (G-rank and S-rank) of each natural community, which ranges from critically imperiled (G1 and S1) to secure (G5 and S5), and may include additional ranks (e.g., GU, or globally unrankable) (NatureServe 2002; Tables A2, A3). For example, sites with the potential to support volcanic cliff (G4G5, S2), volcanic bedrock glade (GU, S2), and northern bald (GU, S1) were given the highest priority.



Figure 2. Digital elevation model with hillshade effect of Mt Voodoo showing steep topography (dark shading) indicating the potential for bedrock communities such as volcanic cliff, volcanic bedrock glade, or northern bald.

Within each priority survey area we surveyed, we determined the identity, boundaries, and ecological integrity of each natural community. We assessed the ecological integrity of natural communities following Natural Heritage methodology, which considers three factors: size, landscape context, and condition (Faber-Langendoen et al. 2008, 2015). If a site meets defined requirements for these three criteria (MNFI 1988), it is categorized as an element occurrence (EO) of that specific natural community type. An element occurrence is an area of land or water where an element of biodiversity (rare species or natural community) currently or historically occurred. Each EO, which may be comprised of multiple observations of a species or community through space or time, is given a unique numeric identifier, the EOID and tracked in the Michigan Natural Heritage Database (MNFI 2023). Each EO is assigned a rank from A (Excellent estimated viability/ecological integrity) to D (Poor estimated viability/ecological integrity) (Table A4). Condition is based upon several biotic (e.g., species composition and diversity, forest canopy closure, typical age and diameter at breast height

[DBH] of dominant trees, biological threats such as invasive species and threats) and abiotic (e.g., soil characteristics, hydrology, slope, and aspect) factors that may vary among different natural communities. The same factors that define condition also help define the identity of natural communities, and the boundaries between them.

An important tool for assessing condition is conducting a Floristic Quality Assessment (FQA) for each natural community (Reznicek et al. 2014, Freyman et al. 2016). The FQA utilizes plant species composition to derive the Floristic Quality Index (FQI). The FQI is a quantitative metric of habitat quality that can be used as a relatively objective comparison among natural community occurrences of the same type. Drawing upon expert consensus among botanists familiar with the flora of Michigan, each vascular plant species native to Michigan has been assigned an a priori coefficient of conservatism (C-value) that ranges from 0 to 10 on a scale of increasing conservatism or fidelity to pre-European colonization habitats (Reznicek et al. 2014).



TNC's Doug Pearsall assisting with data collection in the Montreal River Boreal Forest. Photo by J.M. Lincoln.

Plant species with a C-value of 7 to 10 are considered highly conservative with a strong fidelity to specific, quality habitats (Herman et al. 2001). A C-value of 4 to 6 indicates moderate conservatism and a C-value of 1 to 3 indicates low or no conservatism (e.g., ruderal species). Non-native species were given a C-value of 0 for these calculations.

We calculated FQI for each natural community occurrence as:

$$FQI = \bar{C} \times \sqrt{n}$$

where \bar{C} = mean C-value and n = species richness. Michigan sites with an FQI of 35 or greater possess sufficient conservatism and richness that they are considered floristically important from a statewide perspective (Herman et al. 2001). FQI scores greater than 50 indicate exceptional sites with extremely high conservation value (Herman et al. 2001). Mean C-values may represent a less biased indicator of relative conservation value and are provided with conservation metrics (Matthews et al. 2005, Slaughter et al. 2015). Tracking changes to the FQI or Mean C-value of a site following biodiversity stewardship is a useful means of evaluating the success of management.

Documenting rare plant species

We documented rare plant species encountered while conducting natural community surveys. For each rare plant species, we collected data on population size, spatial distribution, and habitat, including associated species and edaphic conditions. Following Natural Heritage Methodology, we documented each rare plant EO in the Michigan Natural Heritage Database (MNFI 2023) and assigned each EO an EO rank.

Ground-truthing natural community map

We collected data to ground-truth a natural community map that TNC provided. This map, developed by Dr. Parth Bhatt at Michigan Technological University, was developed using various spatial data layers and machine learning to classify existing land cover in the KHPA according to the MNFI Natural Community Classification (Kost 2007, Cohen et al. 2015). As feasible while conducting natural community surveys, we confirmed boundaries and classifications, or advised revisions (i.e., boundary adjustments or reclassifications). We do not include results in this report, and instead have provided TNC with a data layer summarizing findings.



Pale vetchling, a conservative plant species (C=8) observed in volcanic cliff. Photo by T.J. Bassett.

RESULTS

We conducted surveys in 47 of the 106 identified site leads, resulting in documenting or updating 38 natural community EOs representing 12 natural community types (Table 1, Figure 3). Where EO criteria were not met, we generally described conditions for 22 communities in 19 priority survey areas (Table 2). We also recommend surveys in 43 priority survey areas and one newly identified site (Table 3). Finally, we documented 17 EOs of eight rare plant species (Table 4). Data compiled on these EOs were entered into MNFI's Natural Heritage Database (MNFI 2023) and are summarized here.

Natural community surveys

We documented 37 new natural community EO and updated one existing natural community EOs in the KHPA, including one bog, one boreal forest, one dry northern forest, three dry-mesic northern forests,

five mesic northern forests, one northern bald, two northern fens, two northern wet meadows, two poor conifer swamps, one poor fen, five rich conifer swamps, three volcanic bedrock glades, and 11 volcanic bedrock cliffs (Table 1). These high-quality natural communities cover 1476 acres or 4.5 % of the KHPA. The following site summaries contain a detailed discussion for each of the 38 natural community EOs organized by the 4 separate parcels then alphabetically by natural community type. Some EOs are grouped into complexes and are organized alphabetically by natural community type within complex, and ordered within each parcel by the first community listed in that complex. Refer to Figures 4-7 for natural community maps of Keweenaw Alpine, Harbor View, Little Betsy Shoreline, and The Point, respectively.



McKenzie Heights Northern Bald. This community type is critically imperiled and this is one of only ten northern balds documented in Michigan. Photo by J.M. Lincoln.

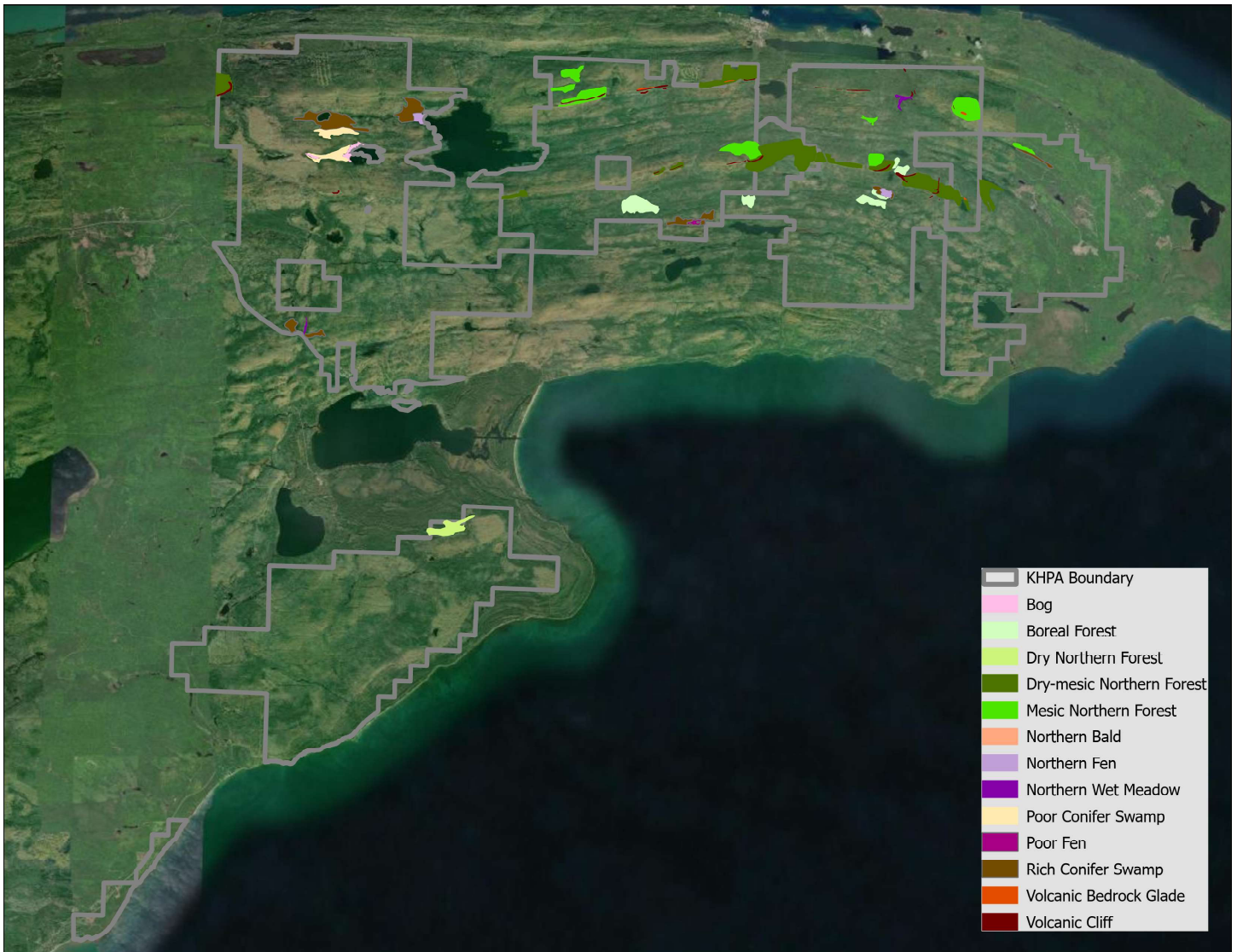


Figure 3. Natural community EOs of the Keweenaw Heartlands Project Area.



There were concentrations of natural communities throughout the project areas, including this northern fen, surrounded by rich conifer swamp, and high-quality dry-mesic northern forest and volcanic cliff in the background. Photo by J.M. Lincoln

Table 1. Natural community element occurrences in the Keweenaw Heartlands Project Area.

EOID	Site Name	Community Type	Priority Survey Area	Size (Acres)	Overall Rank	Total FQI	S-Rank
Alpine							
26696	Meadow Lake Bog	Bog	46	18.7	AB	43.7	S4
26703	Silver River Forest	Dry-mesic Northern Forest	87	48.7	BC	34.9	S3
26902	Medora Fen	Northern Fen	11	12.6	BC	37.9	S3
26906	Bohemia West Meadow	Northern Wet Meadow	76	4.2	C	19.2	S4
26701	Meadow Lake Swamp	Poor Conifer Swamp	46	44.4	AB	31.2	S4
26929	Gull Lake Spruce Swamp	Poor Conifer Swamp	47	39.2	B	33.3	S4
26900	Gull-Medora Cedar Swamp	Rich Conifer Swamp	11, 47	165	AB	57.3	S3
26905	Bohemia West Swamp	Rich Conifer Swamp	76	30.5	BC	36.1	S3
26702	Silver River Cliffs	Volcanic Cliff	5	6.5	AB	34.5	S2
26930	Little Mandan Cliff	Volcanic Cliff	79	1.7	CD	30.2	S2
Harbor View							
26700	Montreal River Boreal Forest*	Boreal Forest	30, 53, 39, 60, 67, 103	158.0	BC	39.0	S3
26683	Keweenaw Lodge Forest	Dry-mesic Northern Forest	51	99.0	BC	30.9	S3
26697	McKenzie Forest	Mesic Northern Forest	4	116.6	B	35.5	S3
26937	Estivant Ridge	Mesic Northern Forest	27	72.7	B	25.8	S3
26694	McKenzie Heights	Northern Bald	4	1.0	AB	32.4	S1
26903	Breakfast Lake West Fen	Poor Fen	98	8.5	BC	42.9	S3
26964	Breakfast Lake West Swamp	Rich Conifer Swamp	98	41.2	B	35.3	S3
26691	Keweenaw Lodge Glade	Volcanic Bedrock Glade	70	1.3	CD	23.7	S2
26693	Bausano Glade	Volcanic Bedrock Glade	71	3.3	BC	25.0	S2
26690	Keweenaw Lodge Cliff	Volcanic Cliff	70	1.5	BC	28.2	S2
26692	Bausano Bluffs	Volcanic Cliff	71	8.8	B	32.4	S2
26695	McKenzie Cliffs	Volcanic Cliff	4	7.2	AB	37.1	S2
26934	Estivant Cliffs West	Volcanic Cliff	27	8.8	B	35.3	S2
Little Betsy							
26704	Little Betsy Forest	Dry Northern Forest	43	61.7	CD	22.9	S3
The Point							
17853	Lost Lake Forest*	Dry-mesic Northern Forest	8, 10, 41, 110, 111	269.0	AB	50.2	S3
27028	Manganese Forest	Mesic Northern Forest	10	24.3	BC	24.6	S3
26907	East Bluff Forest	Mesic Northern Forest	16, 18	98	B	32.6	S3
26705	Secret Ravine	Mesic Northern Forest	97	9.7	C	28.2	S3
26698	Powderhouse Fen	Northern Fen	60	11.4	AB	40.2	S3
26671	Vulcan Creek Meadow	Northern Wet Meadow	64	13.2	B	17.4	S4
26699	Powderhouse Swamp	Rich Conifer Swamp	60	10.2	BC	28.8	S3
27009	Vulcan Headwaters	Rich Conifer Swamp	18	15	C	25.8	S3
26908	East Bluff Glade	Volcanic Bedrock Glade	16	2	BC	29.6	S2
26936	Estivant Cliffs East	Volcanic Cliff	66, 103, 111	15.2	AB	43.8	S2
26670	Vulcan Creek Cliffs	Volcanic Cliff	20	3.2	C	23.1	S2
26924	Vulcan Cliffs West	Volcanic Cliff	65	3.0	C	30.7	S2
26925	East Vein Cliffs	Volcanic Cliff	107, 108	1.4	CD	28.1	S2
26933	East Bluff Cliff	Volcanic Cliff	16	0.4	CD	22.4	S2

*denotes sites that occurred in both The Point and Harbor View

KEWEENAW ALPINE

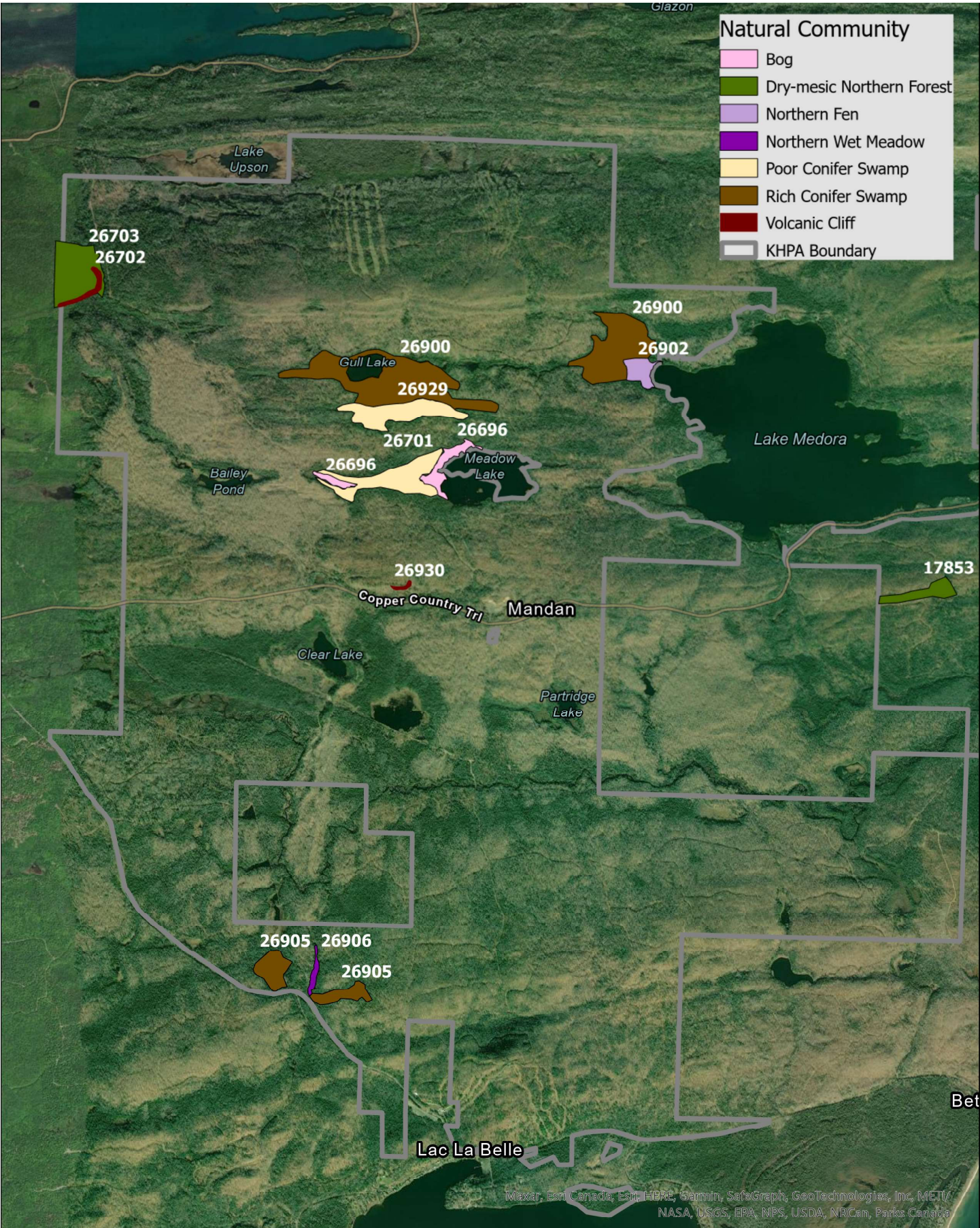


Figure 4. Keweenaw Alpine parcel and natural community EOs.

Meadow Lake Complex – Meadow Lake Bog

Natural Community Type: Bog

Rank: G3G5 S4, vulnerable to secure globally and secure in Michigan

Element Occurrence Rank: AB, excellent to good occurrence

Size: 18.8 acres

Element Occurrence Identification Number: 26696

The wetland complex on the western shoreline of Meadow Lake includes two small zones of bog embedded within a poor conifer swamp. The floating sphagnum bog at lake margin transitions into black spruce (*Picea mariana*) dominated poor conifer swamp. Sweet gale (*Myrica gale*) and beak-rush (*Rhynchospora fusca*) are abundant along lake with wiregrass sedge (*Carex lasiocarpa*), bog sedge (*Carex limosa*), narrow-leaved cotton-grass (*Eriophorum angustifolium*), and arrow grass (*Scheuchzeria palustris*). The soils at the margin of Meadow Lake are acidic (pH 4.5) fibric peats over acidic (pH 4.5) hemic peats to depths greater than 1 m. Away from the lake margin are zones with

pitcher-plant (*Sarracenia purpurea*), small cranberry (*Vaccinium oxycoccos*), and bog-laurel (*Kalmia polifolia*) with leatherleaf (*Chamaedaphne calyculata*) and stunted tamarack (*Larix laricina*) and spruce at the edge of forest. The bog opening away from the lake is very acidic (pH 4 to 4.3) fibric peat to a depth of 15 or 20 cm, over 10 cm of hemic peat, over sapric peat to depth greater than 1 m. At edges of seep areas with open water, soils are neutral (pH 7.0) hemic peats, and the system transitions towards poor fen. This pH gradient locally influences composition and the site is diverse. There were several beaver channels and at least two lodges but these both appear to have been excavated by bears or wolves.



Meadow Lake Bog and Poor Conifer Swamp. Photo by J.M. Lincoln.

Meadow Lake Complex – Meadow Lake Swamp

Natural Community Type: Poor Conifer Swamp

Rank: G4 S4, vulnerable to secure globally and secure in Michigan

Element Occurrence Rank: AB, excellent to good occurrence

Size: 44.4 acres

Element Occurrence Identification Number: 26701

The poor conifer swamp surrounding the Meadow Lake bogs is characterized by a sparse canopy of stunted black spruce with infrequent tamarack and supercanopy white pine (*Pinus strobus*). The swamp features a continuous layer of deep sphagnum moss. A sample of the sphagnum moss was fibric (pH 4.0 to 4.3) to a depth of approximately 5 cm. Below that was hemic peat (pH 4.0 to 4.3) to depth of around 20 or 30 cm, then sapric peats to depth of over 1m and

very acidic (pH 4.0 to 4.3). This supports a continuous low shrub layer with Labrador-tea (*Rhododendron groenlandicum*), Canada blueberry (*Vaccinium myrtilloides*), and bog-laurel (*Kalmia polifolia*). There are a few sedges and few other herbaceous species. White cedar increases in abundance on the upland edge, indicating an intermediate state between rich and poor conifer swamp. Soils here are sapric peats over sands (pH 5.5 to 6.0).



Meadow Lake Poor Conifer Swamp. Photo by J.M. Lincoln.

Silver River Complex – Silver River Forest

Natural Community Type: Dry-mesic Northern Forest

Rank: G4 S3, secure globally and rare or uncommon in Michigan

Element Occurrence Rank: BC, good to fair occurrence

Size: 48.7 acres

Element Occurrence Identification Number: 26703

The Silver River Forest is a sparsely-canopied white pine (*Pinus strobus*) forest on shallow soils over sloping bedrock. This is a second-growth forest with trees consistently around 150-year-old. There are a few old-growth white pine and white cedar (*Thuja occidentalis*) along the steepest slopes near river. One 91.4 cm DBH white pine was aged and estimated to be between 300 and 350 years old.

The subcanopy is predominantly composed of fir (*Abies balsamea*), white cedar, and pine. Old man's beard lichen (*Usnea* sp.) is abundant on fir. Low shrubs are Canadian fly honeysuckle (*Lonicera canadensis*), inland serviceberry (*Amelanchier interior*), and thimbleberry (*Rubus parviflorus*). Blueberries and bilberries (*Vaccinium* spp.) are relatively infrequent though locally dominant along the gorge along the Silver River and at the cliff top. The ground layer is dominated by pipsissewa (*Chimaphila umbellata*), bracken fern (*Pteridium aquilinum*), wild sarsaparilla (*Aralia nudicaulis*), rough-leaved rice-grass (*Oryzopsis asperifolia*), and fibrous-root sedge (*Carex communis*). The highest quality zone occurs along the extreme slope along the river, with the oldest trees and highest diversity of shrubs and

herbaceous species. Cliffs at base of slope drop directly into the river and are very dangerous.

The dry-mesic northern forest shifts towards boreal forest as the slope descends northwards towards Lake Superior where red maple (*Acer rubrum*), paper birch (*Betula papyrifera*), quaking aspen (*Populus tremuloides*), fir and cedar are dominant. The system is strongly influenced by severe weather, shallow soils, drought, and infrequent fire from lightning strike. Pine is not reproducing and a low-frequency historic fire cycle likely regenerated pine. It is unclear the degree to which ignition was by Indigenous people vs. lightning driven. Berry-producing plants (e.g. bilberries and blueberries) are abundant here, and were historically managed by Indigenous people, suggesting potential Indigenous influence. Soils are shallow, 20 cm to bedrock with 1 cm of pine needles and organic duff (pH 7) over dark, fine loam (pH 7). The shallow soils and extreme weather conditions facilitate a patchy canopy and coarse woody debris at several stages of decay. There are zones of intense windthrow with canopy gaps and wind-snapped fir throughout. There are moss-covered logs and rocks due to constant moisture from Lake Superior.



Silver River Dry-mesic Northern Forest. Photo by J.M. Lincoln.



Silver River Dry-mesic Northern Forest. Photo by J.M. Lincoln.

Silver River Complex – Silver River Cliffs

Natural Community Types: Volcanic Cliff

Rank: G4G5 S2, apparently secure to secure globally and imperiled in Michigan

Element Occurrence Rank: AB, excellent to good occurrence

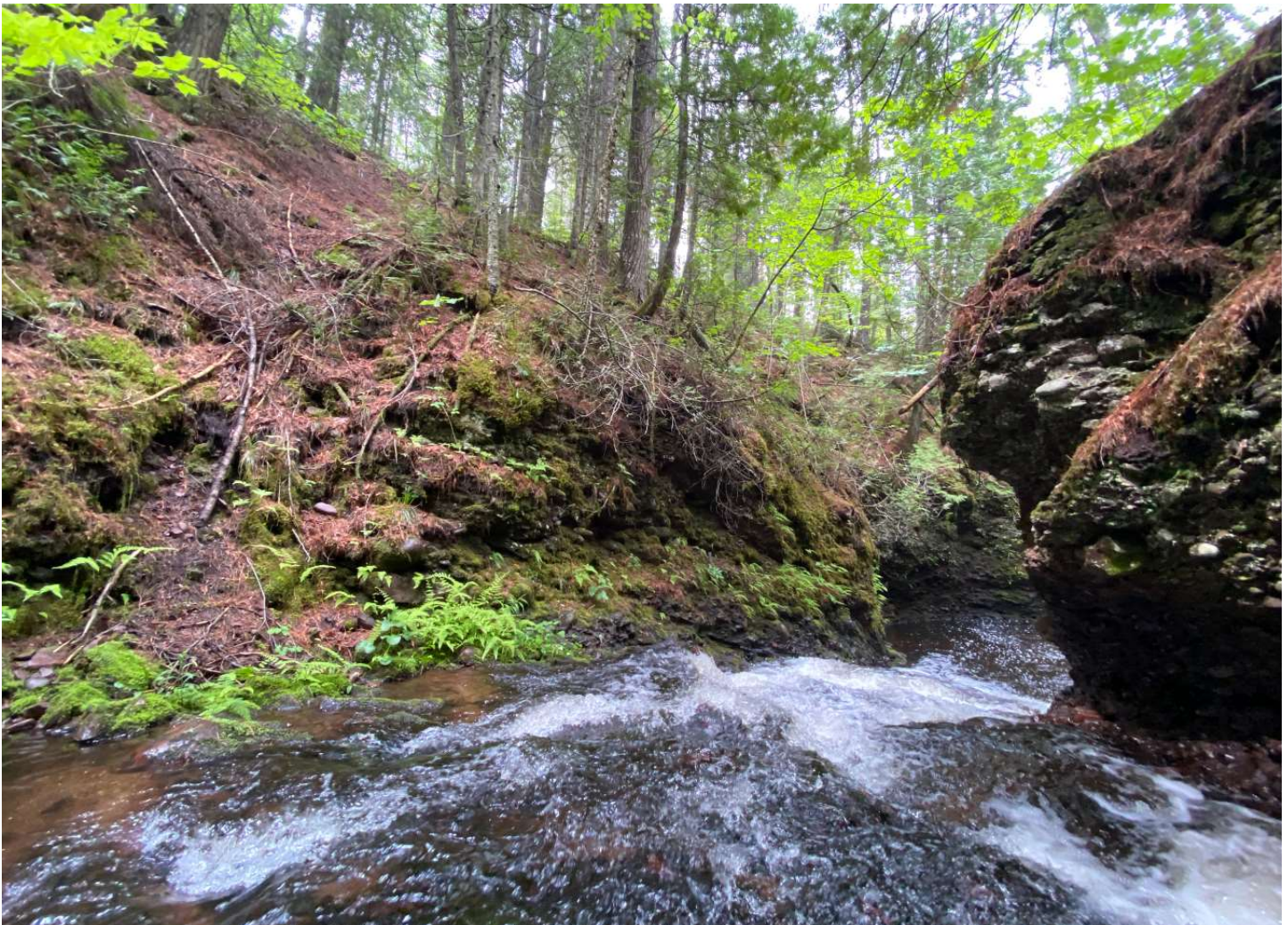
Size: 6.5 acres

Element Occurrence Identification Number: 26702

Below the dry-mesic northern forest along the Silver River is a bench of volcanic conglomerate bedrock cliff above cedar swamp. There is at least 330 m of essentially unbroken, vertical conglomerate cliff face, ranging from 5 to 10 m in height. It extends for an unknown distance to the west onto neighboring property. This is a complex rock face with terraces and cracks forming through erosion, allowing soil to accumulate in areas of the face and in a sloping pile of talus and gravel at the base. Small, stunted trees occur along the face. Tree species include red oak (*Quercus rubra*), northern white cedar (*Thuja occidentalis*), white spruce (*Picea glauca*), and paper birch (*Betula papyrifera*). An 18 cm DBH white cedar was aged to 79 rings. The south facing cliff is covered with moss, *Pulmonaria* lichen, and several fern species, including common polypody (*Polypodium virginianum*), fragile fern (*Cystopteris fragilis*), and

northern holly-fern (*Polystichum lonchitis*). There was 1 cm of decaying lichen and organic deposits (pH 6.5) over 1 cm of weathered rock/loam (pH 6.5) between coarse gravel from conglomerate decay.

The cliff continues along both sides the Silver River, forming a narrow canyon for another 240 m. Within the canyon, the cliff occurs on both sides and forms the wall of the river channel. This area is highly variable and occasionally interrupted by sloughing of the land above. Several rapids over 3 m tall terminate in swirling pools over 2 m deep. The vertical rock faces are between 2 and 12 m tall and often covered with moss and several fern species, including bulblet fern (*Cystopteris bulbifera*), maidenhair spleenwort (*Asplenium trichomanes*), smooth cliff-brake (*Pellaea glabella*), and a small population of the Special Concern green spleenwort (*A. viride*).



Silver River Volcanic Cliff. Photo by J.M. Lincoln.



Special Concern green spleenwort on Silver River Cliff. Photo by J.M. Lincoln.



Silver River Dry-mesic Northern Forest. Photo by J.M. Lincoln.

Gull-Medora Complex - Medora Fen

Natural Community Type: Northern Fen

Rank: G3 S3, vulnerable globally and in Michigan

Element Occurrence Rank: BC, good to fair occurrence

Size: 37.9 acres

Element Occurrence Identification Number: 26902

Medora Fen occurs along the western inlet to Lake Medora. The vascular plant community is characterized by an even species distribution and is dominated by a mixture of low shrubs, primarily sweet gale (*Myrica gale*) and leatherleaf (*Chamaedaphne calyculata*), as well as tussock sedge (*Carex stricta*) and wiregrass sedge (*Carex lasiocarpa*). The low shrub community is abundant, diverse and even, with winterberry (*Ilex verticillata*), bog rosemary (*Andromeda glaucophylla*), red-osier dogwood (*Cornus sericea*), speckled alder (*Alnus incana*), Labrador-tea (*Rhododendron groelandicum*), and many others. Species such as red-osier dogwood that are typically 2 m or more in height are short here, under 1 m. The herbaceous component is interspersed with low shrubs, and includes blue-joint grass (*Calamagrostis canadensis*), marsh cinquefoil (*Comarum palustre*), bog buckbean (*Menyanthes trifoliata*), and bog goldenrod (*Solidago uliginosa*). Vertical and horizontal heterogeneity increases to

the west with increasing tree density and height. Microtopography ranges from absent closer to Lake Medora, with increasing hummock formation to the west, supporting advanced tree regeneration. Hummocks are significant, from 0.5 to 1.5 m tall, and support white cedar (*Thuja occidentalis*), black spruce (*Picea mariana*), tamarack (*Larix laricina*), and white pine (*Pinus strobus*). A 16.5 cm DBH white cedar had 54 rings with very even growth due to minimal light competition. A 11.6 cm DBH black spruce had 79 rings. Total tree canopy is estimated at 10-20%. Groundwater discharge from Gull-Medora Cedar Swamp (EOID 26900) to the west culminates in a 5-10 m wide channel at the inlet to Lake Medora, with an aquatic plant community including yellow pond-lily (*Nuphar advena*), Illinois pondweed (*Potamogeton illinoensis*), and white water-lily (*Nymphaea odorata*). The substrate of the fen is a solid peat mat lacking an unstable expanding mat on the edges. Soils are fibric to hemic peat generally to 30 cm, over deep (> 1 m) sapric peat (pH 7.0).



Medora Fen with Gull-Medora Cedar Swamp in background. Note the advancing front of white cedar from the adjacent rich conifer swamp. Photo by T.J. Bassett.

Gull-Medora Complex - Gull Lake Spruce Swamp

Natural Community Type: Poor Conifer Swamp

Rank: G4 S4, apparently secure globally and in Michigan

Element Occurrence Rank: B, fair occurrence

Size: 39.2 acres

Element Occurrence Identification Number: 26929

Gull Lake Spruce Swamp occurs west of Lake Medora in the Gull Lake basin directly south of Mt Voodoo ski hill, where it is associated with a rich conifer swamp (EOID 26900) to the north. Rich conifer swamp surrounds Gull Lake and is fed by multiple springs, and the rich and poor conifer swamps are apparently hydrologically isolated. The transition between poor and rich conifer swamp is abrupt, characterized by a rapid canopy turnover from black spruce (*Picea mariana*) to white cedar (*Thuja occidentalis*) and a shift in the understory from sphagnum moss and low shrubs to the hummocky microtopography typical of cedar swamps.

This swamp has an open canopy structure (40-60% cover), with several openings, and is strongly dominated by black spruce, with canopy trees mostly 10-20 cm DBH. A 19.6 cm DBH black spruce was aged at 240 years. The subcanopy has 30% cover and is dominated by black spruce. There is a prominent (50-70% cover) and diverse low-to-

medium shrub layer dominated by Labrador-tea (*Rhododendron groenlandicum*), mountain holly (*Ilex mucronata*), and leatherleaf (*Chamaedaphne calyculata*). The bog-like groundlayer (90% cover) is dominated by sphagnum mosses, which often form mounds, and three-seeded sedge (*Carex trisperma*). Vascular plant diversity is somewhat low at 28 species, but no non-native species were observed. Soils are sapric peat (pH 4.5-5.0) with some hemic-sphagnum peat, to greater than 1 m. Occasional white cedar and balsam fir (*Abies balsamea*) dominate boreal forest "islands" that punctuate this EO and the adjacent rich conifer swamp, in low ridges mostly concealed underneath the peat. A broad swath in the eastern end of this EO is intermediate between poor and rich conifer swamp and dominated by tall shrubs speckled alder (*Alnus incana*) and mountain holly. This intermediate structure may be due to hydrological disruption from a road along the eastern boundary of the polygon.



Gull Lake Spruce Swamp. Black spruce canopy with black ash subcanopy (left). Soil core showing mixture of sapric, hemic, and fibric peat; typical sphagnum moss ground layer (right). Photos by T.J. Bassett.

Gull-Medora Complex - Gull-Medora Cedar Swamp

Natural Community Type: Rich Conifer Swamp

Rank: G4 S3, apparently secure globally and vulnerable in Michigan

Element Occurrence Rank: AB, excellent to good occurrence

Size: 165 acres

Element Occurrence Identification Number: 26900

This rich conifer swamp occurs in a broad depression associated with Lake Medora between volcanic ridges, including Brockway and Voodoo Mountains to the north. The swamp is in two separate localized depressions, a 62-acre eastern polygon immediately west of Lake Medora, and a 103-acre western polygon associated with Gull Lake. These two patches are hydrologically connected by a narrow channel that originates in the northeastern corner of the western polygon, and bisects the eastern polygon before flowing into Lake Medora. Additional localized depressions occur to the south and west, supporting bog, northern fen, poor conifer swamp, and other peatlands.

White cedar (*Thuja occidentalis*) is the overwhelming dominant in the canopy, which is generally ~ 90% cover, ranging to well below 50% in localized areas such as a large blow down in the north of the eastern polygon. Canopy white cedar range broadly in size from 10.6-90.5 cm DBH, and in age from ~150-300 years old. White and black spruce (*Picea glauca* and *P. mariana*), tamarack (*Larix laricina*), and yellow birch (*Betula allegheniensis*) are locally important in the

canopy. White pine (*Pinus strobus*) is likely reduced compared to historical density, although some old-growth trees remain. Old-growth supercanopy white pine is occasional including a 58.4 cm DBH tree estimated at 300-400 years. A supercanopy of old-growth white (and possibly black) spruce is more abundant, including 23.8 cm and 48.0 cm trees aged at 290 and 350 years, respectively. Younger age classes are present too, including a 12.5 cm DBH tamarack that was aged at 75 years. The subcanopy and tall shrub layers are heterogeneous, about 50% cover overall, with higher density in lower wet peat zones between cedar hummocks and near seeps. These areas are dominated by speckled alder (*Alnus incana*), while red maple (*Acer rubrum*), white cedar, and black ash (*Fraxinus nigra*) are common, at least locally. Three-seeded sedge (*Carex trisperma*), soft-leaf sedge (*Carex disperma*), and bladder sedge (*Carex intumescens*) are common throughout in the ground layer, which is somewhat patchy with a cover of 70%. Sphagnum moss, tussock sedge (*Carex stricta*), and Canada yew (*Taxus canadensis*) are dominant locally. Vascular plant species richness is high at 117 species (115 native), with 92 and



Gull-Medora Cedar Swamp. Photo by T.J. Bassett.

70 species observed in the eastern and western polygons, respectively, as many species are unique to each polygon. Evenness is also high, including notable patchiness in the distribution of most species.

Soils are generally deep, saturated sapric peat (pH 7.0-7.5). Inundation was observed between 20 cm and greater than 1 m, suggesting variation in local groundwater discharge. A soil sample in the western polygon near the boundary with poor conifer swamp was sapric to 40 cm, hemic to 80 cm, fibric peat below that, and slightly acidic (pH ~ 6.8). The transition between rich and poor conifer swamp to the south is abrupt, characterized by a rapid canopy turnover from white cedar to black spruce, and a shift in the understory from the hummocky microtopography typical of cedar swamps to sphagnum mosses and low shrubs.

In addition to a frequently dense canopy of large diameter trees and trees > 200 years old, abundant coarse woody debris of small to large (5-40+ cm) downed cedar suggests old-growth conditions are present. Canopy gaps are occasional localized ash mortality and usually small but include a large blowdown area occur in the eastern polygon. There is notable cedar regeneration in several areas and dense Canada yew zones throughout, suggesting

low deer density. Several low ridgelines are apparent in the hillshade DEM imagery as low linear peaks, in the western polygon and the poor conifer swamp (EOID 26929) to the south, which support small "islands" of boreal forest. The demarcation with poor conifer swamp to the south may be associated with a submerged ridgeline. Cover in the canopy of these inclusions is 70%, dominated by 150-year old white cedar. The subcanopy is dominated by speckled alder, although white cedar is common. The groundlayer has no clear dominant but includes tall bilberry (*Vaccinium membranaceum*), bracken fern (*Pteridium aquilinum*), twinflower (*Linnea borealis*), and balsam fir (*Abies balsamea*). Soils at one island is mildly acidic to neutral sands: O-horizon to 5 cm (pH 6.0-6.4), gray sand (pH 6.5) to 50 cm, red/gray sand (pH 6.5) to 60 cm, and red sand (pH 7.0) to greater than 1 m.

The composition and structure are structured by natural processes, including groundwater hydrology and gap-phase canopy dynamics. Aside from historical removal of old-growth white pine from the canopy, there are no apparent anthropogenic disturbances, and only two non-native species were observed. European swamp thistle (*Cirsium palustre*) is a potential threat to biodiversity, and should be managed where encountered.



Canada yew was locally abundant in Gull-Medora Cedar Swamp. Photo by T.J. Bassett.

Bohemia West Complex – Bohemia West Meadow

Natural Community Type: Northern Wet Meadow

Rank: G4G5 S3, apparently secure to secure globally and apparently secure in Michigan

Element Occurrence Rank: C, fair occurrence

Size: 4.2 acres

Element Occurrence Identification Number: 26906

This northern wet meadow occurs immediately north of Lac LaBelle and northwest of Mount Bohemia, along a stream in a narrow outwash channel bordered by low gradual slopes of young white cedar (*Thuja occidentalis*) and balsam fir (*Abies balsamea*). The stream is fed in part by seeps in the adjacent rich conifer swamp (EOID 26905) and flows north toward the Montreal River. Vegetative cover in the ground layer of the meadow is dense (90-100%), with the characteristic layering seen in wet meadows and other grasslands. This meadow is dominated by wiregrass sedge (*Carex lasiocarpa*), though not strongly. Many other calciphile and generalist graminoids or forbs are common to locally abundant, including yellow sedge (*Carex flava*), blue-joint grass (*Calamagrostis*

canadensis), Joe-pye weed (*Eutrochium maculatum*), northern bugle weed (*Lycopus uniflorus*), and Canada anemone (*Anemone canadensis*). Dense patches of the tall goldenrod (*Solidago altissima*) and common blackberry (*Rubus allegheniensis*), and local dominance of the invasive reed canary grass (*Phalaris arundinacea*), may indicate eutrophication or disturbance from rapid hydrological fluctuations. This meadow is flanked by moderate thickets of speckled alder (*Alnus incana*), locally at 80% cover, but overall 40-50%. The soil, sampled approximately halfway between the stream and upland edge, is sapric peat (pH 7.0-7.5) to 50 cm, over gray inundated sand (pH 7.5-8.0) to 65 cm, over gray inundated to saturated sand (pH 8.0) to 80+ cm.



Bohemia West Meadow. Photo by T.J. Bassett.

Bohemia West Complex – Bohemia West Swamp

Natural Community Type: Rich Conifer Swamp

Rank: G4 S3, apparently secure globally and vulnerable in Michigan

Element Occurrence Rank: BC, good to fair occurrence

Size: 30.5 acres

Element Occurrence Identification Number: 26905

This swamp is comprised of a northwestern and southeast polygon (17.5 and 13.0 acres, respectively), the seepage from which flow north into a confluence before draining into the Montreal River. Canopy coverage is on average 65%, but ranges widely from 40-80%. White cedar (*Thuja occidentalis*) dominates the canopy, DBH mostly 20-50 cm. White spruce (*Picea glauca*) and yellow birch (*Betula allegheniensis*) are locally important in the canopy, especially in the northwestern polygon. Balsam fir (*Abies balsamea*) and white pine (*Pinus strobus*) are rare to infrequent. A 53.7 cm DBH white cedar and a 52.0 cm DBH white spruce were estimated at 194 and 204 years, respectively. A 34.8 cm DBH white cedar had 136 rings. Cover in the subcanopy-shrub layer is variable (especially in the shrub layer), about 60% overall. Microtopography is high due to hummocky islands of cedar-spruce canopy but sparse subcanopy, interspersed within swampy spots and openings with dead ash. Speckled alder (*Alnus incana*) is abundant in swampy spots and dominates the subcanopy. White cedar is abundant to locally dominant, with a high degree of advance regeneration. Other common species include balsam fir and black ash (*Fraxinus nigra*). The groundlayer (40-80%) is equally patchy. Three-seeded sedge (*Carex trisperma*) is abundant overall; white cedar and dwarf raspberry (*Rubus pubescens*) are common;

fowl manna grass (*Glyceria striata*), golden saxifrage (*Chrysosplenium americanum*), and mad-dog skullcap (*Scutellaria lateriflora*) are locally abundant in moist low-lying areas.

Soils are deep, slightly alkaline, sapric peat. A sample in the northwest polygon is sapric peat (pH 7.0-7.5) to greater than 1 m, barely saturated. A sample in the southeastern polygon is sapric peat (pH 7.0) to 75 cm, and saturated sapric peat (pH 7.0-7.5) to greater than 1 m. Coarse woody debris is prominent and large diameter. The adjacent uplands are lightly thinned, 100-yr old mesic forest with a few supercanopy white pine. A 2.5-acre bog or poor conifer swamp inclusion is formed by hydrological disturbance associated with a two-track in the east edge of the northwestern polygon. A thin canopy (30% cover) of 10-25 cm trees in this bog is dominated by black spruce. Common species in lower strata include sphagnum mosses, mountain holly (*Ilex mucronata*), leatherleaf (*Chamaedaphne calyculata*), tussock sedge (*Carex stricta*), small cranberry (*Vaccinium oxycoccos*), false mayflower (*Maianthemum trifoliatum*), bog sedge (*Carex limosa*), star sedge (*Carex echinate*), and few-seeded sedge (*Carex oligosperma*). Soils in this inclusion are hemic peat (pH 4.5-5.0) to ~ 30 cm, sapric peat (pH 6.5) to 70 cm, and saturated to inundated sapric peat (pH 7.0) to greater than 1 m.



Bohemia West Swamp. Photo by T.J. Bassett.

Little Mandan Cliff

Natural Community Type: Volcanic Cliff

Rank: G4G5 S2, apparently secure to secure globally and imperiled in Michigan

Element Occurrence Rank: CD, fair to poor occurrence

Size: 1.7 acres; 10-20 m (33 - 65 ft) high, 230 m (750 ft, 0.14 mi) long

Element Occurrence Identification Number: 26930

This cliff occurs in a broad depression associated with Lake Medora between two volcanic ridges at the tip of Keweenaw peninsula along one of several ridges of basalt and/or conglomerate volcanic bedrock. This cliff ranges from 10-20 m high, and is 230 m long. It is comprised of a steep talus bottom slope of basaltic volcanic bedrock, transitioning to a symmetrical steep cliff grading into outcrop on either end, associated with an adjacent ravine. Embedded in thinly logged mesic to dry-mesic northern forest, the canopy was aged at 140 years and is dense (90% cover), dominated by white pine (*Pinus strobus*) and red oak (*Quercus rubra*) and co-dominated by sugar maple (*Acer saccharum*), with occasional individuals of paper birch (*Betula papyrifera*), yellow birch (*Betula allegheniensis*), and ironwood (*Ostrya virginiana*). Tree diameters generally range from 10-25 cm, with larger individuals of both dominants. The canopy density is due to the somewhat gradual slope allowing for establishment of canopy trees throughout (in addition to above and below): trees along the cliff itself are smaller diameter and canopy height is lower compared to canopy in the surrounding and adjacent forest. The subcanopy is not well differentiated from the canopy and shrub layers. Bush-honeysuckle (*Diervilla lonicera*) and tall bilberry (*Vaccinium membranaceum*) are common in the shrub layer (the latter locally abundant at the very top of cliff). Additional species include low bush blueberry (*Vaccinium angustifolium*), common juniper (*Juniperus communis*), inland serviceberry (*Amelanchier interior*), and mountain maple (*Acer spicatum*). The groundlayer is heterogenous according to slope, aspect, and soil depth and on average 50% cover. Species typical of cliffs are common, including rusty woodsia (*Woodsia ilvensis*), common polypody (*Polypodium virginianum*), fragile fern (*Cystopteris fragilis*), showy goldenrod (*Solidago speciosa*), and smooth pussytoes (*Antennaria parlinii*). Species from the surrounding mesic to dry-mesic northern forest are interspersed, including rough-leaved rice-grass (*Oryzopsis asperifolia*), downy Solomon-seal (*Polygonatum pubescens*), false melic (*Schizachne purpurascens*), and pipsissewa (*Chimaphila umbellata*). Three non-native

species were observed – king devil (*Hieracium caespitosum*), wood bluegrass (*Poa nemoralis*), and common speedwell (*Veronica officinalis*). Wood bluegrass is often invasive in primary communities, and is locally abundant to dominant in portions of this EO. Soils are red sandy loam (pH 5.5) to varying depths depending on slope position. The O-horizon (pH 4.5) is up to 5 cm deep.



Little Mandan Cliff. Photo by T.J. Bassett.

HARBOR VIEW

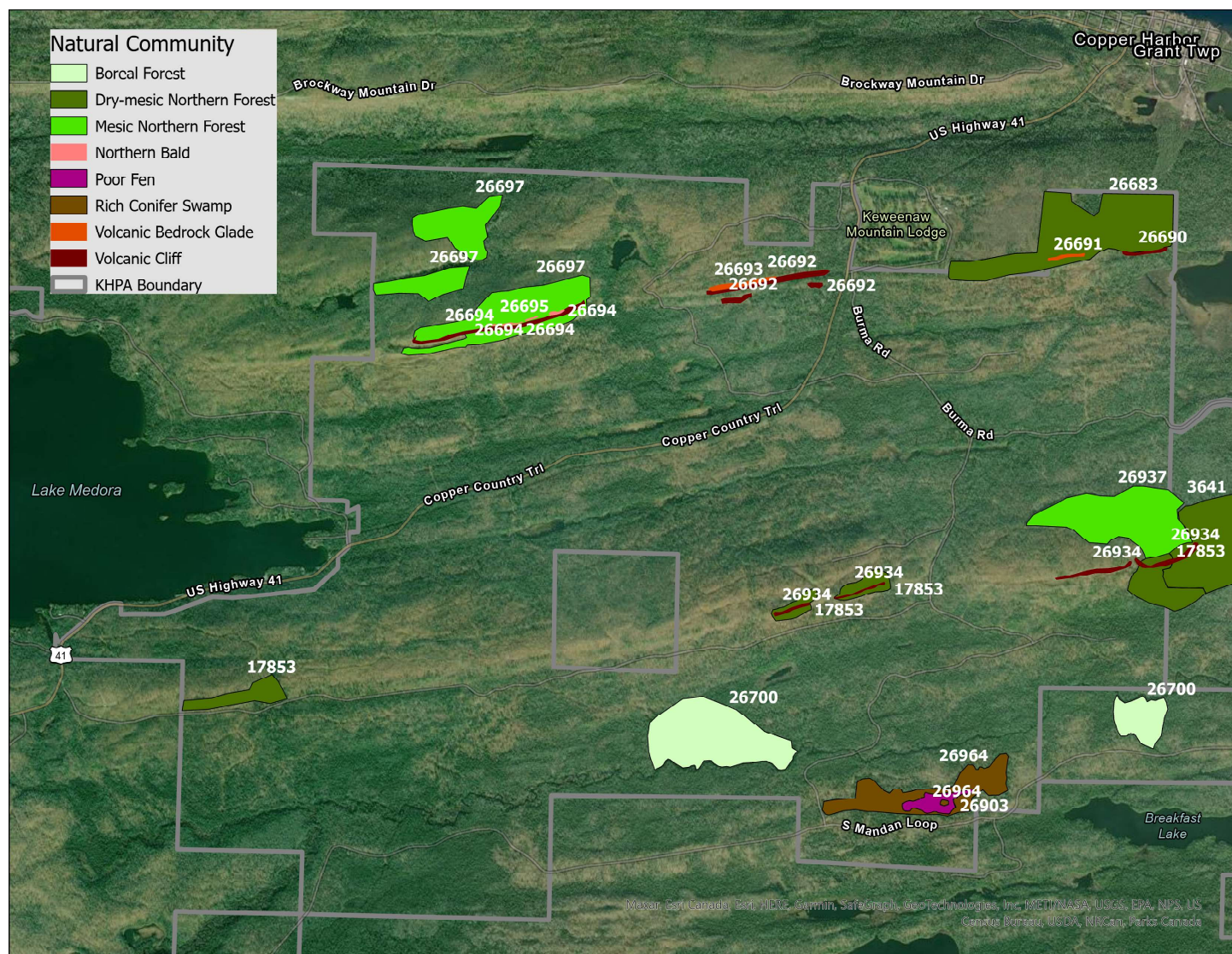


Figure 5. Harbor View Parcel and natural community EOs.



McKenzie Heights Northern Bald and Cliff are embedded in Mesic Northern Forest. Photo by J.M. Lincoln.

Montreal River Boreal Forest

Natural Community Type: Boreal Forest

Rank: GU S3, unrankable globally and vulnerable in Michigan

Element Occurrence Rank: BC, good to fair occurrence

Size: 158.6 acres

Element Occurrence Identification Number: 26700

This boreal forest is distributed among six polygons (6.9-75.3 acres, mean = 26.5 acres) occurring in slopes primarily along the Montreal River corridor. The sparse canopy is dominated by white cedar (*Thuja occidentalis*) with infrequent supercanopy white pine (*Pinus strobus*), white spruce (*Picea glauca*), and quaking aspen (*Populus tremuloides*). Other canopy associates include occasional paper birch (*Betula papyrifera*), red maple (*Acer rubrum*), and sugar maple (*A. saccharum*). Yellow birch (*Betula allegheniensis*) and balsam fir (*Abies balsamea*) are uncommon in the canopy. Typical canopy white cedar range from 30 to 60 cm DBH and are around 150 years old, though trees of this size can range widely in age, up to an estimated 400 years old. One 54.0 cm DBH white cedar was estimated to be 308. Another

white cedar with an 86.4 cm DBH was estimated to be between 360 and 440 years old (with 191 rings on 18.5 cm of core). A very large and apparently healthy white cedar had a diameter of 121.2 cm and was the largest individual of the species observed in the KHPA. Similarly, some of the largest surviving white pine in the KHPA occurred in this boreal forest. Most supercanopy white pine occur along the river and were between 60 and 80 cm DBH and estimated to be about 200 to 250 years old but several were over 90 cm and the largest was 110.8 cm. The subcanopy is sparse with fir, white cedar, paper birch, red maple, white spruce, and sugar maple. Shrubs are infrequent and include beaked hazelnut (*Corylus cornuta*), mountain maple (*Acer spicatum*), Canadian fly honeysuckle (*Lonicera canadensis*), and thimbleberry



Montreal River Boreal Forest occurs along the edges of the Montreal River. Photo by J.M. Lincoln.

(*Rubus parviflorus*). The herbaceous layer is typically sparse but locally dominant with rough-leaved rice-grass (*Oryzopsis asperifolia*), bracken fern (*Pteridium aquilinum*), twin-flower (*Linnaea borealis*), bladder sedge (*Carex intumescens*), star-flower (*Trientalis borealis*), goldthread (*Coptis trifolia*), bluebead-lily (*Clintonia borealis*). Within the upland forest are inclusions of rich conifer swamp with white cedar in the canopy with black ash (*Fraxinus nigra*) in the subcanopy. These areas of permanently saturated soils are typically small and linear and correspond to depressions in the underlying bedrock.

This boreal forest features thin soils over bedrock. The O-horizon is 1 cm of needle duff (pH 6.5) with worm frass, under deciduous leaf litter (predominantly red maple). The A-horizon is loam with organics and small bits of gravel from weathered bedrock (pH 6.0 to 6.5) to a depth of 10 cm to underlying volcanic bedrock. The system is influenced by windthrow and infrequent fire that is likely caused by lightning strike. There are likely additional areas of boreal forest adjacent to the mapped natural community that are worthy of inclusion and further surveys are recommended (see Table 3).



The Montreal River Boreal Forest had some extremely large trees, including this 121 cm DBH white cedar. Photo by J.M. Lincoln.



The Montreal River Boreal Forest. Photo by J.M. Lincoln.

Keweenaw Lodge Complex – Keweenaw Lodge Forest

Natural Community Type: Dry-mesic Northern Forest

Rank: G4 S3, apparently secure globally and vulnerable in Michigan

Element Occurrence Rank: BC, good to fair occurrence

Size: 99.1 acres

Element Occurrence Identification Number: 26683

The Keweenaw Lodge Complex occurs on a large bedrock feature with a ridgeline at the south end that runs east west. North of the ridge, the feature is north facing and slopes gradually towards Lake Superior. This slope supports high-quality dry-mesic northern forest. The southern edge of this feature transitions abruptly to cliff along the eastern end and glade in the west-central portion where there is not unbroken vertical cliff face.

The forest is characterized by a supercanopy of white pine (*Pinus strobus*) and infrequent white spruce (*Picea glauca*) over a canopy (30 to 60% cover) of pine and quaking aspen (*Populus tremuloides*) and infrequently red oak (*Quercus rubra*) and paper birch

(*Betula papyrifera*). Quaking aspen is locally dominant with white cedar (*Thuja occidentalis*) in the subcanopy and increasingly abundant towards the lower slope where the system transitions to boreal forest. This is a second growth forest with trees consistently around 135-year-old, with no recent stumps. White pine is the most dominant species and typically ranges in size from 40 to 80 cm. A 43.2 cm DBH pine had 135 rings. A 47.8 cm DBH quaking aspen had 134 rings. A 43.2 cm DBH white spruce had 114 rings. Very old white or red pine stumps persist from the original 1800s clearing. A charred stump from the 1800s clearing event had a 79.2 cm diameter. The core from the stump was 17 cm and had 135 rings and was estimated to be about 250 years old.



Keweenaw Lodge Forest. Photo by J.M. Lincoln.

There were numerous trees that were struck by lightning and shallow soils and extreme weather conditions facilitate windthrow such that there is abundant coarse woody debris at several stages of decay. The bedrock outcrops and patchy canopy lead to a locally extensive shrub and herbaceous layers. The system is strongly influenced by severe weather, shallow soils, drought, and infrequent fire from lightning strike. Pine is not reproducing and a low-frequency historic fire cycle likely regenerated

pine. It is unclear the degree to which ignition was by Indigenous people vs. lightning driven. Berry-producing plants (e.g. bilberries and blueberries) are abundant here, and were historically managed by Indigenous people, suggesting potential Indigenous influence. Soils are thin and occur on conglomerate outcrops. Leaf litter and needle duff is acidic (pH 5.5) and 2 cm deep, over gravelly loam (pH 5.5 to 6.0), 4 cm deep over conglomerate bedrock.



Keweenaw Lodge Forest, from drone looking toward Copper Harbor. Photo by J.M. Lincoln.

Keweenaw Lodge Complex – Keweenaw Lodge Glade

Natural Community Type: Volcanic Bedrock Glade

Rank: GU S2, unrankable globally and imperiled in Michigan

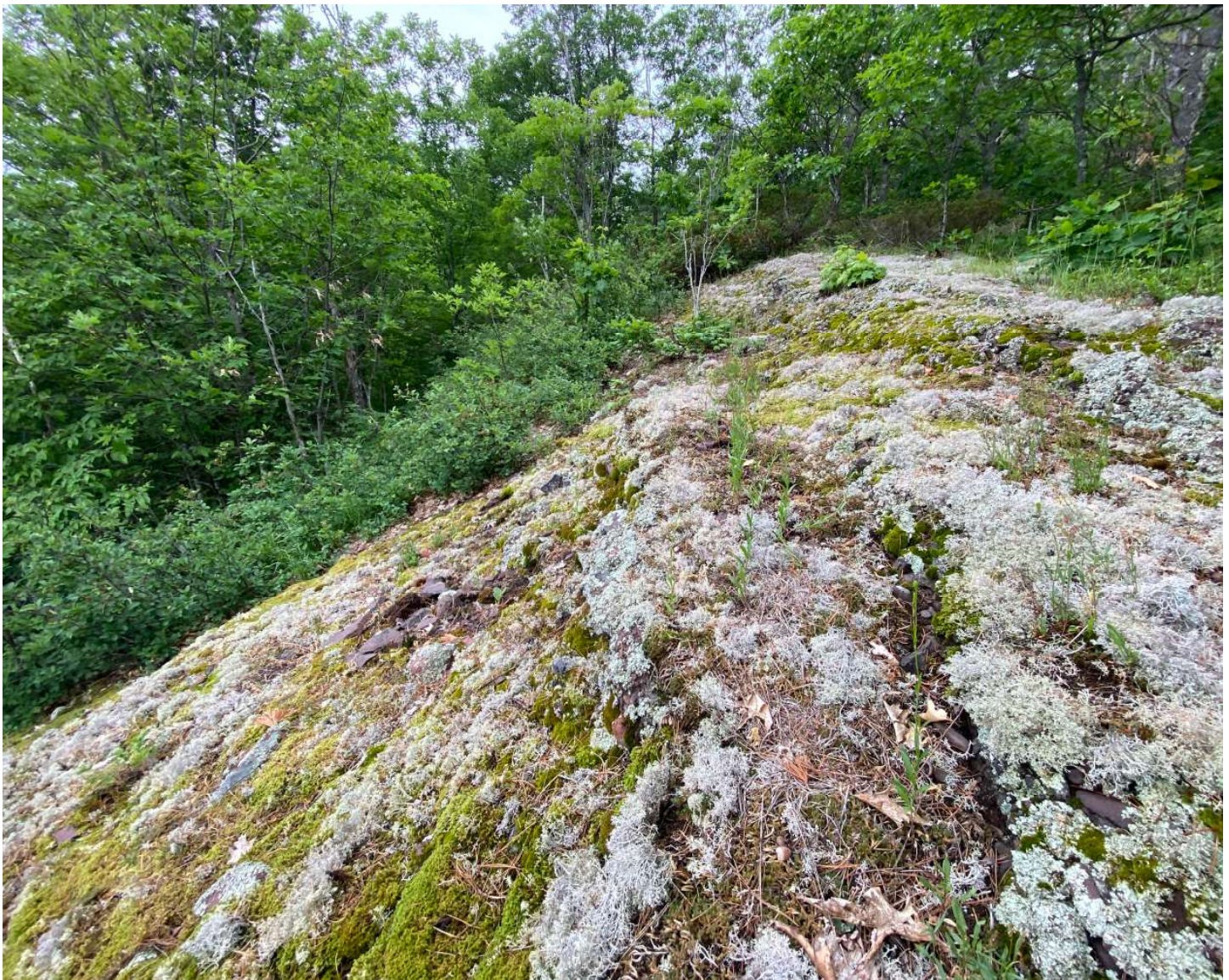
Element Occurrence Rank: CD, fair to poor occurrence

Size: 1.2 acres

Element Occurrence Identification Number: 26691

This glade occurs as a series of rocky openings above a tall outcrop ridge embedded in the dry-mesic northern forest EO. The glade is 250 m long and 10 to 15 m wide. Much of the site is unvegetated and covered in reindeer lichen (*Cladonia* spp.) and various mosses. The low shrub layer is patchy to locally dense with low sweet blueberry (*Vaccinium angustifolium*), common juniper (*Juniperus communis*), shadbush serviceberry (*Amelanchier spicata*), smooth sumac (*Rhus glabra*), and bearberry (*Arctostaphylos uva-ursi*). The latter species is locally dominant. Herbaceous species are locally abundant to infrequent, including Pennsylvania sedge (*Carex pensylvanica*), bastard-toadflax (*Comandra*

umbellata), pink corydalis (*Capnoides sempervirens*), wild-basil (*Clinopodium vulgare*), and sleepy catchfly (*Silene antirrhina*). Invasive species are frequent at the margins of the glade, especially near a trail that is impacting the glade. These include Canada bluegrass (*Poa compressa*), timothy (*Phleum pratense*), king devil (*Hieracium caespitosum*), and common St. John's-wort (*Hypericum perforatum*). The slope of the bedrock towards the cliff prevents the accumulation of organic matter. Soils accumulate in cracks and small level areas. Soils are thin over conglomerate bedrock: an acidic top layer of organics under moss (pH 5.5 to 5.0) over 1 cm or less of decayed bedrock mixed with gravel (pH 5.5 to 5.0).



Keweenaw Lodge Glade. Photo by J.M. Lincoln.

Keweenaw Lodge Complex – Keweenaw Lodge Cliff

Natural Community Type: Volcanic Cliff

Rank: G4G5 S2, apparently secure to secure globally and imperiled in Michigan

Element Occurrence Rank: BC, good to fair occurrence

Size: 1.5 acres

Element Occurrence Identification Number: 26690



The Keweenaw Lodge Cliff occurs on 300 m of exposed conglomerate cliff face which is up to 10 m tall with talus slope at base. It features a complex rock face with terraces and cracks forming, allowing soil to accumulate in areas of the face and in a sloping talus pile at the base. There are stunted trees along the face, including red oak (*Quercus rubra*), white pine (*Pinus strobus*), and red maple (*Acer rubrum*). The cliff is embedded in the surrounding forest, and the microclimate allows for lichens to accumulate on the rock face.

Common species are wild basil (*Clinopodium vulgare*), common polypody (*Polypodium virginianum*), maidenhair spleenwort (*Asplenium trichomanes*). Bush-honeysuckle (*Diervilla lonicera*), sand violet (*Viola adunca*), and poverty grass (*Danthonia spicata*). Thimbleberry (*Rubus parviflora*), mountain maple (*Acer spicata*), and beaked hazelnut (*Corylus cornuta*) occur on the talus slope at bottom. Invasive species are infrequent to locally abundant with the most frequent being Canada bluegrass (*Poa compressa*), king devil (*Hieracium caespitosum*), and common speedwell (*Veronica officinalis*). The soils are thin and slightly acidic (pH 5.5 to 6) decaying conglomerate bedrock.

Keweenaw Lodge Cliff. Photo by J.M. Lincoln.

McKenzie Complex – McKenzie Forest

Natural Community Type: Mesic Northern Forest

Rank: G4 S3, apparently secure globally and vulnerable in Michigan

Element Occurrence Rank: B, good occurrence

Size: 116.5 acres

Element Occurrence Identification Number: 26697

The McKenzie Complex features a forest dominated by sugar maple (*Acer saccharum*) on a large bedrock formation. There is a lower ridge and an upper ridge with continuous cliff that transitions to northern bald above the forest canopy. The lower ridge is a series of small multifaceted rock outcrops 1 to 4 m tall with no continuous cliff and is embedded in the mesic northern forest. At the base of the cliff, talus slopes down to a trough between the lower ridge of outcrop. There are elements of dry-mesic northern forest at the top of the outcrop ridge, but the talus

pile is dominated by sugar maple. There are several old growth individuals throughout the forest but the system is largely second growth and old pine stumps from the original clearing event in the 1800s persist. The shallow soils over bedrock and proximity to Lake Superior cause trees to be stunted and there is high turnover so that individuals are short-lived compared to more protected areas. There is abundant coarse woody debris occurs at various stages of decay. The subcanopy is dominated by sugar maple, red oak (*Quercus rubra*), and paper birch (*Betula*



McKenzie Forest, dominated by sugar maple. Above the cliff, the forest occurs on thin acidic soils over bedrock and the canopy features stunted sugar maple, ironwood, and red oak. Photo by J.M. Lincoln.

papyrifera). Common shrubs include inland serviceberry (*Amelanchier interior*), red-berried elder (*Sambucus racemosa*), bush-honeysuckle (*Diervilla lonicera*), and Canadian fly honeysuckle (*Lonicera canadensis*). Herbaceous species include long-stalked sedge (*Carex pedunculata*), rough-leaved rice-grass (*Oryzopsis asperifolia*), hair grass (*Avenella flexuosa*), fibrous-rooted sedge (*Carex communis*), fragile fern (*Cystopteris fragilis*), false spikenard (*Maianthemum racemosum*), and wood millet (*Milium effusum*). The forest above the cliff is somewhat unusual with a canopy of stunted ironwood (*Ostrya virginiana*), sugar maple, contorted red oak, and infrequent supercanopy white pine.

Soils below the cliff are shallow, with depth to bedrock 4 cm. The O-horizon (pH 7.0) is 2 cm deep and dense with roots, over gray sandy loam with organics (pH 5.5). Soils at a north facing slope above cliff are 1 cm of leaf litter over 1 cm of organics (pH 5.5 to 6.0), over gravel and conglomerate decay (pH 5.0) to 7 cm over bedrock.



Despite their small size, many trees are very old. This 30.0 cm dbh tree had 205 rings. Lungwort lichen grows on many old trees. Photo by J.M. Lincoln.



McKenzie Forest surrounds extensive volcanic cliff with areas of northern bald at the top of the cliff. Photo by J.M. Lincoln.

McKenzie Complex – McKenzie Heights

Natural Community Type: Northern Bald

Rank: GU S1, unrankable globally and critically imperiled in Michigan

Element Occurrence Rank: AB, excellent to good occurrence

Size: 1.3 acres

Element Occurrence Identification Number: 26694

McKenzie Heights northern bald occurs as a series of openings on sloping bedrock above the conglomerate cliff. The openings of the northern bald transition to dry-mesic and mesic northern forest to the north and 20 to 30 m tall vertical cliff face to the south.

The system occurs where the cliff extends above the forest canopy is influenced by drought, high winds, and infrequent fires from lightning strike. The sparse canopy features stunted red oak (*Quercus rubra*) and infrequent white pine (*Pinus strobus*). The exposure causes severe growing conditions and trees are small and stunted (aka “Krummholz” growth form) with red oak being 2 to 3 m tall, 15 to 20 cm DBH and about 100 years old. A 21.1 cm DBH red oak had 89 rings. A 42.7 cm DBH white pine stump at the cliff top was cored and the 4 cm of readable core had 44 rings and it was estimated to be about 190 when cut in the 1800s. There are several species of shrubs including round-leaved serviceberry (*Amelanchier sanguinea*), low sweet blueberry (*Vaccinium angustifolium*), common juniper (*Juniperus communis*), and creeping juniper (*Juniperus horizontalis*). The herb layer is patchy but diverse and variable. There are extensive

unvegetated surfaces dominated by reindeer lichen (*Cladonia* spp.) and various mosses, sometimes covering more than 50% of the bald. Openings feature several species including hair grass (*Avenella flexuosa*), Special Concern blue-lips (*Collinsia parviflora*), and poverty grass (*Danthonia spicata*). Areas with more tree cover feature greater diversity with Pennsylvania sedge (*Carex pensylvanica*), bastard-toadflax (*Comandra umbellata*), hairy goldenrod (*Solidago hispida*), old-pasture bluegrass (*Poa saltuensis*), and several others. Invasive species are present but generally at low abundance and include Canada bluegrass (*Poa compressa*), king devil (*Hieracium caespitosum*), and common St. John's-wort (*Hypericum perforatum*).

The bedrock slopes severely towards the cliff and prevents the accumulation of organic matter. Soils accumulate in cracks and small level areas and are acidic (pH 5.5 to 6.0) gritty conglomerate decay. There are infrequent but large ant colonies that are up to 3 x 3 m wide and 15 to 20 cm tall with black ants about 5 to 7 mm long.



McKenzie Heights northern bald occurs at the top of volcanic cliff where the cliff extends above the forest canopy below. Photo by J.M. Lincoln.

McKenzie Complex – McKenzie Cliff

Natural Community Type: Volcanic Cliff

Rank: G4G5 S2, apparently secure to secure globally and imperiled in Michigan

Element Occurrence Rank: BC, good to fair occurrence

Size: 1.5 acres

Element Occurrence Identification Number: 26695

McKenzie Cliff features nearly 1200 m of essentially unbroken, vertical conglomerate cliff transitioning to northern bald. The cliff ranges from 10 to 15 m tall at the western end to 30 m tall at the eastern end. Both the western portion of the cliff and the talus slope at the base are embedded in mesic northern forest and are influenced by a moist microclimate dense with moss. The cliff top is not exposed above the canopy along the western third. The eastern end the cliff extends at least 10 m above the canopy and features less dense vegetation, composed of species with affinities for hot, dry conditions. There are numerous lichens on the cliff face, including rock tripe (*Umbilicaria americana*) and several crustose lichens. Vegetation includes hair grass (*Avenella flexuosa*), prairie cinquefoil (*Drymocallis arguta*),

Special Concern fragrant woodfern (*Dryopteris fragrans*), early saxifrage (*Micranthes virginensis*), hairy goldenrod (*Solidago hispida*), and rusty woodsia (*Woodsia ilvensis*). There are narrow terraces with serviceberry, white cedar, smooth sumac (*Rhus glabra*), basswood (*Tilia americana*), thimbleberry (*Rubus parviflora*), and Canada bluegrass (*Poa compressa*). There are also near-vertical cracks with vegetation featuring false spikenard (*Maianthemum racemosum*), big-leaved aster (*Eurybia macrophylla*), round-lobed hepatica (*Hepatica americana*), and harebell (*Campanula rotundifolia*). Trees are infrequent and difficult to safely measure. A red oak at the top had a diameter of 28.7 cm. A 33.0 cm DBH bigtooth aspen (*Populus grandidentata*) had 94 rings.



McKenzie Cliff is the longest contiguous cliff documented during the 2023 surveys. Photo by J.M. Lincoln.

Estivant Ridge

Natural Community Type: Mesic Northern Forest

Rank: G4 S3, apparently secure globally and vulnerable in Michigan

Element Occurrence Rank: B, good occurrence

Size: 72.7 acres

Element Occurrence Identification Number: 26937

Estivant Ridge occurs along the north-facing slope of the central volcanic ridge at the tip of Keweenaw peninsula, directly to the west of Estivant Pines Dry-mesic Northern Forest (EOD 3641). Mesic northern forest grades into volcanic cliff and dry-mesic northern forest to the south that are associated with volcanic outcrops on the south face of the ridge, and into boreal forest to the north. Sugar maple (*Acer saccharum*) is a consistent canopy dominant, sharing dominance with red oak (*Quercus rubra*) near the top of the slope with ironwood (*Ostrya virginiana*) increasing in importance moving down slope. Eastern hemlock (*Tsuga canadensis*) and yellow birch (*Betula allegheniensis*) also increase in importance down slope, with white cedar (*Thuja occidentalis*) becoming important at the very bottom. Supercanopy white pine (*Pinus strobus*) is occasional, but reduced in importance by historical logging, especially when compared to the adjacent old growth stand in Estivant

Pines. The multi-aged second growth dominants were aged at 124 and 154 years, while the old growth component of the canopy exceeded 250 years old. The subcanopy is dominated by ironwood, and locally by sugar maple, red oak, and balsam fir (*Abies balsamea*). Also important in the subcanopy are white cedar and red maple (*Acer rubrum*). The low shrub layer includes white cedar, thimbleberry (*Rubus parviflorus*), ironwood, inland serviceberry (*Amelanchier interior*), sugar maple, Canadian fly honeysuckle (*Lonicera canadensis*), red maple, oval-leaved bilberry (*Vaccinium ovaefolium*), and red oak. The ground layer is not diverse, considering the range of aspect, soil depth, and canopy composition. Typical ground layer species include Canada mayflower (*Maianthemum canadense*), sarsaparilla (*Aralia nudicaulis*), and long-stalked sedge (*Carex pedunculata*). Seedlings of sugar maple and red oak are locally abundant.



Eastern extent of Estivant Ridge, near boundary with Estivant Pines. North-facing slope, transitional to volcanic cliff. Sugar maple is abundant in the canopy, and white cedar seedlings are common. Photo by T.J. Bassett.

Soil at the topslope are clayey sandy loam to 8 cm, pH 5.5, sand to at least 80 cm, pH 6.5. Soil at the lower slope is duff to 3 cm, then deep clayey sandy loam over bedrock, pH 4.5-5.5. Soils here are deeper and less acidic than some other nearby mesic forest (e.g., EOID 26697, 26907), so able to support a taller canopy of straighter growing trees. Toward the base of the slope, trees increase in size and coarse woody debris is moderately large (mean = 15-25 cm) and more frequent. A few recent (~50 yr) decaying stumps

were observed, but included within the mapped area as they were rare and the surrounding canopy is of old, large-diameter trees. Several large trees were marked with paint, especially leaning individuals of yellow birch. Two non-native species were observed, Canada thistle (*Cirsium arvense*) and European marsh thistle (*Cirsium palustre*), both of which may require management, especially if any thinning produces canopy gaps.



Supercanopy white pine over canopy sugar maple in Estivant Ridge. Photo by T.J. Bassett.

Breakfast Lake West Complex – Breakfast Lake West Fen

Natural Community Type: Poor Fen

Rank: G3 S3, vulnerable globally and in Michigan

Element Occurrence Rank: BC, good to fair occurrence

Size: 8.5 acres

Element Occurrence Identification Number: 26903

Breakfast Lake West Fen is situated in a small isolated basin on a low ridge between Mandan Loop Rd to the south and the Montreal River to the north. The remainder of the basin supports rich conifer swamp, which may be hydrologically connected to the Montreal River. Zonation is well defined. The center is inundated at the surface and dominated by low graminoid vegetation, including white beak-rush (*Rhynchospora alba*), alpine bulrush (*Trichophorum alpinum*), and bog muhly (*Muhlenbergia uniflora*), with occasional to locally abundant species including spatulate-leaved sundew (*Drosera intermedia*), bog buckbean (*Menyanthes trifoliata*), bog goldenrod (*Solidago uliginosa*), wiregrass sedge (*Carex lasiocarpa*), and rough cotton-grass (*Eriophorum tenellum*). Low shrubs, especially sweet gale (*Myrica gale*), are common but never dense. Moving outward, vertical structure increases with more stable and decomposed peats, as well as sphagnum hummocks.

These hummocks support small trees, mostly white cedar (*Thuja occidentalis*), but included tamarack (*Larix laricina*) and white pine (*Pinus strobus*). A 12.5 cm DBH white cedar was aged at 99 years. Areas transitional toward rich conifer swamp have increasing low to tall shrub density, mainly speckled alder (*Alnus incana*). Soils are mostly slightly acidic (pH 6.0-6.5) fibric peat, inundated at the surface in the center to saturated on the margins. Soils are inundated at 20 cm on the margins. A sample from a 0.5 m high sphagnum hummock was fibric(-sapric) peat (pH 6.8-7.0). Areas of more finely decomposed peat (hemic to sapric) also occur in the center near small swamp forest island and on edges with denser and higher shrub zone. A small deep pool was observed at the eastern tip, presumably a spring. Anthropogenic disturbances are minimal and not apparent. Minor hydrological disruption is likely from surrounding clearcuts and Mandan Loop Rd.



Breakfast Lake West Fen. White tufts are alpine bulrush. Photo by T.J. Bassett.

Breakfast Lake West Complex – Breakfast Lake West Swamp

Natural Community Type: Rich Conifer Swamp

Rank: G4 S3, apparently secure globally and vulnerable in Michigan

Element Occurrence Rank: B, good occurrence

Size: 41.2 acres

Element Occurrence Identification Number: 26964

This swamp occurs in a small, isolated basin and surrounds poor fen. The swamp may be hydrologically connected to the Montreal River on its northwest corner, where a logging road may interrupt outflow of any seepage originating in the swamp. The surrounding uplands are recently clearcut mesic northern and boreal forest, with high-quality boreal forest on nearby slopes above the Montreal River. Structure and composition are variable with heterogeneous vertical and horizontal structure. Soil moisture (and to lesser extent probably pH and texture) appears to drive much of the variation, with pockets of saturated-inundated muck and small to large hummocks of white cedar (*Thuja occidentalis*) roots distributed through a matrix of stable moist peat. The canopy is overwhelmingly dominated by white cedar between 185 and 250 years old. Hummocky rises are often co-dominated by white pine (*Pinus strobus*) and white cedar, while the wet veins are dominated by red maple (*Acer rubrum*) and tamarack (*Larix laricina*) over often dense speckled alder (*Alnus incana*), with dead-standing black ash (*Fraxinus nigra*). The subcanopy layer is sparse at 20% while the shrub layer is dense at 80%. Advanced white cedar regeneration in the shrub and sapling layers is moderate but local. There is no definitive dominant in the groundlayer (60-70% cover), but tussock sedge

(*Carex stricta*), golden saxifrage (*Chrysosplenium americanum*), and sensitive fern (*Onoclea sensibilis*) are locally dominant or abundant, and dwarf raspberry (*Rubus pubescens*), three-seeded sedge (*Carex trisperma*), and softleaf sedge (*Carex disperma*) are common. No non-native species were observed. The moist to inundated sapric peat is slightly alkaline (pH 7.0-7.5).

A few small “islands” of boreal forest are distributed throughout this swamp. The canopy is 70-80%, and strongly dominated by ~ 30 to > 50 cm DBH white cedar, with occasional red maple and supercanopy white pine, and balsam fir (*Abies balsamea*) common in the subcanopy. A 34.7 cm DBH white cedar was estimated at 525 years and a 29.7 cm white cedar at 266 years. Occasional species in the shrub layer include red maple, beaked hazelnut (*Corylus cornuta*), and Canadian fly honeysuckle (*Lonicera canadensis*). Bracken fern (*Pteridium aquilinum*) is occasional in the ground layer, while trailing arbutus (*Epigaea repens*), oak fern (*Gymnocarpium dryopteris*), and pipsissewa (*Chimaphila umbellata*) were rare. Soils are O-horizon (pH 4.0) to 2 cm, A-horizon of gray sandy loam (pH 4.5) to 20 cm, B-horizon of red sandy loam (pH 6.0) to 45 cm pH 6.0, over gravel and bedrock.



Wet vein in Breakfast Lake West Swamp, locally dominated by golden saxifrage. Note the structural heterogeneity. Photo by T.J. Bassett.

Bausano Complex – Bausano Glade

Natural Community Type: Volcanic Bedrock Glade

Rank: GU S2, unrankable globally and imperiled in Michigan

Element Occurrence Rank: BC, good to fair occurrence

Size: 3.1 acres

Element Occurrence Identification Number: 26693

The Bausano Complex is a south facing cliff that transitions to glade at the top of the feature. The glade is influenced by drought, infrequent fires from lightning strike, and high winds where the cliff extends above the forest canopy. Thin soils and southerly aspect cause trees to be stunted and short lived. Red oak (*Quercus rubra*) and white pine (*Pinus strobus*) are the prevalent canopy species and are typically 20 to 40 cm DBH. A 22.9 cm DBH red oak had 99 rings. The subcanopy and understory is sparse with red oak, white pine, and red maple (*Acer rubrum*). The tall shrub layer is sparse with red oak, inland serviceberry (*Amelanchier interior*), and white pine. The low shrub layer is patchy to locally dominant with low sweet blueberry (*Vaccinium angustifolium*), common juniper (*Juniperus communis*), bush-honeysuckle (*Diervilla lonicera*), and shadbush serviceberry (*Amelanchier spicata*), and choke cherry (*Prunus virginiana*). There are extensive unvegetated surfaces dominated by reindeer lichen, sometimes covering more than 50% of the open glade. Herbaceous species are infrequent

to locally abundant, including Pennsylvania sedge (*Carex pensylvanica*), Back's sedge (*C. backii*), rough-leaved rice-grass (*Oryzopsis asperifolia*), pipsissewa (*Chimaphila umbellata*), bastard-toadflax (*Comandra umbellata*), wild sarsaparilla (*Aralia nudicaulis*), wild-basil (*Clinopodium vulgare*), big-leaved aster (*Eurybia macrophylla*), false melic (*Schizachne purpurascens*) and sweet-cicely (*Osmorhiza berteroi*).

Much of the site is unvegetated and covered in reindeer lichens (*Cladonia* spp.) and various mosses. The slope of the bedrock glade prevents the accumulation of organic matter. Soils accumulate in cracks and small level areas. Soils are thin over conglomerate bedrock: an acidic top layer of organics under moss (pH 5.5 to 5.0) over 1 cm or less of decayed bedrock mixed with gravel (pH 5.5 to 5.0). There are two species of ants forming extensive colonies with multiple mounds.



Bausano Glade. Photo by J.M. Lincoln.

Bausano Complex – Bausano Bluffs

Natural Community Type: Volcanic Cliff

Rank: G4G5 S2, apparently secure to secure globally and imperiled in Michigan

Element Occurrence Rank: B, good occurrence

Size: 8.8 acres

Element Occurrence Identification Number: 26692

Bausano Bluffs is a south facing ridgeline with a parallel set of east-west oriented cliffs embedded in mesic forest. The northern upper cliff is essentially 800 m of unbroken, vertical conglomerate bedrock, ranging from 3 to 15 m in height. The southern lower cliff is a 7 m tall outcrop ridge with intermittent cliff face, terraces, and talus slopes. There are three separate areas of cliff, the largest on the upper ridge, and two smaller areas on the lower ridge. The system is routinely influenced by drought, windthrow, lightning, and severe weather. Freeze thaw and weathering of rock weathering creating talus slope at base. Most vegetation occurs at the base of the cliff, on small terraces along the vertical face, along cracks in continuous rock, or at the top of the cliff. Trees occur along the cliff where pockets of soil accumulate and are typically stunted and prone to windthrow.

A quaking aspen was 26.2 cm DBH, a paper birch was 22.1 cm DBH, a white cedar was 17.5 cm DBH, a white pine was 26.23 DBH, and a red oak was 19.6 cm DBH. Prevalent species at the top of cliff are poverty grass (*Danthonia spicata*), bracken fern (*Pteridium aquilinum*), bush-honeysuckle (*Diervilla lonicera*), and low sweet blueberry (*Vaccinium angustifolium*). The cliff face is locally covered with mosses and lichens. Species on the vertical face include mountain maple (*Acer spicatum*), inland serviceberry (*Amelanchier interior*), and choke cherry (*Prunus virginiana*), Graham's rock cress (*Boechera grahamii*), fragile fern (*Cystopteris fragilis*), and maidenhair spleenwort (*Asplenium trichomanes*). Soil accumulates in terraces and at the base of cliff in talus piles. Soils are coarse weathered stone with gravel (pH 6.5 to 7).



Bausano Cliff. Photo by J.M. Lincoln.

Estivant Cliffs West

Natural Community Type: Volcanic Cliff

Rank: G4G5 S2, apparently secure to secure globally and imperiled in Michigan

Element Occurrence Rank: B, good occurrence

Size: 8.8 acres

Element Occurrence Identification Number: 26934

Estivant Cliffs West is comprised of four separate polygons, along the south-facing aspect of the central volcanic ridge along the tip of the Keweenaw, and embedded within dry-mesic northern forest, including Estivant Pines (EOID 641) and Lost Lake Forest (EOID 17853). These polygons range in height from 6 to 30 m, are from 250 to 515 m long and are collectively 1590 m long. The canopy (70% cover) is co-dominated by red maple (*Quercus rubra*) and white pine (*Pinus strobus*), the latter of which is concentrated along the top of the cliff. Canopy trees generally range from 25-50 cm DBH, with pine ranging to 73 cm, with ages between 118 and 125 years. Sugar maple (*Acer saccharum*) (17.2 and 25.2 cm) is locally dominant in occasional patches toward the talus in densely shaded bottom of the slope. The subcanopy ranges from 50-80% cover, with red oak occurring frequently and local concentrations of sugar maple and ironwood (*Ostrya virginiana*). The shrub layer is patchy (40% cover) with no clear dominant, although tall bilberry (*Vaccinium membranaceum*), bush-honeysuckle (*Diervilla lonicera*), white cedar (*Thuja occidentalis*), and coralberry (*Symphoricarpos albus*) are occasional to locally common. Additional

species include Canadian fly honeysuckle (*Lonicera canadensis*), staghorn sumac (*Rhus typhina*), thimbleberry (*Rubus parviflorus*), and choke cherry (*Prunus virginiana*). The groundlayer is patchy (50%), especially on steeper slopes and in dense pine stands, and supports typical cliff species like bearberry (*Arctostaphylos uva-ursi*), maidenhair spleenwort (*Asplenium trichomanes*), fragile fern (*Cystopteris fragilis*), common polypody (*Polypodium virginianum*) and rusty woodsia (*Woodsia ilvensis*); as well as mesic and dry-mesic northern forest species such as long-stalked sedge (*Carex pedunculata*), big-leaved aster (*Eurybia macrophylla*), cow-wheat (*Melampyrum lineare*), northern beech-fern (*Phegopteris connectilis*), old-pasture bluegrass (*Poa saltuensis*), and rosy twisted-stalk (*Streptopus lanceolatus*). Three non-native species were observed: Canada bluegrass (*Poa compressa*), wood bluegrass (*Poa nemoralis*), and common speedwell (*Veronica officinalis*). Soil is 8 to ~ 30 cm deep reddish sand or sandy loam over bedrock. The State Threatened Ross' sedge (*Carex rossii*) occurs occasionally throughout this cliff.



State Threatened Ross' sedge in Estivant Cliffs West. With spikelet bract exceeding spikelet (*left*); growth form and associates, including maidenhair spleenwort (*right*). Photos by T.J. Bassett.



Estivant Cliffs West, with Mt. Houghton to the south in the background. Photo by T.J. Bassett.

LITTLE BETSY SHORELINE



Figure 6. Little Betsy Shoreline Parcel and natural community EOs.

Little Betsy Forest

Natural Community Type: Dry Northern Forest

Rank: G3? S3, vulnerable (inexact) globally and vulnerable in Michigan

Element Occurrence Rank: CD, fair to poor occurrence

Size: 61.7 acres

Element Occurrence Identification Number: 26704

Little Betsy Forest is a white pine (*Pinus strobus*) dominated forest on a sandy dune ridge 10 to 15 m above the surrounding landscape. This dune ridge appears to be a unique formation on the Keweenaw Peninsula. The forest features a patchy supercanopy dominated by white pine with infrequent white spruce (*Picea glauca*) over a canopy dominated by white pine. Other canopy species include paper birch (*Betula papyrifera*), red maple (*Acer rubrum*), and big-tooth aspen (*Populus grandidentata*). Supercanopy pines typically range from 40 to 60 cm DBH and are typically around 100 years old with some larger

individuals around 1 m DBH and potentially around 200 years old. A few individual eastern hemlock (*Tsuga canadensis*) occur on north facing slopes. The subcanopy and understory are patchy with paper birch, balsam fir (*Abies balsamea*), red maple, white cedar, white spruce, and white pine. There is abundant beard lichen (*Usnea* sp.) on many of the spruce and fir. The low shrub layer is variable and sparse to locally dominant and features several berry-producing species but especially tall bilberry (*Vaccinium membranaceum*), low sweet blueberry (*V. angustifolium*), oval-leaved bilberry (*V. ovalifolium*),



Little Betsy Forest. Photo by J.M. Lincoln.

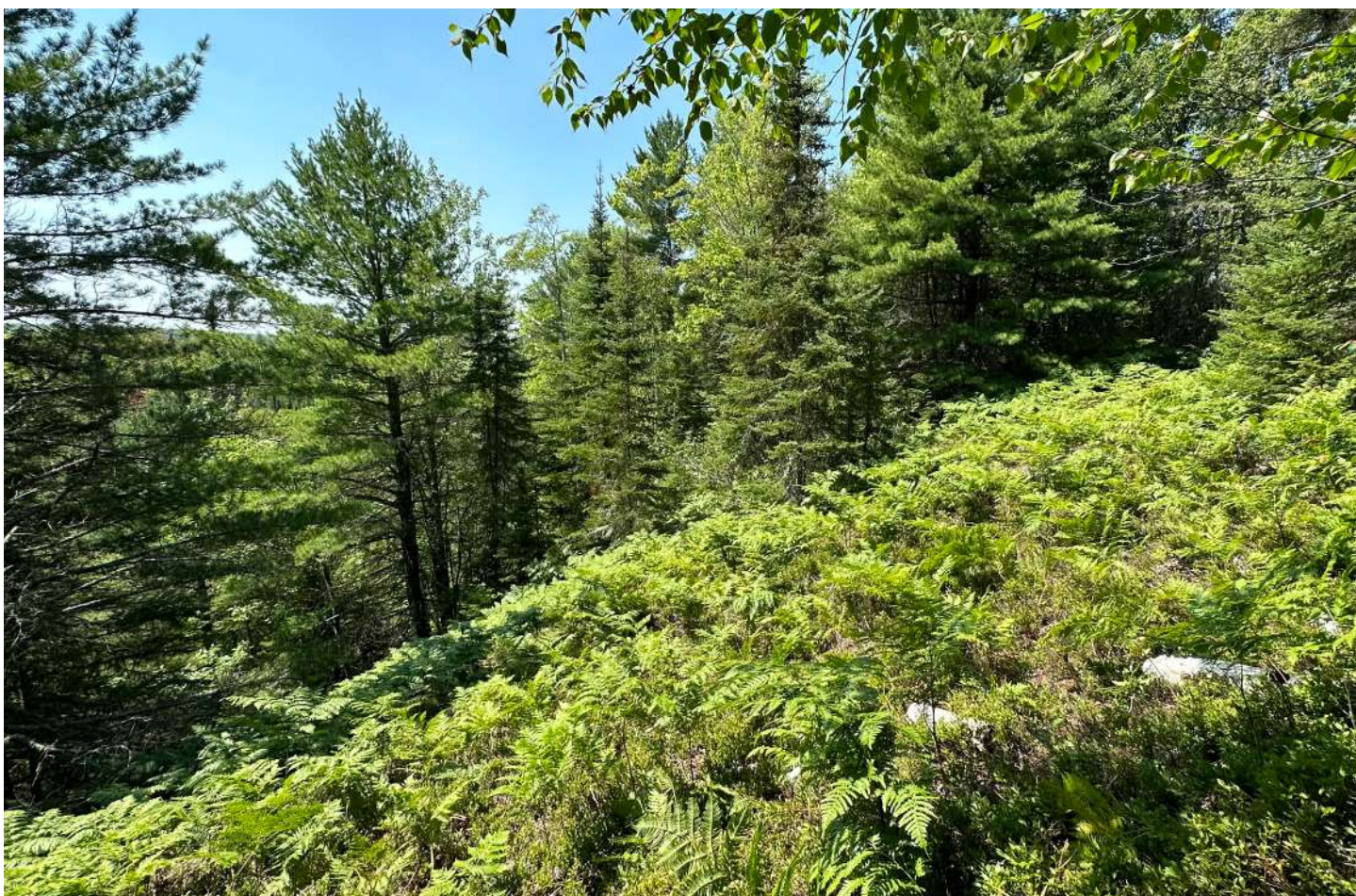
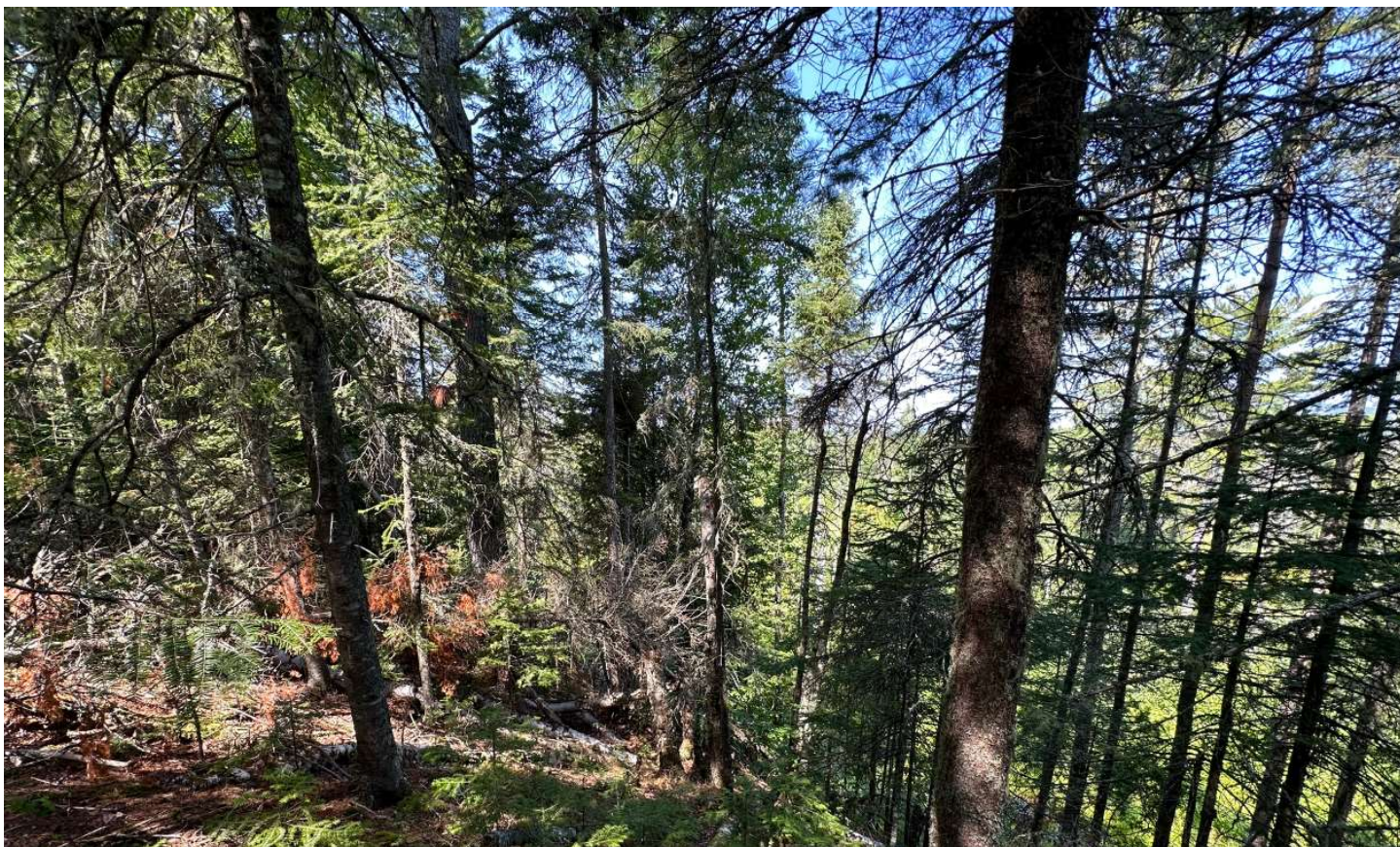
velvetleaf blueberry (*V. myrtilloides*), and shadbush serviceberry (*Amelanchier spicata*). The ground layer is patchy with low diversity. Characteristic species include bracken fern (*Pteridium aquilinum*), wintergreen (*Gaultheria procumbens*), Canada mayflower (*Maianthemum canadense*), bluebead-lily (*Clintonia borealis*), and wild sarsaparilla (*Aralia nudicaulis*). The sandy soils are acidic: O horizon, 1 cm duff and organics (pH 4.5), A horizon, 4 cm dark sands with organics (pH 4.0 to 4.5), over fine gray sands (pH 4.5 to 5.0).

Some areas within the forest have had canopy pine removed. This has fundamentally altered composition by increasing the abundance of fir, maple, and birch. These species would have been suppressed by frequent fire. Under these circumstances, this forest grades into boreal forest, especially given the proximity to Lake Superior and the associated cool, wet microclimate that encourages formation of boreal forest. Dry northern forests typically have red and jack

pine (*Pinus resinosa* and *P. banksiana*) and a much lower component of white pine. The composition of this forest is likely influenced by historic clearing of red pine, low abundance of jack and red pine on the landscape, and lack of recent fire. Several stumps appeared to be red pine and the species may have been more prevalent prior to logging in the 1800s and subsequent fire suppression. Pine is not reproducing and a low-frequency historic fire cycle likely regenerated pine. It is unclear the degree to which ignition was by Indigenous people vs. lightning driven. Berry-producing plants (e.g. bilberries and blueberries) are abundant here, and were historically managed by Indigenous people, suggesting potential Indigenous influence. There are also two potential cache pits on steep south facing slopes above wetland in the southwestern portion portion. There was more evidence of deer browse within this forest than other places observed on the Keweenaw during 2023 field surveys.



Several pine stumps from the 1800s were found. A 5.5cm core was taken from this 54.7 cm diameter red pine stump and had 25 growth rings, suggesting about 125 years old. Photo by J.M. Lincoln.



Fir dominates understory of Little Betsy Forest and bracken is often the most dominant herbaceous species. The application of fire may help improve the condition of the community. Photo by J.M. Lincoln.

Natural Community

- Boreal Forest
- Dry-mesic Northern Forest
- Mesic Northern Forest
- Northern Fen
- Northern Wet Meadow
- Rich Conifer Swamp
- Volcanic Bedrock Glade
- Volcanic Cliff
- KHPA Boundary

Map labels: Copper Harbor, Grant Twp, Fort Wilkins State Park, Lily Lake, Mud Lake, Breakfast Lake, Copper Lake, Hoar Lake, Bay Lake, Schlatter Lake, Lost Lake.

Map numbers: 26683, 26691, 26690, 26925, 26924, 26670, 26671, 26907, 26933, 26908, 26705, 26937, 3641, 17853, 26934, 17853, 26700, 26964, 27028, 26936, 26700, 17853, 26699, 26700, 26699, 26936, 26936, 17851, 26907, 27009, 17853.

Map credits: Map data: Esri, DeLorme, Garmin, GeoTechnologies, Inc., METI/NASA, USGS, EPA, NPS, USDA, NRCAN, Parks Canada.

A photograph of a dense forest. The scene is filled with numerous green trees and thick foliage. In the foreground, there's a mix of green leaves and some brown, fallen leaves on the ground. A prominent, thick, dark tree trunk is on the left side. On the right side, a large, light-colored, fallen log lies horizontally across the frame. The background shows more trees and a hint of a distant, hazy landscape. The overall lighting is soft, suggesting an overcast day or a shaded forest interior.

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Lost Lake Forest

Natural Community Type: Dry-mesic Northern Forest

Rank: G4 S3, apparently secure globally and vulnerable in Michigan

Element Occurrence Rank: AB, excellent to good occurrence

Size: 307.5 acres

Element Occurrence Identification Number: 17853

Lost Lake Forest occurs as nine polygons along a prominent ridgeline. The ridge feature is around 30 m tall with extensive, multifaceted outcrops and local inclusions of volcanic cliff. The aspect is typically south facing though small inclusions of east and north facing cliff and outcrop occur. Areas of volcanic cliff natural community (EOID 26934 and 26936) have been mapped within the EO where unbroken sections of outcrop over approximately 5 m high extend for at least 100 m. The distinction between occurrences of volcanic cliff and inclusions of outcrop in the forest is ambiguous, as outcrops are variable in angle, contiguity and other features. There was an existing EO for the forest which was described in 2010. The original polygon occurred adjacent to Lost Lake and the surveys from 2023 identified an additional eight polygons worthy of inclusion. The EO now consists of 308 acres over nine polygons and extends ten

km along a prominent ridge feature. Though similar to Estivant Pines (EOID 641), another dry-mesic northern forest EO occurring on the same ridgeline on land owned by the Michigan Nature Association, Lost Lake Forest primarily represents old second growth conditions as opposed to the true old growth conditions represented by Estivant Pines. As a result, we maintained the two EOs as separate.

The forest features a patchy supercanopy dominated by white pine (*Pinus strobus*) with rare white spruce (*Picea glauca*) over a canopy of red oak (*Quercus rubra*) and white pine. Other canopy species include paper birch (*Betula papyrifera*), yellow birch (*B. allegheniensis*), red maple (*Acer rubrum*), sugar maple (*A. saccharum*), big-tooth aspen (*Populus grandidentata*), quaking aspen (*P. tremuloides*), and white cedar (*Thuja occidentalis*). Pine dominates the top of the ridge and oak becomes more prevalent



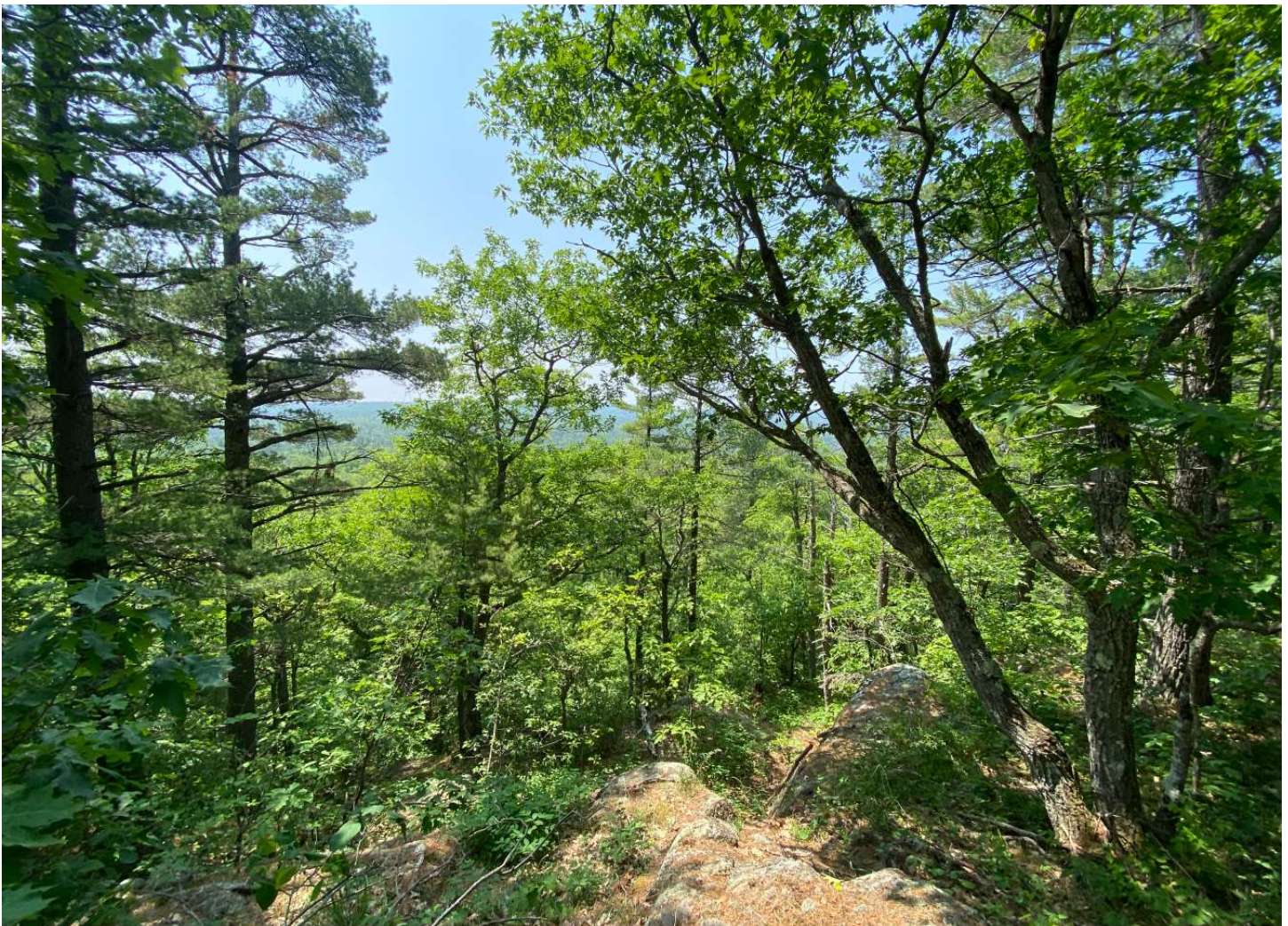
Lost Lake Forest. Photo by J.M. Lincoln.

along the slope. Supercanopy pines typically range from 40 to 70 cm diameter and are typically around 130 to 150 years old with some larger individuals aged around 200. Red oak range from 23 to 90 cm with typical ring counts between 130 and 160 though one 76.6 cm DBH individual was estimated to be around 290 and one 84.3 cm DBH individual was estimated to be 230 years old.

Sugar maple and white cedar are infrequent and more prevalent along slopes that are not directly south facing, and typically between 20 and 30 cm DBH. Locally, sugar maple is dominant in talus along the base of one of the western polygons, and in narrow ravines between large outcrop features. One 62.2 cm DBH cedar was estimated to be 410 years-old. Another 42.7 cm DBH cedar was estimated to be 229. One 56.9 DBH sugar maple had no rot and 230 rings were counted. Red pine (*Pinus resinosa*) was not observed during 2023 surveys, and has only been documented in the polygon adjacent to Lost Lake (in Copper Country State Forest) where the community was first described. The original pine was removed in the 1800s and stumps from those clearing events occur throughout, often with char and frequently larger

DBH than trees growing today. There has been no recent (circa 50 years) logging in most of the EO.

The subcanopy and understory are patchy with paper birch, red oak, quaking aspen (*Populus tremuloides*), sugar maple, white cedar, and balsam fir (*Abies balsamea*). Other species include ironwood (*Ostrya virginiana*), serviceberry (*Amelanchier interior*), shadbush serviceberry (*A. spicata*), white spruce, and white pine. The low shrub layer is sparse to locally dense with tall bilberry (*Vaccinium membranaceum*), low sweet blueberry (*V. angustifolium*), Bush-honeysuckle (*Diervilla lonicera*), hawthorn (*Crataegus chrysocarpa*), thimbleberry (*Rubus parviflorus*), and wild rose (*Rosa blanda*). Mountain maple (*Acer spicatum*), striped maple (*A. pensylvanicum*), and beaked hazelnut (*Corylus cornuta*) are concentrated in piles of talus at the bottom of cliffs. The ground layer is patchy but diverse, particularly on steep slopes with extensive volcanic outcrop. Graminoids are generally more abundant than forbs and include rough-leaved rice-grass (*Oryzopsis asperifolia*), hair grass (*Avenella flexuosa*), old-pasture and glaucous bluegrass (*Poa saltuensis* and *P. glauca*), western fescue (*Festuca occidentalis*), fibrous-rooted and Pennsylvania sedge (*Carex communis* and *C.*



Lost Lake Forest. Photo by J.M. Lincoln.

pennsylvanica), and poverty grass (*Danthonia spicata*). Forbs include pipsissewa (*Chimaphila umbellata*), big-leaved aster (*Eurybia macrophylla*), wild sarsaparilla (*Aralia nudicaulis*), hairy goldenrod (*Solidago hispida*), cow-wheat (*Melampyrum lineare*), spreading dogbane (*Apocynum androsaemifolium*), and wild-basil (*Clinopodium vulgare*). Ferns are locally abundant with bracken fern (*Pteridium aquilinum*) occurring throughout and common polypody (*Polypodium virginianum*), rusty woodsia (*Wood ilvensis*), and maidenhair spleenwort (*Asplenium trichomanes*) occurring on the rock outcrops and cliff.

The forest is influenced by drought, windthrow, lightning, and severe winter weather. There is high turnover of supercanopy white pine on ridges from high winds and shallow soils. Fires caused by lightning strike are an important disturbance feature. Numerous living trees had fire scars and there were several dead trees with char. The dominance of sugar maple in parts of the canopy and subcanopy is consistent with a prolonged period of fire suppression following historically frequent fire. Pine is not reproducing and a low-frequency historic fire cycle likely regenerated pine. It is unclear the degree to which ignition was by Indigenous people vs. lightning

driven. Berry-producing plants (e.g. bilberries and blueberries) are abundant here, and were historically managed by Indigenous people, suggesting potential Indigenous influence. It seems likely that cultural fires periodically played an important role in shaping this natural community type considering the long history of copper extraction and regular seasonal occupancy of Indigenous peoples, and well-documented use of prescribed fire by Indigenous peoples in the region. Soils are generally shallow and acidic, but variable due to the complexity of the volcanic bedrock outcrops. Numerous samples were taken and the following is a compilation of these samples: The O-horizon consists of needle duff and organics and is between 4 to 7 cm deep and acidic (pH 4.5 to 5.0). The A-horizon is tan/burgundy silt/fine weathered bedrock rock and is 2 to 12 cm deep and generally less acidic (pH 5.0 to 5.5). This is over a B-horizon of fine loam/weathered bedrock (pH 4.5 to 5.5). Depth to bedrock ranged from 10 to 24 cm. Deeper soils (e.g., 50-60 cm to bedrock) form along terraces and at the top of the slope, and are less acidic (pH 6.5). Leaf and needle duff can be absent on outcrops but can be exceed depths 25 cm along talus piles of the extremely steep slope.



Volcanic outcrop embedded in Lost Lake Forest. Photo by T.J. Bassett.

Manganese Forest

Natural Community Type: Mesic Northern Forest

Rank: G4 S3, secure globally and rare or uncommon in Michigan

Element Occurrence Rank: BC, good to fair occurrence

Size: 26.4 acres

Element Occurrence Identification Number: 27028

This is a sugar maple (*Acer saccharum*) dominated forest on a large, sloping bedrock formation. Other important canopy associates are red oak (*Quercus rubra*), white pine (*Pinus strobus*), big-tooth aspen (*Populus grandidentata*), paper birch (*Betula papyrifera*), and ironwood (*Ostrya virginiana*). Sugar maple appears to be a mix of second growth and old growth, with the most accessible areas being completely logged once and less accessible areas only having white pine taken out in the 1800s. Old pine stumps from the original mid-1800s clearing persist. Sugar maple generally ranges from 20 to 40 cm DBH and from 6 to 10 m tall, depending on depth of soil. Stunted trees are surprisingly old, a 35.3 cm DBH tree had 226 rings. Another 22.9 cm DBH sugar maple had 130 rings. These are likely approaching the upper limit of ages given the harsh conditions. Canopy ironwood were 15 to 20 cm DBH. It is likely a system with high turnover and coarse woody debris occurs at various stages of decay. The subcanopy is dominated by sugar maple, red oak, and paper birch. Common shrubs include tall bilberry (*Vaccinium membranaceum*), thimbleberry (*Rubus parviflorus*), and Canadian fly honeysuckle (*Lonicera canadensis*). Herbaceous species include long-stalked sedge

(*Carex pedunculata*), rough-leaved rice-grass (*Oryzopsis asperifolia*), hair grass (*Avenella flexuosa*), fibrous-rooted sedge (*Carex communis*), false spikenard (*Maianthemum racemosum*), and wood millet (*Milium effusum*). Soil Sample: O horizon 2 cm, pH 5.5-6. Over fine loamy organics 5.5 to 5. Depth to bedrock 4cm.

The forest is intermediate with dry-mesic northern forest, given the prominence of red oak and white pine in the canopy, probably due to influence by severe weather, shallow soils, drought, and infrequent fire from lightning strike. A large bedrock feature with large boulders occurs on the north facing slope, and thin soils may contribute to the dry-mesic gradient as well. Manganese Forest also grades entirely into dry-mesic northern forest along the cliff to the south (Lost Lake Forest, EOID 17853). In areas, the forest intergrades to boreal forest with large boulders and outcrop throughout. Sugar maple is too prevalent to be dry-mesic northern forest. White cedar (*Thuja occidentalis*) and balsam fir (*Abies balsamea*) are present but never dominant and red oak too is prevalent for the forest to be classified as boreal forest.



Manganese Forest. Photo by J.M. Lincoln.

East Bluff Complex – East Bluff Forest

Natural Community Type: Mesic Northern Forest

Rank: G4 S3, apparently secure globally and vulnerable in Michigan

Element Occurrence Rank: B, good occurrence

Size: 97.3 acres

Element Occurrence Identification Number: 26907

East Bluff Forest occurs at and near East Bluff. This EO, which is associated with volcanic cliff (EIOD 26933) and volcanic bedrock glade (EIOD 26908) natural communities, occurs in two polygons. The 84-acre East Bluff polygon occurs at the bluff itself and on adjacent slopes, while the 13-acre Vulcan Creek polygon occurs on a south-facing slope above a rich conifer swamp (EIOD 27009) at the headwaters of Vulcan Creek. Overall, the canopy of East Bluff Forest is dominated by 20-35 cm DBH, 120-170 year-old, sugar maple (*Acer saccharum*) and red oak (*Quercus rubra*). Locally the canopy is dominated by balsam fir (*Abies balsamea*), ironwood (*Ostrya virginiana*), and white pine (*Pinus strobus*), following a gradient of aspect (north to south) and soil moisture and depth (moist and deep to dry and shallow). Scattered individuals of 50-60 cm DBH, 200+ years old, old growth maple and oak are present. Sugar maple and red oak dominate the heterogenous subcanopy (10-70% cover), which also includes balsam fir,

white cedar (*Thuja occidentalis*), ironwood, and red maple (*Acer rubrum*), listed in decreasing density. Shrubs include inland and round-leaved serviceberry (*Amelanchier interior* and *A. sanguinea*), hazelnut (*Corylus cornuta*), and Canadian fly honeysuckle (*Lonicera canadensis*).

The Vulcan Creek polygon has a generally dense understory of balsam fir and maple saplings, and low ground layer diversity (10 vascular plant species recorded). Variation in soil depth and aspect in the East Bluff polygon underpins compositional heterogeneity in all strata, and moderate ground layer diversity (41 vascular plant species recorded). A boreal forest inclusion along northern, shaded slopes has dense sapling and midstory layers, while a dry-mesic northern forest inclusion occurs on western and southern exposure and has a less dense subcanopy, especially with thin soils.



East Bluff Forest at East Bluff. Photo by T.J. Bassett.

The ground layer in East Bluff Forest ranges from 20-40% cover with large patches of leaf litter lacking vegetative cover. The groundlayer includes typical mesic forest species big-leaved aster (*Eurybia macrophylla*), Canada mayflower (*Maianthemum canadense*), drooping woodland, graceful, and long-stalked sedges (*Carex arctata*, *C. gracillima*, and *C. pedunculata*), spinulose and evergreen wood fern (*Dryopteris carthusiana* and *D. intermedia*), wood millet (*Milium effusum*), rosy twisted stalk (*Streptopus lanceolata*), cow-wheat (*Melampyrum lineare*), wild sarsaparilla (*Aralia nudicaulis*), and rough-leaved rice grass (*Oryzopsis asperifolia*). Dry, thin soils with southern exposure also support low sweet blueberry and tall bilberry (*Vaccinium angustifolium* and *V. membranaceum*), pipsissewa (*Chimaphila umbellata*), hairgrass (*Avenella flexuosa*), bracken fern (*Pteridium aquilinum*), and pale vetchling (*Lathyrus ochroleucus*).

The ground layer composition is often dominated by tree seedlings, including sugar maple, red oak, and showy mountain-ash (*Sorbus decora*).

Soils in this EO are gray to red, highly (pH 4.5) to mildly (pH 6.5) acidic sandy loams, 20 to > 100 cm deep over conglomerate bedrock. There are large chunks of coarse woody debris, and minimal tip-up mounds, particularly in the East Bluff polygon. Beaver activity has reduced the western extent of the Vulcan Creek polygon.

Non-native species include Canada bluegrass (*Poa compressa*) and common speedwell (*Veronica officinalis*). The former may be problematic, especially in areas of thin soil over bedrock. Special Concern species male fern (*Dryopteris filix-mas*) occurs in this forest.



East Bluff Forest above Vulcan Creek headwaters. Photo by T.J. Bassett.

East Bluff Complex – East Bluff Glade

Natural Community Type: Volcanic Bedrock Glade

Rank: GU S2, unrankable globally and imperiled in Michigan

Element Occurrence Rank: BC, good to fair occurrence

Size: 2 acres

Element Occurrence Identification Number: 26908

East Bluff Glade occurs at the eastern tip of East Bluff along the northernmost ridge of several along the tip of the Keweenaw Peninsula, facing east over much of the tip of the Keweenaw Peninsula. The view is absolutely incredible, similar to the East and West Vistas at Porcupine Mountains State Park. This glade is surrounded by mesic northern forest, but also could be mapped with dry-mesic northern forest patches (which are currently treated as inclusions within mesic northern forest); and grades into narrow outcrop and cliff to west and north. The conglomerate bedrock substrate is thinly and patchily covered with 0 to 8 cm of red sandy loam (pH 5.5). Ground layer plant cover is 70%. Bare bedrock is dominated by reindeer lichen (*Cladonia* spp.) and hairy-cap moss (*Polytrichum* spp.). The low-growing plant community associated with the shallow soil portions is locally dominated by bearberry (*Arctostaphylos uva-ursi*), round-leaved service berry (*Amelanchier sanguinea*), or low sweet blueberry (*Vaccinium angustifolium*), while hairgrass (*Avenella flexuosa*), poverty grass (*Danthonia spicata*), and Special Concern blue-lips (*Collinsia parviflora*) are common overall. A low, thin (20%) tree canopy is limited to the margins of the glade and is dominated by stunted *Quercus rubra* between 16

and 19 cm DBH. An 18.7 cm DBH individual was estimated at 117 years. These stunted oaks approach the gnarled, krummholz growth form that differentiates glade from northern bald. A few supercanopy white pine (*Pinus strobus*) also ring the glade, ranging in size from 26.9-51.0 cm DBH. The sparse canopy is absent in the east, increasing in canopy toward west. The subcanopy and low shrub strata are sparse (10% and 20% respectively). The subcanopy includes white spruce (*Picea glauca*), white cedar (*Thuja occidentalis*), red oak and the low shrub layer includes common juniper (*Juniperus communis*), buffalo berry (*Shepherdia canadensis*), red oak, creeping juniper (*Juniperus horizontalis*), sweet low blueberry, and tall bilberry (*Vaccinium membranaceum*).

Four non-native species were observed: king devil (*Hieracium caespitosum*), Canada bluegrass (*Poa compressa*), common mullein (*Verbascum thapsus*), and common speedwell (*Veronica officinalis*). Canada bluegrass is potentially invasive in this context. Special Concern species blue-lips (*Collinsia parviflora*), and State Threatened species Ross' sedge (*Carex rossii*) and woodland cudweed (*Omalotheca sylvatica*), occur in this glade.



East Bluff Glade, looking north toward Lake Superior. Photo by T.J. Bassett.

East Bluff Complex – East Bluff Cliff

Natural Community Type: Volcanic Cliff

Rank: G4G5 S2, apparently secure to secure globally and imperiled in Michigan

Element Occurrence Rank: CD, fair to poor occurrence

Size: 0.3 acres

Element Occurrence Identification Number: 26933

This 3-10 m high, 113 m long volcanic cliff occurs at the eastern tip of East Bluff along the northernmost ridge along the tip of the Keweenaw Peninsula, facing east over much of the tip of the Keweenaw Peninsula. It is composed of several solid angled conglomerate chunks that blend into a steep sandy loam slope on all sides. This cliff is deeply embedded within surrounding mesic northern forest, with some canopy trees rooted in the cliff itself. Canopy cover is 80%, comprised of 15-30 cm DBH red oak (*Quercus rubra*; dominant), 30-50 cm quaking aspen (*Populus tremuloides*; occasional), ~ 20 cm sugar maple (*Acer saccharum*; uncommon), and 15-20 cm paper birch (*Betula papyrifera*; rare). The plant community includes a diversity of typical cliff species though no

clear dominants: maidenhair spleenwort (*Asplenium trichomanes*), hairgrass (*Avenella flexuosa*), Graham's rockcress (*Boechera grahamii*), fragile fern (*Cystopteris fragilis*), western fescue (*Festuca occidentalis*), common polypody (*Polypodium virginianum*), northern holly fern (*Polystichum lonchitis*), hairy goldenrod (*Solidago hispida*), and sand violet (*Viola adunca*). Some mesic forest species also grow on the cliff, including long-stalked sedge (*Carex pedunculata*), wood millet (*Milium effusum*), and downy Solomon-seal (*Polygonatum pubescens*). Non-native invasive species Canada bluegrass (*Poa compressa*) was also documented here.



East Bluff Cliff, an isolated, 120-m long steep conglomerate outcrop. Also pictured: *A. trichomanes*, *C. pedunculata*, S. Kyriakakis and E. Johnston. Photo by T.J. Bassett.

Secret Ravine

Natural Community Type: Mesic Northern Forest

Rank: G4 S3, secure globally and rare or uncommon in Michigan

Element Occurrence Rank: C, fair occurrence

Size: 9.7 acres

Element Occurrence Identification Number: 26705

Secret Ravine is a mesic northern forest centered around a steep ravine. Surrounding uplands have been heavily logged in recent decades, including clearcuts in the past decade. This forest was protected from recent logging by steep slopes. There are inclusions of boreal forest, rich conifer swamp, and dry-mesic northern forest, the latter concentrated on a high volcanic outcrop in the south of the mapped polygon. The closed canopy (80-90% cover) is dominated by old second growth sugar maple (*Acer saccharum*), mostly ranging from 25-40 cm DBH. A 55 cm DBH individual was estimated at 210 years old. White cedar (*Thuja occidentalis*) is consistently present to locally dominant in the canopy, ranging from ~ 20-40 cm DBH. Yellow birch (*Betula allegheniensis*) and red maple (*Acer rubrum*) are occasional, with the latter more important on the dry-mesic outcrop. Red oak (*Quercus rubra*) is locally dominant on the outcrop – a 60.3 cm DBH individual was aged at ~316 years. Additional canopy species include white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), ironwood (*Ostrya virginiana*), paper birch (*Betula papyrifera*), and quaking aspen (*Populus tremuloides*).

The subcanopy varies from about 10% in much of the ravine to 50% on some edges. Balsam fir is locally dominant, especially in boreal inclusions, and sugar maple is locally abundant to dominant.

Mountain maple (*Acer spicatum*) and white cedar are occasional; beaked hazelnut (*Corylus cornuta*) is uncommon; and ironwood, choke cherry (*Prunus virginiana*), and round-leaved serviceberry (*Amelanchier sanguinea*) are rare. The groundlayer is mostly sparse and dominated by leaf litter, with 10-20% vegetative cover, and locally dominated by sugar maple, and overall by trees and shrubs (~50% of the ground flora). Herbaceous species generally occur sparsely and include baneberry (*Actaea pachypoda*), bladder sedge (*Carex intumescens*), pipsissewa (*Chimaphila umbellata*), big-leaved aster (*Eurybia macrophylla*), oak fern (*Gymnocarpium dryopteris*), round-leaved hepatica (*Hepatica americana*), false melic (*Schizachne purpurascens*), and starflower (*Trientalis borealis*). Richness is somewhat low considering the range of soil moisture and aspect. Coarse woody debris and tip-up mounds were sparse and local.

Soils were sampled midslope in the ravine, and were dark, silty sandy loam (a little clayey) (pH 6.5). Bits of conglomerate are mixed throughout the soil profile, including occasionally at the surface. A few conglomerate boulders were observed on the slopes of the ravine. Soils at the base of the ravine range from dark loam to wet clay at lower positions, with local muck deposits in the small rich conifer swamp inclusion.



Secret Ravine, with ostrich fern in foreground. Photo by T.J. Bassett.

Powderhouse Complex – Powderhouse Fen

Natural Community Type: Northern Fen

Rank: G3 S3, vulnerable globally and vulnerable in Michigan

Element Occurrence Rank: AB, excellent to good occurrence

Size: 11.4 acres

Element Occurrence Identification Number: 26698

The Powderhouse Complex features a northern fen embedded within a rich conifer swamp. This is a small example of northern fen in a low point on the landscape where there is substantial seepage. The system features an emergent marsh zone at the beaver dam in the southeast. Small beaver-cut channels with horned bladderwort (*Utricularia cornuta*), sweet-scented waterlily (*Nymphaea odorata*), and round-leaved sundew (*Drosera rotundifolia*). Characteristic species of the fen zone include sedges wiregrass and yellow sedge (*Carex lasiocarpa* and *C. flava*), alpine bulrush (*Trichophorum alpinum*), bog goldenrod (*Solidago uliginosa*), and bog lobelia (*Lobelia kalmia*). As the open fen transitions to rich conifer swamp at the edges, there is a narrow band of shrub thicket with sweet gale (*Myrica gale*),

alder-leaved buckthorn (*Rhamnus alnifolia*), speckled alder (*Alnus incana*), and small white cedar (*Thuja occidentalis*). The soils of the fen are neutral (pH 7.0) peats to depths greater than 1 m.

There is a beaver channel with a dam and lodge at the southeastern end where the wetland drains. There appears to be substantial fluctuations of water level, likely associated with spring snow melt that collects in the valley and possibly beaver activity. A small area of outcrop near the emergent marsh zone indicates the degree of seasonal fluctuation is close to 30 cm. This may also be impacted by the presence of the beaver, which was not obviously present in 2023. This lodge appears to have been excavated by a bear and did not appear to be active.



Powderhouse Fen. Photo by J.M. Lincoln.

Powderhouse Complex – Powderhouse Swamp

Natural Community Type: Rich Conifer Swamp

Rank: G4 S3, apparently secure globally and vulnerable in Michigan

Element Occurrence Rank: BC, good to fair occurrence

Size: 10.2 acres

Element Occurrence Identification Number: 26699

Surrounding the fen is a small rich conifer swamp dominated by white cedar (*Thuja occidentalis*). Others associates of the sparse canopy include spruce (*Picea glauca*), tamarack (*Larix laricina*), and white pine (*Pinus strobus*). Black ash (*Fraxinus nigra*) was historically around 1-2% of canopy. Canopy trees are between 25 and 60 cm DBH and become more stunted towards fen. A 47.5 cm DBH cedar was aged to 248. A 51.5 tamarack was aged to 81 years old. The subcanopy species are white cedar, paper birch (*Betula papyrifera*), yellow birch (*Betula alleghaniensis*), and balsam fir (*Abies balsamea*). Shrubs include speckled alder (*Alnus incana*), mountain maple (*Acer spicatum*), Canadian fly honeysuckle (*Lonicera canadensis*), and thimbleberry (*Rubus parviflorus*). The groundcover is patchy with soft-leaf sedge (*Carex disperma*), goldthread

(*Coptis trifolia*), bunchberry (*Cornus canadensis*), and creeping-snowberry (*Gaultheria hispida*).

Forests on the steep topography adjacent to swamp were logged in last 20 years. Much of this small swamp is second growth with scattered winter-cut stumps, some 2 m high. Only the area northwest of the fen is old-growth and this area has very complex structure with trees scattered in every direction with coarse woody debris at all stages of decay. Elsewhere, the swamp is in good condition but lacks structural complexity and large coarse woody debris. Trees become increasingly stunted towards fen. Soils are 6 cm of cedar duff (pH 7.0), over saturated sapric peat (pH 7.0) to depth greater than 1 m. Large expanses of mosses occur over the saturated patches of muck.



Powderhouse Swamp. Photo by J.M. Lincoln.

Vulcan Creek Complex – Vulcan Creek Meadow

Natural Community Type: Northern Wet Meadow

Rank: G4G5 S4, apparently secure to secure globally and apparently secure in Michigan

Element Occurrence Rank: B, good occurrence

Size: 13.2 acres

Element Occurrence Identification Number: 26671

This is a sedge and shrub dominated meadow in a beaver-mediated opening along Vulcan Creek within a conifer swamp. *Carex stricta* and blue-joint (*Calamagrostis canadensis*) are overwhelmingly dominant in the herbaceous layer. Speckled alder (*Alnus incana*) is the overwhelmingly dominant shrub and is locally quite dense, especially away from the creek. Other shrubs are sweet gale (*Myrica gale*) and sandbar willow (*Salix exigua*). The system is

characterized by fluctuating water levels due to beaver activity. Sedge-dominated zones correspond to seasonal flooding and a high-frequency of flooding during rain events. The shrub zones towards the margins are less frequently inundated. Beaver activity is likely part of long cycles of flooding and draw down with the latest stage being encroachment of the swamp towards the stream edge.



Vulcan Creek Meadow. Photo by J.M. Lincoln.

Vulcan Creek Complex – Vulcan Creek Cliffs

Natural Community Type: Volcanic Cliff

Rank: G4G5 S2, apparently secure to secure globally and imperiled in Michigan

Element Occurrence Rank: C, fair occurrence

Size: 2.5 acres

Element Occurrence Identification Number: 26670

Vulcan Creek Cliffs occurs as three small separate polygons of sparsely vegetated conglomerate cliff ranging from 3 to 6 m in height along 700 m of a ravine. Two polygons on opposing faces of the south end of the ravine are 1.0 and 0.4 acres, respectively, while the third polygon at the north end is 1.1 acres. The ravine runs southeast to northwest above Vulcan Creek. Between the polygons are areas of extensive outcrop, particularly on the west-facing portion of the gully. At the top of the cliff is boreal forest with inclusions of volcanic bedrock glade that were too small to map. The cliff top features balsam fir (*Abies balsamea*), paper birch (*Betula papyrifera*), white pine (*Pinus strobus*), and red maple (*Acer rubrum*). These are generally stunted but increase in size away from cliff or where pockets of soil accumulate. Trees are generally 15 to 40 cm DBH. Most vegetation occurs at the base of the cliff, on small terraces on

the vertical face, along cracks in continuous rock, or at the top of the cliff where there are open, glade-like conditions. The tall shrub layer features mountain maple (*Acer spicatum*), bearberry (*Arctostaphylos uva-ursi*), Canadian fly honeysuckle (*Lonicera canadensis*), bush-honeysuckle (*Diervilla lonicera*), and thimbleberry (*Rubus parviflorus*). Graminoids are common in the vegetated areas and include hair grass (*Avenella flexuosa*), poverty grass (*Danthonia spicata*), and western fescue (*Festuca occidentalis*). Forbs are less frequent and include hairy goldenrod (*Solidago hispida*), big-leaved aster (*Eurybia macrophylla*), wild-basil (*Clinopodium vulgare*), and wild strawberry (*Fragaria virginiana*). A soil sample was taken from the top of the cliff. Soils are generally shallow leaf and lichen duff over weathered rock. The duff is 2 cm deep (pH 6.0). Below the duff, loam has collected to a depth of 3.0 cm (pH 5.5).



Vulcan Creek Cliffs. Photo by J.M. Lincoln.

Vulcan Cliffs West

Natural Community Type: Volcanic Cliff

Rank: G4G5 S2, secure globally and imperiled in Michigan

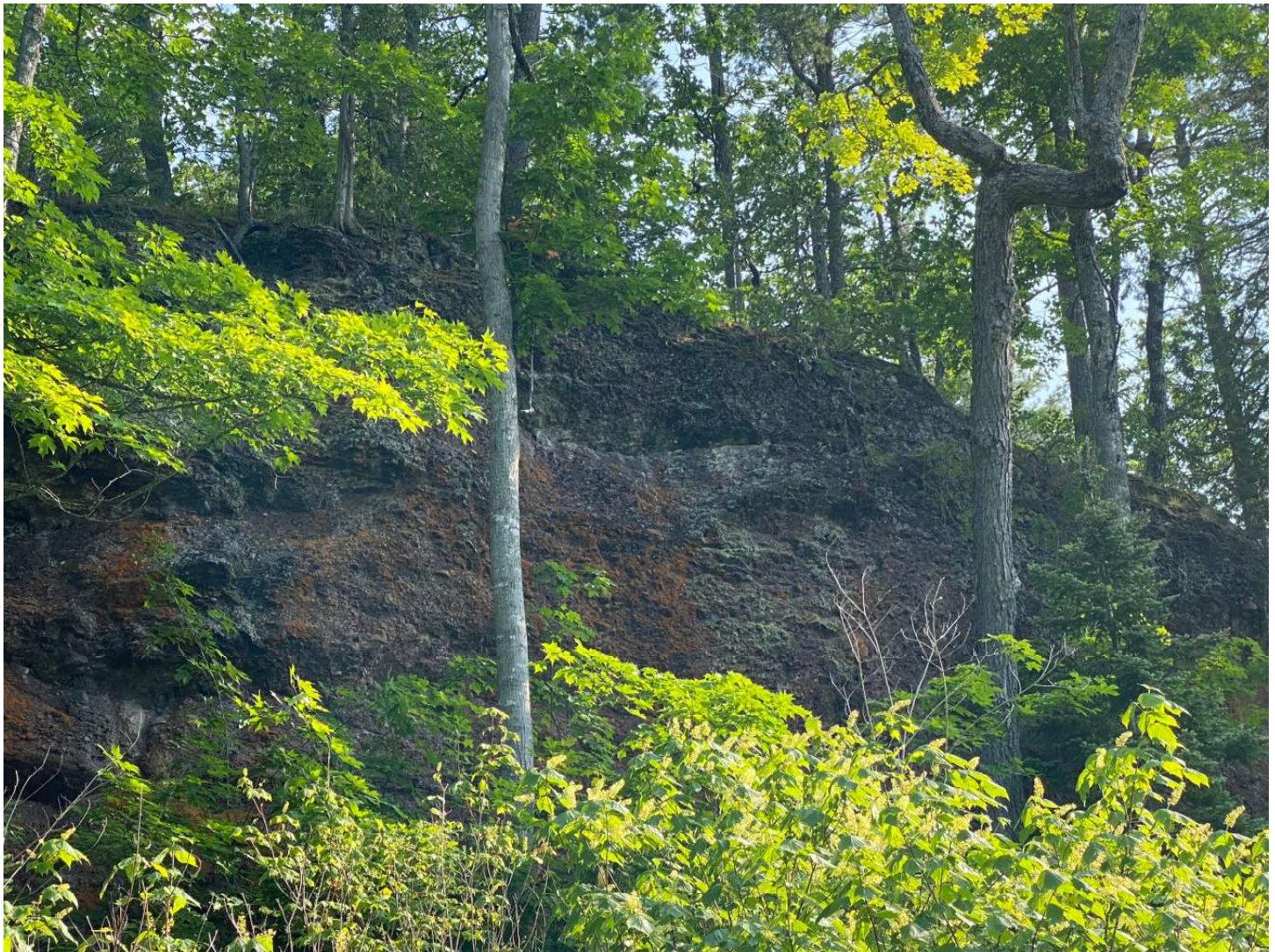
Element Occurrence Rank: C, fair occurrence

Size: 3.0 acres

Element Occurrence Identification Number: 26924

This is 530 m of essentially unbroken, vertical south facing conglomerate volcanic cliff, ranging from 3 to 12 m in height. The feature runs east-west along the Keweenaw Peninsula and continues to the west where it has been degraded by logging roads, where it is mapped as a separate EO (East Vein Cliffs, EOID 26925). To the east, the cliff transitions to subtle outcrop until the small ravine along Vulcan Creek where there are additional small areas of exposed vertical conglomerate cliff (Vulcan Creek Cliffs, EOID 26670). This south facing cliff is routinely influenced by drought, windthrow, lightning, and severe weather. The feature is mostly embedded within the surrounding forest. The forest below is mesic northern forest, dominated by sugar maple (*Acer saccharum*). Where forest below is intact, the cliff face and terraces support more vegetation.

There are numerous mosses and lichens on the cliff face: especially rock tripe (*Umbilicaria americana*) and several indistinguishable crustose lichens. Most vegetation occurs at the base of the cliff, on small terraces on the vertical face, along cracks in continuous rock, or at the top of the cliff where there are open, glade-like conditions. The cliff top features stunted trees, including red oak (*Quercus rubra*), white pine (*Pinus strobus*), and big-tooth aspen (*Populus grandidentata*). Trees are generally 15 to 40 cm DBH. One 18.8 cm DBH big-tooth aspen had 71 rings observed. A 15.7 cm DBH red oak had 85 rings observed. Shrub species include mountain maple (*Acer spicatum*), low sweet blueberry (*Vaccinium angustifolium*), bearberry (*Arctostaphylos uva-ursi*), choke cherry (*Prunus virginiana*), wild red raspberry (*Rubus strigosus*), tall bilberry (*Vaccinium*

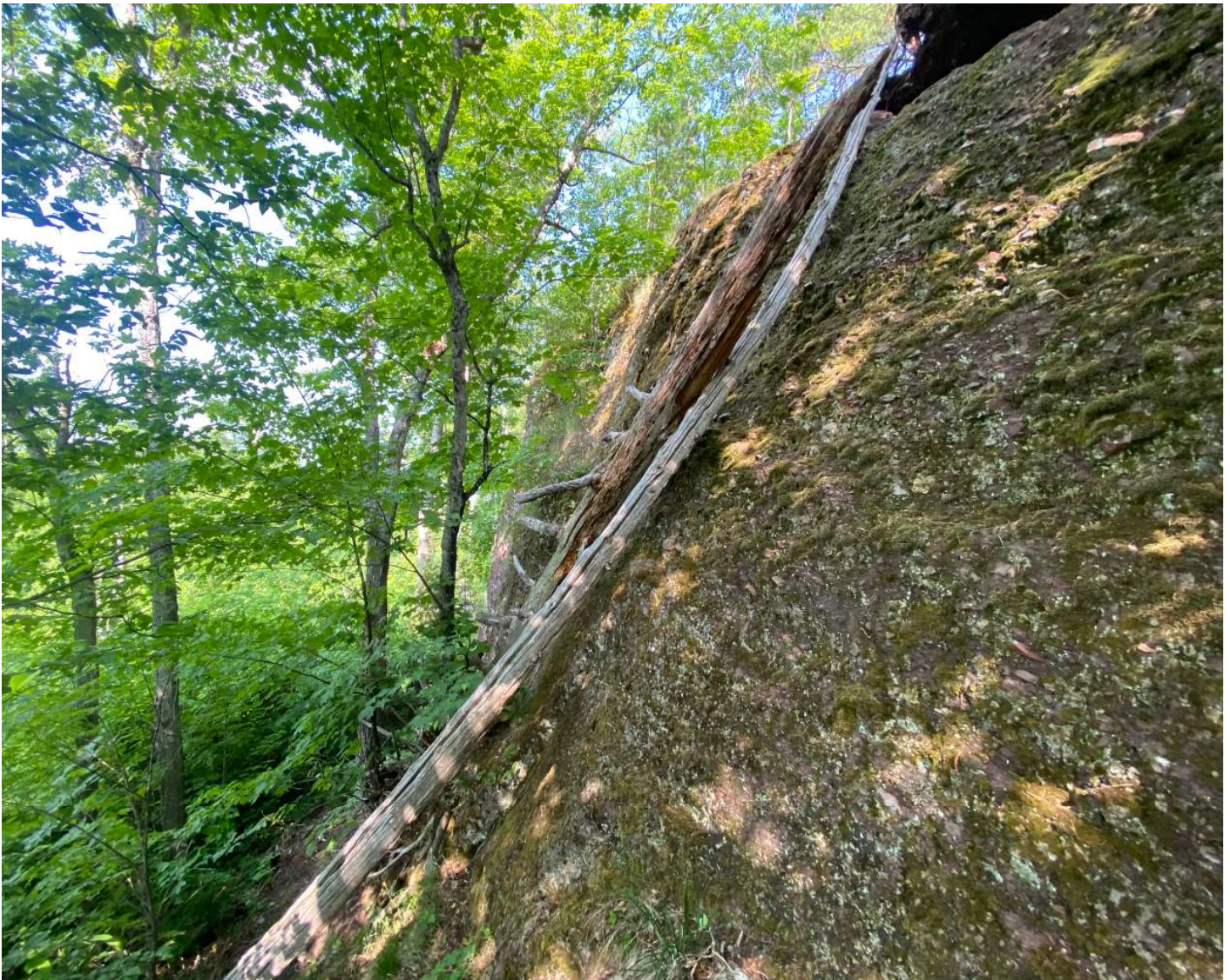


Vulcan Cliffs West. Photo by J.M. Lincoln.

membranaceum), and thimbleberry (*Rubus parviflorus*) is especially abundant along the base of the cliff. There are extensive areas of unvegetated cliff face with hair grass (*Avenella flexuosa*), common polypody (*Polypodium virginianum*), and harebell (*Campanula rotundifolia*) growing in cracks. Graminoids are common in the vegetated areas and include poverty grass (*Danthonia spicata*), western fescue (*Festuca occidentalis*), rough-leaved rice-grass (*Oryzopsis asperifolia*), fibrous-rooted sedge (*Carex communis*), and false melic (*Schizachne purpurascens*). Forbs are less frequent and include hairy goldenrod (*Solidago hispida*), big-leaved aster (*Eurybia macrophylla*), wild-basil (*Clinopodium vulgare*), and woodland strawberry (*Fragaria vesca*), Graham's rock cress (*Boechera grahamii*), and sand violet (*Viola adunca*). Ferns are infrequent to locally abundant and include rusty woodsia (*Woodsia ilvensis*) and maidenhair spleenwort (*Asplenium trichomanes*) on the cliff face. Glade-like openings at the top feature cow-wheat (*Melampyrum*

lineare), bracken fern (*Pteridium aquilinum*), pale vetchling (*Lathyrus ochroleucus*), American vetch (*Vicia americana*), and bastard-toadflax (*Comandra umbellata*).

Invasive species are especially prevalent along nearby logging roads and ORV trails within the surrounding forest. Prevalent non-native graminoids along the cliff include wood and Canada bluegrass (*Poa nemoralis* and *P. compressa*) which are both locally abundant. Common invasive forbs include common speedwell (*Veronica officinalis*), king devil (*Hieracium caespitosum*), sheep sorrel (*Rumex acetosella*), and common St. John's-wort (*Hypericum perforatum*). A soil sample was taken from a small cliff terrace. Soils are generally shallow duff over weathered rock. The leaf/needle duff (pH 6.5-7.0) is 1 cm deep. Below the duff, loam (pH 7.0) has collected to a depth of 4.0 cm. Several ant mounds occur in a glade-like opening at the cliff top. These ranged from 0.5 m² to roughly 5 m² in area.



Vulcan Cliffs West. Photo by J.M. Lincoln.

Estivant Cliffs East

Natural Community Type: Volcanic Cliff

Rank: G4G5 S2, apparently secure to secure globally and imperiled in Michigan

Element Occurrence Rank: AB, excellent to good occurrence

Size: 15.0 acres

Element Occurrence Identification Number: 26936

Estivant Cliffs East is comprised of five polygons between 0.4 and 7.2 acres in size and 75 and 750 m in length. Height is variable throughout and ranges from 6 to 80 m. Aspect is also extremely variable, generally south-facing in the large central polygon but including significant east-facing portions. This series of cliff faces is embedded within a high-quality second-growth dry-mesic northern forest (Lost Lake Forest, EOID 17853) along a ridge with

extensive volcanic bedrock outcrop. The distinction between volcanic cliff and inclusions of outcrop in the forest is difficult due to the variability in slope and contiguity of the cliff features. Cliffs are often broken by large fissures and terraces that support trees and vegetation.

White pine (*Pinus strobus*) is generally the canopy dominant, with sugar maple (*Acer saccharum*) and



Estivant Cliffs East is embedded in Lost Lake Forest. Photo by T.J. Bassett.

red oak (*Quercus rubra*) locally dominant in areas. The canopy becomes sparser where the slope transitions from steep outcrop to cliff. White cedar (*Thuja occidentalis*), balsam fir (*Abies balsamea*), and quaking aspen (*Populus tremuloides*) are sparse in the canopy throughout. A 46.7 cm DBH white pine was aged at 136 years old, and a 36.7 cm DBH quaking aspen was aged at 101 years. The sparse subcanopy includes all canopy species, especially sugar maple and red oak. Mountain maple (*Acer spicatum*) and beaked hazelnut (*Corylus cornuta*) are locally common in the talus at the base of the steepest sections of cliff. Common shrubs include low sweet blueberry (*Vaccinium angustifolium*) and shadbush serviceberry (*Amelanchier spicatum*), and less commonly pin cherry (*Prunus pensylvanicum*), bush-honeysuckle (*Diervilla lonicera*), prairie willow (*Salix humilis*), soapberry (*Shepherdia canadensis*), common juniper (*Juniperus communis*), and creeping juniper (*J. horizontalis*). Bearberry (*Arctostaphylos uva-ursi*) is locally abundant along cracks and draped over outcrops from terraces above. Many of the species listed in dry mesic northern forest that the cliffs occur within. Species typical of the exposed cliff and surrounding bedrock outcrops include long-stalked sedge (*Carex pedunculata*), rusty woodsia (*Woodsia ilvensis*), common polypody (*Polypodium virginianum*), rough-leaved rice-grass (*Oryzopsis asperifolia*), hairgrass (*Avenella flexuosa*), bastard toadflax (*Comandra umbellata*), and hairy goldenrod (*Solidago hispida*). Additional species include slender

wheatgrass (*Elymus trachycaulus*), pink corydalis (*Capnoides sempervirens*), poverty grass (*Danthonia spicata*), western fescue (*Festuca occidentalis*), early saxifrage (*Micranthes virginensis*), spreading dogbane (*Apocynum androsaemifolium*), rice-grass (*Piptatheropsis pungens*). This cliff supports populations of State Threatened Ross' sedge (*Carex rossii*), and Special Concern species fragrant fern (*Dropteris fragrans*) and blue wild-rye (*Elymus glaucus*).

Soils are generally shallow and acidic, but variable due to the complexity of the volcanic bedrock outcrops. The O-horizon consists of needle duff and organics and is between 4 to 7 cm deep and acidic (pH 4.5). The A-horizon is tan to burgundy silt and is 2 to 10 cm deep and generally less acidic (pH 5.5-6.5). This is occasionally over a B-horizon of fine loam (pH 4.5 to 5.5). Depth to bedrock ranged from 2 to 20 cm.

The system is routinely influenced by drought, windthrow, lightning, and severe weather. There is high turnover of supercanopy white pine from high winds and shallow soils. Fires caused by lightning strike is an important disturbance feature. Numerous living trees had fire scars and there were several dead trees with char. The original pine was removed in the 1800s and stumps from those clearing events occur throughout, often with char and frequently larger than trees growing today.



Estivant Cliffs East. Photo by J.M. Lincoln.

East Vein Cliffs

Natural Community Type: Volcanic Cliff

Rank: G4G5 S2, secure globally and imperiled in Michigan

Element Occurrence Rank: CD, fair occurrence

Size: 1.4 acres

Element Occurrence Identification Number: 26925

This EO includes two polygons separated by 220 m, a western polygon that is 330 m long and contains the highest portions, and an eastern polygon that is 150 m long; ranges from 3-15 m high and is 480 m long total. The canopy is sparse (30% cover) and estimated at 72 years, with the following species in declining importance: red oak (*Quercus rubra*), white pine (*Pinus strobus*), and red maple (*Acer rubrum*). The subcanopy is sparse (40%) and patchy, with the following species in declining importance red oak, red maple, white pine, choke cherry (*Prunus virginiana*), balsam fir (*Abies balsamea*), common juniper (*Juniperus communis*), green alder (*Alnus viridis*), white cedar (*Thuja occidentalis*), and white spruce (*Picea glauca*).

The ground layer is dense outside the actual cliff face (70% cover), diverse, and includes typical cliff species such as round-leaved serviceberry (*Amelanchier sanguinea*), small pussytoes (*Antennaria howellii*), bearberry (*Arctostaphylos uva-ursi*; locally dominant), hair grass (*Avenella flexuosa*), Drummond's rock

cress (*Boechera stricta*), poverty grass (*Danthonia spicata*), rough hawkweed (*Hieracium scabrum*), pale vetchling (*Lathyrus ochroleucus*), hairy goldenrod (*Solidago hispida*), American vetch (*Vicia americana*), sand violet (*Viola adunca*), and rusty woodsia (*Woodsia ilvensis*). Species of dry-mesic and mesic northern forest are also occasional, including pipsissewa (*Chimaphila umbellata*), blue bead-lily (*Clintonia borealis*), gay-wings (*Polygala paucifolia*), and downy Solomon-seal (*Polygonatum pubescens*). Both stretches of cliff occur adjacent to a maintained gravel road, but appear to lack anthropogenic modifications. However, the road is clearly a source of non-native propagules. Non-native species observed include king devil (*Hieracium caespitosum*), St John's-wort (*Hypericum perforatum*), Canada bluegrass (*Poa compressa*), and sheep sorrel (*Rumex acetosella*). Special Concern species Douglas' hawthorn (*Crataegus douglasii*) and State Threatened Ross' sedge (*Carex rossii*) were associated with this cliff. Soils were not sampled in 2023.



East Vein Cliffs. Photo by T.J. Bassett.

Additional survey results

We conducted surveys in priority survey areas, or portions of some priority surveys areas, in which we did not map natural community EOs (Table 2). This was either because natural communities did not meet size or condition criteria (e.g., too small or degraded), or surveys were not sufficient to adequately describe the natural community. For example, a small section of conglomerate cliff embedded in degraded mesic northern forest in priority survey area 9 was in good to fair condition, supporting a diverse plant community including conservative species such as marginal shield fern (*Dryopteris marginalis*), melic grass (*Melica smithii*), maidenhair spleenwort (*Asplenium trichomanes*), and many other species representative of volcanic cliff and mesic northern forest. Yet, this 30 m long, 2-5 m high cliff was neither high nor long enough to satisfy EO criteria. In contrast, priority survey area 76 contained 200-300 acres of mature, but thinly logged forest dominated by 100-year old

sugar maple (*Acer saccharum*). This forest was of sufficient size, but not sufficient condition, primarily due to recent logging. In contrast, ecological integrity is likely high enough to satisfy EO criteria in some sites that received only a cursory survey due to time constraints. For example, a northern fen in priority survey area 85 was diverse with many representative species, including sweet gale (*Myrica gale*), blue-joint grass (*Calamagrostis canadensis*), and a diversity of sedges (*Carex utriculata*, *C. stricta*, *C. buxbaumii*, *C. viridula*). This site, which grades into a rich conifer swamp to the north that was not surveyed, received only a brief survey along the southern edge in favor of higher priority sites. Data associated with these cursory surveys can still contribute to conservation planning at the KHPA, providing a more comprehensive understanding of the range of quality across natural community occurrences.

Table 2. Additional survey data.

Priority Survey Area	Community Type	Survey Date	Potential EO?	Dominant Species	Description
Alpine					
5	Rich Conifer Swamp	6.28.2023	No	<i>Thuja occidentalis</i>	Southern stand is rich conifer swamp that was selectively cut
34	Mesic Northern Forest	8.8.2023	No	<i>Acer saccharum</i>	Slopes are cut over
76	Mesic Northern Forest	8.9.2023	Yes	<i>Acer saccharum</i>	Grades into boreal forest; lightly thinned; some old-growth trees [red oak, 53.9 cm DBH (189 rings), sugar maple 62.3 cm (180 rings)]
99	Rich Conifer Swamp	6.28.2023	No	<i>Thuja occidentalis</i>	Areas have been selectively cut, old-growth individuals; small inclusion of mesic northern forest
Harbor View					
4	Volcanic Cliff	7.1.2023	No	<i>Gymnocarpium dryopteris</i>	Moist cliff along Garden Brook; mix of cliff, forest, and wetland spp.
27	Hardwood-conifer Swamp	6.29.2023	Yes	<i>Acer rubrum</i> , <i>Picea glauca</i>	Small swamp (~ 2 acres) but mature canopy and diverse
32	Mesic Northern Forest	8.2.2023	No	<i>Acer saccharum</i>	Areas have been selectively cut but old-growth individuals remain; mesic northern forest with boreal and rich conifer inclusions
56	Dry-mesic Northern Forest		No	<i>Quercus rubra</i>	Mature, young (ca. 100 years) canopy, recent stumps
75	Mesic Northern Forest	6.30.2023	Yes	<i>Quercus rubra</i>	Along north-facing slope north of 75; sugar maple dominates understory; 66.7 cm DBH white pine - 115 years
Little Betsy					
44	Poor Conifer Swamp	8.10.2023	No	<i>Picea mariana</i>	Young canopy and several stumps
81	Hardwood-conifer Swamp	8.10.2023	Yes	<i>Acer rubrum</i> , <i>Picea glauca</i>	Cursory survey; but recent stumps noted; very hummocky, with peaty depressions; 35.5 cm DBH white spruce - 270 years
The Point					
9	Mesic Northern Forest	6.27.2023	No	<i>Acer saccharum</i>	Young canopy but no apparent stumps
9	Rich Conifer Swamp	6.27.2023	No	<i>Thuja occidentalis</i>	Too small to map; Typical ground layer
9	Volcanic Cliff	6.27.2023	No	<i>Acer saccharum</i>	Too small to map: 30 m long X 2-5 m high conglomerate cliff.
20	Volcanic Bedrock Glade	6.22.2023	Yes	<i>Pinus strobus</i> , <i>Abies balsamea</i>	A few openings along Vulcan Creek, at top of gully. Small and discontinuous. Worth a follow-up survey.
28	Mesic Northern Forest	6.23.2023	No	<i>Acer saccharum</i>	Extensive selective cutting throughout; old growth individuals remain.
37	Rich Conifer Swamp	6.26.2023	Yes	<i>Thuja occidentalis</i>	Typical ground layer (e.g., <i>Carex stricta</i> , <i>Carex trisperma</i>).
65	Volcanic Bedrock Glade	6.22.2023	Yes	<i>Pinus strobus</i> , <i>Abies balsamea</i>	A few large openings between Priority Areas 65 and 20, much is impacted by trail and is locally quite weedy. Worth follow-up surveys.
85	Northern Fen	6.26.2023	Yes	<i>Myrica gale</i> , <i>Alnus incana</i>	High sedge diversity; grades into rich conifer swamp to north
96	Dry-mesic Northern Forest	8.4.2023	No	<i>Pinus strobus</i> , <i>Quercus rubra</i>	Too small to map and surrounded by clearcut; outcrops prominent; maturing canopy: white pine: 40.0 cm (177 years)
96	Rich Conifer Swamp	8.4.2023	Yes	<i>Thuja occidentalis</i>	Too small to map unless other polygons added; mature cedar (31.8 cm DBH, 190 years); canopy gaps from ash die-off with dense alder
106	Dry-mesic Northern Forest	8.4.2023	No	<i>Quercus rubra</i> , <i>Populus tremuloides</i>	Too small to map and surrounded by clearcut; outcrops prominent; maturing canopy [red oak, 24.5 cm DBH (73 rings)]
107	Dry-mesic Northern Forest	8.10.2023	Yes	<i>Pinus strobus</i> , <i>Quercus rubra</i>	Extends to east, north of 65; mature canopy [red oak, 44.1 cm (329 years)], with few stumps, diverse ground layer

Many sites that received only a cursory survey in 2023 are candidates for future surveys (Table 3). Future survey priorities also include priority survey areas that we did not survey in 2023, as well as mapped natural community EOs that would benefit from more intensive surveys to provide a more detailed description and refined boundary delineation. Several priority survey areas were inaccessible for surveys because they fall within lands covered under a long-term lease with the owners of Mount Bohemia and Mount Voodoo ski hills. These likely contain undocumented northern bald, among other communities. We urge extremely careful planning with regards to the development of these areas. Many northern balds have been degraded through infrastructure development and these remaining

examples are extremely important to conservation as there are several rare plant species with high fidelity to the this community type (see Table 4). We recommend continued natural community surveys to provide a comprehensive understanding of the conservation value of the natural features within the KHPA. In Table 3, we also provide an updated prioritization, updated informed by our experience with natural communities gained through 2023 surveys. For example, the rugged landscape in priority survey areas 17 and 38, combined with an apparently mature canopy with supercanopy white pine (*Pinus strobus*), is consistent with other sites in the KHPA that supported high-quality dry-mesic northern forest.

Table 3. Future survey priorities.

Priority Survey Area	Expected Community Type	Priority	Notes
Alpine			
1	Northern Bald, Volcanic Bedrock Glade	1	Inaccessible due to Mt Bohemia Lease; Special Concern <i>Collinsia parviflora</i> EOID 7131, last obs here 1982; Special Concern <i>Dryopteris filix-mas</i> EOID9050 last obs here 1982
2	Volcanic Cliff	1	Inaccessible due to Mt Bohemia Lease; State Threatened <i>Pterospora andromedea</i> EOID 5114, last obs here 1953
3	Volcanic Cliff	1	Inaccessible due to Mt Bohemia Lease
6	Northern Bald, Volcanic Bedrock Glade	1	Inaccessible due to Mt Bohemia Lease
12	Poor or Rich Conifer Swamp	2	Open peatland inclusion
27	Mesic Northern Forest	3	Western half of EO needs better survey
31	Dry-mesic Northern Forest	3	Western half of priority survey area may contain additional dry-mesic northern forest
35	Dry-mesic Northern Forest, Conifer Swamp	2	Open peatland inclusion; interesting ridgeline, may contain primary community
45	Poor or Rich conifer swamp	2	Open peatland inclusion
88	Northern Bald, Volcanic Bedrock Glade	1	Inaccessible due to Mt Voodoo Lease; Special Concern <i>Collinsia parviflora</i> EOID 11421, last obs here 1982
89	Northern Bald, Volcanic Bedrock Glade	1	Inaccessible due to Mt Voodoo Lease; Special Concern <i>Collinsia parviflora</i> EOID 11421, last obs here 1982
90	Northern Bald, Volcanic Bedrock Glade	1	Inaccessible due to Mt Voodoo Lease
91	Northern Bald, Volcanic Bedrock Glade	1	Inaccessible due to Mt Voodoo Lease
92	Northern Bald, Volcanic Bedrock Glade	1	Inaccessible due to Mt Voodoo Lease
95	Northern Bald, Volcanic Bedrock Glade	1	Inaccessible due to Mt Voodoo Lease
101	Boreal Forest or Conifer Swamp	2	Open peatland inclusion
109	Dry-mesic Northern Forest	2	Inaccessible due to Mt Bohemia Lease
Harbor View			
40	Boreal Forest	2	
50	Rich Conifer Swamp	2	
75	Mesic Northern Forest	3	Could add to Estivant Ridge (EOID 26937)
Little Betsy			
NA	Sandstone Bedrock Lakeshore or Lakeshore Cliff	1	Shoreline in southern 1/4 of northern parcel, majority of southern parcel; both bedrock and low (~2 m) cliff noted at: 47.3047744°N, 88.0225505°W
58	Hardwood-conifer Swamp	2	
59	Poor Fen	2	
81	Rich Conifer or Hardwood-conifer Swamp	2	

Table 3 (continued). Future survey priorities.

Priority Survey Area	Expected Community Type	Priority	Notes
The Point			
17	Dry-mesic Northern Forest	2	
19	Rich Conifer Swamp	2	
20	Volcanic Bedrock Glade	1	Small glade openings at top of gully east of Vulcan Creek
21	Dry-mesic Northern Forest; Boreal Forest	1	Extends from Ft. Wilkins State Park south to Priority Area 20, boreal forest in 21 transitioning to dry-mesic northern forest toward 107. Rich conifer swamp inclusions.
29	Boreal Forest	1	
30	Boreal Forest	3	Eastern half needs better survey
36	Rich Conifer Swamp	2	
37	Rich Conifer Swamp	2	
38	Dry-mesic Northern Forest	2	
52	Northern Wet Meadow; Poor Fen	2	
53	Boreal Forest	3	Eastern half needs better survey
60	Rich Conifer Swamp	1	Survey for additional conifer swamp to the west
61	Northern Wet Meadow; Poor Fen	2	
65	Volcanic Bedrock Glade	2	Between Priority Areas 65 and 20, impacted by trail
67	Boreal Forest	2	Supercanopy white pines in imagery; survey only covered the eastern edge
67	Rich Conifer Swamp	2	
85	Northern Fen, Rich Conifer Swamp	2	
107	Dry-mesic Northern Forest	1	Extends from Ft. Wilkins State Park south, boreal forest in 21 transitioning to dry-mesic northern forest toward 107



Rusty woodsia in Estivant Cliffs East. Photo by T.J. Bassett.

Rare plant surveys

We documented or updated 17 EOs of 8 rare plant species within the KHPA (Table 4). The rare plant species we observed in 2023 include green spleenwort (*Asplenium viride*, Special Concern; one update), Ross' sedge (*Carex rossii*, State Threatened; five new EOs), blue-lips (*Collinsia parviflora*, Special Concern; one update, one new EO), Douglas' hawthorn (*Crataegus douglasii*, Special Concern; one update), male fern (*Dryopteris filix-mas*, Special Concern; one new EO), fragrant fern (*Dryopteris fragrans*, Special Concern; two new EOs), blue rye (*Elymus glaucus*, Special Concern; two new EOs), and woodland cudweed (*Omalotheca sylvatica*, State Threatened; three new EOs), totaling three updates and 14 new EOs.

These rare plant occurrences are most frequently associated with exposed volcanic bedrock (e.g., balds, glades, and cliffs) with hot and dry southern exposure, especially Ross' sedge, blue-lips, Douglas' hawthorn, fragrant fern, and blue rye. Blue-lips, Ross' sedge, and Douglas' hawthorn are examples of plant species in the Keweenaw Peninsula that are disjunct from a core range in mountains of western North America (Marquis and Voss 1981). Many plant species in Michigan attain their highest density or occur only in the Keweenaw Peninsula, which generates a unique floristic signature to the region. These species are generally adapted to volcanic bedrock communities, making conservation of these communities vital for conserving this unique flora.



State Threatened woodland cudweed (*bottom left*), Special Concern fragrant fern (*bottom right*) and Special Concern Douglas' hawthorn (*top*). Photos by T.J. Bassett.

Table 4. Rare plant species documented in the KHPA. Last observed dates in **bold** indicate EOs first observed during 2023 surveys.

Species Name	Common Name	State Status	S-Rank	Last Observed	Priority Survey Area(s)	Estimated Population Size	EOID
Alpine							
<i>Asplenium viride</i>	Green spleenwort	SC	S3	2023	5	15	6638
<i>Collinsia parviflora</i>	Blue-lips	SC	S2	2023	4	100	27033
<i>Collinsia parviflora</i>	Blue-lips	SC	S2	1982	88, 90	unknown	11421
<i>Collinsia parviflora</i>	Blue-lips	SC	S2	1982	1, 2	unknown	7131
<i>Dryopteris filix-mas</i>	Male fern	SC	S3	1982	4	unknown	1157
<i>Dryopteris filix-mas</i>	Male fern	SC	S3	1982	1, 2	unknown	9050
<i>Dryopteris fragrans</i>	Fragrant fern	SC	S3	2023	4	5	27032
<i>Elymus glaucus</i>	Blue wild-rye	SC	S3	2023	4	1	27012
<i>Mertensia paniculata</i>	Northern bluebell	SC	SNR	1895	77	unknown	22968
<i>Pterospora andromodea</i>	Pine-drops	T	S2	1953	1, 2	unknown	5114
Harbor View							
<i>Carex rossii</i>	Ross' sedge	T	S2	2023	27	50	27022
<i>Carex rossii</i>	Ross' sedge	T	S2	2023	31, 75	50	27023
Little Betsy							
<i>Omalotheca sylvatica</i>	Woodland cudweed	T	S1	2023	41	20	27025
The Point							
<i>Carex rossii</i>	Ross' sedge	T	S2	2023	96, 106, 107	100	26973
<i>Carex rossii</i>	Ross' sedge	T	S2	2023	16	10	26977
<i>Carex rossii</i>	Ross' sedge	T	S2	2023	103	25	27021
<i>Collinsia parviflora</i>	Blue-lips	SC	S2	2023	16	100	12752
<i>Crataegus douglasii</i>	Douglas' hawthorn	SC	S3S4	2023	108	5	21414
<i>Dryopteris filix-mas</i>	Male fern	SC	S3	2023	16	20	27020
<i>Dryopteris fragrans</i>	Fragrant fern	SC	S3	2023	10, 103	40	27024
<i>Elymus glaucus</i>	Blue wild-rye	SC	S3	2023	10	1	27031
<i>Omalotheca sylvatica</i>	Woodland cudweed	T	S1	2023	96	1	27026
<i>Omalotheca sylvatica</i>	Woodland cudweed	T	S1	2023	16	1	27027
<i>Pyrola minor</i>	Lesser pyrola	SC	SNR	1988	30	unknown	20526

Green spleenwort, male fern, and woodland cudweed, in contrast, are associated with habitats that are moist and protected. Green spleenwort is associated with moist, protected cliff faces, while male fern occurs in talus or shallow soil in closed-canopy forests. Woodland cudweed, in contrast, is associated with generally disturbed conditions throughout its range in Michigan as within the KHPA, known for the most part from old logging roads or adjacent habitats (MNFI 2023). First observed in Michigan in 1989, the nativity of this species is questionable. These are the first published reports of woodland cudweed from the Keweenaw Peninsula, although casual observations have been made as far back as 2019 (N. Martineau, pers comm).

Future surveys should include searches for known EOs and target specific habitats for likely undocumented occurrences. There were seven EOs, previously documented within the KHPA with location information specific enough to facilitate relocation, that we did not observe in 2023 (MNFI 2023). The focus of the 2023 surveys was documenting high-

quality natural communities, so we did not conduct targeted surveys to update these EOs. Four of these EOs were located within the land leased by Mt Voodoo (one EO of blue-lips) and Mt Bohemia (one EO each of blue-lips, male fern, and pine-drops [*Pterospora andromodea*, State Threatened]) ski hills. While these occur in locations that were initial survey targets in 2023, the conditions of the lease prohibited MNFI surveys (Table 3). Additionally, one EO each of male fern, northern bluebell (*Mertensia paniculata*, Special Concern), and lesser pyrola (*Pyrola minor*, Special Concern) may still persist in the KHPA. EOs documented in 2023 and in prior years are concentrated in Alpine (ten EOs total, four in 2023) and The Point (11 EOs total, ten in 2023), and not in Harbor View (two EOs total, both in 2023) or Little Betsy (one EO total, in 2023). This distribution is in part due to the concentration of habitat for rare species in Alpine and The Point, particularly volcanic outcrops.

DISCUSSION

The Keweenaw Peninsula is a region of considerable conservation value with several high-quality natural communities and populations of rare species (Figure 8). Prior to the establishment of the KHPA, 22,780 acres of Keweenaw County (not including Isle Royale National Park) were in conservation ownership. The addition of the 32,450 acres of the KHPA greatly expands the conservation potential of the region. We identified 37 previously undocumented natural community occurrences and 14 previously undocumented rare plant species occurrences, including several that are imperiled to critically imperiled (G2/S2 to G1/S1). The five new EOs of State Threatened Ross' sedge (*Carex rossii*; G5/S2) increase the statewide total to 13, all of which occur in Keweenaw County. The three new EOs of State Threatened woodland cudweed (*Omalotheca sylvatica*; G4G5/S1) are the first documented in Keweenaw County and bring the statewide total to nine. We documented 11 new volcanic cliff (G4G5/

S2) EOs, increasing the total in Keweenaw County to 15, and the statewide total to 26. These newly documented volcanic cliffs total 23 hectares (57 acres) and 8.3 kilometers (5.2 miles) in length and include the largest documented continuous cliff in Keweenaw County (1.2 km [0.75 miles]; McKenzie Cliffs, EOID 26695). We also documented a new northern bald (GU/S1) EO, one of only 10 in the state, several of which are severely degraded. Finally, Lost Lake Forest (EOID 17853) was expanded more than five-fold from 58 to 307 acres, about twice the median size of 157 acres for dry-mesic northern forest (G4S3) EOs in Michigan and the 14th largest of 74 EOs.

Here, we put these noteworthy results in the context of conservation planning. We emphasize that with careful planning, management, and continued surveys, the most valuable natural features of the KHPA can be protected and expanded while allowing for abundant recreational opportunities



East Bluff Glade, looking west over The Point and the rest of the KHPA. Photo by T.J. Bassett.

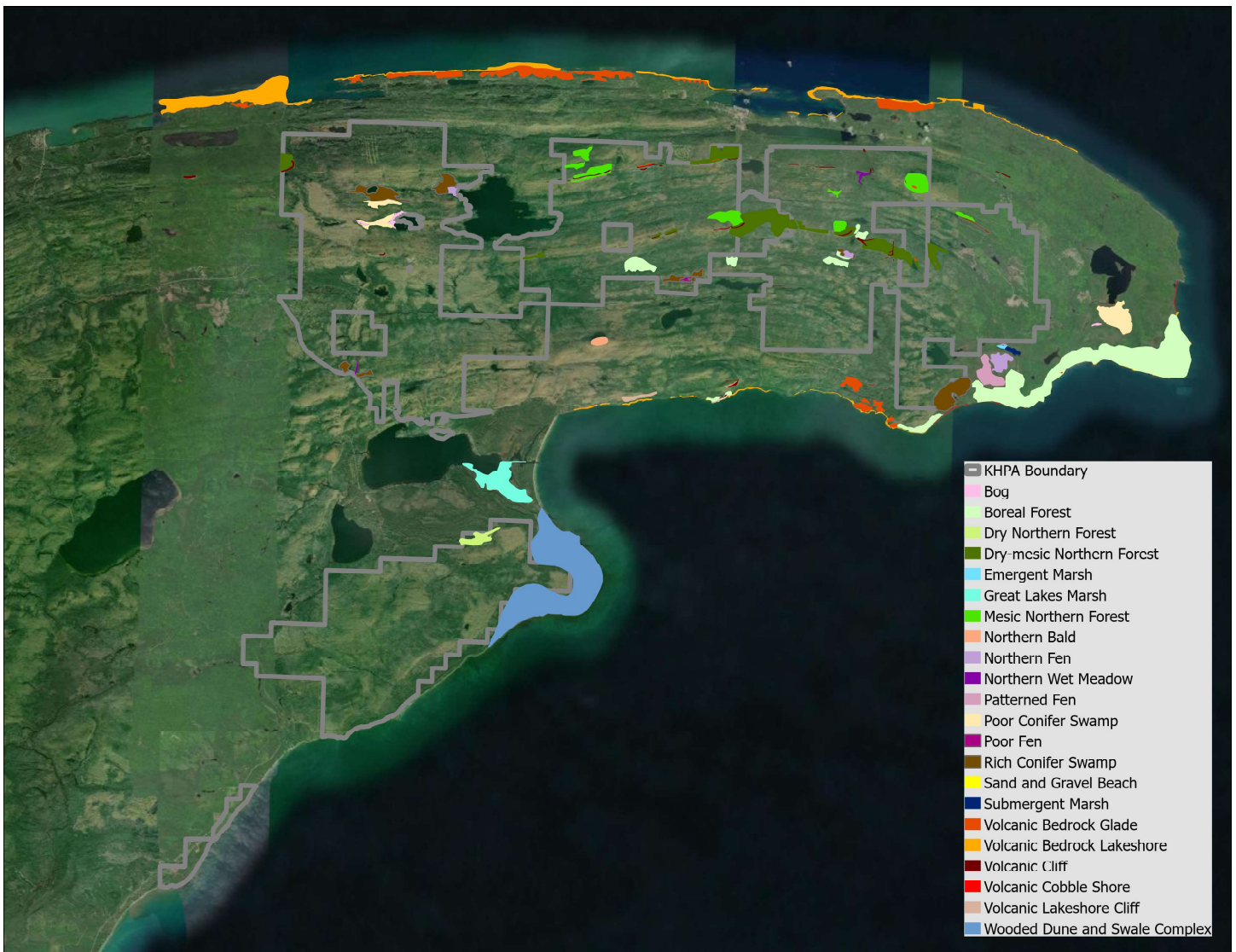


Figure 8. Natural community EOs in the KHPA and surrounding areas.

Landscape context and degradation

While the broader landscape features extensive natural cover, the natural communities described in this report occur in the context of nearly two centuries of degradation due to mining and industrial forest management. Accessible upland forests have been most impacted by logging. Where high-quality upland forests persist, it is because the topography was too steep for modern logging equipment. Widespread, continual cutting simplifies forest composition (e.g., by eliminating or reducing species such as white pine) and structure (e.g., by creating young, even-aged forest stands lacking vertical and horizontal heterogeneity). Young forests with simplified composition and structure support less biodiversity overall, including important conservation targets like neotropical migrant birds (e.g., Goetz et al. 2010). This simplification occurs at the landscape scale as well, reducing the heterogeneity associated with mature forests. In particular, most of the high-quality mesic northern forests that historically comprised the majority of the uplands have been eliminated or degraded (Comer et al. 1995).

Conservation planning

Despite areas of degradation, the Keweenaw Peninsula features an especially high concentration of high-quality natural communities, rare plant species, and charismatic megafauna. Both state and tribal agencies and non-profit conservation organizations protect and manage land in the region, including TNC, Michigan Nature Association (MNA), Keweenaw Bay Indian Community, Michigan Department of Natural Resources (MDNR) Parks and Recreation Division, and MDNR Forest Resources Division (i.e., State Forests). Preserves like Estivant Pines (MNA) and the Helmut and Candis Stern Preserve at Mt Baldy (TNC) are among the most iconic nature preserves in Michigan. The State Forests have an unusual concentration of high-quality natural communities compared to other State Forest holdings.

Concentrations of natural communities documented and updated during 2023 surveys can serve as focal areas for conservation planning. The greatest impacts for biodiversity will be found by protecting the rarest community types, the highest quality examples of natural communities, and the protection of large areas of intact natural cover from further

fragmentation. To support conservation planning efforts, we provide the following recommendations. The goal of these recommendations is to maximize the protection and ecological integrity of the highest quality and rarest natural community types. Our top recommendations are: *developing buffers* to prevent additional fragmentation around high-quality natural communities; *minimizing ORV use* and other forms of recreation around bedrock communities; *closing roads* to limit the spread of invasive species and increasing habitat connectivity; *treating invasive species*; and *investigating application of prescribed fire*, particularly in dry and dry-mesic northern forests.

Developing conservation buffers

Developing large conservation buffers of natural cover around existing concentrations of natural communities will protect those natural communities from degradation (e.g., edge effects) and increase connectivity between natural communities. Within these conservation buffers, we suggest that forests are allowed to continue maturing, roads and trails are eliminated or limited, and monitoring and treatment of invasive species is prioritized.

Minimizing ORV use and closing roads

Former logging roads are extensively utilized by off-road vehicles (ORVs). In conjunction with ORV use is an increase in unsanctioned camping on state land, causing accumulation of refuse in the absence of necessary services. These activities are often focused on some of the rarest natural community types where ORVs convene, such as volcanic bedrock glade and volcanic bedrock shoreline. Similarly, to protect ecological integrity we recommend discouraging the expansion of mountain bike trails and climbing activities near and within bedrock communities. The noise from extensive ORV use may also have detrimental impacts on occupancy by gray wolves (*Canis lupus*) and black bears (*Ursa americanus*), which are critical components to a functioning landscape.

Trails and roads encourage habitat fragmentation. We urge managers to close trails and logging roads when possible, and minimize the creation of new trails and roads, to reduce degradation of high-quality natural communities. Invasive species are not prevalent in the KHPA, except along trails and logging roads. ORVs are a vector for invasive species dispersal from trails and roads, in addition to direct soil disturbance in high-quality natural communities. Reducing the density of trails and roads will limit the 'points of entry' for invasive species into natural communities.

Treating invasive species

Invasive plant species generally occur at low densities in the KHPA. However, the Keweenaw Peninsula's logging history has resulted in extensive logging roads that are a major vector for the spread of invasive plant species. We observed spotted knapweed (*Centaurea stoebe*), oxeye daisy (*Leucanthemum vulgare*), clovers (*Trifolium* spp. and *Melilotus* spp.), hawkweeds (*Hieracium aurantiacum* and *H. caespitosum*), common St. John's-wort (*Hypericum perforatum*), sweet vernal grass (*Anthoxanthum odoratum*), non-native bluegrasses (*Poa pratensis*, *P. nemoralis*, and *P. compressa*), European swamp thistle (*Cirsium palustre*), common buttercup (*Ranunculus acris*), and common tansy (*Tanacetum vulgare*) at very high densities along logging roads. Some of these species are dispersing out of these concentrated populations, and becoming increasingly frequent and abundant, especially in glade and cliff communities.

Therefore, in addition to closing roads, we recommend monitoring for invasive species and prioritizing the treatment of invasive plant species in and around natural communities. Canada bluegrass, sheep sorrel, common St. John's-wort, and non-native hawkweeds are especially widespread and likely to be locally dominant. Spotted knapweed is dominant along trails and has the potential to spread into high-quality areas, especially with the density of trails and prevalence of ORVs and dirt bikes that go off-trail.



Invasive wood and Canada bluegrass in Little Mandan cliff. Photo by T.J. Bassett.

Investigating prescribed burns

Fire is a natural disturbance regime in some of the natural communities that were surveyed. Historically, the fire return interval in upland forest types dominated by white pine (*Pinus strobus*) like dry and dry-mesic northern forests ranged between 60 and 300 years (Heinselman 1973, Heinselman 1981, Whitney 1986, Drobyshev et al. 2008). We observed many white (and presumably red [*P. resinosa*]) pine stumps in these communities with fire scars or char from lightning strikes. What is not clear is if lightning has historically been the primary ignition source, or whether Indigenous peoples played a role in the application of cultural fires. Dry and dry-mesic northern forests feature numerous berry-producing plants and the abundance of these culturally important species may be associated with historic indigenous influence. Further, pine is not regenerating in pine-dominated forests in the KHPA, despite ample light availability from canopy gaps and a low abundance of deer that would otherwise suppress recruitment. The local dominance of maple in the understory of dry-mesic forests and the lack of regenerating pine suggest that fire historically played an important role. Without fire, pine- and oak-dominated dry-mesic northern forest is succeeding toward maple-dominated mesic northern forest, a process often referred to as 'mesophication'. Considering the long history of copper extraction and regular seasonal occupancy of Indigenous peoples it seems likely that cultural fires played an important role in shaping natural communities in the region (Martin 1999, Stewart 2009). Research into the topic is warranted and there are approaches for reconstructing historic fire regimes that utilize tree rings in stumps from the logging era of the 1800s. We urge managers to collaborate with local tribes to understand historic fire regimes and cultural significance of Little Betsy Forest, Silver River Forest, Keweenaw Lodge Forest, and Lost Lake Forest.



Unidentified bird next in volcanic cliff. Photo by T.J. Bassett.

Future work

In addition to the conservation planning and management priorities outlined above, we emphasize that additional surveys are almost certain to document additional important natural features. As previously summarized (Table 3; *Additional survey data*), we were unable to complete all our survey priorities in 2023 due to time constraints. This fact highlights that the conservation potential in the KHPA, already immense, can be even greater. While we identified many important natural features, there are potentially several additional natural community occurrences left to be documented, as well as occurrences of rare and plant and animal species. Protecting high-quality natural communities is a coarse-scale approach for protecting rare species that occur on the Keweenaw Peninsula by protecting potential habitat, including the raptors peregrine falcon (*Falco peregrinus*, State Threatened) and merlin (*Falco columbarius*, Special Concern), northern long eared bat (*Myotis septentrionalis*, State Threatened and Federally Endangered) and tricolored bat (*Perimyotis subflavus*, State Threatened), the insects incurvate emerald (*Somatochlora incurvata*, Special Concern) and yellow banded bumble bee (*Bombus terricola*, Special Concern), and the mussels eastern ellipto (*Elliptio complanata*, Special Concern) and a land snail (*Vertigo modesta modesta*, State Endangered). Documenting occurrences of rare animal species, rare plant species (Table 4), and large mammals such as gray wolf and black bear, provides greater assurance of their conservation. A more comprehensive understanding of the biodiversity supported by the KHPA will augment the impact of conservation efforts in the region.

Conclusion

The results of 2023 focal community surveys summarized here comprise one step of a significant conservation and land protection effort. The conservation value of the 38 natural community EOs and 17 rare plant EOs described in this report will be balanced with tribal concerns and a local economy. Conservation planning needs to include continuing forestry and diverse recreational activities. Ideally, these objectives will be compatible and reinforce each other to maintain a landscape that continues to support a wealth of biodiversity. We hope that conservation planning provides the highest levels of protection for as much of the KHPA as possible. The KHPA protects a unique concentration of imperiled and vulnerable natural communities and therefore represents a once in a generation conservation opportunity.

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Looking southeast from Brockway Mountain over the Harbor View parcel, McKenzie Forest, Cliff, and Bald in the distance. Photo by T.J. Bassett.

APPENDIX

Table A1. Priority survey areas identified as site leads for 2023 surveys.

Priority Survey Area	Cover Type	Priority	Surveyed	Natural Community	Plant EOs
ALPINE					
1	Glade	1	No*	potential northern bald, volcanic bedrock glade	
2	Glade	1	No*	potential volcanic cliff	
3	Glade	1	No*	potential volcanic cliff	
5	UF	1	Yes	Dry-mesic Northern Forest, Volcanic Cliff; sub-EO rich conifer swamp	<i>Asplenium viride</i>
6	Unknown	3	No	potential northern bald, volcanic bedrock glade	
11	LF	1	Yes	Northern Fen, Rich Conifer Swamp	
12	Glade	1	No	potential poor or rich conifer swamp	
33	Glade	1	No		
34	Glade	1	No	sub-EO mesic northern forest	
35	LF	2	No	potential dry-mesic northern forest, poor or rich conifer swamp	
42	LF	1	No*		
45	LF	1	No	potential poor or rich conifer swamp	
46	LF	1	Yes	Bog, Poor Conifer Swamp	
47	LF	1	Yes	Poor Conifer Swamp, Rich Conifer Swamp	
48	NFW	2	No		
49	NFW	3	No		
76	Various	1	Yes	Northern Wet Meadow, Rich Conifer Swamp; potential mesic northern forest	
77	LF	3	No		
78	Glade	1	No		
79	Glade	1	Yes	Volcanic Cliff	<i>Carex rossii</i>
86	NFW	3	No*		
87	UF	1	Yes	Dry-mesic Northern Forest, Volcanic Cliff	
88	Glade	1	No*	potential northern bald, volcanic bedrock glade	
89	Glade	1	No*	potential northern bald, volcanic bedrock glade	
90	Glade	1	No*	potential northern bald, volcanic bedrock glade	
91	Glade	1	No*	potential northern bald, volcanic bedrock glade	
92	Glade	1	No*	potential northern bald, volcanic bedrock glade	
93	LF	2	No		
94	LF	2	No		
95	Glade	1	No*	potential northern bald, volcanic bedrock glade	
99	LF	1	No	sub-EO rich conifer swamp	
100	Glade	1	No		
101	LF	2	No	potential boreal forest or rich conifer swamp	
104	LF	2	No*		
109	Glade	2	No*	potential dry-mesic northern forest	
110	LF	NA	No*		

*These priority survey areas were inaccessible for surveys, as they are within the Mt Bohemia or Mt Voodoo lease

Table A1, continued. Priority survey areas identified as site leads for 2023 surveys.

Priority Survey Area	Cover Type	Priority	Surveyed	Natural Community	Plant EOs
HARBOR VIEW					
4	Glade	3	Yes	Mesic Northern Forest, Northern Bald, Volcanic Cliff	<i>Collinsia parviflora</i> , <i>Dryopteris filix-mas</i> , <i>Dryopteris fragrans</i> , <i>Elymus glaucus</i>
27	Glade	1	Yes	Mesic Northern Forest, Volcanic Cliff; potential hardwood-conifer swamp	<i>Carex rossii</i>
31	Glade	1	Yes	Dry-mesic Northern Forest, Rich Conifer Swamp	<i>Carex rossii</i>
32	UF	3	Yes	Boreal Forest, Mesic Northern Forest	
39	LF	2	Yes	Boreal Forest	
40	LF	2	No	potential boreal forest	
41	Glade	1	Yes	Dry-mesic Northern Forest	<i>Omalotheca sylvatica</i>
50	LF	2	No	potential rich conifer swamp	
51	LF	3	Yes	Dry-mesic Northern Forest	
54	Glade	1	No		
56	Glade	1	Yes	sub-EO dry-mesic northern forest	
68	UF	1	Yes	Dry-mesic Northern Forest	
70	UF	1	Yes	Dry-mesic Northern Forest, Volcanic Cliff	
71	Glade	1	Yes	Volcanic Bedrock Glade, Volcanic Cliff	
72	Glade	2	No		
73	NFW	2	No		
74	Glade	1	No		
75	Glade	1	Yes	Dry-mesic Northern Forest, Volcanic Cliff; potential mesic northern forest	<i>Carex rossii</i>
98	LF	2	Yes	Poor Fen, Rich Conifer Swamp	
LITTLE BETSY					
43	UF	1	Yes	Dry Northern Forest	
44	LF	2	Yes	sub-EO conifer swamp with boreal forest inclusion	
57	UF	3	No		
58	LF	2	No	potential hardwood-conifer swamp	
59	NFW	3	No	potential poor fen	
80	LF	2	No		
81	LF	2	Yes	potential hardwood-conifer swamp	<i>Omalotheca sylvatica</i>
THE POINT					
8	Glade	1	Yes	Dry-mesic Northern Forest	
9	LF	3	Yes	sub-EO mesic northern forest, rich conifer swamp, volcanic cliff	
10	UF	1	Yes	Dry-mesic Northern Forest, Mesic Northern Forest	<i>Dryopteris fragrans</i> , <i>Elymus glaucus</i>
13	UF	3	No		
14	LF	3	No		
15	Glade	NA	No		
16	Glade	1	Yes	Mesic Northern Forest, Volcanic Bedrock Glade, Volcanic Cliff	<i>Collinsia parviflora</i> , <i>Carex rossii</i> , <i>Dryopteris filix-mas</i> , <i>Omalotheca sylvatica</i>
17	Glade	2	No	potential dry-mesic northern forest	
18	Glade	1	Yes	Mesic Northern Forest, Rich Conifer Swamp	
19	LF	2	No	potential rich conifer swamp	
20	Glade	1	Yes	Volcanic Bedrock Glade, Volcanic Cliff	
21	UF	3	Yes	potential boreal forest	

Table A1, continued. Priority survey areas identified as site leads for 2023 surveys.

Priority Survey Area	Cover Type	Priority	Surveyed	Natural Community	Plant EOs
THE POINT, continued					
22	UF	3	No		
23	LF	2	No		
24	LF	2	No		
25	UF	3	No		
28	UF	1	Yes	Dry-mesic Northern Forest; sub-EO mesic northern forest	
29	LF	2	No	potential boreal forest	
30	LF	3	Yes	Boreal Forest	
36	LF	2	No	potential rich conifer swamp	
37	LF	2	Yes	potential rich conifer swamp	
38	UF	2	No	potential dry-mesic northern forest	
52	NFW	3	No	potential northern wet meadow, poor fen	
53	LF	2	Yes	Boreal Forest	
55	LF	2	No		
60	NFW	3	Yes	Boreal Forest, Northern Fen, Rich Conifer Swamp	
61	NFW	3	No	potential northern wet meadow, poor fen	
62	Glade	1	No		
64	NFW	3	Yes	Northern Wet Meadow	
65	Glade	1	Yes	Volcanic Cliff; potential volcanic bedrock glade	
66	Glade	1	Yes	Dry-mesic Northern Forest, Volcanic Cliff	
67	LF	1	Yes	Boreal Forest; potential rich conifer swamp	
82	UF	1	No		
83	LF	3	No		
84	LF	2	No		
85	LF	3	Yes	potential northern fen, rich conifer swamp	
96	Glade	1	Yes	potential rich conifer swamp; sub-EO dry-mesic northern forest	<i>Carex rossii</i> , <i>Omalotheca sylvatica</i>
97	Glade	1	Yes	Mesic Northern Forest	
102	Glade	2	No		
103	Glade	1	Yes	Dry-mesic Northern Forest, Volcanic Cliff	<i>Carex rossii</i> , <i>Dryopteris fragrans</i>
106	Glade	1	Yes	sub-EO dry-mesic northern forest	<i>Carex rossii</i>
107	Glade	1	Yes	Volcanic Cliff; potential dry-mesic northern forest	<i>Carex rossii</i>
108	Glade	1	Yes	Volcanic Cliff	<i>Crataegus douglasii</i>
111	UF	1	Yes	Dry-mesic Northern Forest, Volcanic Cliff	



Broad-leaved twayblade orchid, in rich conifer swamp. Photo by T.J. Bassett.

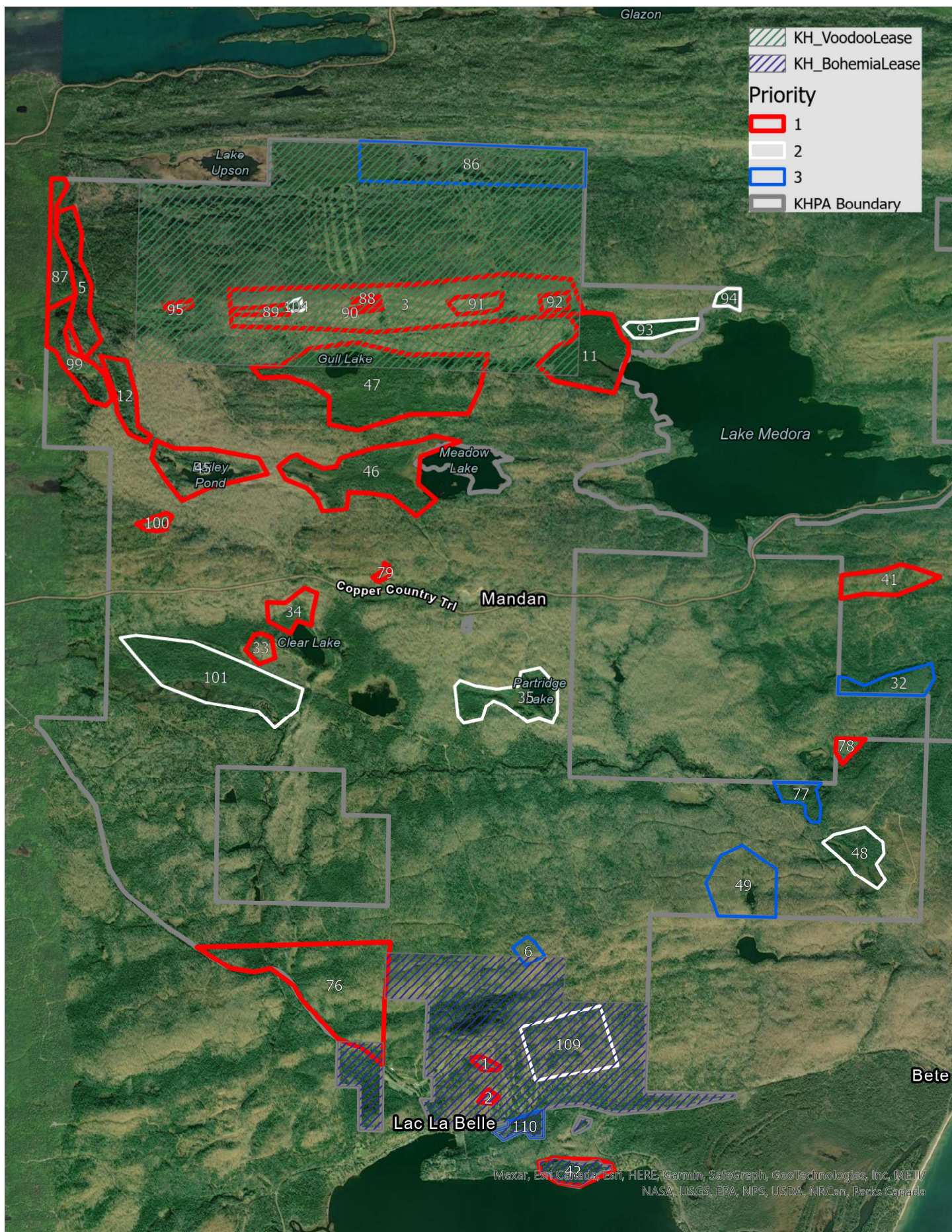


Figure A1. Priority survey areas in the Keweenaw Alpine parcel.

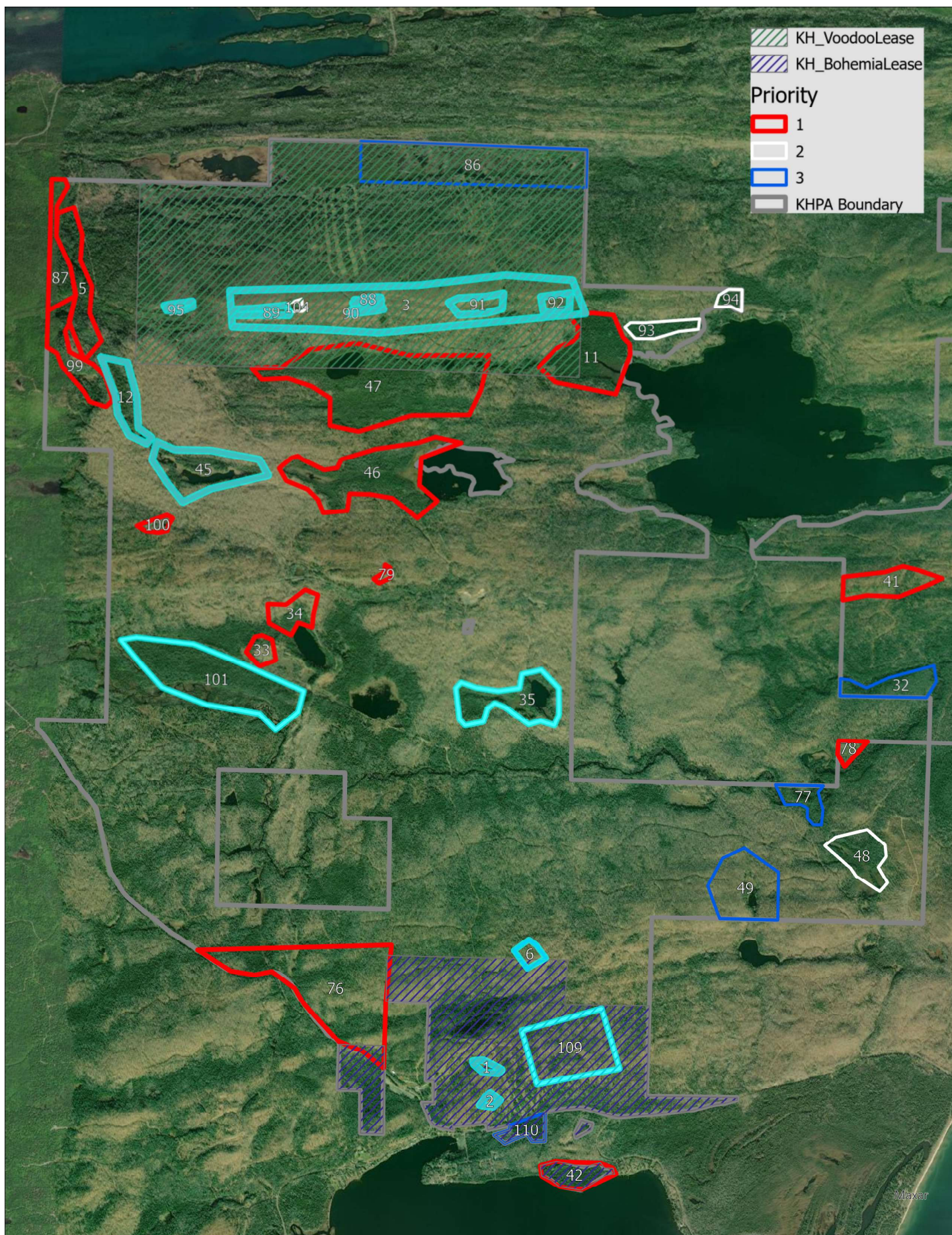


Figure A2. Priority survey areas in the Keweenaw Alpine parcel, with future survey priorities highlighted.

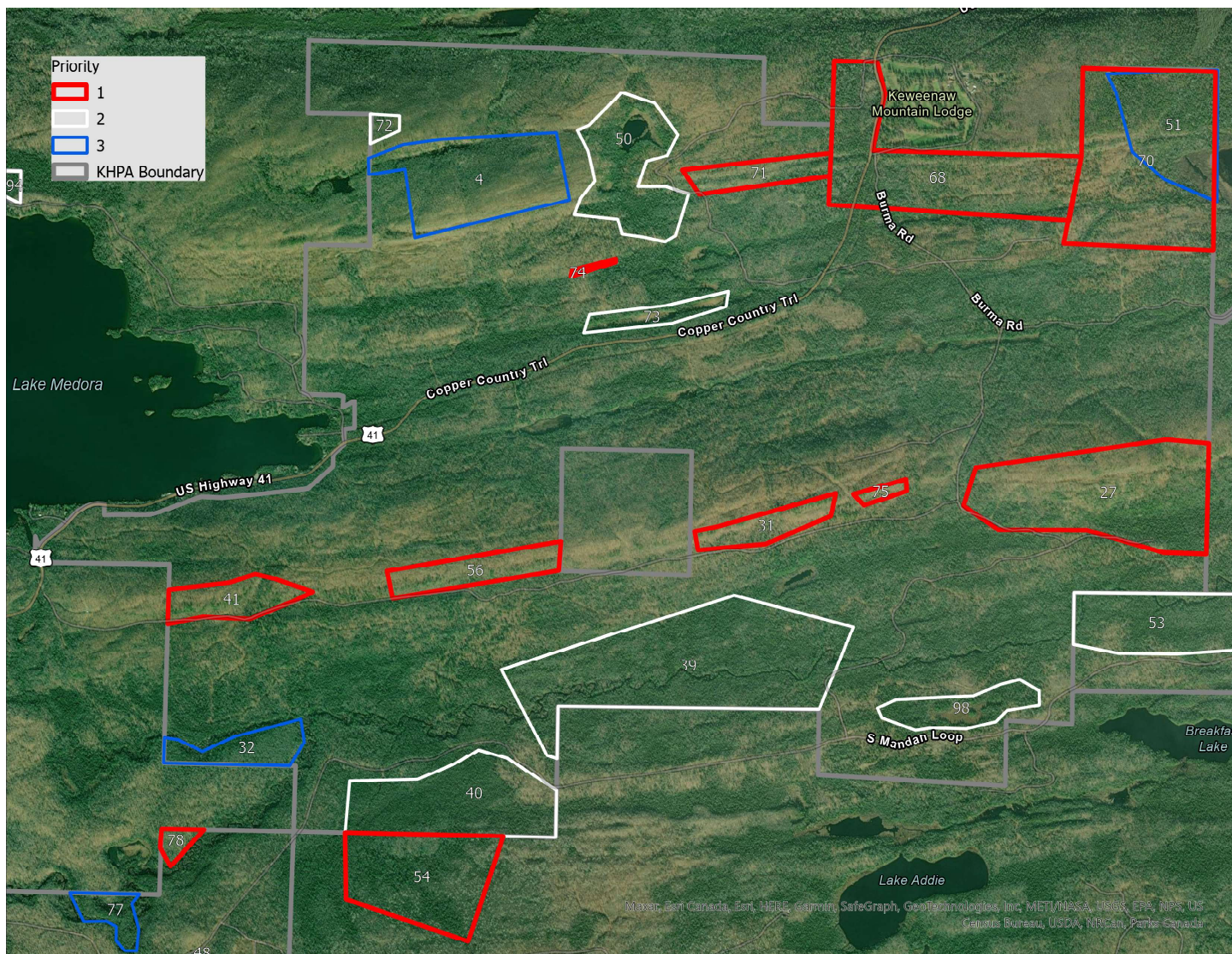


Figure A3. Priority survey areas in the Harbor View parcel.

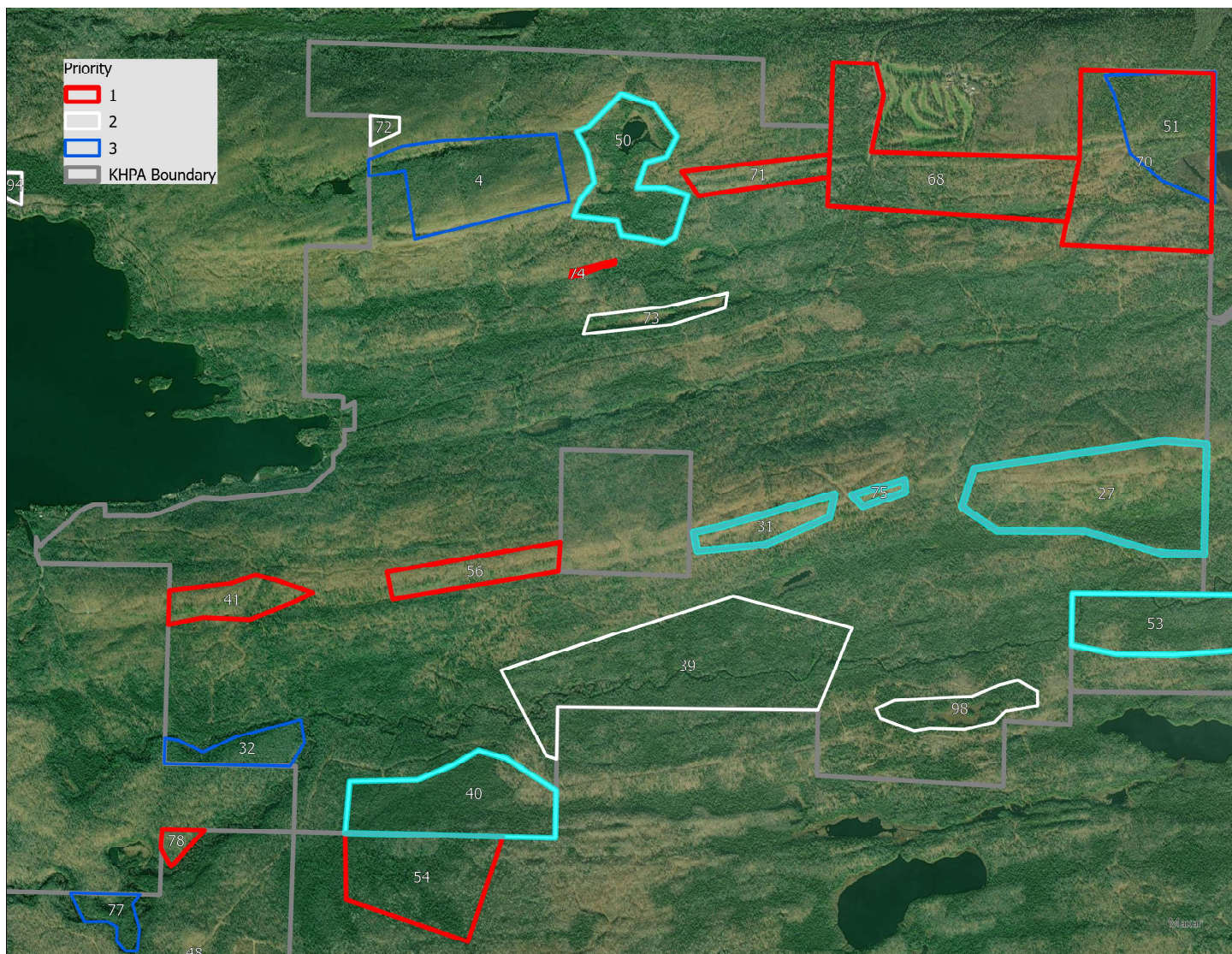


Figure A4. Priority survey areas in the Harbor View parcel, with future survey priorities highlighted.

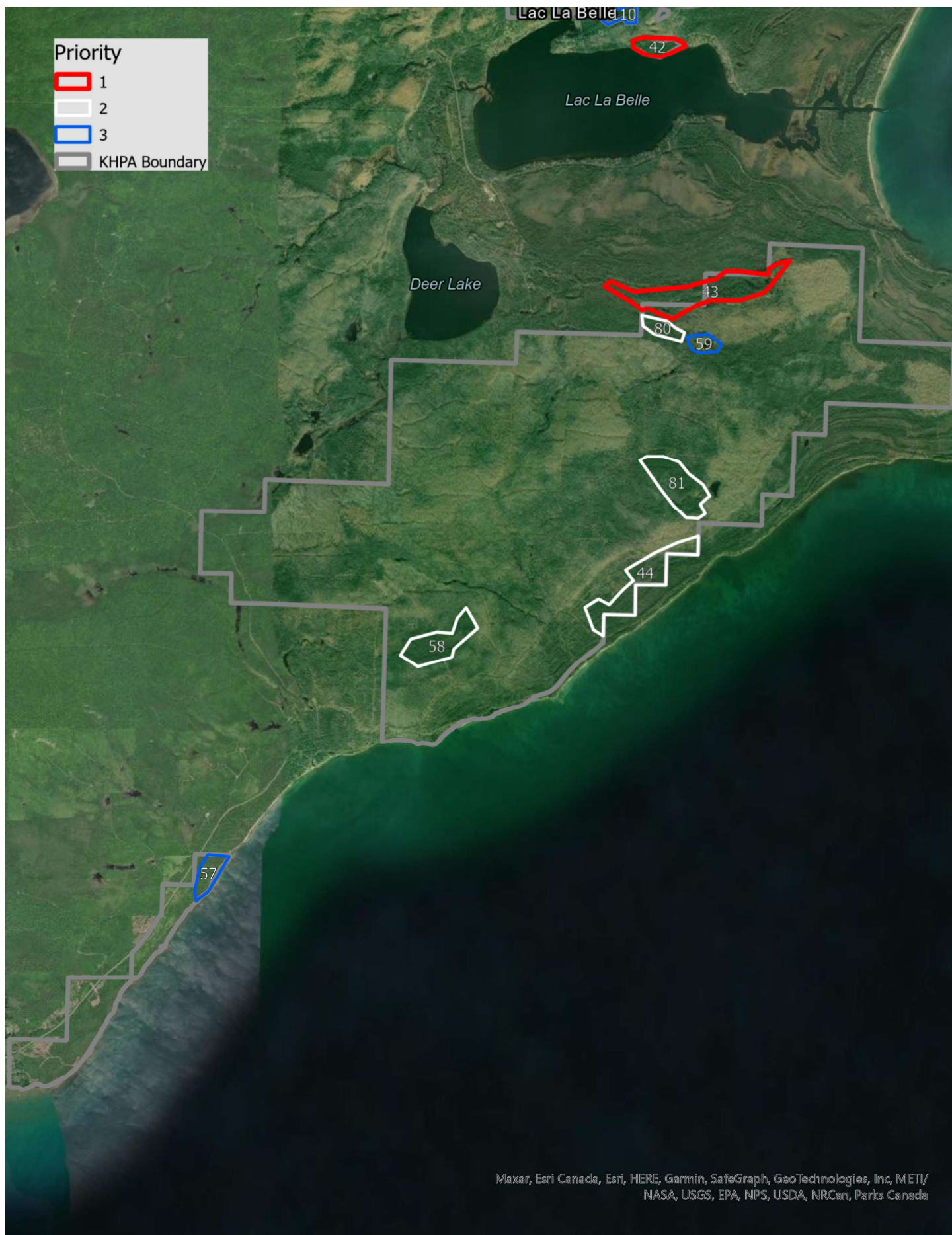


Figure A5. Priority survey areas in the Little Betsy Shoreline parcel.

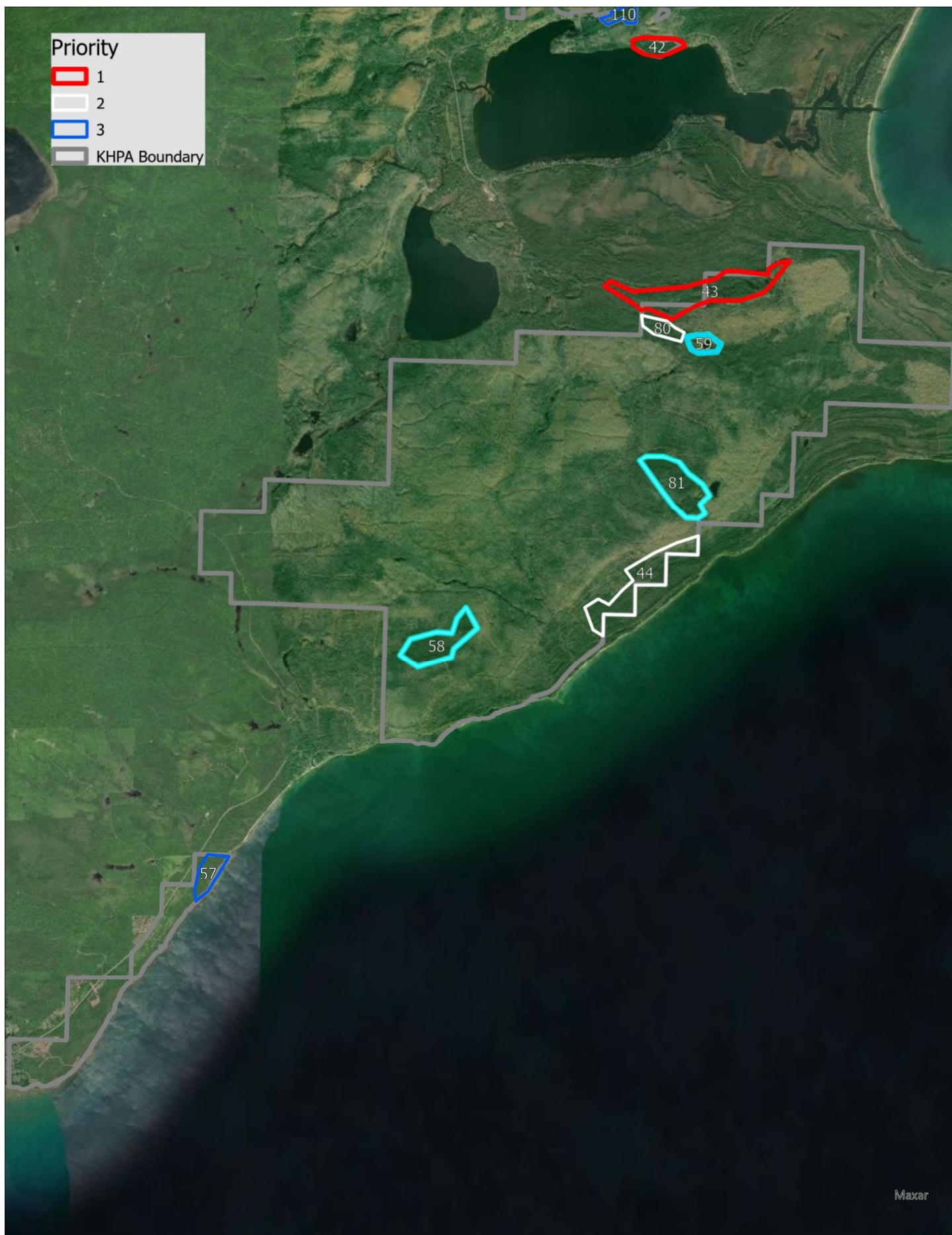


Figure A6. Priority survey areas in the Little Betsy Shoreline parcel, with future survey priorities highlighted.

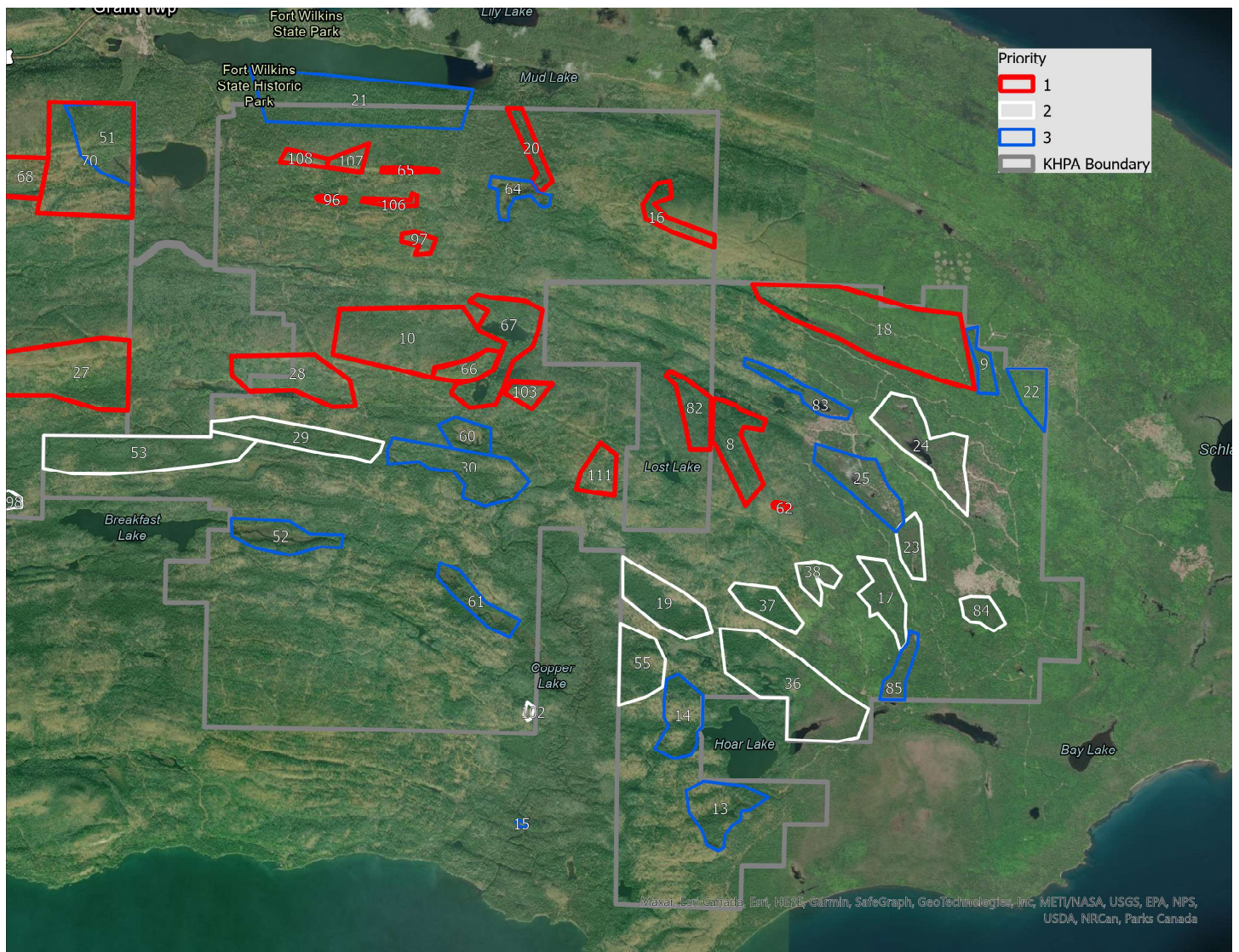


Figure A7. Priority survey areas in The Point parcel.

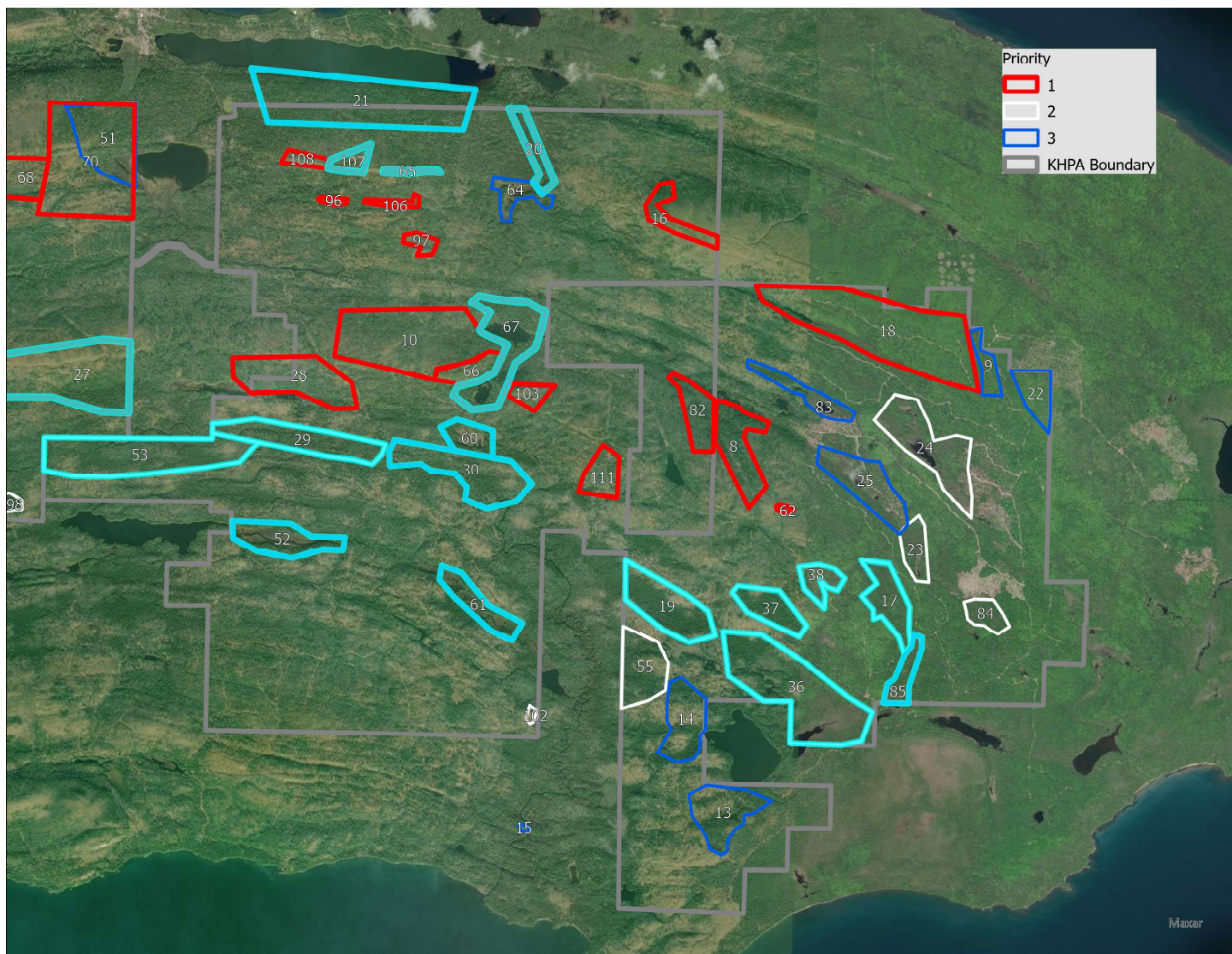


Figure A8. Priority survey areas in The Point parcel, with future survey priorities highlighted.

Table A2. Global element rank definitions

Global Rank		DEFINITION
G1	Critically Imperiled	At very high risk of extinction or elimination due to extreme rarity (often 5 or fewer occurrences), very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors.
G2	Imperiled	At high risk of extinction or elimination due to restricted range, few populations or occurrences (often 20 or fewer), steep declines, severe threats, or other factors.
G3	Vulnerable	At moderate risk of extinction or elimination due to a fairly restricted range, relatively few populations or occurrences (often 80 or fewer), recent and widespread declines, threats, or other factors.
G4	Apparently Secure	At fairly low risk of extinction or elimination due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
G5	Secure	At very low risk of extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats.
GH	Possibly Extinct (species) or Eliminated (communities)	Known from only historical occurrences but still some hope of rediscovery. Examples of evidence include (1) that a species has not been documented in approximately 20–40 years despite some searching and/or some evidence of significant habitat loss or degradation; (2) that a species or ecosystem has been searched for unsuccessfully, but not thoroughly enough to presume that it is extinct or eliminated throughout its range.
GX	Presumed Extinct (species) or Eliminated (natural communities)	Not located despite intensive searches and virtually no likelihood of rediscovery (species); Eliminated throughout its range, due to loss of key dominant and characteristic taxa and/or elimination of the sites and ecological processes on which the type depends (natural communities).
GU	Unrankable	Currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
G?	Inexact	Incomplete data

Table A3. Sub-national element rank definitions

Subnational (State) Rank		DEFINITION
S1	Critically Imperiled	At very high risk of extirpation in the state because of extreme rarity (often 5 or fewer occurrences) or other factors making it especially vulnerable to extirpation, including: very restricted range, very few populations or occurrences, very steep declines, or severe threats.
S2	Imperiled	At high risk of extirpation in the state due to restricted range, few populations or occurrences (often 20 or fewer), steep declines, severe threats, or other factors.
S3	Vulnerable	At moderate risk of extirpation in the state due to a fairly restricted range, relatively few populations or occurrences (often 80 or fewer), recent and widespread declines, threats, or other factors.
S4	Apparently Secure	At a fairly low risk of extirpation in the state due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
S5	Secure	At very low or no risk of extirpation in the state due to a very extensive range, abundant populations or occurrences, with little to no concern from declines or threats.
SH	Possibly Extirpated	Known from only historical records but still some hope of rediscovery. There is evidence that the species or ecosystem may no longer be present in the jurisdiction, but not enough to state this with certainty. Examples of such evidence include (1) that a species has not been documented in approximately 20-40 years despite some searching and/or some evidence of significant habitat loss or degradation; (2) that a species or natural community has been searched for unsuccessfully, but not thoroughly enough to presume that it is no longer present in the jurisdiction.
SX	Presumed Extirpated	Species or ecosystem is believed to be extirpated from the state. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered. [equivalent to "Regionally Extinct" in IUCN Red List terminology]
SNR	Unranked	National or subnational conservation status not yet assessed.
S?	Inexact	Incomplete data

Table A4. Element occurrence rank definitions

EO Rank	DEFINITION
A Excellent Viability	<p>Occurrence exhibits optimal or at least exceptionally favorable characteristics with respect to population size and/or quality and quantity of occupied habitat; and, if current conditions prevail, the occurrence is very likely to persist for the foreseeable future (i.e., at least 20-30 years) in its current condition or better. These occurrences have characteristics (e.g., size, condition, landscape context) that make them relatively invulnerable to extirpation or sustained population declines, even if they have declined somewhat relative to historical levels. For species associated with habitat patches or ephemeral or particularly dynamic habitats, occurrences warranting an A rank generally consist of metapopulations rather than single demes (unless exceptionally large and robust). Occurrences of this rank typically include at least 1,000 mature individuals but may be smaller (100s) or might require larger populations (10,000s), depending on the species and its demographic characteristics. However, occurrences can be ranked A even if population size is not known. For example, for occurrences lacking information on population size, an A rank may be appropriate under the following circumstances: the population is clearly very large but it is not known how large; the area of occupied habitat is exceptionally large; or the occurrence has excellent condition and landscape context and a long history of occurrence persistence. Occurrences with excellent estimated viability are ranked A even if one or more other occurrences have a much larger population size and/or much greater quantity of occupied habitat. In most cases, occurrences ranked A will occupy natural habitats. However, "natural" is an ambiguous concept, and occurrences in "unnatural" conditions (e.g., somewhat modified by human actions) may still be assigned a rank of A if they otherwise meet the criteria.</p>
B Good Viability	<p>Occurrence exhibits favorable characteristics with respect to population size and/or quality and quantity of occupied habitat; and, if current conditions prevail, the occurrence is likely to persist for the foreseeable future (i.e., at least 20-30 years) in its current condition or better. B-ranked occurrences have good estimated viability and, if protected, contribute importantly to maintaining or improving the conservation status of threatened or declining species. For species associated with habitat patches or ephemeral or particularly dynamic habitats, a high-quality occurrence may warrant a B rank if it consists of a single deme rather than a metapopulation (unless the single deme is exceptionally large and robust, in which case an A rank may be appropriate).</p>
C Fair Viability	<p>Occurrence characteristics (size, condition, and landscape context) are non-optimal such that occurrence persistence is uncertain under current conditions, or the occurrence does not meet A or B criteria but may persist for the foreseeable future with appropriate protection or management, or the occurrence is likely to persist but not necessarily maintain current or historical levels of population size or genetic variability. This rank may be applied to relatively low-quality occurrences with respect to size, condition, and/or landscape context if they still appear to have reasonable prospects for persistence for the foreseeable future (at least 20-30 years). Examples include very small non-degraded relict occurrences as well as some remnant occurrences of former landscape-level species such as many extant occurrences of tall-grass prairie insects. These occurrences represent the lower bound of occurrences worthy of protection.</p>

Table A4, continued. Element occurrence rank definitions

EO Rank	DEFINITION
D Poor Viability	If current conditions prevail, occurrence has a high risk of extirpation (because of small population size or area of occupancy, deteriorated habitat, poor conditions for reproduction, ongoing inappropriate management that is unlikely to change, or other factors). Questionably viable occurrences that could be restored to at least fair viability should not be ranked D if restoration is deemed feasible and plausible; in most such cases CD should be used. Very small occurrences that may be vulnerable to deleterious stochastic events may be ranked as follows: If the stochastic event is highly theoretical or of very low probability in the appropriate time frame (e.g., 20-30 years), then a C or CD rank may be appropriate. If a minority of other similar occurrences have disappeared as a result of, say, disease or inbreeding, then perhaps CD is best. If most of these small occurrences have been extirpated or are disappearing due to such events, then D is probably appropriate. The D rank also applies if the population is so small that there will inevitably be a year (or generation) in the near future in which by chance all adults will be the same gender.
E Verified Extant	Occurrence recently has been verified as still existing, but sufficient information on the factors used to estimate viability of the occurrence has not yet been obtained. Use of the E rank should be reserved for those situations in which the occurrence is thought to be extant, but an A, B, C, D, or combination rank cannot be assigned.
F Failed to Find	Occurrence has not been found despite a search by an experienced observer at a time and under conditions appropriate for the Element at a location where it was previously reported, but the occurrence still might be confirmed to exist at that location with additional field survey efforts. For occurrences with vague locational information, the search must include areas of appropriate habitat within the range of locational uncertainty.
H Historical	Recent field information verifying the continued existence of the occurrence is lacking. Examples of this rank include occurrences based only on historical collection data, or occurrences that previously were ranked A, B, C, D, or E but that are now, without field survey work, considered to be possibly extirpated due to general habitat loss or degradation of the environment in the area. H may be applied to recently verified occurrences if two or more competent subsequent efforts that should have found the species did not, or if there has been a known major disturbance since the last observation such that continued existence of the occurrence is in doubt (for example, an isolated Lepidoptera occurrence that was sprayed with Dimilin®).
X Extirpated	Adequate surveys by one or more experienced observers at times and under conditions appropriate for the species at the occurrence location, or other persuasive evidence, indicate that the species no longer exists there or that the habitat or environment of the occurrence has been destroyed to such an extent that it can no longer support the species.