Pathway to Good Harbor: Heritage Trail Segment 9 Tree Survey

Cleveland and Centerville Townships, Leelanau County, MI

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Cover Photograph: Large eastern hemlock on forested dune in Section 4 of the Pathway to Good Harbor that is within the trail route (Sept 20, 2023).

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Executive Summary

The Heritage Trail is a paved recreational trail that runs through Sleeping Bear Dunes National Lakeshore in Leelanau County, Michigan. The Pathways to Good Harbor is a 4(+)-mile portion known as Segment 9, and is the last segment of recreational trail to be constructed, bringing the total length of the Heritage Trail to approximately 27 miles. Stakeholders have raised concerns about the route this last trail segment takes, and the potential impacts on the forested ecosystems, particularly the impact on the forest. This study measures the size-class, species, and number of trees along the route, providing a stand inventory of the potentially impacted area. Ancillary information and incidental observations of rare species, invasive species, and pests and diseases are included.

A potential 7,300 trees may be removed to create the Pathway to Good Harbor. The most common species are American beech and sugar maple, making up 20% and 15% of individual stems across all size classes within the pathway, respectively. White pine make up 12%, red oak make up 10%, and ironwood and eastern hemlock make up 8% of stems each. Most of the trees within the trail route are saplings and small adults; beech bark disease and emerald ash borer have caused high mortality in mesic northern forest and wooded dune communities, and American beech root sprouts make up the largest demographic. There was no hemlock wooly adelgid or other emerging invasive species observed. There were no rare, threatened, or endangered (RTE) species found within the trail route during the survey. Three and half miles (85%) of the trail is within protected Critical Dune Area, including barrier dune and wooded dune and swale complex, vulnerable communities in the State of Michigan. The trail also crosses regulated wetlands near RTE species habitat. Because of this, it is recommended that an Environmental Assessment is done on the impact of the route that this trail takes and in comparison to other potential routes.

Introduction

The Heritage Trail is an existing paved recreational pathway that spans approximately 22 miles through Sleeping Bear Dunes National Lakeshore, south from Empire and north to the intersection of Bohemian Road (Co. Rd. 669) and M-22. Segment 9 of the Heritage Trail is planned to be constructed from Bohemian Road to Good Harbor Trail (Co. Rd. 651), referred to as the "Pathway to Good Harbor." The Pathway to Good Harbor is proposed to travel approximately 4(+) miles with an expected common practice clearing breadth of up to 25 feet. If constructed as currently planned, this trail segment will pass through mesic northern forest, rich conifer swamp, Critical Dune Areas, and several wetlands.

Stakeholders have raised concern about the environmental impact that trail construction would have on the forested ecosystems that the trail traverses, and have inquired about the number of trees that will be cut during construction at the past public meetings (MDOT, 2023). To further investigate this, the Little Traverse Lake Association contracted Borealis Consulting LLC to conduct an inventory of the trees that may be impacted by Trail construction. This report presents a forest stand inventory, providing the species and number of trees that may be impacted by Pathway to Good Harbor construction and observations of forest pests and disease, invasive species, natural communities, and rare, threatened and endangered species.

Figure 1. Proposed route of the Sleeping Bear Heritage Trail Pathway to Good Harbor (Sleeping Bear Heritage Trail Webpage, 2023)

Methodology

Pre-survey Review

The preliminary centerline of the Pathway to Good Harbor was determined to have been staked and flagged approximately every 100 feet by OHM Advisors of Petoskey, MI, in May of 2023. This was further represented by published maps on the Heritage Trail website (Fig. 1). Preliminary field investigations in September 2023 revealed several potential natural communities along the route, including mesic northern forest, rich conifer swamp, and wooded dune and swale complex. The survey was divided into four sections, based on the dominant natural community along the flagged route of the Pathway (Fig. 2):

1. *M-22 Corridor:* Bohemian Rd. (Co. Rd. 669) to West Traverse Lake Rd. along M-22, composed of fallow field, yards, and roadside edge of mesic northern forest.
2. *Rich Conifer Swamp:* The west end of Little Traverse Lake Rd. from M-22 to the first bend in the road, composed of rich conifer swamp and includes Shalda Creek.
3. *Forested Dune:* North of Traverse Lake Rd. from the west bend, and east to the point where the trail turns into the woods towards Bufka Farm. This area is wooded dune (second growth mesic northern forest) and is designated Barrier Dune in Critical Dune Area.
4. *Wooded Dune and Swale Complex*: East of East Traverse Lake Rd. to Good Harbor Trail (Co. Rd. 651). This area is predominately wooded dune and swale complex (second growth) and partially designated Barrier Dune in Critical Dune Area.

A pre-survey review of invasive species, pests and diseases, and rare, threatened and endangered (RTE) plant species and rare natural communities was conducted for Cleveland Township T29N, R13W Sections 1, 10, 11, and 12, and Centerville Township R12W Section 6. The Midwest Invasive Species Information Network (MISIN) and iNaturalist (*inaturalist.org)* was reviewed for species of interest, particularly emerging invasive species, pests, and diseases. The Michigan Natural Heritage Database (MNHD) was queried for Element Occurrences of RTE species and natural communities. The University of Michigan Herbarium was reviewed for RTE and invasive species records (Michigan Flora 2011). The Atlas of Critical Dune Areas was reviewed for dunes protected by the by Part 353 of the Michigan Natural Resources and Environmental Protection Act (MDNR 1989). The National Wetlands Inventory was queried for wetlands within the trail route (USFWS 2019).

Field Survey

A research study permit was obtained December 2023 from the National Park Service. The survey was conducted by walking along the staked and flagged centerline of the Pathway to Good Harbor Heritage Trail segment from Bohemian Road (Co. Rd. 669) to Good Harbor Trail (Co. Rd. 651). The weather conditions were mild and there was no snow accumulation, allowing limited herbaceous plants species observations. A 25-foot maximum breadth of potential impact was chosen for the width of the survey area; this was informed by common practice from past trail construction (Fig. 3) and confirmed by MDOT in an August 2023 presentation to at the Little Traverse Lake Association annual meeting by Krista Phillips, MDOT engineer, and Julie Clark, CEO of Traverse Area Recreation and Transportation Trails (MDOT, 2023). The 25-foot breadth was visually estimated, using a measuring tape as needed, to verify the boundary. Where the trail passes private property, it is required to be within the 66-foot road right-of-way (ROW; 33 feet from the road center line); this was also used as a reference for trail location and impact area. On National Park land, the trail often leaves the ROW and the centerline flagging was relied upon. The survey track was recorded using a handheld Garmin GPSMAP 62.

All trees' species and size class within the 25-foot breath along each section of the pathway were recorded. Nomenclature and physiognomy follow Michigan Flora Online (2011). Size classes were divided between saplings (breast height to 10cm (4 in) DBH), small adults (11-25 cm (4.1-10 in) DBH), medium adults (26-50 cm (10.1-20 in) DBH), large adults (50-75 cm (20.1-30 in) DBH), and very large adults (>75 cm (>30 in) DBH). Size classes were visually estimated, unless very close between two categories, then a standard DBH (diameter at breast height) tape was used to confirm size. Seedlings were not enumerated due to project constraints. Observations of natural communities, invasive species, tree pests and diseases, or rare species were noted.

The data was summarized using Microsoft Excel and QGIS software. The length of the trail sections were calculated using QGIS referencing field survey tracks. The survey area was calculated as the length of the trail multiplied by the 25-foot maximum clearance breadth. Trees per acre utilizes the area calculations for each trail section as the divisor for number of trees recorded for that section.

Figure 2. Common practice trail construction showing typical breadth, between Forest Haven Drive and M-109, April 2012 (Courtesy of D. Skjaerlund).
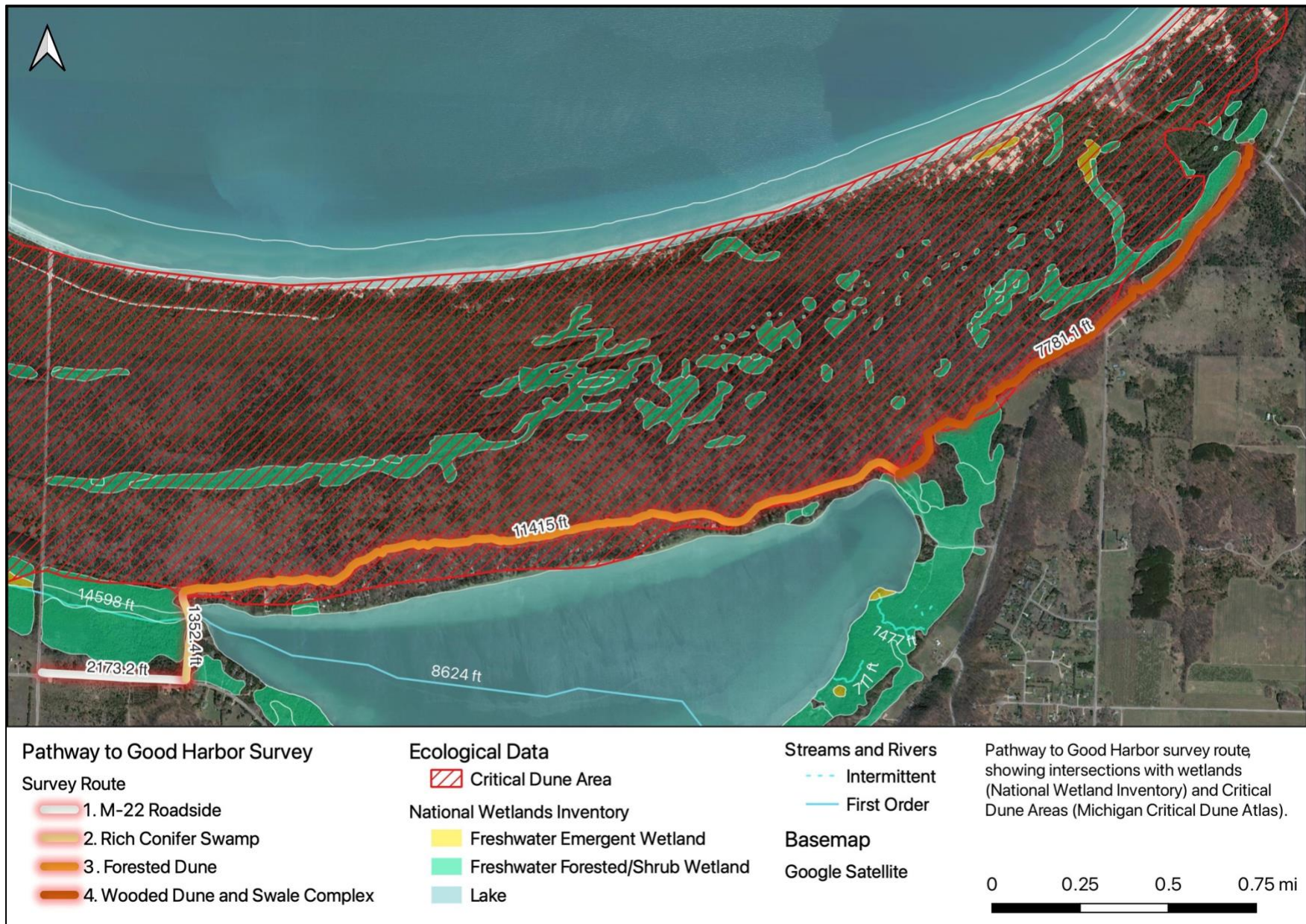
Figure 3. Map of the Pathway to Good Harbor survey sections, critical dunes, and wetlands.

Pathway to Good Harbor Survey

Survey Route
1. M-22 Roadside
2. Rich Conifer Swamp
3. Forested Dune
4. Wooded Dune and Swale Complex

Ecological Data
Critical Dune Area

National Wetlands Inventory
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Lake

Streams and Rivers
Intermittent
First Order

Basemap
Google Satellite

Pathway to Good Harbor survey route, showing intersections with wetlands (National Wetland Inventory) and Critical Dune Areas (Michigan Critical Dune Atlas).

0   0.25   0.5   0.75 mi

RESULTS AND DISCUSSION

Tree Survey

The Pathway to Good Harbor, Segment 9 of the Heritage Trail, is approximately 4.25 miles long with a potential impact to 12.8 acres and 7,268 trees (Table 1, App. A). Saplings and small adult trees (breast high to 25 cm (9.8 in) DBH) make up 80% of the trees within the trail route (3,010 and 2,923 trees, respectively). The most common species are American beech *(Fagus grandifolia)* and sugar maple *(Acer saccharum),* making up 20% and 15% of individual stems across all size classes within the pathway, respectively. White pine *(Pinus strobus)* make up 12%, red oak *(Quercus rubra)* make up 10%, and ironwood *(Ostrya virginiana)* and eastern hemlock *(Tsuga canadensis)* make up 8% of stems each. American beech saplings were the largest demographic, with nearly double the number of stems of any of size class of any species.

Rich conifer swamp, Section 2, has the lowest tree density, with 235 trees per acre. Section 2 is mostly within the ROW which is partially cleared with some open wetland. The highest tree density is along Section 1, along M-22, where a large number of small stems were inventoried along the forest edge in high light in the ROW. Forested dune (Section 3) and wooded dune and swale complex (Section 4) have similar tree densities, 568 and 542 trees per acre, respectively. These are similar forest types with similar compositions. On average, the trail route has 568 trees per acre or one tree for every three linear feet.

Typical forest stand inventory methodologies often exclude small saplings (e.g. when used for basal area or board feet estimates), therefore the tree densities may be slightly high compared to those estimated by traditional methods (40% of stems are in the sapling size class). In addition, the trail length and corresponding acreage may be underestimated because it is based on remote GIS estimates, as opposed to actual ground length walked in the field. This reduces the precision (i.e. does not include small turns or elevation in the route), and therefore can underestimate ground length thus impacted area. The number of trees removed and the estimated impacted acreage is based on a 25-foot clearing breadth, which may not always be practiced. This estimate does not include potential parking areas or turn-offs, or adjustments in the trail route, so should be considered an estimate.

Table 1. Summary of tree counts for each section.

Trail Section	Approx. Section Length	SAPLINGS (Breast Height to 10 cm DBH)	SMALL TREES (11-25 cm DBH)	MEDIUM TREES (26-50 cm DBH)	LARGE TREES (51-75 cm DBH)	VERY LARGE TREES (>75 cm DBH)	Total Trees per Section
1. M-22 Roadside	0.4 mi	349	433	100	8	4	894
2. Rich Conifer Swamp	0.25 mi	79	86	18	0	0	183
3. Wooded Dune	2.1 mi	1895	1247	453	136	19	3,750
4. Wooded Dune and Swale Complex	1.5 mi	687	1157	480	106	11	2,441
Total Stems	4.25 mi	3010	2923	1051	250	34	7,268

Section 1. M-22 Roadside

The section of the trail routed along M-22 from Bohemian Road to West Traverse Lake Road is a mixture of fallow field dominated by non-native smooth brome *(Bromus inermis)*, early successional forest, and mesic northern forest edge community. A total of 894 trees were counted within the trail route in this section, which was estimated to be 0.4 mi and 1.2 acres in area with 745 trees per acre. The high stem count is mostly made up of dense white ash *(Fraxinus americana)* saplings along the roadside (25%), dense ironwood saplings and small adults (20%) and a young aspen *(Populus tremuloides)* clone (20%, Fig. 4).
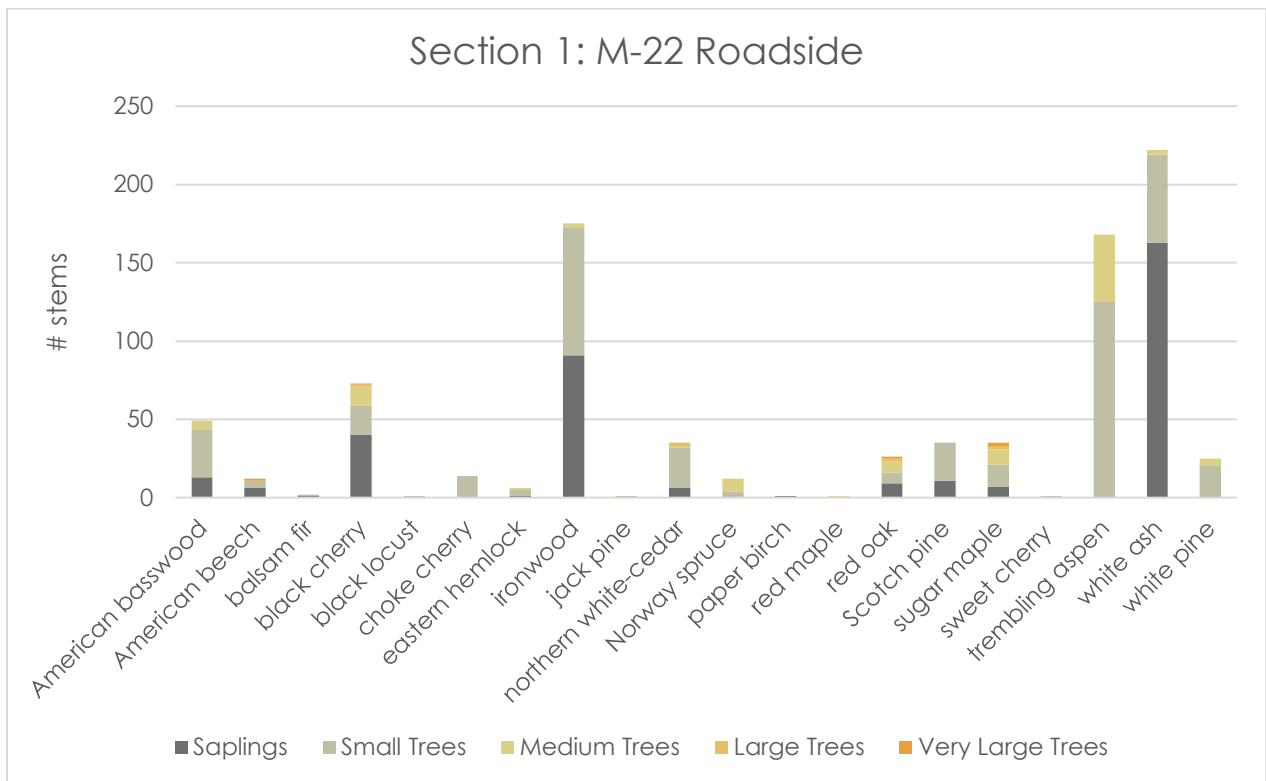
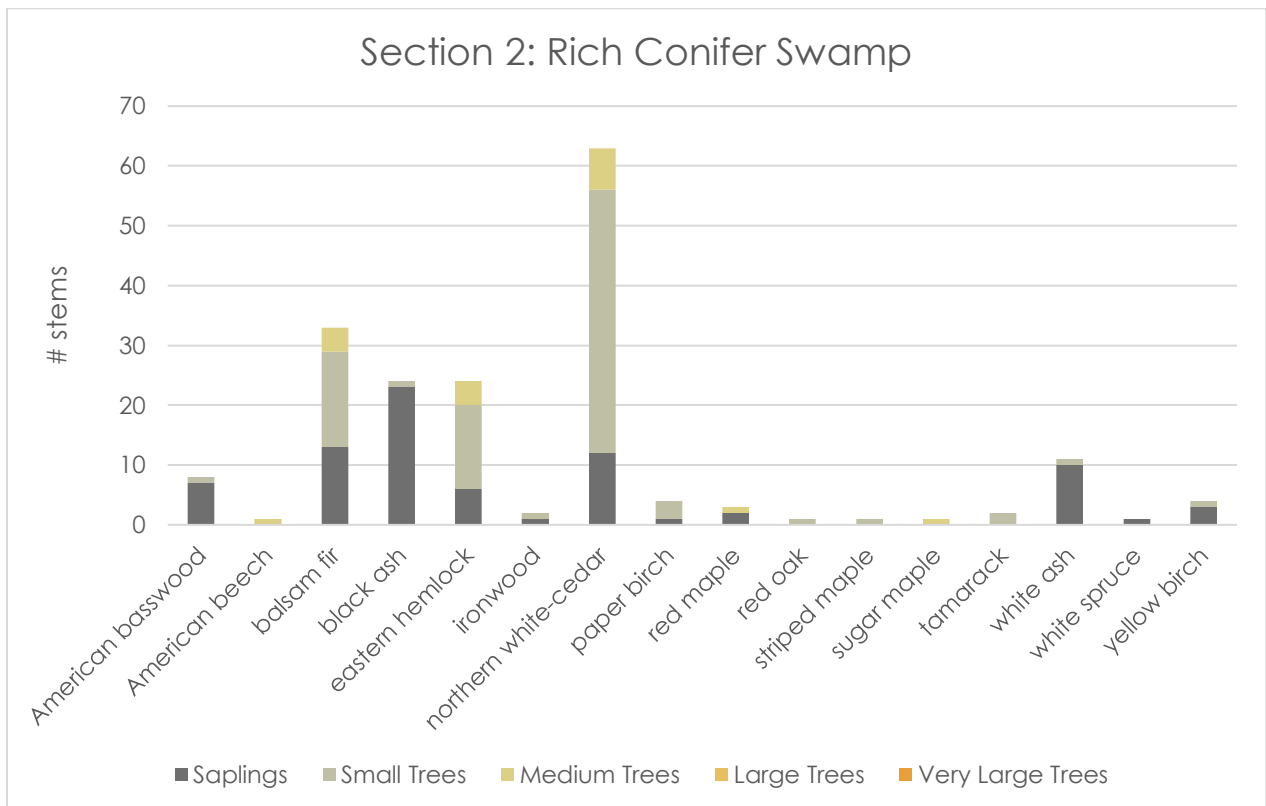**Figure 4. Composition of the trail corridor in Section 1.**

Figure 5. Composition of the trail corridor in Section 2.

Figure 6. Centerline of the Trail as it runs along a wooded dune-swale in Section 4 (Sept 20, 2023)

Section 2. Rich Conifer Swamp

The trail section along West Traverse Lake Rd. is approximately 0.25 mi and 0.78 acres. This is classified as rich conifer swamp, a northern white-cedar *(Thuja occidentalis)* dominated community that occupies lowlands, often near headwater streams. This area is a State-regulated wetland under Part 303 of the Natural Resources and Environmental Protection Act (1994 P.A. 451) because it is over 5 acres in size and hydrologically connected to surface water. A total of 183 trees were recorded as being within this trail section, dominated by northern white-cedar (34%). Balsam fir *(Abies balsamea)* contributes 18%, and black ash *(Fraxinus nigra)* saplings and eastern hemlock saplings and small trees each contribute 13% to the stand composition (Fig. 5). The open wetland along the roadside and Shalda Creek corridor lower the stand density as compared to other areas (235 stems per acre).

Section 3. Forested Dunes

Section 3 is approximately 2.1 miles long (6.6 ac in area), about half the total length of the Pathway to Good Harbor. The forested dune is historical barrier dunes that is now covered by mesic northern forest, a sugar maple-American beech dominated community north of Little Traverse Lake. This area is classified as a Critical Dune Area by the State of Michigan and is protected by Part 353 of the Michigan Natural Resources and Environmental Protection Act (MDNR 1989). A total of 3,750 trees occur within the trail route in the wooded dune, or 568 per acre (Fig. 7).

The most abundant species is American beech, making up 33% of stems in this section. Most of the large American beech trees have died back in the aftermath of beech bark disease; less than 2% of live beech trees are larger than 25 cm (10 in) DBH (note: there were two live American beech greater than 75 cm (30 in) in diameter observed). Beech trees that have lost their canopy branches have sent up vigorous root-spouts forming sapling thickets, representing this species in the forest inventory. Sugar maple are the second most common species, making up 17% of trees. Sugar maple size-classes are well distributed, forming the typical "inverse-J" demographic with many saplings and young adults and a decreasing number of larger trees. Red oak *(Quercus rubra)* make up 13% of trees in this section, most of them small and medium trees. Sixteen red oaks were recorded to be greater than 75 cm (30 in) in diameter, representing the largest trees of the study. White pine *(Pinus strobus)* make up 16% of trees, 63% of them sapling-sized. The western portion of this section has been subjected to a controlled burn, killing most of the saplings and adult northern white-cedar, in that area.
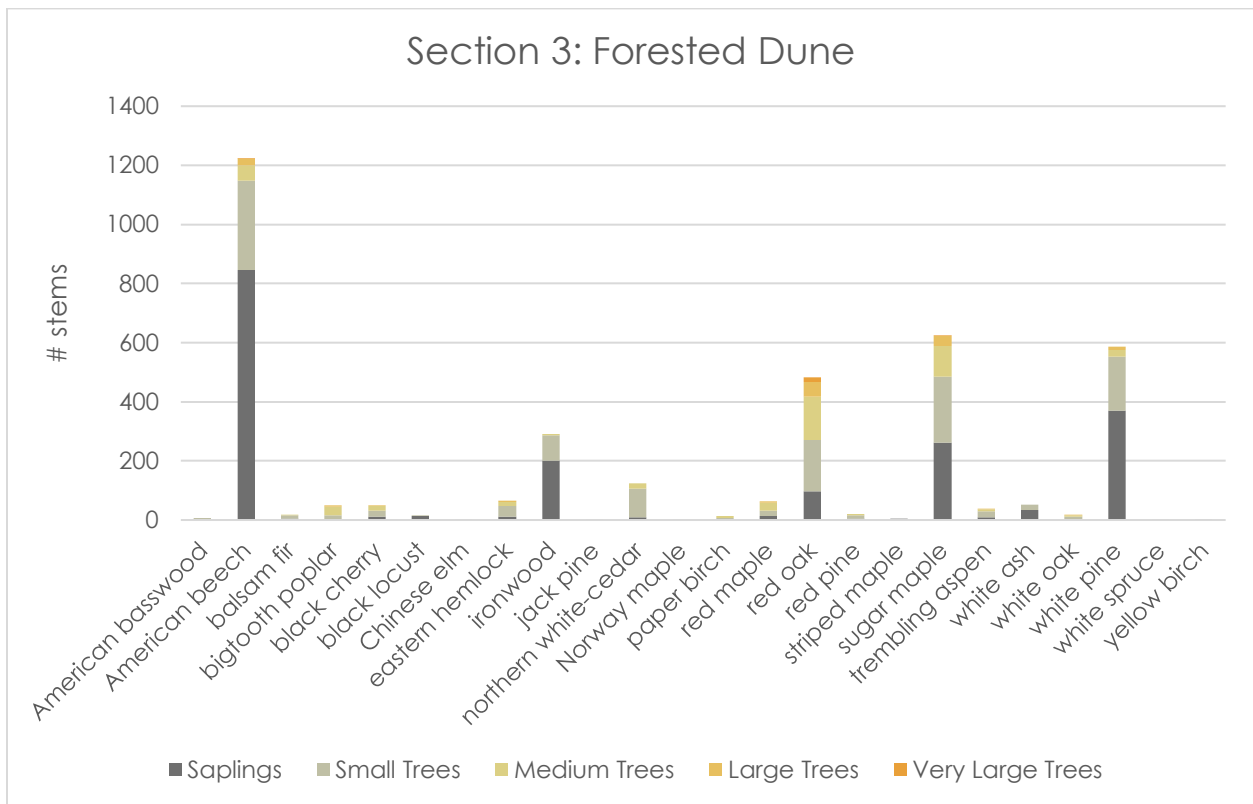
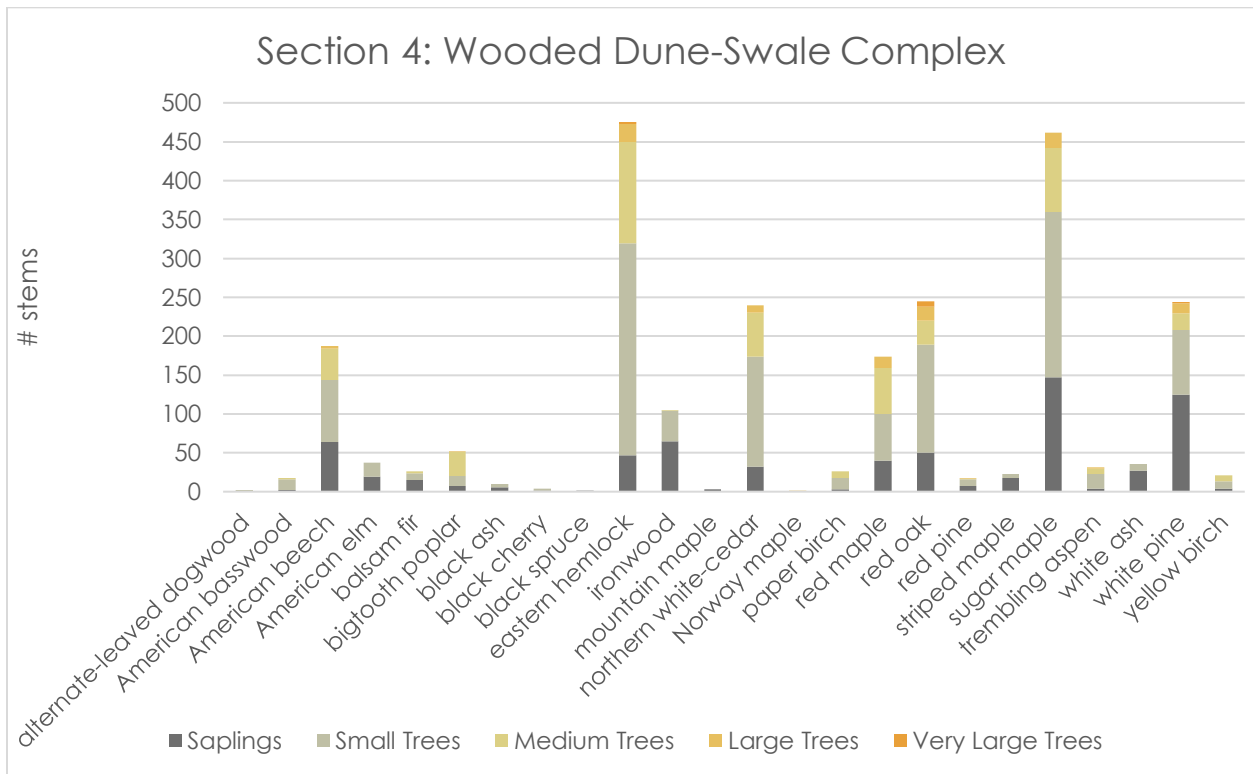**Figure 7. Composition of the trail corridor in Section 3.**

Figure 8. Composition of the trail corridor in Section 4.

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Wooded dune and swale complex is the second largest community impacted by the Pathway to Good Harbor. This trail section is approximately 1.5 mi long and would potentially impact 4.5 acres. Wooded dune and swale complex is made up of parallel, alternating wetland swales and upland dune ridges formed by receding water levels post-glaciation, and is considered a dune formation. Section 4 of the Pathway to Good Harbor route follows the edge of the Critical Dune Area as mapped (see Fig. 3), however, during field surveys Section 4 was found to be entirely within the wooded dune and swale complex natural community and the trail follows dune swales in part (Fig. 6).

A total of 2,441 trees were inventoried along this section (542 trees per acre; Fig. 8). Eastern hemlock and sugar maple were the most common species, each contributing to 19% of the section composition. White pine, red oak, and northern white-cedar each contribute an additional 10% to the composition. This area had the highest native tree richness, with 23 species observed. Taxa unique to this section include alternate-leaved dogwood *(Cornus alternifolia)*, black spruce *(Picea mariana)*, and mountain maple *(Acer spicatum)*.

Pests, Diseases, and Invasive Species

No invasive species records were found in the MISIN database or the iNaturalist webpage in the pre-season review of the trail section. However, several incidental observations of pests, diseases, and invasive species were noted during the course of the field survey.

Beech bark disease and emerald ash borer are well established in Sleeping Bear Dunes National Lakeshore and have widespread impacts on the forests, including those surveyed here. Emerald ash borer has caused the mortality of nearly all adult ash trees, which have fallen over the past decade and were largely absent from the survey. Beech bark disease is at the "killing front" stage of infestation. All adult American beech trees are dead or mostly dead, with only 123 American beech trees greater than 25 cm DBH (about 9% of the beech population). Crown dieback has spurred dense root sprout regeneration, contributing to the large number of American beech saplings (n=913, about 30% of all saplings sampled). No hemlock wooly adelgid, nor any other emerging pests, were observed during the course of the survey.

Invasive species were relatively sparse, particularly in the forested dune and wooded dune and swale complex. Populations are concentrated along M-22 and in wetland openings. Smooth brome is dominant along M-22 in the old fields near Bohemian Road along Section 1. The road ROW along Section 2 has narrowleaf cattail, European marsh thistle, and autumn olive *(Elaeagnus umbellata)*. Occasional garden and yard escapes were noted along Traverse Lake Road in Section 3, including myrtle *(Vinca minor)* and snow-on-the-mountain *(Aegopodium podagraria* var. *variegatum)*. The wetland swales in Section 4 have populations of Japanese barberry *(Berberis thunbergii)*, reed canary grass *(Phalaris arundinacea)*, Canada thistle *(Cirsium arvense)* and European swamp thistle.

Trail creation is likely to create new invasive species risks. Trails have been well-established as vectors for invasive species (e.g. Anderson et al 2015) through several mechanisms. Tree removal, depending on the extent, can cause edge effects in forests (more light, higher temperatures). This, combined with soil surface disturbance created by trail construction, creates favorable seed germination sites for early successional, ruderal, and invasive species. Movement along the trail moves invasive species seeds down the trail to new germination sites via treads on shoes and tires, hitchhikers on clothing, etc. An emerging invasive species, slender false-brome *(Brachypodium sylvaticum),* has been found spreading along the Heritage Trail (and other areas) since its installation in Critical Dune Area between the Dune Climb and Glen Haven, and is of particular concern. Himalayan blackberry *(Rubus bifrons),* another emerging invasive species in Michigan, has also been observed spreading in forest openings in Leelanau County and is along the trail near Glen Haven. Though this is animal-dispersed, it may take advantage of newly created germination sites and should be monitored.

Rare, Threatened and Endangered Elements

Four Element Occurrences were found in the preliminary site review and are known to occur along the proposed Pathway to Good Harbor, two vascular plants and two records of the dune communities occupying the Good Harbor embayment. No additional observations were made during the field survey. (Note, surveys were also conducted by Michigan Natural Features Inventory during the summer of 2023 on behalf of M-DOT, with the same findings).

- State Special Concern cut-leaf water parsnip *(Berula erecta)* (2022 Private Landowner Survey, in review for MNHD)
- State Threatened pine-drops *(Pterospora andromedea)* (MNHD Element Occurrence)
- Wooded Dune and Swale Complex (MNHD Element Occurrence)
- Critical Dune Area (Barrier Dune, Critical Dune Atlas)

Cut-leaf water parsnip occurs on tributaries to Shalda Creek on private property along Section 2. This population is near the proposed Pathway, occurring approximately 15 feet west of the ROW extent (45 feet west of the centerline). It was documented in 2022 after conducting botanical surveys on private property and in review for the MNHD. Cut-leaf water parsnip was downranked from State Threatened to State Special Concern in 2023 and is no longer protected under the Endangered and Threatened Species Act of Michigan, Part 365. State Special Concern identifies this species as a "…declining or relict species in the state. While not protected by law, these species need protection to prevent them from becoming Threatened or Endangered" (MNFI 2023). Though the population was not mapped within the ROW, impacts to canopy cover, hydrology, and invasive species are a concern and measures should be taken to minimize disturbances. Narrowleaf cattail *(Typha angustifolia)* and European marsh thistle *(Cirsium palustre)* are two invasive species that occur in the ROW and may impact cut-leaf water parsnip, especially if the canopied is opened.

State Threatened pine-drops are known to occur in the wooded dune and swale complex and forested dunes along Good Harbor Bay (Section 3 and 4; MNFI 2023, Michigan Flora Online 2011). No observations of pine drops were made during the survey. Pine-drops are protected under the Endangered and Threatened Species Act of Michigan, Part 365. This rules that "a person shall not take, possess, transport, import, export, process, sell, offer for sale, buy, or offer to buy, and a common or contract carrier shall not transport or receive for shipment, any species of fish, plants, or wildlife appearing on the Threatened and Endangered Species List." Destruction of a plant or its habitat constitutes a taking. Permits may be issued to remove, capture, or destroy a threatened or endangered species to alleviate damage to property or to protect human health.

The wooded dune and swale complex along Good Harbor Bay is a vulnerable natural community that is a documented Element Occurrence in the MNHD. Section 4 of the Pathway to Good Harbor route follows the outside edge of the MNHD Element Occurrence as mapped, however, during field surveys Section 4 was found to be entirely within the wooded dune and swale complex, this community contiguous with wooded dune and swale complex identified in the MNHD. Wooded dune and swale complex is ranked as Vulnerable at the State and Global level due to a restricted range, relatively few occurrences (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation (Faber-Langendoen et. al. 2012). Wooded dune and swale communities are declining in size and condition due to residential and recreational development and accompanying road building, causing disrupted hydrological conditions, wetland destruction, nutrient loading, and the introduction of invasive species (Cohen et. al. 2020).

The Critical Dune Area includes the entirety of Section 3, the forested barrier dunes, and Section 4, the wooded dune and swale complex (Fig. 3). The Michigan Legislature enacted Part 353 Sand Dunes Protection and Management as part of the Natural Resources and Environmental Protection Act 451 of 1994 to provide protection of Michigan's critical dune areas. As part of the state law, "The legislature finds that: (a) The critical dune areas of this state are a unique, irreplaceable, and fragile resource that provide significant recreational, economic, scientific, geological, scenic, botanical, educational, agricultural, and ecological benefits to the people of this state and to people from other states and countries who visit this resource" (324.35302 Legislative findings, Sec. 35302). Earthmoving, vegetation

removal, and construction activities are prohibited within Critical Dunes and regulated through a permit process.

Conclusion

The Pathway to Good Harbor, Segment 9 of the Heritage Trail, will entail the removal of about 7,300 trees and is routed through road right-of-way, fallow fields, protected Critical Dune Areas, regulated wetlands, and state and globally vulnerable natural communities. It also will impact land near populations of RTE species, though no populations were found within the trail route during the survey. Forest communities along the route have been impacted by beech bark disease and emerald ash borer, causing structural and compositional changes in some areas, but are relatively free of invasive plant species and are in fairly good condition otherwise. Trail construction in the extant natural communities is likely to create disturbance-associated ecological changes such as increased edge effects in closed canopy areas, changes in species composition and structure, introduction of invasive species. Since much of the trail is routed through protected and/or vulnerable communities, it is suggested that an Environmental Assessment be completed specific to this last proposed trail segment, and in comparison to any alternative route options that might be available as a Pathway to Good Harbor.

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Appendix A: Additional Data Tables and Charts

Table 2. Section 1 tree survey data.

Species	Saplings	Small Trees	Medium Trees	Large Trees	Very Large Trees
Section 1. M-22 Fallow Field and Roadside (2,127 ft)	349	433	100	8	4
American basswood	13	30	6		
American beech	6	5			1
balsam fir	1	1			
black cherry	40	19	12	2	
black locust		1			
choke cherry		14			
eastern hemlock	1	4	1		
ironwood	91	81	3		
jack pine		1			
northern white-cedar	6	26	1	2	
Norway spruce		4	8		
paper birch	1				
red maple			1		
red oak	9	7	7	2	1
Scotch pine	11	24			
sugar maple	7	14	10	2	2
sweet cherry		1			
trembling aspen		125	43		
white ash	163	56	3		
white pine		20	5		

Appendix A: Additional Data Tables and Charts

Table 3. Section 2 tree survey data.

Species	Saplings	Small Trees	Medium Trees	Large Trees	Very Large Trees
Section 2. Rich Conifer Swamp (1,347 ft)	79	86	18		
American basswood	7	1			
American beech			1		
balsam fir	13	16	4		
black ash	23	1			
eastern hemlock	6	14	4		
ironwood	1	1			
northern white-cedar	12	44	7		
paper birch	1	3			
red maple	2		1		
red oak		1			
striped maple		1			
sugar maple			1		
tamarack		2			
white ash	10	1			
white spruce	1				
yellow birch	3	1			

Appendix A: Additional Data Tables and Charts

Table 4. Section 3 tree survey data.

Species	Saplings	Small Trees	Medium Trees	Large Trees	Very Large Trees
Section 3. Forested Dune (11,106 ft)	1895	1247	453	136	19
American basswood	1	5			
American beech	847	300	53	23	2
balsam fir	4	12	1		
bigtooth poplar		16	30	3	
black cherry	11	21	15	1	
black locust	14	1			
Chinese elm		1			
eastern hemlock	12	36	12	5	
ironwood	200	87	4		
jack pine		2			
northern white-cedar	9	98	17		
Norway maple		1			
paper birch		6	7		
red maple	14	17	27	5	
red oak	96	175	146	49	16
red pine	4	12	4		
striped maple	4				
sugar maple	262	224	102	35	1
trembling aspen	10	20	7	1	
white ash	33	19			
white oak	3	8	5	2	
white pine	369	183	23	12	
white spruce		3			
yellow birch	2				

Appendix A: Additional Data Tables and Charts

Table 5. Section 4 tree survey data.

| Species	Saplings	Small Trees	Medium Trees	Large Trees	Very Large Trees
Section 4. Wooded Dune and Swale Complex (7,705 ft)	687	1157	480	106	11
alternate-leaved dogwood		2			
American basswood	2	14	2		
American beech	64	80	40	3	
American elm	19	18			
balsam fir	15	9	2		
bigtooth poplar	7	13	31	1	
black ash	6	4			
black cherry	1	3			
black spruce	1				
eastern hemlock	47	272	131	23	2
ironwood	65	39	1		
mountain maple	3				
northern white-cedar	32	142	56	10	
Norway maple				1	
paper birch	3	15	8		
red maple	40	60	59	15	
red oak	50	139	31	18	7
red pine	7	9	1	1	
striped maple	18	5			
sugar maple	147	213	82	20	
trembling aspen	4	19	7	1	
white ash	27	9			
white pine	125	83	21	13	2
yellow birch	4	9	8		
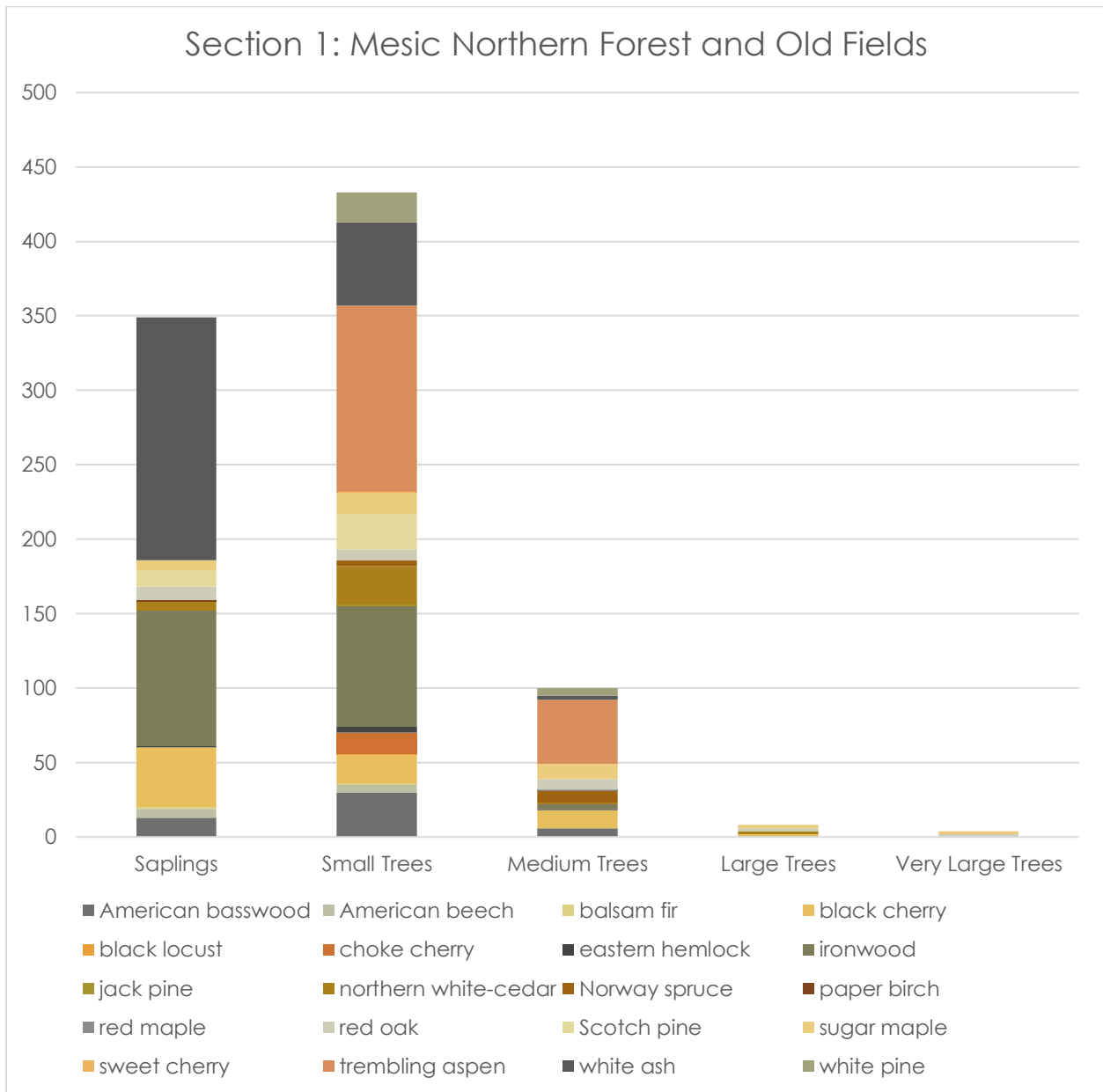
Figure 9. Section 1 size-class structure.
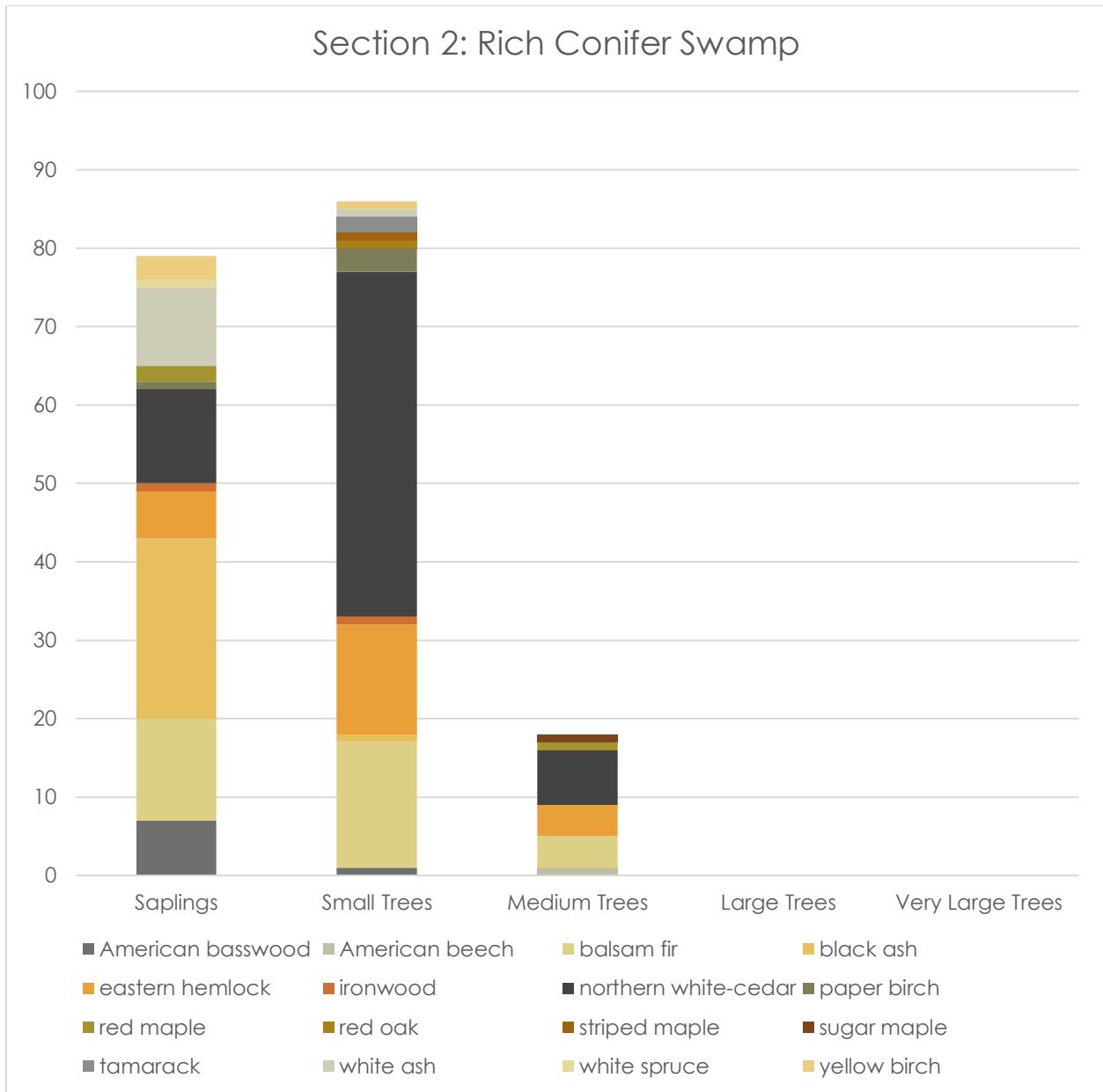
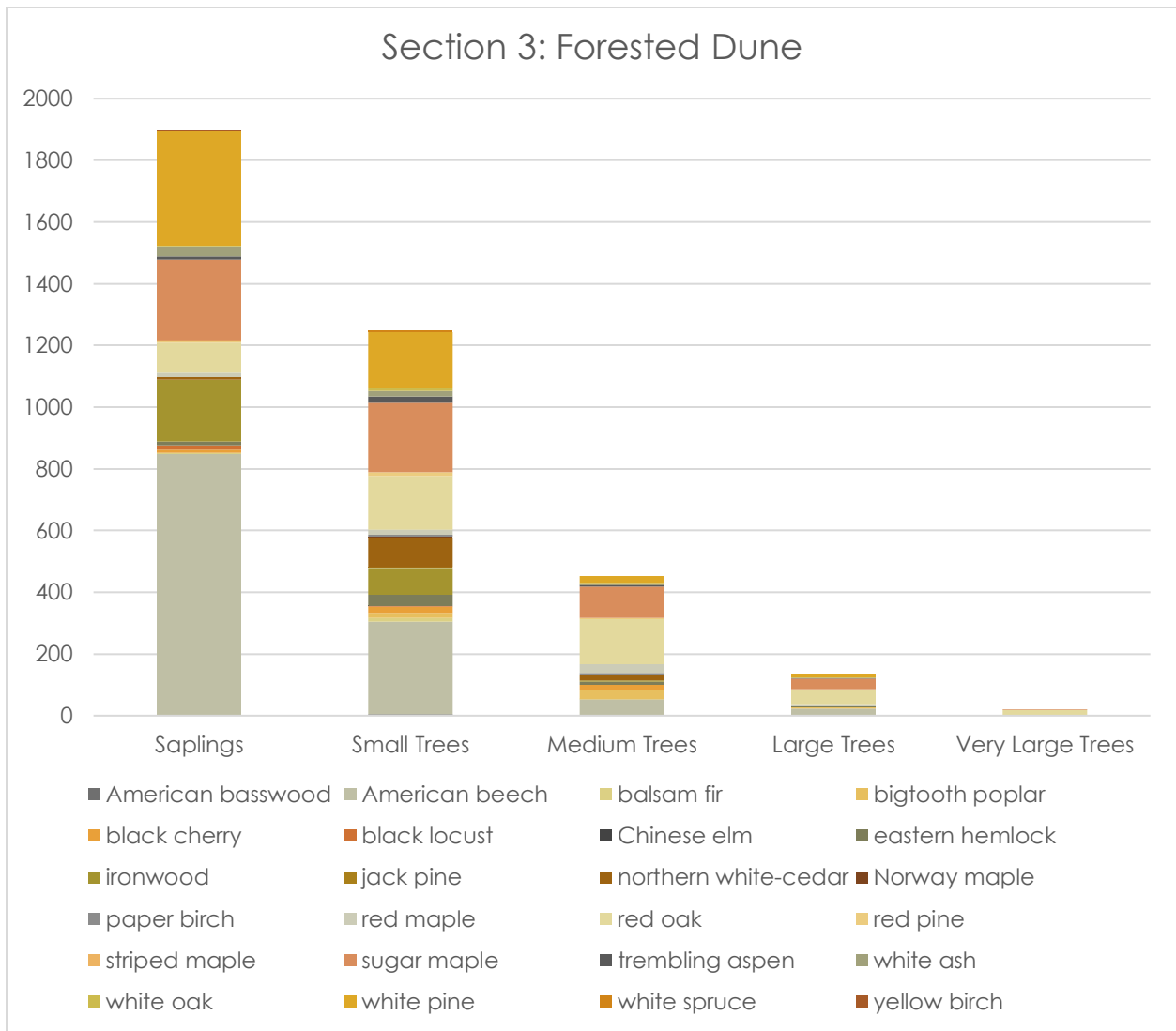**Figure 10. Section 2 size-class structure.**

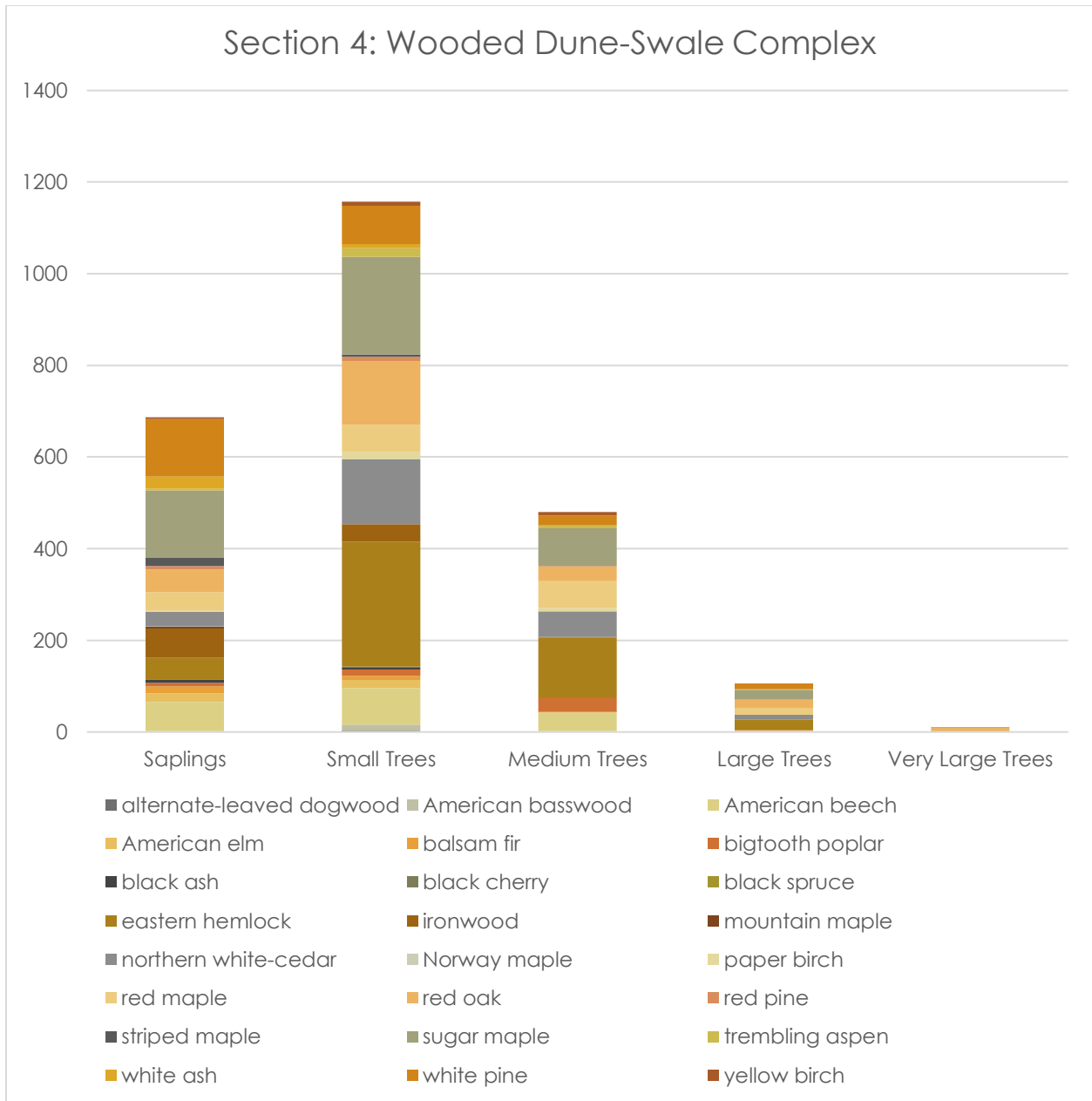**Figure 11. Section 3 size-class structure.**

Figure 12. Section 4 size-class structure.

Appendix B: Author Bio

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Liana May is the owner/operator of Borealis Consulting LLC, located in Traverse City MI. Liana holds a B.S. in Environmental Science and an MSc in Terrestrial Ecology and Informatics from the University of Michigan and has operated Borealis Consulting LLC for nine years. Borealis Consulting LLC is a woman-owned small business specializing in natural resource management services with past satisfactory performance for Smithsonian Environmental Research Center, NatureServe, Michigan Natural Features Inventory, US Fish and Wildlife Service, Michigan Department of Environment, Great Lakes and Energy, Michigan Department of Natural Resources, the Leelanau Conservancy, the Grand Traverse Regional Land Conservancy, the Little Traverse Conservancy, and other organizations.