

The Legacy Dune Trail

Designing Sustainable Hiking Trails Within Lake Michigan's Coastal Dune Ecosystems.

Prepared By Eli Lowry, Jack Guirey, Alissa Paquette, Joseph Powell and Dillon Martin

Prepared For Southwest Michigan Land Conservancy and the National Park Service

Advisor Robert Grese







Executive Summary

The western shore of Lake Michigan is home to some of the largest freshwater dunes in the world. Three preserves (Pilgrim Haven, Porter Legacy Dunes, and Van Buren State Park) have been established just south of South Haven, MI to protect critical dune habitat and provide recreational access to the dunes and Lake Michigan. A fourth property—Syndicate Park Dune Area—contains both private lands as well as a network of public lands held by Van Buren County. In January of 2022, a masters project team from the School for Environment and Sustainability (SEAS) formed to research and develop trail concepts for the Legacy Dune Trail through these four properties simultaneously protecting the sensitive dune environment while allowing visitors to experience the unique landscape. The project was sponsored by the Southwest Michigan Land Conservancy (SWMLC) and the Rivers, Trails, and Conservation Assistance Program of the National Park Service (NPS). The team analyzed both cultural and natural features of the properties, engaged with stakeholders from local communities, and developed design concepts for the interdunal Legacy Dune Trail, connecting all four properties as well as a more detailed trail design for the Porter Legacy Dunes property.

Acknowledgements

We would like to express our deepest appreciation to all those who provided us the possibility to complete this report. A special thanks to Bob Grese, SEAS Professor Emeritus and our project advisor, who's continued encouragement and insightful prompts lead to the successful completion of this project. We would also like to thank Mitch Lettow, Stewardship Director at Southwest Michigan Land Conservancy, and Katharine (Kat) Shiffler, University of Michigan Alumni and Landscape Architect at the National Park Service, for their endless support and enthusiasm in bringing these trails to life.

Furthermore, we are grateful to the faculty at the University of Michigan who Provided thoughtful input and and feedback throughout the process. We are especially grateful to Dr. Richard Norton. Taubman College Professor of Urban & Regional Planning, and Dr. Drew Gronewold, associate professor at SEAS and adjunct professor in the University of Michigan Department of Civil and Environmental Engineering for lending their expertise. For keeping us grounded in the local community, we would like to thank Robert Burr, former Mayor of South Haven, residents of the Syndicate Park Dunes neighborhood, and everyone who attended our stakeholder meetings.

Project made possible by cooperation from:





Contents

Executive Summary	4
Acknowledgements	5
1 Introduction	10
1.1. Vision + Mission.....	11
1.2 Just Dune It Team.....	11
1.3 Project Description	12
2 Site Context	16
2.1 History.....	16
2.2 Ecology.....	17
2.3 Lake Level Dynamics.....	20
2.3 Property Boundaries.....	21
2.3.1 Pilgrim Haven Natural Area	23
2.3.2 Porter Legacy Dunes	24
2.3.3 Syndicate Dunes and Subdivision	26
2.3.4 Seawall Construction.....	29
2.3.5 Van Buren State Park	31
2.4 Regional Trail Connectivity.....	31
2.4.1 Kal-Haven Trail.....	32
2.4.2 Van Buren Spur Trail	33
3 Project Process	34
3.1 Trail Design Process.....	34
3.2 Site Visit.....	36
3.2.2 Data Collection	36
3.3 Stakeholder Engagement	39
3.4 User Survey.....	40
3.5 Lake Level Dynamics and Dune Movement Analysis.....	43
3.5.1 Historical Imagery	43
3.5.2 Geo-referencing	44
3.5.3 Distance Measurements	45
3.5.4 Conclusions.....	46
3.6 Existing Trails and Models.....	47

3.6.1 Least Cost Path Van Buren State Park	47
4 Design Results	48
4.1 Porter Legacy Dunes	49
4.1.1 Trail Concept 1.....	51
Homestead Loop.....	51
Flatwoods Loop	51
Dune Overlook Loop.....	52
4.1.2 Trail Concept 2.....	53
Dune Overlook Loop.....	56
4.2 Syndicate Dunes	58
4.3 Van Buren State Park	61
4.4 Legacy Dune Trail	61
4.5 Wayfinding and Interpretive Signage	64
4.5.1 Wayfinding System	64
4.5.2 Interpretive Signage	68
4.6 Future Recommendations.....	70
Works Cited	72

List of Figures

Figure 1. Project Boundaries	13
Figure 2. Project Area Dune Elevation Section.....	14
Figure 3. Chief Simon Pokagon, Pokagon Band of Potawatomi....	17
Figure 4. Illustration of a typical freshwater dune cross section ..	18
Figure 5. Vegetation cover types of Porter Legacy Dunes	19
Figure 6. Site Context Map	21
Figure 7. Project Boundaries along Lake Michigan Shoreline	22
Figure 8. Pilgrim Haven Natural Area and Porter Legacy Dunes	23
Figure 9. Common Trillium above	24
Figure 10. American Ginseng.....	25
Figure 11. Porter Legacy Dunes, Mesic Northern Forest.....	26
Figure 12. Plat map circa 1910 of the Syndicate Park Subdivision	27
Figure 13. Current Land Ownership, Syndicate Park Area	28
Figure 14. Signage and snow fencing that was installed as part of a restoration effort in Syndicate Park Dunes.....	29
Figure 15. Active construction of a seawall along the Syndicate dune portion of the lakeshore observed in June of 2022.	30
Table 1. Property ownership and area.....	31
Figure 16. Regional non-motorized trail map.....	32
Figure 17. Regional non-motorized trail connectivity diagram.....	33
Figure 15. Trail Design Process Diagram	35

Figure 16. Team meeting with SWMLC members, South Haven residents, and former Mayor Robert Burr 36

Figure 17. ArcGIS Web Map used for Data Collection In ArcGIS Collector.....37

Figure 18. May 19, 2022 Field Data Collection Route 38

Figure 19. October 21, 2022 Collaborative Design Activity 40

Figure 20. SMPC Sybdicate Dune Park Area dune movement study 44

Figure 21. Just Dune It team dune movement analysis45

Table 2. Dune Movement Analysis results and calculation of yearly averages 46

Figure 22. Porter Legacy Dunes Trail Concept Map 152

Figure 23. Porter Legacy Dunes Trail Concept Map 2.....56

Figure 24. Boardwalk system allows for dune access without trampling nearby vegetation57

Figure 25. Raised boardwalk allows visitors safe access to dramatic views from the dune over Lake Michigan59

Figure 26. Syndicate Dunes Park Trail Concept Map..... 61

Figure 27. Van Buren State Park Trail Concept Map..... 62

Figure 28. Legacy Dunes Trail Concept Map..... 64

Figure 29. Porter Legacy Dunes trailhead kiosk.....67

Figure 30. Trail intersection signage installation detail..... 68

Figure 31. Intersection sign and screen printed trailblazers 69

Figure 32. Trail marker at John Dellenbeck Dunes, Coos County, Oregon 69

Figure 33. Interpretive signage mockup 70

Figure 34. Common trillium interpretive sign..... 71

List of Tables

Table 1. Property ownership and area.....33

Table 2. Dune Movement Analysis results and calculation of yearly averages 48

List of Graphs

Graph 1. Pilgrim Haven preferred trail length survey results 43

Graph 2. Van Buren preferred trail length survey results 43

Graph 3. Pilgrim Haven interest in trail amenities survey results 44

Graph 4. Van Buren interest in trail amenities survey results 44

Appendices

Appendix A: Site Profiles and History76

Appendix B: List of Stakeholders 80

Appendix C: User Survey and Results..... 81

Appendix D: Dune Movement Analysis 93

Appendix E: Previous Trail Design Concepts 96



Introduction

In January of 2022, Mitch Lettow with the Southwest Michigan Land Conservancy (SWMLC) and Katharine (Kat) Shiffler a SEAS, MLA Alumni with the National Park Service, Rivers Trails Conservation Assistantship Program (NPS, RTCA) submitted a University of Michigan School for Environment and Sustainability (SEAS) Master's Project Proposal to design an interdunal trail network along the west coast of Michigan dubbed the Legacy Dune Trail. The SWMLC is a 501(c)(3) nonprofit land conservancy established in 1991. They work in nine counties of southwest Michigan to preserve wild and scenic places for today and into the future. The RTCA is a unique program of the National Park Service that "assists communities and public land managers in developing or restoring parks, conservation areas, rivers, and wildlife habitats, as well as creating outdoor recreation opportunities and programs that engage future generations in the outdoors" (nps.gov). Together the clients selected five SEAS masters students for the project consisting of four Master of Landscape Architecture (MLA) students and one Geospatial Data Science (GDS) student. Early in

the project we came up with the informal name the "Just Dune It" team and that has become a motto to guide us through the unique challenges of designing a sustainable trail through the complex and ever shifting ecosystems that make up west Michigan's coastal freshwater dunes.

1.1. Vision + Mission

Through a community input session we were able to come to a consensus with our clients on the what the mission and vision of the trail system should be, they are the following:

Vision: Connect and enrich trail life and Lake Michigan landscapes for all

Mission: Create an accessible community trail network to connect residents and visitors to a dynamic South Haven area dune landscape

The proposed interdunal trail is located 5 miles south of the City of South Haven, MI which is known as a "trail town" because it is home to several hiking and biking and kayaking trails that are popular among residents and attract visitors alike (South Haven Area Recreation Authority 2018). The interdunal trail has the potential to add to the overall appeal of the area as a premiere hiking and biking and kayaking destination.

1.2 Just Dune It Team

Our team consists of five School for Environment and Sustainability students attending The University of Michigan. The following is a list of the team members and their area of study. Master's of Landscape Architecture Students include Alissa Paquette, Dillon Martin who is also pursuing a degree in Environmental Systems and Management, Eli Lowry and Joseph Powell. The fifth member of the team is Jack Guirey who is pursuing a Master's in Geospatial Data Science. Together we share an interest in natural areas management, restoration ecology, along with park and trail design and management.



Alissa Paquette
MLA



Joseph Powell
MLA



Eli Lowry
MLA



Dillon Martin
MLA, MS Ecosystem
Science & Management



Jack Guirey
MS Geospatial
Data Science

1.3 Project Description

The intention of this project is to design a variety of hiking trail concepts that will allow users to seamlessly navigate through a variety of interdunal ecosystems spanning multiple property boundaries within Michigan’s lower west coast. Both managed and informal trails already exist throughout these properties. The dynamic nature of open dune ecosystems poses unique design challenges for directing foot traffic and keeping visitors on designated trails within the project sites (Carlson and Godfrey 1989). This project will assess the quality of existing trails and propose strategies for increasing trail network sustainability. Additional points of entry and trail wayfinding infrastructure will also be considered to ensure visitors can safely navigate the trail and access the Lake Michigan coast. The trail network will highlight popular vistas and features of the dunes, while aiming to protect the fragile endemic ecosystem within. Interpretive signage will be incorporated throughout the trail to provide ecosystem education and acknowledge indigenous cultures that originally inhabited the lands.

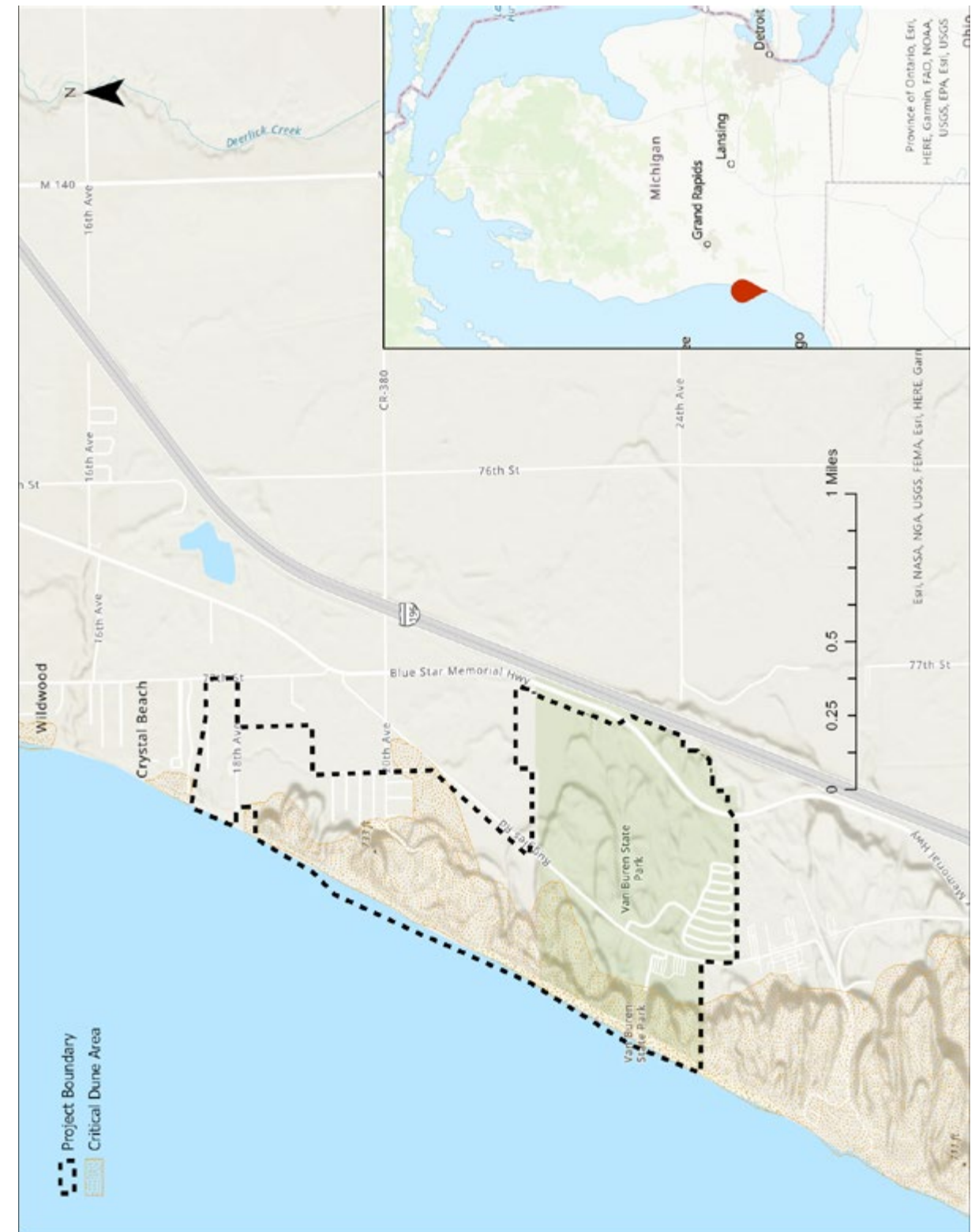


Figure 1. Project Boundaries

The project area is a lakeshore dune corridor which stretches nearly 2 miles south to north from Van Buren State Park to Pilgrim Haven Natural Area. The project area is shown as a black dotted line in Figure 1. Critical dune areas are present within the project area and are protected by state legislation, Part 353. This regulation protects exceptional dunes from construction and prohibits other modifications to the landscape unless they are approved by the state. Additional regulations were included as recently as 2014 to prohibit development on dune slopes greater than 25% and on the lakeward-facing slope of the first significant dune features closest to the lakeshore (White et al. 2019).

The eastern shoreline of Lake Michigan hosts the largest concentration of freshwater coastal dunes in the world (Peterson and Eckhart 1981). The largest dunes are found along the Eastern shoreline of Lake Michigan (Albert and Dennis 2000), which can contribute up to 300 feet in elevation. A section of the height and scale of the dunes within the project area are represented in figure 2. These dunes are also some of the most heavily used landscapes in the region, with national, state, and local parks along the shoreline attracting over 2.5 million visitors per year (White et al. 2019). In total, Lake Michigan’s shoreline and the shores of Lake Superior contain about 70,000 acres of critical dune habitat.

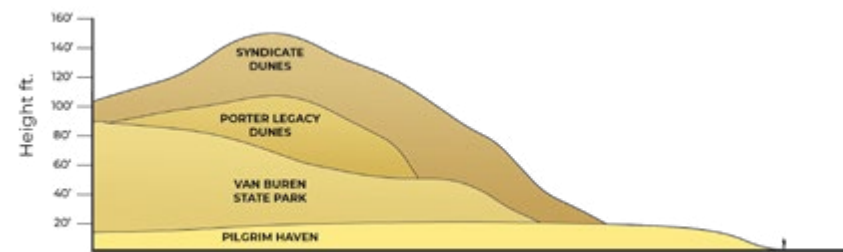


Figure 2. Project Area Dune Elevation Section

Human impacts such as recreation and development, which includes sand mining, construction of homes, commercial buildings, and infrastructure, threaten to heavily impact or eradicate the sensitive dune habitats and increase runoff and erosion. These impacts are expected to be exacerbated by climate change. Rising temperatures and an increase in extreme rain events are projected to alter lake level dynamics in the coming decades. These changes will directly affect the natural forces that shape and maintain the dune ecosystem (Kayastha et al. 2022; Gronewold and Rood 2019). With these factors in mind, we took special care

to consider the potential impacts hiking trails can have on the dynamic dune ecosystems and buffer the trail from potential rising lake levels.

To complete the project goals we developed a series of interdunal trail network concepts to connect disjointed natural areas. The trail concepts were created through multiple design workshops, and decisions were made based on stakeholder feedback gathered through public surveys and stakeholder meetings and collaborative design sessions. The team utilized the information gathered during these sessions to develop multiple trail concepts for the properties. The trail concepts include easy access to parking areas, restroom facilities, benches and resting areas and various trail lengths and difficulty levels.



Site Context

2.1 History

Today, the city of South Haven, Michigan sits on the ancestral homelands of the Anishinaabe people, the People of the Three Fires: the Ojibwe, Odawa, and Potawatomi. Prior to the arrival of colonizers, the Pokagon Band of Potawatomi established a village among the dunes, between the Black River and Lake Michigan, called Nik-o-nong, derived from the Algonquin words “nik” (sunset) and “o-ni-gis,” (beautiful). In 1900 Chief Simon Pokagon (Figure 3), describing the area, stated, “Ki-ja-Man-i-to (the Great Spirit)... planted in saw-kaw (the forests) along the shore the most beautiful woodland flowers that ever bloomed on Earth; and filled all the trees with birds that sang the sweetest songs that ever fell on mortal ears” (Pokagon 1900).

The City of South Haven was established in 1833 by J.R. Monroe. Initially, the city was built up around the lumber industry. Trees from southeast Michigan were shipped to Chicago and Milwaukee,

and early steam-powered ships were built in the shipyards along Lake Michigan. When the lumber was exhausted, farmers moved into the area and helped establish Michigan’s “fruit belt,” growing blueberries, peaches, cherries, and more. In the 1920s and 1930s commerce boomed and South Haven became a vacation destination for people to enjoy the beaches, resorts and entertainment, including an opera house (South Haven n.d.).



Figure 3. Chief Simon Pokagon, Pokagon Band of Potawatomi

2.2 Ecology

The site sits within the Southern Michigan Lakeplain Sub-subsection of the Allegan Subsection of Southern Lower Michigan. The soil texture in this area is characterized by lacustrine sand and gravel with an overlay of dune sand (Farrand and Bell 1982). The vegetation circa 1800 was primarily beech-sugar maple-hemlock forest and open dune, but also contained areas of mixed hardwood swamp, beech-hemlock forest, black ash swamp, and mixed conifer swamp (Comer et al. 1998). A recent survey of Porter Legacy Dunes Preserve (PLD) by the Michigan Natural Features Inventory (MNFI) found that the preserve contained six cover types, two anthropogenic land cover types (homesite, planted pines), two degraded cover types (acidic sandy flatwoods, dry-mesic southern

forest), and two high quality land cover types (open dunes, mesic northern forest) (Bassett and Lincoln 2022). A typical cross section of the coastline (Figure 4) along the site consists of sand and gravel beach, open dune (foredune), mesic northern forest (backdune), and dry mesic southern forest.

Open dunes are a prevalent feature across all of the properties. These natural communities are considered vulnerable both locally and globally, receiving a NatureServe ranking of S3 and G3 respectively. In Michigan open dunes occur primarily on the western coast, along Lake Michigan, with some occurrences in the Upper Peninsula. Michigan hosts the greatest concentration of freshwater dunes in the world (Peterson and Eckhart 1981). Open dunes are a grass and shrub dominated community that is largely affected by lake-driven winds. They are home to many federally and state listed threatened species including Pitcher’s Thistle (*Cirsium pitcheri*), Dwarf Lake Iris (*Iris lacustris*), and Houghton’s Goldenrod (*Solidago houghtonii*) (Kost et al. 2007).

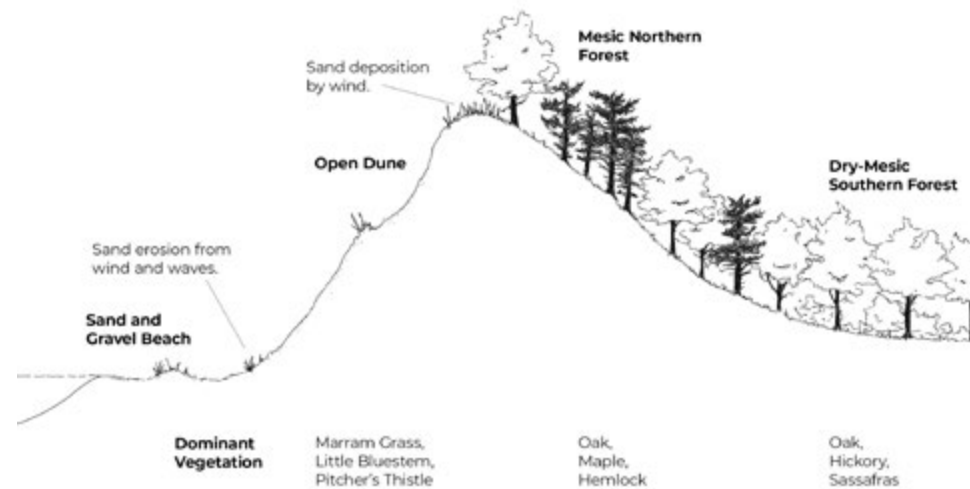


Figure 4. Illustration of a typical freshwater dune cross section

The backdune is forested with mesic northern forest and gives way to dry-mesic southern forest in the flatlands behind the dunes. Mesic northern forest is a moist to dry-mesic forest type that occurs primarily above the climactic tension zone, although in Michigan its range extends south along Lake Michigan (Kost et al. 2007). The PLD mesic northern forest is dominated by northern red

oak (*Quercus rubra*) with co-dominants including sugar maple (*Acer saccharum*), black cherry (*Prunus serotina*), basswood (*Tilia americana*), and eastern hemlock (*Tsuga canadensis*). The dominance of sugar maple in the understory suggests that oak regeneration has stagnated and the canopy will be dominated by maple over time. The herbaceous layer is diverse and dominated by spring ephemerals including dutchman’s breeches (*Dicentra*

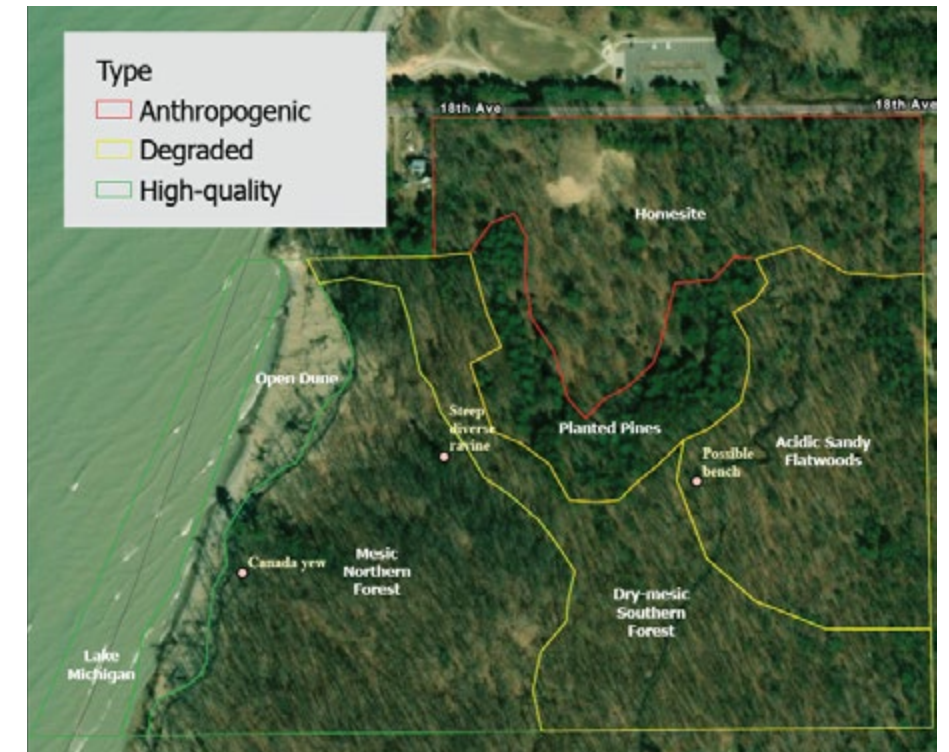


Figure 5. Vegetation cover types of Porter Legacy Dunes (Source: Bassett and Lincoln 2022)

cucullaria), common trillium (*Trillium grandiflorum*), spring-beauty (*Claytonia virginica*), and yellow trout lily (*Erythronium americanum*) (Bassett and Lincoln 2022).

Several species of conservation concern were found during the 2021 MNFI Ecological Evaluation of PLD, two state-listed species Pallas’ bugseed (*Corispermum pallasii*; state special concern) and ginseng (*Panax quinquefolius*; state threatened) and Canada Yew (*Taxus canadensis*), which is not state or federally recognized but is considered a species of concern. Pallas’s bugseed is an annual forb found mostly on open dunes and sandy beaches along the Great Lakes in Michigan. This species is common to

Michigan open dunes and was associated with winged pigweed (*Cycloloma atriplicifolium*), tall goldenrod (*Solidago altissima*), sassafras (*Sassafras albidum*), and marram grass (*Ammophila breviligulata*). American ginseng is found in moist, shaded mesic forest of the backdune and is associated with hairy sweet cicely (*Osmorhiza claytonii*), enchanter's-nightshade (*Circaea canadensis*), and big-leaved aster (*Eurybia macrophylla*) (Bassett and Lincoln 2022).

2.3 Lake Level Dynamics

Situated along the shore of Lake Michigan, the project site is affected by lake level dynamics in a variety of ways. This is often most apparent in periods when high and low lake levels interact with coastal dune features such as “foredunes,” “dune ridges,” and blowouts.” Fore dune refers to short, mound-like structures that are typically found near the back edge of beaches and are created by aeolian processes (or the erosion, transportation, and/or deposition of sediments by wind (Aeolian Dune Landforms, National Park Service n.d.). In low lake level conditions, sand from widened beaches can be blown inland to help form these foredunes or increase the size of larger, existing dunes (van Dijk 2004 429). Alternatively, high lake levels expose the foredunes to wave erosion and composite sands may be blown further inland or recollected back into the nearby shore system by retracting waters (van Dijk 2004 429). Dune ridges are structures that generally form behind foredunes. Due to plant growth and accumulation over time, ridges are often older and more stable than their smaller counterparts (van Dijk 2004 430). The maturity and density of plant life on these dunes are often used by researchers to determine their age. Finally, blowouts are large depressions or hollows created by wind erosion that generally occur on larger, more established sand deposits (Hesp 2022). They often form in areas where little to no vegetation is present to secure a dune; continued erosion overtime may help to enlarge the original disturbance or even alter the flow of wind patterns within (van Dijk 2004 430).

Furthermore, these forms may even funnel sands carried by the wind up and into greater parabolic dunes; this movement is known as leeward motion (Zelenka n.d.). In conjunction with aeolian processes, human activity can be seen as a cause for blowouts as well. This is largely due to the trampling of stabilizing plants and creation of social trails where more official routes are

undermaintained (Burkley 2014). These landscape features among others, and the ways that the fluctuating waters of Lake Michigan interact with them have played a big part in our understanding of the interdunal landscape. The spatial and temporal challenges that the site presents have emphasized the importance of adaptive infrastructure and clearly defined paths throughout the trail design.

2.3 Property Boundaries

The goal of the Legacy Dune Trail is to connect currently disjointed properties from Van Buren State Park on the south to Pilgrim Haven Natural Area, on the north into a cohesive trail experience for a longer, more continuous experience of the dune landscapes. The team faced multiple design challenges as they attempted to traverse these varied physical, ecological and political boundaries. These challenges required that we pay special attention to understanding the relationship between where property boundaries exist and the locations where the trail would be ideally located. To help orient readers of this report, we will provide a general overview of the property boundaries with in-depth sections to describe each area. The major properties include Pilgrim Haven Natural Area, Porter Legacy Dunes (PLD), Syndicate Park Dunes, and Van Buren State Park. Figure 7 provides a view of properties as seen from the Lake Michigan shoreline.

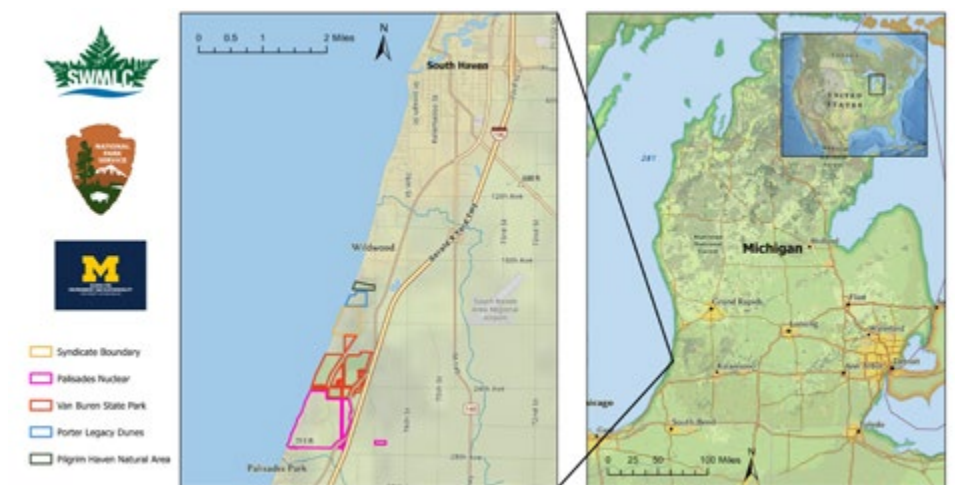


Figure 6. Site Context Map

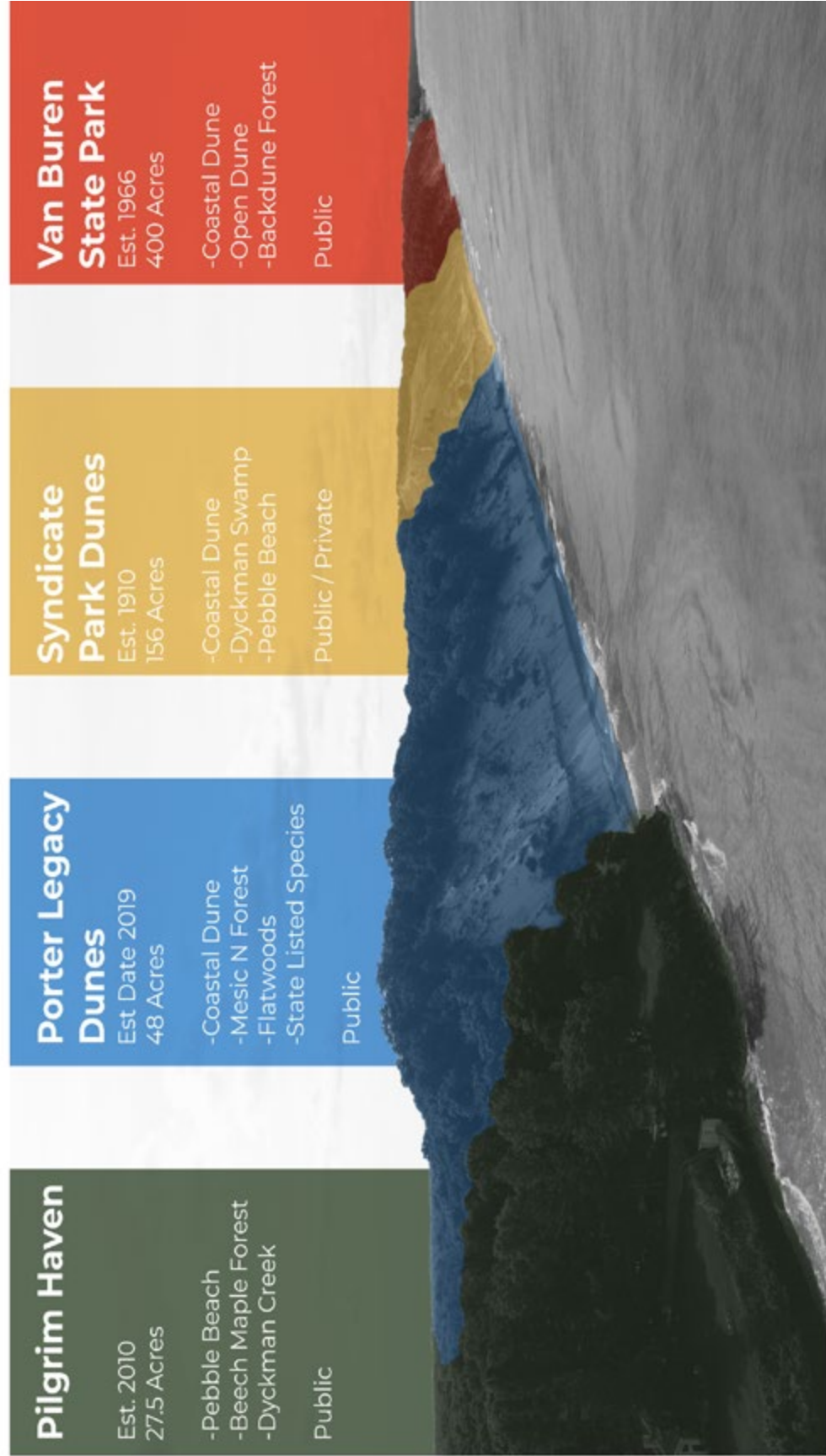


Figure 7. Project Boundaries along Lake Michigan Shoreline

2.3.1 Pilgrim Haven Natural Area

Pilgrim Haven Natural Area, also referred to simply as Pilgrim Haven is a 27-acre nature area that was conserved in 2010 by the late Suzanne Upjohn DeLano Parish estate. In 2017, an agreement was reached between the SWMLC and the South Haven Area Recreational Authority (SHARA) to manage the site (Parker 2012). The area provides a 45-car parking lot with two accessible spaces, 0.33 miles of hiking trails, and an accessible walkway leading to Lake Michigan. Improvements to the site have been funded by various sources, including grants from Entergy Corporation-Palisades and the Michigan Natural Resources Trust Fund, along with donations from private individuals and SWMLC supporters. Pilgrim Haven’s rich history as an all-girls camp has helped to generate support for the site. With the site securely designated as a conservation area the diverse ecosystems located here continue to provide valuable habitat for migratory birds following the Lake Michigan flyway, as well as beneficial pollinators such as the monarch butterfly.



Figure 8. Pilgrim Haven Natural Area and Porter Legacy Dunes (Credit: Eli Lowry)

2.3.2 Porter Legacy Dunes

Adjacent to Pilgrim Haven, the Porter family owned and protected a 48-acre parcel of land for nearly 140 years until Catherine Porter passed away. She left the property to her fiancé, Scott Royle, who wished to hand the land over to a responsible conservation agency. In late 2019, the SWMLC, SHARA, and Van Buren County obtained \$2.3 million in funding from the Michigan Natural Resources Trust Fund (MNRTF) to acquire the property and protect it through a conservation agreement (Moore 2019).



Figure 9. Common Trillium above (Credit: Mitch Lettow)

A Michigan Natural Features Inventory was performed on the site in May 2022. The inventory identified several natural ecosystems that range from high quality to degraded due to human use and have been mentioned in the ecology section of the report. At the northernmost point of the site lies the old homestead of the Porter family. Some small remnants still remain, including the ruins of an old chimney and a small wind turbine. While this area is disturbed and mostly populated by non-native species, a few species of conservation concern have been observed that are commonly associated with dry prairies and dunes, including prickly pear (*Opuntia humifusa*), little bluestem (*Schizachyrium scoparium*), poverty grass (*Danthonia spicata*), and hairy hawkweed

(*Hieracium gronovii*) (Bassett and Lincoln 2022). South of the homestead are planted pines of mostly red pine (*Pinus resinosa*) and white pine (*P. strobus*). The plantation gives way to low quality dry-mesic southern forest and acidic, sandy flatwoods that buffer Dyckman Creek, which runs north/south along the eastern side of the preserve. The gentle topography of these areas make them ideal locations for accessible trails.



Figure 10. American Ginseng (Credit: Jesse M. Lincoln)

The steeper back dune consists of a high quality mesic northern forest with dense patches of spring ephemerals including common trillium (*Trillium grandiflorum*) and dutchman's breeches (*Dicentra cucullaria*). The steep dunes provide a challenge for hikers but offer rewarding views of lake Michigan at their peaks. Bird watchers can enjoy a plethora of songbirds in the warm seasons including hooded warblers (*Setophaga citrina*), and scarlet tanagers (*Piranga olivacea*). The open dune along the coast is considered high quality and has a healthy population of marram grass (*Ammophila breviligulata*) and Pallas' bugseed (*Corispermum pallasii*), a state-listed species of conservation concern. The dunes are quite steep and prone to blowout. In our design we recommend special measures that can be taken to reduce foot traffic and climbing in these areas.



Figure 11. Porter Legacy Dunes, Mesic Northern Forest (Credit: Mitch Lettow)

2.3.3 Syndicate Dunes and Subdivision

The Syndicate Park Dunes area is composed of a complex network of publicly and privately owned parcels. The Syndicate Park Subdivision plan was plotted in 1910 by the Syndicated Press based in Chicago (Vander Bilt, Karsten, and Van Dijk 2013). As part of the publications marketing strategy they offered a 20 ft by 100 ft lot on the shores of Lake Michigan free with a subscription to the Chicago Tribune. The original plat map is shown in Figure 12. The plan divides the 80 acre area into over a thousand narrow lots that extend right up to the shores of Lake Michigan. The map neatly divided the land without considering the topography of the area which includes large areas of open dune.

Many of the parcels were too narrow to develop on their own and eventually were reclaimed by the county. Van Buren County owns the majority of the parcels located within the open dune area however some narrow undeveloped privately owned lots remain. The shoreline of the area continues to settle to this day, losing nearly 3' of lakeshore per year. The lots that were plotted in the western edge of the lakeshore are now submerged under the highwater mark of Lake Michigan. Several houses eastward of the dunes are threatened by dune advance. An analysis of air photos

from 1938 to 2010 showed that the dunes along the Syndicate Park Dunes shoreline were advancing an average of several feet per year. (SMPC 2012). A map displaying the current land ownership pattern within the area is provided in Figure 13.

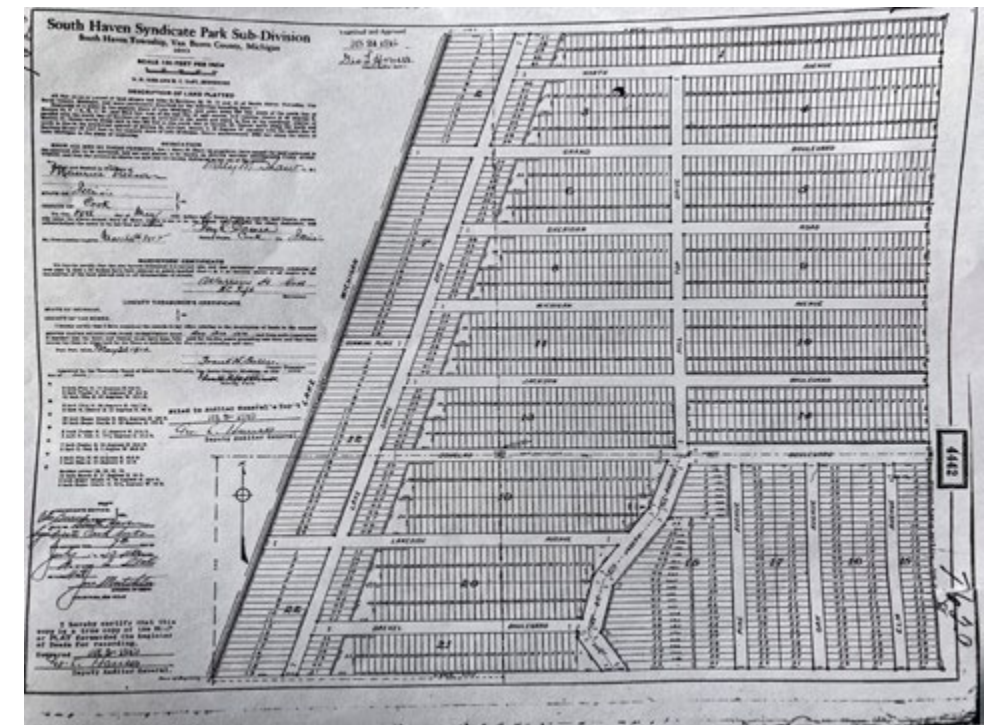


Figure 12. Plat map circa 1910 of the Syndicate Park Subdivision

In 2013, Lucas Vander Bilt, James Karsten, and Deanna van Dijk from Calvin College published a detailed report titled “Investigation of the Syndicate Park Dune Area,” which was commissioned by the Van Buren County Board of Commissioners. The report findings revealed that the area has been heavily impacted by human use and recreational activity by visitors and residents of the subdivision directly inland from the shoreline. The open dune area exhibited 14 blowouts, which are saucer-, cup- or trough-shaped depressions or hollows formed by wind erosion on preexisting sand deposits. (Hesp 2002). Blowouts also show a visible lack of dune vegetation, such as Marram grass (*Ammophila breviligulata*), which is highly specialized vegetation that covers the dune surface and retains sand, acting as a protective skin on the fragile hillslopes.

Some figures of note from the report include the following: 35% of the total dune area showed a high percentage of bare sand areas susceptible to wind erosion. Through their observations it was determined that up to 40% of visitors climb on the dunes and some visitors use ATV's (Vanderbilt, Karsten and van Dijk, 2013). Since the publishing of this report an agreement was made with the residents of Syndicate Park to restrict ATV use to designated trails and along the beach. This was confirmed through stakeholder engagement sessions and through our own observations on site.

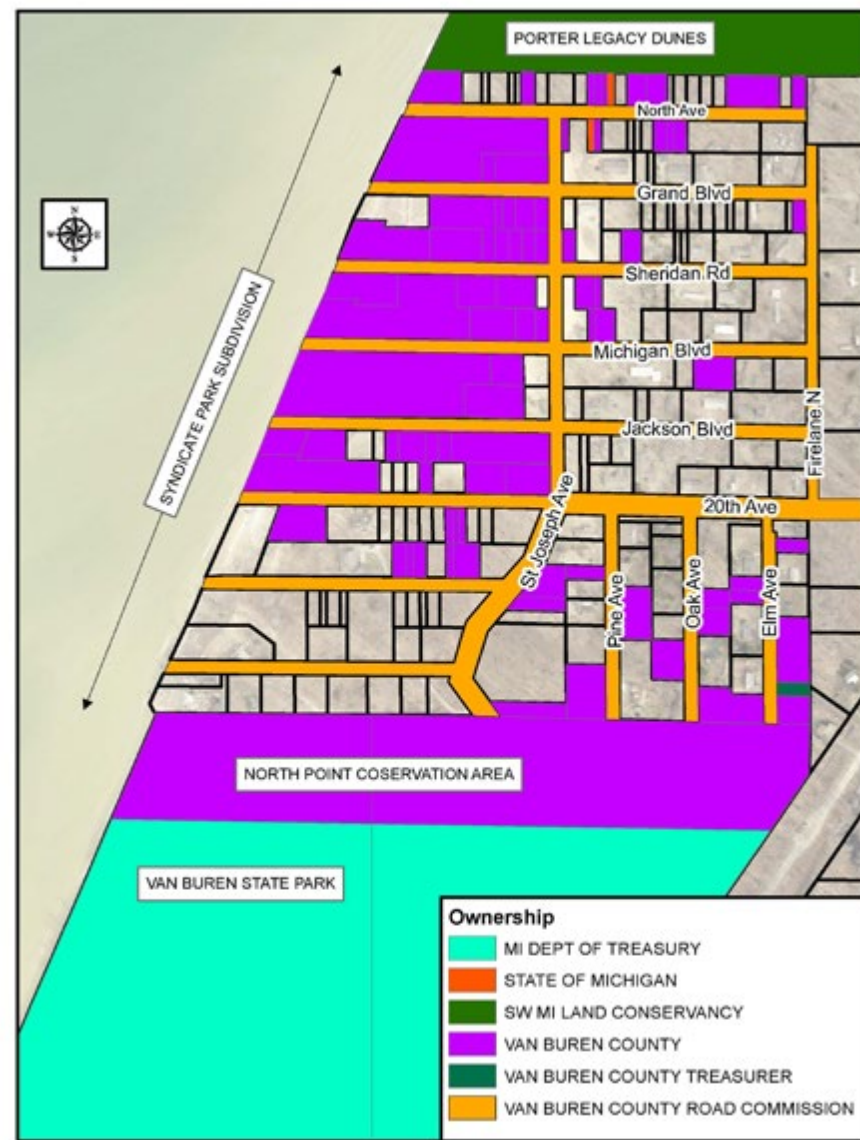


Figure 13. Current Land ownership Pattern, Syndicate Park Area (Source: Van Buren County)

Restoration and management practices have been put in place since 2013. Snow fencing was installed on highly eroded slopes to help retain sand that is blown from the shoreline during high winds. Other areas have been restricted to Syndicate Park residents only. The efficacy of these measures is difficult to quantify and could be investigated for further study.

The team has been able to utilize the information provided from previous investigations of the area as well as stakeholder engagement sessions to inform the design of the proposed interdunal trail concept. This includes the location of entry and exit points of the interdunal trail and recommendation for area restrictions to protect the dunes from recreational activity to allow for ecological restoration.



Figure 14. Signage and snow fencing that was installed as part of a restoration effort in Syndicate Park Dunes

2.3.4 Seawall Construction

A more recent development observed in this area is the construction of seawalls and shoreline hardening practices along the coast commissioned by private landowners. In 2020 lake levels reached historic highs and eroded large portions of the foredune (Gronewold and Rood 2019). This contentious practice is an

attempt to arrest the natural fluctuation of the dune landform as lake levels ebb and flow. Seawalls adjacent to the Syndicate Park Dunes have created a significant barrier to public access to and along shoreline areas.

Michigan Public Trust Doctrine states that the public has the right to walk along the water, between the water’s edge and the natural ordinary high water mark, even if it’s behind someone’s house (Norton 2022). Further protections to the public trust are included under the Part 325 Great Lake Submerged Lands Act which was amended into the Natural Resources and Environmental Protection Act (NREPA), 1994 PA 451. This act states that “if a proposed private use would adversely impact the public trust, the State of Michigan’s regulatory authority requires that the proposal be modified or denied altogether in order to minimize those impacts”. (EGLE 2023). While we are not in a position to make determinations about the legality of this specific practice it appears that this construction heavily impacts public access along the shoreline. There is a permit process that was established in 1965 to construct on or occupy Great Lakes bottomlands. The permits are reviewed by the state regulatory agency EGLE and approval is determined by the impact the projects will have on the public trust.



Figure 15. Active construction of a seawall along the Syndicate dune portion of the lakeshore observed in June of 2022.

2.3.5 Van Buren State Park

Van Buren State Park is the largest contiguous area within the project boundary. The State owned land spans nearly 400 acres of backdune forests, open dune ecosystem and sandy beach. The state park and campground was established in 1966. The site offers ample car and bike parking along 220 campsites that range from primitive camps to RV hookups. Based on survey data this site attracts many out of town visitors looking for quick access to Lake Michigan beachfront in the summer months. The State Park is the southernmost property within the project boundary and is an ideal entry and exit point for the interdunal trail due to the abundant parking and the proximity to the Van Buren Spur Trail. The inclusion of the interdunal trail will add valuable options for exploring the unique and expensive freshwater dune ecosystems of West Michigan.

Table 1. Property ownership and area

Property	Ownership	Total Area (acres)
Pilgrim Haven	Southwest Michigan Land Conservancy	27.5
Porter Legacy Dunes	Southwest Michigan Land Conservancy	48
Syndicate Park Dunes	Van Buren County, Private	81.66 (County) 74 (Private)
Van Buren State Park	State of Michigan	400

2.4 Regional Trail Connectivity

The city of South Haven is known as a “trail town” because it is home to several hiking and biking trails that are popular among residents and visitors alike. As a “trail town,” South Haven is committed to promoting outdoor recreation and ecotourism in the area (South Haven Visitors Bureau 2023) The town has embraced its status as a destination for hiking and biking enthusiasts, and has worked to develop and maintain a network of trails that are accessible to people of all ages and skill levels. The interdunal

trail has the potential to add to the overall appeal of the area as a premiere hiking and biking and kayaking destination. The Kal-Haven and the Van Buren Spur Trail, can link to the proposed interdunal system to further enhance a regional non-motorized trail network. Bangor-South Haven Heritage Water Trail can allow kayakers to reach the trail via Lake Michigan from South Haven. By linking these trail systems, visitors can access the lakeshore without the need for an automobile. The ample camping options provided by Van Buren State Park can attract bike-packers and hikers to incorporate the interdunal trail into a multi-day hiking or biking adventure.

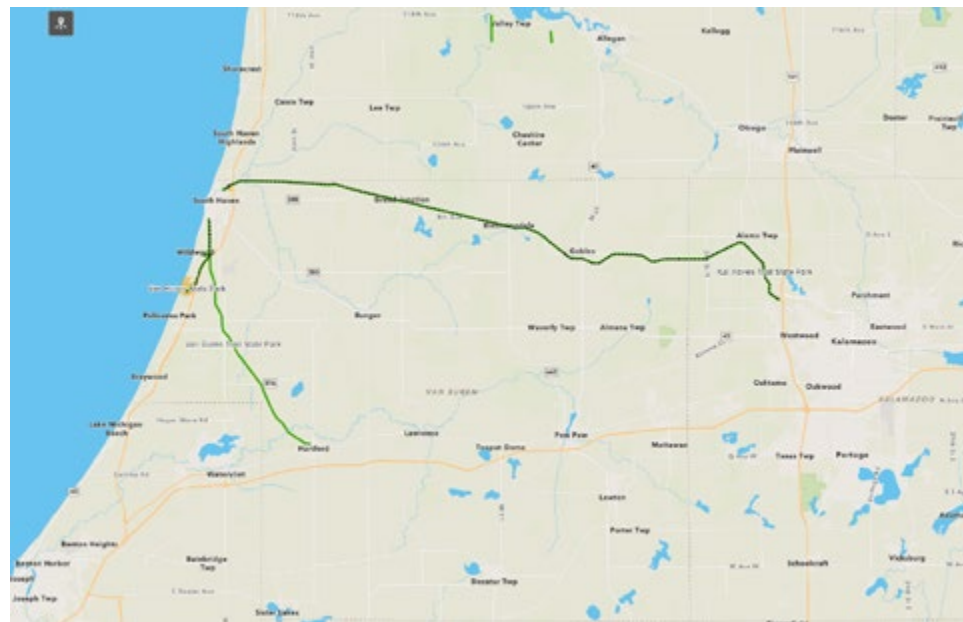


Figure 16. Regional non-motorized trail map

2.4.1 Kal-Haven Trail

The Kal-Haven is a 35-mile stretch of mostly paved trail that starts in Kalamazoo to the east and ends in South Haven to the west. This multi-use trail offers scenic views of rural western Michigan and is open to hikers, bikers, joggers, and horseback riders. This trail can be easily linked with other trails in the area, such as the Van Buren Trail, which runs from South Haven to Hartford, and the Bangor-South Haven Heritage Water Trail, which is a 21-mile paddle trail that runs along the Black River and Lake Michigan.

2.4.2 Van Buren Spur Trail

At the southern extent of the interdunal trail is Van Buren State Park. The park can be accessed by car on Ruggles Rd. or by the Van Buren Spur Trail otherwise known as the Van Buren State Park Trail. The trail begins in Hartford and Ends in South Haven. The Spur Trail is another multi-use trail that is open to walking, biking, horseback riding and skiing in the winter. To improve access to the interdunal properties and ensure pedestrian and bike safety, we propose additional bike lanes be added to 77th street and Ruggles Rd. The additional bike lanes are shown as the dotted blue line in Figure 14. We also propose the addition of bike parking at the North Point Park access point allowing for cyclists to easily enter and exit from the midway point of the trail system.



Figure 17. Regional non-motorized trail connectivity diagram



Project Process

3.1 Trail Design Process

Our trail design process was deliberately iterative and incorporated multiple spaces for stakeholder engagement and feedback. Our design methodology (Figure 18) is broken down into 5 steps, each meant to inform the next: Site Visit, GIS Analysis, Stakeholder Feedback, Update Concepts, and Ground Truth and Finalize.

The process begins with visiting the site after a review of initial documents provided by SWMLC. During this visit data was collected on the site conditions, geography, flora and fauna, and social conditions. Meeting with local residents and stakeholders during this phase helped to create relationships early on and ensure there is a shared vision. Following the site visit, the collected data was fed into GIS software program to predict the best route based on the available information. This early trail concept was shared

with stakeholders for feedback and collaboration. Taking the original concept, along with the initial feedback from stakeholders, the trail concept was updated to address concerns, new ideas, and impossibilities. The final trail concept was then ready to be ground truthed, the process of checking the results of the concept against the real world conditions. This ground truthing step is yet to be done. Once the trail concept is ground truthed, the trail may need to be moved a few feet to avoid a tree or because the route turns out to be impassable due to an obstacle undetected by GIS software. The results of ground truthing can then be incorporated into a finalized construction document, or the process can continue with collecting more data, adjusting the GIS model, receiving more feedback, and updating the design. The final design products presented in this report are not intended to be final construction ready documents but rather well thought out design concepts used as a guide to inform the final construction documentation that is needed before construction can begin.



Figure 18. Trail Design Process Diagram

At the request of SWMLC, our team varied this process somewhat using the last month of our project timeline to focus on more detailed trail design for the Porter Legacy Dunes property. That trail design has been used as the basis for a proposal to the Natural Resources Trust Fund for trail development funding.

3.2 Site Visit

We conducted an initial site visit from May 19 - 22, 2022, to conduct the site inventory and analysis process. The assessment began at Pilgrim Haven Nature Area, where we met with Mitch Lettow and Katharine Shiffler for the first time in person. In addition, we were warmly welcomed by other members of the Southwest Michigan Land Conservancy and the former Mayor of South Haven Robert Burr. This initial introduction underscored the importance of the project to the community and highlighted the trail's potential to enhance access to the unique natural resources of the area.



Figure 19. Team meeting with SWMLC members, South Haven residents, and former Mayor Robert Burr

3.2.2 Data Collection

During our site visit, we utilized several mobile applications and devices to collect and record field data with precision and accuracy. A handheld Trimble GPS, smartphones, and iPads were employed to gather trail locations and points of interest. The ESRI mobile map application, ArcGIS Collector, was the primary software used

for data collection. To normalize the data collection process, a web map was created on ArcGIS Online and shared with all members of the team to allow for simultaneous data uploads on a single map. Data that was collected includes GPS points, elevations, existing trails, new trails, and points of interest. The application also enabled the team to capture photos with geotags, allowing for photos to be used as references during the trail concept design phase. To supplement the data collection, we used the Avenza Map mobile application, allowing us to upload customized georeferenced PDF maps and collect GIS data. Additionally we tracked their path in real time using the mobile app Strava.

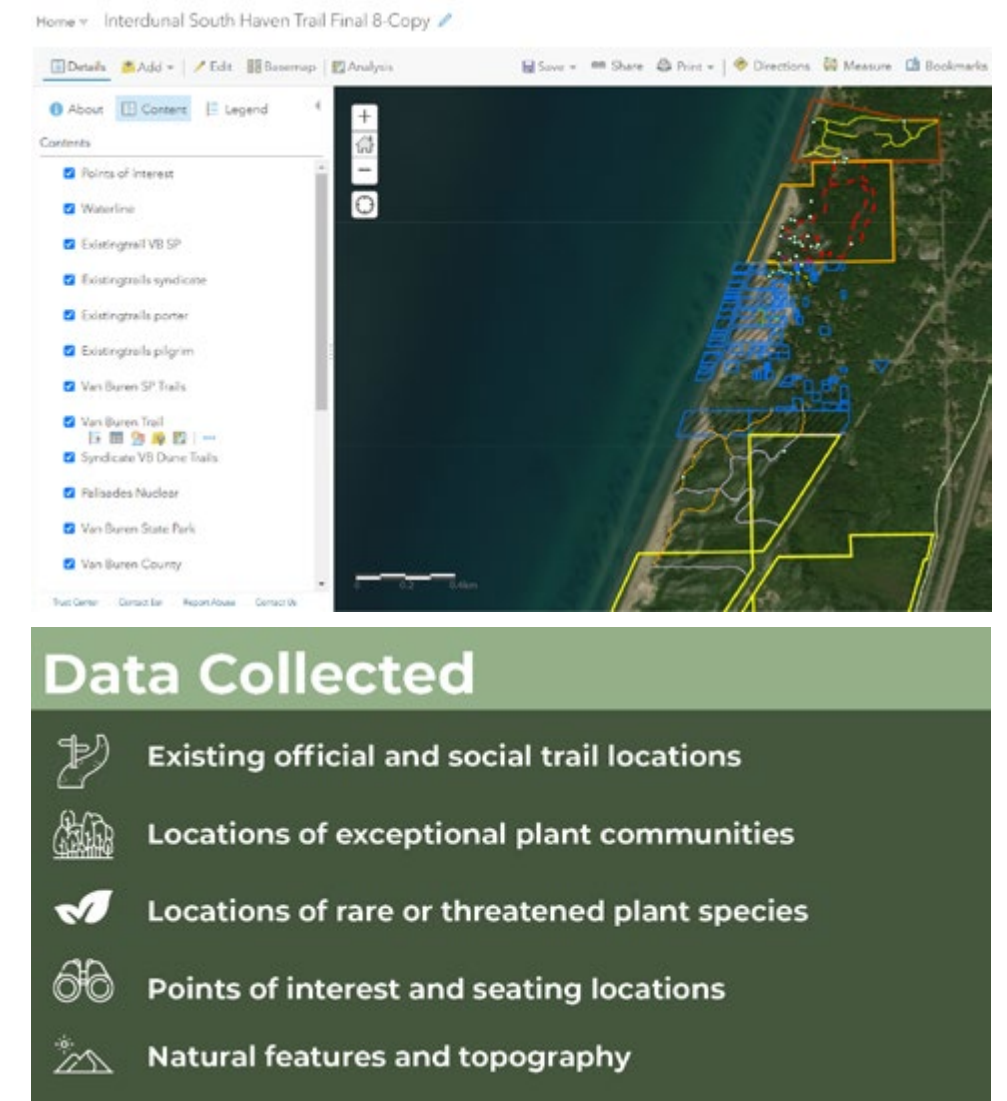


Figure 20. ArcGIS Web Map used for Data Collection In ArcGIS Collector

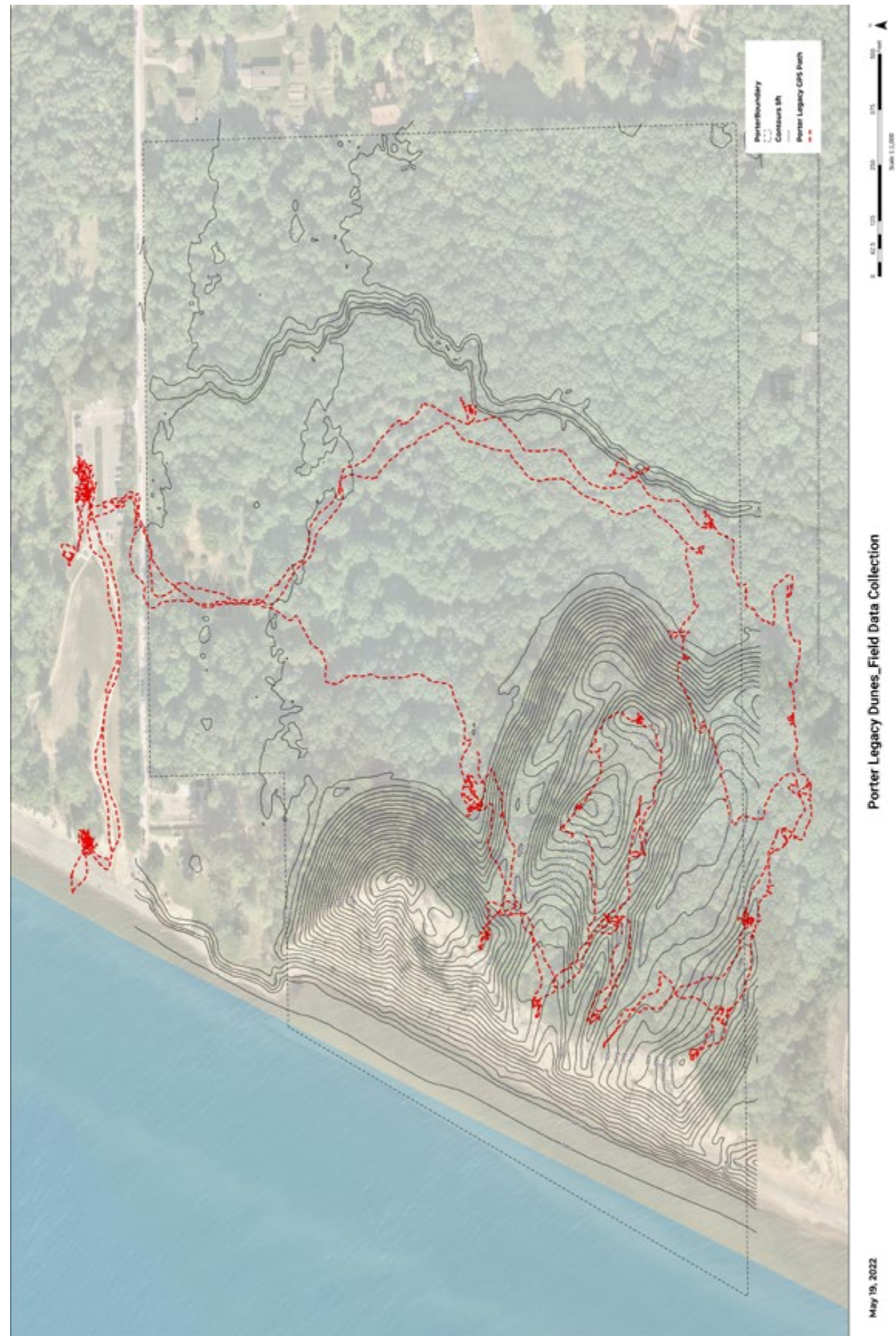


Figure 21. May 19, 2022 Field Data Collection Route

3.3 Stakeholder Engagement

Stakeholder engagement efforts began prior to the inception of this Master’s Project. Mitch Lettow (SWMLC) and Katharine Shiffler (NPS) organized the initial public meetings which were held before our involvement with the project. The first meeting was held on October 29th, 2021, to introduce the project concept and assess local interest in developing the interdunal trail system. The meeting was attended by various stakeholders, including a Syndicate Dune Resident, John Faul of the Palisades community advisory board, representatives from the Michigan Department of Natural Resources, and SHARA representatives, among others. The majority of the stakeholders expressed support for the project. Concerns were raised primarily regarding the Syndicate Park Subdivision, where some residents might object to a public trail passing through the semi-private road system of Syndicate Park Subdivision. A full list of the stakeholders involved in the design process are provided in Appendix B.

Mitch and Katharine continued to engage with the stakeholders regularly and provide updates to our project team during regular monthly meetings. On October 21st, 2022 we organized an event to engage with stakeholders directly at the South Haven Michigan Maritime Museum. The goal of the event was to share our trail design concepts with the local experts and gather feedback to be incorporated into the final designs. The members present were well informed officials that were already familiar with the interdunal trail project. Attendees included SHARA, SWMLC and NPS representatives, a Syndicate Park Resident, Officials from the city and township of South Haven, South Haven Parks Department Staff as well as Van Buren County officials.

The meeting began with a mission and visioning session facilitated by NPS staff member Patrick Lydon. The goal was to gather phrases and statements that would help shape the messaging associated with the interdunal trail project for future promotion and education efforts. A name for the trail system was proposed as the ‘Van Buren Interdunal Trail’ however the final decisions regarding the mission, vision and names were ultimately finalized by SWMLC, the NPS and their partners. Afterwards it was our chance to present our most recent work related to the design and placement of the trail network, followed by a discussion of our methodology for finding the best fit path for the trail as it traversed multiple physical and political boundaries.

Our team member Alissa Paquette presented and discussed survey results from data collected at Pilgrim Haven and Van Buren State Park. This survey data had been prepared and collected by SWMLC and their volunteers. Meeting members were then asked to break out into groups and participate in a collaborative design session using three large print-out maps for each site: Porter Legacy Dunes, Syndicate Park, and Van Buren State Park. We gained insightful feedback from the professionals at the meeting who were able to share their knowledge related to the local history, ordinances and past projects. We collected the feedback at this meeting and have incorporated it into our future trail design concepts.



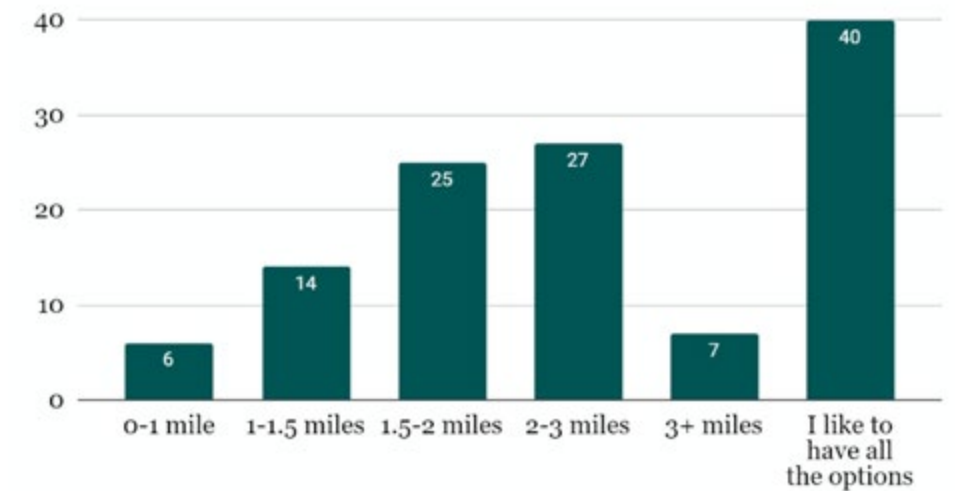
Figure 22. October 21, 2022 Collaborative Design Activity

3.4 User Survey

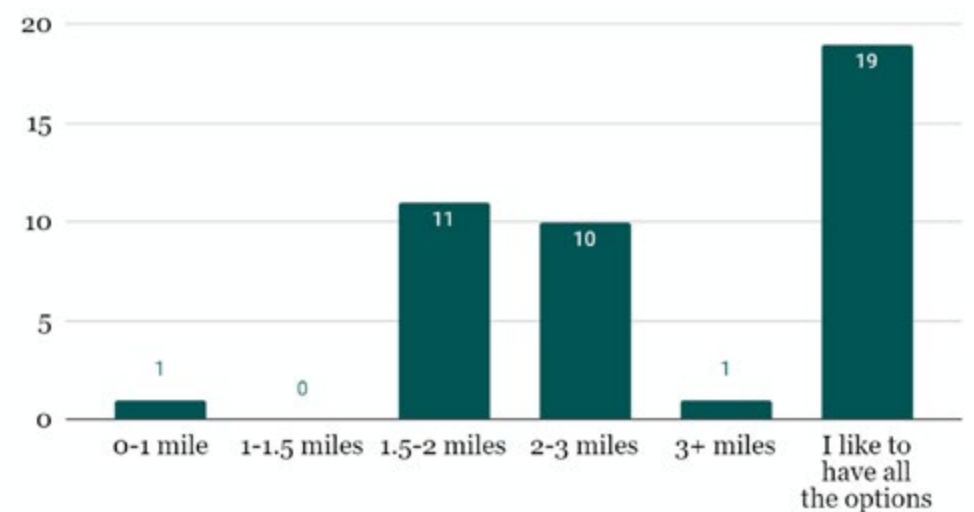
During the summer of 2022, SWMLC wrote the South Haven Natural Areas Survey. The goal was to determine what needs visitors of Pilgrim Haven Natural Area and Van Buren State Park have, what improvements they would like to see for the areas, and what recreation opportunities they would like to see for future recreation developments, including the interdunal trail discussed in this report.

132 survey responses were collected at Pilgrim Haven Natural Area by SWMLC staff and volunteers between August 12 and September 18. At Van Buren State Park, 49 surveys were collected between August 14 and September 20. The complete survey as well as the results can be found in Appendix C. Our team have analyzed the data from the survey and summarized it below.

Graph 1. Pilgrim Haven preferred trail length survey results

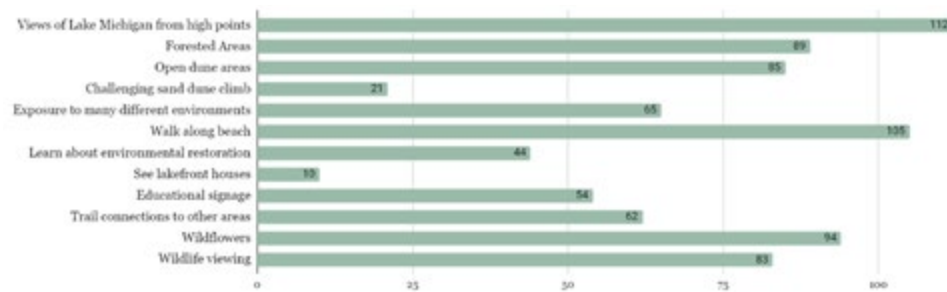


Graph 2. Van Buren State Park preferred trail length survey results



General trends identified from the survey responses were that Van Buren State Park has slightly more out of town visitors than Pilgrim Haven, which has more seasonal and year-round residents of the area within a 25 minute drive. Additionally, the age range of visitors was larger for Pilgrim Haven (17 - 88 years) than for VBSP (27 - 78 years). This was in part due to the fact that there was a group of school kids who visited Pilgrim Haven for a geology field trip, and it's a popular destination among the senior community to come for walks and rock collecting due to the higher level of accessibility of the site. One concern of note for Van Buren State Park was the general lack of wayfinding. The survey also revealed that people visit the South Haven Natural Areas during all parts of the year, so it's important to provide amenities and recreation opportunities that can be used year-round, no matter the weather. It was discovered that many people prefer to have many options when it comes to choosing a hiking trail length (Graph 1 and 2). Additionally, it was determined that many people want a dune overlook, but few people want a challenging dune climb to get there. For this reason and others, accessibility is a main consideration of our trail design, particularly as it relates to the dune overlook (Graph 3 and 4)

Graph 3. Pilgrim Haven interest in trail amenities survey results



Graph 4. Van Buren State Park interest in trail amenities survey results



3.5 Lake Level Dynamics and Dune Movement Analysis

When thinking about the trail design, it was important to consider how the lakeshore and dune landscapes along Lake Michigan have changed over time. Beginning with the fluctuating water levels in recent years, Lake Michigan's water level peaked in 2020, adding an additional 5ft onto its normal level. Furthermore, recent climate models based around the Great Lakes Atmospheric Regional Model (GLARM) predict that lake levels will rise approximately 17 inches by 2050 due to climate change (Xue et al. 2022). This could have adverse effects on the shoreline, especially in high risk erosion areas where recession landward has seemingly been occurring for a long time. This is particularly true for the Porter Legacy Dunes and Syndicate Dune properties, which will be key parts of the interdunal trail. To measure the amount of movement in these areas, a Dune Movement Analysis using historical aerial imagery was completed. Much like a recent test conducted by the Southwest Michigan Planning Commission that gauged changes from 1938 to 2010 (2012, 4), this analysis observed shoreline and dune migration inland over the period of 1997 to 2021 (~25 years). The years of 1997, 2006, 2011, 2016, 2018, and 2021 were the focus of data collection.

3.5.1 Historical Imagery

Before beginning the analysis, the historical images depicting the Porter Legacy Dunes and Syndicate Dunes properties between 1997 to 2021 were first compiled via the USGS Earth Explorer and Google Earth Pro applications. When navigating Earth Explorer, a number of different imagery types were explored including NAPP (National Aerial Photography Program), NHAP (National High Altitude Photography), aerial photo mosaics, and single frame photos among others. Of these choices, NAPP and the aerial photo mosaics yielded the most relevant results. Receiving imagery from Google Earth Pro was made much simpler by its Historical Imagery Slider option. Available pictures for each applicable year were labeled and saved for analysis. After all necessary imagery was collected, they were then exported to ArcGIS Pro for Geo-referencing.

3.5.2 Geo-referencing

In order to ensure numeric consistency across the images before measurement, it was important that they share the same GCS (or Geographic Coordinate System). A GCS uses a network of lines, known as a graticule (longitude and latitude) to define locations on Earth (Smith 2020). All of the images were mapped to the WGS (World Geodetic System) 1984 coordinate system. A line-type feature layer depicting a network of roads throughout the Syndicate Dunes area was subsequently loaded into the project to serve as a base for geo-referencing. Using the “geo-reference” option, a series of control points were placed at road intersections on the line layer. These control points were then used to stretch and contort the aerial images from each year to align them as accurately as possible.

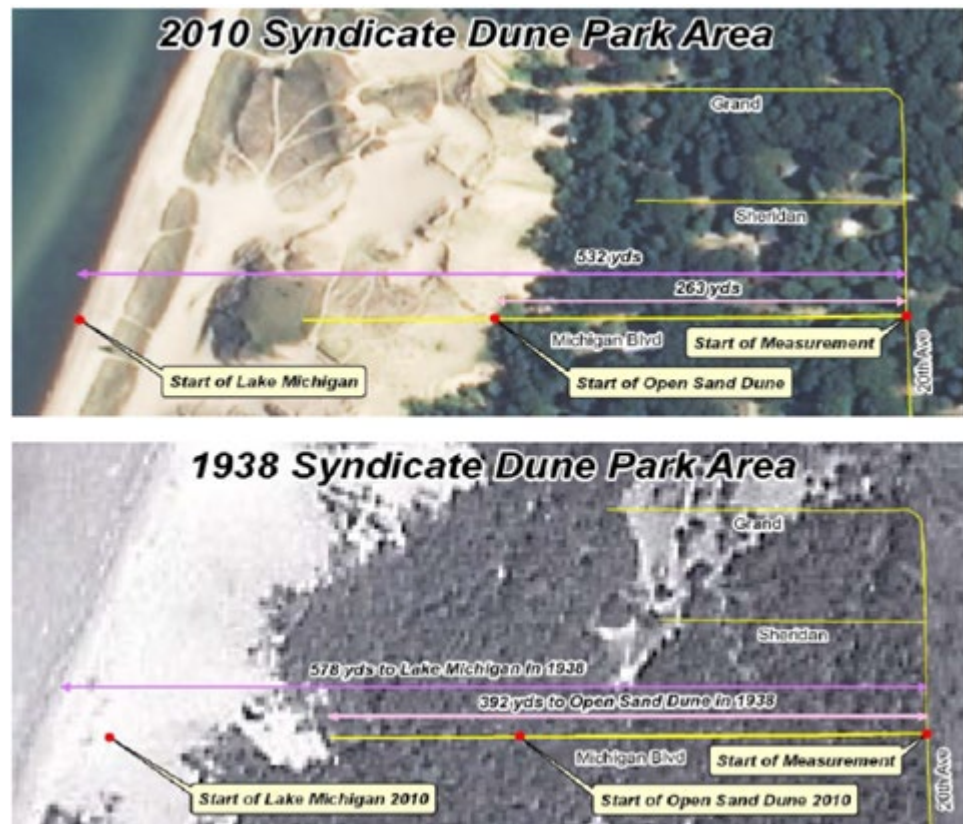


Figure 23. SMPC Sybdicate Dune Park Area dune movement study

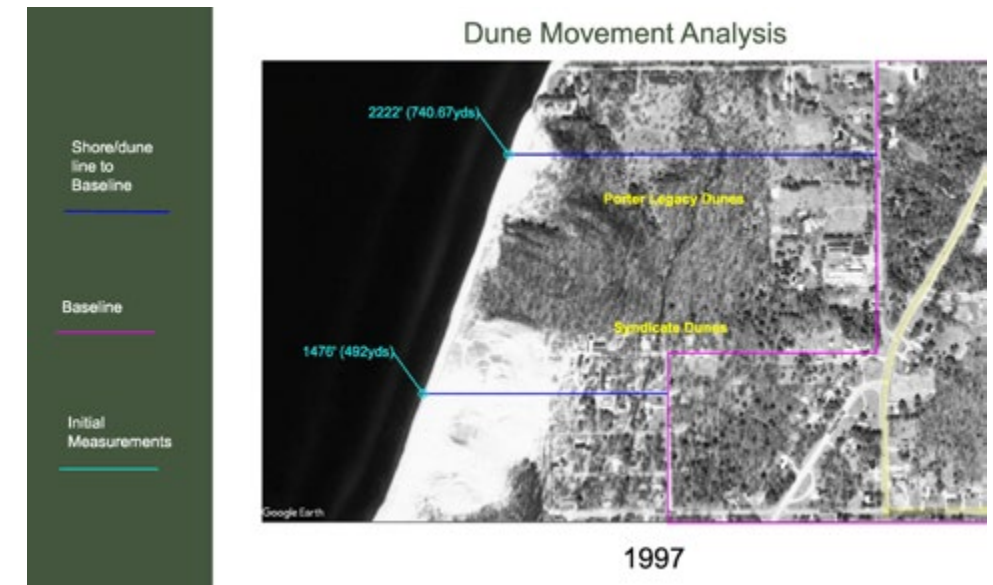


Figure 24. Just Dune It team dune movement analysis

3.5.3 Distance Measurements

To begin the measurement process, the imagery was exported to AutoCAD. Taking on many qualities of the aforementioned test by the Southwest Michigan Planning Commission, the Dune Movement Analysis was composed of a number of lines along the shore of Lake Michigan (Figure 24). Consisting of two lines that measured the distance from the point where the shore/dune line meets the water to an established baseline further inland, this template was reused for each of the 6 years for comparison. Calculations taken for the year of 1997 were labeled as the “initial measurements” for those derived in subsequent years to be contrasted from (the full process can be seen in the appendix). This helped to better gauge the level of difference between each image.

3.5.4 Conclusions

After measurements for each of the 6 focus years were compared and recorded, the total amounts of difference at the Porter Legacy Dunes and Syndicate Dunes from 1997 to 2021 were averaged, yielding average differences of 2.24ft per year and 1.43ft per year respectively (Table 2). Largely on par with the results of the 2012 SMPC study, these measurements show a gradual, but

Table 2. Dune Movement Analysis results and calculation of yearly averages

Location of Change		Porter Legacy Dunes	Syndicate Park Dunes
Difference in lake dune length from 1997 to observed year (ft)	2005	0	0
	2006	8	5
	2011	20	15
	2016	55	25
	2018	96	60
	2021	157	110
Average difference from 1997 to 2021 (ft)		56	35.83
Average difference per year (ft)		2.24	1.43

sure inland movement of the shore and dune line along Lake Michigan over time. Coupled with the largely stagnant vegetative line, these observations seem to confirm wave erosion, leeward sand movement, and the landward movement of dunes as actively occurring in the interdunal landscape. In response, modular and adaptive infrastructural options have been explored for the final trial design. Due to the nature of these geological changes, however, these options may not apply to proposed routes that cross beach areas.

3.6 Existing Trails and Models

The interdunal trail network consists of many existing formal trails, social trails, and yet to be created trails. Of the properties Pilgrim Haven has the most recently established and well marked network of official managed trails. For that reason there was little focus on the design of the trail system through this property. Porter Legacy Dunes features remnants of wide trails and access roads within the homesite and planted pine area. Few trails were

observed in the acidic flatwoods area across Dyckman Creek. Less formal trails exist within the forested backdune area where the topography becomes steep and the vegetation is more dense. The Syndicate area is divided into two main parts: the public Syndicate Park Dunes, and the privately owned Syndicate Park Subdivision. Located within the public lands are some of the most prominent and steep dunes. There is an existing network of foot trails that are reserved exclusively for Syndicate residents as well as an ATV route that Syndicate Dune Residents are allowed to use for beach access. The residents are highly sensitive to plans that may disturb the dunes, as any destabilization of the existing dune vegetation has the potential to increase sand dispersal into the subdivision. For those reasons the team faced a series of design challenges when it came to traversing Syndicate Park Dunes and connecting to the trails within the county owned land to the south. The county owned land consists of North Point Park and Van Buren State Park. For simplicity the North Point property is incorporated into the Van Buren State Park property boundary. Both properties host a complex network of managed and social trails but there is no official wayfinding and signage provided to inform visitors which trails are official and which are social. To aid in the initial development of trail concepts we developed GIS models to weigh the ecologically sensitive areas of the dunes, steep topography, and identified and avoided private lands within the Syndicate area.

3.6.1 Least Cost Path Van Buren State Park

The use of GIS data allowed our team to develop analytical models for exploring alternative trail routes. Our workflow began with a GIS data inventory and the compiling of available environmental and GIS data such as soil compositions, land use land cover data, digital elevation models, hydrology data, and existing trail GIS location data. The trail model was constructed in ArcGIS Pro's model builder work studio. The different sources of GIS and environmental data were brought into a workflow model to make a cost distance raster surface. The cost distance raster represents the cost of traveling over each cell of the land's surface. The cost distance surface was then run through a least cost path tool to create a path that travels through the least costly route. This least cost path model was applied to the section of trail in the back dune environment of Van Buren State Park. It worked off of existing GPS points the team collected while walking through the wooded back dune and made an optimal trail for the route.



Design Results

Over a period of 16 months, our team conducted extensive research on the project site, solicited public input, and collaborated with our clients, local experts, and area residents to develop design concepts. This section presents comprehensive design concepts that incorporate our site analysis, GIS modeling, literature review, and field work. The deliverables are organized by property boundaries, starting with Porter Legacy Dunes, followed by Syndicate Park Dunes and Van Buren State Park. These concepts are incorporated into a full extent map of the Legacy Dune Trail. In addition, a Wayfinding and Interpretive Signage section is included, outlining technical signage recommendations, and trail marker location recommendations. These designs are presented as working concepts, with the understanding that adjustments may be necessary based on further consultation with professional consultants and engineers. Nonetheless, the concepts provide a general layout of the trail network, highlighting key amenities such as scenic overlooks, restrooms, parking, and more.

4.1 Porter Legacy Dunes

The SWMLC, Van Buren County, and their partners have secured significant funding for trail development within PLD. The funds were received from donors and other organizations including Entergy Nuclear Operations Inc., the company responsible for the operation of the Palisades Nuclear Plant. Early design concepts included features such as Dyckman Creek crossings, trail signage and trail kiosks. In January of 2022 Mitch Lettow of SWMLC proposed that our team collaborate on a Michigan Natural Resources Trust Fund grant to seek additional trail development funds. This meant changing the focus of our project during February and March to further refine the design of trails for PLD.

Our team worked closely with the SWMLC to help provide the supplementary materials and information necessary for the grant application. Our trail design and drawings illustrate how the trail system will serve visitors and add to the accessibility and protection of the unique dune ecosystem, especially the critical dune area. Ultimately, two finalized design options were developed. Concept 1 utilized a minimal trail construction approach up the backdune to the scenic overlook, rendering it moderately difficult and less accessible. This design reduces the amount of built trail structures as much as possible to minimize the impact within the critical dune area. The challenge was finding a balance between reducing access to sensitive areas while offering a variety of trail experiences through the distinct ecosystems present at the PLD site. The second design, Concept 2, is a fully accessible trail system that utilizes modular boardwalk technology to achieve the climb up the steep backdune. A gentle slope is made possible by a trail alignment that utilizes switchbacks and short ramps that range between 5% and 10% slope for short periods followed by rest intervals. The standards followed for this design are provided in the USDA Accessibility Guidebook for Outdoor Recreation and Trails.

PORTER LEGACY DUNES

CONCEPTUAL TRAIL MAP 1

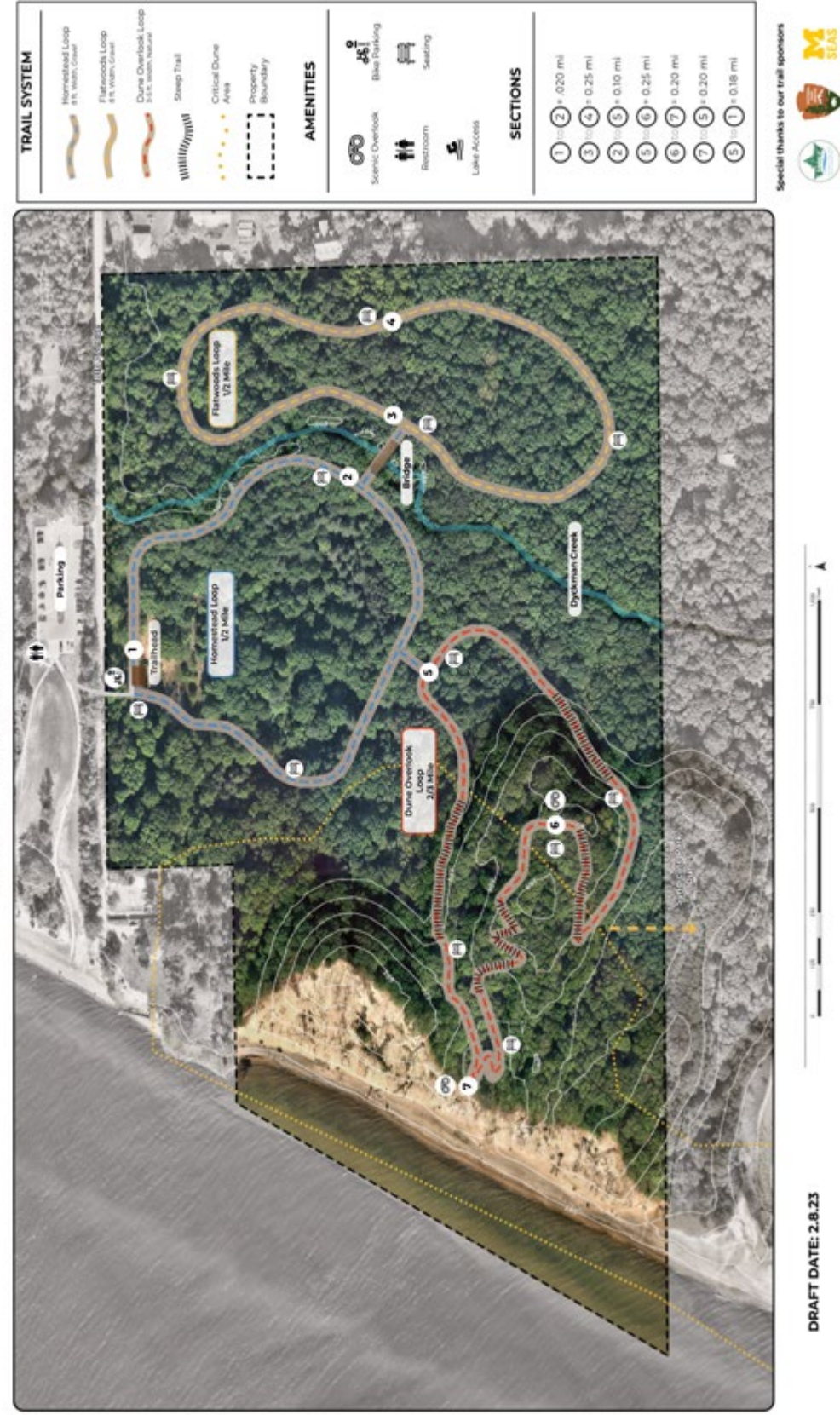


Figure 25. Porter Legacy Dunes Trail Concept Map 1

4.1.1 Trail Concept 1

Homestead Loop

The 1/2 mile long Homestead Loop was designed to be the most accessible trail on site and is the main point of entry to the preserve. The connection to the trail entryway is conveniently located next to the parking lot of Pilgrim Haven which offers easy access to ADA parking spaces and restrooms. The trail surface is 8' wide and constructed using a compacted limestone base. As the name implies this loop begins at the old home site and meanders through the planted pines and into the dry-mesic southern forest. The habitat quality of the northern half of this area has been degraded by human use and includes many non-native and invasive species.

Despite that, the area also includes dry prairie and dune species including prickly pear cactus (*Opuntia humifusa*) and the prairie grass little bluestem (*Schizachyrium scoparium*) and offers opportunities for demonstrations of ecological restoration. The southern half of the loop edges into a dry-mesic southern forest that is dominated by a canopy of red oak (*Quercus rubra*) and young sassafras (*Sassafras albidum*). On the ground level visitors can enjoy a dense layer of spicebush (*Lindera benzoin*) and native herbaceous plants such as Solomon's-seal (*Polygonatum pubescens*), jumpseed (*Persicaria virginiana*) and Canada mayflower (*Maianthemum canadense*) (Bassett, and Lincoln 2022). The eastern edge of the loop hugs Dyckmans creek where there is a crossing by foot bridge into the flatwoods loop. This loop also includes several features from the old homestead such as the chimney and wind turbine that could be used for interpretation of the cultural history of the site.

Flatwoods Loop

The bridge crossing Dyckman Creek in the flatwoods loop was intentionally placed in the interior of the preserve to prevent visitors from creating unofficial trails and entryways from 18th Avenue. The trail maintains a safe distance from the road encouraging visitors to loop back to the bridge and exit via the Homestead Loop. The eastern edge of the site is primarily acidic sandy flatwoods. This community offers a similar backdune forest experience as the homestead loop with a canopy of red

oak, black gum (*Nyssa sylvatica*) and white pine (*Pinus strobus*). What sets this area apart is the abundance of greenbrier (*Smilax rotundifolia*) that can have prickles that can be unpleasant to hike through. Fortunately the trail will be wide enough for walkers and wheelchairs to pass by with ease, and the greenbrier can be an incentive to stay on the trail.

Dune Overlook Loop

By far the most interesting and challenging loop is the dune overlook. Visitors can make their way up the backdune from the Homestead Loop or via the trail connection with the Syndicate Dune Park. The main attraction of this loop is an opening in the canopy on top of a dune that overlooks Lake Michigan. The ascent along the northern slope crosses through high quality and diverse northern mesic forest with an estimated 99 native plant species. This mature second-growth forest boasts a much older and larger red oak canopy with dense patches of Paw-paw trees (*Asimina triloba*) scattered throughout the subcanopy. During the spring, visitors will be wowed by the abundance of dazzling spring ephemerals such as dutchmen's breeches (*Dicentra cucullaria*), common trillium (*Trillium grandiflorum*), Yellow trout lily (*Erythronium americanum*), and many more ephemerals, some of which are rare or threatened in the state.

We took great pains to explore options for access up the steep and biologically diverse slope while simultaneously preventing unnecessary impact on the landscape from foot traffic and erosion. According to Hammit et al. (2015, 140) shade adapted plants found in the mesic northern forest are "generally susceptible to trampling due to their large leaves and thin stems". To help minimize trail impacts on the vegetation, protective buffer areas were marked around the locations of rare species and sensitive areas. These areas were identified in the MNFI report and recorded during site visits. The native vegetation plays an important role in the stabilization of the dune. If that vegetation were to be lost due to trampling, the area would become more vulnerable to erosion and more prone to the invasion of exotic invasive plant species.

To minimize erosion and enhance trail sustainability the trails that ascended the dune were oriented perpendicular with the prevailing slope to allow for gradual accents wherever possible. Trails that follow the contours of the land are known as sidehill trails and they

have a high slope alignment angle (Smith 2006). These trails are less prone to erosion and offer a more compelling experience of the landscape. It is recommended that hiking trails do not exceed 5-12% grade and only exceed that range for short sections. (Hesselbarth 2000). Maintaining a high slope alignment angle is especially important considering the loose substrate that underlie the hillslopes of PLD. The addition of rolling grades or drainage dips can be incorporated along steeper trail sections at intervals of 20 to 50 feet to help manage the water flow and reduce erosion. Rolling grades are best installed during trail construction and essentially involve a gentle fall in the grade for a short distance that rises back up. The low points become a miniature watershed that gather and convey water off the trail. (Smith 2006).

4.1.2 Trail Concept 2

On February 8th 2023 a trail summit meeting was organized by Katharine Shiffler to consult with trail building experts, park managers and ecologists to discuss the viability of various trail concepts and recommend possible improvements. Members present included the park manager of Sleeping Bear Dunes National Lakeshore, Technical experts of the National Park Service and the Superintendent of Indiana Dunes State Park. After consulting with trail experts from across the region, it was decided to design the trail system taking a universal design approach. According to the Forest Service Trail Accessibility Guidelines (FSTAG) universal design is defined as:

"The principle that programs and facilities must be designed to be usable by all people, to the greatest extent possible, without separate or segregated access for people with disabilities."

The Homestead and Flatwoods Loops remain relatively unchanged as they are on fairly level terrain. The dune overlook loop, however, was redesigned using an elevated boardwalk that will have more gradual slopes up the steep backdune to an overlook platform. The proposed boardwalk has been designed based on a prefabricated modular system that is commercially available. The benefits of the modular systems is that they have foundations that can be easily moved in the event that the dune shifts over time. Boardwalks have been shown to reduce human impacts on fragile environments (Carlson and Godfrey 1989). A company that provides these boardwalk systems has recently installed an accessible dune

PORTER LEGACY DUNES
CONCEPTUAL TRAIL MAP 2

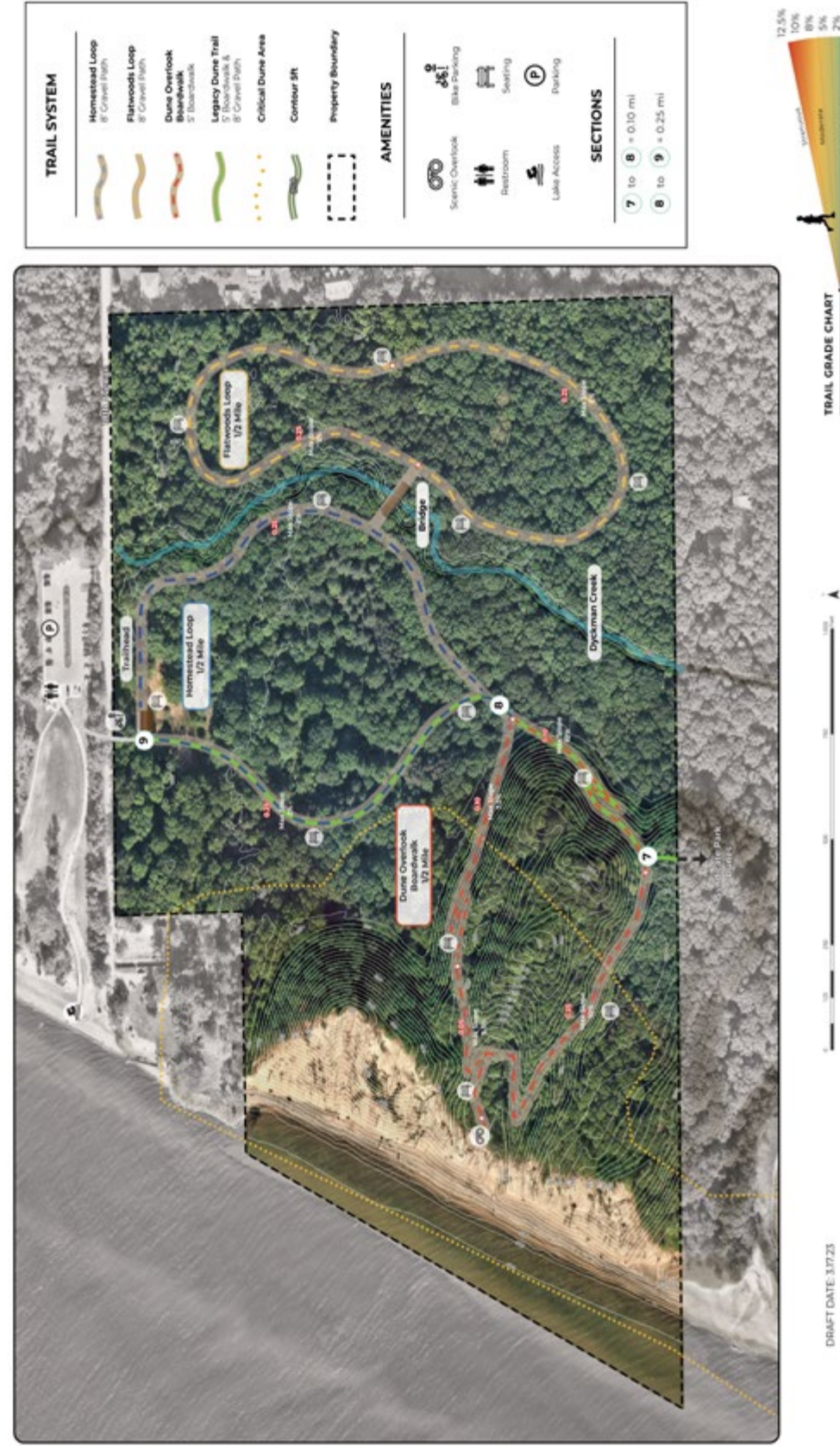


Figure 26. Porter Legacy Dunes Trail Concept Map 2

crossing at the nearby Arcadia Dunes State Park and they were recommended by experts from the Sleeping Bear Dunes National Lakeshore. The boardwalk design exceeds the minimum passing width of 60 inches for wheelchairs making them ideal for universal design.

A major design goal of the dune overlook trail was for the trail to remain under 1:20 or 5% slope and only exceed 5% for short intervals. Sections that exceed that are to be followed by rest intervals which are relatively level areas that provide an opportunity for people to stop and catch their breath. Rest intervals are not required for more level sections of the trail at the top of dune areas, however we recommend following the USDA and Forest Service guidelines for access trails. Boardwalk sections with running slopes that range between 5% and 8.33% should not extend more than 200 feet and ideally are shorter than 30 feet in length. Rest intervals must be at least 60 inches long and 36 inches wide with a slope that does not exceed 2%. The boardwalk sections with a slope that exceeds 1:20 or 5% must include handrails and edge protection (Zeller, Doyle, and Snodgrass 2012). All sections of the proposed boardwalk will include handrails except where it is necessary for trail crossings and points of entry.



Figure 27. Boardwalk system allows for dune access without trampling nearby vegetation

Based on a GIS analysis, the sections of boardwalk that climb the dune were calculated to have average slopes below 2.5%. There are short sections that exceed 8% however this may be mitigated by regrading of the ground plane or adjustments made to the boardwalk supports. prefabricated boardwalks come in 12 ft sections and utilize two different anchor systems depending on the slope. The steep slope sections will require helical piers that are drilled into the hillslope for added stability. The boardwalk will continue within the more gentle slopes on top of the dune as an effort to control foot traffic and discourage the creation of social trails. Within the areas of level terrain the boardwalk will be supported by stilts that float freely on top of the ground plane. This reduces time and cost for installation and allows for easy modification of the system as needed.

Some concerns regarding the incorporation of the boardwalk were discussed amongst the team and the clients. Concerns raised were the potential impacts of construction on the unstable hillside and damage or loss of endemic plants communities. The other potential impact is the shading of the forest floor from the boardwalk. A final concern is the potential for the boardwalk to be damaged from falling limbs and downed trees over time. After consulting the literature on this topic we determined that the benefits of the boardwalk system could outway the potential impacts. Benefits include increased accessibility, containment of foot traffic and mitigation of social trails that can trample plants and cause erosion. (LePage et al. 2015). The boardwalk design incorporates rest spots along the ascent and descent of the slopes which reduces strain on trail users and adds to the aesthetic of the overall experience. From an ecological standpoint, providing roughly 3cm (1.18in) of space between the boards and raising the walkway around 0.5m (19.69in) above the surface may allow enough light penetration for plants to grow and accumulate underneath, thus reducing the impact on plant communities. (Carlson and Godfrey 1989).

Dune Overlook Loop

The dune overlook will serve as a point of rest for visitors traveling along the boardwalk trail. Allowing visitors to traverse the dunes freely would trample vegetation and increase sand movement and the likelihood of blowouts (Burkley et al. 2014). The outlook platform will allow them to reach the top of the dune in a sustainable way. To ensure safety, guardrails will be installed around the perimeter. If a two-level approach is feasible, a 42 inch

(1,065 millimeter) high gate with vertical rails throughout may be the next best option. Ideally, spaces between each vertical rail will be large enough to allow a small sphere of around 4 inches (100 millimeters) to pass through. Furthermore, from a visibility standpoint, this type of guardrail would be excellent for wheelchair bound adults (whose eye level is generally above 42 inches (1,065 millimeters) and children sitting on the deck (Zeller, Doyle, and Snodgrass 2012, 55). In anticipation of landward movement of the dune, the overlook will be offset several feet from the ridge of the dune. In addition, the landing will be a moveable structure like much of the rest of the boardwalk and could be adjusted in response to future changes in the dune.

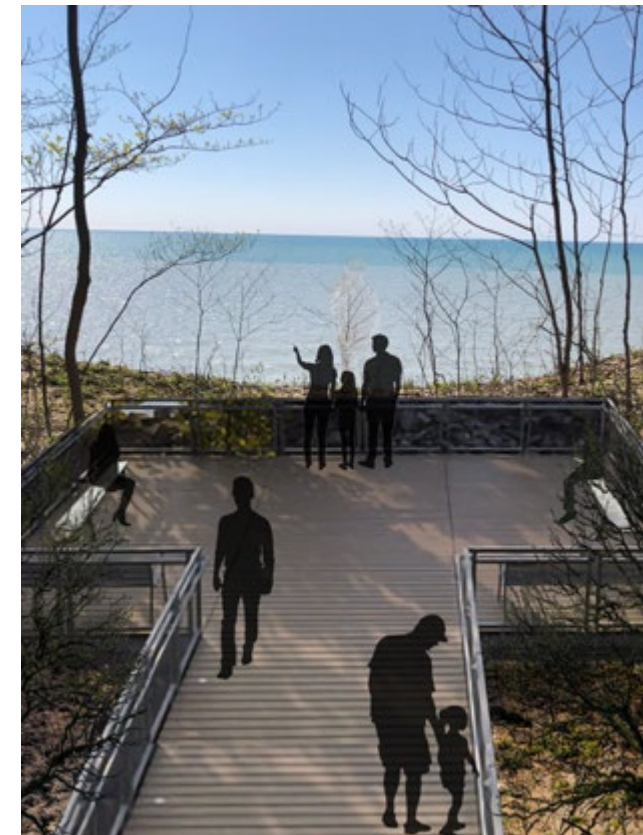


Figure 28. Raised boardwalk allows visitors safe access to dramatic views from the dune over Lake Michigan

4.2 Syndicate Dunes

Syndicate Dunes Park proved to be a challenge for our team. The challenge of finding viable paths through the area to connect the Van Buren trails to the Porter Legacy Dune trails became a nearly unsolvable problem. We encountered two significant obstacles that demanded a creative approach: the park's close proximity to the Syndicate Dune Park neighborhood and the exceedingly steep dune topography in the region. The only existing and reliable path over the dune is designated as an ATV path. With much of the other parts of the dunes being virtually impassable due to their steepness, it was challenging to conceive of accessible routes.

After collecting more data on viable routes over the dunes and consulting with a Syndicate Dunes Park resident, we settled on a two trail solution to the problem. The first trail option would follow 20th ave, Fire LN N, and Grand BLVD around the easterly side of the neighborhood, avoiding the majority of residential properties. The second trail option would go over the least steep section of the dunes avoiding both the ATV path and the steepest parts of the dune. A conceptual design of a stair system was created by the team to help make the syndicate dune trail option both more accessible and less erodible. We suggest that posts similar to those shown in figure 35 be installed at 25' - 50' intervals along the open dune and beach section to ensure that users do not lose their way in eas that are not confined by trees and or permanent paths.

During our October visit to the site, the team found an already existing trail just north of the Dunes that leads from the beach to the Dune Overlook Loop in Porter Legacy Dunes. We incorporated this into our trail design, giving us the final connection from the two Syndicate trail options to the Porter Legacy Dune Trail network. Additionally there was an offshoot trail from this newly found connection trail that led to an opening in the woods with an optimal view of the Syndicate Dunes. We included this location in our final design as a designated dune view point. However, the trail connecting the Porter Dune Trail to the Syndicate Dune Trail is a work in progress and we are exploring other options. One possible solution would be for Van Buren County to acquire the remaining undeveloped parcels within the dune area which would reduce the chances of unintentional trespassing from trail users. Additionally the county could seek to acquire parcels north of Grand Boulevard that border the Porter Legacy Dunes property line. This could create a public easement between the two properties that could be accessed from the road system.

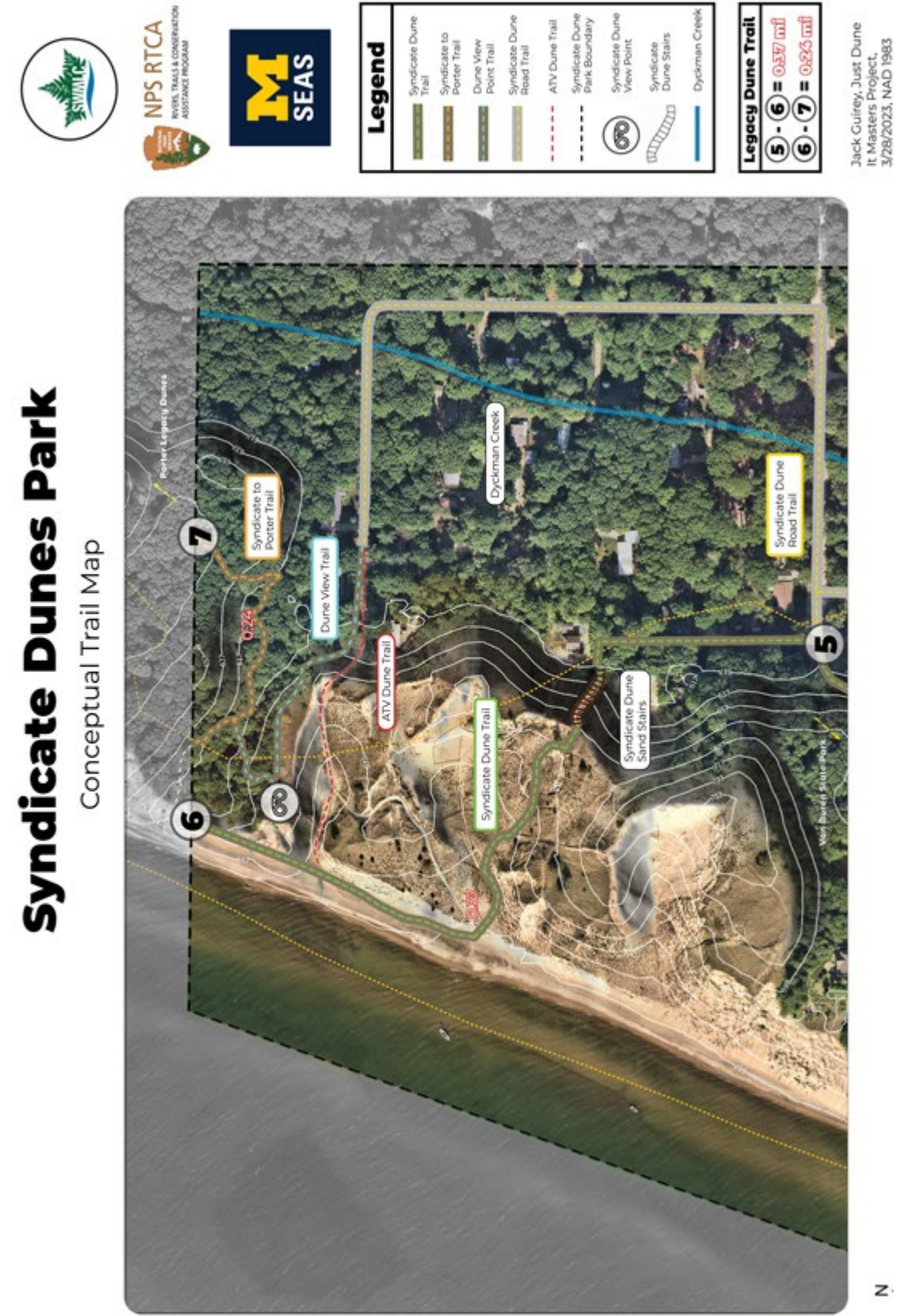


Figure 29. Syndicate Dunes Park Trail Concept Map

VAN BUREN STATE PARK CONCEPTUAL TRAIL MAP

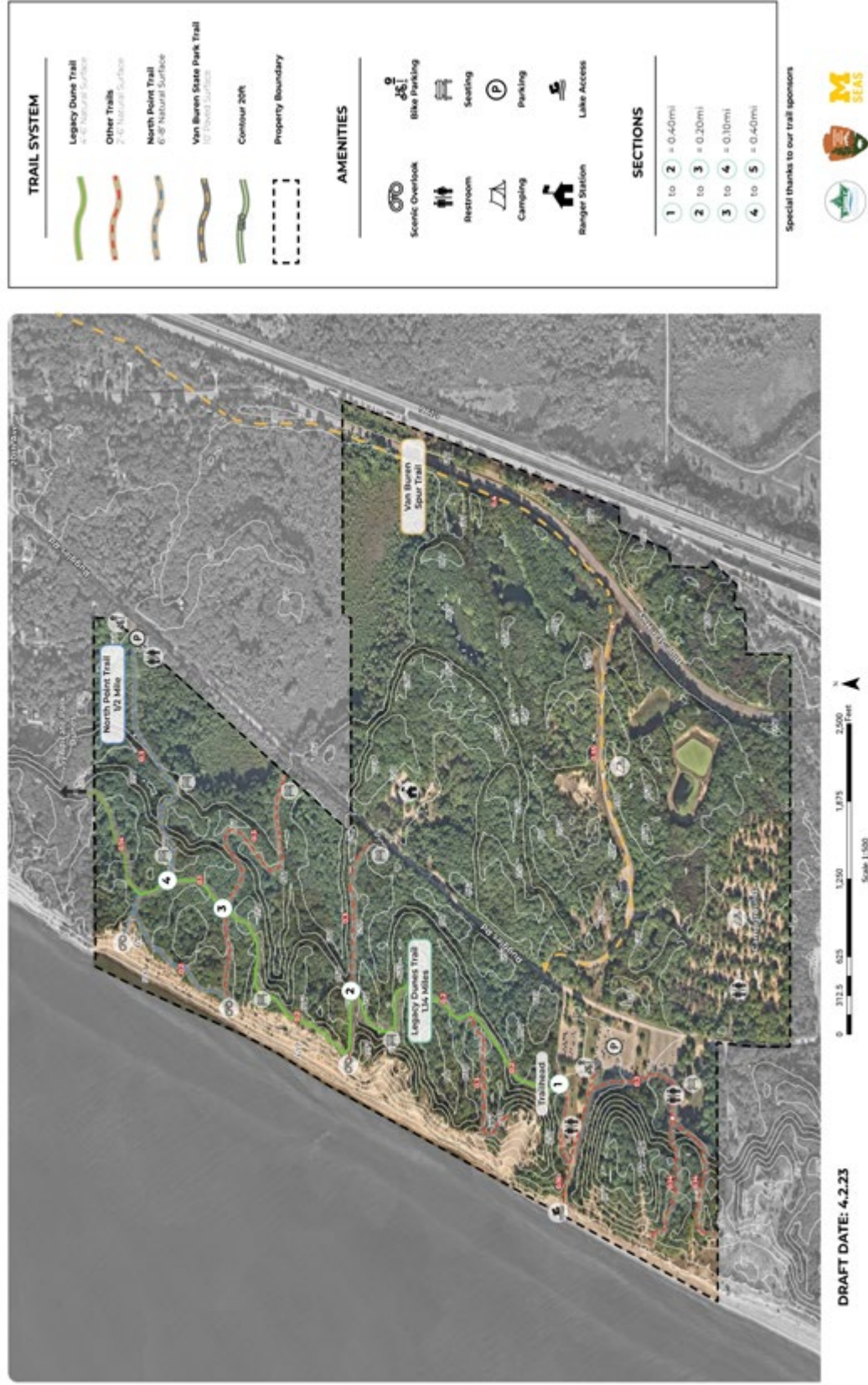


Figure 30. Van Buren State Park Trail Concept Map

4.3 Van Buren State Park

The 400 acre Van Buren State Park is the most developed and heavily visited property within the Legacy Dune Trail System. The park is an ideal point of entry for the system due to the abundant parking, direct access to the lakefront, restroom facilities and ample sites for camping. The site can be safely accessed by regional non-motorized traffic via The Van Buren Spur Trail, which connects the city of South Haven and Hartford. At the time of our team’s study, park managers are developing a new management plan for the state park. The trail concept described here along with trail marker recommendations will serve as a useful guide and starting point for future trail developments. This plan for Van Buren State Park remains a high level concept and further ground truthing and analysis would be required before trail construction could begin. This concept is intended to map out the general trail layout that will provide users with a compelling and engaging experience as they traverse the unique habitats, natural resources and topography of the area.

We have suggested the addition of 1.14 miles of trail that will offer visitors the first planned and marked trail system for the park. Trail users will begin their experience by ascending nearly 60’ from the parking into the dense forested backdune. From there a more gently sloped trail meanders for about 1/2 mile to the trail marker #2. From this point visitors are offered their first chance to stop at one of the designated dune overlooks and hike along the ridge of the dune. Hikers can choose to travel down to the beach or continue along the trail. We also suggest the use of marker posts along this section (Figure 35). Trail Marker #3 connects with an existing trail network that crosses unique human developments including a historical abandoned mansion construction site. Trail marker #4 connects with the well developed North Point County Park trail system that currently is a popular entry point into the dunes. The design suggests improvements to the existing parking area by providing bike parking as well as a new vault toilet and changing room for visitors.

4.4 Legacy Dune Trail

The final trail concept that connects the four properties of Pilgrim Haven, Porter Legacy Dunes, Syndicate Park Dunes and Van Buren State Park is the Legacy Dune Trail. This 3 mile trail fits well within the preferred hiking trail length as indicated by

LEGACY DUNE TRAIL

Conceptual Trail Map

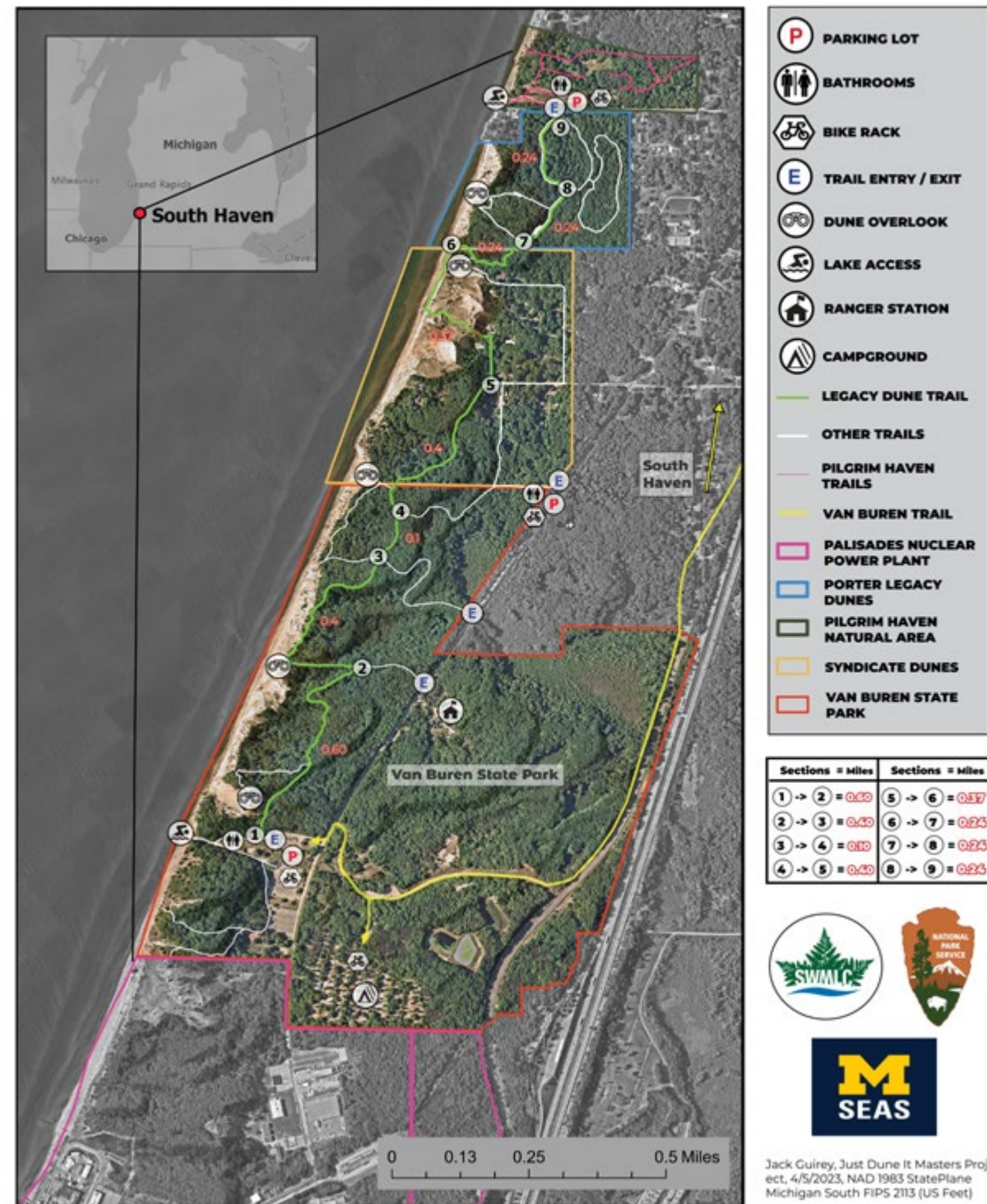


Figure 31. Legacy Dunes Trail Concept Map

our survey results (1.5-3 miles). Easy access from car and non-motorized transportation is provided by two designated vehicle and bike parking areas on the north and south ends. There are three additional trail entry locations with parking located along Ruggles road next to the State Park. Additional bike parking is proposed at the North Point Park entrance that is conveniently located near the midpoint of the trail. Adventurers can choose to hike the entire length of the trail or complete the trail in segments. This is made possible by the inclusion of 5 entry and exit points dispersed throughout the length of the trail. The multiple entry points also allow for easy access throughout the trail in the case of an emergency or injury on trail. Other important amenities incorporated throughout the trail system are benches and restroom facilities which were listed as some of the top amenities that visitors want when visiting the parks.

Lake access is a huge draw for tourists in the area, and Pilgrim Haven and Van Buren both offer accessible paths directly to the lake. We anticipate that many visitors will wish to combine these activities especially during warm weather. To our surprise, hiking, walking and running was the most popular activity for both Van Buren and Pilgrim Haven with over 84% of respondents listing that as a primary activity. Based on the survey feedback we anticipate that this trail will be a popular attraction for regular park patrons and first time visitors. The survey helped inform the design of the final concept and the overall experience of the trail. Views of lake Michigan from high points was the most desired amenity for respondents. The Legacy Dune Trail offers over 5 scenic overlooks that offer spectacular views of Lake Michigan.

Considering that the average age of respondents was over 50 years old, it was important to design the trail system to be as accessible as possible. The team used GIS modeling and site analysis data to design a path through the varied topography that maintained minimal trail slope angles and reduced unnecessary grade changes. This was a unique challenge due to the steep dune topography however it was important to design this trail to be as inclusive to as many users as possible regardless of ability, age and fitness. This design strategy is exemplified within the Porter Legacy Dunes section where a wheelchair accessible boardwalk will allow visitors to traverse a gentle slope to a platform overlooking lake Michigan from nearly 70' above.

A numbered trail wayfinding system was incorporated along the trail to help users navigate the space and make decisions based on section distance. At each trailhead there is a kiosk with a detailed

map which provides information related to trail amenities, trail distance, topography, trail material and general trail width. Throughout the trail are numbered trail intersection maps which provide smaller maps that correspond with the property of which they are located. The numbered maps are strategically placed along major intersections of existing trails. More details related to the wayfinding system are covered in the Wayfinding and interpretive Signage Section.

4.5 Wayfinding and Interpretive Signage

Interpretive and wayfinding signage is an important component of a successful trail system. We were tasked with providing a strategy for wayfinding systems and on-site educational signage.

4.5.1 Wayfinding System

Having legible wayfinding signage is important to the overall experience of visitors, particularly first time visitors. “Wayfinding is the process of determining and following a path or route between an origin and destination” (Dijkstra et al. 2014). The wayfinding strategy we created includes trailhead kiosks, trail intersection signage, trail blazers, and dune posts. Best practices for map, signage design, and placement were developed based on a literature review. Key takeaways include:

- Incorporating contour information aids wayfinding as users can confirm their locations by comparing terrain
- Information that can be included directly on the map is preferred over information on map legends
- Black and white maps are acceptable, but color maps can improve map feature discrimination (such as water)
- Wayfinding signage should be redundant and placed at every junction
- Maps should be mounted matching the orientation of the trail as opposed to cardinal directions
- Maps should be regularly updated
- Maps should include a ‘you are here’ marker otherwise known as a YAH map



Figure 32. Porter Legacy Dunes trailhead kiosk

The trailhead kiosk for Porter Legacy Dunes will be placed at the crosswalk that will connect the site to Pilgrim Haven (Figure #). The kiosk contains relevant information about PLD as well as the interdunal trail. The maps will include information related to the trail distance, material, width and slope percentage. Based on that information trail users are equipped to make decisions about which routes to choose based on their own physical ability and preferences. The kiosk maps will also include information related to amenities within and nearby the property including points of interest. To complement the PLD specific map we recommend including a full extent of the Legacy Dune Trail so users can gain a sense of their location within the entire trail system.

Trail intersection signage should be placed at every junction along the trail (Boon Kee and Smith-Jackson 2004). The signs we designed include the name and color code of each of the trails intersecting at the junction as well as information about the location and direction of amenities such as parking and restrooms (Figure #). Junction numbers should also be placed on each sign post (Boon Kee and Smith-Jackson 2004). Maps placed on signposts should be oriented with the trails as opposed to cardinal directions (Smith 2006). Ideally the maps are placed so that when read on the trail they are in line with the direction the visitor is facing. For example if the visitor is facing due west, then the trail map should be

oriented so that west is facing up. (Kaplan, Kaplan, and Ryan 1998, 57). This orientation is the most effective and intuitive because left and right on the vertical map corresponds with left and right on the ground. When a map is not aligned with the direction in front of the user then it is contralined; maps oriented in this way have proven to be confusing and can send users in the wrong direction (Levine 1982). Another feature that improves map legibility is a “You are here” marker which shows the position of the trail user on the map with a line indicating the on the ground orientation of the map post on the map itself. (Levine 1982). For safety Protruding objects under 80” overhead including signage cannot extend more than 4” into the width of the path. This reduces overhead hazards for visitors paying attention to other things and those who are blind or have low vision. (Zeller, Doyle, and Snodgrass 2012).

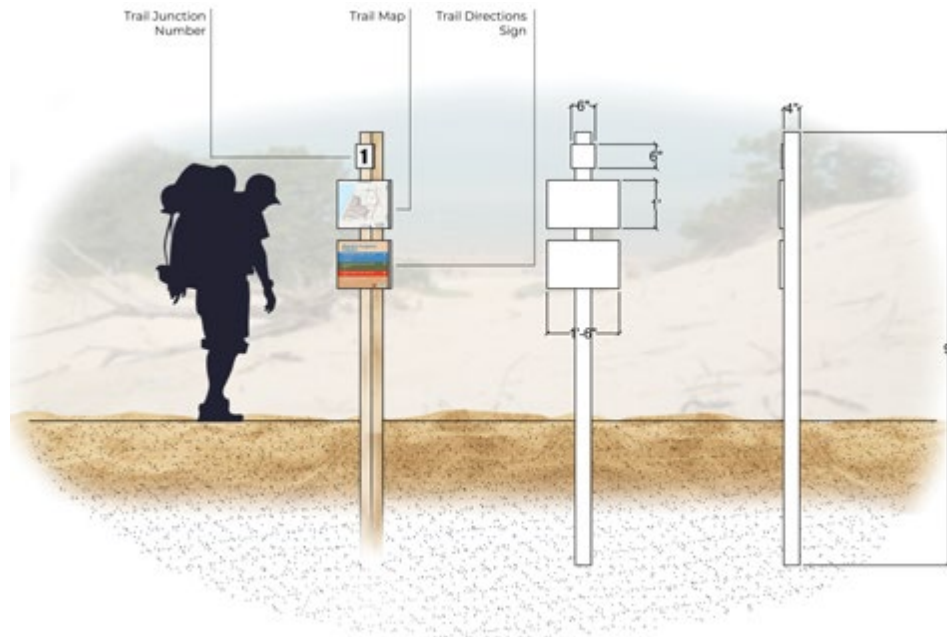


Figure 33. Trail intersection signage installation detail

SWMLC uses prefabricated trail blazers by Voss Signs on their properties. Blazers can be an important navigational tool, but they may not be universally understood by novice hikers or international visitors. To help with recognition, blazers should match the color of the trail they belong to (Boon Kee 2002). Having them screen printed with the name of the trail can also help to make their message clear (Figure 34). In the open dune portions of the trail, wooden posts can be driven into the ground trailside and their

tops painted to match the color of trail, similar to those at John Dellenbeck Dunes in Oregon (Figure 35).



Figure 34. Intersection sign and screen printed trailblazer concept



Figure 35. Trail marker at John Dellenbeck Dunes, Coos County, Oregon

4.5.2 Interpretive Signage

Interpretive signage is a great way to increase access to the dune trail experience to those who are unable or do not desire to complete the full trail. By providing information that highlights the native flora, dune dynamics, and history of the site, you create an attraction that is both experiential and educational. Our strategy proposes using two types of signage: large, informational signs (figure 36) and small flora signs (figure 37). To provide consistency across the site, the color scheme for interpretive signage uses the same colors as the wayfinding signage, and additional colors were sampled from photographs taken on site.



Figure 36. Interpretive signage mockup

The large format signs should be kept to the homestead trail loop (Figure #) within PLD. This is the most anthropogenic portion of the site, and the increased footprint of an interpretive trail will have less of an effect on the local ecology. Opportunities for interpretive topics include the formation of the landscape by glaciers, dune ecology, dune dynamics, indigenous history, post-colonial history, the homestead and remnant chimney, and human use of the native flora and fauna. To ensure the signs are accessible to all visitors, the mounting height should be 24-30 inches with an angle of 30-45 degrees (USDA Forest Service 2005).



Figure 37. Common trillium interpretive sign

Small flora signs, measuring 6x8", can be used throughout the interdunal trail. They can be used to draw attention to visually appealing, useful, rare, or otherwise important flora species. Each sign consists of the common and latin name for the species, an image of the species, an interesting fact, and a QR code that links to the Michigan Flora webpage for each species. These signs sit just off the ground or attached to the boardwalk and have a low impact on the surrounding ecology.

4.6 Future Recommendations

Due to time constraints, there were some matters that weren't addressed, or weren't discussed in much detail by our team. To further the interdunal trail experience and design, there are several topics that other masters project groups from UM and student teams from other universities or colleges in Michigan could address in the future. Recommendations for trail maintenance and a land management plan would improve the practicality and sustainability of our designs. A restoration plan for the Porter Legacy Dunes former homesite would serve to preserve the history and culture of the site. A more detailed design for the Van Buren State Park Trail would provide advice for the State Park managers to improve accessibility, wayfinding, and ecosystem health for the property. More specific recommendations regarding the placement of signage, both for wayfinding and education, can inform the need for signage funding and further signage design. Continued research related to trail sustainability and foot traffic management is an ongoing need for all natural areas as the environment and visitor demographics change, and is therefore a great opportunity for future teams. The possibility of incorporating the Palisades site to the trail network will become more feasible to consider when it is better understood what will happen to the nuclear plant; this alone would require much research. Lastly, an implementation timeline could be developed with the collaboration of our clients, likely broken down into phases based on the properties and funding opportunities.

Works Cited

- “Aeolian (Dunes) Landforms.” National Parks Service, U.S. Department of the Interior, 1 Dec. 2022, <https://www.nps.gov/subjects/geology/aeolian-landforms.htm#:~:text=Aeolian%20processes%20involve%20erosion%2C%20transportation,hot%20deserts%2C%20and%20agricultural%20fields>.
- “Great Lakes Bottomland Conveyances.” SOM - State of Michigan. EGLE, 2023. <https://www.michigan.gov/egle/about/organization/Water-Resources/shipwrecks/great-lakes-bottomland-conveyances>.
- “Rivers, Trails, and Conservation Assistance Program (U.S. National Park Service).” National Parks Service. U.S. Department of the Interior. Accessed April 12, 2023. <https://www.nps.gov/orgs/rta/index.htm>.
- “South Haven Area Recreation Authority.” 2018 - 2022. Parks and Recreation Plan § (2018).
- “South Haven/Van Buren County Convention and Visitors Bureau.” South Haven Visitors Bureau, 2023. <https://www.southhaven.org/experience/trails-town>.
- “South Haven Van Buren County Convention and Visitors Bureau.” (n.d.). South Haven History. South Haven of Lake Michigan. Retrieved March 31, 2023, from <https://www.southhaven.org/south-haven-history>
- “Southwest Michigan Planning Commission (SMPC).” 2012. Syndicate Park Subdivision, South Haven Township: Study of Van Buren County Owned Parcels (Draft), 30.
- “USDA Forest Service.” (2005). Interpretive Media Design Guidelines. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5167249.pdf
- Albert, Dennis A. Borne of the Wind: An Introduction to the Ecology of Michigan’s Sand Dunes. Michigan Natural Features Inventory, 2000
- Bassett, T. J. and J. M. Lincoln. 2022. Ecological Evaluation of Porter Legacy Dunes Preserve. Michigan Natural Features Inventory, Report Number 2022-17, Lansing, MI. 32 pp.
- Boon Kee Soh & Tonya L. Smith-Jackson (2004) Influence of Map Design, Individual Differences, and Environmental Cues on Wayfinding Performance, *Spatial Cognition & Computation*, 4:2, 137-165, DOI: 10.1207/s15427633scc0402_2
- Boon Kee Soh. “Developing Outdoor Map Design Guidelines Using a Real World Wayfinding Task.” Master’s Thesis. (Virginia Polytechnic Institute and State University, 2002).
- Burkley, Katie, Abigail Hocking, Barak Howell, Eric Medema, Joel Newswanger, Cal Thorne, and Angela Tiemeyer. “Blowouts and Unmanaged Trails in Hoffmaster State Park, Michigan.” FYRES: Dunes Research Report 11 (2014).
- Carlson, Lars H., and Paul Jeffrey Godfrey. “Human impact management in a coastal recreation and natural area.” *Biological Conservation* 49, no. 2 (1989): 141-156
- Comer, Patrick J., Dennis A. Albert, R. A. Corner, B. L. Hart, D. M. Kashian, D. L. Price, J. B. Raab, D. W. Schuen, and H. A. Wells. “Vegetation of Michigan circa 1800.” Michigan Natural Features Inventory, Lansing (1998)
- Dijkstra, J., de Vries, B., & Jessurun, J. (2014). Wayfinding Search Strategies and Matching Familiarity in the Built Environment through Virtual Navigation. *Transportation Research Procedia*, 2, 141–148. <https://doi.org/10.1016/j.trpro.2014.09.018>
- Farrand, William R., and D. L. Bell. Quaternary geology of Michigan. Michigan Geological Survey Division, 1982.
- Gronewold, Andrew D., and Richard B. Rood. “Recent water level changes across Earth’s largest lake system and implications for future variability.” *Journal of Great Lakes Research* 45, no. 1 (2019): 1-3.
- Hammitt, William E., David N. Cole, and Christopher A. Monz. *Wildland recreation: ecology and management*. John Wiley & Sons, 2015.
- Hesp, P. 2002. Foredunes and blowouts: initiation, geomorphology and dynamics. *Geomorphology*
- Hesselbarth, Woody. Trail construction and maintenance notebook. USDA Forest Service, Technology & Development Program, 2000.
- Kaplan, Rachel, Stephen Kaplan, and Robert Ryan. *With people in mind: Design and management of everyday nature*. Island press, 1998.
- Kayastha, Miraj B., Xinyu Ye, Chenfu Huang, and Pengfei Xue. “Future rise of the Great Lakes water levels under climate change.” *Journal of Hydrology* 612 (2022): 128205.

Kost, M.A., D.A. Albert, J.G. Cohen, B.S. Slaughter, R.K. Schillo, C.R. Weber, and K.A. Chapman. 2007. Natural Communities of Michigan: Classification and Description. Michigan Natural Features Inventory, Report No. 2007-21, Lansing, MI.

LePage, Gabe, Bastian Bouman, Benjamin Johnson, Ryan Kiper, and Madison Smith. "Boardwalk Interactions with a Lake Michigan Dune System." (2015).

Levine, M. (1982). You-are-here maps: Psychological considerations. *Environment and Behavior*, 14, 221–237. <https://doi.org/10.1177/0013916584142006>

Moore, Lindsay. "\$2.3M Grant Awarded to Preserve 47-Acre Porter Legacy Dunes near South Haven." *mLive*, December 18, 2019. <https://www.mlive.com/news/kalamazoo/2019/12/23m-grant-awarded-to-preserve-47-acre-porter-legacy-dunes-near-south-haven.html>.

Norton, Richard J. "How Should We Respond? Planning for and Managing Resilient Great Lakes Shorelands and Coastal Communities." *Planning for Coastal Community Sustainability*. Lecture. Accessed March 30, 2022. <https://www.youtube.com/watch?v=UcR4Bg3Zi1I&t=3725s>.

Parker, Rosemary. "Pilgrim Haven Natural Area on Lake Michigan near South Haven Opens for Sneak Preview Saturday." *mLive*. Kalamazoo, July 27, 2012. https://www.mlive.com/news/kalamazoo/2012/07/new_natural_area_on_lake_michi.html.

Peterson, Joan M., and Eckhart Dersch. A guide to sand dune and coastal ecosystem functional relationships. Michigan State University Cooperative Extension Service, 1981.

Pokagon, S. (1900). "Algonquin Legends of South Haven." C.H. Engle.

Smith, Christopher A. "Creating and managing sustainable trails in Nichols Arboretum." PhD diss., 2006.

Smith, Heather. "Geographic and Projected Coordinate Systems." *ESRI: ArcGIS Pro Blog*. February 27, 2020.

Vander Bilt, L., J. Karsten, and D. van Dijk. "Investigation of the Syndicate Park dune area." Report to Van Buren County Commissioners. Grand Rapids (MI): Department of Geology, Geography and Environmental Studies, Calvin College (2013).

Van Dijk, Deanna. "Contemporary geomorphic processes and change on Lake Michigan coastal dunes: an example from Hoffmaster State Park, Michigan." *Michigan Academician* 35.4 (2004): 425-454.

White, Raechel A., Kevin Piraino, Ashton Shortridge, and Alan F. Arbogast. "Measurement of vegetation change in critical dune sites along the eastern shores of Lake Michigan from 1938 to 2014 with object-based image analysis." *Journal of Coastal Research* 35, no. 4 (2019): 842-851.

Zelenka, David. "Great Sand Dunes- Dune Types: Parabolic Dunes." National Parks Service, U.S. Department of the Interior. April 18, 2018.

Zeller, Janet, Ruth Doyle, and Kathleen Snodgrass. *Accessibility guidebook for outdoor recreation and trails*. USDA Forest Service, Technology and Development Program, 2012.

Appendix A Site Profiles and History

Pilgrim Haven Natural Area	
Area	27.5 Acres
Elevation Gain	25 Feet
Natural Features	Pebbled beach Beech-maple forest Dyckman creek outfall
Built Features	45 car parking lot with 2 accessible spaces 0.33 miles of trail
History	<ul style="list-style-type: none"> • 1913 Purchased by the Chicago Council of Camp Fire Girls as a summer camp for city girls, 'Camp Kiwanis Nawakwa'. It featured cabins where the present day parking lot is located. • 1948 purchased by the Michigan Congregational Conference of the United Church of Christ (UCC) and renamed, Camp Pilgrim Haven • 1980 Suzanne Upjohn DeLano Parish purchases the camp and protected the area from development • 2010 after Suzanne's death her estate donated the property to SWMLC with the intention to preserve the property as a natural area and public recreation space.

Porter Legacy Dunes	
Area	48 Acres
Elevation Gain	120 Feet
Natural Features	Critical dune Open dune (High Quality) Mesic northern forest (High Quality) Second-growth forest

	<p>Red oak dominated with sugar maple, black cherry, basswood co-dominated Canopy coverage 80 - 90 % Dry mesic southern forest (Degraded) Red oak-sassafras dominated Acidic sandy flatwoods (Degraded) Red oak and red maple dominated Two state listed plant species and rare naturally occurring Canada yew (<i>Taxus canadensis</i>)</p>
Built Features	Old Homesite consisting of disturbed openings Planted pines consisting of red and white pine
History	<ul style="list-style-type: none"> • Protected by the Porter Family for 140 years and sold to South Haven Area Recreation Authority (SHARA) and SWMLC by Scott Royal. • 20 year memorandum for SWMLC to manage the preserve.

(Syndicate Park) Private And County Owned Land	
Area	74 Acres
Elevation Gain	150 Feet 57 County owned parcels have slopes greater than 25%
Natural Features	Critical dune Pebble beach Foredune
Built Features	Educational signage Sand fencing
History As it relates to this project	<ul style="list-style-type: none"> • 2012 Southwest Michigan Planning Commission recommends dune stabilization efforts • 2013 Investigative Report by Denna van Dijk - Calvin College recommends stabilizing dune blowouts. • 2014 Van Buren County awarded grant to conduct engineering and design of a dune restoration project

	<p>on the county owned property. (Abonmarche and Cardno JFNew)</p> <ul style="list-style-type: none"> • 2017 final project site plan
--	---

	<p>effort, the county may need to acquire privately held property in the dune area.</p>
--	---

(Syndicate Park Subdivision) County Owned Land	
Area	81.66 Acres
Soil Profiles and Slope	<p>Western Slopes Dunes Steep with Soil class 36E Oakville Fine Sand</p> <p>Eastern Slopes 8A – Morocco loamy sand with 0 to 2 percent slopes 17A – Brems sand with 0 to 2 percent slopes 45B – Covert sand with 0 to 4 percent slopes 48A – Pipestone – Kingsville complex with 0 to 3 percent slopes. 57 County owned parcels have slopes greater than 25%</p>
Natural Features	<p>Critical dune Dyckman Swamp Drain runs through the eastern edge of the Syndicate Park Subdivision.</p>
Built Features	<p>Original plat map for the subdivision was divided into 1,233 lots, 20' x 100'</p> <p>Today there are 260 Parcels 25 Acres are county owned and all undeveloped as of 2012 39.13 acres are private and divided into 165 parcels</p>
History	<ul style="list-style-type: none"> • 1910 Marketing Scheme by Syndicated Press, Chicago, offering a lot on Lake Michigan with a subscription • The Michigan Legislature in 1976 passed the Sand Dune Protection and Management Act (Act 222). This act gave authority to local units of government and the State of Michigan to undertake specific steps to ensure the wise use and protection of Michigan's designated critical sand dunes. • County Goals Dispose of county-owned property on the east side of the dune. Develop a management plan to stabilize the dune. To accomplish the stabilization

Van Buren State Park	
Area	400 acres
Elevation Gain	90'
Natural Features	<p>Critical dune Open dune (High Quality) Backdune Forest</p>
Built Features	<p>Picnic tables, grills and picnic shelter Restroom buildings Campground with 220 campsites with electricity Van Buren State Park Spur Trail 4-miles paved route</p>
History	<ul style="list-style-type: none"> • Established in 1966

Appendix B List of Stakeholders

1. Mitch Lettow (SWMLC)
2. Dave Brown (SWMLC)
3. Scott Reinert (SHARA)
4. Robert Burr (SHARA, SWMLC Board Member)
5. Jen Sistrunk (SHARA)
6. Ross Stein (SHARA)
7. Mike Chappell (Van Buren County)
8. John Faul (formerly Van Buren County)
9. Matt Metzger (DNR)
10. Jill Sell (DNR)
11. Justin Gerould (DNR)
12. Patrick Whalen (DNR)
13. Janice Varney (former SWMLC Board Member, Pilgrim Haven Committee)
14. Dick Brunvand (Pilgrim Haven Committee)

Appendix C User Survey and Results

SOUTH HAVEN NATURAL AREAS SURVEY
SUMMER 2022

Thank you for taking the time to fill out our survey, which should take less than 5 minutes.

Your participation in this survey will directly influence possible park improvements and future recreation options. Survey results will also help managers of Van Buren State Park and Pilgrim Haven Natural Area understand the needs and patterns of visitors that use these natural spaces.

Today's Date: _____

Location of Survey: _____
 Pilgrim Haven Natural Area
 Van Buren State Park

1. Age: _____

2. Gender
 Male
 Female
 Non-Binary

3. Which of the following describes your residency status?
 A. Year-round resident of the area (within 15 minute drive)
 B. Seasonal resident of the area (within 15 minute drive)
 C. Out of town visitor (more than 15 minutes away)

4. How did you arrive here today?
 A. Car
 B. Bike
 C. Walk
 D. Public transportation
 E. Other: _____

5. How often do you visit this area to recreate?
 A. Daily
 B. Weekly
 C. Monthly
 D. Yearly
 E. Other: _____

6. What seasons do you recreate in this area?
 Summer
 Fall
 Winter
 Spring

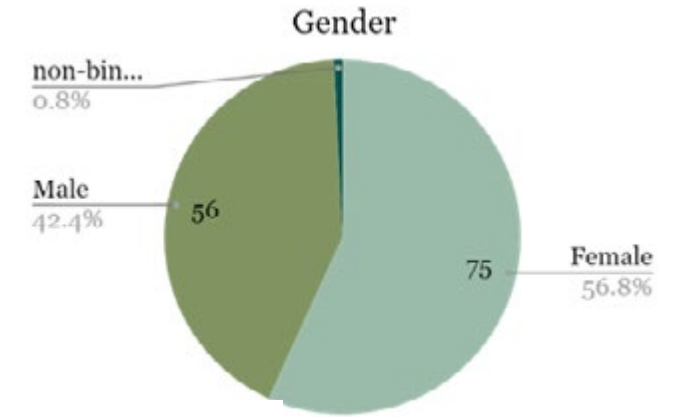
7. Please check ALL of the activities that you participate in when visiting this natural area:
 Hiking/Walking
 Camping
 Running
 Photography
 Bicycling
 Picnicking
 Fishing from shore/dock
 Sunbathing
 Picking berries/mushrooms
 Swimming
 Paddling
 Rock picking/collecting
 Nature observation (birding, etc.)
 Other: _____

8. What amenities are important to you when visiting this natural area?
 Benches
 Restroom facilities
 Water fountains/dog water bowl
 Bike racks
 Beach access
 Directional signage
 Interpretive signage (flora, fauna, culture, history, etc.)
 Picnic shelter
 Campground
 Trail connections to other areas
 Other: _____

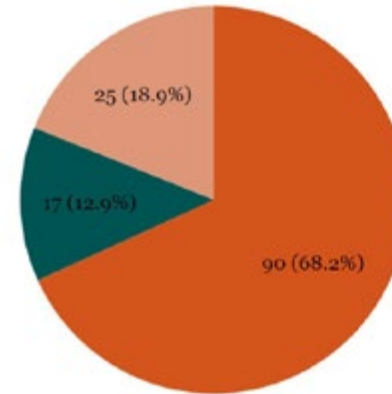
9. Are there any additional amenities that you would suggest?

Survey Results: Pilgrim Haven Natural Area

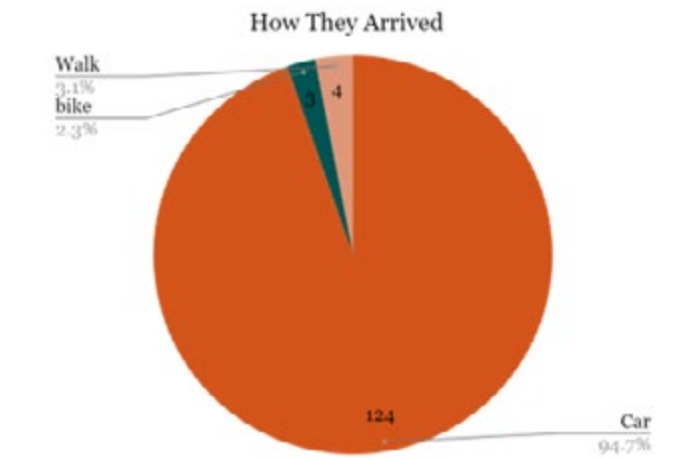
- 132 surveys completed from 8/12/22 through 9/18/22
- Average age = 54
- Median age = 58
- Age range = 17-88



Residency Status



- Out of town visitor (more than 15 minutes away)
- Seasonal resident of the area (within 15 minute drive)
- Year-round resident of the area (within 15 minute drive)



10. Have you used the hiking trails at this park?
 Yes
 No
11. If yes, how difficult did you find the trails, physically?
 No problem
 Moderately difficult
 Challenging
12. If yes, how difficult did you find the trails to navigate?
 No problem
 Moderately difficult
 Challenging
13. Is accessibility here a challenge for you, your friends, or family?
 Yes
 No
14. In your opinion, how could area trails be more accessible for users of all abilities?
15. If there was a trail connection between this park/natural area and others along the lakeshore, would you be interested in going for a longer hike to experience more of the lakeshore?
 Yes
 No

16. What would you be interested in experiencing along the proposed trail?
 Views of Lake Michigan from high points
 Forested areas
 Open dune areas
 Challenging sand dune climb
 Exposure to many different environments
 Walk along beach
 Learn about environmental restoration
 See lakefront houses
 Educational signage
 Trail connections to other areas
 Wildflowers
 Wildlife viewing
 Other: _____

17. What is your preferred hiking trail length?
 A. 0-1 mile
 B. 1-1.5 miles
 C. 1.5-2 miles
 D. 2-3 miles
 E. 3+ miles
 F. I like to have all the options.

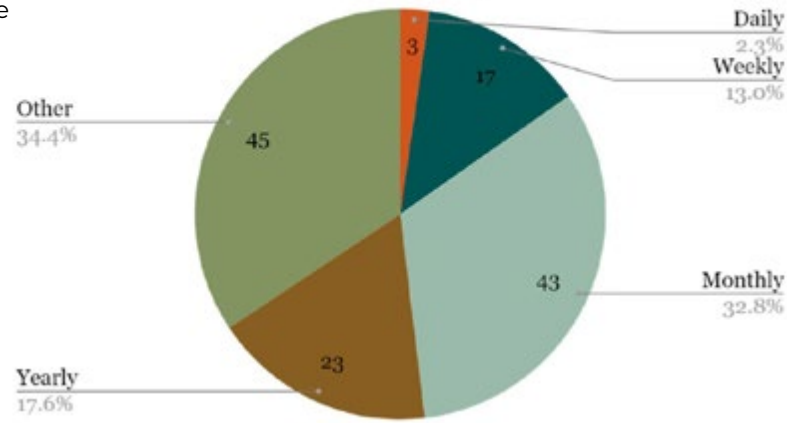
18. What other beaches and/or natural areas do you visit locally?

Thank you and have a great day!!!

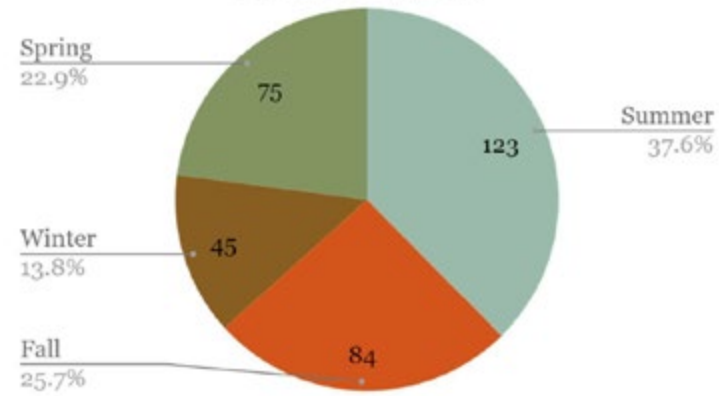
Notes/Additional comments:

25 people were visiting for the first time

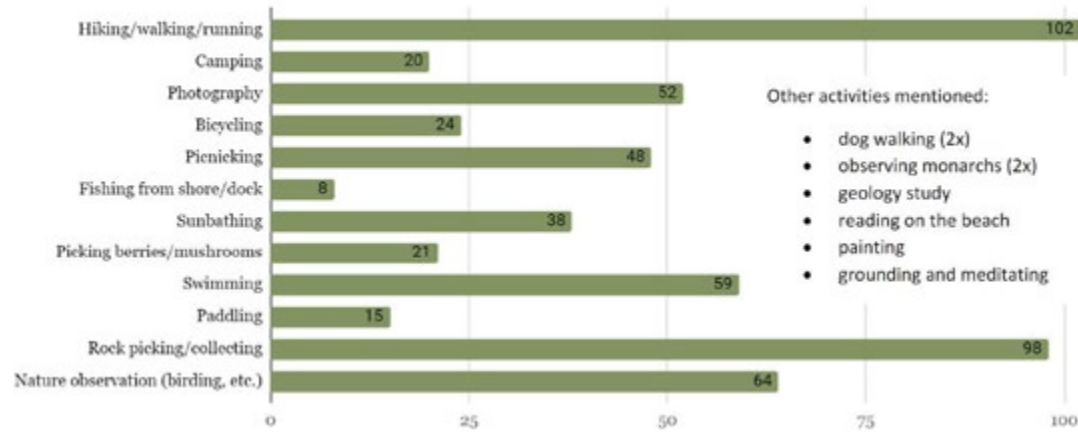
Visit Frequency



Seasons They Visit

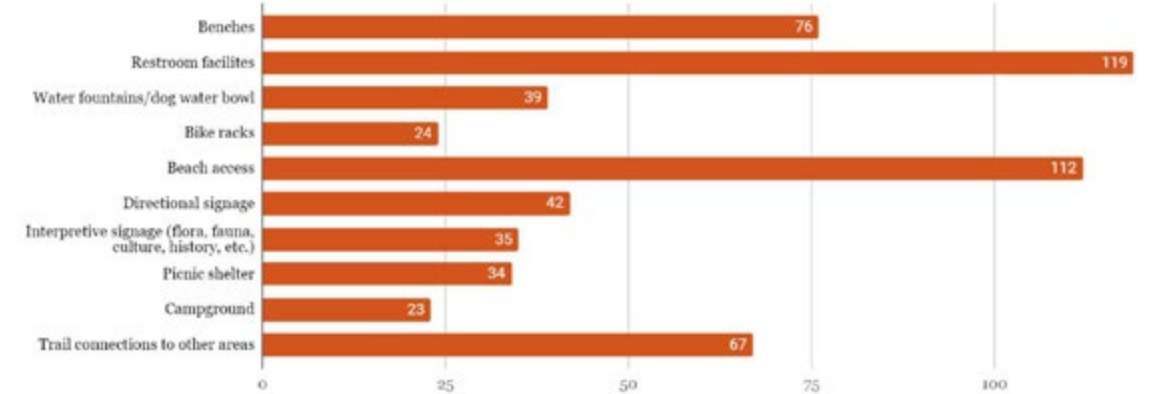


Activities Participated in When Visiting



- Other activities mentioned:
- dog walking (2x)
 - observing monarchs (2x)
 - geology study
 - reading on the beach
 - painting
 - grounding and meditating

Important Amenities

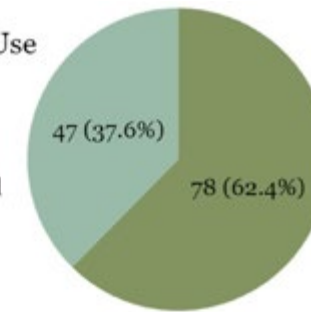


Other amenities mentioned:

- signage: geology of area rocks
- rental cabins for campground
- picnic tables (2x)
- beach access for dogs (4x)
- water fountains
- water fountains to wash feet (3x)
- directional signage: "We need a sign at 18th"
- ADA accessibility (2x)
- accessible tick keys for tick removal
- trail pickup
- vending machine area
- trails to other areas
- more benches
- small bridge over creek closer to east side of property
- more rules

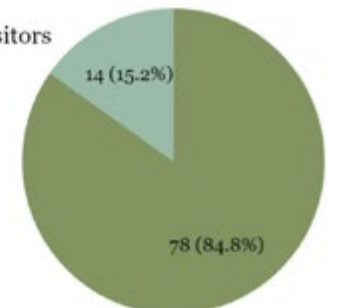
Hiking Trail Use

- Have used
- Have not used



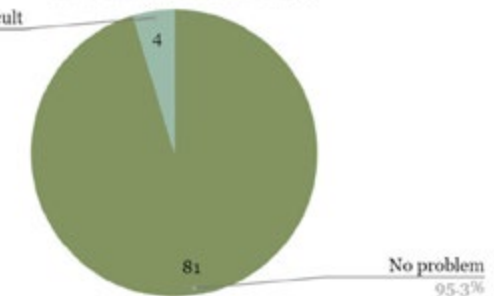
Trail Difficulty for Visitors

- No problem
- Moderately difficult

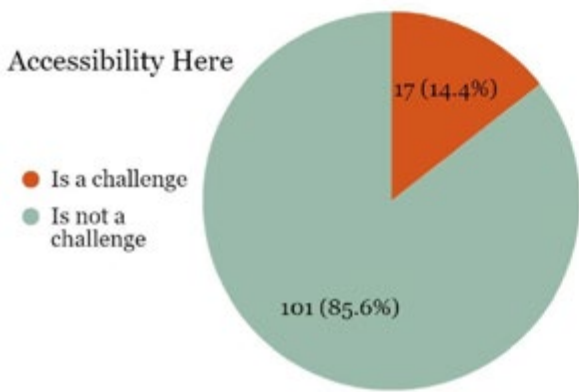


Trail Navigation Difficulty

- Moderately difficult
- No problem



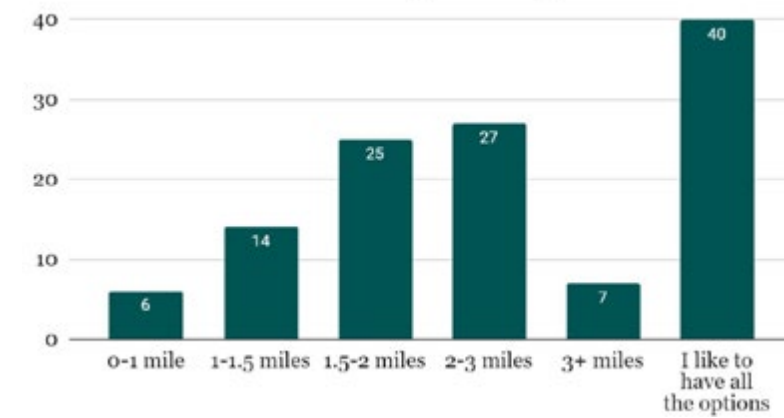
Accessibility Here



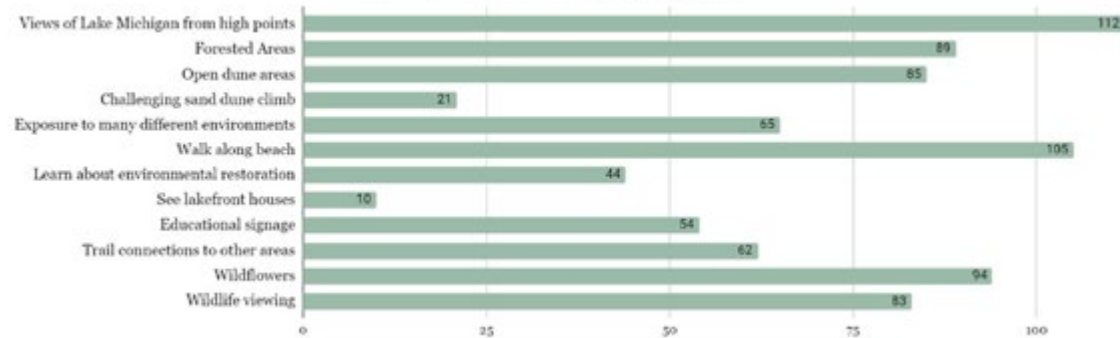
Recommendations to improve accessibility for all users:

- PA
- easy launch sites/entry/exit
- "Just more trails would be great they are in great shape!"
- signage (3x)
- wider trails
- "Wider, more level; needs signage to Pilgrim Haven"
- "Accessibility is somewhat of an issue on the rocks"
- Good maps online and sign at trailhead
- "Spray for weeds so trails are more visible"
- things to grab with arms in steep areas
- clear more branches off the trail
- better surface, fewer roots
- "be paved"
- variable difficulty trails
- "wheelchairs and walkers (for assistance for a person who has balance issues)"

Preferred Hiking Trail Length



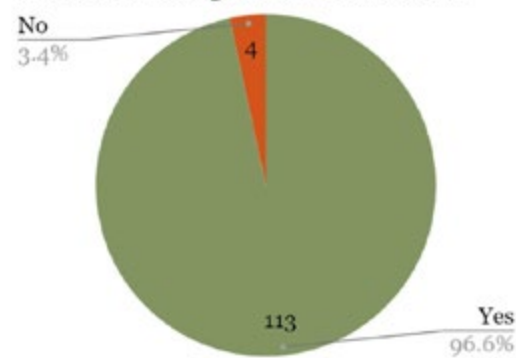
Interest in Amenities for Proposed Trail



Other interests mentioned:

- Animals/insects
- Benches
- "Important to preserve natural features. Should take priority above. Very fragile"

Interest in Longer Trail Connection



Other beaches and/or natural areas people visit locally:

Van Buren State Park, Wau-ke-na, Kal Haven Trail, South Beach, Haven Beach, the Haven, Deerlick, Saugatuck State Park, North Point, Pier Cove, 8th Ave Nature Area, Areas North of Glenn, Leland, Charlevoix, Warren Dunes, Bridgeman Westside Park, Warren Woods, Rocky Gap, Paw Paw River, Packard Park, Black River Preserve, Chipman, West End Park, West Co. Park, Holland, Indiana Dunes, Douglas, SWMLC preserves, MNA preserves, Oak Beach, "All in Van Buren and Allegan County, Saugatuck Dunes, Portman Black river, Ft. Custer, Muskegon State Park, Asylum Lae, El Sabo, Eliason Preserve, Lilian Anderson Arboretum, Chicago Area, New Buffalo, Casco, Covent Township Park, Ludington State Park, Pack Lake State Park, Ox Bow/Mt Baldy, Ross Nature Preserve, Fisherman's Point, Pere Marquette, Van Buren Trail, Yankee Springs State Park

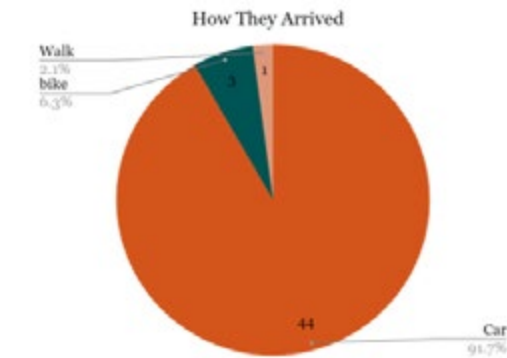
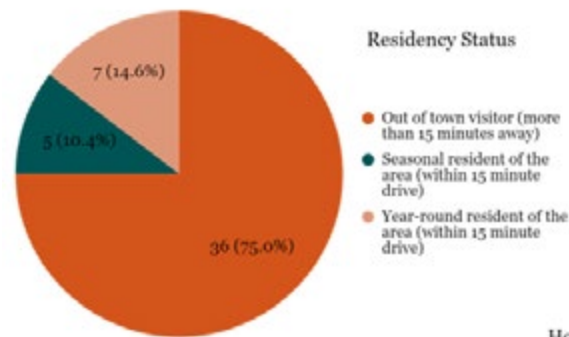
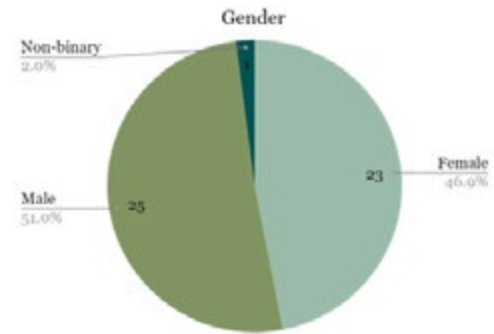
Other notes and comments people made:

- bird viewing and nesting environments, sand hill cranes
- rock club
- "Remove tractor tires by creek. Leave signage: Leave the lake better than you found it. Don't Litter"
- "I love that Pilgrim Haven is accessible to those w/ disabilities/different abilities."
- "They just wrote: "1. Bathrooms much appreciated - how often are they maintained? 2. Barrier free access to water appreciated 3. Pilgrim Haven sign on 18th street, both sides. 4. Concern over keeping trails clean"

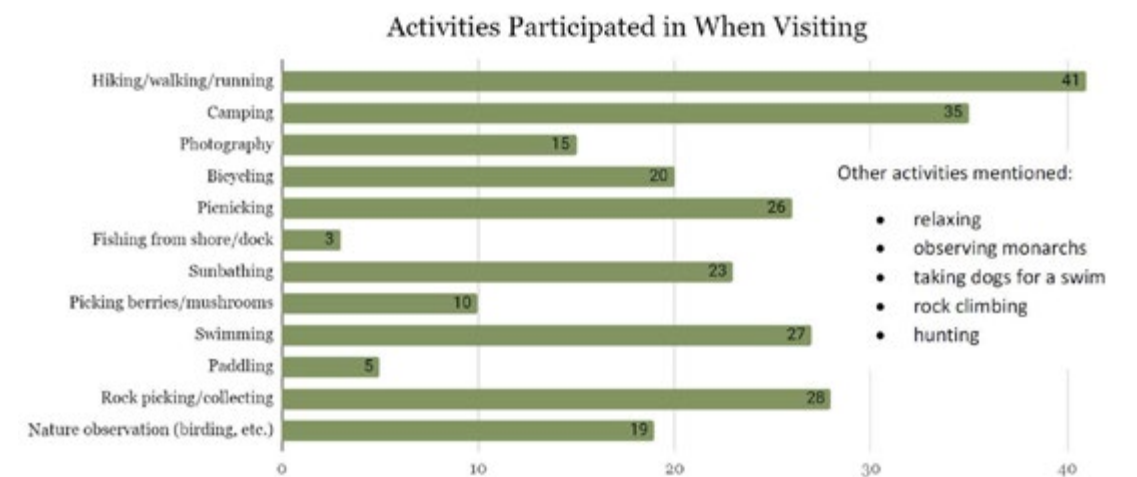
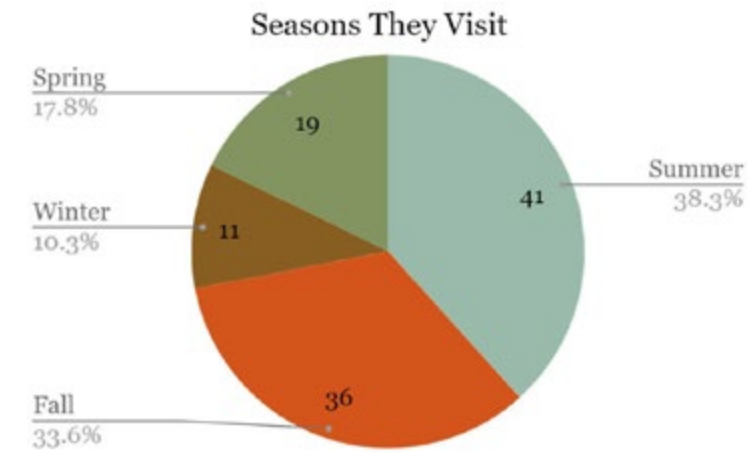
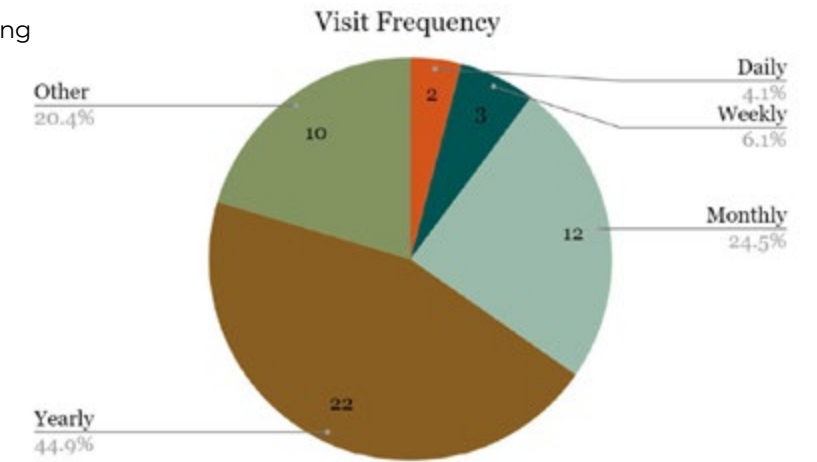
- "Some exposed roots (often marked with red paint) are stumbling hazards"

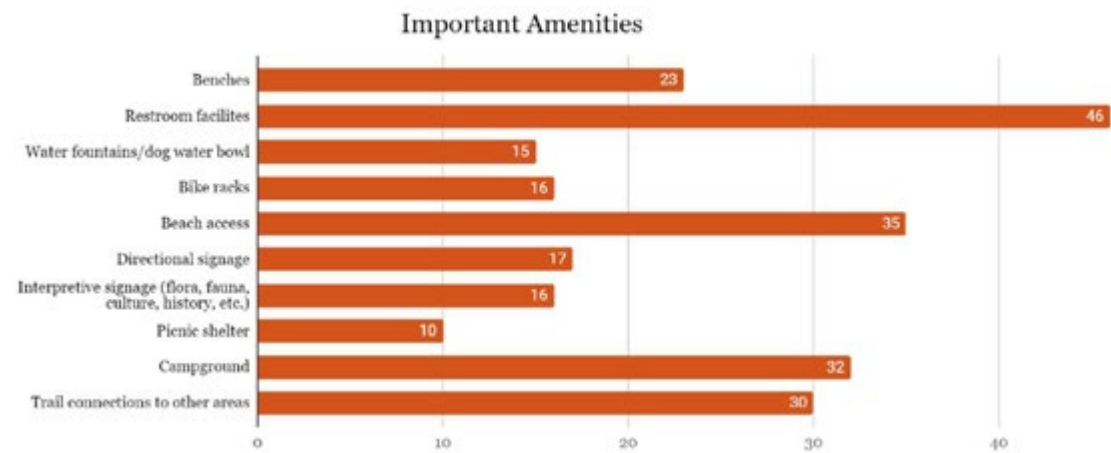
Survey Results: Van Buren State Park

- 49 surveys completed from 8/14/22 through 9/20/22
- Average age = 54
- Median age = 59
- Age range = 27-78



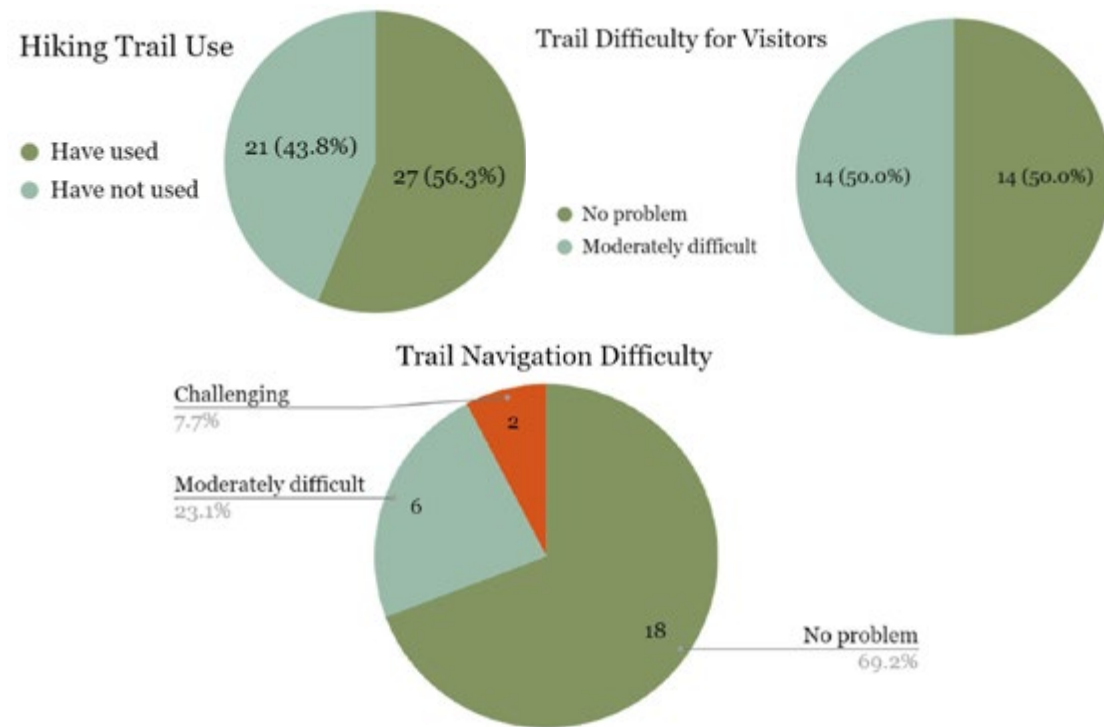
8 people were visiting for the first time





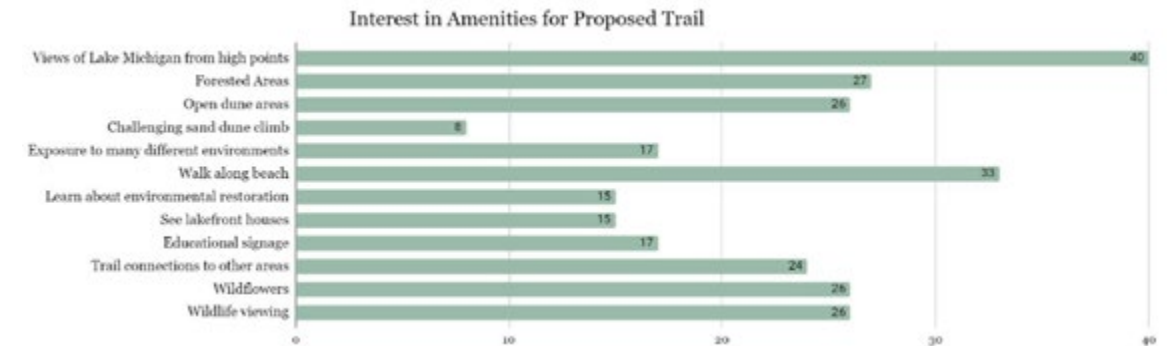
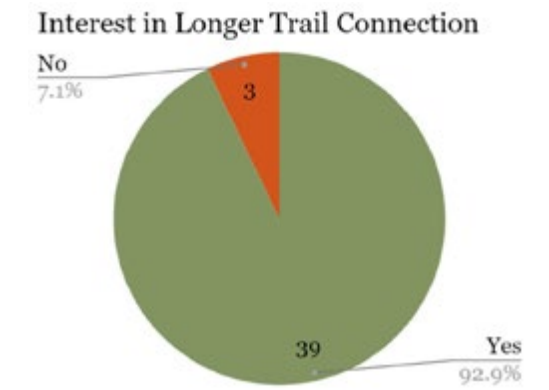
Other amenities mentioned:

- Gazebo by overflow
- More trails from campground
- More trash cans
- Backpacking
- ADA accessibility
- Archery range
- Full hookups for RVs
- Water filling stations
- Painting classes



Recommendations to improve accessibility for all users:

- variable difficulty trails (2x)
- better signage and maps, showing trail lengths (2)
- mile markers
- well-posted difficulty ratings
- Mobi-Mat at beach
- "pave the dunes"
- benches
- wheelchairs and walkers (for assistance for a person who has balance issues)
- paved trails



Other interests mentioned:

- Paved biking trails

- Horse trails
- Benches to rest and bathrooms



Other beaches and/or natural areas people visit locally:

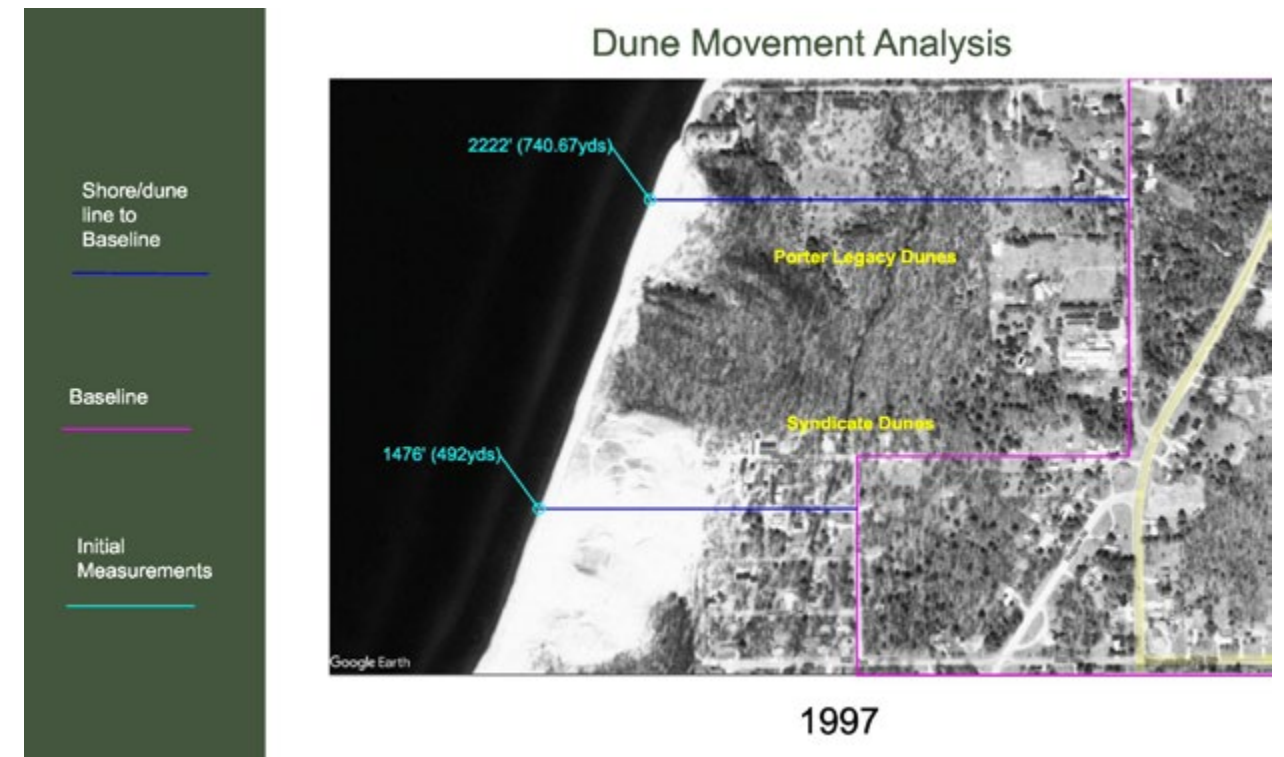
Saugatuck State Park, North Point, Pier Cove, 8th Ave Nature Area, Areas North of Glenn, Leland, Charlevoix, Warren Dunes, Bridgeman Westside Park, Warren Woods, Rocky Gap, Paw Paw River, Packard Park, Black River Preserve, Chipman, West End Park, West Co. Park, Holland, Indiana Dunes, Douglas, SWMLC preserves, MNA preserves, Oak Beach, "All in Van Buren and Allegan County, Saugatuck Dunes, Portman Black river, Ft. Custer, Muskegon State Park, Asylum Lae, El Sabo, Eliason Preserve, Lilian Anderson Arboretum, Chicago Area, New Buffalo, Casco, Covent Township Park, Ludington State Park, Pack Lake State Park, Ox Bow/Mt Baldy, Ross Nature Preserve, Fisherman's Point, Pere Marquette, Van Buren Trail, Yankee Springs State Park

Other notes and comments people made:

- very poor signage Van Buren and Warren Woods State Parks
- "I would be interested in more biking trails, not hiking." bikepacking, day biking trips, multipurpose trails (fitness/transportation, etc.)
- Senior rates (for state park)

Appendix D Dune Movement Analysis

The Dune Movement Analysis was a test run by the Just Dune It team to measure inland movement along the east shore of Michigan. Focusing on shoreline changes near the Porter Legacy Dunes and Syndicate Dunes properties, this study utilized aerial imagery from the years of 1997, 2005, 2006, 2011, 2016, 2018, 2021 for data collection. The remaining years that were not directly assessed were included in the derived averages. After georeferencing was completed in ArcGIS Pro, measurements were taken and recorded through the use of various lines in AutoCAD. The final results of this analysis helped to confirm inward shore/dune movement as an important factor in the trail design process.



Small Amount of Movement since 1997

Shore/dune line to Baseline

Baseline

Initial Measurement

Least Movement Observed: 2005- 2011



Location of Change	Difference in lake dune length observed from 1997 to observed year (ft)						Average Difference from 1997 to 2021 (ft)	Average Difference Per Year (ft)
	2005	2006	2011	2016	2018	2021		
Porter Legacy Dunes	0	8	20	55	96	157	56	2.24
Syndicate Park Dune Area	0	5	15	25	60	110	35.83	1.43

Large Amount of Movement since 1997

Shore/dune line to Baseline

Baseline

Initial Measurement

Most Movement Observed: 2016- 2021



Appendix E Previous Trail Design Concepts

Porter Legacy Dunes

GIS analysis Trial

This initial trail concept was developed using a combination of the existing trail data and input from the GIS based least cost path model. We used this model to convey our early design ideas with stakeholders and gather feedback

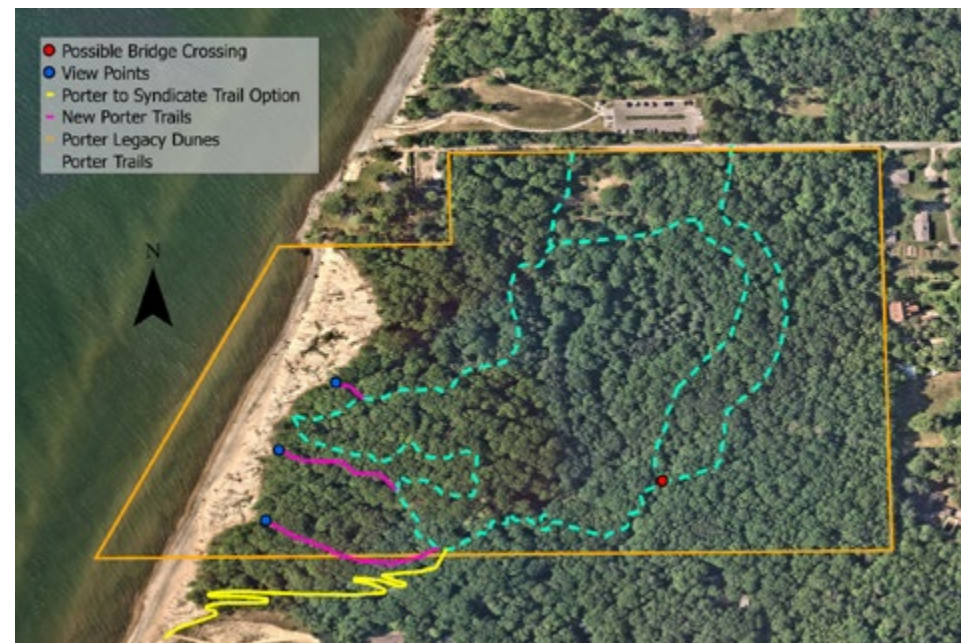


Figure E1. Porter Legacy Dunes GIS Model Trail Concept Date: October 4th, 2022

First Draft Illustrative Trail Concept

The trail concept was converted into a more legible and illustrative trail concept. This design was presented in January during an interim project presentation and more feedback was provided by the clients and UM faculty and students.

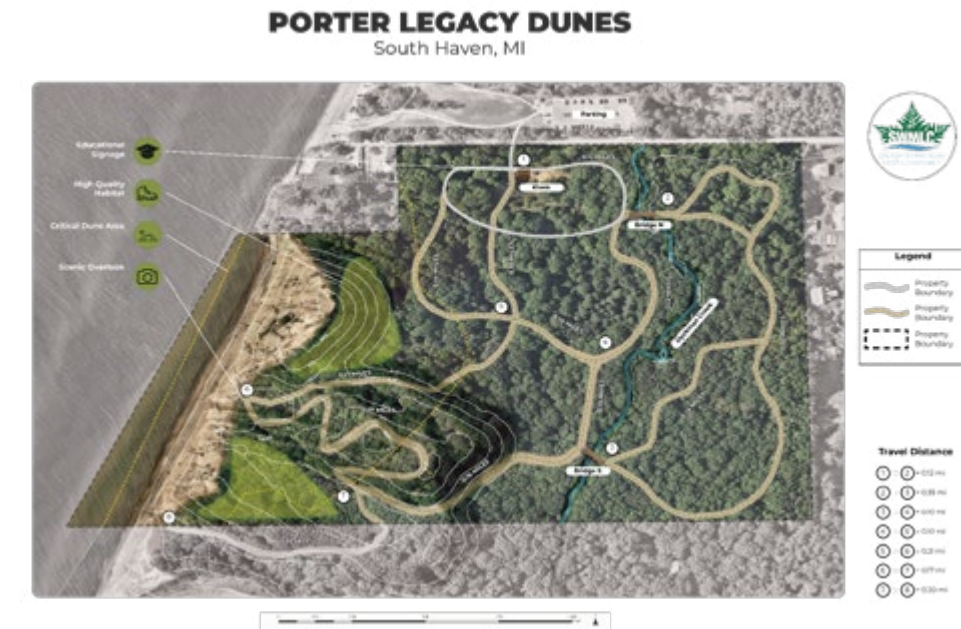


Figure E2. Porter Legacy Dunes First Draft Illustrative Trail Concept Date: January 14th, 2023

Slope Analysis Technical Draft

This technical draft was developed in conjunction with the final trail concept no. 2. This iteration includes a boardwalk system to ascend and descend the dune located in the southwest corner of Porter Legacy Dunes. This map was developed using a combination of ArcPro and AutoCAD Software. The advantage of this method is that the AutoCAD software allowed us to very accurately model where the trail would be located on the ground. The polylines drawn in CAD were then imported into ArcPro and divided into sections. The analysis tools within ArcPro allowed us to calculate the length, average slope, and maximum slopes of each section. This information was used for costs estimates and project budgeting.

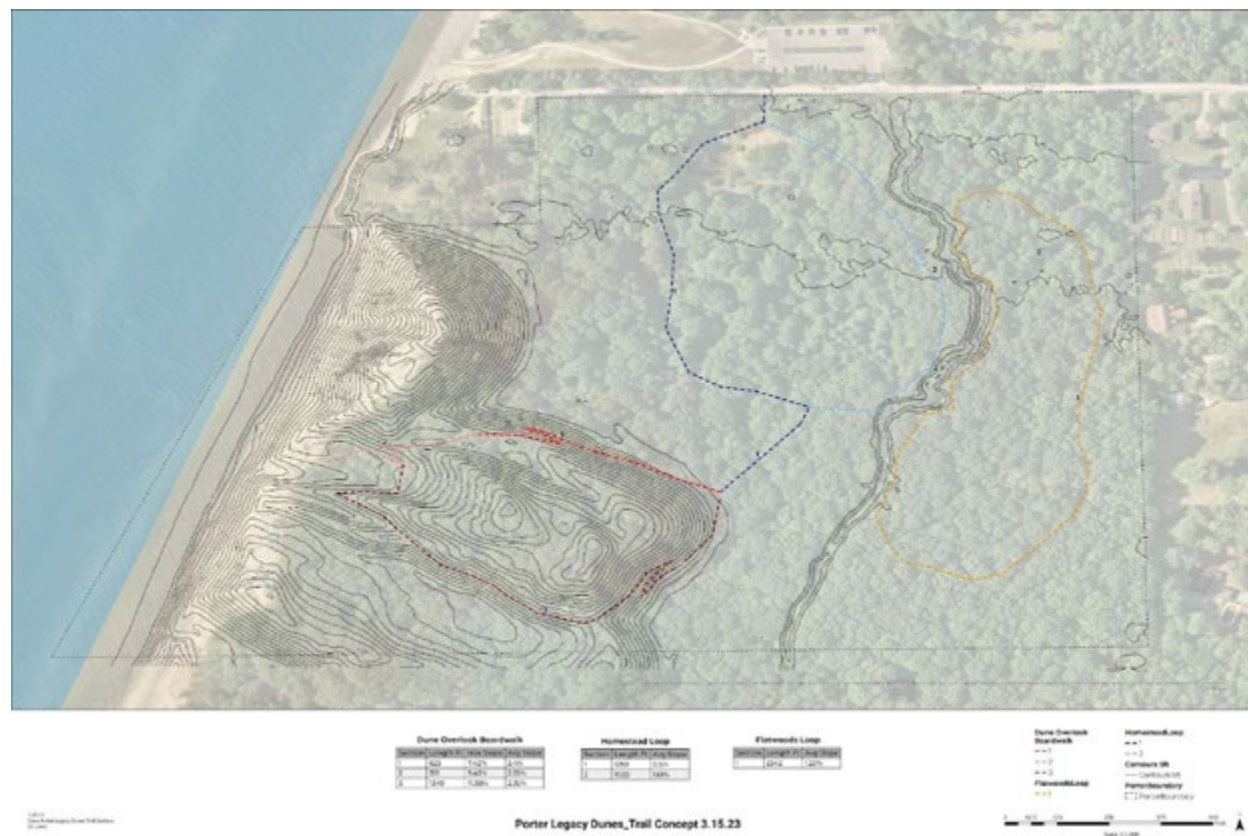


Figure E3. Slope Analysis Technical Draft Date: March 15th, 2023

Syndicate Dunes

The original Syndicate Dune trail concept initially proposed three trail options through the dunes, as shown in Figure 4. However, two of these options were eventually removed from future conceptual trail designs. The first of these was the Fire LN Trail (Figure 5.), which would have crossed over county land within the Syndicate Dune neighborhood and over the dune and ATV trail to meet up with the

Porter to Syndicate connection trail (Figure 8). Regrettably, due to safety concerns associated with crossing an active ATV path, this trail was deemed unsuitable for future inclusion. The second trail option to be removed was the Beach Point Trail, as depicted in Figure 6. This trail would have traced the entirety of the Syndicate Dune beach and connected with the Van Buren State Park beach at the southern end of the Syndicate Dunes site. However, due to uncertainties regarding the trail's accessibility brought about by rising lake levels and the construction of a seawall, it was deemed unfeasible for inclusion in future trail designs.

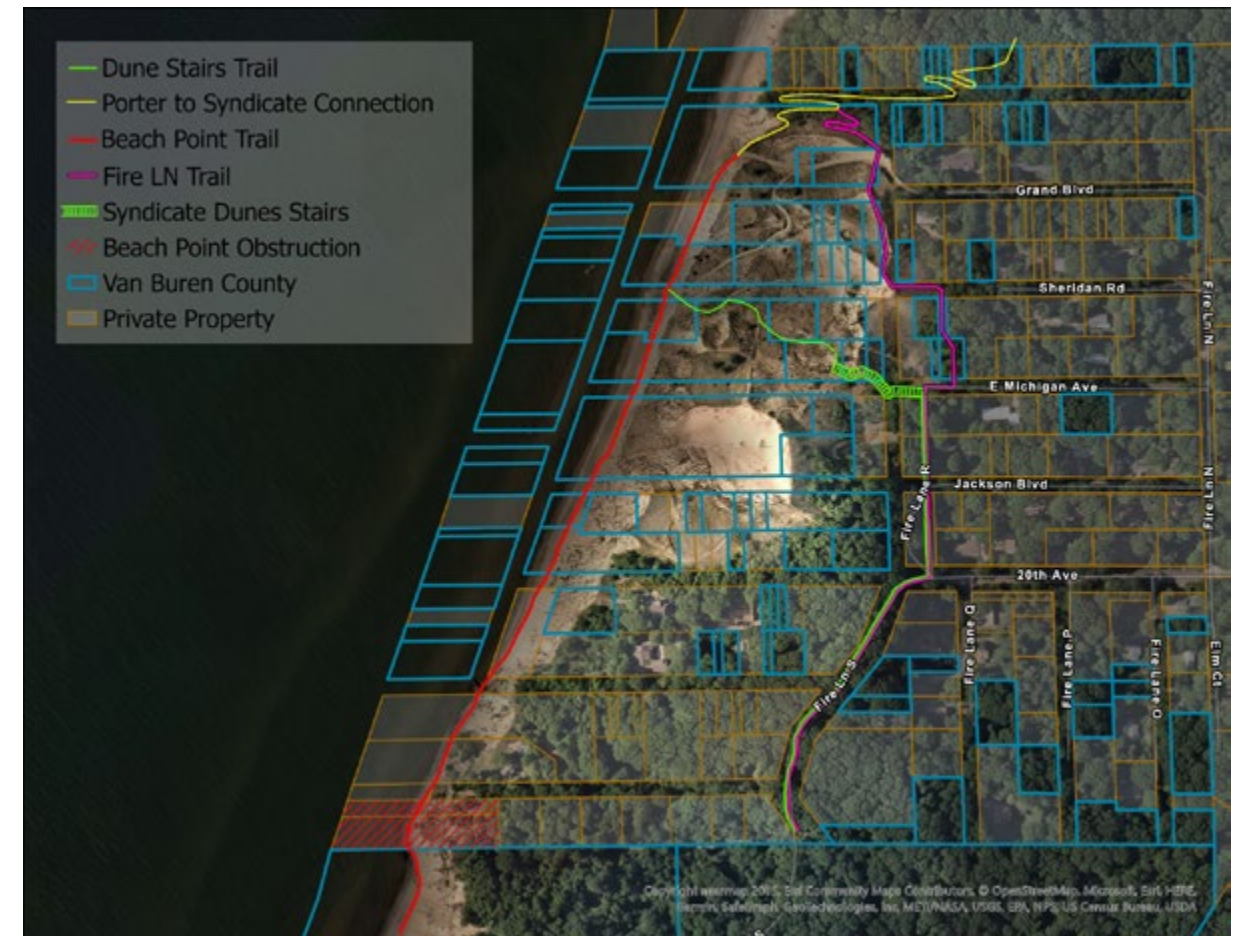


Figure E4.



Figure E5.



Beach Point Access Trail

Figure E6.



**Fire Lane Rd. Dune Stair Case
Connection Trail**

Figure E7.



**Porter Dune Trail to Syndicate
Dune Beach Trail**

Figure E8.

