Information on the Proposed Delineation and Assessment of Michigan's Critical Dune Areas

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MICHIGAN DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
3DEP	3-D Elevation Project
CDA	Critical Dune Area
CZM	Coastal Zone Management
DEM	Digital Elevation Model
EPC	Exemplary Plant Communities
EGLE	Michigan Department of Environment, Great Lakes, and Energy
EO	Element Occurrence
EPC	Exemplary Plant Community
GEI	GEI Consultants of Michigan, P.C.
GIS	Geographic Information Systems
KEAs	Key Ecological Attributes
LiDAR	Light Detection and Ranging
LWD	Low Water Datum
MEC	Michigan Environmental Council
MEC 2018	Dunes mapped by Arbogast, et al. (Arbogast 2018) for the *Valuing Michigan's Coastal Dunes* report
MNFI	Michigan Natural Features Inventory
MNFI 2019	Dunes mapped by Paskas, et al. (Paskas 2019) for the *Spatial Data to Improve Coastal Resiliency and Better Inform Local Decision* Making report
MSU	Michigan State University
MTU	Michigan Technological University
NED	National Elevation Dataset
NREPA	Natural Resources and Environmental Protection Act
NHD	Natural Heritage Database
RFP	Request for Proposals
SSURGO	Soil Survey Geographic Database
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey

Executive Summary

The State of Michigan has long recognized the importance of protecting its freshwater sand dunes. In response to development pressures and the recognition of the need to protect especially important dunes, in 1989 the Legislature ordered the Michigan Department of Natural Resources (MDNR) to designate approximately 74,000 acres of critical dune areas (CDAs) throughout the state that require special protection. Today these CDAs are regulated by the Department of Environment, Great Lakes and Energy (EGLE) under Part 353, Sand Dunes Protection and Management, of the Natural Resources and Environmental Protection Act, 1994 PA 541, as amended (NREPA). This act regulates actions that can be taken in areas designated as CDAs that were mapped in the *Atlas of Critical Dunes* (MDNR 1989) published by MDNR.

Following a legislative requirement, EGLE has contracted with GEI Consultants of Michigan, P.C. (GEI), the Michigan Natural Features Inventory (MNFI), Michigan Technological University (MTU), and Michigan State University (MSU) to conduct a delineation and assessment of critical dune areas. The effort will include a combination of desktop reviews and field-based assessments to designate new CDAs, de-designate existing CDAs that may no longer meet designation criteria, or correct CDA boundaries as appropriate based on physical and ecological conditions, using updated geospatial data and field assessments. The project will include development or refinement of criteria for the designation of CDAs using scientifically defensible methodology that can serve as a model for future updates to the atlas.

Background

The sand dunes of the Great Lakes represent the largest collection of freshwater dunes in the world and contain a multitude of rare and endemic natural communities and species. The sand dunes directly contribute to the economy of the state by driving tourism along the coastline and are responsible for providing the sand necessary to build and maintain beaches. After regulating sand dune mining in the 1970s, the legislature further recognized the benefits sand dunes provide the people of Michigan with the passage of the Sand Dunes Protection and Management Act in 1989, later codified as Part 353, Sand Dunes Protection and Management, of the NREPA. Part 353 directs EGLE's Water Resources Division (WRD) to regulate developmental, silvicultural, and recreational activities within designated critical dune areas through a permitting program. Critical dune areas (CDAs) are designated in the 1989 Atlas of Critical Dunes and represent around 74,000 acres of the 230,000 acres of total dunes in the state.

Request for Proposals

In the Fiscal Year 2024 budget, the Michigan Legislature required that WRD conduct a delineation of sand dunes in the state and assess critical dune areas. Following this requirement, WRD published a request for proposals (RFP) to award a contract for completion of this work. WRD identified three major areas of change to be addressed through the delineation effort: 1) Correct and update the existing atlas through the use of modern high-resolution light detection and ranging (LiDAR) and aerial imagery. 2) Designation of existing high-quality dune systems that are not currently CDAs along Great Lakes shorelines, especially Lake Huron. 3) De-designation of existing CDAs that lack diversity, quality, functions, and values typical of CDAs.

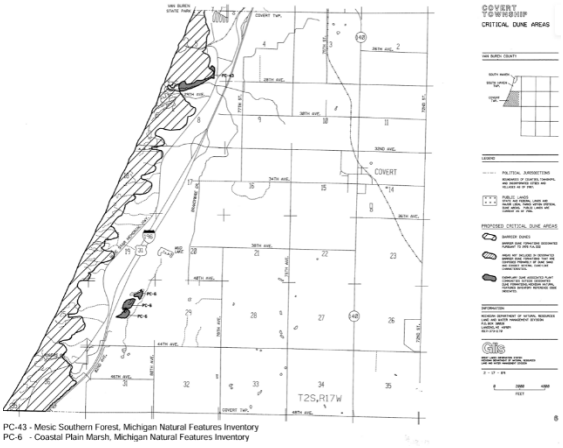
The RFP was posted on August 1, 2024. WRD received two bids for the project. The contract was awarded to GEI Consultants of Michigan who are subcontracting with MSU, MTU, and MNFI.

Past Studies

The project is intended to build upon previous statewide efforts to identify and map dunes and critical dune areas throughout the state of Michigan. Relevant literature and past efforts are described below.

1989 Atlas of Critical Dunes

Figure 1: Sample area of the 1989 Atlas of Critical Dunes.



In 1989, the Michigan Department of Natural Resources (MDNR) published the *Atlas of Critical Dunes* (MDNR 1989). The atlas (1989 Atlas) is a series of maps of barrier dunes and exemplary dune associated plant communities that have been designated *critical* throughout the State of Michigan. Originally issued in hard copy format, the atlas has been digitized and is available through the State of Michigan website at:

https://gis-michigan.opendata.arcgis.com/datasets/egle::critical-dune-areas/about

The 1989 Atlas used both physical and biological characteristics to designate dune areas in Michigan as critical. These primarily included:

- Features composed primarily of dune sand
- Features within 1.5 miles of a Great Lakes shoreline
- Dune features at least 1 mile in length along a Great Lakes shoreline
- Dunes that are at least 20' in height
- Dune-related plant communities that are considered "exemplary"

Using these criteria, the atlas designated approximately 74,000 acres as critical within the state.

Final Report on a Natural Features Inventory of Michigan's Designated Sand Dunes

In support of the Sand Dune Protection and Management Act, the MNFI was commissioned to collect data on the natural communities of Michigan's sand dunes in the early 1980s (Reese 1986, Appendix A). The effort was intended to identify high quality dune-associated plant communities along Lake Michigan, using element occurrence (EO) ranking system of A-D, with A being the highest quality and D being the lowest. To evaluate the sites, MNFI created a "Duneland Natural Heritage Scorecard."

The mapping began with interpretation of maps and aerial photographs and was followed with field investigations. The initial mapping identified 119 sites for field checking—these included Open Dunes, Interdunal Wetland, Boreal Forest, Mesic Northern Forest, Great Lakes Barrens, and Sand/Gravel Beach. Field investigations of mapped sites began with a preliminary rapid assessment of the sites to determine EO ranking and the need for further investigation. Of the sites investigated, forty-eight were ranked excellent or good (A or B), and 48 were ranked as fair (BC and C). Follow up visits were completed to sites ranked C or better, in an attempt to more closely assess the vegetation, soil, wildlife, and disturbances at each site.

Valuing Michigan's Dunes

The most detailed and comprehensive mapping of Michigan's Holocene-aged coastal sand dunes developed in a digital geographic information system (GIS) environment was assembled through the work of Dr. Alan Arborgast (et. al.), Chair of the Department of Geography, Environment and Spatial Sciences at MSU. The following summary was assembled from *Valuing Michigan's Coastal Dune: GIS information and Economic Data to Support Management Partnerships* (Arbogast, 2018, Appendix B).

Mapping for this project was conducted by visual identification of physical dune forms on digital elevation models (DEM) obtained from the MDNR and United States Geological Survey (USGS). Across the state, spatial resolution of DEMs was variable. Some counties have high-resolution (1-meter pixel size) LiDAR derived DEMs while the rest of the state is covered by the USGS National Elevation Dataset's (NED) 3-D Elevation Project (3DEP) seamless product, with a range of spatial scales available. The product used in the creation of the map had a spatial resolution of approximately 10-meter resolution imagery (1/3 arc second). Higher resolution 1m DEMs are now available for all coastal dune areas in Michigan.

In addition to the analysis of LiDAR imagery, ancillary data, such as USDA's Soil Survey Geographic Database (SSURGO) soils data, aerial photography and satellite imagery, topographic maps, and previously mapped dune sites (the 1989 *Atlas of Critical Dunes*) were used to inform mapping decisions. Field verification was used to test the accuracy of the interpreted coastal dune boundaries and assess the accuracy of spatial-age relationship between Holocene and Pleistocene coastal dune systems. Representative sites were selected during the mapping process and field verification was conducted to clarify the location of boundaries and map accuracy. This effort led to the mapping of 230,714 acres of dunes in the state of Michigan.

Spatial Data to Improve Coastal Resiliency and Better Inform Local Decision Making

After decades of effort spanning several research projects to map and manage Michigan's coastal dunes, basic, but important, information gaps remained to be addressed. The MNFI and the MDNR Coastal Zone Management (CZM) Program recognized that much of the current data was fragmented across several agencies and an all-encompassing geospatial dataset and methodology to evaluate the ecological integrity of dune ecosystems would be needed to provide a resource to make data driven decisions for coastal dune protection, planning, and zoning efforts. In 2017-18, the MNFI, funded by the CZM Program, lead a project focused on the development of key geospatial datasets to address three CZM Program focus areas: coastal resilience, coastal habitat, and coastal development. The following summary was assembled from *Spatial Data to Improve Coastal Resiliency and Better Inform Local Decision-Making* (Paskus, Enander, 2019, Appendix C).

The MNFI compiled and digitized three existing research projects, which represented the best available information to date on both coastal erosion and coastal dunes in Michigan, into spatial data layers to create a format that would be easily accessible to a range of users. *Humphry's Shoretype Classification (1958)* and additional spatial info (USDA SSURGO soils data, USGS topographical quadrangles, and recent aerial imagery) were used to analyze and designate high-risk erosion areas along Great Lakes shorelines. The MNFI then digitized W.C. Buckler's coastal dune maps (1978-79) through a process of scanning and geo-rectifying each map to the existing USGS topographic layer in ArcGIS. Using the coastal dune layer produced by MSU GESS (Arbogast 2018) and ancillary datasets (aerial imagery, DEMs, LiDAR, and SSURGO soils data), the MNFI reviewed all coastal dune boundaries for accuracy and mapped all dune types using heads-up digitizing.

The culmination of research into a geospatial dataset provided a tool to identify and classify coastal dunes throughout the state, but no methodology existed to evaluate the ecological integrity of coastal dune habitats. An Advisory Committee (AC) of freshwater coastal dune experts was assembled and the AC adopted protocols from NatureServe Heritage and Open Standards for the Practice of Conservation to develop and apply a prototype Coastal Dune Health Index that could be used to assess the overall quality of specific dune sites. The result was an index that includes both GIS and field-based criteria to measure overall ecological health.

The prototype Coastal Dune Health Index was organized into two major categories: 1) Condition, which focused on the internal health of the dune site itself through 16 indicators identified and described under the Key Ecological Attributes (KEAs), and 2) Landscape Context, which focused on the health of lands immediately adjacent to the dune site through four indicators under the KEAs. Thresholds for each indicator were developed using an absolute scoring method to create a maximum potential score for each category and a combined maximum potential index score. Using this protocol, the MNFI evaluated 18 sites located along the mainland of eastern Lake Michigan and found the observed scores to be representative of the sites selected for field surveys when compared to the maximum potential index score. This effort led to the mapping of 346,688 acres of dunes and dune-associated plant communities in the State of Michigan. The increase in acreage over the MEC 2018 mapping is primarily due to the addition of dune-related plant communities that were not mapped during the 2018 effort.

Work Plan Development

As stated in the RFP, the work plan will support three major areas:

1. Correct and update the existing atlas
2. Designation of existing high-quality dune systems that are not currently CDAs
3. De-designation of existing CDAs that lack the diversity, quality, functions and values typical of a CDA.

The development of criteria for designation and de-designation of CDAs is a primary goal of the proposed project. The CDA atlas developed in 1989 utilized several primary criteria to establish the CDAs—these included the following criteria:

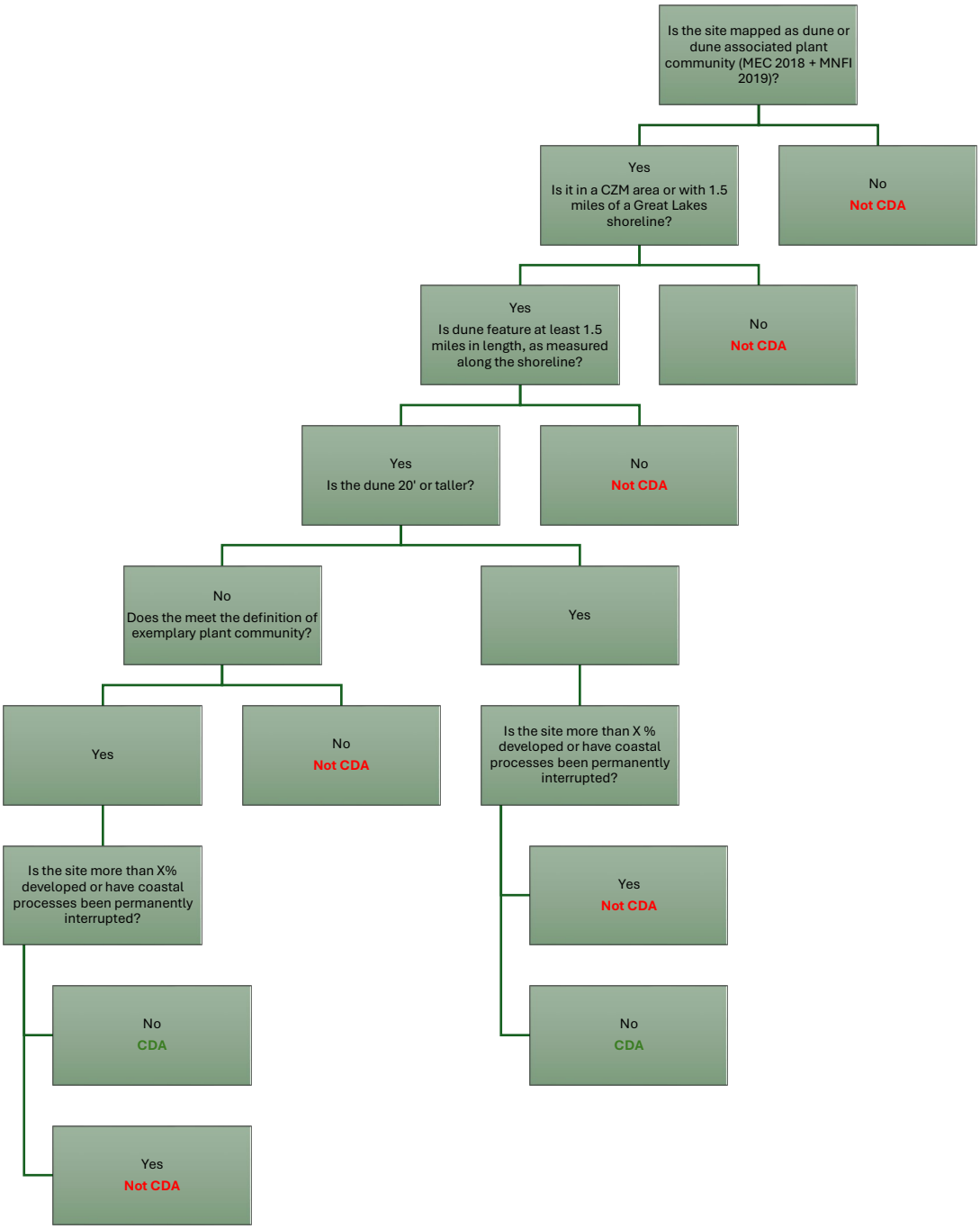
- Features composed primarily of dune sand
- Features within 1.5 miles of a Great Lakes shoreline
- Dune features at least 1 mile in length along a Great Lakes shoreline
- Dunes that are at least 20' in height
- Dune-related plant communities that are considered "exemplary"

While some of the original criteria can be clearly quantified, others may be left open to interpretation. To build upon previous work while also updating the CDA mapping using updated data, technology, and science, the project will use the following approach, which is described in detail below and depicted in the following decision tree (Figure 2).

1. Review original methodology for CDA designation
2. Re-delineate CDAs using current data and technology
3. Establish criteria for designation/de-designation of CDAs
4. Field verification of CDA designation
5. Finalize updated CDA maps

This approach will, at a minimum, update CDAs using the same physical criteria as the 1989 Atlas but using current data and technology. The methodology then offers an opportunity to refine CDA designation based on additional criteria such as natural communities and disturbance, updating the designation to align with current science and practice. This two-staged approach will provide multiple options for CDA designation that will provide legislators with the opportunity to choose which designation most closely aligns with the goals of the State and Part 353, Sand Dunes Protection and Management, of the NREPA.

Figure 2: Proposed Decision Tree for Designation/De-Designation of CDAs



Delineation of CDAs with 1989 Criteria and Current Data

The technology and available data have changed significantly since the development of the original 1989 Atlas. With this consideration, the methodology for designation and de-designation of CDAs will be built upon the original criteria established for the 1989 Atlas but will use currently available data and technology to re-delineate the CDAs with a refined level of precision. There will be three primary components to the refined methodology:

1. Re-delineate CDAs using original 1989 criteria and currently available data and technology
2. Apply refined measures for designation/de-designation based on impacts, development, and natural communities
3. Field verification of desktop-derived data

Physical Features

As noted, the original 1989 Atlas used primarily physical features to designate CDAs throughout the state. Because these characteristics have generally become accepted by lawmakers, regulators, and stakeholders, it is practical and defensible to begin the re-delineation by using the original criteria to update the CDA atlas. The mapping effort, through a desktop GIS analysis, will use the following steps and protocols:

1. The MNFI 2019 dune mapping (Paskus 2019), via GIS shapefile, to establish a boundary for re-delineation of the CDAs, unioned with the MEC 2018 data.
    a. The union of the MNFI and Michigan Environmental Council (MEC) data layers will be used because it draws a wider initial boundary for dunes and includes dune-associated habitat such as wooded dune-swale. The more expansive initial boundary will create a more comprehensive initial area of investigation.
2. Combined DEM product derived from:
    a. The 1-meter DEM developed by USGS for topography
    b. USACE/NOAA Topobathy DEM for areas near the Great Lakes shoreline
3. The low water datum (LWD) elevation will be used to establish the lakeward horizontal and vertical location for delineation of the dunes. The elevations will be as follows in feet, per the United States Army Corps of Engineers (USACE)*:
    a. Lake Michigan/Lake Huron=577.50
    b. Lake Superior=601.10
    c. Lake St. Clair=572.30
    d. Lake Erie=569.20

    *LWD are provided in IGLD 85 datum

4. CDAs will be drawn for areas that meet the following criteria:
    a. The site must be mapped as dune, per the 2019 MNFI mapping or 2018 MEC mapping.
    b. Sites must be located within 1.5 miles of a Great Lakes shoreline or within a CZM area.
    c. Sites must be at least 1.5 miles in length, as measured along the shoreline
    d. Sites must be 20' or higher in elevation above the low water datum for the adjacent Great Lake, including Lakes Michigan, Huron, Superior, and St. Clair.
    e. Where critical dunes exist, they will extend to the shoreline/water's edge, which will be defined as the LWD.

Exemplary Plant Communities

The exact original criteria used to designate Exemplary Plant Communities (EPC) are unclear, although they appear to have been derived from the MNFI mapping completed in the early 1980s, the comparison to the NHD mapping gave inconsistent results—while some community mapping and rankings from the NHD appear consistent with what may be considered an exemplary plant community, some do not. Due to inconsistencies between the two mapping efforts and a lack of site-specific data, field investigations will be completed at sites where the NHD plant community mapping and EPC community mapping do not align, or in places where a CDA is mapped as an EPC, but the NHD ranking is lower than what might generally be considered high quality or exemplary.

We developed a rapid assessment protocol to assess the status of the existing 20 exemplary communities to determine whether or the site should qualify as an EPC using a comparative analysis of areas designated in the 1989 Atlas.

It is anticipated that the designation of CDAs based on natural community will be based primarily on two factors, the specifics of which will be determined through the development of the designation criteria:

1. Rarity of natural community, based on NatureServe and MNFI Ranking (S1-S5).
2. Quality of natural community, based on NHD EO ranking

The ecological integrity of each site will be assessed based on modified Natural Heritage Methodology. Ecological integrity is defined as, "an assessment of the structure, composition, function, and connectivity of an ecosystem as compared to reference ecosystems operating within the bounds of natural or historical disturbance regimes" (page

3 in Faber-Langendoen 2016). This methodology evaluates natural communities to assign a quality rank based on three rank factors: size, condition, and landscape context (NatureServe 2002). These approaches developed from the same methodology used by Reese et al. (1986), to conduct a natural areas inventory of Michigan sand dunes, which formed the basis for selecting EPCs for the original CDAs. Other team members have also used Natural Heritage Methodology and found it useful for rapid assessment of coastal plant communities.

Condition – The condition of natural communities includes most of the site-level characteristics that describe ecosystem quality and includes plant community structure and composition, plant and animal indicator species, ecological processes, and hydrology.

Size – Larger occurrences of any natural community are assessed more favorably than smaller ones, but the expected or historical size of each natural community type varies. *Matrix* communities dominated large portions (patch size typically 2,000 to 10,000 hectares [ha]) of the Michigan landscape prior to European colonization and include most upland forests. *Large patch* communities did not dominate the historical landscape but typically occupied large areas (50 to 2,000 ha), and included peatlands such as fens, bogs, and meadows. *Small patch* communities occur in discrete positions in the landscape (1 to 50 ha) and include specialized wetlands such as coastal plain marsh and wet-mesic sand prairie.

Landscape context – The ecological integrity of natural communities is also influenced by landscape context. Natural communities that are embedded in landscapes dominated by high quality natural communities are more buffered from biological and anthropogenic stressors than those that are embedded in heavily managed, agricultural, or developed landscapes.

Development of Refined Metrics for Designation and De-Designation of CDAs

The 1989 Atlas designated CDAs primarily based on physical features and plant communities. While the physical feature criteria are understood, the selected plant community designations are less clear. In addition to these criteria, there are places where dunes have been impacted through development or armoring to a point where the natural dune processes no longer, or only partially function. A key component of this project is to develop refined or new metrics for the designation or de-designation of CDAs. Using physical features, plant communities, and an assessment of functioning coastal processes, criteria will be developed based on precedent and currently available data and

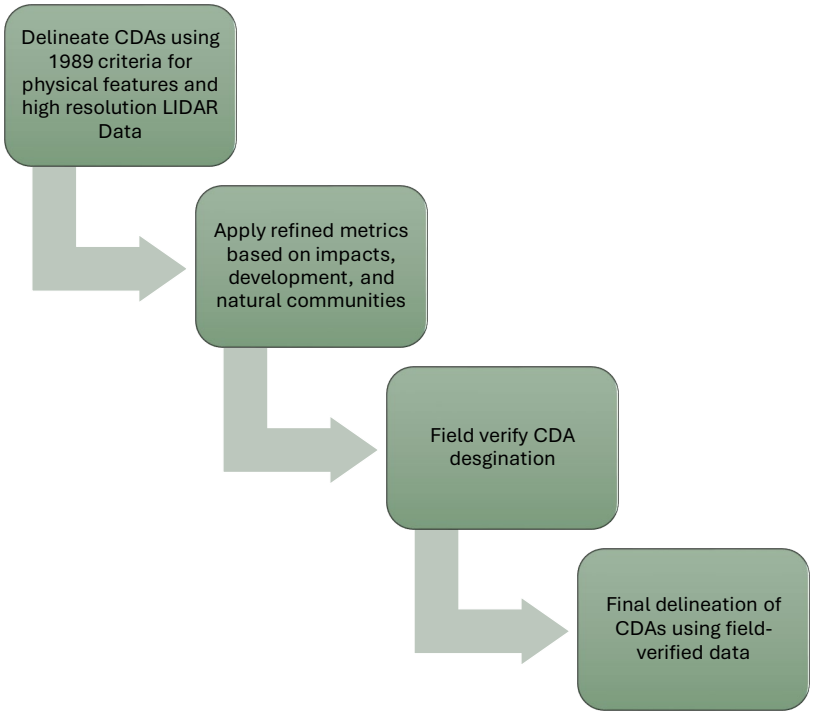
science that can be applied in a scientific and defensible way, with the intent of refining CDAs in a manner consistent with Part 353, Sand Dunes Protection and Management, of the NREPA.

CDA designation will rely on two primary categories after the CDA has been delineated based on physical features: 1) EPCs, 2) Disturbance/degradation that has interrupted natural dune processes. Criteria for designation/de-designation does not currently exist for these two categories and therefore will need to be developed. To accomplish this, the project team will be subdivided into working groups based on each individual's area of expertise. Each team will meet weekly and work collaboratively to develop criteria that will be used for both the field and desktop delineation of CDAs.

Delineation of Critical Dune Areas and Field Verification

The designation and/or de-designation of CDAs will combine previously developed criteria with new, updated criteria, modern technology, and field verification to re-draw CDA lines on all of Michigan's Great Lakes shorelines. The new delineation will build upon already accepted criteria that were developed in support of Part 353, Sand Dunes Protection and Management, of the NREPA, but apply a consistent and defensible approach to the new delineation that is backed in current practice and science.

Figure 3: CDA Delineation Process



Desktop Delineation

As discussed, the desktop delineation will be completed in two major phases: 1) Update CDA delineation based on previous criteria, and 2) Re-delineate based on new criteria. The initial delineation will be completed in early 2025 while the new CDA criteria are being developed (See Section 8—Schedule). Once the new criteria have been developed, we will complete a desktop delineation of CDAs using the new criteria from February to April 2025, in preparation for field verification during the 2025 growing season. Delineations will be updated where needed based on field verification, working closely with the field team to integrate data.

Field Verification

While some criteria for classifying Critical Dune Areas can be assessed remotely using available spatial data layers, field verification will be necessary to assess geomorphological and ecological criteria and ground-truth proposed boundaries in many areas. Prior to field verification, sites can be confirmed as Critical Dunes using existing data and knowledge, including:

- Personal knowledge – is the site known by a team member to possess or not possess critical dunes?
- Existing spatial data – MNFI natural communities, land cover datasets such as the newest National Land Cover Dataset (NLCD, see https://www.usgs.gov/centers/eros/science/national-land-cover-database) and the Bi-National Great Lakes Coastal Wetland and Land Use Map (Bourgeau-Chavez et al. 2015) to identify key cover types (e.g., urban, wetland, agriculture, upland forest, etc.)
- Current site characterizations, including reports and other published work
- Ownership
- Known conservation easements
- Protected Area Database
- EGLE CDA Permit Database

Sites that cannot be verified using desktop assessment will require field verification, which will be completed during the growing season (mid-April through September) and have two primary goals: 1) ground-truthing proposed boundaries of both Critical Dune Areas and EPCs, and 2) characterized sites based on both geomorphological parameters and parameters related to ecological integrity to evaluate inclusion as either CDA or EPC. Survey protocols will maintain consistency with field surveys that supported delineation of the original CDAs and EPCs that followed early Natural Heritage Methodology (Reese et al. 1986). Developments to Natural Heritage Methodology that have occurred over the past 40 years will be adapted to evaluate criteria for inclusion as CDAs or EPCs (NatureServe 2002, Faber-Langendoen et al. 2016, 2024). Up-to-date drone imagery of sites will be included in the surveys to provide overview images and additional capability to map element occurrences (EO) of plant community boundaries. These surveys will collect data to describe the following criteria of each dune system: plant community composition, invasive species and pests, ecosystem structure, current and historic anthropogenic disturbance, ecological processes, species of conservation concern.

Field teams shall be constructed of trained ecologists from MNFI and GEI working collaboratively, with EGLE staff assisting when schedules allow.

Final Delineation

Following field verification and assessment of the desktop-delineated CDAs, we will complete the final delineation of CDAs. The delineation will use field-acquired data to adjust CDA boundaries, as appropriate, to ensure that the CDA designation is in alignment with the defined criteria. This will be a major focus for the final three months of the project, once all field data has been collected and made available for updating initial delineations. The team will continue the digitizer / checker plan where a person other than the GIS CDA polygon digitizer will check their updated polygon edits. The revised CDAs, including de-designation areas, will be reviewed by senior members of the project team. EGLE will conduct a final review and approval of all work products.

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