

# Sediment Budget and Foredune Dynamics

Addison Arendt, Paige Brodeur, Josiah Eising, Jack Hiegel, and Madeleine Snella

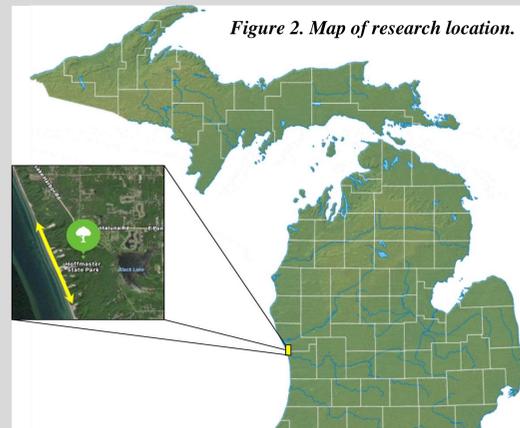


## Abstract

Given the impacts of rising lake levels on the West Michigan shoreline, information regarding the changing beach dynamics is of great importance. The data collected in this study helps to evaluate the changing shoreline and the sediment exchange between beach and foredune. A main study objective included measuring and mapping scarp heights at various intervals and classifying them as nonexistent, low, medium, or high. We also calculated the percentage of the shoreline that was covered by each height category of scarp. This data was acquired primarily through direct scarp height measurements and the GPS mapping of approximately 70% of the shoreline of P.J Hoffmaster State Park. Our study found that only 13% of the mapped beach-dune boundary had no scarp, while low and medium scarps made up approximately 20% of the shoreline each. High scarps were much more prevalent, consisting of 42% of the shoreline. The elevated levels of scarp indicate that the foredune is contributing to the sediment budget through substantial wave erosion taking place.

## Study Area

P.J. Hoffmaster State Park is a public recreation area on the shores of Lake Michigan (Fig. 2), located five miles north of Grand Haven at the southwest corner of Norton Shores in Muskegon County.



## Methods

We categorized the foredune scarp into nonexistent, low, medium, and high scarps (Fig. 3). We mapped the sections of scarp that fell into those categories, along with the waterline, using the line function on the GPS. The heights of scarps at various points along the beach were measured with a stadia rod. All GPS data was then analyzed in ARCGis.

Figure 3. Boundary categories with photo examples.

Beach-Foredune Boundary Category	Description
Non-existent scarp	No scarp present
Low scarp	Scarp present is <50 cm high
Medium scarp	Scarp present is 50-125 cm high
High scarp	Scarp present is >125 cm high

## Discussion

GPS points were plotted over an older Google Earth aerial photograph so that we could compare the previous and current waterlines. The water levels have risen significantly [2].

One of our explanations for the increased scarp heights is that the scarping is actually into the dune ridge, not the foredune. Comparing past photographs to the present, we can see that the water level has risen completely over the old foredune. This means that the dune being scarped is the dune ridge.

## Conclusions

In mapping the beach-foredune boundary, we found that the majority was scarped and the scarp heights varied from low to very high. This means that the foredunes were being eroded, therefore adding sediment to the beach. Some of the larger scarp heights occurred where the foredune was completely eroded, and the waves were cutting further inland to the dune ridge. In most of the areas with no scarp we saw a lot of wrack which indicated that non-scarped areas experienced substantial deposition. Our research also sets a baseline, so that future studies can compare our data on foredune scarp and the waterline in order to evaluate shoreline changes over time.

## Acknowledgments

We would like to thank Katie Benedict for guiding our research throughout the entire project, as well as Dr. Deanna van Dijk for providing key input regarding the structure of our study. A special thanks goes to P.J Hoffmaster State Park for allowing us to conduct our study on its beach. Lastly, we would like to thank Michigan Space Grant for their funding which facilitated our transportation over the course of our research.

## References

- [1] Davidson-Arnott, Robin, Patrick Hesp, Jeff Ollerhead, Ian Walker, Bernard Bauer, Irene Delgado-Fernandez, and Thomas Smyth. 2018. "Sediment Budget Controls on Foredune Height: Comparing Simulation Model Results with Field Data." *Earth Surface Processes and Landforms* 43: 1798-1810.
- [2] Mathew, Sojan, Robin G.D. Davidson Arnott, and Jeff Ollerhead. 2010. "Evolution of Beach-Dune System Following a Catastrophic Storm Overwash Event: Greenwich Dunes, Prince Edward Island, 1936-2005" *Canadian Journal of Earth Sciences* 47: 273-290.
- [3] Suanes, Serge, Jean-Marie Cariolet, Romain Cancouet, Fabrice Arduin, Christophe Delacourt. 2012. "Dune Recovery After Storm Erosion on a High Energy Beach; Vougot Beach, Brittany (France)." *Geomorphology* 139-140: 16-33.

## Introduction

Foredunes have been studied to understand the impacts beaches and dunes have on each other [1-3]. The foredune is vulnerable to scarping (Fig. 1), especially during the current high Lake Michigan levels, which moves sand from the dune to the beach's sediment budget. Our study was designed to discover how foredunes add or detract from a beach's sediment budget.

Figure 1. Example of a scarp.



## Results

Figure 4. Percentages of different scarp categorizations.

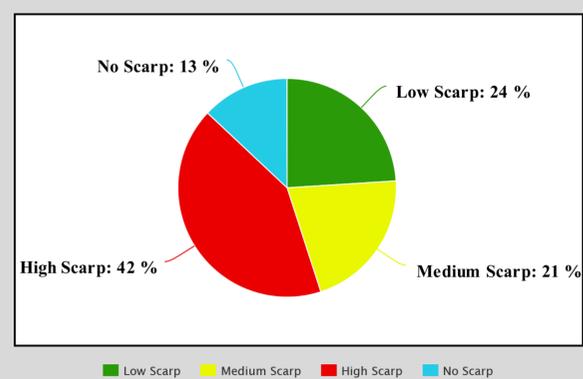
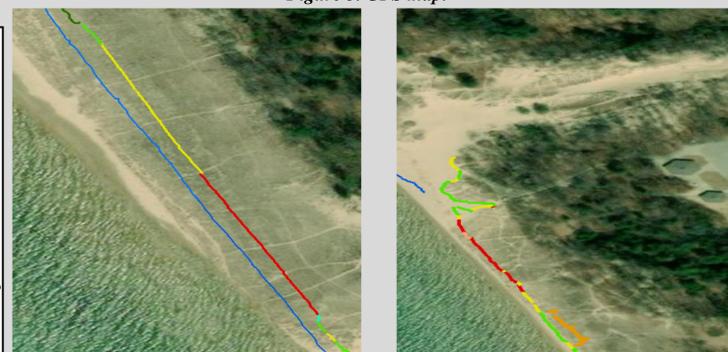
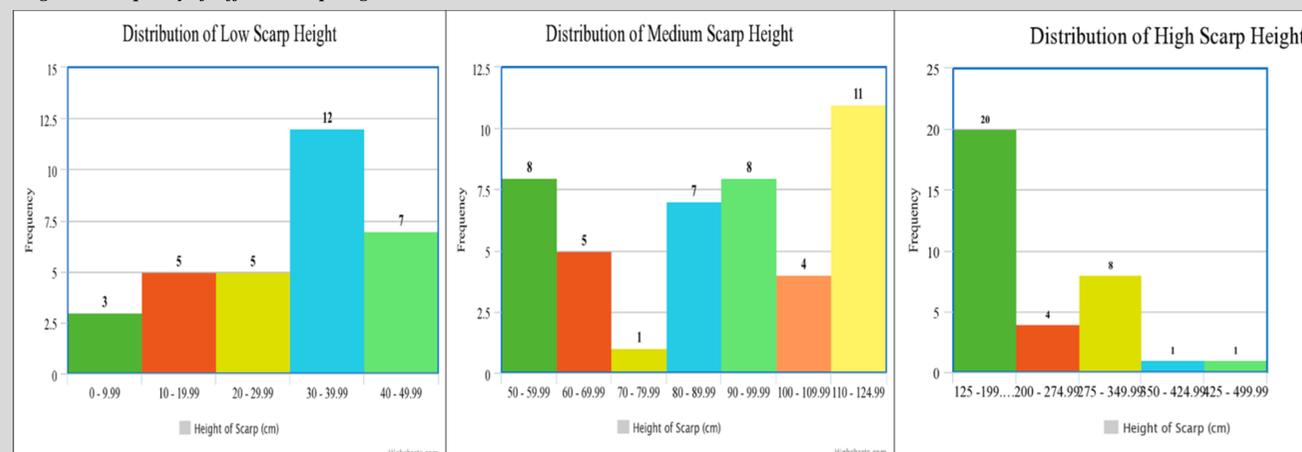


Figure 5. GPS map.



We mapped 70% of the shoreline of P.J Hoffmaster State Park. Only 13% of the mapped beach-dune boundary had no scarp, whereas high scarps were very prevalent, consisting of 42% of the shoreline (Fig. 4 and 5).

Figure 6. Frequency of different scarp heights.



The histograms (Fig. 6) represent the distribution of scarp heights within the categories of low, medium, and high. Even within the low and medium scarp category, most of the data points trend toward a greater scarp height.

## Project Goals

The objectives of this study were to:

- Map the boundary between the beach and foredune
- Record and categorize scarp heights, as indicators of erosion and additions to the sediment budget
- Collect baseline measurements for use in future studies