

Lake Michigan Coastal Dune Interaction with Storms

Kathryn E. Gerber, Jen-Li Sin, Jacob T. Swineford, Alek K. Zapata

CALVIN
College



Abstract

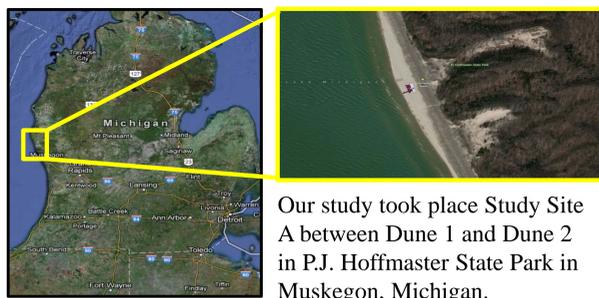
Storms have long been recognized as having an effect on dune landscape evolution on Lake Michigan. It is surprising, then, that little data exists to study exactly how these storms affect dune ecosystems. Hence, an area between Dune 1 and Dune 2 in Hoffmaster State Park was studied during October and November of 2012 to investigate the effects of fall storms on specific coastal foredunes. We used an electronic total station, erosion pins, a time-lapse camera, anemometer data, and reference pins to map the site topography, measure sand movement and measure water level respectively. The results show that most of the effects on a foredune from a storm come from the abnormal wind speeds and the wave erosion on the recreational beach. Scarping, increased rates of erosion and deposition, and substantial wave run-up are more specific examples of how this occurred.

Introduction

Storms are an important part of a dune system because they possess the capability to alter the landscape of a dune. Past studies have shown the recovery of a dune system after a large storm event [1] but few represent data during the storm and none have been conducted regarding the Great Lakes region. This study sought to uncover more specific effects of storms on Michigan's coastal dunes during the tempestuous late fall season.

Objectives

- Compare wind speeds to sand transport using erosion pin data and the anemometer station
- Observe the effects of wave erosion on the recreational beach following a storm event
- Determine specific changes that autumn storms makes to the foredune system



Our study took place Study Site A between Dune 1 and Dune 2 in P.J. Hoffmaster State Park in Muskegon, Michigan.

Methods

- Total station survey to study initial foredune shaping before any observed storms
- Reference posts to evaluate wave run-up length set 5 meters apart 20 meters up the recreational beach
- Time-lapse photography to record wave run-up
- Erosion pins to study erosion and deposition patterns following storm events
- Anemometer tower to document wind speeds

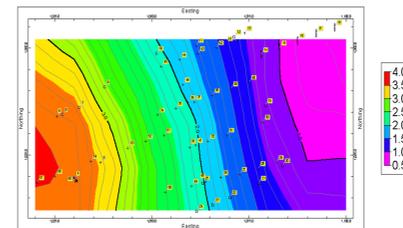


Figure 1: A topographical map of the foredune and recreational beach made with the SOKKIA total station. Yellow points are locations of erosion pins.

Results

Erosion and Deposition

In the period between our first two measurements, there was a strong storm system that traveled through the area. Although there was no distinct pattern of erosion and deposition, most erosion pins displayed a change within 5 centimeters due to sand transport. Between our second two measurements, a similar storm occurred, forming similar results.

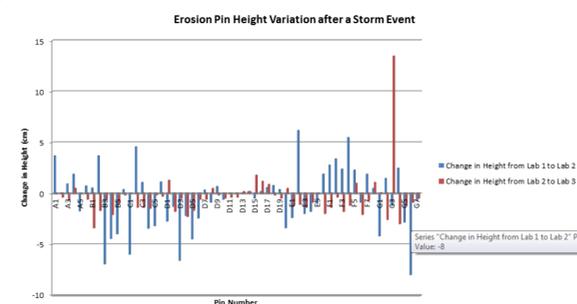


Figure 2: The change in centimeters of the heights of the erosion pins at Study Site A during the two week period are represented by blue for the first week and red for the second.

Wave Run-up Height

Data collected from the time-lapse camera demonstrates instances in which the wave run-up during storm periods increased its distance upon the beach.



Figure 4: The run-up moved to the 4th pin; 10 meters up the recreational beach

Wind Data

The wind data showed that during the storm systems the average wind speed in meters per second peaked. Maximums of the storms were 13.85 and 14.35 m/s, respectively.

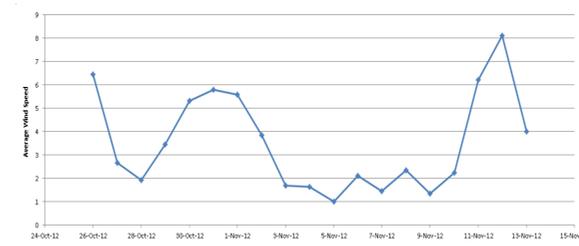


Figure 3: The fluctuation of average wind speed in meters per second over the two week study period demonstrates when large storms passed through the area with high relative wind speeds

Recreational Beach Change

Following a storm event, a unique physical change called scarping was observed on the recreational beach because of the higher-than-average wind speeds and increased wave run-up lengths.



Figure 5: Scarping was also a dramatic effect of wave erosion and run-up

Discussion

Erosion and deposition on the dune are accredited to the fact that the storm system had low precipitation and wind speeds up to 10 meters per second higher than normal. Wind speeds during this storm were reaching up to 13.85 m/s, and according to the National Weather Service [4], precipitation was 1.016 mm over two days of the storm. Low precipitation will keep the sand free from moisture, allowing for high transport rates [3].

The wave run-up also increases substantially, enough to erode the beach. As observed, scarping increases and the waves are able to move, in some cases, 10 meters up the beach.

Conclusions

The results of our study shows the primary effect of autumn storms on Lake Michigan foredunes occurs because of high wind speeds and wave erosion. Wave run-up adds to scarping and recreational beach erosion, and the combination of low precipitation and high winds made the impacts of sand transport much more dramatic. We were also able to make connections based on the anemometer data and the erosion pins, in that the higher wind speeds resulted in copious amounts of deposition and erosion on the foredune. This is consistent with previous studies that suggest autumn winds produce the largest amount of aeolian activity of the year [2].

Acknowledgements

Special thanks to the National Science Foundation, P.J. Hoffmaster State Park, Dr. Deanna van Dijk, and Linden Brinks.

References

- [1] Mathew, S., Davidson-Arnott, R., Ollerhead, J. (2010) "Evolution of a beach-dune system following a catastrophic storm overwash event: Greenwich Dunes, Prince Edward Island, 1936-2005" *Canadian Journal of Earth Science* 47: 273-290
- [2] van Dijk, D. (2004). "Contemporary geomorphic processes and change on Lake Michigan coastal dunes: An example from Hoffmaster State Park, Michigan." *Michigan Academician* 35: 425-453
- [3] van Dijk, D. (2010). "Beyond the Basics: Wet sands and wind processes." *Lake Michigan Coastal Dunes*.
- [4] Webmaster, GRR. "National Weather Service Weather Forecast Office." *National Weather Service Forecast Office*. National Weather Service, 11 July 2012. Web. 15 Nov. 2012. <<http://www.crh.noaa.gov/grr/climate/f6/data/?site=mkg>>.