The Effects of Autumn Storms on an Artificial Dune

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Abstract

The variability of autumn storms in West Michigan requires more study focused on how storms affect dunes. Local effects of storms were investigated on an artificial dune named Perseverance Dune at Calvin University in Grand Rapids, Michigan. The objectives of this study were to assess storm characteristics, measure the patterns of erosion across the dune surface, and compare dune change with storm characteristics. In the months of October and November 2020, an erosion pin grid was used to measure changes in erosion and sand samples were taken to determine moisture content. On-site measurements of storm characteristics included wind speed and direction and precipitation. During one storm, wind and precipitation caused downslope erosion on the dune. Most of the erosion was from runoff, which was a product of the grass layer beneath the artificial dune. During another storm, strong winds with little precipitation resulted in upslope erosion. The amount of runoff erosion on the artificial dune indicates the importance of good drainage of water through the sands of most natural dunes.

Introduction

Significant storm erosion patterns have been recorded on Lake Michigan sand dunes [1]. Autumn storms have large and complicated impacts because of high winds and variables such as rain and snow [2]. Our research focused on the impacts of autumn storms on Perseverance Dune, a young, artificial dune with no prior research.

Study Objectives

- Assess storm characteristics
- Measure surface change across the dune surface
- Compare dune surface change with storm characteristics

Study Area

Perseverance Dune (Figure 1) was created in August 2020 on the campus of Calvin University in Grand Rapids, MI for student research experiences. Locally-mined sand was deposited on an existing slope that faced northwest.

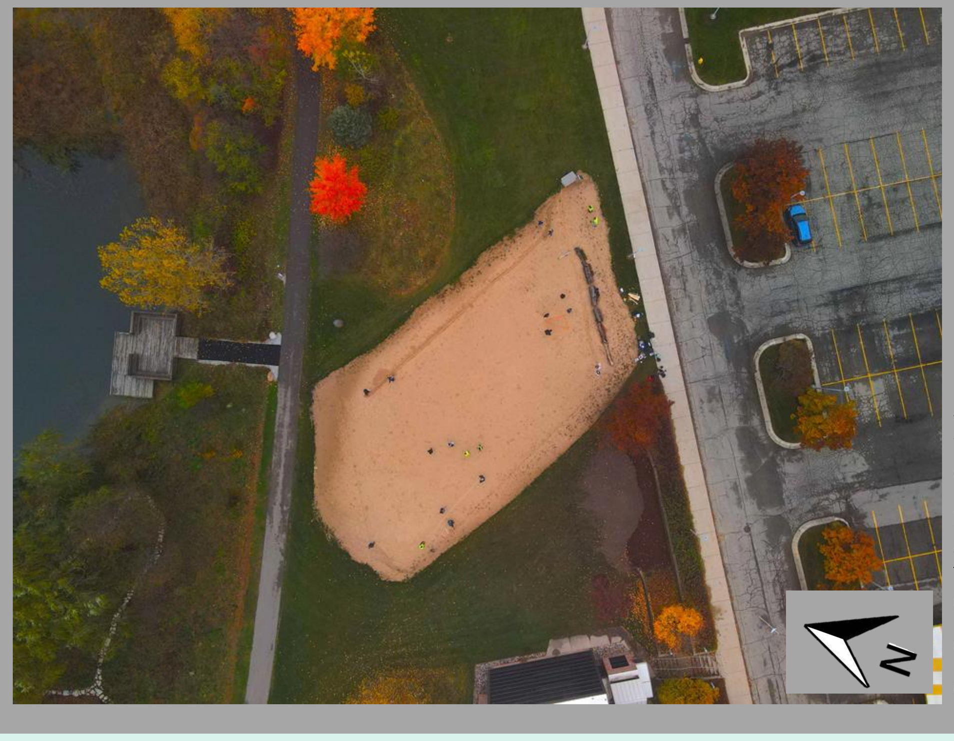

Figure 1. Aerial view of Perseverance Dune shows infrastructure including a parking lot (south), building (west) and pathway (north) of the dune.

Methods

We used a variety of methods to understand different aspects of autumn storms and to collect data from Perseverance Dune (Table 1; Figure 2). Amounts of surface change were compared for each storm to identify the most influential variables.

Study Objective	Variable	Method
Assess storm characteristics	Wind speed	Anemometer
	Wind direction	Wind vane
	Precipitation	National Weather Service data
Measure surface change across the dune surface	Sand deposition or erosion	Erosion pins
	Surface moisture	Oven-drying collected samples
	Sand movement	Visual/photos

Table 1. Methods are shown relative to the study objectives they fulfill.

Figure 2. Measurement locations are shown relative to the dune area.

Results

Storms: Three autumn storms are summarized in Table 2. The first storm had the most precipitation and lowest wind speeds. The second storm had much stronger winds, lower temperatures and a mix of rain and snow. The third storm was windy with almost no precipitation. Winds from the south in the third storm contrasted with the west winds in the first two storms.

	Storm Dates	Wind Speed (max m/s)	Wind Direction (degrees)	Precipitation (cm)	Temperature (high/low ˚C)
Storm 1	Oct 22-23	6.65	261.5 (W)	2.77 (rain)	20/4
Storm 2	Oct 31- Nov 1	12.58	289.4 (W)	0.48 (rain/snow)	12/-4
Storm 3	Nov 10-11	10.10	186.4 (S)	trace	14/-1

Table 2. Measured characteristics of the autumn storms.

Surface Changes: The storms produced a wide range of deposition and erosion across the dune surface (Figure 3). The first storm had small changes across the surface, while the second storm had areas of much higher erosion. The final storm showed deposition across most of the area. Surface moisture measurements showed the first two storms had a moisture content of 10%, while the third storm had a moisture content of 5%.

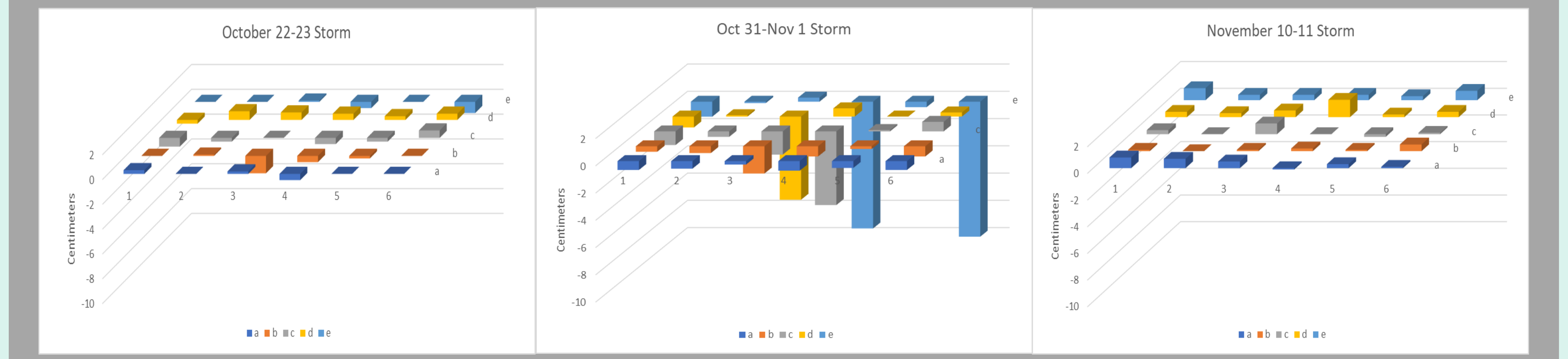

Figure 3. Measured surface changes at erosion pins for each storm. Pin a1 is in the northwest corner and pin e6 is in the southeast corner of the erosion pin area.

Comparison: Water erosion at the base of the dune occurred during the first storm with moderate west winds and high precipitation. Areas of large wind erosion occurred during the second storm with strong west winds and low precipitation. Consistent wind deposition occurred during the third storm with strong south winds and little to no precipitation.

Discussion

Our study suggests that differences in storm characteristics determine the type of surface change. The first two storms produced higher moisture content in the sand with inconsistent surface change. The third storm led to more consistent deposition of sand due to lower moisture levels in the sand and a different wind direction. This data supports the conclusion that higher wind speeds move more sand, but the surface moisture impacts how much of the sand is moveable.

Natural dunes are comprised largely of sand which allows for good drainage of storm precipitation. Unlike natural dunes, this artificial dune has a grass/soil layer relatively close to the surface of the dune. Water collecting on the grass/soil layer cause the sand to become over-saturated and slide down the slope (Figure 5).

Figure 5. Photos of the north (bottom) edge of the dune show A) over-saturated sand on Oct. 23 approx. 35 cm from the sidewalk and B) the dune edge 0 cm from the sidewalk on Nov. 11.

Conclusions

The three autumn storms during the study period had different combinations of wind and precipitation. The storm with the strongest winds and lower amount of precipitation had the largest wind-related erosion. While the artificial dune experienced more water erosion than a natural dune, the dune is still responsive to the complicated variables of autumn storms.

Acknowledgements

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Works Cited

[1] Hansen, E., S. DeVries-Zimmerman, D. van Dijk, and B. Yurk. 2009. "Patterns of Wind Flow and Aeolian Deposition on a Parabolic Dune on the Southeastern Shore of Lake Michigan." *Geomorphology* 105 (1–2): 147–57.

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