Autumn Storms and Perseverance Dune

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Abstract

Perseverance Dune is an artificial dune on the campus of Calvin University. Since it was created in the summer of 2020, this is the first time the dune is experiencing autumn storms. Our study investigates how the characteristics of autumn storms influence erosion and surface characteristics on Perseverance Dune. We measured patterns of erosion on the dune surface with a grid of erosion pins. An array of anemometers, wind vanes, and rain gauges on the dune documented storm characteristics. The dune characteristics we measured were surface moisture content, surface temperature, and visual observations. We studied a total of two storms during the data collection period. Results show a significant difference of surface change from the start of a storm to the end of the storm. With this research we can better understand how much autumn storms affect inland sand dunes like Perseverance Dune.

Introduction

This research study was centered around the impacts of autumn storms on the Perseverance Dune and was conducted by four undergraduate Calvin students. Significant storm erosion patterns have been recorded on the Lake Michigan sand dunes (Brinks et al. 2013). Perseverance Dune is a young, artificial dune on which the effects of storms had not yet been analyzed. Our main goal in this project was to analyze and understand the effects autumn storms have on Perseverance Dune by collecting specific data both before, during, and after storm events.

Study Objectives

The objectives of this study were to analyze patterns of erosion on the dune surface, investigate dune characteristics before and after a storm, and assess storm characteristics.

Study Area

This study focused on Perseverance Dune on Calvin University's Campus in Grand Rapids, Michigan. It is a man-made dune with one big building to the west and a pond to the north (Figure 1).

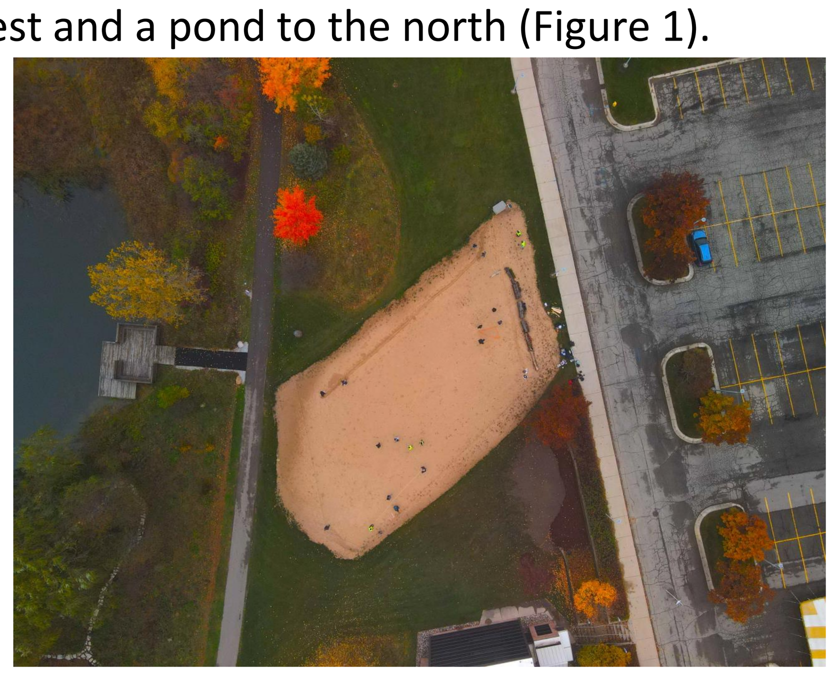

Figure 1. This image shows an aerial view of Perseverance Dune.

Methods

We used anemometers located around the dune, as well as on the wind tower, to collect wind data (Figure 2).

We collected temperature readings and moisture content samples, and we also monitored rain gauges.

We also set up an erosion pin grid with 30 erosion pins at the bottom of the dune.

Figure 2. Pictured is a GPS map of our erosion pin grid and the other instruments utilized for research.

Results

Two storms occurred during the study period, which are summarized in table 1.

Storm Dates	Average Wind Speed (meters/second)	Wind Direction	Precipitation (cm)
22-23 Oct	1.1555	E and SW by S	2.1
29 Oct-1 Nov	1.82	N and NW by W	1.5

Table 1. Storm characteristics during the study period.

The first storm occurred between October 22 and 23. This storm produced rain and wind from the southwest (Figure 3). On October 31-November 1, a much stronger wind and snowstorm occurred. This storm produced less precipitation but stronger winds from the southeast, north, and northwest. The strongest winds were from the northwest, so they likely resulted in the greatest erosion.

The most prevalent surface change was erosion. The first storm caused only slight erosion at the south end of our study area (avg -0.08 cm). The second storm resulted in the greatest erosion, especially at the south end of the dune, which had an average of 2.2 cm erosion (Figure 4).

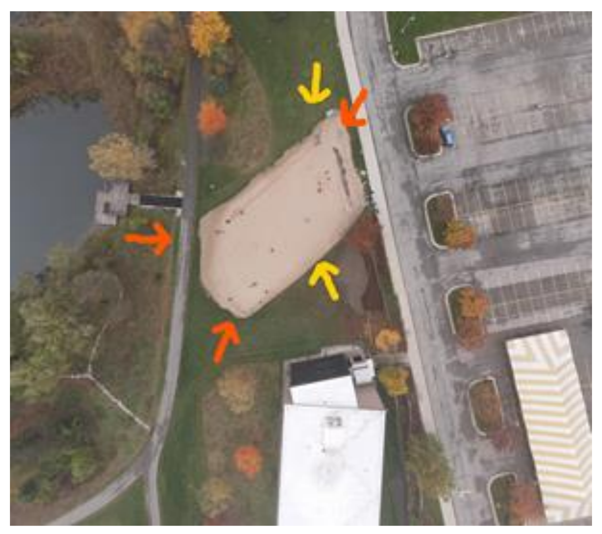

Figure 3. Storm wind directions. The yellow arrows represent directions of the first storm. Orange arrows represent the wind directions of the second storm.

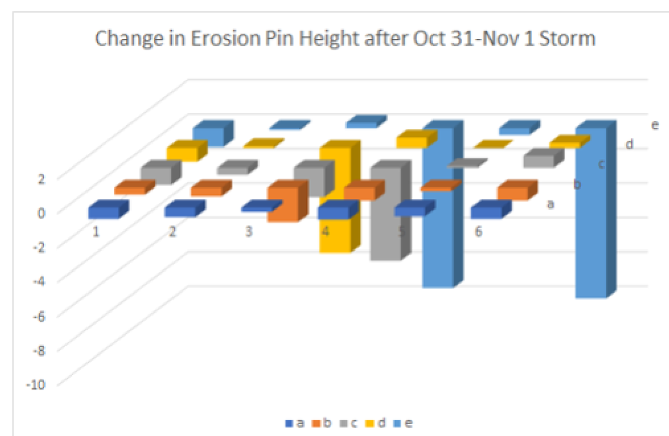

Figure 4. This graph shows the change in erosion pin height after the second storm.

The sand water content percentage was significantly higher during stormy days. The percentage was highest at the lowest point of our grid which is close to a small scale outwash plain.

The rain collected in the gauge was significantly higher during the storm days. Our rain gauge had 0.6 cm more water after the first storm than after the second storm.

Sand temperatures dropped by an average of 3.25 C after the first storm and 14.2 C after the second storm. With sand temperature, we can see a trend in decreasing sand temperatures post storm.

Discussion

We interpret the greater erosion on the south section of our study area to primarily be a result of wind and rain runoff. We theorize that northwest winds, which were typically the strongest, likely increased as they moved up the dune slope, eroding a greater amount of sand. While the building in figure 4 may be blocking some wind, that effect does not seem significant based on erosion data.

Precipitation was much greater during the first storm than the second, indicating that rainwater runoff is the probable cause of some erosion during the first storm. Some of that sand may have flowed down the west side of the dune to a small outwash on the north end of the dune. However, this runoff likely did not significantly affect erosion since the water flow was generally not near our study area (Figure 5).

Figure 5. This image shows a before and after of the sand movement to the sidewalk. At the beginning of the research period, the sand was a distance of 35 cm. Recently, the sand was at a distance of 0 cm.

Conclusions

In our study of autumn storms on Perseverance Dune, the data collected shows that the greatest, erosion-causing storm characteristics of two significant storms during the research period were wind and rain. The first storm had greater rainfall, whereas the second had stronger wind speeds. The stronger wind speeds of the second storm had greater erosion impact than the first storm. The erosion pin data, and other measurements, support the conclusion that notable erosion was caused by storms therefore causing the sediment to move south (up the dune).

Acknowledgements

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References

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