Dune Advance on Mt. Baldy

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Abstract

Due to the location of P.J. Hoffmaster State Park's visitor center in relation to a large parabolic dune, the authorities want to know Mt. Baldy's rate and direction of advance. Our study was created to determine the current risk the dune imposes upon the park's visitor center. Erosion, deposition and vegetation were studied by using quadrats, erosion pins, and monitoring posts. Weekly measurements of sand advance were collected on both the edge and throughout the slipface. GIS mapping was used to construct a plan view map of the slipface and blowouts, and additional maps were created to display the locations of erosion pins and quadrats. Vegetation inside the quadrats was measured and recorded as well to show average vegetation for an area. Results from the study indicate a slow dune advance north eastward. The areas with more vegetation showed slower advance rates than the areas with no or minimal vegetation. Due to the minimal sand advance rate and the general direction of migration, it can be concluded that Mt. Baldy poses no imminent threat on the park's facilities.

Introduction

Dune advance rate is an important factor to consider in dune management [1]. In relation to dune advance, vegetation represents an important variable that should be considered [2]. This project investigates the overall movement of Mt. Baldy in relation to vegetation and this movement in regards to the location of the visitor center.

Study Area

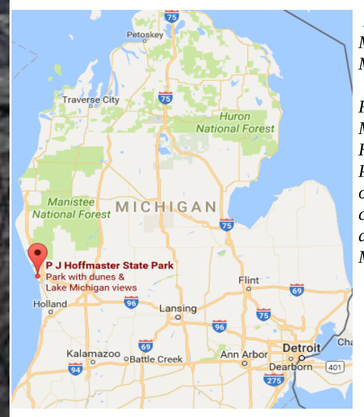

Figure 1 (left) Map of Michigan

Figure 2 (right) Map of Hoffmaster State Park with a star over the visitor center and an arrow showing Mt. Baldy

The area of this study was a large coastal parabolic dune on the east coast of Lake Michigan (figure 1). Mt. Baldy is the largest dune in Hoffmaster State Park, located just northeast of the Visitor Center (figure 2).

Objectives and Methods

- Calculate and assess Mt. Baldy's advance
- Assess and map the different vegetation regions on the slipface of Mt. Baldy using quadrats and GPS (figure 3)
- Assess the influence of vegetation on Mt. Baldy's slipface angle, erosion and deposition, and advance

The quadrats are randomly taken within certain regions to get a good representation of the average vegetation in that area. The erosion pins were set up in a grid over the slip face so as to provide a general idea of where sand movement is occurring. The monitoring post measurements were a measurement from the post to the base of the slipface, thus providing overall movement data.

Figure 3 (below) Table of methods

Purpose	Equipment	Location	Frequency
Assess vegetation	Quadrat (marked with GPS)	10 in each vegetation region	Taken once
Measure sand movement on slipface	Erosion Pin	3 across slipface at 3 elevations	Measured during 3 site visits
Measure dune advance	Monitoring Posts (marked with GPS)	Ascending numbers from S to N along slipface edge	Over 3 visits as well as previous year's data

Results

Net changes in height of the erosion pins (from beginning of study to end) can be found in figure 4. A positive number shows sand erosion and a negative number shows sand deposition. This data shows that there was more sand deposited on the north side; this could point to an overall northeast movement of the dune.

	Crest			
South	0.09	0.022	0	North
	-0.01	-0.005	-0.01	
	0.005	0.05	-0.005	
	Bottom			

Figure 4. Erosion pin measurements (in m)

Vegetation differences were found at the differing pins (figure 5) including trees at pin numbers 8, 15, 22, 23, 24, sparse dune grass at pin 4, 8, 11, and 21, reed-like vegetation at pin 23, and denser grass at pins 10 and 15. The most deposition appears to be occurring in the sparse dune grass area where the dune is most active. This would correlate with a general movement of the dune to the northeast.

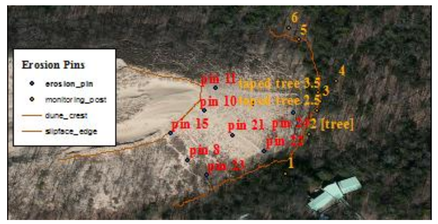

Figure 5. Erosion pin and monitoring post map

In 2014/2015 there was a dune advance of 0.08m at monitoring post 1 and 0.34m at post 5 (figure 6). In 2015/2016 there was a dune retreat of 0.16m at monitoring post 1 and 0.14m at post 5. These results would average out to movement towards posts 4 and 5.

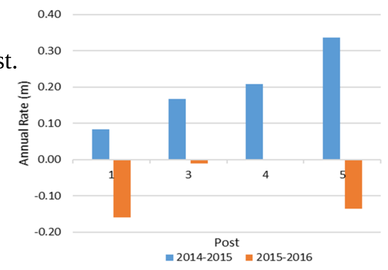

Figure 6. Monitoring post measurements

Discussion

We found that overall most of the erosion pins had a loss of sand, which means that much erosion down the dune slip face was occurring. Only three pins showed sand deposition, two of which are on the right side, which can imply that the main dune body itself is building on that side. From observation we could see sand sliding down the slip face and airborne sand being carried away from the top of the dune, both of which tell us that erosion is definitely present, which explains the loss of sand at erosion pins.

Despite erosion, we can conclude that for the most part the dune vegetation is doing a good job at holding the dune back and stabilizing it, which is what our sources told us beforehand [3]. It can be seen by comparing all of our data that the areas losing sand were the least vegetated and the areas gaining sand were the most vegetated.

Measurements taken closer to the north edge of the slipface showed greater dune advance, suggesting that the dune is moving more northeast than southeast. The minimal advance and measured retreat at Posts 1 and 3, which encompass the direction of the Visitor Center, suggest that the dune is not advancing significantly in the direction of the Visitor Center as it progresses.

Conclusion

In conclusion, the areas with vegetation are more stabilized than the areas with bare sand. Our findings showed that Mt. Baldy is moving northeast, not in the direct path of the visitor center. This means that the building is in no danger.

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References

[1] Dong, Z., X. Wang, G. Chen. 2000. "Monitoring sand dune advance in the Taklimakan Desert." *Geomorphology* 35:219-231.

[2] Hesp, P., M. Martinez, G. M. da Silva, N. Rodríguez-Revelo, E. Gutierrez, A. Humanes, D. Laínez, I. Montaño, V. Palacios, A. Quesada, L. Storero, G. González Trilla, C. Trochine. 2011. "Transgressive dunefield landforms and vegetation associations, Doña Juana, Veracruz, Mexico." *Earth Surface Processes and Landforms* 36:285-295.

[3] Girardi, J. D., and D. M. Davis. 2010. "Parabolic dune reactivation and migration at Napeague, NY, USA; insights from aerial and GPR imagery." *Geomorphology* 114(4):530-541.