The Interactions Between Blowout Features and Sand Transport

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Abstract

Sand transport shapes blowout characteristics and, in turn, blowout characteristics control wind and sand transport patterns. To better understand blowout interactions we studied three neighboring blowouts on a large parabolic dune in Hoffmaster State Park. Blowout characteristics were measured with field observation, stadia rod surveys, GPS, and aerial photos. Wind speed and direction were measured with anemometers on the foredune and at the entrance and crest of the largest blowout. At the crest of each blowout, sand transport was measured with sand traps. Results revealed a sequence of blowouts comprised of a saucer blowout, a grassy depression, a second saucer blowout, and a large trough blowout. Each blowout contained a mostly bare deflation area surrounded by small shrubs and grasses. Each blowout in the sequence increased in height and had its central axis shifted more towards the south. There was a greater amount of sand transport on the trough blowout than at either of the saucer blowouts. These results should spur future investigations of the dynamics of connected blowouts.

Introduction

Wind is one of the key factors in the formation and shaping of blowouts. Previous studies have shown that blowouts affect the patterns of entering wind flows [1]. Our study sought to better understand how blowout characteristics and wind interact in the context of a series of connected blowouts.

Our objectives for this study were to:

1. Measure the features of three connected blowouts.
2. Track wind movement and sediment transport through the blowouts.
3. Compare the wind patterns with the blowout characteristics.

Study Area

The study took place in Hoffmaster State Park on the southwest coast of Michigan. We focused on a series of three blowouts nested inside a parabolic dune (Fig.1).

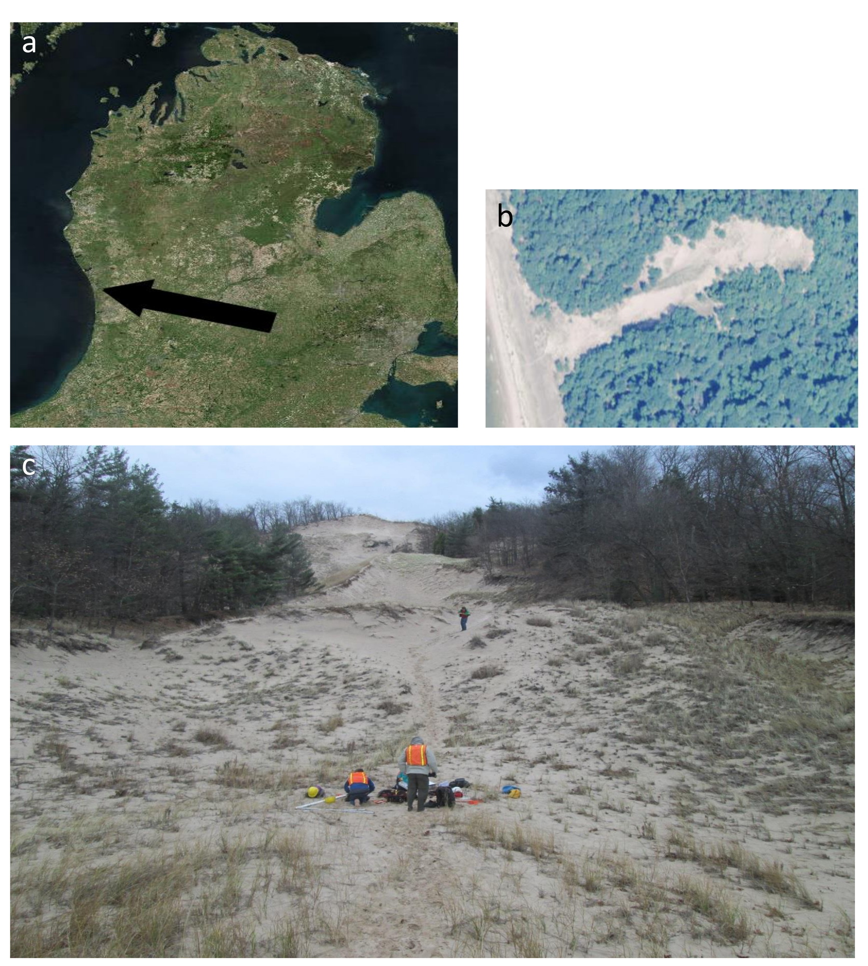

Fig. 1 a) Area location map, b) aerial photo of study area, and c) ground photo of blowouts inside parabolic dune. (Aerial imagery derived from Michigan Dune Inventory.)

Methods

We studied several different variables including blowout features during the 2015 fall season (Table 1). On November 12 we measured wind patterns and sand transport.

Variable	Method	Comments
Blowout shape	GPS, GIS	Blowout areas were mapped with GPS. GIS was used to determine the orientation of the blowouts' deflation areas.
Blowout width, length, and slope	Stadia rod survey (Fig.2), GIS	We surveyed transects of each blowout's deflation axis and took GIS measurements of the widths.
Blowout features	Observations, aerial photos	These methods were utilized chiefly for determining vegetation density.
Wind patterns	Anemometers, vane, and observations	Wind was measured at the entrance and crest of the largest blowout. Wind speed and direction were recorded at the foredune.
Sand transport	Sand traps, observations	Traps were placed at the crest of each blowout. Patterns were visually observed on site.

Table 1. Variables and methods.

Fig.2 The team sets up a stadia rod measurement.

Results

The series of blowouts consists of a bowl-shaped saucer blowout (S1), a narrow saucer blowout (S2), and a large trough blowout (T1) (Fig.3). For each consecutive blowout the deposition area increased in size. Each deflation area was mostly bare with scattered small vegetation such as dune grass.

The three blowouts had different characteristics (Table 2) with the trough blowout having the greatest length, area, and height. Each successive blowout had its deflation area central axis shift to the south. The blowouts grew in overall height as we progressed into the dune system (Fig.4).

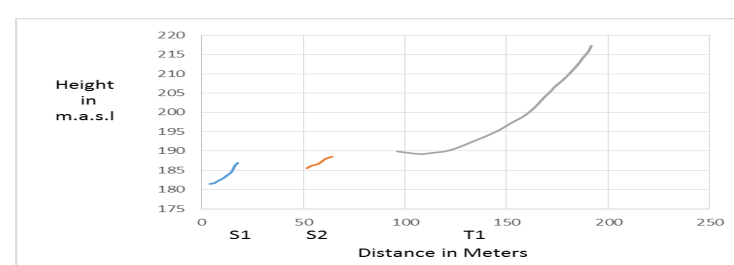

Fig. 4 Deflation area profiles of each blowout.

Fig. 3 Locations and characteristics of blowouts.

Blowout	Slope* (m/m)	Shape	Width (m)	Length* (m)	Area* (m^2)	Height (m)	Vegetation*	Orientation* (degrees)
Saucer 1 (S1)	0.279	Saucer	7.0	17.7	124	4.94	Sparse	54 (NE)
Saucer 2 (S2)	0.236	Saucer	5.2	14.8	77	3.5	Very sparse	58 (NE)
Trough 1 (T1)	0.267	Trough	20.3	102.0	2070	27.3	Sparse	78 (NE)

Table 2. Blowout characteristics (*indicates deflation area measurement).

Sediment collected by the sand traps increased on each consecutive blowout (Fig.5). Sand transport was observed to be following trails through the dune system.

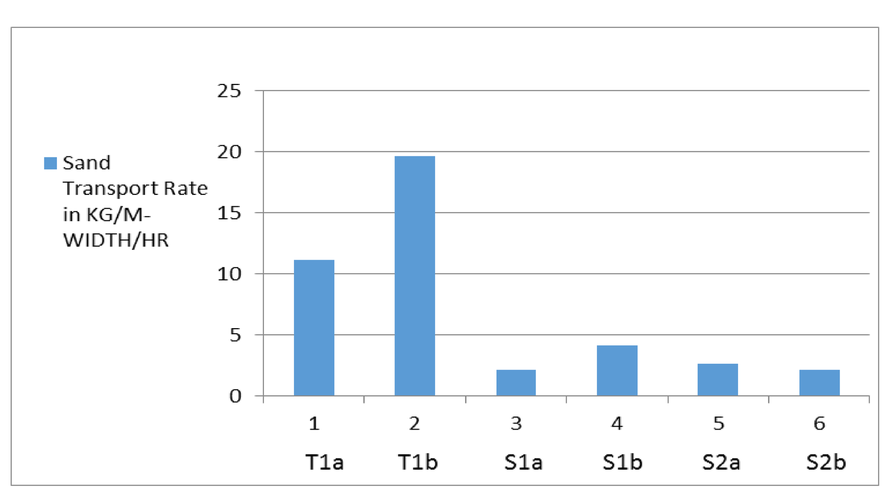

Fig. 5 Sand transport rates measured at sand traps.
(Note: S2b is incomplete as the sand trap collapsed during measurement.)

Our highest wind speeds were observed at the crest of the trough blowout (Fig.6). These measurements are examples of storm conditions with winds greater than 16 m/s. Wind direction was between 270 and 300 degrees (W-WNW).

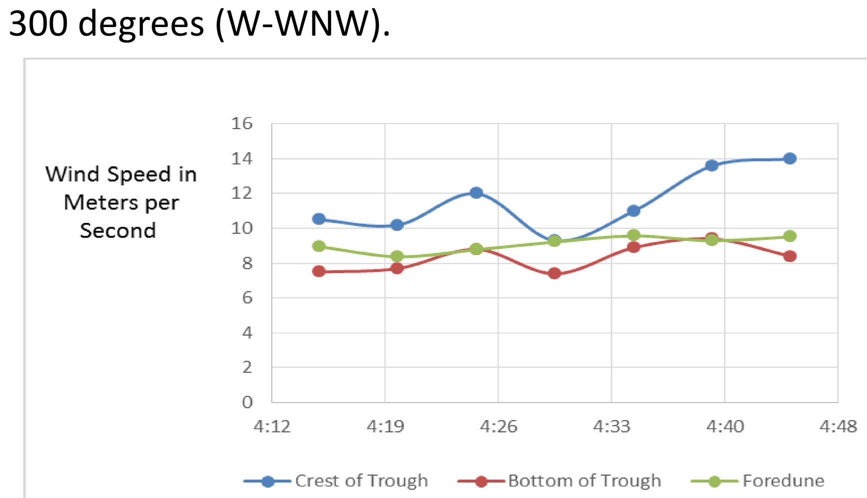

Fig. 6 November 12 wind measurements.

Discussion

These findings indicate that the effects of the wind patterns and blowout features intensified the further one went into the system. This could be explained by the previously studied phenomenon of wind speed increasing as it exits a blowout [2,3] (Fig. 8). The interactions between blowout and wind would also account for the increased amount of sand trapped on each sequential blowout in the dune system.

Fig. 8 Saucer 1 during storm conditions.

The differing shapes and sizes might also have had an effect on wind patterns as the trough blowout, with a larger area and height, saw more sediment transport than either of the smaller saucer blowouts. Due to the high winds present, our results are typical of storm conditions (Fig. 9).

Fig. 9 The three blowouts during the storm.

Conclusions

The trough blowout was significantly larger than the two saucer blowouts and saw much more sand transport. Wind speeds were higher at the crest of the blowout than at the foredune or the bottom of the dune. Further research will be helpful in understanding how blowouts interact with one another and affect the movement of coastal dunes.

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Works Cited

[1] Fraser, G.S., S.W. Bennett, G.A. Olyphant, N.J. Bauch, V. Ferguson, C.A. Gellasch, C.L. Millard, B. Mueller, P.J. O'Malley, J.N. Way, and M.C. Woodfield. 1998. "Windflow Circulation Patterns in a Coastal Dune Blowout." *Journal of Coastal Research* 14(2): 451-460.

[2] Hesp, Patrick A. 2002. "Foredunes and Blowouts: Initiation, Geomorphology and Dynamics." *Geomorphology* 48: 245-268.

[3] Hugenholtz, Chris H. and Stephen A. Wolfe. 2009. "Form-flow Interactions of an Aeolian Saucer Blowout." *Earth Surface Processes and Landforms* 34: 919-928.