Evaluation of Stability and Restoration of a Michigan Coastal Dune

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Abstract

There have been a series of studies on the effectiveness of planting vegetation to stabilize dunes, but how well does this management technique restore the natural dune environment? On coastal dunes, *Ammophila Breviligulata* is often planted as a management technique to slow dune advance. This study investigated the stability of North Beach dune, Michigan, and compared the natural and planted communities. Dune stability over ten years was evaluated by finding the advance rates using monitoring posts, and the change in vegetation cover using aerial photographs. The vegetation was measured to compare height, health, and percent cover between the planted vegetation on the upper windward slope, and the natural vegetation at the lower windward slope. From 2006 to 2016, stability has been established, as indicated by the vegetation, which has covered most of the bare sand, and advance rates that have slowed. The planted community remained a single species, while the natural community contained a greater number of species. The results indicate planting *Ammophila Breviligulata* is successful in establishing stability, but rehabilitating plant communities requires more than ten years to restore species diversity.

Introduction

As in other parts of the world, some Lake Michigan dunes are in danger of being damaged or destroyed because of the increase in tourism [1], which results in an increase of trampling [2]. Some of these dunes have been planted with *Ammophila breviligulata* (*Figure 1)* as a rehabilitation effort since it is an early colonizer and very effective at stabilizing dunes [3]. As opposed to other environments, monoculture plantings on dunes are effective in rehabilitation projects [4]. Our study investigated the effectiveness of planting vegetation as a management technique in restoring the natural dune environment and the stability of a Lake Michigan dune.

Figure 1) September 2009 photo of A. brev. *Planted on North Beach dune.*

The objectives for the study were to:

1) Measure the change in vegetation cover.
2) Study dune advance rates.
3) Compare the vegetation characteristics between the planted and natural communities.

Study Site

North Beach dune is located in Ferrysburg, Michigan (*Figure 2)*. A 2004 study found the dune was advancing towards the only road connecting a residential area to the local town [5]. Due to this threat, extensive management efforts were implemented between 2005-2008, one of which was the planting of *A. breviligulata.*

Figure 2) North Beach dune with Lake Michigan to the west. The road running south of the dune provides the only access to over 300 homes.

Methods

Changes in vegetation cover were measured by comparing ground and aerial photos *(Table 1)*. Dune advance rates were measured relative to previously installed monitoring posts. Vegetation characteristics were measured using quadrats and transects within selected zones on the dune *(figure 3)*.

Objective	Variables	Methods
Measure the change in vegetation cover	Percent cover of vegetation on the windward slope	Compare ground photos from 2008 to 2016. Compare aerial photos from 2005 and 2014.
Study dune advance rates	Dune edge positions Dune advance rate	Measure the distance of the slipface edge from posts. Compare dune edge positions from 1997 to present.
Compare vegetation characteristics between the natural and planted communities.	Plant height Species present. Plant health	Measure average tallest plant in a 0.5m^2 quadrat. Count the number of species within a quadrat. Rate the vegetation on a 1-5 scale.

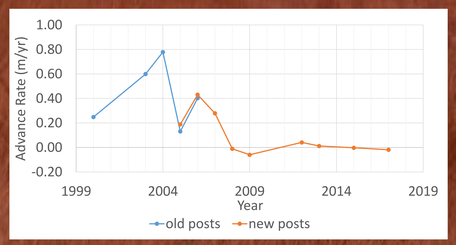
Table 1) Methods and variables measured for each objective.

Figure 3) North Beach dune was divided into a grid of 9 squares on the windward slope and numbered by zone to allow for randomization in the data collection.

Results

Ground photos show the vegetation cover increased by 23% on the windward slope of the dune from 2008 to 2016 *(Figure 4)*. Aerial photos indicate an increase of 54% vegetation cover from 2005 to 2014.

Figure 4) The vegetation cover on North Beach dune has changed from 68% in 2008 to 91% in 2016 based on ground photos. Aerial photos indicate a change from 14% in 2005 to 68% in 2014.



Measurements indicate North Beach dune advanced from 1998 to 2004 *(Figure 5)*. Between 2004 and 2008, advance rates decreased to 0 m/yr. Since 2008 the dune advance rate has remained relatively stable.

Figure 5) Advance rates of North Beach dune in three stages: an increase in activity until 2004, a period of decreasing rates until 2008, and inactivity from 2008 on.

The measurements of the vegetation (*Figure 6)* reveal there is a difference of 13cm from the tallest average plant to the shortest. In all measured locations, plant health and species were low, with health ratings from 1 to 3. Only one species was found among the planted vegetation and on the slipface, compared to 2 in the mixed communities and 3 in the natural vegetation.

Plant health			Species present			Average tallest plant			
2	3	2	1	1	1	30.3	31.6	31.6	Planted (Upper windward)
2	0		1	2		35.4	31.8		Mixed
		3			3			30.4	Natural (Lower windward)

Legend				
Plant Health	0	1	2	3
Species	1		2	3
Average tallest plant	Shaded green for order of tallest average vegetation to shortest average from dark to light			

Figure 6) Distributions of plant characteristics on North Beach dune.

Discussion

Since planting *A. brev.* in 2005, the dune advance rate has decreased. Due to dune inactivity, leaf litter and surface reworking make dune position difficult to measure *(Figure 7)*. This likely produced the variability in *Figure 5.*

Although there is variability in the change in vegetation cover between aerial and ground photo measurements, the trend of the data indicates planting *A. brev.* on North Beach dune *(figure 8)* is effective at rehabilitating disturbed sites. The increased vegetation cover would slow dune advance.

Figure 7) Leaf litter at the base of the slipface.

Figure 8) September 2009, planted A. brev.

Between the natural and planted communities, the vegetation characteristics differed only slightly in height and health. Species diversity showed a trend in which planted vegetation remained a single species while the natural community included three species. These results are consistent with a ten-year study on a dune that had undergone planting *A. brev.* as a rehabilitation technique [6].

Conclusion

Dune advance rates and changes in vegetation cover indicate planting *A. brev.* is successful in establishing dune stability, but rehabilitating plant communities requires more than ten years to restore species diversity. Based on dune advance rates and changes in percent cover, it is recommended to plant *A. brev*. to stabilize disturbed dune surfaces. To restore species diversity, either more time is required or more species should be introduced.

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Works Cited

[1] F. van der Meulen & A. H. P. M. Salman. 1996. "Management of Mediterranean coastal dunes" *Ocean & Coastal Management*, Vol. 30, No. 2-3, pp. 177-195.
[2] Daniela C. Talora, Teresa C. Magro and Ana C. Schilling. 2007. "Impacts associated with trampling on tropical sand dune vegetation" *Forest Snow and Landscape Research*, Vol. 81, pp. 151-162.
[3] M. A. Maun and J. Lapierre. 1984. "The effects of burial by sand on *Ammophila breviligulata*." *Journal of Ecology*, Vol. 72, No. 3, pp. 827-839
[4] Sarah M. Emery and Jennifer A. Rudgers. 2010. "Ecological assessment of dune restorations in the Great Lakes region" *Restoration Ecology,* vol. 18, pp. 184-194.
[5] Jamieson, K., and D. van Dijk. 2004. "A study of the active parabolic dune in North Beach Park, Ottawa County, Michigan." Report to Ottawa County Parks and Recreation Commission. Grand Rapids (MI): Department of Geology, Geography and Environmental Studies, Calvin College. 41 p.
[6] Francoise Rozé and Servane Lemauviel. 2004. "Sand dune restoration in North Brittany, France: a 10-Year monitoring study." *Restoration Ecology* Vol. 12, No. 1, pp. 29-35.