

First-Year Research in Earth Sciences: Dunes



Long-term Effects of Planted *Ammophila breviligulata* on North Beach Dune

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ABSTRACT

Ammophila breviligulata is a beach grass commonly planted for dune management because of its burial tolerance and effectiveness in sand stabilization. The long term effect of planted beachgrass is not fully understood. This study investigated the vegetation health, distribution, and density of planted *A. breviligulata* in relation to the characteristics of a Lake Michigan coastal dune site. The study location is North Beach dune, which in 2004 was moving towards the only access road for many shoreline homes. To stabilize the dune, Ottawa County Park staff and volunteers have been planting *A. breviligulata* periodically over the past ten years. The investigation included comparing photographs from 2004 to 2014 and using GPS to map vegetated areas. The study area was divided into 9 sections and randomly-selected quadrats were used to measure plant health, maximum height, and density. Photographic comparisons show that the planted beach grass has spread across much of the windward slope of the dune. Grass near sand fences was taller and healthier than grasses in transition areas between bare sand and full vegetation. Areas with steeper slopes had generally taller, healthier plants than areas with gentle slopes. The results suggest that 5-10 years after being planted, *A. breviligulata* was moderately healthy and offering greater protection to the dune surface.

INTRODUCTION

Ammophila breviligulata (American beach grass) is a commonly used beachgrass for management and stabilization purposes because of its tolerance for burial (Figure 1). It extends its roots laterally, forming rhizomes sometimes several meters long that help it to sustain erosion and deposition occurring frequently in a dynamic dune environment (Maun 1985). There have been many studies done on *A. breviligulata* and how it helps to stabilize dune systems (Freestone and Nordstrom 2001; Emery and Rudgers 2011). But few studies have been done specifically on plant characteristics several years after planting. This study focused on planted *A. breviligulata* and its establishment on a Lake Michigan dune 5-10 years after planting.



Figure 1: Planted *Ammophila breviligulata* at North Beach dune, Michigan.

The objectives for the study were to:

1. Determine condition of planted *A. breviligulata*,
2. Assess distribution of beachgrass over the dune, and
3. Investigate relationship between plant characteristics and environmental conditions.

BACKGROUND

Interaction between vegetation and dunes is a topic that has been explored by many different studies in both marine environments (Hertling and Lubke 1999; Freestone and Nordstrom 2001; Gallego-Fernández *et al.* 2011) and the Great Lakes (Emery and Rudgers 2010; Emery and Rudgers 2011). Various topics of interest have been studied such as the stabilizing and successional effects of beach grass (Emery and Rudgers 2010), wind and surface conditions (Hansen *et al.* 2009), and the various distinguishing features of *Ammophila breviligulata* (Maun 1984).

Ammophila species have been used as dune stabilizers from South Africa (Hertling and Lubke 1999) to New Jersey (Freestone and Nordstrom 2001) because of their hardy nature and durability in unstable conditions. Historically, *Ammophila breviligulata* played a crucial role in stabilizing dunes after large disturbances, such as storm events (Mathew *et al.* 2010), and in stabilizing dunes at restoration sites (Emery and Rudgers 2010). Stabilizing dunes is an important practice in the Great Lakes region, as many cases of extreme dune movement have involved potential damage to both private (Vander Bilt *et al.* 2013) and public land (Jamieson and van Dijk 2004). In these circumstances, *A. breviligulata* is almost always used in monoculture plantings for restoration purposes (Emery and Rudgers 2010). In the Great Lakes region, restored sites normally take a 20-30 year time-frame before they begin to resemble a natural ecosystem in terms of diversity and ecosystem processes (Emery and Rudgers 2010).

The active dune environment can be inhospitable to most vegetation because it requires species with high tolerance for sand movement and burial. For example, wind speeds accompanying strong autumn storms in west Michigan can exceed 15 m/s (Swineford *et al.* 2014). Because of topographic acceleration, wind speeds on the windward slope of a large parabolic dune can be anywhere from 10-90% stronger than wind speeds on the beach (Hansen *et al.* 2009). Such active environments can result in a fairly low natural diversity and plant coverage.

A. breviligulata is one of the few species that can do well in these environments because of its tolerance for sand movement and resulting burial. Various studies have been done that have assessed *A. breviligulata*'s response to disturbance. *A. breviligulata* can maintain its density growth in sand deposition up to 60cm (Maun 1984). After this point, it reduces density by about 50 percent, but can still survive up until about 100cm of burial (Maun 1984). This tolerance of burial is one reason why it is a highly dominant species in most Michigan dune environments (Hansen *et al.* 2009). In relation to other plants, *A. breviligulata* is naturally dominant by nature, and studies have shown its continual planting could have detrimental effects on abundance and diversity of other species on the dune (Cheplick 2005). In addition, the presence of *A. breviligulata* can impact the occurrence and seed rain of native herbs and plants in certain areas (Cheplick 2005).

STUDY SITE

This study took place on North Beach dune, a large parabolic dune on the central east coast of Lake Michigan (Figure 2). The dune is located north of Grand Haven and south of Hoffmaster State Park. North Beach dune is part of the North Ottawa Dunes county park managed by the Ottawa County Parks and Recreation Commission. The focus of this study was the upper windward face of the dune—just west of a sand fence running laterally across the dune face—where it is known that a large amount of plantings have occurred.



Figure 2: Study site location (a) and map (b). Focus was the upper windward face of North Beach Park dune. Zones have been overlaid to show division of sampling (c).

In the early 2000's, local residents noted that there had been sand appearing on the road just south and west of North Beach dune (Jamieson and van Dijk 2004). This road, North Shore Drive, was the solitary connection between a stretch of lakeside homes and the town of Ferrysburg, Michigan. Measurements showed that the dune was approaching the road at an estimated pace of 0.67 meters per year (Jamieson and van Dijk 2004). As a result, the Ottawa County Parks and Recreation Commission decided to stabilize the dune. Within the last decade, many measures have been taken to stabilize the dune from further movement, including sand fence installation, boardwalk installation, planting of *Ammophila breviligulata*, and laying biodegradable mesh over top of the dune (Parkin *et al.* 2012).

METHODS

Measurements took place over a period of 2 weeks, from October 23 to November 6, 2014. The methods employed were designed to meet the stated objectives in the most effective manner possible.

To determine the condition of planted *A. breviligulata*, the study area was divided into 9 zones (Figure 2c). Vegetation characteristics were sampled with 7 randomly-placed 0.5 m x 0.5m quadrats in each zone (Figure 3). Randomization was done by dividing the zone into a 0.5m grid and assigning each square a number, and then using a random number generator to choose the quadrat. In each quadrat (Figure 4), *A. breviligulata* height was measured by tallest shoot. Health was measured on a numeric scale based on the general condition of the grass (Table 1). For each zone, zone dimensions, estimated vegetation cover, and dune slope were calculated and recorded.

To assess the distribution of beachgrass over the dune, photographic comparisons of the dune from 2004 to 2014 were made. Past pictures were replicated by estimating where the picture was

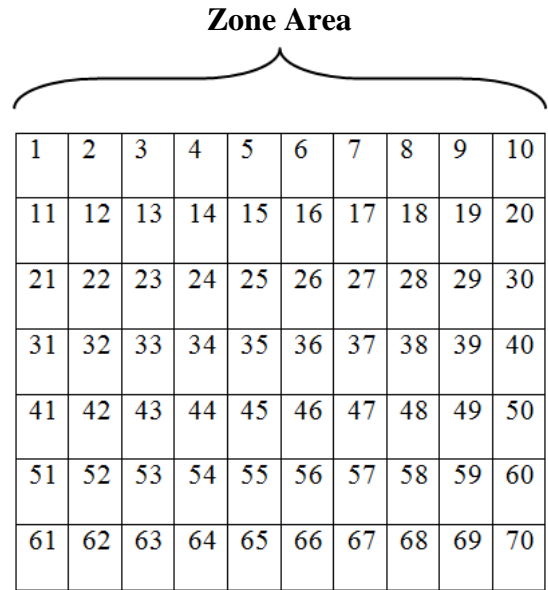


Figure 3: Grid outlining randomization process. Each cell represents a 0.5m x 0.5m area, and the sum of the cells is the area of one zone.



Figure 4: A researcher sampling vegetation using a 0.5m x 0.5m quadrat.

Rank	Category	Description of Grass Health Observations
1	Poor	Complete discoloration, damage noticed, dying or dead grass
2	Below Average	Significant discoloration, some damage
3	Average	Some discoloration, trace damage
4	Above Average	Very little discoloration, no damage noted
5	Excellent	No discoloration or damage, perfect condition

Table 1: Guidelines for ranking grass health. Numeric rank, category name, and description are provided.

taken from and taking a photo of the same landscape. Visual assessment of beachgrass distribution was also done in each zone, and mapped over the dune face using Juno Trimble GPS units. Records of dune plantings were assembled from various sources, such as e-mail records and park manager’s reports.

To investigate the relationship between plant characteristics and environmental conditions, other species were observed and noted within each of the quadrats. In addition, proximity to other management techniques, such as a nearby sand fence, was noted. Dune slope for each zone was calculated using a topographic map generated from site data collected with a SOKKIA total station. On the topographic map, multiple transects were drawn perpendicularly to the contour lines and the slope angle was calculated for each transect. Slope angles for each zone were averaged to produce one measure of slope for the zone.

RESULTS

Plant Conditions

In 2014, *A. breviligulata* had an average height of 72.7 centimeters among all zones (Table 2). The tallest plants were found in zone 8 with an average height of 88.23 centimeters, and the shortest plants were found in zone 4 with a height of 56.57 centimeters. Overall, plant

Zone	Average Height	Average Health	Zone Dimensions (m)	Vegetation Cover	Species Types	Slope (degrees)	Percent Coverage
1	71.86	2	12 x 20	somewhat dense	A	45	95
2	71.71	2.7	21 x 22	somewhat dense	A	46	95
3	65.33	2.9	12 x 25	somewhat dense	A	44	95
4	56.67	1	12 x 21	less sparse	A	38	50
5	68.40	2.9	21 x 21	less sparse	A, P	33	85
6	75.00	3.4	12 x 23	less sparse	A	39	90
7	84.67	3.3	14 x 16	sparse	A	69	20
8	88.23	2.35	14 x 14	sparse	A	43	30
9	N/A	N/A	15 x 13	sparse	BW	69	20
Average	72.73	2.57	---	---	---	47	64

Table 2: Various characteristics of zones and sampled vegetation in each zone.

health was categorized as average with a health ranking of 2.57. The main observations leading to the health rating were signs of damage to leaf blades and discoloration in many of the specimens. The healthiest plants were in zone 6, with a health of 3.4 and the least healthy plants were found in zone 4 with a health of 1.

Distribution of A. breviligulata

In 2005, photographic evidence shows that the study area was mostly bare sand with some *A. breviligulata* present in small patches around the perimeter (Figure 5). By 2014, vegetation covered most of the upper windward face and near the perimeter (Figure 5). The central portion of the dune was still mostly bare sand. Estimated vegetation coverage of the study site from GPS mapping is approximately 65% (Figure 6).

Between 2004 and 2009, there were periodic plantings of *A. breviligulata* plugs by volunteers in events organized by the Ottawa County Parks and Recreation Commission (Table 3). Photos taken at irregular intervals between 2004 and 2014 show the spread of grass over time (Appendix A).



2005



2014

Figure 5: Photographic comparison of vegetation on North Beach dune over a period of 10 years.



Figure 6: GPS map of vegetated areas. Shaded green areas are vegetated, red lines are zone boundaries, and black diamonds are quadrat locations.

Date	Activity	Source
9 Oct 2004	Volunteer dune grass planting	E-mail records
Sept/Oct 2007	Volunteer dune grass planting	Park Manager's report
19 Apr 2008	20 volunteers planted 1,500-2,000 square feet	Park Manager's report
18 Apr 2009	Volunteer dune grass planting	Spring 2009 park newsletter

Table 3: Records of volunteer plantings of *A. breviligulata* on North Beach dune

In 2014, the upper zones (1-3) and lower zones (7-9) of our study area had different vegetation densities. The upper zones were densely vegetated, almost exclusively with *A. breviligulata*, and the lower zones were very sparsely vegetated, but had a higher species diversity including a rare species. Zone 9 had no *A. breviligulata* specimens in any quadrats but *Artemisia campestris* (beach wormwood) was found in this zone. A federally-threatened plant endemic to the Great Lakes, *Cirsium pitcheri* (Pitcher's Thistle), was found in zone 5.

Environmental Relationships

Dune slope measurements showed that zone 7 and 9 had the steepest slopes with certain areas at approximately 69 degrees, and zone 5 had the gentlest slope with some areas at 33 degrees. The grass near sand fences (in zones 7-9), was taller and healthier than grasses in transition areas between bare sand and full vegetation (in zones 4-6).

DISCUSSION

Plant Conditions

Plant health values were lower than expected, with an average value of 2.57. These moderate plant health values may reflect the plants losing vigor after a certain period of time. In addition to this, the presence of new species, particularly *Artemisia campestris*, shows the possibility that suppressing effects from *A. breviligulata* are becoming less effective. Plants were generally tall, with an average height of 72.7 cm, as expected from a mature community of *A. breviligulata*.

Distribution of A. breviligulata

Photographs show a spread of *A. breviligulata*, suggesting that the plantings have been successful in re-establishing vegetation on the upper windward slope (Figure 7). A sign of recovering ecological health is the presence of additional species such as *C. pitcheri* and *A. campestris*. These two species are of specific interest, as they are rarely found in restoration sites (Emery and Rudgers 2010). Because both were found, there is evidence that the North Beach restoration has potential to grow further into a natural distribution of species as opposed to a monoculture of planted vegetation. The presence of these two species does not suggest that the entire vegetation population resembles a natural



Figure 7: *A. breviligulata* has spread over much of the windward face of the dune

population; however it does provide support

for the vegetation population becoming more natural. Despite having planting ages of 10 years or less, the restoration at North Beach dune appears to be slightly ahead of where it is predicted to be. Other studies show a standard restoration takes 20-30 years to reach “many measures of diversity and ecosystem processes” (Emery and Rudgers 2010). Additional research is needed to investigate whether the above-average pace of restoration at North Beach dune might be from the many simultaneous management strategies put into place.

Environmental Relationships

The observed increase in *A. breviligulata* height on the steeper slopes may result from *A. breviligulata* thriving in areas of disturbance, which correlate with higher instability (Maun 1984). In this case, the disturbance is provided by the inherent instability of steeper slopes. The upper zones had no other species noted but were densely vegetated, and the lower zones had additional species noted but were sparsely vegetated. This suggests that the *A. breviligulata* on the upper slopes has an impact on diversity, and it maintains this quality because of potential suppressing effects on other species (Cheplick 2005; Emery and Rudgers 2010).

CONCLUSIONS

In 2014, *A. breviligulata* was found to be well established across the upper windward slope of the North Beach dune. After irregular plantings between 2004 and 2009, followed by natural vegetation spread, *A. breviligulata* covered a majority of the windward face. Plant health was average with a score of 2.57, as is expected from an older community of *A. breviligulata*. Mean plant height was 72.7 cm. An increased species diversity shows that the community is moving forward in successional stage. In addition, the presence of new species combined with the decreased health of *A. breviligulata* shows that the suppressing effects from monoculture *A. breviligulata* planting are losing potency in some areas and new plants are more able to take root.

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APPENDIX A: Photos of (Planted) Vegetation on North Beach Dune



24 May 2005: Upper windward slope of North Beach dune.



24 May 2005: Planted *A. breviligulata* among debris on upper windward slope.
(Later observations suggest that few if any plants survived from this planting).



20 May 2008: Windward slope of North Beach dune.



17 July 2008: Planted *A. breviligulata* between sand fences on upper windward slope. View is from south arm of dune.



16 September 2009: Planted *A. breviligulata* viewed from upper north arm.



16 September 2009: Planted *A. breviligulata* in biodegradable mat near crest of dune.



October 2012: Windward slope of North Beach dune as viewed from lower boardwalk.



18 July 2013: Windward slope of North Beach dune as viewed from lower boardwalk.



25 September 2014: Windward slope of North Beach dune as viewed from lower boardwalk.



6 November 2014: Planted *A. breviligulata* viewed from upper north arm (see 16 September 2009 photo for comparison).