Visiting A Great Lakes Sand Dune: The Example of Mt. Pisgah in Holland, Michigan

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Mt. Pisgah is a large parabolic dune and attractive local landmark on the southeast coast of Lake Michigan in Holland, Michigan. A 2005 study of Mt. Pisgah investigated local claims that visitors are causing a decrease in dune height. Methods included mapping dune topography and surface characteristics, administering questionnaires to dune visitors and local residents, and collecting historical information from interviews, written accounts and photographs. Results show that Mt. Pisgah’s height of 48 meters above Lake Michigan is lower than its reported height by 8 meters. Dune changes are caused by a combination of natural aeolian processes and human impacts. The most distinctive human impacts are a ramp of sand on the dune’s slipface along a popular pathway, widening of the blowout on the dune’s windward slope, and development of a notch at the dune crest. More than 3400 people visit Mt. Pisgah each summer; most visitors are not from the local area and do not believe there are problems with the dune. In contrast, local residents believe that the amount of visitors and damage to the dune are major problems. A management strategy of boardwalks, stabilization and public education could mitigate impacts of the high numbers of visitors.

Keywords: Great Lakes, coastal dunes, human impacts, dune management

Introduction

Coastal dunes are dynamic natural environments that draw people for their scenic viewpoints, flora and fauna, recreation, or simply because of their proximity to the coast. Many of the same characteristics that attract people make coastal dunes vulnerable to the impacts of human activities on dune ecology, topography and natural processes. The effects of human trampling (Boorman and Fuller 1977; McDonnell 1981; Hylgaard and Liddle 1981; Rickard et al. 1994; Andersen 1995; Kutiel et al. 1999), off-road vehicles (Hosier and Eaton 1980; Godfrey et al. 1980; Anders and Leatherman 1987; Kutiel et al. 2000; Priskin 2003), and other recreational activities (Bonanno et al. 1998; Tzatzanis et al. 2003) are being studied at coastal dunes around the world. Global trends of increasing populations, development, and recreation pressures in coastal environments (Nordstrom 2000) suggest that the human pressures affecting dune systems are likely to produce significant environmental changes in the twenty-first century (Thomas 1999). Dunes in the Great Lakes region are also vulnerable to the impacts of human visitors (Bowles and Maun 1982), but few studies of human disturbance have focused on Great Lakes dunes.

Mt. Pisgah in Holland, Michigan, is an example of a Great Lakes coastal dune that attracts many visitors and is vulnerable to the potential impacts of their activities. In 2005, the county authority that manages the dune...
commissioned a study to investigate local claims that the dune crest is being lowered by visitor activities. The objectives of the study were to:

1) investigate the current activity of the dune,
2) document the history of the dune including changes,
3) describe the current impacts of human activities on the upper slopes of the dune, and
4) recommend management strategies.

A primary question in the study of Mt. Pisgah was whether dune changes are the result of natural processes or human activities.

**Study Area and Context**

Mt. Pisgah is a parabolic dune located in Ottawa County on the east coast of Lake Michigan (Figure 1). The dune lies north of Lake Macatawa in Holland, Michigan, near Holland State Park and is part of the Ottawa County Parks system (Figure 2). A historic district of summer cottages known as Ottawa Beach borders the dune to the south and west. East of the dune are the Holland State Park headquarters, maintenance buildings, and campground. A trail system provides access to the top of the dune from the Ottawa County Parks properties north of the dune. People also gain access to the dune by climbing the slipface or taking one of several trails that originate in the parking lot of the Ottawa Beach community. Mt. Pisgah reaches a reported height of 185 feet or 56 m (OCPRC 2004; DuFresne 2005), but in recent years local residents and visitors expressed concern that the dune was not as high as it had been in the past.

Large parabolic dunes like Mt. Pisgah are common along the east coast of Lake Michigan between Holland and Manistee, where they occur in a semi-continuous band. In plan view, the dunes are crescent-shaped with wings pointing towards the lake, lengths of up to a kilometer inland from the shore, and dune axes roughly perpendicular to the shoreline. Arbogast and Loope (1999) describe the dunes as lake-terrace dunes, perched on lacustrine deposits that accumulated after deglaciation; the dunes have bases roughly 15 meters above the modern level of Lake Michigan (176 m above mean sea level). Radiocarbon dates from buried soils beneath the dunes give ages of 6000 to 3000 calibrated years B.P., suggesting that the dunes...
formed during or after the Nipissing high lake stand (Arbogast and Loope 1999; Van Oort et al. 2001; Arbogast et al. 2002). No radiocarbon dates are available for Mt. Pisgah, but dunes north of Holland in Grand Haven have been dated at 3300 to 2900 cal. yrs B.P. (Arbogast and Loope 1999), and dunes south of Holland have been dated at 4300 to 3900 cal. yrs B.P. (Hansen et al. 2006). After formation, the parabolic dunes went through periods of dune activity and stability (some lasting hundreds of years) up to the present (Arbogast et al. 2002).

Contemporary processes on Lake Michigan coastal dunes have seasonal patterns that reflect the mid-latitude location of the dunes (van Dijk 2004; Hansen et al. 2006). During the summer months, when dune sand is dry and vegetation cover is at its maximum, winds are generally weak and little sand transport occurs. Most aeolian activity takes place during the late fall and winter under the influence of strong northwesterly winds (van Dijk 2004). Although the vegetation protection of dune surfaces is reduced, aeolian processes are complicated by other seasonal variables such as wet surfaces during fall storms, and snow, ice and ground-freezing in winter. In a study of a large, active parabolic dune south of Holland, Hansen et al. (2006) found that most sand transport occurred along the dune axis, despite varying wind directions. During high-energy wind events in fall and winter, sand moved from the unvegetated backslope (the windward slope) over the dune crest to deposits on the upper and middle slipface where cementation by snow and ice produced high slope angles. During spring thaws, there was net downslope movement of sand to the bottom of the slipface, and by the end of May, the net dune advance was measured at 1.6 m (Hansen et al. 2006).

Human activities near Mt. Pisgah began to intensify in the mid-1800s when the city of Holland was established by Dutch immigrants to the United States (Wagenaar 1997). From the 1880s to the 1920s, the area near Mt. Pisgah was a popular tourist destination and local development included the Ottawa Beach cottages and two nearby resort hotels. There are reports of a wooden water reservoir, serving the hotel and the Ottawa Beach cottages, located on the forested slopes of Mt. Pisgah (Dalvini 2005; Pollack 2005). In 1928, Holland State Park was established. During the Great Depression years and World War II, tourism decreased and the Ottawa Beach community fell into disrepair. After the war ended, interest in the neighborhood resumed and many Ottawa Beach cottages were purchased and renovated for summer vacation use or year-round residence. Holland State Park became one of the busiest parks in Michigan, currently drawing more than 1.5 million visitors annually (DuFresne 2005).

**Methods**

Topographic data for Mt. Pisgah were collected in summer 2005 with an electronic total station. Benchmarks (n=24) were established (mostly on sturdy trees) which could also be used for future studies of dune change. A total of 684 survey points were taken to map dune topography and distinctive dune regions including bare sand, types of vegetation cover, and stable or unstable dune surfaces. To identify dune elevations relative to Lake Michigan and sea level, the survey included several points at the edge of Lake Michigan on 4 August 2005 when the recorded lake level was 176.2 meters above sea level (United States Army Corps of Engineers 2005). Rockworks mapping software was used to generate maps of dune topography and distinct regions, as well as to calculate distances, areas, slope angles, and bearings.

To collect information on dune visitor characteristics and activities, questionnaires were administered to two populations associated with Mt. Pisgah: 1) people encountered on the dune itself (dune visitors); and 2) residents of the houses in the Ottawa Beach community adjacent to the dune (dune neighbors). Both questionnaires included questions about activities on the dune, frequency and timing of visits, perceptions of dune problems, and demographics. The Neighbor Questionnaire included additional questions focused on personal views and experiences with Mt. Pisgah. For example, neighbors were asked whether there was any noticeable change in the shape or height of the dune in the years the person had lived in the area. Visitor Questionnaires were administered in the last week of June and first two weeks of July during randomly-chosen time periods that included Monday through Saturday 8am to 1pm, 1pm to 5pm, and 5pm to 8pm. All groups or individuals on Mt. Pisgah during the selected time periods were asked if one member of their party would be willing to participate in the study by filling out the questionnaire. Neighbor Questionnaires were administered in person at each Ottawa Beach residence. If no one was home, a questionnaire was left at the residence with a letter of explanation and a self-addressed stamped envelope. Questionnaire results were tabulated and analyzed using statistical software (SPSS).
Historical information about Mt. Pisgah and the surrounding community—including photographs, written accounts and oral histories—was obtained from a variety of sources. Archived materials were obtained from the Hekman Library at Calvin College and the Holland Museum. Long-time residents were formally interviewed (tape-recorded sessions) and short informal interviews of local residents occurred while the Neighbor Questionnaires were being administered. Vertical air photographs were obtained from Ottawa County (1973, 1984, 1990 and 1994) and the U.S. Geological Survey (1997). Dune descriptions
and photographs from different time periods were compared to assess dune changes over time.

Observed human activities on Mt. Pisgah were recorded whenever researchers were at the dune for the ground survey or to administer questionnaires. Collected data included the number, general ages, activities and timing of people seen at the dune. Evidence of human activity such as locations and types of litter, trails, and human structures were also noted. Data on observed human activities supplemented the information collected by questionnaire.

**Results**

### Dune Topography and Surface Characteristics

The ground survey shows that Mt. Pisgah is a large parabolic dune with a main axis oriented approximately 60° from north (Figure 3). The dune has a height of 48 meters (157 feet) above Lake Michigan, with the highest point located on the north arm. The lowest point on the dune is at the bottom of the slipface to the east; the dune rises 39 m (128 feet) above the lowest point. The dune is 160 meters wide and 200 meters long, and it covers an area of approximately 30,200 m².

Figure 3 shows a distinct ramp or lobe of sand extending from the crest of the dune down the slipface. This lobe marks the location of a major pathway between the dune crest and the Holland State Park property to the east. The orientation of the lobe is 105° from north, which is 45° east of the main axis of the dune. On the upper and middle slipface, the surface of the lobe rises 3 to 8 meters above the underlying dune surface. At the bottom of the slope, the lobe extends Mt. Pisgah roughly 15 meters beyond the slipface.

Figure 4 shows a distinct ramp or lobe of sand extending from the crest of the dune down the slipface. This lobe marks the location of a major pathway between the dune crest and the Holland State Park property to the east. The orientation of the lobe is 105° from north, which is 45° east of the main axis of the dune. On the upper and middle slipface, the surface of the lobe rises 3 to 8 meters above the underlying dune surface. At the bottom of the slope, the lobe extends Mt. Pisgah roughly 15 meters beyond the slipface.

Collected data on surface characteristics have been mapped to show a number of distinctive dune regions (Figure 4). Approximately 37% of the dune surface has been classified as bare sand. This area includes much of the backslope (Figure 5) and part of the dune crest. On a windy study day, erosion and sand transport from the upper backslope across the exposed dune crest were observed. There is evidence of small slope failures along the steeper margins of the bare sand area where erosion is undercutting vegetation. Throughout the bare sand area, footprints and other evidence of human disturbance were common. The bare sand region on the dune slipface is the pathway that appears as a lobe on the topographic map. This region has a slope...
angle of 33° and an unstable, loose-sand surface. Downslope movement of sand under the influence of gravity and human trampling was frequently observed.

Regions of low vegetation include the lower, western portion of Mt. Pisgah where *Ammophila breviligulata* (American beachgrass) and other early successional dune vegetation are found (Figure 6). Small plants and shrubs include *Opuntia humifusa* (Prickly pear cactus) and the invasive species *Centaurea maculosa* (spotted knapweed). To the west, *Pinus resinosa* (red pine) are mixed in with the shrubs and grasses. Local accounts suggest that the trees were planted by a local doctor or the Boy Scouts (Pollack 2005). There is little evidence of wind activity or slope processes disturbing the low vegetation. Several small trails leading to the Ottawa Beach community are evidence of human disturbance. The low vegetation on the upper backslope of Mt. Pisgah is *A. breviligulata* planted in 2004 by volunteers working with the Ottawa County Parks and Recreation Commission.

Stable forested regions include the north side of the dune (Figure 6) where the beech-maple forest has a healthy understory of herbaceous plants, a forest soil exists, and the ground is covered by leaf litter. Despite a slope angle of 35°, there is little evidence of disturbance by slope processes. Forested areas with similar vegetation and soil but low to moderate slope angles occur in the western portion of Mt. Pisgah and in areas adjacent to the dune.

The remaining forested slopes of Mt. Pisgah (28% of total dune area) have been classified as vulnerable to disturbance. These slopes are similarly vegetated with beech-maple forests and a herbaceous understory, but the ground conditions are unstable (Figure 7). Both leaf litter and soil layers are thin and discontinuous. Slope angles are quite steep: 35° on the north arm of the dune and 36° on the south arm. Numerous small pathways weave across the
slopes. Leaf litter and sand are pushed downslope with each footstep taken by people walking on the slope.

**Observed Human Activity and Impacts**

A total of 455 people were observed on Mt. Pisgah during twelve site visits ranging in length from 3 to 7 hours. Observed rates of people visiting the dune ranged from a low of 12 people in 6 hours to a high of 122 people in 3 hours; the average was 8 people per hour. The most popular activity of dune visitors was climbing the dune and then running down the active slipface. Many people simply walked over the dune. Other activities included tossing a football, sledding, jumping from high spots, playing Frisbee, climbing trees, digging holes, and playing tag.

The most popular route for visitors was the path on the active slipface. Visitors were also observed on other trails including paths in the low vegetation area, the pathway onto the dune from the Ottawa Beach cottages, and the northwestern ridge trail. Most visitors stopped at the dune crest where both Lake Macataw and Lake Michigan are visible. From the dune crest, visitors either went down the slipface pathway or walked down the backslope of the dune towards the Holland State Park beach.
Evidence of human activities was observed in the form of litter in most areas of the dune, including food wrappers, beverage containers and cigarette butts. The largest concentrations of litter were observed along the boundary between the base of the dune and the surrounding area.

**Questionnaire Results**

**Visitors to Mt. Pisgah**

<table>
<thead>
<tr>
<th>Activity</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Go for walk</td>
<td>0.270</td>
<td>1.603</td>
<td>1.000</td>
</tr>
<tr>
<td>Walk dog</td>
<td>1.771</td>
<td>1.183</td>
<td>1.000</td>
</tr>
<tr>
<td>Climb the dune</td>
<td>20.266</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Enjoy the scenery</td>
<td>5.627</td>
<td>1.018</td>
<td>1.000</td>
</tr>
<tr>
<td>Play games</td>
<td>4.094</td>
<td>1.043</td>
<td>1.000</td>
</tr>
<tr>
<td>Run down</td>
<td>15.104</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>See wildlife</td>
<td>5.015</td>
<td>1.025</td>
<td>1.000</td>
</tr>
<tr>
<td>Other</td>
<td>0.022</td>
<td>1.883</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Figure 9. Comparison of visitor and neighbor activities on Mt. Pisgah with summary statistics from tests for differences between visitors and neighbors. Highlighted activities indicate a significant difference ($p < 0.05$) between the two populations.
uncommon. In total, the 69 questionnaires account for 230 people on the dune.

The population visiting Mt. Pisgah is relatively young, not from the local area, and composed mostly of repeat visitors who come to the dune during the summer. The majority of visitors to the dune (69%) were in the age category of 0–16 years, with the remaining visitors fairly evenly distributed among the age categories 17–25 years, 26–40 years and 41–55 years, and very few visitors older than 55 years. Only 9% of visitors were from the local area.

Figure 10. Comparison of visitor and neighbor perceptions of selected problems at Mt. Pisgah. Summary statistics indicating significant differences are in parentheses below each graph.
Figure 11. Neighbor opinions of dune management and interpretation activities
Neighborhood and Visitors

The majority of visitors (60%) live outside Holland, Michigan, but within an hour drive of the dune. However, 88% of visitors indicated that they had been to Mt. Pisgah before. The repeat visitors were most likely to visit the dune once a year (35% of responses) or several times a year (30%). Verbal comments from respondents to the questionnaires indicated that some people camp near the dune (in the Holland State Park campground) for a week or more once a year, and while they camp they might visit the dune a number of times. Only 20% of the summer visitors reported visiting Mt. Pisgah in a season other than summer.

Visitors to Mt. Pisgah participate in a variety of activities; the most popular activities are climbing the dune (86%), running down the slopes of the dune (71%) or going for a walk on the dune (55%). Nearly half of the visitors (44%) come to Mt. Pisgah to enjoy the scenery. Low numbers of visitors come to the dune to play games (22%), observe wildlife (19%) or walk the dog (10%). Visitors reported participating in other activities including: ‘watch the sunset’, ‘to have fun’, ‘route to the beach’, ‘lie out in the sun’, ‘meet girls’, and ‘to dig holes’.

When asked, most visitors reported that there was no or very little problem with a number of specified issues, including noise from vehicles, noise from visitors, dune climbers, dog waste/noise, dune crowding, damage to the dune, and management efforts. The majority of visitors saw litter as a problem, with 38% reporting that it was a moderate or major problem and 42% reporting it as a minor problem.

Neighbors of Mt. Pisgah

Forty-two completed Neighbor Questionnaires were obtained from 29 questionnaires administered in person and 33 left at the door; the overall response rate was 68%. The population living next to Mt. Pisgah is comprised of households of 1–2 adults, families or extended family groups, with many houses occupied by the same family group for decades. Almost 50% of neighbor responses came from 2-person households, with 75% of those households reporting ages of 55 years and above. Many families (1 or 2 adults with children) occupy houses near Mt. Pisgah, and children aged 0–16 years are 27% of the population. Some households report large numbers of people (10, 12, 37) with mixtures of children and adults. Comments indicated that the number of people in the household fluctuates from week to week and depends on the time of year. Length of residence ranged from 4 to 81 years, with a third of the neighbors living in the area for 40 years or more.

Neighbor responses reveal different patterns of visiting Mt. Pisgah than the visitor population encountered on the dune. Twenty-six percent of respondents living close to Mt. Pisgah do not visit the dune at all. Neighbors who visit the dune tend to do so at rates of once a month to once a year or less. A seasonal comparison shows that more neighbors than visitors are likely to visit the dune during the winter, fall and spring months; but the highest percentages of both neighbors and visitors went to Mt. Pisgah during the summer compared to other times of year (Figure 8). A comparison of neighbor and visitor activities (Figure 9) shows no statistically significant differences (p < 0.05) between the percentages of visitors and neighbors going for a walk or walking the dog on the dune. For other activities, differences are statistically significant. Visitors are more likely to climb the dune than the neighbors, but the neighbors are more likely to run down the dune during their visits. More neighbors than visitors come to Mt. Pisgah to enjoy the scenery and to observe wildlife. More visitors play games on the dune compared to the neighbors.

Neighbors and visitors differ in their views about possible problems on Mt. Pisgah. The two groups were statistically similar in opinions that litter is a problem, but vehicle noise, dog waste/noise, and crowding on the dune are not. With respect to noise from visitors, dune climbers, damage to the dune, and management efforts, the neighbors reported each of these issues as a more severe problem than the visitors did (Figure 10). Opinions of dune climbers and damage to the dune showed the biggest differences in response: most visitors felt that these posed no problem, but most neighbors felt that dune visitors and damage to the dune were major problems. There was closer agreement between percentages of visitors and neighbors who indicated there is no problem with management efforts, but neighbor opinions were evenly divided between feeling management efforts were no problem and feeling they are a major problem.

A majority of neighbors had noticed physical changes to the shape, size or height of the dune (73%). Of the 11 neighbors who responded that they had not noticed any changes to the dune, 5 had been living near Mt. Pisgah for 8 years or less. Over 70% of the neighbors said that there has been an increase in the number of people visiting the dune.
The neighbors are generally supportive of most management and interpretive activities on the dune, but the support is not unanimous (Figure 11). The management strategy of planting dune grass to stabilize the dune received the strongest support, and the placement of sand fencing to stop sand movement was also seen positively by most neighbors. Opinions were divided over building a boardwalk to protect the dune surface: 37% of respondents opposed or strongly opposed the idea compared to 43% of respondents who favored or strongly favored the idea. There was stronger support for limiting access to protect dune areas. Of the two interpretive options presented, the neighbors were more positively inclined towards signs with dune information. Responses to the idea of educational programs such as public walks/talks were mixed: a large number of respondents were neutral (29%) compared to 36% who were in favor and 19% who were opposed. Some neighbors commented that it is important to educate people in the right way. Neighbors also expressed concern that walks would bring more people to the dune and cause more degradation.

Both visitors and neighbors were asked to assess how much they knew about sand dunes. The largest numbers of visitors (42%) and neighbors (38%) put themselves into a middle category of knowing a little bit about sand dunes. Most of the rest of the visitors (42% of visitor respondents) indicated that they knew less than a little to almost nothing about sand dunes. In contrast, most of the rest of the neighbors (42% of neighbor respondents) indicated that they knew more than a little to a lot about sand dunes.

These results show that neighbors of Mt. Pisgah have a higher opinion of their knowledge of sand dunes than the people who visit the dune. The differences in self-proclaimed knowledge between the visitors and neighbors are statistically significant (t=-2.915, df=109, p=.004).

**Historical Changes to Mt. Pisgah**

Photographs of Mt. Pisgah from the early 1900s show the parabolic dune rising to a peak at the dune crest; the dune crest and arms are forested but the windward slope is almost completely unvegetated. The bare sand has a steep slope and there is possible undercutting at the rim of the bare-sand area where roots of trees and other plants provide some resistance to erosion. By the 1930s, photographs show fewer trees and the beginning of a notch across the crest of the dune (Figure 12). The general shape of the dune continues to narrow towards the crest, and more trees are visible along the north arm than the south arm. The windward slope remains unvegetated with scarpers along the north and south rims of the blowout and some visible sandflows. Footprints up the center axis of the dune are evidence of visitors during this time period; and the sign saying ‘Keep Off’ in the middle of the dune indicates a response to the visitors (Figure 12). No clear images of Mt. Pisgah from the 1940s were obtained, and a partial image of the dune taken during the 1950s shows the bare sand of the blowout, many footprints, and tree debris on the upper slopes from erosion at the rim of the blowout.

Photographs from the last four decades indicate some changes to the dune in shape and vegetation. Dune changes visible from comparing vertical air photos from 1973, 1984, 1990, 1994 and 1997 include erosion along the north and south arms of the dune as the scarpers along the blowout margins recede. The upper two-thirds of Mt. Pisgah’s windward slope remain consistently unvegetated on all the photos. However, between 1973 and 1997 there appears to be an increase in vegetation cover at the bottom of the windward slope, accompanied by a decrease in the number and sizes of pathways. At the top of the dune, a decrease in tree cover along the dune crest occurs between the 1973 and 1990 photos. The northeast, east, southeast and south slipfaces can be clearly distinguished from surrounding forests by the lighter color indicating more bare sand on the dune surfaces beneath the trees. The greatest evidence for sand movement occurs along the main axis of the dune where decreased vegetation cover and sand flows are visible.
on the slipface in 1984 and 1990. On the 1994 photo, low vegetation cover is visible in many of the slipface openings visible on the earlier photos. The main pathway on the slipface (oriented approximately 45° east of the main dune axis) is clearly visible on all of the air photos from 1973 on as a bare sand surface. Oblique aerial views and ground photographs of Mt. Pisgah’s windward face also show that the blowout widens between the late 1960s and mid-1980s although vegetation cover increases at the bottom of the windward slope. The dune crest appears wider and flat (rather than peaked) with a noticeable shallow dip in a 1986 photograph.

In 2005, Mt. Pisgah retains the active blowout area and the distinct notch across the top of the dune. Local residents such as Mr. Dalvini (2005) say that they have seen the height of Mt. Pisgah lower during their years in the area and a clear ‘saddle’ form at the top of the dune. It is difficult to estimate the change in height from the collected images which were taken at different scales with different camera locations. If the present-day edges of the notch were continued straight across the top of the dune, one could estimate that Mt. Pisgah has lost approximately 5 meters (15 feet) of height at its crest since the early 1900s.

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Figure 13. Locations of recommended management activities at Mt. Pisgah
Discussion

The study results indicate significant changes to Mt. Pisgah over the last century, particularly in the form of the notch developing on the dune crest. Both the photographic evidence and accounts of long-time residents of the neighborhood agree that the notch is a recent development. The photographic evidence suggests that the beginnings of the notch were apparent as early as the 1930s. Personal accounts suggest that the notch has deepened over time, although rates of change are impossible to determine from local memory or the photographs. On sand dunes, pedestrian pathways often have a funnel shape—flaring out at dune bases and narrow on dune crests—as pedestrians converge on the pathway from different areas and then diverge to different destinations at the end of the pathway (Rickard et al. 1994). The characteristic notching and lowering of dune crests results from the intense continued use of a single pathway over the dune crest by pedestrians; ultimately the dune could split in a significant alteration of the topography (Rickard et al. 1994). The 2005 dune survey shows that the notch between the crests of the south and north ridges (arms) dips approximately 5 meters below the highest (north) ridge. This notch constitutes a significant topographic feature of Mt. Pisgah—one that both serves as a pathway for visitors and enhances sand movement by wind across the top of the dune.

The study results do not support the commonly-reported height of 185 ft (56 m) for Mt. Pisgah (OCPRC 2004; DuFresne 2005). The 2005 survey of Mt. Pisgah indicated a height of 48 meters (157 ft) above Lake Michigan or 39 meters (128 ft) from lowest to highest point. It is not clear when, by whom, or on what basis, the dune height was originally declared to be 185 ft. The 1972 USGS topographic map (with elevations based on 1969 air photos) shows a dune height of 750–760 feet (229-232 meters), or approximately 53.5 meters above the mean level of Lake Michigan. Comparing the USGS figures with the current study suggests that the crest of Mt. Pisgah is 5.5 meters (18 feet) lower in 2005 than in 1969. Along with the change in height, the location of the dune’s highest point appears to have shifted over time from a central peak in the early 1900s to a point on the north arm of the dune in 2005.

It is notable that photographs show a bare windward slope of Mt. Pisgah since 1900. The exposed slope suggests that Mt. Pisgah has been active to some degree (in terms of sand movement by wind) for the last century. Changing characteristics of a blowout, such as enlarging or deepening, can result from natural wind processes, human impacts, or a combination of both. Evidence of human impacts elsewhere on Mt. Pisgah suggests that changes to the blowout are likely a result of both human impacts and natural processes.

Mt. Pisgah has a topographic feature that is not common to parabolic dunes: the distinctive ramp of sand at the slipface trail location. The bare sand of this pathway is consistently visible on aerial photographs dating back to 1973. The orientation of this topographic feature—45° off the main dune axis—suggests that the ramp does not result from natural dune processes of sand movement along the dune axis. The most likely explanation is that, at some time prior to 1973, people climbing the dune produced a trail at this location. As human use of the trail increased, vegetation cover was removed, and footsteps pushed sand down the steep slope. The widening bare surface presented an attractive location for more people to climb and run down the dune, preventing vegetation from re-establishing itself and pushing more sand down the dune slope to form the lobe. The human impacts have been severe enough to create a distinct and unnatural feature on the dune.

Study results suggest that more than 3420 people per summer visit Mt. Pisgah. This estimate is based on the average number of people per day (38) observed on the dune during field data collection. The estimate is low because all observation periods were less than a day in length. A future, more detailed study of the numbers of visitors to Mt. Pisgah would be helpful for understanding human impacts.

The number of visitors to Mt. Pisgah has a high level of human impact on the dune. The estimated 3420 visitors per summer exceeds the number of pedestrian passes shown to constitute severe trampling pressure resulting in bare ground in many dune studies (Boorman and Fuller 1977; Bowles and Maun 1982; Hylgaard and Liddle 1981; McDonnell 1981; Rickard et al. 1994). Areas of the dune which receive most of the visitor traffic are the bare slipface pathway, the notch across the crest of the dune, and a route along the center of the blowout. These areas cannot recover naturally under current levels of use, and deterioration will continue. Along other dune pathways, even a portion of the total visitor traffic constitutes significant impacts on the pathway. With continued use, the trails established on Mt. Pisgah cannot recover naturally and are likely to widen and deepen on vulnerable slopes.
People visiting Mt. Pisgah probably do not realize the impact of their activities on the dune. On the questionnaire, many visitors reported limited knowledge of sand dunes. Comments in responses to other questions also indicated some misunderstandings of dune processes and how various management activities worked with the dune. In particular, visitors showed some understanding that wind and rain shape the dune but very little indication that people play a role as well. Furthermore, it is difficult for individual users to comprehend the combined effects of their actions with all other visitors to the dunes. Most visitors encounter few other people while they are on the dune. To reduce visitor impacts, it will be important to communicate how visitor activities affect the dune and that many people on the dune have a cumulative effect.

The favorable views of dune management held by neighbors represent a surprising result. There was an expectation of negative responses to the questions about management because of reported and encountered vocal opposition to Ottawa County activities. Strongly-held views against some or all management strategies were included with the questionnaire responses. However, most of the neighbors expressed support of management strategies, particularly planting vegetation and using sand fences to stabilize the dune surface. Opposition to (or at least reservations about) building a boardwalk on the dune stemmed in part from a concern over dune aesthetics and in part from concerns that a boardwalk and viewpoints would attract more visitors to the dune. Concern over attracting more people also produced opposition to public education programs. Some of the reluctance concerning management of Mt. Pisgah may result from a general resistance to change. Neighbors’ verbal and written responses also indicated that the Ottawa County administration has a poor reputation in the Ottawa Beach community. Many residents expressed a lack of confidence in the County’s ability to improve or manage the situation. Clear communication of management goals and methods will be very important if Ottawa County Parks would like the neighbors of Mt. Pisgah to participate in reducing human impacts to the dune.

The neighbors of Mt. Pisgah are important stakeholders in dune management, but visitors from outside the local community constitute the largest number of people and impacts on the dune. As a result, management efforts should be primarily directed towards visitors, and local residents can play important roles in monitoring the effectiveness of dune management. One practical implication of the largely non-local visitor population is that public education needs to be directed towards people who are in the community for short periods of time (days to weeks). Therefore, signs and pamphlets may be more effective than a neighborhood education strategy of talks and media information. An ongoing area of conflict between neighbors and dune visitors that needs to be addressed is the issue of private property. Neighbors experience visitors encroaching on their property whereas visitors are likely unaware that they have left park property. With their long-term investment in the local community, neighbors could be recruited to participate in dune management through helping with dune plantings, monitoring and reporting changes in visitor patterns, and reporting developing problems as management strategies are implemented.

Management Recommendations

A master plan study for county park parcels at Ottawa Beach recommends a number of actions to ‘preserve the sensitive natural features of Mt. Pisgah and also provide the opportunity to enjoy the natural and scenic qualities of this coastal landscape’ (OCPRC 2004, 25). The results of this study affirm those recommendations and provide information to make the recommendations more effective. Figure 13 shows the locations of recommended structures and activities described in the text.

Recommendation 1. Restore eroded areas.

Areas which are eroding because of human activities should be stabilized with sand fences, planting vegetation, and natural recovery. There are four primary areas of concern: the bare slipface pathway, the bare windward slope, the bare dune crest, and the many small trails criss-crossing the dune. The most effective strategy for halting human impacts at the slipface pathway is keeping people off the slope with barriers such as fences or by constructing a boardwalk/stairway that weaves back and forth across the pathway opening. Natural recovery of vegetation when human trampling halts can be enhanced by strategic plantings of species from nearby slopes. Erosion on the dune’s windward slope and crest can be reduced with a combination of sand fences or woody debris to slow sand transport and planting Ammophila breviligulata for longer-term stabilization.

\[ \text{Ammophila breviligulata} \]
stabilization of the surfaces. While the vegetation establishes itself, plantings may need to be protected from destruction by the many visitors to the dune.

**Recommendation 2. Eliminate inappropriate paths.**

There are many surplus small trails crossing the dune where human trampling should be halted to allow natural recovery of vegetation. Studies show that natural recovery to the percent cover and species present in adjacent areas can take place within a couple of years when human trampling is halted (Bowles and Maun 1982; Carlson and Godfrey 1989; Hylgaard and Liddle 1981; Rickard et al. 1994). The trails that are on the steep forested slopes of Mt. Pisgah are particularly susceptible to human impacts. Park staff may need to place substantial barriers, such as fences, ropes, piles of debris or planted shrubs, at trail entrances to deter people from using the closed trails.

**Recommendation 3. Limit human activities to low-impact uses.**

Visitor activities on Mt. Pisgah should be limited to low impact uses, particularly in dune areas most vulnerable to erosion. Activities which destroy vegetation, break up soils, and move sand around include running and jumping on the dune slipface, warm-weather surfing or sledding on dune surfaces, mountain-biking, digging holes, and climbing up steep slopes of the dune by tugging on vegetation. Low impact uses are those which cause the least disturbance to dune soils and vegetation, including walking on established trails, and standing, sitting or lying on unvegetated dune surfaces. Even low impact uses like walking will affect the dune if sufficient numbers of people participate.

**Recommendation 4. Utilize structures to control dune access and use.**

Boardwalks, stairs, and viewing platforms should be used to reduce the impacts of large numbers of visitors on vulnerable dune areas such as the slipface, dune crest, and upper backslope. An appropriate configuration would be a stairway on the slipface connected to a boardwalk on the dune crest with viewing platforms looking west over Holland State Park towards Lake Michigan, looking east over the Holland State Park campground, and looking south over Lake Macatawa. Some of the structures could be raised above the dune surface to permit sand movement by wind or slope processes as Mt. Pisgah adjusts to changes in human impacts. Natural recovery of vegetation will be enhanced by structures that permit light to reach the dune surface (e.g., by leaving gaps between boards). The structures must be part of a comprehensive management plan because people may seek alternative locations to climb or run down the dune when the existing pathway is blocked off.

**Recommendation 5. Make trails compatible with surrounding land uses.**

The overall trail system at Mt. Pisgah should be made compatible with surrounding land uses which include Holland State Park, the Ottawa Beach residences, and other county park properties. Comments from dune visitors and neighbors suggest there is significant confusion about routes over Mt. Pisgah, caused in part by Holland State Park staff encouraging campers to go over the dune to get to the beach. Consistent and accurate information on dune routes and connections to the surrounding area should be presented to visitors by posted signs, maps, and communications from park staff.

**Recommendation 6. Provide signs to direct use and interpret natural features.**

Signs that direct dune use and explain dune features are an essential component of changing the human activity patterns that are damaging the dune. People are more likely to participate in taking care of the dune if they appreciate the value of the dune environment and understand how their actions affect the dune. Visitors are more likely to comply with signs that present positive messages (e.g., ‘Please stay on pathway to allow vegetation in fenced area to recover’) instead of negative messages (e.g., ‘Do not enter fenced area’).

**Recommendation 7. Monitor dune and visitor activity to understand changes.**

Ottawa County should monitor dune activity, human impacts, and restoration efforts to assess the effectiveness of managing Mt. Pisgah. Data on topography and surface characteristics collected in this study provide reference information for comparison with future studies to
determine dune changes. A more detailed study of visitor numbers is needed to better understand current human impacts. A monitoring program should include tracking visitor numbers; measuring dune changes with repeated measurements at reference markers, repeated dune surveys/mapping at chosen intervals, or repeated aerial photography; and documenting recovery of dune areas. Repeated measurements of visitor numbers and dune characteristics are important to understanding the effects of management actions such as building a boardwalk or planting vegetation.

Conclusions

Mt. Pisgah is a large parabolic dune changing in response to both natural dune processes and human impacts. The unvegetated backslope and crest of the dune are exposed to the region’s westerly winds which transport sand to the slipface during high-energy wind events. However, the greatest evidence of change on the slipface occurs at a popular pathway where people’s activities have pushed sand downslope to form a distinctive ramp. Other dune changes during the 20th century, including widening of the blowout and the development of a notch at the dune crest, can occur naturally on parabolic dunes but the number of visitors to Mt. Pisgah suggests that human impacts play a significant role in dune changes. Visitor numbers of greater than 3400 per year are high enough to severely impact dune surfaces and prevent natural recovery of vegetation that could stabilize dune areas.

A substantial part of coastal dune management is managing human activities, and the human impacts on Mt. Pisgah pose some interesting challenges. The number of visitors to the dune is likely to remain high because of the proximity of Holland State Park which has more than 1.5 million visitors per year. Almost 90% of visitors to Mt. Pisgah are not from the local area, and most are repeat visitors with patterns of activity on the dune they may be reluctant to change. Whereas local residents acknowledge a number of problems connected to Mt. Pisgah including the amount of visitors and damage to the dune, dune visitors perceive very few problems with the dune. The impacts of large numbers of visitors to Mt. Pisgah could be mitigated by a coordinated management strategy of building boardwalks on highly-traveled but vulnerable dune areas; stabilizing eroded areas with fences and planting vegetation; closing off surplus pathways to permit natural recovery of vegetation; using signs and educational programs to encourage visitor participation in dune management; and monitoring the changes to the dune and visitor activities to gauge management effectiveness and adjust strategies accordingly.

In the Great Lakes region, Mt. Pisgah is only one example of a coastal dune that is being modified by human activities. The interactions between natural processes and cultural factors affecting each coastal dune system may produce unique sets of changes and resulting dune topography. More studies of dune processes, human impacts, and the effectiveness of management strategies in Great Lakes dune environments are needed, both for better understanding of the coastal dune dynamics in human contexts and for more effective management of the Great Lakes coastal dunes.

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References


