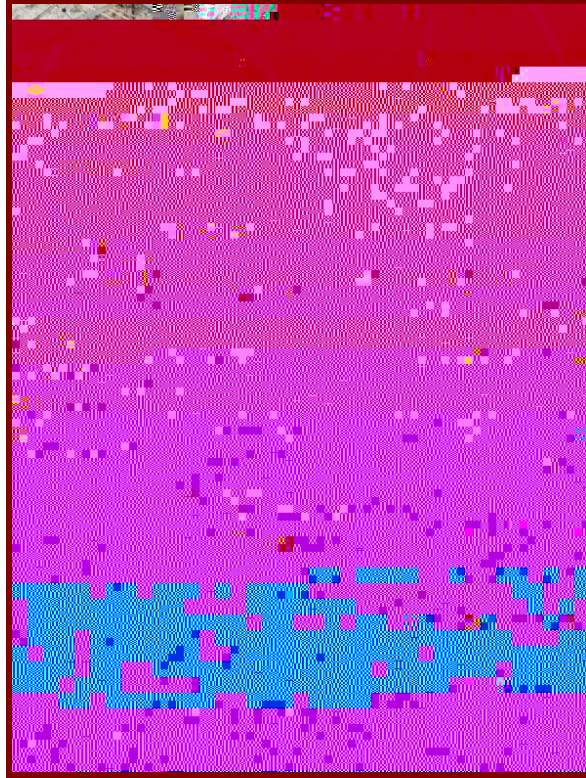


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**Impacts of White-Tailed Deer
on a Lake Michigan Parabolic Dune System**

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Abstract

White-tailed deer, *Odocoileus virginianus*, have a significant impact on environments in North America with many populations over the carry capacity of their habitats. This is the case in PJ Hoffmaster State Park, Michigan, where we investigated a large parabolic dune system to determine where deer have the most impact. We mapped individual tracks, scat and trails with Trimble GPS units, and areas were visually assessed for the impacts of deer. In areas with deer evidence, vegetation quality was noted within quadrats. The foredune had the most presence of deer as shown by scat and tracks going to and from Lake Michigan. Deer tracks on human unmanaged trails suggest that deer use these trails as well as creating their own trails. Vegetation results show deer have not significantly impacted the quality of American beach grass. With the low level of vegetation damage, sand movement has not increased beyond what is characteristic for this type of dune system. While the significant presence of deer is noticed especially on the foredune this study suggests no current concern for destabilization of the dune system.

Introduction

White-tailed deer, *Odocoileus virginianus*, have grown in population over the last century across the eastern United States (Russell *et al.* 2001). With populations in the millions, deer have had a big impact on different environments (VerCauteren and Hygnstrom 2011). Deer are labeled a keystone herbivore because of the large effect they have on their environment (Waller and Alverson 1997). There is evidence that deer affect the growth rate of tree seedlings and saplings, prevent adult recruitment into tree canopy (Russell *et al.* 2001: 1). The majority of studies done on deer take place in various forests throughout North America, and only a few focus on deer in dune environments.

Our study focused on how the presence of deer affect the stability of a parabolic dune system.

Our study objectives were to:

- ◁ document and map deer impacts in the study area,
- ◁ assess quality of vegetation related to deer impacts, and
- ◁ assess the relationship between active deer trails and various areas of dune.

Background

About White-Tailed Deer

White-tailed deer came about their name because the underside of the tail is covered with white hair, and when the deer run the tail is often held erect so the white hair is visible (Fergus and Shope 2014). The species is the smallest member of the North American deer family, commonly

forests show that seedling/sapling stands¹ can support the greatest number of deer (Fergus and Shope 2014). A pole-timber stand² an area with trees at a diameter of 60-130 cm³ above the ground² can support few or no deer, and saw-timber stands³ trees at a diameter of 130-250 cm³ can support a moderate number of deer (Fergus and Shope 2014).

History of White-Tailed Deer in America

In 2011, an estimated 10 million deer inhabited the Midwest, which was more than any other region in North America (VerCauteren and Hygnstrom 2011). If one was to go back in history, the deer population was much smaller. When Europeans first immigrated in the 1400s, the white-tailed deer density has been estimated as 3.1-4.2 deer/km² (Rooney 2001). By the 1700s, the deer population started to decline because of overhunting by the colonists, as deer were used for food, clothing, and other personal uses. Widespread habitat modification following European settlement (Rooney 2001) included activities such as cutting down forests for agriculture, building materials, and fuel. Since deer use the forest as shelter, particularly during winter (National Geographic 2010), this left the deer without a major part of their habitat. Because of market hunting pressures (Rooney 2001), by the early 1900s, white-tailed deer were nearly extirpated from some regions of North America (VerCauteren and Hygnstrom 2011). In 1900 the Lacey Act was enacted to prohibit the interstate trafficking of venison and other wild game, and market hunting for white-tailed deer began to slow (VerCauteren and Hygnstrom 2011). In 1908, 41 states established departments of conservation to further protect the deer (HuntingNet Staff 2008). In the 1900s, as habitat conditions improved (eg. forests grew back) and predator numbers decreased, the deer population responded by growing (Rooney 2001). Rooney (2001: 202) gunko cvgu'yj cv'kp"4222."öf ggt "gzeggf gf í r tg-settlement densities by a factor of 2-12 in the deciduous and mixed coniferous forests qh'pqt'vj gtp"Y kueqpukpö0With increased population, white-tailed deer have expanded their range westward and now occupy areas of the Great Plains where they have never been before (VerCauteren and Hygnstrom 2011).

¹ C'ucpf 'kp'hqtgut { 'vgo u'o gcp"öC"ugevqp'qh'hqtguv'j cxlpi 'tgrv'xgn' 'vplh'qto "eqo r qukkqp'kp'tgi ctf 'vq'ur gekgu.'uk' g' structure, and f gpuks {=f kuxpi wuj cdng'itqo "qvj gt'ucpf u'd { 'cwt'kdwgu'uwej 'cu'yj gugö"Y guv'Xkti kpk Forestry Association 1998).

² Pole timber diameters at breast height measurements defined by West Virginia Forestry Association (1998); metric conversions are 10 to 25 cm at a height of 1.37 m above the ground.

White-Tailed Deer Impacts on the Environment

Several studies have been done on deer and their effect on the environment around them. Averill *et al.* (2018) investigated the interactions between white-tailed deer and invasive plants in North American forests. With abundant large herbivores, plant community composition is altered by a lower density of flowering plants, reduced native plant richness and abundance, and increased cover of invasive plants (Averill *et al.* 2018). Invasive plants considered unpalatable by change as their presence (i) reduces native biodiversity and (ii) increases the relative abundance of introduced plants, two of the major drivers affecting modern plant communities and ecosystems (Averill *et al.* 2018: 18).

Frelich and Lorimer (1985) focused on how deer affect hemlock forests in the Upper Peninsula. The investigation found a trend between the increasing population of deer and the decreasing population of hemlock seedlings. Their results suggest that the decline in the population of deer overwintering in the lakeshore area as hemlock disappears from the forest canopy (Frelich and Lorimer 1985: 117). However, hemlock lives a long time, and in areas where the hemlock canopy is fully intact, long-term changes from 60 years of heavy browsing have barely begun. Therefore, it is possible to alter the trend of species conversion in most hemlock stands by controlling the deer population.

On Lake Huron sand dunes, Phillips and Maun (1996) concentrated on the effects of simulated herbivory by white-tailed deer (*Cirsium pitcheri*). Because of the rarity of *Cirsium pitcheri*, the plants were grown under controlled conditions in a greenhouse. As the plants grew, the researchers simulated browsing by clipping treatments with different amounts (25%, 50%, 75% and 100% of the plant being clipped 1-3 times off different age groups (Phillips and Maun 1996). The study found the plants could recover from being grazed but those exposed to severe grazing often experienced an immediate reduction in root growth (Phillips and Maun 1996). The regrowth of shoots came at the expense of the root biomass, regardless of the amount of leaves removed. The greater the frequency of grazing, the greater was the decrease in root biomass of the plant (Phillips and Maun 1996).

Study Area

Our study location was at P.J. Hoffmaster State Park in Ottawa County, Michigan (Figure 1). This dune is a parabolic dune system with several blowouts on it (Figure 2). The foredune is heavily vegetated. A swale separates the foredune from the dune ridge. This swale has an unmanaged trail running parallel to the shoreline. The dune ridge is also vegetated but has several unmanaged trails on it and a blowout near the south arm. For this study, the first blowout east of the dune ridge is referred to as the crest of the first blowout. The relatively open (not forested) mid-section of the windward slope of the parabolic dune.

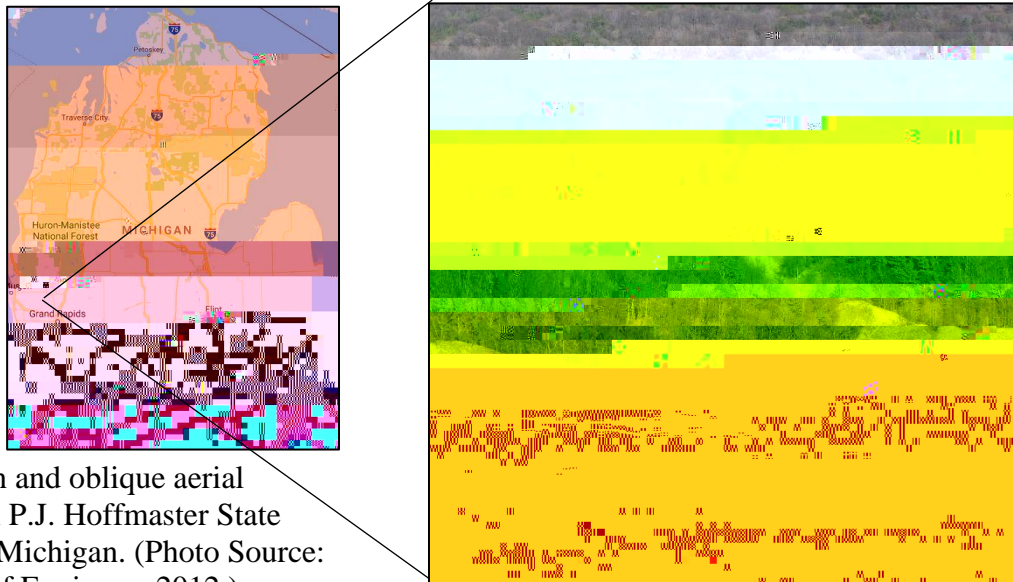


Figure 1. Location and oblique aerial view of Dune 2 in P.J. Hoffmaster State Park, Muskegon, Michigan. (Photo Source: US Army Corps of Engineers 2012.)



Figure 2. Geomorphic areas of beach-dune system shown on aerial view of study area.



Category	Damage Level	Description	Picture
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Collecting Context Information on Deer in Park

To gain more knowledge about the park's deer population, I interviewed the Park Naturalist, Elizabeth Brockwell-Tillman. The interview format was semi-structured, with prepared questions to guide the conversation, such as: "Why did the deer population increase?" and "What factors contribute to the deer population growth?"

Results

Deer in Context

In Hoffmaster State Park, the carrying capacity for deer has been estimated by the Park Naturalist and biologists to be 65 deer (Brockwell-Tillman 2017). The actual deer population in the park is estimated at 3-4 times that many deer (Brockwell-Tillman 2017). At one point, there were annual hunts to control the deer population, but hunters had reported complaints about the terrain and they would not hike back into the dunes (Brockwell-Tillman, 2017). Instead, hunters were hiking near the road, which was not safe, and they were running into each other while hunting. The kill rate was dropping as hunters came back unsuccessful (Brockwell-Tillman 2017). With the end of the annual hunts, deer population grew and with this growth the deer grazed the trillium flower to non-existence outside of deer exclosures. Similarly, at one point Hoffmaster State Park had sand cherry bushes, but now these bushes are not found within park boundaries (Brockwell-Tillman 2017).

Deer Presence in Fall 2017

On the dune, we found 25 samples of scat with 23 of the samples on the foredune (Table 3). The other two samples were found in the open area of the parabolic dune further up the windward slope. Single deer tracks were found in many dune locations with 22 tracks mapped. Five tracks were found on the foredune, seven

tracks were found in the main deflation area, four tracks were found in the forest, and the rest of the tracks were spread out in other areas of the dune.

Both deer trails and unmanaged trails are found in many areas of the dune. Several deer trails were mapped connecting Lake Michigan and various areas of the dune (Figure 3). Deer trails are found both on the forested arm and the open areas of the dune (Figure 4). Some unmanaged trails also had deer tracks on them. Several single tracks were found in the open areas of the dune near trails created either by humans or deer. The tracks heaW0 612 q0.092 r6649o12 0 612 792 reW*nBT/F1 12 Tf1 C

Deer Impacts and Vegetation Quality

Visual impacts from deer ranged from no damage (1) to ample damage (4) and scores were generally consistent across site visits (Table 4). The foredune is heavily vegetated (

Figure 7. Tree missing bark due to deer scraping antlers.

Discussion

The quantity of deer evidence and vegetation damage found on the foredune suggest that deer spend significant time in this dune environment and they are grazing on the American beach grass (*Ammophila breviligulata*). American beach grass on the dune has had some impact by the deer grazing. Nevertheless, the beach grass is still growing and doing well, as demonstrated by the vegetated foredune. We were unable to find published studies indicating whether beach grass is or is not a common food source for deer.

The various trees on the dune have had some impact from browsing and bucks scraping off bark by

With unmanaged trails found over the entire dune, it is hard to distinguish which trails are used only by deer. Deer tracks on unmanaged trails suggest that deer are using these trails as well as humans. From the direction of the tracks, deer use the trails to get water from Lake Michigan, forage on the foredune as well as in the forest, and shelter in vari

