First-Year Research in Earth Sciences: Dunes

Distribution of Oak Trees on North Ottawa Dunes

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1.0 Abstract

Hardwood forests across the Midwest are threatened by invasive pathogens such as oak wilt. One of the most sensitive areas to vegetation loss are the forested dunes along Michigan's coast. Our study investigated the forest properties of North Ottawa Dunes. Using Trimble GPS devices tree locations, health, and species were recorded. This data was then entered into ArcGIS for analysis. Roughly a third of recorded trees were oaks with 96% of the oaks belonging to the species red oak. Oak trees were concentrated in inland flat environments. No new oak wilt infections were recorded in our sampling sites. The concentration of red oaks in the wooded dune areas may be detrimental to manager efforts to prevent the spread of oak wilt in North Ottawa Dunes park.

2.0 Introduction

Much of the lower peninsula of Michigan is dominated by hardwoods such as trees in the oak (*Quercus*) family (MDNR 2017; Figure 1). One environment that remains forested is older stable dune systems. In 1944 the first cases of a fungal disease known as oak wilt were recorded (Haight *et al.* 2011). This disease then spread through the Midwest putting old growth forests at risk first and more recently affecting stabilized dune systems. One such dune system under the threat of oak wilt is North Ottawa Dunes. This study focuses on understanding the properties of Ottawa County's forested dune system in order to better respond to the spread of oak wilt.

Our study objectives were to:

1. Assess the species diversity of oak trees across the forested dune environment.
2. Record the health and size of oak trees within four designated dune environments.
3. Measure the densities of both oak and non-oak trees within four designated dune environments.

Figure 1. Oak forest in Michigan. (Photo by Adrienne L. Bozic in Kost *et al.* 2007)

3.0 Background

Oak wilt is caused by a fungus known as *Ceratocystis fagacearum*. It is able to spread through two main methods. The first involves the spreading of spores via beetle. A severe infection of oak wilt leads to a fungal mat being produced beneath the bark of the tree. This mat releases an odor that attracts beetles which then involuntarily pick up spores (Saito *et al.* 2016). These beetles then feed on other trees, furthering the spread of the disease.

The second method of transportation occurs subterraneously, involving the tree's root systems. Well-forested areas usually contain vast networks of interconnected root systems called grafts, which the fungus can use to travel from one oak tree to another (Obrien *et al.* 2011). These grafts can occur at distances of almost 30 meters (100 feet) from one tree necessitating the use of large mitigation areas (Obrien *et al.* 2011). Sandy soils encourage greater spread of root systems, enlarging the distance that infection can spread from the tree (Obrien *et al.* 2011).

Although the infection period can vary due to the variety of oak, infected trees usually die within a year (Frei 2015; Saito *et al.* 2016). This is particularly true of red oak trees (Saito *et al.* 2016). In a well-established dune system, the loss of tree cover can be devastating, both for sediment stability and biodiversity (Pollen-Bankhead *et al.* 2009). Remobilization of the sediments alters the dynamics of the system which can lead to increased stress on the other vegetation in the area and even on nearby residential properties.

One of the major factors in the spread of an invasive pathogen is the diversity of the host. Since oak wilt specifically targets oak trees, a greater variety of trees in the area should slow down the spread of oak (Prospero and Cleary 2017). Another consideration is the specific species of oak. Oak trees will display varying levels of resistance depending on the species. White oak trees will exhibit a fairly high level of resistance and red oaks will exhibit a very low level (Saito *et al.* 2016). Root grafts are also very unlikely to form between two different species of oak. Thus, to determine the vulnerability of an area to a pathogen such as oak wilt tree biodiversity must be recorded not just on the genus level but also at the species level.

Oak species differ not just in their resistance but also in their growth patterns. White oak trees (*Q. alba*) are better adapted to heavier soils and have a slower growth rate than their red oak (*Q. rubra*) counterparts (Moore 2017). Acorns from a white oak also differ in that there is no dormant period; instead the acorns sprout immediately (Moore 2017).

4.0 Study Area

This study took place within the county park known as North Ottawa Dunes (Figure 2). The area is comprised of 593 acres of parkland located on the western edge of Ottawa County (Ottawa County 2017). The majority of the park is made up of wooded parabolic dunes. Because these dunes are heavily vegetated, many of the dunes within the park are stable with limited movement. Vegetation consists of mainly hardwood trees with ferns filling in the understory. The park is bordered along the north-eastern edge by residential land. The oak wilt infestation is believed to have originated in the residential area since all known infected trees are located along that border (Manion 2016). P. J. Hoffmaster State Park, located directly north, has previously struggled to contain oak wilt (Manion 2016).

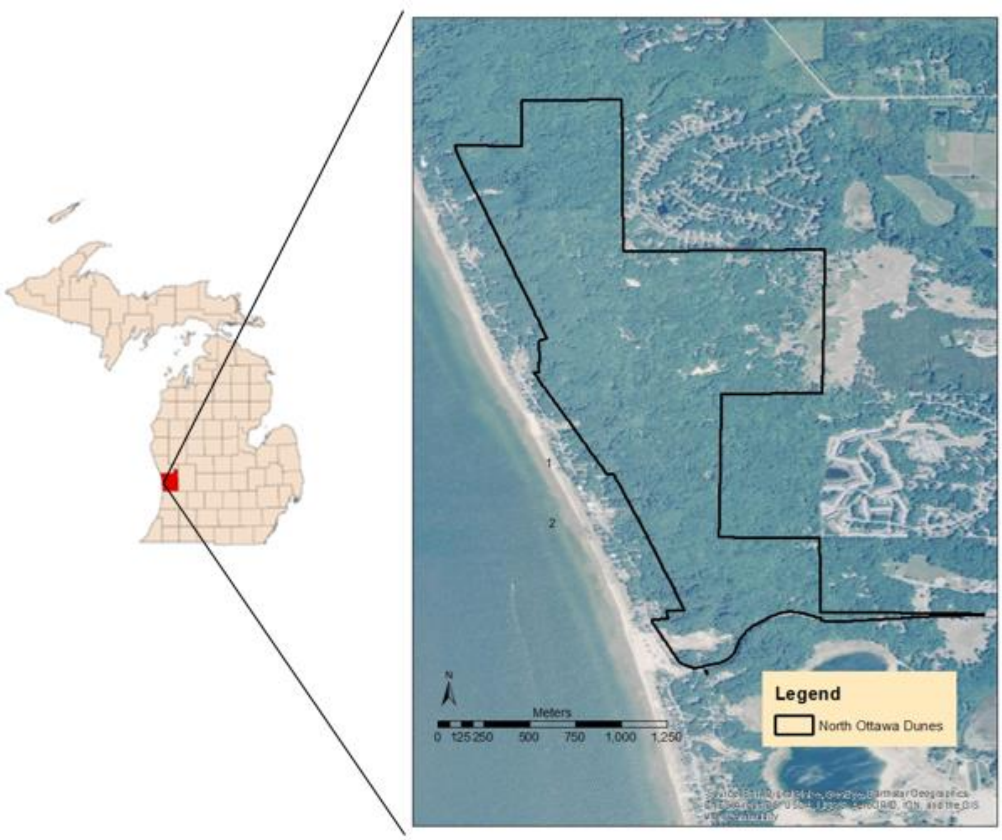


Figure 2. Location of Ottawa County, MI, and North Ottawa Dunes park.

5.0 Methods

Data collection occurred over two weeks from October 27 to November 10, 2016. Data collected included GPS locations, species, health, and circumference of all trees within sampling areas. Sampling occurred in three designated areas in different parts of the park (Figure 3). These areas were chosen to represent the variety of terrain present in the park including the newer parabolic dunes along the coast and the older inland dune systems. Location A was meant to provide samples intermediate between the two distinct terrains. Location B represented the older dune systems along the eastern edge of the park and location C represented the newer coastal dune systems. Preliminary scouting of the area had determined that oak represented a large amount of the vegetation covering all areas of the park.

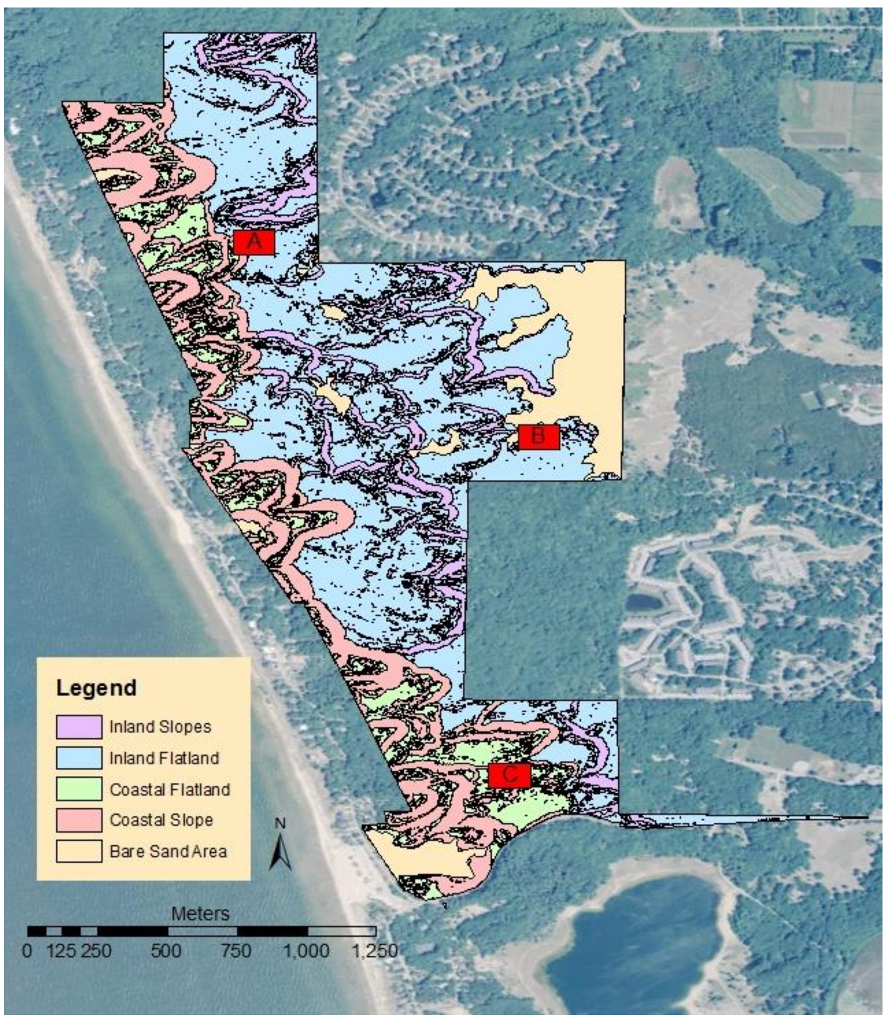


Figure 3. Locations (in red) of study areas A, B, and C, as well as mapped dune environments.

Sampling sites were randomly selected from within the designated areas. Once a site was chosen, a ten-meter by ten-meter square was constructed out of twine to contain the site. Within the square, researchers recorded data for individual trees (Figure 4). Each tree's location was marked as a point on a Trimble GPS unit. Once the species had been identified, it was recorded as either red oak, white oak, or non-oak. The tree's health was then noted using one of three options: healthy, sickly, or infected. Healthy was used to indicate a tree that appeared to be in good health. Sickly noted a tree that appeared to be suffering from some form of parasite or infection. Infected was used for trees suffering from known cases of oak wilt. Each oak tree's circumference was measured at breast height using a tape measure. All field data was recorded into the GPS unit by using a specially-created data dictionary.

Figure 4. Researchers measure the circumference of a tree within the study area. Twine marking the sampling area boundaries can be seen in the foreground.

We obtained GIS data from the Ottawa County GIS Department. This data included a 2m DEM of the parkland. We used the DEM to create a map of the slopes in the park. From the slope map, four distinct environments of the dune system were identified: coastal slopes, inland slopes, coastal flatlands, and inland flatlands (Table 1).

Dune Environment	Coastal Slope	Coastal Flatland	Inland Slope	Inland Flatland
Slope Criterion	≥10°	<10°	≥10°	<10°
Location Criterion	West of the main dune ridge	West of the main dune ridge	East of the main dune ridge	East of the main dune ridge

Table 1. Criteria used to identify distinct environments from DEM.

Data from the GPS was downloaded into ArcGIS. The density of each sampling square was calculated by dividing the total number of trees by the 100m^2 area. Densities of sampling areas within a dune environment were averaged to provide average densities for both total trees and oak trees within each environment.

6.0 Results

In total there were fifteen sampling squares. Five were located in site A, four in site B, and six in site C. These squares were dispersed among the four primary dune environments; coastal slopes, coastal flat lands, inland slopes, and inland flat land. Sampling included a total of 441 trees.

6.1 Species Distribution

The majority of oak trees recorded were determined to be red oaks, *Quercus rubra* (Figure 5). White oak, *Quercus alba*, was only found in three of the four environments and in such low concentrations to be almost negligible. Only 23 total white oaks were found in comparison to the 417 red oaks.

Figure 5. Red oaks in the "coastal slopes" environment in North Ottawa Dunes.

6.2 Oak Tree Circumference and Health

Tree circumferences ranged from 348 to 6cm. Coastal slopes had on average the highest circumference with 113.4cm (Figure 6). Inland flat areas had the lowest average with 48.1cm. No new infected trees were noted throughout the study.

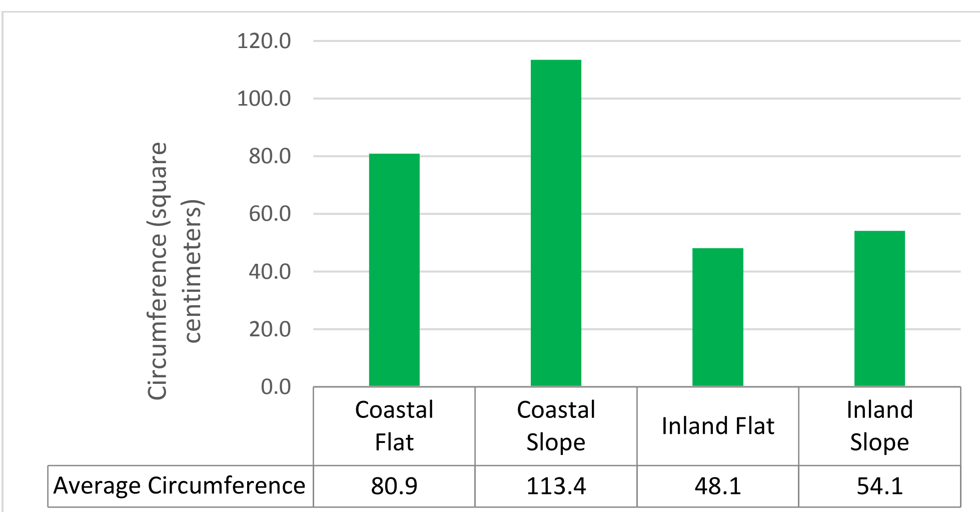
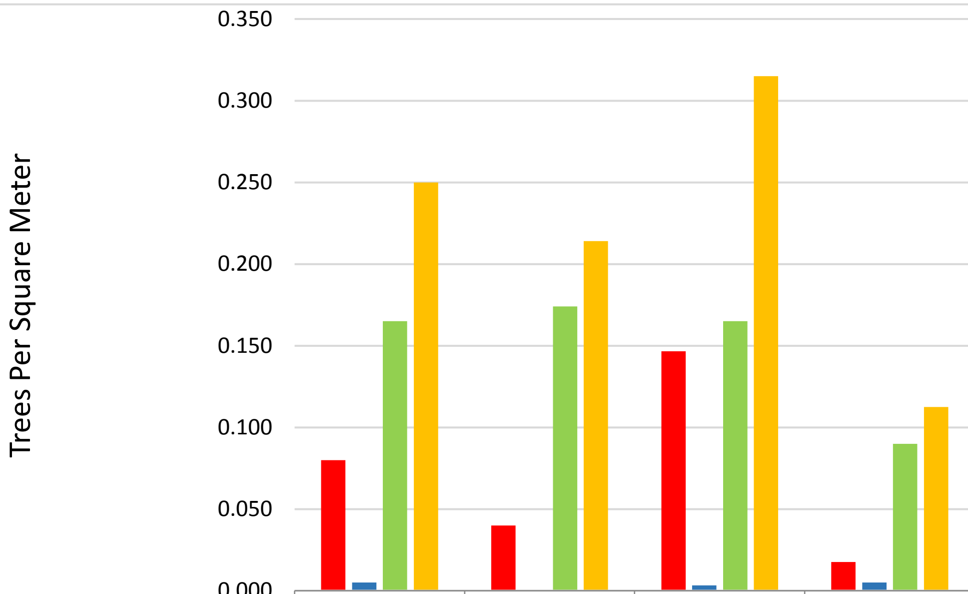


Figure 6. Average oak tree circumference in the four main dune environments.

6.3 Tree Density

Inland flat areas had the highest average tree concentration with 0.315 trees per square meter (Figure 7). Inland slopes had the lowest with 0.113 trees per square meter. Non-oak tree densities remained relatively constant through the different environments but the red oak densities peaked in inland flat areas. White oak densities remained minimal throughout the entire park.



	coastal flat	coastal slope	inland flat	inland slope
Red Oak Density	0.080	0.040	0.147	0.018
White Oak Density	0.005	0.000	0.003	0.005
Other Tree Density	0.165	0.174	0.165	0.090
Total Tree Density	0.250	0.214	0.315	0.113

Figure 7. Densities of species of trees within four dune environments.

7.0 Discussion

7.1 Species Distribution

The ratio of red to white oaks presents a problem to park managers. Because white oaks exhibit a greater resistance to oak wilt, the high ratio of red to white oaks creates an environment that will facilitate the spread of the disease (Saito *et al.* 2016). Since this ratio is fairly constant throughout the park, the greater rate of spreading could present a problem for the park.

7.2 Oak Tree Circumference and Health

It is good news for the park that no new infection zones were located. This suggests that for the time being oak wilt is constrained to the north-east border. This result also supports the idea that the origin for the infection lies in the bordering residential properties. It is unknown why the coastal slope areas had the greatest average circumference. Because the largest trees are located in the coastal area, it means that they are not currently at risk from infection which is also good news for the park.

7.3 Tree Density

The largest concentration of red oaks occurs in the inland flat areas which is also where all current infection zones are located. This could mean the infection would have a quicker infection rate since the chances of forming a root graft are increased with higher concentrations of similar trees.

8.0 Conclusions

Roughly a third of the trees within our sampling areas belonged to the genus *Quercus* (oak). Of those trees, 96% were red oaks. The oaks were mostly concentrated within inland flat environments but no new infections were found. The low diversity in oaks and concentration around the currently infected area will likely be detrimental to efforts to slow the spread of oak wilt.

9.0 Acknowledgements

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