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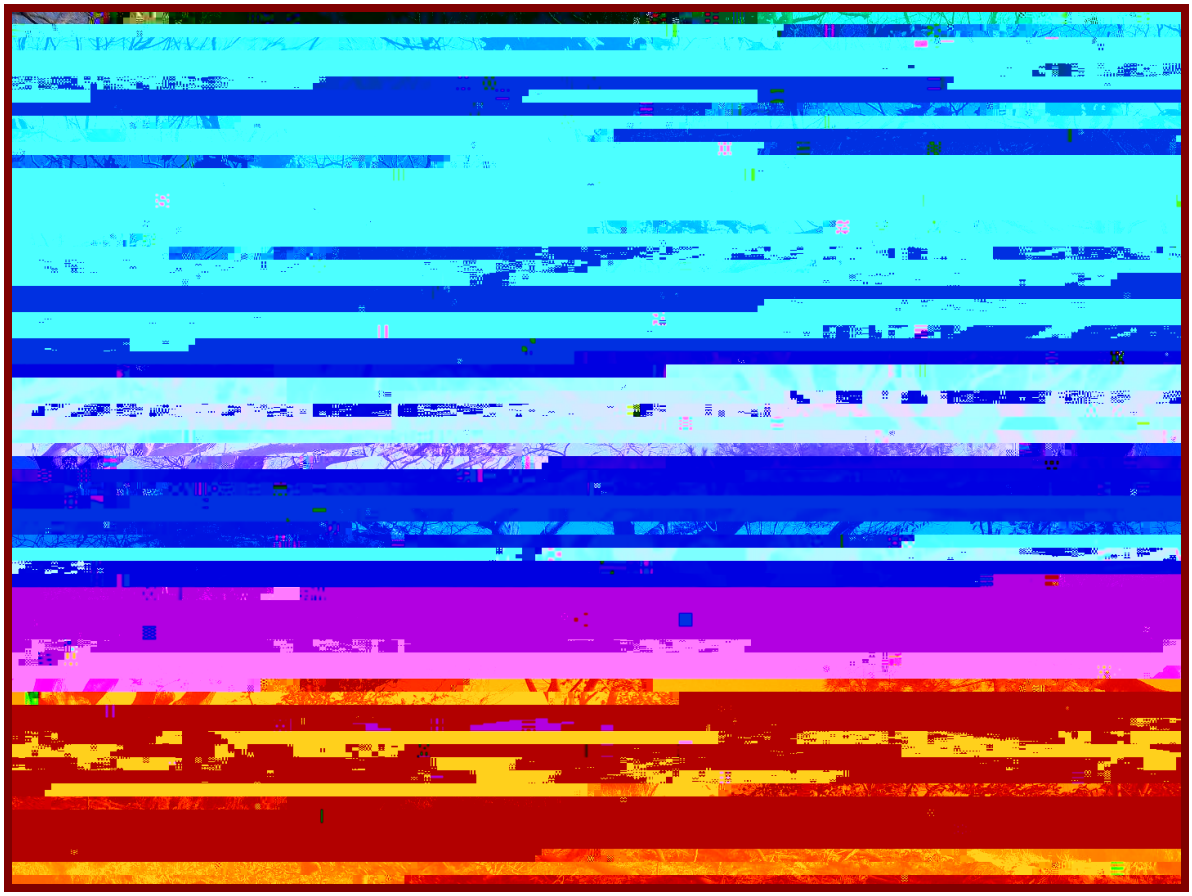

Oak Wilt and Dune Stability in North Ottawa Dunes

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FYRES: Dunes Research Report #26
June 2017

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Abstract

Slope stability in coastal dune environments is threatened when surface stabilizers are removed. In North Ottawa Dunes, located in western Michigan, an infectious fungal disease requires the removal of hundreds of oak trees, which have extensive root systems used to maintain slopes. Our study investigated the vulnerability of the slope in areas marked for treatment. Using Trimble GPS devices, we mapped tree cover in two areas marked for tree removal and imported the data into ArcGIS to create a map showing the impact removal will have on these two areas. We analyzed DEM data to predict future slope instabilities based on slope angles, dune environment, and tree density. Surprisingly, a flat area may be more vulnerable to erosion following treatment as compared to a steeply sloped area where there are lower concentrations of oak trees. Our analysis also shows that new methods of mitigation are able to decrease tree mortality significantly, minimizing the impact of removal.

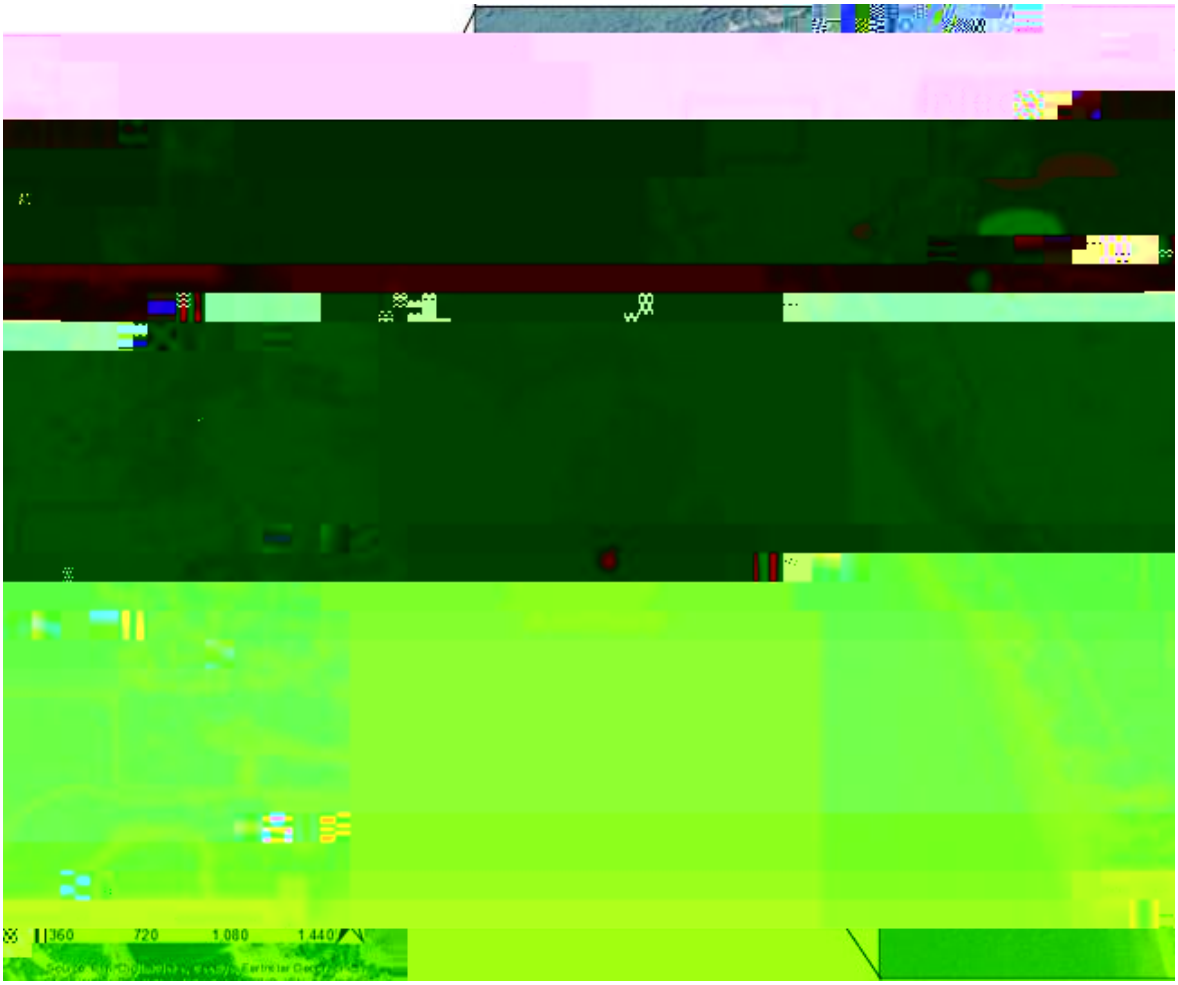
Introduction

Ceratocystis

increase stress (Schwartz et al. 2010). Additionally, the possibility of perpetuating and creating blowouts, both on slopes and flat land, should be considered when removing vegetation as vegetation is a stabilizer (Forman et al. 2008). In light of these impacts, vegetation removal due to oak wilt has the possibility of transforming and destabilizing a dune environment (Forman et al. 2008).

Study Areas

The study was conducted in North Ottawa Dunes, a county park located in Ottawa County, Michigan (Figure 2). The area of the park is 359 acres of forested dunes, with terrain that varies from flat to steep (Ottawa County 2017). The park 0 0 ,so1 12 Tf 1 0 0 1 206.9 519.31 Tm 0 g



has the possibility of

In 2016, dune managers discovered an oak wilt infestation within the park boundaries,

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in ArcGIS were used to calculate the density of oak trees and other trees in the area. Th
calculated data was then used to create a map that illustrates the spatial characteristics of the two
infected areas

Predicting Dune Instabilities after the Decomposition of Roots

The impact of root decomposition on dune slopes was predicted using the pre-existing digital elevation model (DEM) from Ottawa County. The DEM was used to determine the slope angles and elevation of the two affected areas. Other variables, such as previous evidence of erosion or human impacts, were also analyzed

The tree cover of each of the study areas also varied (Table 3). Circle 1

The two areas in the experimental treatment zone exist in two different environments and therefore the

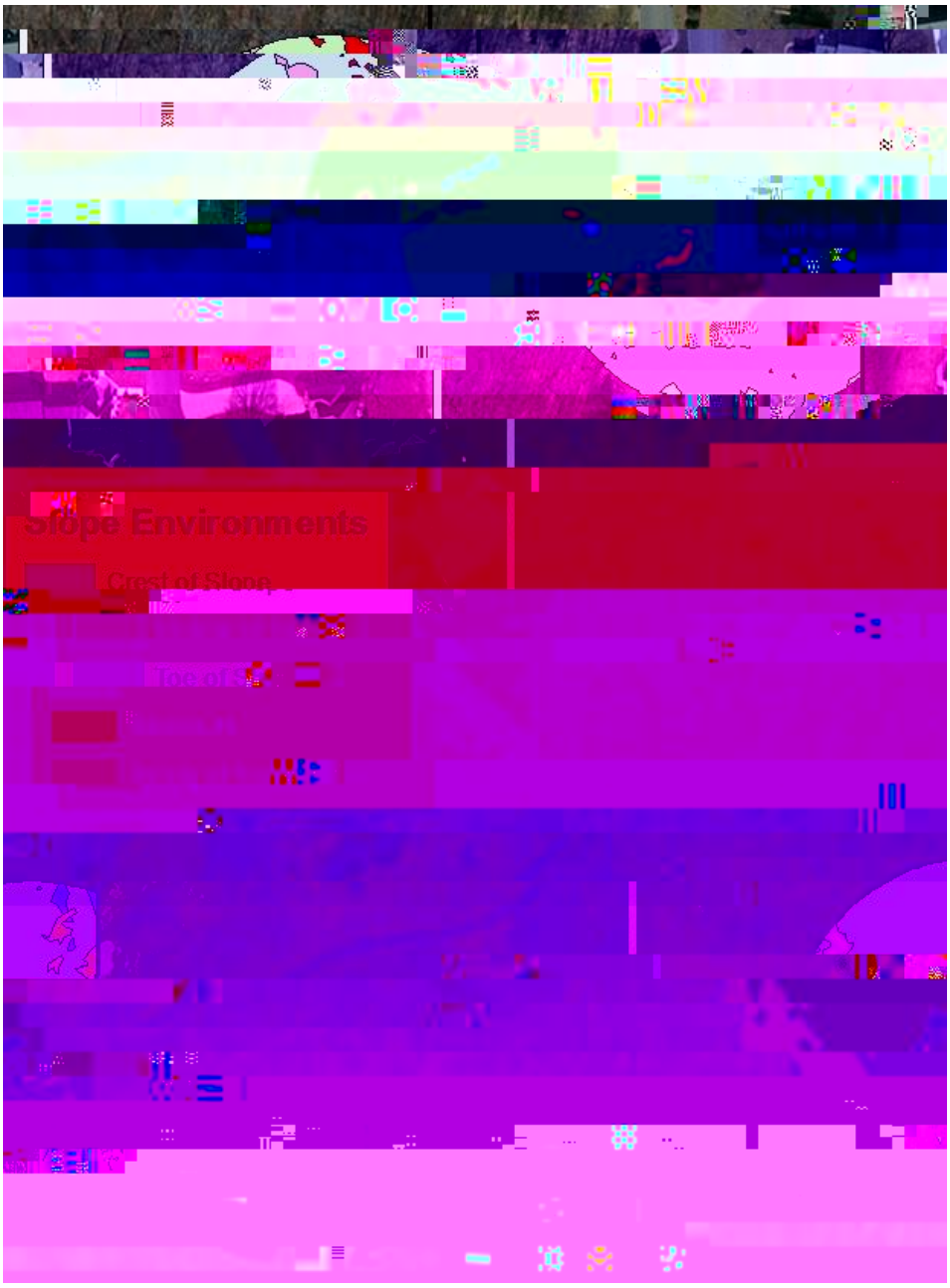

Figure8: Spatial patterns of dune environments in Circles 1 and 2.

Discussion

Results indicate that the experimental treatment saves trees overall, even when the mitigation areas are larger. The reduction of tree mortality is due to the standard treatment method requiring all trees to be killed within the trench, whereas the new mitigation method only kills oak trees within the specified radius from infected trees.

The property line created an interesting challenge for our work because the circles are on only part of the Ottawa County park property and the remainder of the infection was on private property. Since mitigation is only occurring in the park and not on private property, we did not account for those trees in the tree mortality count. Some of the trees along the property line may have been included in our numbers, despite not being located on private property. We corrected this possible mistake in ArcGIS by clipping out the individual trees that were located outside of the property line.

Our slope stability predictions are adapted from the work of Ali et al. (2012), who determined the slope stability of the toe of slope, middle of slope, and crest of slope with or without the presence of a tree. We divided our study areas into environments based on those criteria, although we did not plug our variables into their categories to calculate numeric values for dune instability. Quantifying the analysis may be an interesting direction for future research. Using Ali et al. (2012), we predicted that the toe of the slope is the most critical location for tree removal and is most likely to become destabilized. The crest of the slope is less critical and removal may actually be beneficial to slope stability. Trees at the top of the slope can add weight, which can be problematic when disturbances happen downslope. This analysis is based on the factor of safety, which is calculated as the ratio of the resisting forces or available shear strength to the disturbing forces or shear forces. The factor of safety takes into account factors such as gravity and soil root interaction to calculate the most critical location of the slope during a tree removal event.

Results suggest that Circle 2 is more likely to experience dune instability, including erosional impacts, than Circle 1. Since the ratio of oak trees to other tree species is much higher in Circle 2 compared to Circle 1, a greater percentage of the overall vegetation will be removed. The removal might increase the size of blowouts already in existence in the area. This is especially true for the trees being removed from the toe of slope, which is the most vulnerable

area (Ali et al. 2012). Circle 1, despite being located on a very steep hill, has a low ratio of oak trees to other trees which will continue to help stabilize the dune after mitigation.

Due to our analysis, we recommend that dune managers monitor Circle 2 further after the

Acknowledgments

We would like to give special thanks to the following:

- Dr. Deanna van Dijk, for her support and guidance throughout our study.
- North Ottawa County GIS Department for sending us the North Ottawa Dune DEM data.
- Ottawa County Parks and Recreation for allowing us access to their park.
- Melanie Manion for providing the information about the treatment areas and asking us to conduct this study.
- Calvin College for providing us with the resources we needed to complete this study.
- The Michigan Space Grant Consortium (NASA) for the financial support that made this study possible.

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