Preserving Headstones in Mount Hope Cemetery

GEO479 Professor Bian

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I. Introduction

Mount Hope Cemetery, in Rochester, New York, was founded in 1838 and claims to be America's first municipal Victorian cemetery. It covers an area of 196 acres and is home to many types of trees, famous persons, wildlife, and cemetery iconography. The natural beauty of Mt. Hope-- typified by hills and sudden drops as opposed to the flat landscape of most cemeteries-- has been formed by glacial processes from over 12,000 years ago. Though the glacier's migration helped to contribute to the unique landscape that MtHC is built on, it also creates an opportunity for headstones and gravesites to become disturbed by the underlying geomorphic processes. These processes tend to shift headstones significantly, occasionally toppling them and breaking them apart. It is a disturbance that can be devastating to the integrity of the headstones, but also one that can be avoided with the proper insight when finding new locations for headstones. This study investigates various factors in the geology of the cemetery in an attempt to recognize the factors that are disturbing MtHC headstones and, with the calculated results, help prevent the next generation of burials in MtHC from suffering a similar fate to those who inhabited the cemetery before them.

History and Geology of Mt. Hope Cemetery

From the 17th to the 19th Century, the general consensus as to the formation of MtHC (known previously as Pinnacle Hill) was that Noah's Flood was the culprit. This was agreed upon regarding many landscapes that were carved out by glacial migration. The scientific community at the time had not yet developed sufficient theories regarding glaciers as a force of nature that could create hills and valleys, and deposit unconsolidated sediment. It wasn't until direct observations of deposits on valley floors in the Alps that anyone contested the theory of a biblical-scale flood. The deposits observed were caused by the melting of ice sheets over a number of decades, so when these small scale changes resulted in a landscape that appeared similar to that of other, larger valleys and hills, the stark similarities insinuated that ice-related processes were the architects of such landscapes. The idea persisted and now there is sufficient evidence to support that MtHC was indeed covered in ice some 12,000 years ago; ice that was one to two miles thick and created the kettles and kames that constitute the soil in the area in-and-around Rochester.

This geologic system carved out the shape of what is now the historic section of MtHC. The land itself was not used for anything before the city decided to start burying the dead there. (This occurred around the same time that the glacier theory was being discussed among scientists.) Since the landscape was so uneven, with steep hills and dips seemingly cropping up from the ground as if without warning, the land was deemed uninhabitable by residents and no good for anything other than exploring. Thus it was the perfect place to start a cemetery. With small pox becoming a lethal epidemic in Rochester, many residents passed away at a rapid rate and the need for a new cemetery became apparent.

Issues Facing Mt. Hope and Objectives

Decades after the initial residents of MtHC were buried, the landscape continues to serve its purpose as a modern necropolis and arboretum. Headstones are designed for the affluent families in Rochester and reflect well known Christian, Greek, and Egyptian iconography that tell stories about those who are buried beneath them. Large mausoleums with stained glass windows are built into the hillsides, and obelisks tower over many family plots. Sculptures and ornate headstones are found within a stone's throw from one another. The cemetery is filled with these things, and some of them are falling apart. The results of weathering contributes somewhat to the limestone and other permeable headstones erosion, but others are falling over, sometimes breaking, as a direct result of geomorphic changes beneath them. Unforeseen results of placing burial plots on steep hillsides are picking apart a significant number of headstones one by one. Vegetation is playing a role in this as well. Trees that are over a hundred years old have rooted themselves deeply into the ground and are still expanding their grasp. These thick roots have managed to gradually push the headstones up and away from the ground, eventually tipping them over or warping them in some way. To protect the visual beauty of MtHC and keep future headstones in their initial positions, it is important to look at the two factors that most contribute to the displacement of the stones: vegetation and slope. The objective of this study is to investigate what factors are causing the headstones to fall apart, what can be done to avoid the problem factors when placing new headstones, and what data may be needed in the future when performing a similar study to this one.

II. Relevant Data

Literature concerning the geology of MtHC is not common. Despite being a geologic marvel and a grand example a populated area that was formed by glacial activity, MtHC is generally left alone and/or ignored. No studies have yet been done to protect the headstones in the cemetery, however there are a few studies concerning the evidence of glacial migration that formed the landscape. The Friends of Mount Hope Cemetery volunteer organization has occasionally put together studies about the geology, including the 2004 issue of "Epitaph" in which William Chaisson discusses the historical context of the understanding of MtHC's formation. The essay also mentions the features left behind from the glacier such as kettles and moraines. This turns out to be the best literature available about MtHC's geology as other nearby features, namely the Finger Lakes, have much more to "say" about the glaciers than once migrated across upstate New York.

III. Study Area

This study focuses on the historic and contemporary sections of MtHC. The older, historic section to the north was the first to begin housing the deceased in the early 1800’s. The new section in the southern half of the cemetery was not utilized until the early 1900’s. Both areas are distinct in many aspects. First, the landscape in the newer section is much flatter, having been prepared as an addition to the older section which retains its glacier-cut slopes. Second, the density of gravesites in the newer section is greater with more burials within a given proximity of one another than in the historic section. Third, the vegetation is much younger and smaller in the newer section. The historic section is often considered an arboretum, being the home for a wide variety of trees, some of which have been growing for about 200 years now. These differences become significant when considering their impact of the headstones that are located within them. Issues with headstone integrity are found mainly in the historic section of the cemetery. However this study applies the same criteria and formulations to both the newer and historic sections of MtHC.

IV. Data and Methodology

Using data from various sources and digitized features made especially for this study, the methods used in ArcMap 10 will analyze the relationship between the various features in MtHC. The data is directly related to the geology and topography of MtHC, as are the methods used in the analysis process.

Data Sources

The data needed for this study includes elevation data within the cemetery bounds, tree data, soil data, and aerial photography. The cemetery bounds data was obtained after contacting the Monroe County GIS department at city hall in Rochester. The data provides polygons that outline the boundaries of every cemetery in Monroe County including MtHC. The aerial photography is available on ESRI's website, and Pictometry International provided additional imagery. This was used in creating the tree and vegetation data. There is no available data that has digitized the tree species in Monroe County or in MtHC. Therefore it was necessary to create point data that represents the locations of trees within the cemetery. Using the aerial imagery as a guide, point data was made using the shadows and vegetation as viewed from the imagery. The elevation DEM files for Monroe County were provided by CUGIR. The soil data for Monroe County was provided by the Natural Resources Conservation Service and the Soil Data Mart on their website. All data was processed within ArcMap by ESRI.

Preprocessing

Preparing the data first involved locating the area of study. This was done with the aerial imagery and cemetery bounds data (figure a). The next step was to prepare the elevation data. The converge points for all four Digital Elevation Model images were in the southern section of MtHC (figure b). Once the data for the DEM was properly imported, it was categorized to reflect only those elevation values that are present within the bound of MtHC. This reclassification was combined using the mosaic feature in order to create a uniform DEM for cleaner processing (figure c). Next came the tree data. Since no previous data existed it was necessary to digitize the tree presence in MtHC by referring to the aerial imagery and creating a new shapefile that contained points that represented each tree (figure d). This shapefile was compared to two aerial images, one from ESRI and one from Pictometry International (not pictured due to copyright issues). The next step was to obtain the road locations within MtHC so as to compute the optimal location of headstones outside of the territory covered with a road. This data was clipped to the cemetery bounds polygon for faster processing (figure e). All data was projected onto the NAD 1927 UTM Zone 17N datum.

Processes

Now that all the data had be collected and cleaned, it was ready to be processed in an effort to complete the task of ranking land in MtHC by values that would deem it worthy of new headstones or not. The first calculation done was a reclassification of the slope/elevation data using the Slope Percentage tool. The percentage was ranked from one to ten, one being the most acceptable place seeing as it is the flattest, or has the least amount of slope. The results are shown in figure f. The highest ranking is from 26% to the maximum calculated percentage. 26% was chosen as the highest percentage of slope for an acceptable location of a new burial site. This avoids the issues the headstone would experience over the next century due to the steepness of the hillside it may be residing on. Next the Euclidian Distance tool was used to digitize the distance from each tree. The scale used was the minimum difference between each ranked class: two meters per class, starting from two meters and increasing to twenty. Smaller denominations resulted in inaccurate results, merely calculating the exact location of the digitized tree and not the distance around that tree (figure g). The Euclidian Distance tool was also used in calculating the distance, in meters, from each road in the cemetery (figure h). This was done on a scale of ten ranging from one to ninety. The reason for this is similar to the Euclidian Distance calculated for each tree: the scale seemed to work better with a wide range of values rather than the expected classification (perhaps from one to ten meters instead of one to ninety).

Now that the data had been prepared for processing and classed with ten different categories, it was ready to be combined to produce a final map (figure i). Each value in the completed maps was given a value from one to ten, one being the lowest number represented (e.g. 1-10 meters in the "Calculated Road Distance" map) thus the shortest distance from a tree or road, and the lowest slope percentage.

IV. Results and Discussion

The result of classifying the roads was probably the variable that caused the most differentiation within the results shown in figure i. The road classification seemed to cover most of the cemetery but had a tendency to miss spacious areas between certain sections of roads. These areas would be ideal for new headstone placement since they are away from the roads and typically include few trees, at least in the newer section. Otherwise the calculated results match up with the expected results. The lower ranked values (classified as "closest", "close", and "safe") represent areas that are closest to the roads and therefore not ideal for headstones. As the ranking increases it approaches a mid-point where the results are "safer" and "acceptable". These places are going to be far enough away from the roads and trees that disturbances from each will probably not affect the headstones in the near future. Another benefit to these areas are the minimized slope which falls under 14% and thus is not a major concern for stone toppling or vertical uplift. The highest ranked areas will be acceptable for most headstones, however issues involving shifting headstones will occur sooner in that location than in any other location since the slope is at its maximum angle (less than 26%). Thus the older section of MtHC should have more areas that account for a greater slope percentage than the newer section which is more consistent in elevation. The older section of MtHC also has more trees than the newer section and this is accurately suggested by the results in figure i. One would expect the results to show that the older section of MtHC has less suitable places for new headstones than the newer section, and that expectation is met with all three ranked categories.

V. Conclusion

MtHC is still expanding and new burial plots are being installed year-round. There is not much that can be done for the headstones that have already been broken, but using the results of this project and similar subsequent projects, that fate can be avoided for new stones. Other factors to consider in choosing a new burial site includes the state and consistency of the soil in the immediate area. Soil can be a major factor in deciding how well the landscape will withstand geomorphic influences, as well as how much time will pass until inevitable geomorphic changes will occur. Other changes that would help make this problem manageable include better quality tree data. Studying exactly what species of trees are present in the cemetery helps to uncover how they will grow, to what size, and how quickly. MtHC is an arboretum thus is it important to sustain the life of the trees while working around them. This means allowing the trees to flourish instead of removing them or stunting their growth to make room for new gravesites. Fluvial processes-- those that involve erosion and geomorphic changes due to the presence of water-- also impact the shifting landscape beneath headstones, thus studying fluvial processes may shed some new insight on the types of changes that are to be expected within the cemetery over the next century.

With more data becoming available all the time it is not unrealistic to think that more relevant data will soon be available to expand this project into a functioning model. The technology to map out the burial plots in a cemetery currently exists. The company Ramaker Inc. has produced CIMS, the Cemetery Information Mapping Software that assists cemetery caretakers in organizing plots and planning where to put new ones. Combining these types of maps with the data this project has produced can potentially change the way cemeteries partition new burial sites and help preserve the headstones for longer periods of time. The ideal outcome of this project is that it can be used throughout many cemeteries by quantifying the factors that assist in the destruction of headstones and compromise the integrity of burial plots. Applying the data that can be learned in an extreme case like MtHC would easily be applicable to all sorts of landscapes that cemeteries around the world inhabit.

Helping to preserve historic sites like MtHC help to make Rochester a unique place. The cemetery welcomes visitors on a daily basis and is a rare example of natural beauty and virtually untouched evidence of incredible glacial activity within the bounds of a bustling urban landscape. Using new geospatial technology can assist the city in keeping its popular attractions in great shape, thus improving the overall quality of life for everyone who is living-- and has once lived-- in Rochester.

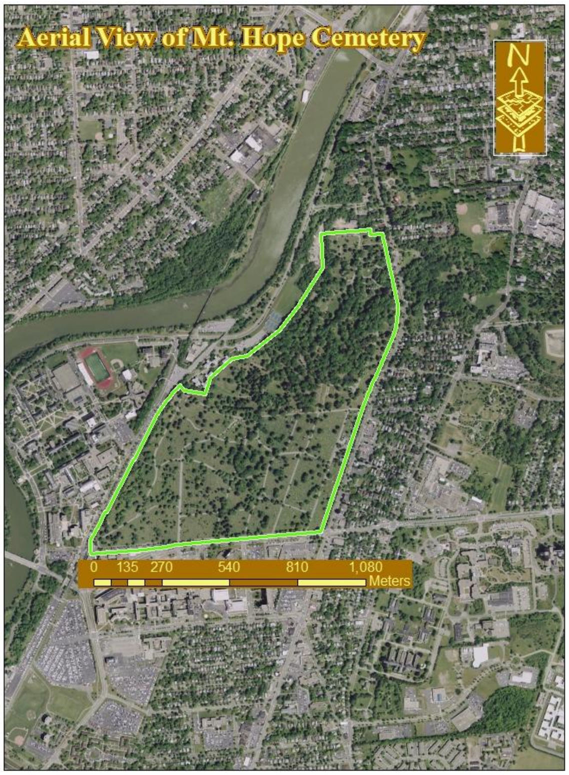

Figure a

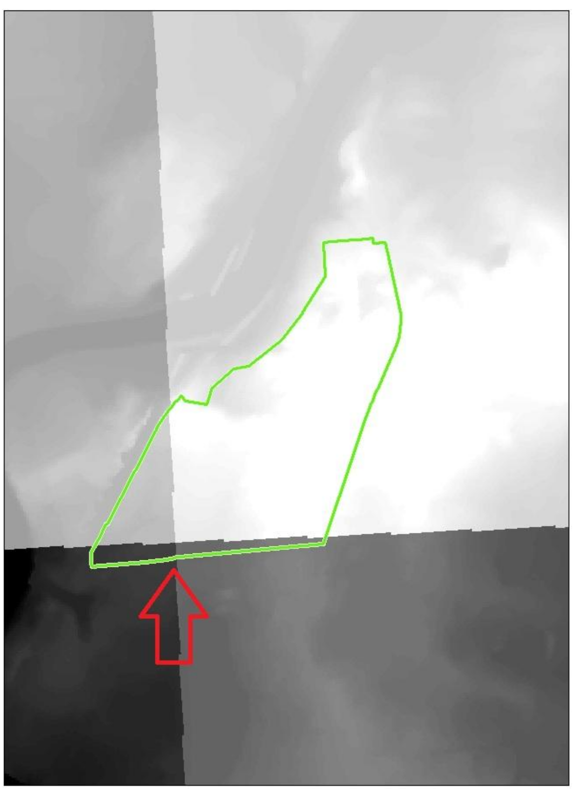

Figure b

Figure c

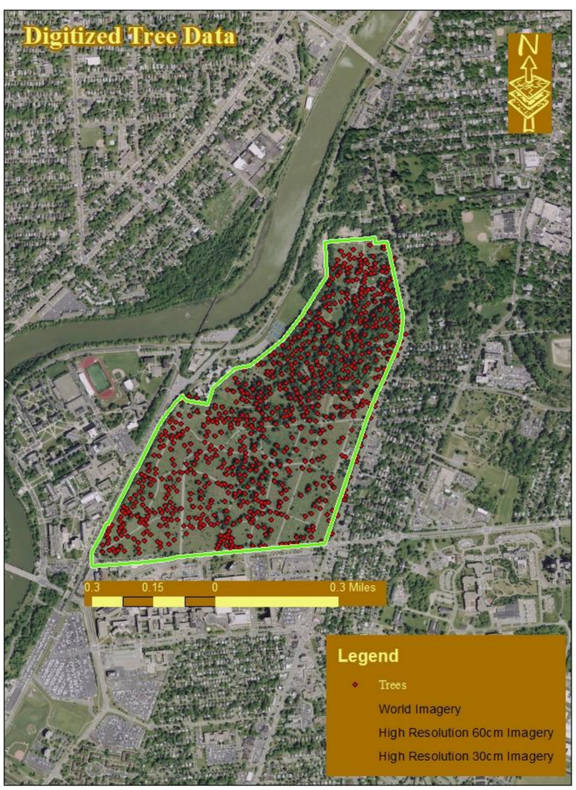

Figure d

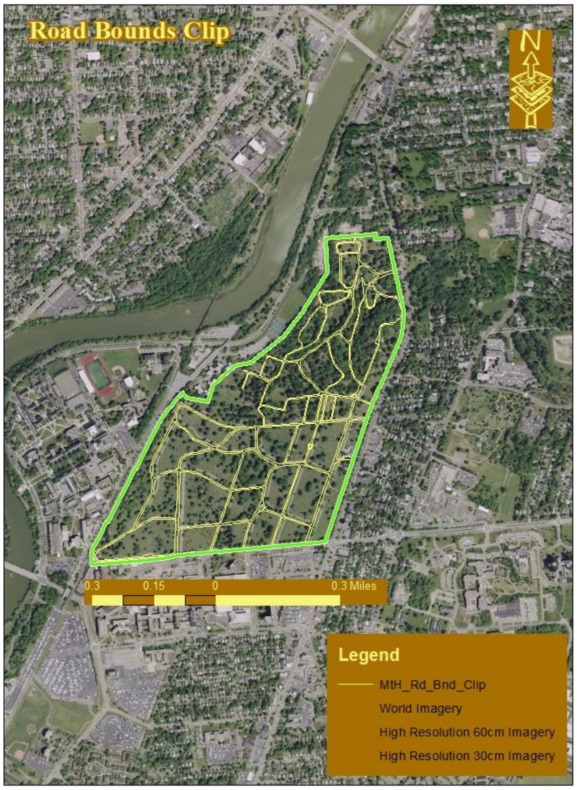

Figure e

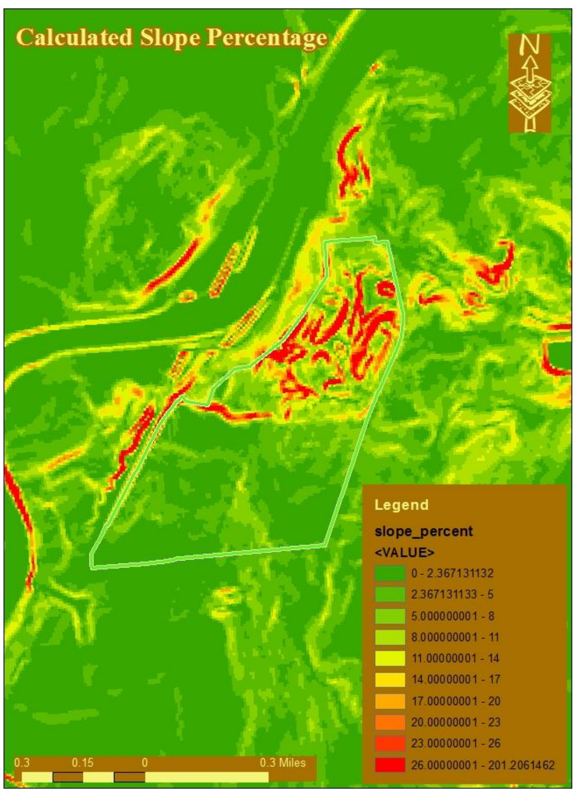

Figure f

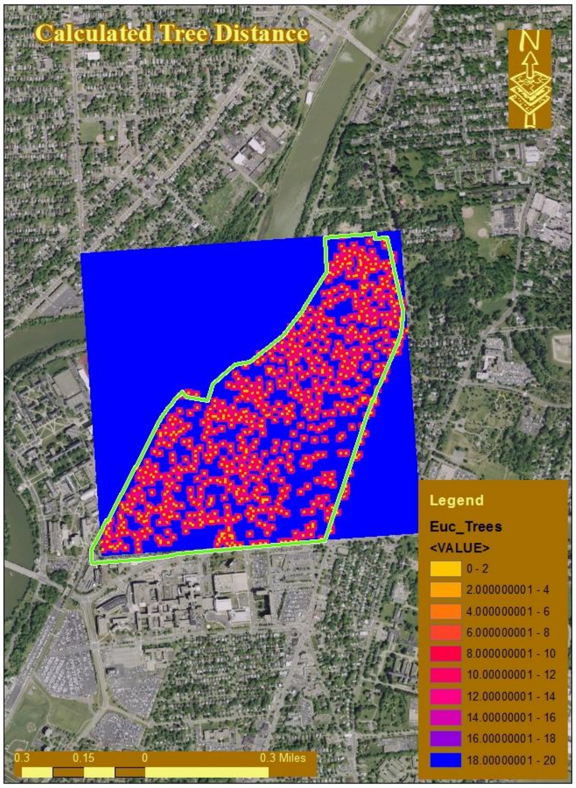

Figure g

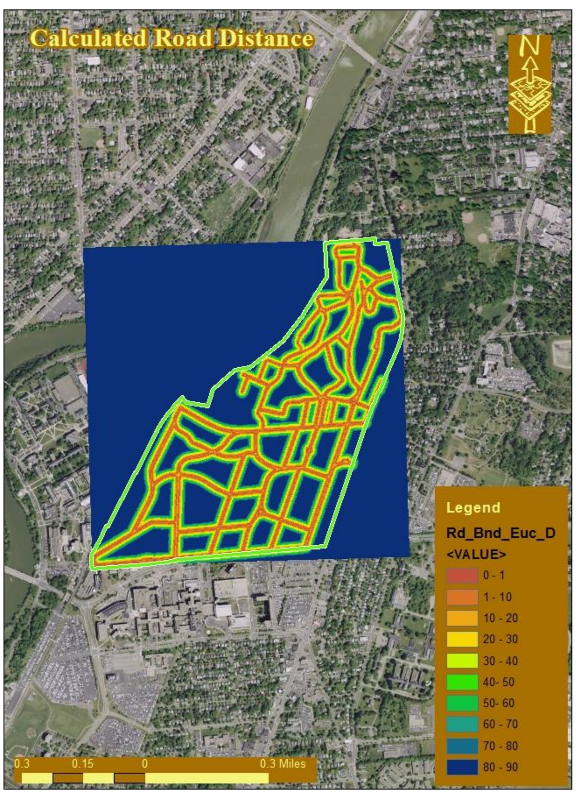

Figure h

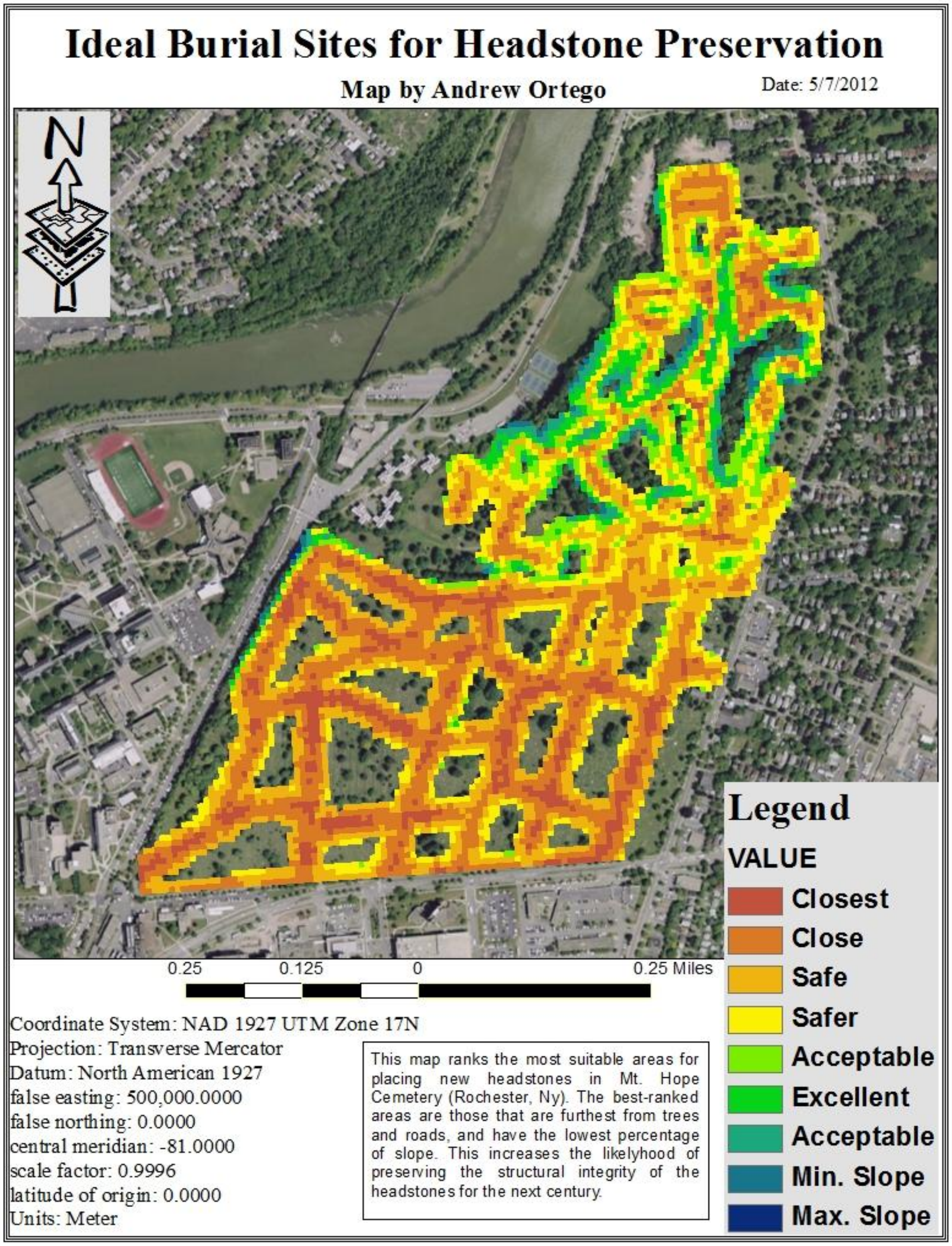
Ideal Burial Sites for Headstone Preservation
Map by Andrew Ortego
Date: 5/7/2012
N
0.25
0.125
0
0.25 Miles
Coordinate System: NAD 1927 UTM Zone 17N
Projection: Transverse Mercator
Datum: North American 1927
false easting: 500,000.0000
false northing: 0.0000
central meridian: -81.0000
scale factor: 0.9996
latitude of origin: 0.0000
Units: Meter
This map ranks the most suitable areas for placing new headstones in Mt. Hope Cemetery (Rochester, Ny). The best-ranked areas are those that are furthest from trees and roads, and have the lowest percentage of slope. This increases the likelihood of preserving the structural integrity of the headstones for the next century.
Legend
VALUE
Closest
Close
Safe
Safer
Acceptable
Excellent
Acceptable
Min. Slope
Max. Slope

Figure i