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Cemetery Management in a GIS Framework: A Case Study of Woodland Hills Memorial Park

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By

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This alternative plan paper has been examined and approved by the following members of the student's committee.

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ABSTRACT

This paper aims to examine the potential uses and applications of geospatial technologies for cemetery management. The Woodland Hills Memorial Park in Mankato, Minnesota, was used as a case study. The hard copy, handwritten records of the Woodland Hills Memorial Park were converted to digital formats, and then combined with GPS gathered data using GIS. The traditional method of storing and keeping these records is time consuming, as the curator must hand write all the information into the physical books. The maps of the park are also hand-drawn, which makes their examination and upkeep tedious. By creating digital copies of all the records, modifications can be made swiftly and simply, and searches for specific information or gravesites can be performed without undue hassle. Some of the risks associated with these records are that they may be lost, damaged, or rendered unreadable. Creating multiple electronic backups, which can be done with a geodatabase, eliminates these risks. Once the initial database has been assembled, it can be linked to the digitally created maps.

By using geodatabases, the locational data gathered using the Trimble Geo7x GPS units was joined to the digitized paper records to create a finished product that functions using both spatial and attribute data. Demographic analysis (Moran's I) is utilized to detect the strength of spatial patterns. The result shows that there are significant clustering patterns for veterans of WWII and Korean War. When examining the spatial distribution of the ages of those interred based on their generation, it is revealed that there are significant clustering patterns in each of the six generations represented. In addition, genealogic analysis is also applied to examine cultural or ethnic information and reveals indicative of the strong German and Scandinavian heritage of Minnesota due to last name such as Anderson, Nelson, and Peterson.

This research allows for better cemetery management techniques, as the geodatabase format is easy to update, provides an ideal framework for spatial and attribute queries, and simplifies the maintenance requirements of the records. It also provides an outline for other projects with the eventual goal of having more cemetery geodatabase to improve management alike. One of the future studies discussed in this paper includes the option to improve the results of the project by adding more demographic data such as gender, ethnicity, and family ties to the geodatabase. Another expansion would be into web mapping and apps. Using programs like ArcGIS Online, hosting a web map or even a custom-made app of the cemetery would be a good alternative for someone unfamiliar with geodatabases or GIS techniques.

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1. INTRODUCTION

1.1 Problem Statement

Cemeteries are important parts of a civilization. Proper disposal of the dead is just as vital to sanitation as it is to the cultural well-being of an area (Thorsheim 2011). They serve as a place for mourning and remembrance, and while burial practices vary between cultures and regions, the need for closure remains constant (Pattison 1955). These burial sites, be it a traditional cemetery or a crematorium, play an important role in a community and need to be properly planned for and maintained.

Modern urban areas are facing many challenges in keeping up with the necessary space and service requirements for disposing of the deceased (Basmajian and Coutts 2010). Not only is it necessary for cemeteries to be available to residences of space-poor inner cities, but even in more open areas numerous prejudices and superstitions surrounding graveyards makes it difficult for cities to build new facilities (Bennett and Davies 2015). Combined with how most cemeteries are private organizations, rather than being a part of local or federal governments, means that these for-profit businesses need to be able to sustain themselves regarding maintenance fees and in the cost of land.

In terms of maintaining cemeteries, there are a number of factors that must be accounted for. Cemetery managers must take into account the cost of keeping up the graveyard when assigning prices to each gravesite. As most cemeteries do not charge a repeating fee for the spaces, this means that the original price must be enough to cover things like landscaping, future improvements to the facilities, the salaries of the staff and any additional laborers, all while continuing to turn enough of a profit to make the business worth operating. With so many items to consider, it is important to note that proper record keeping practices be maintained to know which gravesites are available, which are the most desirable for certain people, and how valuable each gravesite is (Faye and Channac 2017).

Keeping these records should also be important to the local community as well. By knowing the precise locations of each gravesite and having it properly documented means that there is no issue with lost gravesites (Davies and Bennett, 2016). A common problem with older cemeteries, proper records prevent any issues with unknown burials and let cemetery managers know quickly and efficiently what spaces are available for further development in their graveyards.

Along with spatial records, the information of the interred should be carefully noted. These records should be kept for the knowledge of any family members and for future generations. This way not only can individuals come back later and find possibly lost or estranged relatives, but there is a historic and cultural record kept of those who had once lived in the area. In the future, current graveyards could easily become the same havens of knowledge that archaeological gravesites are to modern researchers.

Traditionally, cemeteries have kept paper records. These are most commonly written in bound paper books, noting the owners of each gravesite. The actual information contained within these records varies between cemeteries and can present a number of challenges to researchers and cemetery managers alike (Matero and Peters 2003). Such books are cumbersome to search through, requiring that the interested party either be intimately familiar with the records or read through each entry with a careful eye. This is hardly an ideal situation for someone searching for a particular name or deed. The lack of standardization also means that vital information may not be recorded, or that the records may be initial structured in such a way as to make adding such information impractical. Hardcopy records are just as resistant to any potential alterations of their actual contents. Records written in pencil may be erased and written over, but only so many times. If the initial notes were made in pen, then modification becomes even more difficult.

These records are also very susceptible to damage, both from human interactions and environmental. Pencil markings are notorious for fading over time and are easily smudged. Certain inks are proof against fading or smudging, but the paper itself introduces a variety of potential avenues for damage. The books can easily be misplaced or stolen, and they can easily be rendered illegible from dirt, water damage, or tearing. A single cup of coffee in the wrong place could ruin a cemetery’s entire recording-keeping system, and paper records rarely have any form of backup or security. In contrast, transferring to an electronic format better removes these concerns and allows for backups. It also allows the managers to update their records easily. By keeping electronic records, cemetery managers can easily access information without needing to page through a book.

The most efficient way of keeping track of all of the information discussed above is to convert it into digital form and combine it all into one location. A geodatabase is an objected-based relational database in Geographic Information System (GIS) that can be used to keep track of the spatial locations of each gravesite as well as to link the records and personal information with each site. By using the geodatabase, cemetery managers can access the information by any number of variables (Liebens 2003). Just looking for a specific date of internment would be enough to find all of the available information about the deceased, without having to page through books hoping to catch sight of a certain name or date. It also allows for individuals who may not be certain of their information multiple ways of checking to see if or where someone might be buried.

By using a geodatabase in place of a traditional database, the spatial or locational component of the gravesites can be addressed. Not only does this simplify the process of determining which gravesites are empty and their location within the cemetery, but it also creates the possibility of providing precise directions to the location of an individual grave. Rather than wandering aimlessly through the grounds, cemetery managers can direct people to the exact location they are searching for. Along the same vein, cemetery managers can better match available gravesites to their customers based on number of available spaces surrounding a gravesite, any aesthetic features around the gravesite, or the accessibility of a specific gravesite.

This paper describes how to build a geodatabase containing records and geographic locations of on such cemetery. It details the steps taken, beginning with converting the paper records of the cemetery. The logistics of obtaining the physical locations of the gravesites are discussed, which were obtained using handheld GPS units over the course of three months. It covers the necessary accuracy corrections and describes exporting the features into software to build the geodatabase. This paper uses ArcMap, as it is suited to combing the records with the GPS data and is capable of preforming analyses to best determine the use of a geodatabase to cemetery managers.

1.2 Research Objectives

This proposed research focused on the potential uses and applications of geospatial technologies for cemetery management. It will address the following research objectives.

(a) Collect cemetery data (e.g. grave spaces, walkways, gates, statues) with high-accuracy GPS and then further refine the data using accuracy assessments;

(b) Build a geodatabase of the cemetery records that can be queried by attributes and/or spatial locations in a GIS framework.

(c) Determine what, if any, patterns or trends the data collected (e.g., birth dates, death dates, lifespans, etc.) displays.

2. LITERATURE REVIEW

2.1 Cemetery Management

Cemeteries serve a variety of functions. Arffmann (2000) laid out four uses of cemeteries, which provide a good guideline for how most cemeteries are regarded. They improve sanitation, serve as a place for mourning, give people a place to contemplate their own mortality, and add value to the community around them. They fill an important role in society, and as such the management of cemeteries is a topic that needs to be discussed.

2.1.1 Cemetery Planning

Cemetery management encompasses many different tasks and can be characterized in a few ways. The first step lies in the creation of cemeteries and other burial grounds. Numerous articles have been written detailing the necessity and challenges faced when incorporating cemeteries into city planning (Johnson 2008; Basmajian and Coutts 2010; Coutts, Basmajian, and Chapin 2011; Woodthorpe 2011; Bennett and Davies 2015; Davies and Bennett 2016). The common issues faced are the land requirement and society's opinion on cemeteries.

Pattison (1955) used Chicago as an example of the issues city planners are facing with land management. The result showed that open land is difficult to find in urban areas, especially in large metropolitan centers. Well established cities in the United States (U.S.) are running into issues of space, especially as land prices continue to increase. Cemeteries, which are traditionally a mixture of private or religious organizations lacking a centralized structure, must compete with other businesses to expand. While many hold that burials are a human requirement (Woodthorpe 2011), there is no central governing factor present in many countries (Hussein and Rugg 2008; Coutts, Basmajian, and Chapin 2011; Woodthorpe 2011). This can cause issues when discussing the topic of cemeteries. Private companies need to maintain their profitability, which may not be possible if attempting to make burial practices affordable to those who cannot afford them.

Coutts, Basmajian, and Chapin (2011) specifically detailed another of the upcoming issues that many cemeteries will face. The upcoming deaths of a large elderly population is a major concern in the industry. The article in question specifically looks at the potential effects of the end of the baby boomer generation (born in 1946 – 1964) lifespan, and the implications for major retirement communities in the U.S. While available expense and availability of land for burials is a key issue, the article also discusses issues with logistics and personal requirements to staff and carry out burial plans. This subject was also discussed in broader details in a previously published article by Basmajian and Coutts (2010).

Another issue besides the infrastructure required to support cemetery management is in society's opinion of cemeteries. Traditionally, much as there is no organization of cemeteries, the local rules and regulations have been left to local governments to handle. Numerous studies have been done in London in regard to the status of their burial practices (Hussein and Rugg 2008; Brown 2011; Thorsheim 2011; Scholz 2017**)**. Over time, society has seen a change in how people view cemeteries and other burial spaces (Johnson 2008). While cemeteries were traditionally the purview of either a family or a religious organization such as a churchyard (Rugg 2000), the modern need for cemeteries has expanded beyond such specific structures. However, even when appropriate land is available, cemeteries must overcome the local laws and regulations before they can be created.

Many people have negative connotations with cemeteries, finding them unsettling or that interacting with them is undesirable. Brown (2011) discussed London's project which was to improve public opinion of cemeteries by giving them another purpose as green space within the city. The intent of this practice was to more efficiently use the open spaces cemeteries required. It allowed for the open space these cemeteries required, while also made it possible for surrounding neighborhoods to benefit from the space that can no longer be used for development (Woodthorpe 2011). By pushing for communities to consider a cemetery as a necessary feature that does not detract value from the surrounding neighborhood, the inevitable requirement for burial sites can more easily be fulfilled.

2.1.2 Cemeteries as a Business

Another important factor mentioned previously is that cemeteries, not falling under governmental oversight in most counties, must have some form of financial support. Historically, most burials sites have been under the purview of the local church or religious organization. Family graveyards were uncommon, but it was not unusual for a small community to have a communal burial ground. While some graveyards are still owned and managed by religious organizations (Rugg 2000), most are required to operate as businesses.

This means that grave sites are sold to individuals at a rate that the cemetery believes will pay for operating costs, and the future maintenance of the area. Landscaping is a very important cost for cemetery management. The grass needs to be mowed, the trees and bushes need to be maintained, and the paths and walkways through the cemetery must be kept to a certain level of accessibility. Property taxes, especially in larger cities, are another maintenance cost along with the utilities to keep the cemetery offices running. Employees must be paid, and capital is required to provide services such as cremations, coffin sales, and wakes to customers (Faye and Chanac 2017).

As a business, it is important that a cemetery turns enough of a profit for it to remain in operation, while still being a desirable industry to work in. As cemeteries do not typically receive government funding, they must maintain enough revenue to pay for the upkeep of the burial grounds, while allowing for the possibility of expansion into more land as the available spaces fill (Longoria 2014). This can cause issues with more community-based individuals, who believe that the right to a final resting place is something that should be provided for everyone. While the government may be able to subsidize such an endeavor, local cemeteries are often unable to absorb such a large hit to their profit margins (Woodthorpe 2011).

The largely independent nature of the mortuary business means that there is a lack of standardization in burial practices. This also introduces a common concern with industries and businesses, which is pollution. Fiedler et al. (2012) examined the potential risk cemeteries pose for the environment. Not only are the synthetic materials used in the burial process a potential hazard as they break down over time, but the chemicals used when preparing the deceased for funerals and burials pose a variety of health risks. Basmajian and Coutts (2010) raised similar concerns, and detailed how current practices are being changed to lessen the potential effects on the environment.

2.1.3 Cemetery Organization

The organization and record keeping of a cemetery is vital to its short term and long-term success. Numerous studies have examined how to manage cemeteries (Paine 1992; Matero and Peters 2003; Kong 2010; Nielsen et al. 2015; Spurgeon 2017). Many modern disciplines centered around studying past human behavior such as archeology, anthropology, and history would have benefited from properly collected and maintained records. Current intent is to either recreate these records now (Quesada, Baena, and Blasco 1994) or ensure that modern records are taken appropriately.

A major issue with the management of older cemeteries is lost or incomplete records. When a cemetery no longer has a caretaker, the location is usually forgotten and then lost. Paine (1992) detailed the exhaustive process that must be done to restore these locations, many of which will continue to have important data missing despite the best efforts of those involved. The article also detailed how the graves must be located, what information is present must be gathered, and a comprehensive account of all the available data must be assembled. A lengthy process that could have been avoided had proper records been kept. Matero and Peters (2003) provided their workflow for restoring these abandoned cemeteries while preserving as much of the cultural and historic heritage as possible.

Nielsen et al. (2015) provided a good example of the problems with poor cemetery and burial management. Not only did the improper handling and disposal of bodies lead to the unnecessary spread of the illness, but many of those buried were done so with no record of their names. Without the proper records, only drastic methods like

DNA testing can determine the identity of the deceased. These reasons show why proper cemetery organization methods such as record keeping, the type of information archived, and the layout of the grave plots, must be standardized.

2.2 GIS and Geodatabases

Geographic information system (GIS) is the term used to describe the technology and framework that makes up the discipline of spatial data processing (Parker 1988). Several techniques can be used in GIS, ranging from simple mapping of data to creating a regression equation to fit the trend line of data values, but the unifying theme is that it deals with information present in some location in space (Gold 2006). Within this single constraint, GIS is applicable to nearly every field of science. This ranges from showing the spread of diseases to the determining historic landcover types based on soil distributions. Agricultural efficiency can be monitored and evaluated using GIS techniques, and city expansion can be predicted based on previous land use changes.

Combining the information associated with gravesites with the spatial locations requires a specific type of database. A database stores data in a manner that allows it to be related to other data, for example an image of a gravestone can be connected to the information regarding the owner of the lot (Matero and Peters 2003). Geodatabases allow for the information associated with a cemetery to be conveniently located in one location that can be easily accessed. Many different types of information can be stored in a geodatabase. Geodatabases can be used for a variety of studies such as keeping detail spatial records of landslides in geology (Briner et al. 1999; Superchi et al. 2010) and geomorphology (Caimpalini et al. 2015), managing dig sites and archaeological data for current projects and future research (Gonzalez-Tennent 2009), or resource management for wetlands (Mathiyalagan et al. 2005).

Superchi et al. (2010) described a geodatabase as “a database designed to store, query, and manipulate geographic information and spatial data.” Geodatabases are expansions beyond regular databases that only contain text or numerical information. Adding the locational component allows for a larger range of queries to be carried out, as well as provides the opportunity for preforming spatial analysis on the information. Either commercial GIS software such as ArcGIS or open-source program such as QGIS can be used to store and access this information.

Geodatabases include three types: file geodatabases, personal geodatabases, and enterprise geodatabases. File and personal geodatabases are used on an individual or small group scale, while enterprise geodatabases are commonly used by large businesses or corporations. Enterprise geodatabases also allow multiple people to make edits to the data simultaneously. Personal geodatabases store data in a single Microsoft Access file, and does not allow the user to edit multiple layers or features at once. Many users find the features of an Access file to be beneficial. File geodatabases have better storage structures, storing up to 1 TB of data while a personal geodatabase is effectively limited to only 500 MB (ESRI 2018). Unless familiar with Microsoft Access file use and structure, a file geodatabase is recommended due to its improved functionality within ArcMap and the ability to modify the files contained within simultaneously.

SQL (Search and Query Language) is a programming language that is ideally suited to perform the types of spatial and informational queries that make the best use of a geodatabase. The basic language of an SQL query is SELECT (a record) FROM (a location) WHERE (condition). If looking for all of the students in a class that were Juniors and were majoring in Geography, the SQL query might look like SELECT student name FROM students WHERE status = junior and major = geography. The syntax of these queries can be as complex or as simplistic as required by the users, no matter the size or information contained within the geodatabase. The two restrictions on SQL are the data available in the geodatabase, and the skills of the user in crafting the appropriate statements. An SQL statement can only be written about data actually present and available to be searched, and as with all computer skills, the tools are only as useful as the one making use of them (Garner and Mariani 2015).

Quesada, Baena, and Blasco (1994) made use of geodatabases to store the information of their dig sites and to preform spatial analysis. Paine (1992) would have been enhanced with a geodatabase component, streamlining the process of data gathering and allowing for the geolocation of their discovered gravesites. Using geodatabases also allows for easy updating of data, as records can be kept up to date and the information can be restructured as necessary (Brovelli and Sanso 2009).

Briner et al. (1999) discussed how geodatabases are useful in field data acquisition. They discussed the process that they used to create a geodatabase, in addition to making note of the information they collected from field work and combining with the physical locations of the landslides collected using handheld GPS units. An important component to their research, which is very applicable when discussing the possibility of recording cemetery information for future and widespread use, is that geodatabases have the ability to be shared with multiple individuals. This means that the information is not restricted to a single computer and can be modified and improved on by other people, such as with an enterprise geodatabase.

The structure of the geodatabase is another important consideration (Briner et al. 1999; Superchi et al. 210; Chesnaux et al. 2011; Simpson 2015). While the digital medium of geodatabases allows for easy modification should the need arise, the initial structure plays an important role in how the data is gathered. While missing information or additional categories or feature classes can be added at a later point in time, doing so is inefficient and requires additional field work that may not be possible. Removing sections of the geodatabase is easier but indicates that the fieldwork portion of the project could have been complete in a more timely and efficient fashion (Chesnaux et al. 2011).

2.3 GNSS (Global Navigation Satellite System)

2.3.1 GNSS Technology

One way to collect the locational data required for a geodatabase is with a global positioning system (GPS) unit. With the rise of cell phone navigation, most individuals are familiar with the term GPS, which is used colloquially to refer to geolocational units and methods. The proper name is global navigation satellite system (GNSS), which refers to the system of satellites that orbit the earth, tracking and recording positional data (Hofmann-Wellenhof, Lichtenegger, and Wasle 2008).

GNSS works from the basis of triangulation, which requires the use of at least three satellites to determine the precise position of an individual on earth at any given time. The first satellite emits a signal, and the distance from the satellite can be determined by a receiver. This receiver could be at any position around the satellite that certain distance away, forming a circle of where the satellite could be. By adding a second satellite, the receiver can narrow the area of possibility to where the signals of the two satellites overlap. If the receiver is capable of picking up the signal of three satellites, then it can determine two possible locations, and the three overlapping circles will have two points of overlap, in the same coordinate plane but with differing elevations. While this is usually all that is necessary to determine the location, as whichever point matches the elevation of the earth's surface can be taken as the correct one, it is best to use at least four satellite signals to determine the location of the receiver (Eissfeller 2015).

Having more than four satellites is preferable, to overcome any potential obstructions of satellite signals and to ensure that any errors in the signals are found. By maintaining at least 24 satellites between the 6 orbital planes, GNSS ensures complete coverage of the entire globe. These satellites send signals to GPS receivers, which interpret the signals to determine their location at any given time (Djuknic and Richton, 2001). There are currently six global satellite navigation systems, owned by the U.S. (NAVSTAR GPS), Russia (GLONASS), the EU (Galileo), India (IRNSS), Japan (QZSS), and China (BeiDou) (Eissfeller 2015). However, the U.S. NAVSTAR GPS and the Russian GLOANASS are the only fully operational GNSS.

GPS technology has a variety of uses, as it is a low cost and reliable option for gathering locational data. Hebblewhite and Haydon (2010) discussed the use of GPS devices in ecology, while Segall and Davis (1997) described how GPS is helpful to the discipline of geophysical studies. GPS can be used in conjunction with GIS techniques, either to enhance preexisting data (Yu et al. 2014) or to create it from scratch. The highest accuracy is desired for optimal analysis and representation of the data

2.3.2 GPS Accuracy

Several factors affect the accuracy of GNSS. These include environmental issues, issues with the satellites, and issues with the GPS units (Lejene and Warnant 2008; Martinez, Martinez, and Garcia-Cerezo 2000; Li et al. 2015; Daneshmand, Marthe, and Lachapelle 2016). Satellite signals can be obstructed by landscape features, such as rock outcroppings or heavy tree cover. They are also sensitive to water vapor or other atmospheric components, particularly in the ionosphere (Lejeune and Warnant, 2008). Weather conditions and the locations of satellites in the sky (determining the angle of which the signals will be reaching the receiver) are important factors to consider when using GPS units.

Other issues that need to be considered and accounted for lie with the GPS units and the satellites themselves. As man-made components, the possibility of damaged or defective components in one that must be guarded against. GPS receivers determine their location based on their distance from the satellites, which is determined by how long it takes the receiver to collect the signal emitted by the satellite. This means that the internal clock of both the satellite and the receiver must be correct and in sync, otherwise the location will be incorrectly recorded (Eissfeller 2015).

Differential Correction, occasionally referred to as differential global positioning system (DGPS), is a method of correcting the errors that occur when collected locational data using GNSS (Santerre, Geiger, and Banville 2017). The need of accuracy differs depending on the project, but a high level of accuracy is required for collected cemetery gravesites, due to their close proximity with each other. Differential correction is carried out after the data has been collected and uses the readings from base stations located throughout the U.S. to ensure that the satellite signals were correctly received by the GPS unit. These base stations are kept to a precise standard to ensure that the signals they receive are accurate, which allows for the correction of any faulty data that may have been collected by the handheld unit.

3. METHODOLOGY

3.1 Study Site

The study area is the Woodland Hills Memorial Park (Figure 3.1), which is located at the address of 1605 Woodland Ave, Mankato, Minnesota. The park is located on top of a hill, overlooking the Blue Earth River to the West. The park is approximately 22 acres in size and is bordered by residential neighborhoods. This memorial park was established in 1938 and was previously known as Grandview Memorial Park. Woodland Hills currently hosts 12,190 gravesites, with 5,954 filled graves and 6,236 empty sites. As a memorial park, Woodland Hills has flat bronze plaques instead of upright tombstones. While the style and designs can be chosen at will, there are no vertical structures other than the statues and the urns some of the graves have.

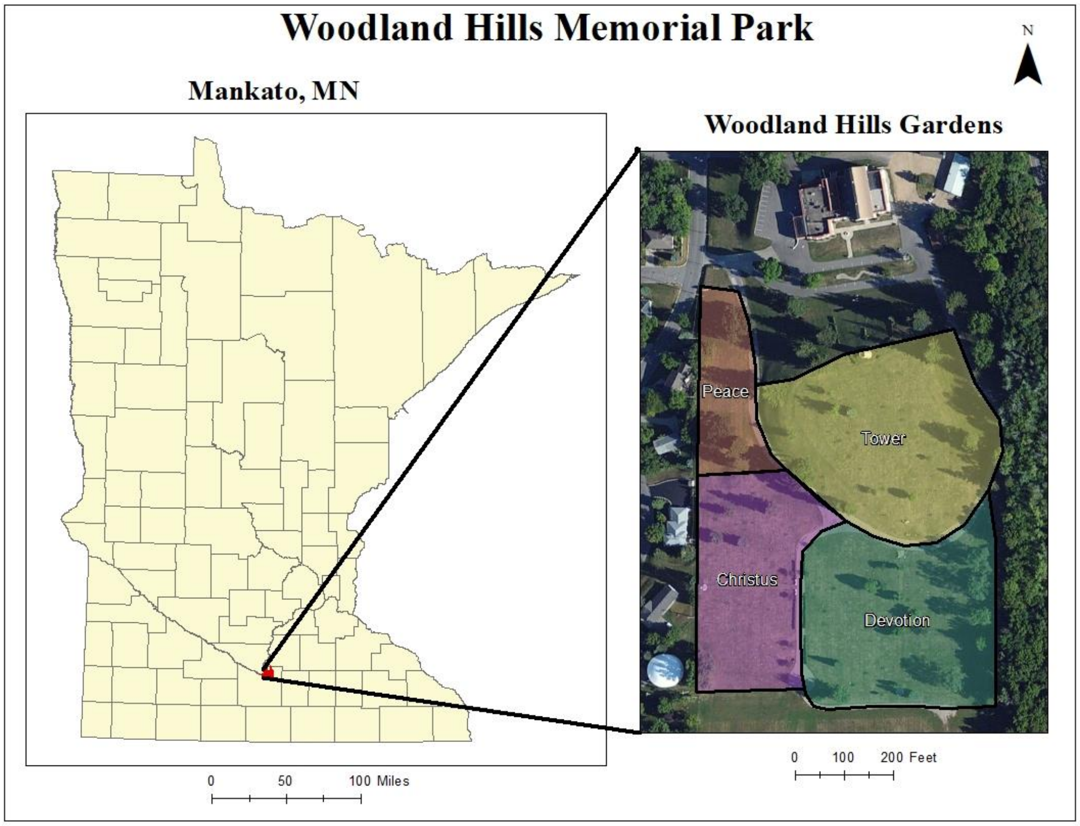


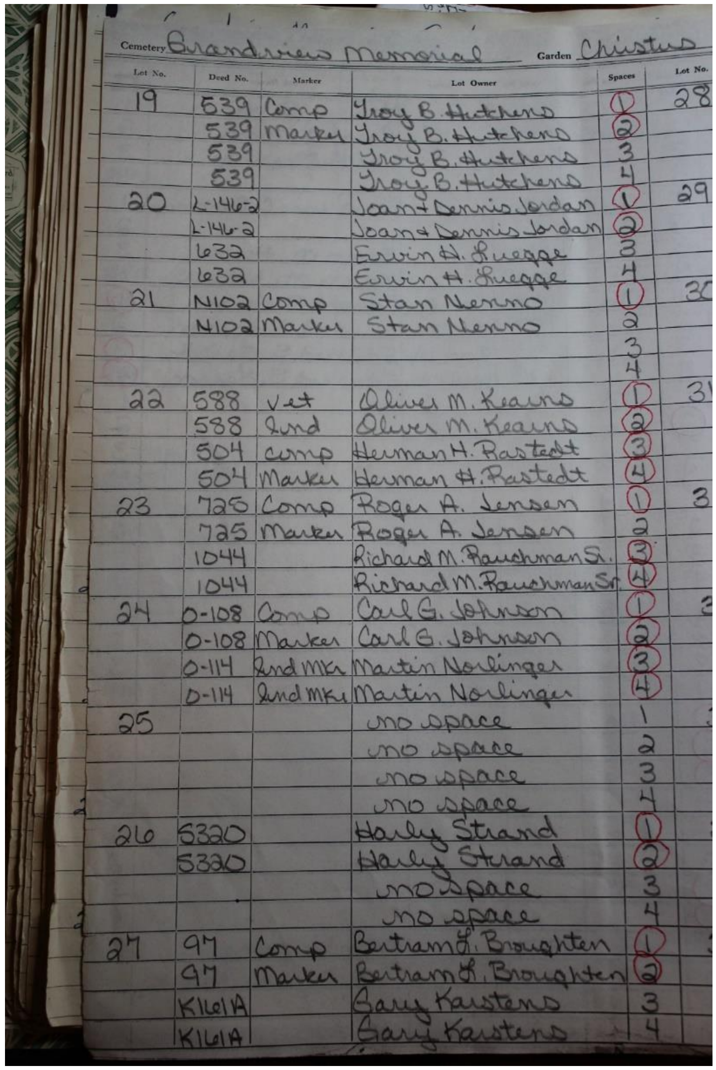
Figure 3.1 Study Site Location

Woodland Hills Memorial Park is divided into four gardens: Christus, Devotion, Tower, and Peace (Figure 3.1). Each garden is divided into lots. These start numbering with one and work their way through the garden. Each lot has four sections associated with it, labeled A – D. Section A is in the upper left corner, section B in the lower left, section C in the upper right, and section D in the bottom right of the lot marker. There are four plots (1 – 4), or grave spaces, for each section. In total, there are 16 grave spaces for each lot. As the records as currently organized, to find information about a specific grave one must manually search through the hardcover book of records, referring to the physical maps in an effort to examine the grave sites in any spatial capacity.

3.2 Data Acquisition

3.2.1 Cemetery Records

The handwritten records (Figure 3.2) were transferred into Excel tables manually over the course of a few months. Pictures were taken of each page of the text, which were then used as reference for entering the information. The lot, section, and plot number were recorded to form an identification number that would be unique to each gravesite. The deed number was recorded when available, as well as any information regarding the type of marker. The name of the lot owners was taken down, and the image of each record was noted for reference.



Cemetery Brandview Memorial Garden Christus

Lot No.	Deed No.	Marker	Lot Owner	Spaces	Lot No.
19	539	Comp	Troy B. Hutchens	1	28
	539	Marker	Troy B. Hutchens	2	
	539		Troy B. Hutchens	3	
	539		Troy B. Hutchens	4	
20	L-146-2		Joan + Dennis Jordan	1	29
	L-146-2		Joan + Dennis Jordan	2	
	632		Erwin H. Ruegge	3	
	632		Erwin H. Ruegge	4	
21	N102	Comp	Stan Nenno	1	30
	N102	Marker	Stan Nenno	2	
				3	
				4	
22	588	Vet	Oliver M. Kearns	1	31
	588	2nd	Oliver M. Kearns	2	
	504	comp	Herman H. Rastedt	3	
	504	Marker	Herman H. Rastedt	4	
23	725	Comp	Roger A. Jensen	1	3
	725	Marker	Roger A. Jensen	2	
	1044		Richard M. Rauchman Sr.	3	
	1044		Richard M. Rauchman Sr.	4	
24	O-108	Comp	Carl G. Johnson	1	3
	O-108	Marker	Carl G. Johnson	2	
	O-114	2nd Mkr	Martin Norlinger	3	
	O-114	2nd Mkr	Martin Norlinger	4	
25			no space	1	
			no space	2	
			no space	3	
			no space	4	
26	5320		Harley Strand	1	
	5320		Harley Strand	2	
			no space	3	
			no space	4	
27	97	Comp	Bertram L. Broughten	1	
	97	Marker	Bertram L. Broughten	2	
	K161A		Gary Karstens	3	
	K161A		Gary Karstens	4	

Figure 3.2 Paper records kept by Woodland Hills

3.2.2 GPS Data

A geodatabase is created using the following steps: (a) consult with cemetery managers, (b) survey the cemetery, (c) build data dictionary, (d) collect data using a GPS unit, (e) deal with post-process, and (f) building geodatabase. Detailed information can be found in the following sections.

3.2.2.1 Setup

The first step of the GPS data collection process was to survey the study area. This was done to determine what type of data could be collected from the cemetery, as well as to become familiar with the landscape. The cemetery mangers were consulted to determine what information would be most useful for their records, and what type of structure would be best for their use.

After determining what data would be collected in the field, a data dictionary was created to streamline the process of data collection. Data dictionaries serve as a template for entering information in a GPS unit. These are essential for large-scale GPS projects, as they can save time and improve the accuracy of the collected data. When using data dictionaries, the input data can be standardized using menus or fields that require specific types of inputs. This prevents errors, such as spelling errors or incorrectly recorded data, from being introduced to the data. It also increases the accuracy of the data, by providing a comprehensive outline of the exact variables to be collected in the field. The structure of the dictionary ensures that the data remains consistent across multiple users or sessions. Data dictionaries also allow for predetermined numeric increases, such as adding one for each new feature collected. This saves time while in the field, as it removes the necessity of entering data by hand for each variable.

The dictionary is uploaded to the GPS, and then used in the TerraSync software when collecting data. It provides options and fields for entering attribute data while in the field, without requiring extensive notes to be taken by hand. Data dictionaries store the information with the location of each feature, ensuring the information remains together when exporting the datafile. Each feature can have a number of attributes attached to it, allowing users to easily note information about the object.

The types of attributes used in this project were numeric, text, and menu. Numeric attributes allow the user to enter a number value. This may be an integer or a decimal, depending on the settings selected. This type of variable was used to store data like the dates of the interred or the lot and plot numbers associated with each grave space. Users enter characters into a text variable, allowing for words or full sentences to be entered. Text variables were used to note the names of the interred. Lastly, menu attributes give the user the option to pick from a list of drop down options. This is particularly useful when entering information that has a particular set of possible options, such as the type of veteran or if there was an urn with the grave.

The data dictionary was created in the Pathfinder Office Data Dictionary Editor, and was made of four point features; Lot, Plot, EmptyPlot, and Issue. The Lot feature had a single numeric attribute for noting the number of each lot marker. The Plot feature had numeric attributes for the lot, section, and plot number, as well as for the date of birth and date of death. Text attributes were used to note the first, middle, and last names. Menu attributes were used to collect the veteran status, if there was an epitaph on the plaque, whether there was an urn present beside the grave, and if the marker stood alone or was connected to another.

After exporting the data dictionary to the handheld device, the next step is to determine the accuracy requirements of the project. The basic requirement for GPS data collection is the ability to receive signals from four satellites to properly record the precise location. However, more satellites are preferable to achieve a higher accuracy, and thus better data collection. This project required a high accuracy, due to the proximity of the gravesites to each other. The accuracy threshold was set as 20 cm, to prevent overlap between the points that may incorrectly indicate the order of the gravesites or cause confusion with the link between the points and the grave information.

The GPS units used for this project were the Trimble Geo7X (Figure 3.3). The Geo7X is highly accurate (up to 1 cm accuracy) while retaining an ease of use that made it ideal for this project. The large touchscreen of the device allows for data entry in the field and was well suited for entering information such as names or dates that would have been more difficult on a less-advanced unit. The Zephyr antenna sensor (Figure 3.4) was used in conjunction with the Geo7x to improve the vertical accuracy. In areas where obstacles blocked satellite signals, the Laser Rangefinder (LRF) sensor was used to accurately collected data. The LRF is a laser attached to the GPS unit. By pointing the sensor at the feature, the user can stand away from the obstacle and the GPS unit will account for the change in position using the sensor’s readings.

Figure 3.3 Trimble Geo7X Handheld Unit

Figure 3.4 Zephyr 2 Antenna

3.2.2.2 Field Collection

The data was collected over the course of the summer of 2017, from June to August, primarily from the hours of 10:00am to 12:00pm, and 1:00pm to 3:00pm. This allowed for the highest accuracy of the region, due to the number and angles of the satellites visible, while remaining within appropriates hours for data collection. It was logged daily as weather conditions permitted. Rain or heavy cloud cover interfered with accuracy, and data was not collected on such days.

Each garden was completed systematically, beginning with the lot markers. The individual plots were collected by lot, beginning with Lot 1 and then continuing down the rows until completed. Each garden took approximately three weeks to complete, with variations arising due to weather conditions and garden size.

3.2.2.3 Post-processing

Once the data had been gathered, it was exported from the Geo7X to Pathfinder Office. Differential correction was performed using the LeSueur base station, and the corrected files were exported as ESRI Geodatabase files. The geodatabase was created by joining the point layers, which were already exported to a geodatabase format, with the records from the Excel tables. The lot, section, and plot numbers were combined to create a unique ID for each grave. As this value was present in the feature layer and the Excel tables, the Join tool in ArcMap was used to link the two.

3.3 Spatial Analysis

The Spatial Autocorrelation (Global Moran's I) tool was used to perform spatial analysis on the data collected. Moran's I is a method used to determine if a set of features displays a pattern, either clustered, dispersed, or randomly distributed over the space. The null hypothesis assumes that the data is randomly distributed and has no pattern over the space. The method produces a coefficient value that indicates the magnitude of the pattern of the data as well as a z-score and p-value, which indicates the statistical significance (Lee and Li 2017). Moran's I was used in this paper to determine if there were any spatial patterns present in the collected data.

GLOBAL MORAN'S I EQUATION

The equation for Moran's I is below in Equation 1. Equations 2, 3, and 4 all expand on the variables found in the global Moran's I equation.

$$I = \frac{n}{S_0} \frac{\sum_i \sum_j W_{ij}(X_i - \bar{X})}{\sum_i (X_i - \bar{X})^2} \quad (1)$$

$$S_0 = \sum_i \sum_j W_{ij} \quad (2)$$

$$Z_i = \frac{I - E[I]}{\sqrt{(E[I^2] - E[I]^2)}} \quad (3)$$

$$E[I] = \frac{-1}{n-1} \quad (4)$$

Equation 1, the global Moran's I index, measures the spatial autocorrelation of the data. Equation 2 is the sum of the weighted matrix. Equation 3 calculates the z-score of the index, while Equation 4 determines the expected Moran's I value, should the data be randomly distributed. As the Moran's I index is the process of proving the null hypothesis wrong, the actual (or observed) value should be different from the expected value found in Equation 4. Moran's I index is calculated using a Spatial Statistics toolbox in ArcMap.

4. RESULTS AND DISCUSSION

4.1 Data Collection

Data was collected during the summer of 2017, from June to August, primarily between 9:00am and 12:00pm, and then 1:00pm and 3:00pm. Once corrected, the data was then exported to an ESRI geodatabase, where it was then linked to the Excel tables that had been created using the written records (Table 4.1). The two data types were linked using the grave identification created using the lot, section, and plot numbers unique to each gravesite.

Table 4.1 Geodatabase Example

LOT	SECTION	PLOT	FIRSTNAM	MIDDLEN/	LASTNAM	DoB	DoD	VETRAN	EPITAPH
71	B	4	Victoria	J.	King	08/25/1949		NO	NO
72	C	1	Roy	A	Petersen	09/14/192	12/27/197	WWII	YES
72	C	2	Flora	M	Petersen	02/23/192	10/24/199	NO	NO
72	D	4	Beverly	A.	Evans	1939		NO	NO
72	D	3	Robert	A.	Evans	1940	1992	NO	NO
73	A	2	Lynelle	C.	Harms	06/17/1949		NO	NO
73	A	1	Steven	M.	Harms	11/02/194	08/22/200	NO	NO
73	B	1	Rginald	D.	Olson	1929	2015	NO	NO
73	B	2	Elaine	F.	Olson	1933		NO	NO
73	B	3	Richard	W	Moore	03/13/192	01/08/201	KOREAN	YES
73	B	4	Carol	J	Moore	05/14/1935		NO	YES
73	C	1	Robert	J.	Holtorf	1930	2015	NO	NO
73	C	2	Lois	L.	Holtorf	1935	2010	NO	NO
73	D	1	Kevin	W.	Moore	02/29/196	10/29/201	NO	YES

4.2 Genealogy and Demographic Results

4.2.1 Section and Plot Availability

In the cemetery there are a total of 6,236 available plots of land for purchase. Tables 4.2 and 4.3 show the distribution of empty and filled graves by garden. Figure 4.1 shows their spacing throughout the cemetery. These plots were broken down by section and by plot, in an effort to determine if there were any indication if certain types were preferred over the others. As Tables 4.4 and 4.5 show, the distribution of empty graves throughout each section and each plot is roughly even. Plot 4 seems to have slightly more empty spaces than the others at 28%, while Plot 1 has only 22.84% empty spaces. This could indicate that there is a slight preference for Plot 1 spaces.

Table 4.2 Total Plots by Garden

Garden	***Count***	***Percent***
Christus	3,261	26.75%
Devotion	4,308	35.34%
Tower	3,650	29.94%
Peace	971	7.97%
Total	12,190	100.00%

Table 4.3 Number of Available Plots by Garden

Garden	***Count***	***Percent***
Christus	1,723	26.41%
Devotion	1,855	28.38%
Tower	2,228	23.38%
Peace	694	10.60%
Total	6,236	100.00%

Table 4.4 Number of Available Plots by Section

Section	***Count***	***Percent***
A	1,522	24.42%
B	1,560	25.02%
C	1,609	25.80%
D	1,545	24.77%
Total	6,236	100.00%

Table 4.5 Number of Available Plots by Plot Number (1 – 4)

Plot	***Count***	***Percent***
1	1,424	22.84%
2	1,434	23.00%
3	1,666	26.17%
4	1,746	28.00%
Total	6,236	100.00%

Then the empty spaces were broken down by their individual places. It can be seen consistently that the categories that contain Plot 4 have more empty spaces than those that do not. The area with the least available gravesites varies in Sections A, B, and D, however there was a very clear preference for C3, with only 15.51% of open spaces (Table 4.6 and 4.7).

Examining the statistics from the available plots, there are few clear preferences for spaces. While it does appear that Plot 4s are slightly less desirable form the others, with 28% open, there is little difference amidst the sections. As most customers at the Woodland Hills are unaware of the organizational setup of the cemetery, it is likely that the location of the gravesites is not a key factor in their decision when selecting a plot. However, breaking the empty plots further into the individual plots within each section, it becomes clear that there are a larger number of C4 plots, and a smaller section of C3 spaces. It is not immediately apparent why this could be, as there is no other similar dip in space availability that might point to a desire for matching sites. However, looking at these numbers does allow cemetery mangers to know they can push sales of C4 to avoid having single empty plots surrounded by filled gravesites.

Table 4.6 Number of Available Plots by Unique Plot Space (A and B)

SPACE	COUNT	PERCENT	SPACE	COUNT	PERCENT
A1	321	23.26%	**B1**	320	22.63%
A2	320	23.19%	**B2**	320	22.63%
A3	355	25.72%	**B3**	382	27.02%
A4	384	27.83%	**B4**	392	27.72%
TOTAL	1380	100.00%	**Total**	1414	100.00%

Table 4.7 Number of Available Plots by Unique Plot Spaces (C and D)

SPACE	COUNT	PERCENT	SPACE	COUNT	PERCENT
C1	332	22.77%	**D1**	318	22.71%
C2	344	23.59%	**D2**	316	22.57%
C3	372	15.51%	**D3**	370	26.43%
C4	410	28.12%	**D4**	396	28.29%
TOTAL	1458	100.00%	**Total**	1400	100.00%

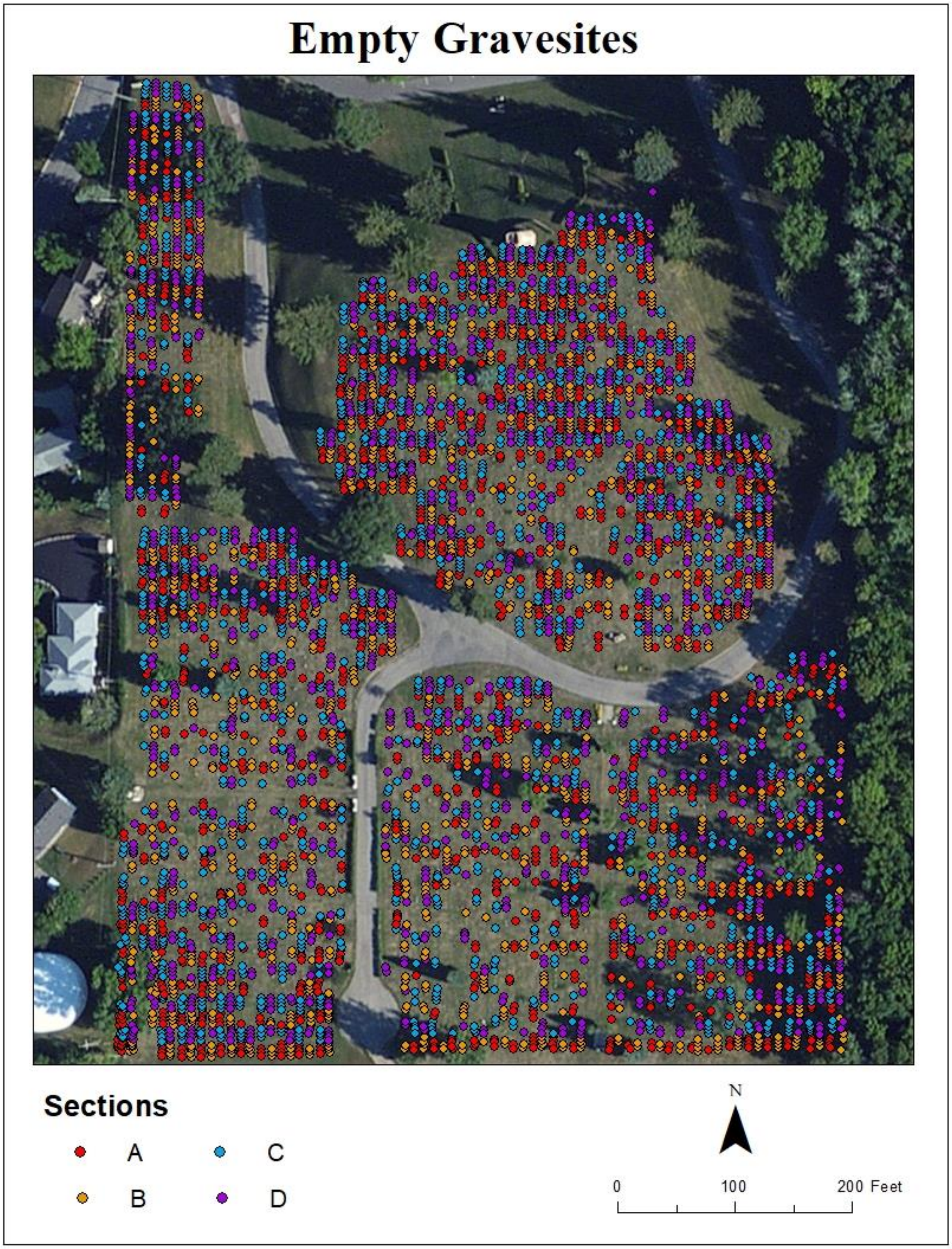


Figure 4.1 Empty Plot Spaces Divided by Section

4.2.2 Name Frequencies

As the names of the interred are present on the plaques, a frequency analysis was performed to determine the five most common first and last names. Table 4.8 shows the five most common first names, which are as would be expected for a Midwestern town like Mankato. The frequency of each of these names is relatively high, ranging from 60 to 100 people. There are fewer repeated last names (Table 4.9), but the frequencies are again fairly high ranging from 42 to 97.

Table 4.8 Frequency of First Names

FIRST NAME	FREQUENCY
ROBERT	100
JOHN	96
WILLIAM	83
MARY	72
DONALD	60

Table 4.9 Frequency of Last Names

LAST NAME	FREQUENCY
JOHNSON	97
ANDERSON	68
NELSON	55
PETERSON	46
MILLER	42

One important genealogical use for storing and maintaining cemetery in databases is the ability to access the demographic data. While most cemeteries do not store cultural or ethnic information, inferences can be made based on inhabitants' names. The first names that most frequently appear in Woodland Park are traditional English names that would be expected in a rural Midwestern town. The last names follow a similar pattern, though they add an additional layer. These names, particularly names such as Anderson, Nelson, and Peterson are common Scandinavian names. This is indicative of the strong German and Scandinavian heritage of Minnesota. While this may not reveal any new information about Mankato, it is possible to trace the ethnicity and immigration patterns through burials sites in a large-scale database.

4.2.3 Veteran Gravesites

There was a total of 531 veterans buried at Woodland Hills. The majority of those soldiers served in WWI, and a large number also served in a variety of positions and minor conflicts (Table 4.10). This is to be expected due both to the size of the cemetery and to its age. Having been founded around 1940, Woodland Hills will have no burials from before that time. Given how much time has passed from WWI in comparison from the Korean War or Vietnam War, it is logical that more individuals would have passed away from old age. The image (Figure 4.2) shows the distribution of the veterans' graves.

Table 4.10 Distribution of Veteran Service

CONFLICT	COUNT
WWI	32
WWII	225
KOREAN	66
VIETNAM	37
OTHER	171
TOTAL	531

The majority of soldiers buried in Woodland Hills served in WWII. The next largest ground of solders is comprised of multiple smaller conflicts such as the Gulf Wars and from general service. There are a lack of veterans from WWI, though again this can be explained by the age of the cemetery. Overall, veterans make up a little over 9% of the inhabitants buried at the cemetery.

Spatially the veteran graves did show a clustered pattern, which does suggest that people prefer to bury veterans in like company. Despite this, most of the categories did not show significant clustering. The two groups that showed clusters were from WWII and the Korean War. Whether this is due to the natural filling of available space is unknown. At this time, the small sample size of a single cemetery is not sufficient to draw more detailed conclusions.

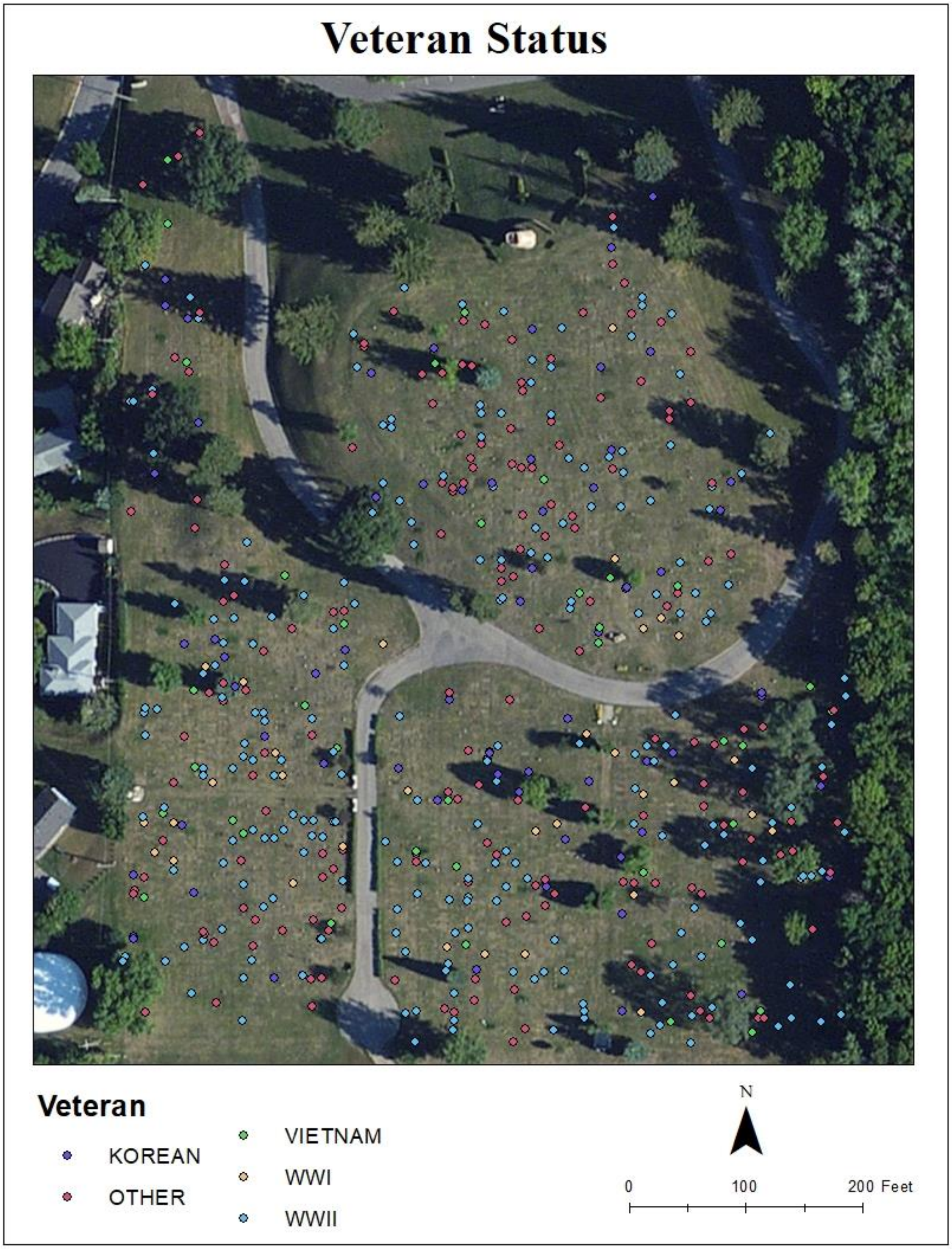


Figure 4.2 Distribution of Veterans Based on Type of Conflict

4.2.4 Generations

Those interred at Woodland Hills have been divided into 7 categories based on their year of birth (Figure 4.3). Those born before 1901 were assigned the category of being Pre-1901, due to a lack of distinction in generations prior to the turn of the century. The GI Generation, characterized by their involvement in the world wars, ranged from 1901 to 1926. 1927 to 1945 were assigned to the Silent Generation, while Baby Boomers were from 1946 to 1964. Generation X ranged from 1965 to 1980, and the Millennials saw in the next turn of the century from 1981 to 2000. Generation Z had little representation and accounted for anyone who was born after 2001 (Novak 2018).

The results of this analysis (Table 4.11) seem to follow what would be expected, with the notable exception of the Pre-1901 generation having only 18.78 percent in comparison to the GI Generation at 45.61 percent. This is due to the age of the cemetery itself. As mentioned previously, there is no one buried at the cemetery prior to its creation, which results in this unusual result.

Table 4.11 Generation Breakdown

GENERATION	COUNT	PERCENT
PRE-1901	1,086	18.78%
GI GEN.	2,638	45.61%
SILENT GEN.	1,393	24.08%
BABY BOOMERS	490	8.47%
GEN. X	89	1.54%
MILLENNIALS	61	1.05%
GEN. Z	27	0.47%
TOTAL	5,784	100.00%

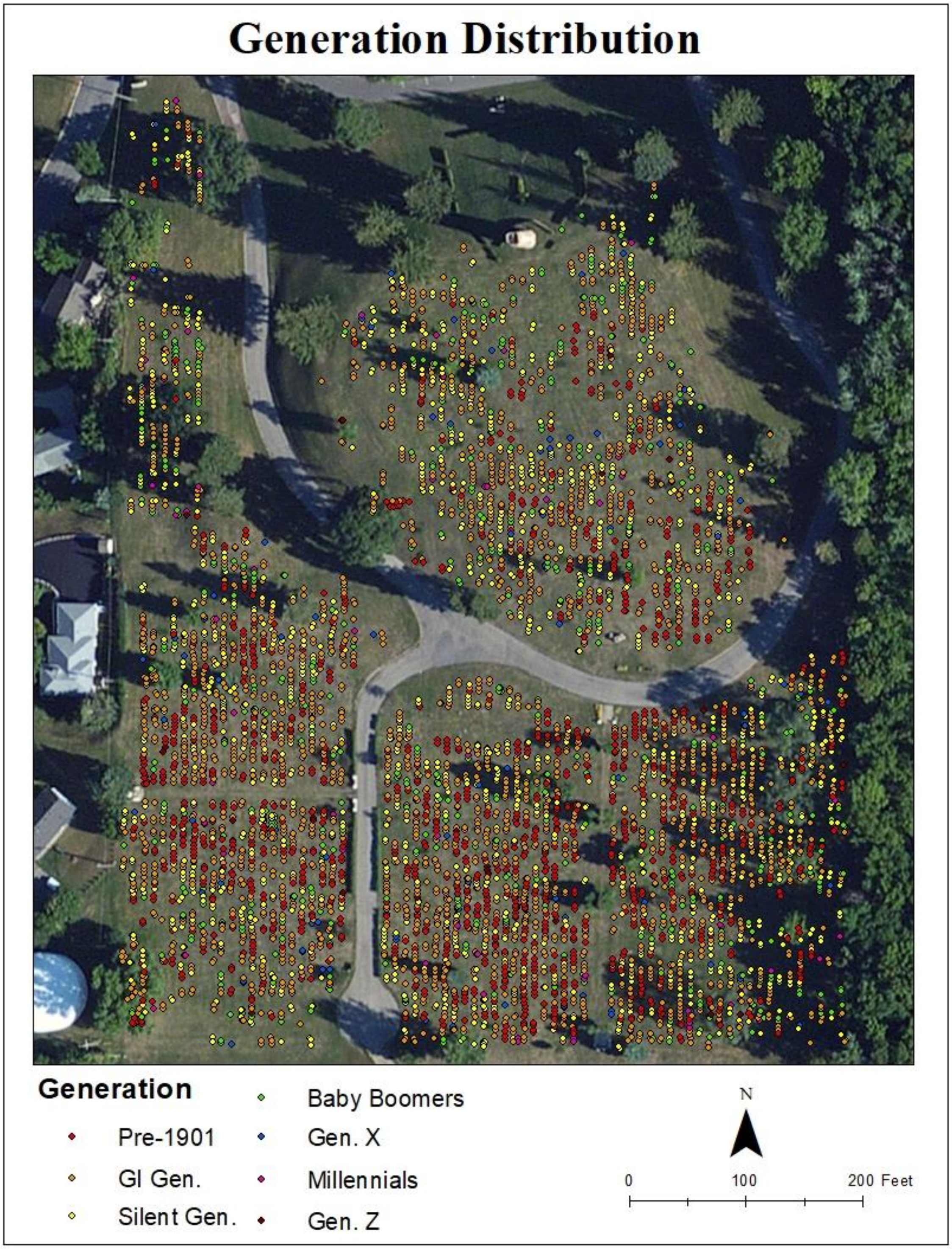


Figure 4.3 Filled Plots by Generation

4.3 Spatial Analysis Results

4.3.1 Veteran Status

The Moran I results for the spatial distribution of veteran graves shows that there was a statistically significant clustering in the veterans from WWII (with 99% confidence), the Koran war, and Overall (with 95% confidence). The method did not find a statistically significant pattern in the graves from WWI, Vietnam, and Other conflicts.

Table 4.12 Moran's I Results of Veterans

VETERAN STATUS	MORAN I'S	Z-SCORE	P-VALUE	SIGNIFICANCE
WWI	0.0359	1.4963	0.1346	
WWII	0.0659	2.6476	0.0081	< 1%
KOREAN	0.0522	2.1238	0.03369	< 5%
VIETNAM	-0.0203	-0.7252	0.4683	
OTHER	0.0305	1.2646	0.2060	
ALL	0.0628	2.5259	0.0115	< 5%

4.3.2 Generation Breakdown

Table 4.13 Moran's I Results of Generation

GENERATION	MORAN'S I	Z-SCORE	P-VALUE
PRE-1901	0.1342	42.7865	0.0000
GI GEN.	0.05818	18.5735	0.0000
SILENT GEN.	0.07559	24.1199	0.0000
BABY BOOMERS	0.05844	18.6715	0.0000
GEN. X	0.01509	4.8840	0.0000
MILLENNIALS	0.01987	6.4297	0.0000
GEN. Z	0.0675	12.2085	0.0000

The results from the Moran's I test for each generation of the interred can be seen in Table (4.12). All generations had Moran's I values indicating a cluster pattern.

The confidence interval for each was at 99% (p-value <0.01), indicating that the results are statistically significant. The Pre-1901 generation was the most clustered, with a Moran's I value of 0.1342, while Generation X had the lowest value at 0.01509.

Unlike the veterans, there are clear cluster patterns with all of the Generation categories. Likely this effect is from a multiple of reasons. One of which could be the desire of cemetery managers to see gardens and spaces filled as much as possible before opening new areas. Another factor influencing this clustering is likely the fact that husbands and wives are traditionally buried next to each other. Since married couples are usually from the same generation, this may be skewing the results of the Moran's I test.

As all of the correlations were high, a good strategy for a cemetery manager would be to put more value on filling up areas. While Woodland Hills sells all of their grave plots at the same rate, other cemeteries may take advantage of such practices. The data suggests that individuals desire to be buried next to other of the same age group, whether out of practical necessity or out of preference for the familiar, and grave sites that lack other empty plots surrounding them will be harder to sell than those with spaces surrounding them.

4.4 KML Layer

Using the Layer to KML tool in ArcMap creates Keyhole Markup Language (KML) files that can be viewed in Google Earth (Figure 4.4). Transforming the features into KML files is a good option when they need to be shared with individuals who many not be familiar with ArcMap or other GIS programs. Since Google Earth can be downloaded free of charge, it allows anyone with access to a computer and the internet the option to view the data quickly and without hassle. It also takes less processing power than ArcMap, allowing for the same data to be accessed on with much lower hardware requirements. The downside is that Google Earth lacks the analysis programs found in ArcMap, but as many do not need these functions the trade-off is favorable for them. KML files are a good alternative for sharing data that might otherwise be unavailable.

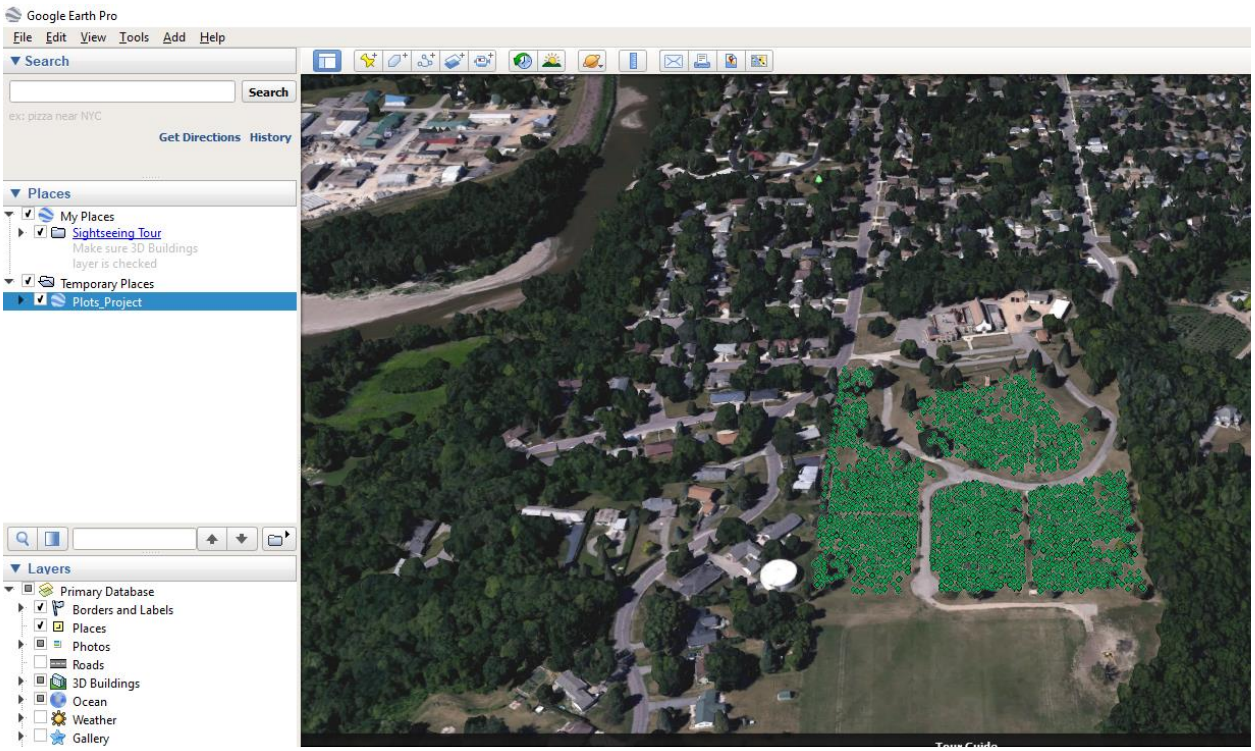


Figure 4.4 KML Layer of Available Plots in Woodland Hills

KML layers are only the start of further applications for web mapping. ESRI has ArcGIS Online, a web-based mapping service that allows members to host and store their maps and data on the internet. By hosting maps online, the data is available for others to access as necessary. Out of town relatives can check on those interred, and researchers or interested parties can easily access the demographic information. Rather than printing documents or paper copies of maps, having them online also allows for easy updates to be made. Should the cemetery expand itself, the information can be expanded and modified with a few clicks instead of a lengthy process of reprinting maps and brochures.

Along with web maps, cemetery managers can also consider creating web applications for their cemeteries. A web app would provide an image of the gravesite, or directions to a specific grave. Much as Google Maps and Google Earth have a street view option that allows users to see their surroundings, another option would be to include a virtual tour of the cemetery. Just as helicopters are currently used to show exotic locations, a drone or even a handheld video recorder could be used to show a walk through the cemetery. These videos and images could be added to the map to show each gravesite, allowing people who are unable to physically reach the cemetery a chance to see the grave of a loved one.

5. CONCLUSIONS AND FUTURE OUTLOOK

The purpose of this paper was to use the case study of the Woodland Hills Memorial Park to examine how geospatial technologies (i.e., GIS, GPS, Geodatabase) can be used in the aid of cemetery management. Cemeteries are an important part of local culture and history, and it is important to preserve them despite the hurdles associated with cemeteries. While many individuals find cemeteries unsightly or unnerving places, there has been a recent push in urban centers to regard these areas as available green spaces that serve a vital role. This paper focused on the organization and management of cemeteries using a GIS framework, specifically with the use of GPS technology to create a geodatabase that can then be managed and analyze spatial data using GIS programs like ArcMap.

The first objecting was to collect cemetery data. Woodland Hills kept their hard-copy records in a handwritten ledger, which was manually transferred into an Microsoft Excel spreadsheet. Information such as the owners of the grave spaces and the deed numbers was kept in this book. Collecting the location of the gravesites was accomplished over the summer of 2017. The cemetery information was collected from the four gardens, Christus, Devotion, Tower, and Peace. The lot markers were collected first, followed by the individual graves. The rest of the features of the cemetery were collected throughout the process, as time permitted. Each feature was collected using the Trimble Geo7X unit with the Zephyr antenna. The collected data was corrected using differential correction in Pathfinder Office. After post-processing, the majority of the data collected was within 2 to 3 centimeters of accuracy.

A geodatabase was built using the hard-copy records of the cemetery with the collected GPS data. Using the lot, section, and plot numbers associate with each grave, a unique ID number was created for each grave. Using the Join tool in ESRI's ArcMap, the two data files were combined to create the geodatabase. This software was chosen because of its ability to locate and query data. ArcMap allows the user to examine the data by way of this spatial location, which works well with the GPS data collected of the gravesites. Using SQL, the database can also support advanced queries based on the attribute data collected from the records and the grave plaques and is able to analyze the data for patterns.

Demographic analyses were performed on the gathered data to determine if there were any patterns or trends. This was done using Moran's I tests in ArcMap to determine whether the gravesites showed any specific clustering or dispersal patterns, or if the distributions were random. It was found that there was significant clustering for veterans of WWII, the Korean war, and overall. The ages of those interred were also examined, based on their generation.

These were split into six categories; Pre-1901, the GI Generation (1901-1926), the Silent Generation (1927-1945), Baby Boomers (1946-1964), Generation X (1965-1980), Millennials (1981-2000), and Generation Z (after 2001). All of the generation breakdowns showed significant clustering patterns, with the Moran's I values close to 0 and p-scores that were effectively zero. This can in part be attributed to the natural way spaces in cemeteries fill up over time and may also point to a proclivity of individuals to be buried by people of a similar generation.

Genealogic examinations were also done. An examination of first and last names supports the common knowledge that much of the Upper Midwest is ethnically German and Scandinavian, with last names such as Johnson, Peterson, and Anderson ranking in the 10 most frequent. A total of 531 veterans have been buried at Woodland Hills, with nearly half of them having served in WWII.

This research contributes to improving cemetery management with one method of recording and preserving data from cemeteries. Using GPS units provides an accurate location for each gravesite, while creating a geodatabase combines the written records with each individual grave. This allows for better cemetery management while making the demographic data readily available to future historians or individuals interested in the local culture and history. It is easy to update a geodatabase and creating backups of the data is as simple as a typed command. Searching the database for attributes like names or dates is a far easier task than paging through a handwritten book. Converting the pervious records into a digital format improves the speed and the efficiency at which cemetery mangers can access their records, and also ensures that they may provide accurate information to potential customers.

This research provides an outline for other projects of a similar vein, with the eventual goal of having more cemetery geodatabases to improve research and management alike. In the future, adding more cemeteries to this or other geodatabases would increase the demographic data available for analysis. Woodland Hills is a relatively small, newer cemetery and therefore the statistical and demographic findings of this paper may not be substantiated through a larger sample size. The demographics of a cemetery in Arizona would be very different to one in Minnesota, and an older cemetery may reveal spatial distributions that aren't present in Woodland Hills.

Another step would be to add more demographic data that can be extrapolated from those interred to the geodatabase. While gender is not marked on the plaques, it would be possible to infer the sex of those buried based on first names cross referenced with the date of birth. Ethnicity and family ties could also be ascertained based on possible local records and from obituaries. These options were not explored during this project due to time restraints, but this information would prove invaluable to a demographic study of the region.

The digital format of the geodatabase also lends itself well to the creation of web maps and applications. By hosting this information online, the data is readily available for both the cemetery managers and for the public. These can be accessed remotely, and do not require the use of a software such as ArcMap or the physical computer the data is sorted on. Web maps are easy to update and maintain, while providing a quick and comprehensive interface to access the data. Accessing web applications is even easier as they can be downloaded and pulled up on a smart phone or mobile device, allowing users to use the apps at their convenience. A web app of a cemetery could also serve a similar function as common direction apps like Google Maps, and direct visitors to the exact gravesite they wish to find.

This study also could be improved by using drone, areal imagery, and other remote sensing data collection. Topographic data could be collected in the field with the GPS data to provide highly accuracy terrain maps that would provide a better understanding of the layout of the cemetery. It would also be useful for displaying the layout of the cemetery, and aiding cemetery managers in expanding the burial ground further. Another expansion of the study is to use ground penetrating radar to determine the whether the vacant graves are truly unused, or to find gravesites that may have been incorrectly marked. While Woodland Hills is new enough that this would be unnecessary, it would be invaluable for an older cemetery that may not have kept such detailed records and organization.

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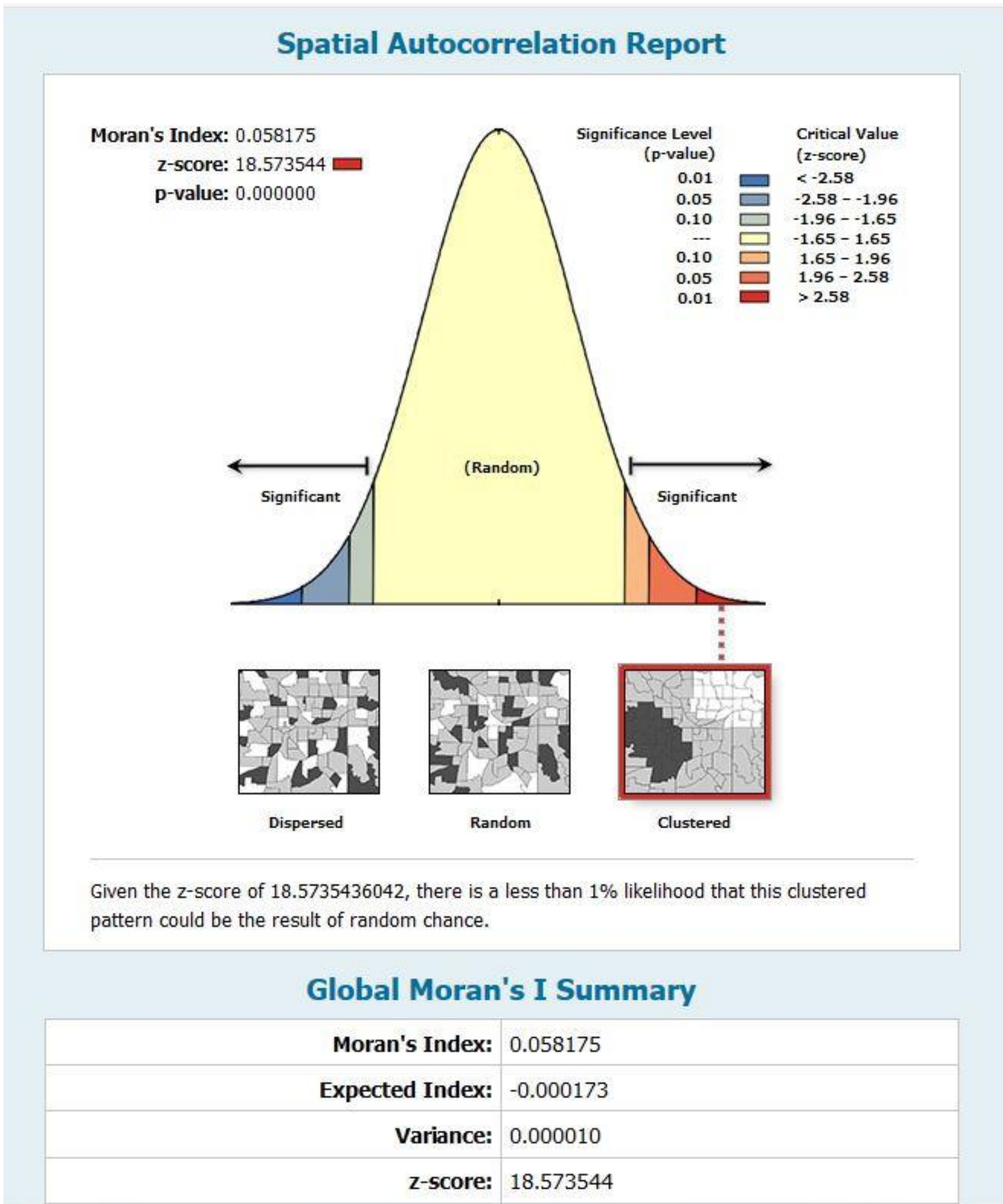
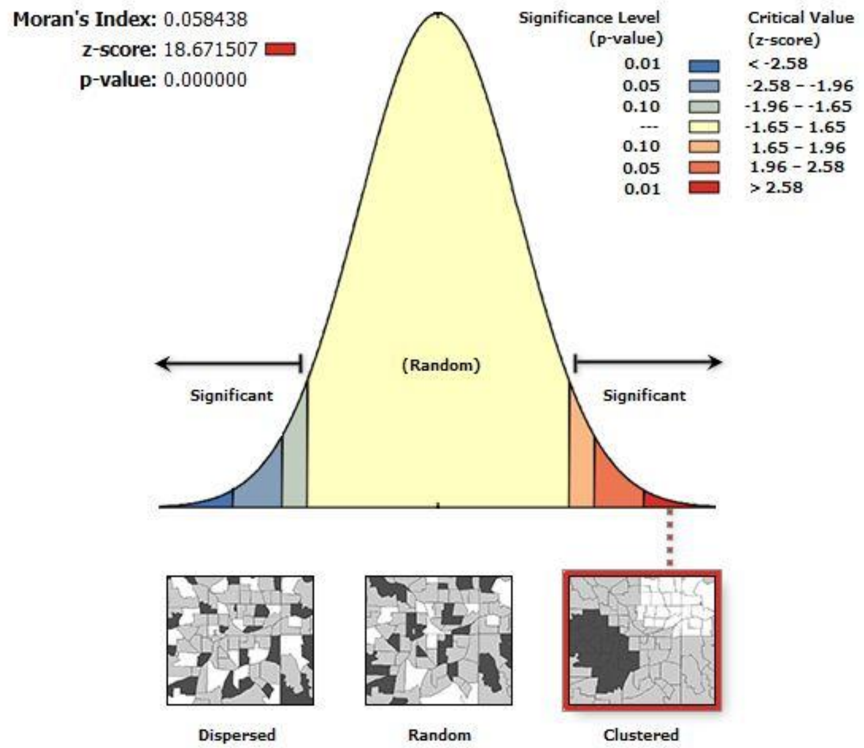
APPENDIX



Appendix A: Moran's I Results for the GI Generation

Spatial Autocorrelation Report



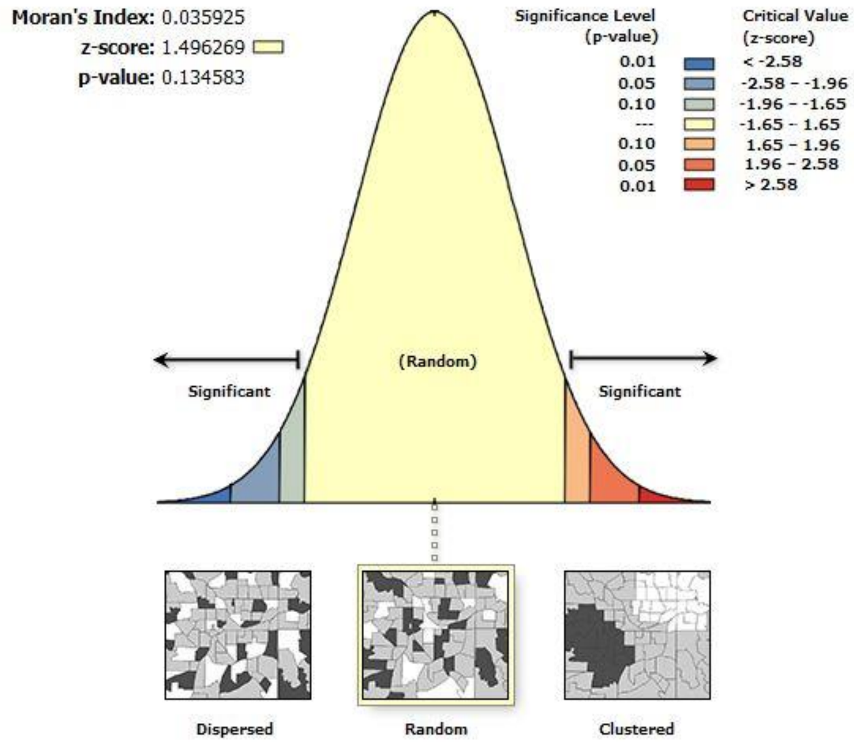
Given the z-score of 18.6715068003, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Global Moran's I Summary

Moran's Index:	0.058438
Expected Index:	-0.000173
Variance:	0.000010
z-score:	18.671507

Appendix B: Moran’s I Results for the Baby Boomer Generation

Spatial Autocorrelation Report



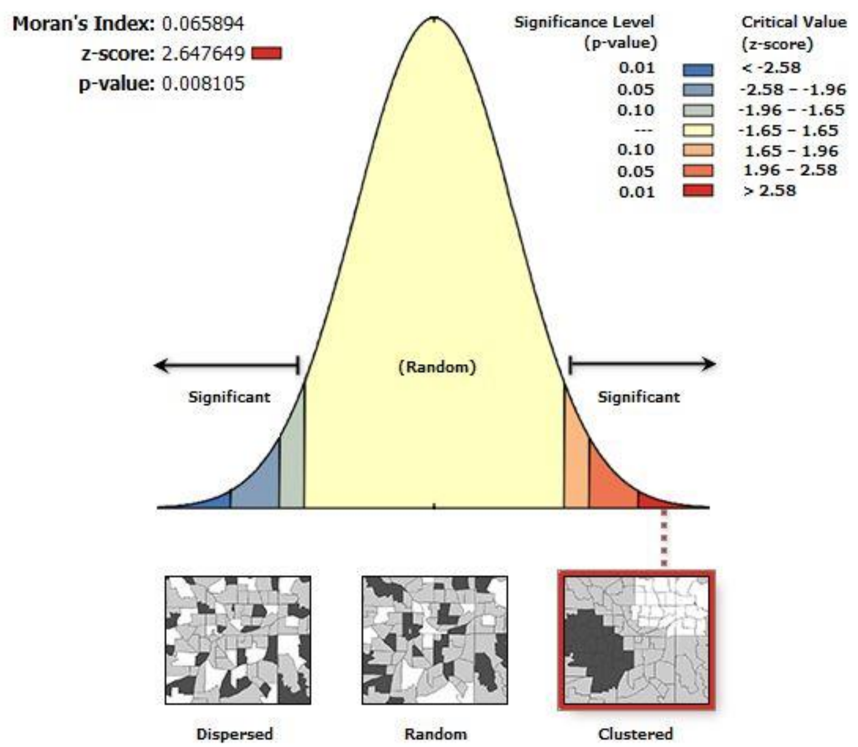
Given the z-score of 1.4962694701, the pattern does not appear to be significantly different than random.

Global Moran's I Summary

Moran's Index:	0.035925
Expected Index:	-0.001887
Variance:	0.000639
z-score:	1.496269

Appendix C: Moran's I Results for the WWI Veterans

Spatial Autocorrelation Report



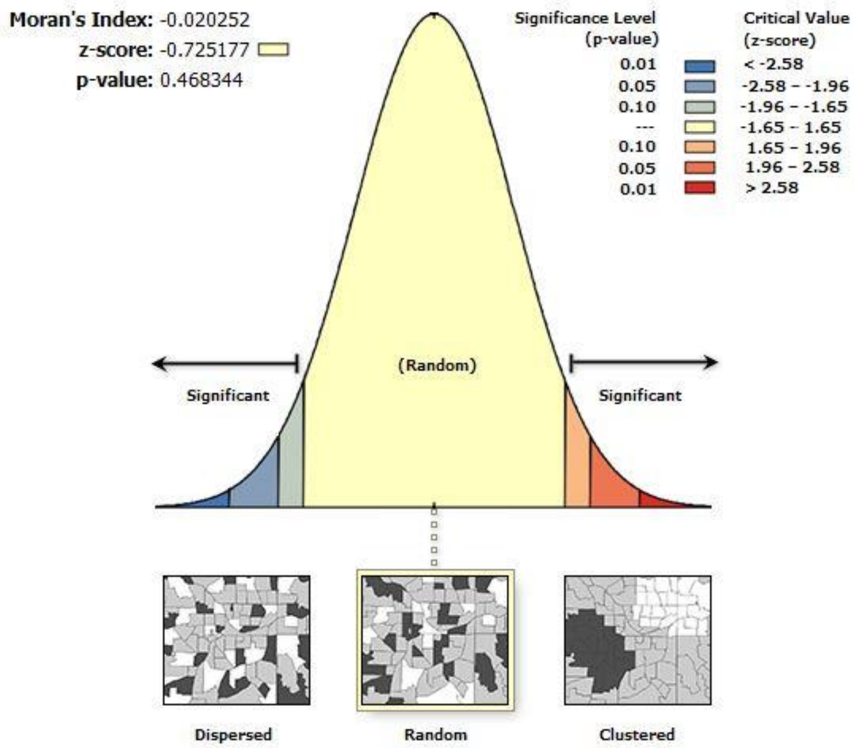
Given the z-score of 2.64764864337, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Global Moran's I Summary

Moran's Index:	0.065894
Expected Index:	-0.001887
Variance:	0.000655
z-score:	2.647649

Appendix D: Moran's I Results for the WWII Veterans

Spatial Autocorrelation Report



Given the z-score of -0.725176858545, the pattern does not appear to be significantly different than random.

Global Moran's I Summary

Moran's Index:	-0.020252
Expected Index:	-0.001887
Variance:	0.000641
z-score:	-0.725177

Appendix E: Moran's I Results for the Vietnam Veterans