Using GIS to Analyze the Spatial and Temporal Changes Concerning Vandalism within the City of Winona, MN

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Abstract

Identification of problematic areas of vandalism were analyzed within the city of Winona, Minnesota for 2001 and 2006. The intent of this study was to explore spatial and temporal analysis methods to study how the crime of vandalism has changed over the past several years. In addition, problematic areas of vandalism were identified within the city and various analysis methods were implemented to determine why vandalism may be occurring within certain geographical locations. From these analysis operations, police and other community members can make more informed decisions to help prevent the economic and social strain that vandalism causes within the city of Winona, Minnesota.

Introduction

Vandalism is a costly crime that continues to plague various cities and towns across America. According to the Minnesota Department of Administration (2007), acts of vandalism encompass any willful or malicious destruction, injury, disfigurement or defacement of any public or private property, real or personal, without the consent of the owner or persons having custody or control by cutting, tearing, breaking, marking, painting, drawing, covering with filth or any other such means as may be specified by law. Often times, vandalism may be overlooked because of more serious crimes occurring in a community. It is important to understand the economic and social problems that arise from acts of vandalism. For example, recent studies conducted by the Office of Juvenile Justice and Delinquency Prevention, from 1998, indicate that vandalism costs the nation's schools, homeowners and businesses approximately $15 billion per year (Office of Juvenile Justice and Delinquency Prevention, 1998). Today, the cost of vandalism would undoubtedly be much higher. In addition, according to an article published by Gary Holland at Oklahoma State University, national studies have revealed that between 10 and 20 percent of all rural households experience some type of vandalism every year (Holland, 2007).

However, these accounts do not address the full impact vandalism has on communities across the country. Everyone is affected by vandalism, either directly or indirectly.

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Local police departments spend hours investigating acts of vandalism, putting a strain on government resources and taking time away from investigating more serious criminal acts within the community. Services may be cut or eliminated in order to pay for damage caused by vandalism. Community members may pay higher taxes and larger insurance premiums as a result of graffiti, broken street lights, stolen signs or vandalized parks. Local business owners may charge higher prices for their products or services to cover the costs of repairing vandalism. In addition to posing a significant financial burden to communities, vandalism also causes increased anger, stress and worries to those in the community.

This study will use temporal and spatial analysis procedures to help identify problematic areas of vandalism within the city of Winona. By studying vandalism both spatially and temporally, police professionals and community members can collaborate to make more informed decisions in helping to reduce the economic and social impacts caused by vandalism.

Background

City of Winona Demographics

The city of Winona is a historic logging community in southeast Minnesota, nestled between the scenic bluffs and the Mississippi River. The city's economy is primarily supported by educational institutions and factory-related work. Winona State University, Saint Mary's University and Minnesota State College (Southeast Technical) provide for a significant workforce within the community. In addition, several factories exist within the city, which produce a wide assortment of industrial related products. In 2000, the United States Census Bureau estimated that the city of Winona had approximately 27,069 residents. More recently, the Minnesota State Demographic Center estimated the city's population to be approximately 27,324 in 2006. The latest census data from 1999 estimates that the median household income for Winona is approximately $32,845 and the median family income is $48,413.

Contributing Factors to Vandalism in Winona

For the past several years, the city of Winona has experienced various acts of vandalism. In 2001, there were 534 reported acts of vandalism within the city of Winona. Since then, the number of reported acts of vandalism has steadily decreased to 311 reported acts of vandalism in 2006. Despite the decrease in occurrences, acts of vandalism continue to pose a significant concern to the city officials and community members.

Though various research studies differ regarding the specific age group that is responsible for vandalism, many studies conclude that teenagers and young adults account for most vandalism-related acts.

It has been a widely held belief by Winona's Law Enforcement specialists, along with the community in general, that college age students are primarily responsible for the amplified amounts of vandalism that occur in and around the centrally located city limits. One possible reason why the downtown area may experience high rates of vandalism is due to the high percentage of college age students who live on or near the city's centrally located Winona

State University campus. In addition, students from Saint Mary's University and Minnesota State College (Southeast Technical) regularly frequent the downtown area.

Another reason vandalism rates may be higher is the prevalence of alcohol in the city center. Downtown Winona boasts a large number of alcohol-related establishments such as bars, clubs, taverns and pubs. Winona's per capita liquor license to population ratio of 1-752 is ranked one of the highest in the state of Minnesota. Various studies across the country have indicated that a combination of college age students and alcohol can contribute to malicious behavior in and around college campuses. Alcohol outlets such as bars tend to foster a binge drinking atmosphere, which results in a higher rate of neighborhood disruption such as vandalism. Furthermore, according to the National Institute on Alcohol Abuse and Alcoholism, about 11 percent of college students report that they have damaged property while under the influence of alcohol (Wechsler et al., 2002).

According to the Harvard School of Public Health College Alcohol Study, local residents and businesses, which are within one mile of a college campus are more than twice as likely as those who live farther away to endure disturbances like vandalism. In addition, the areas of town with the most disturbances also had a high number of liquor stores, bars, clubs and other alcohol outlets (Weitzman E.R. and Nelson, T.F., 2004).

Other research indicates that juveniles or young adolescents are the culprits to blame for vandalism. Contributing factors to vandalism for juvenile offenders can include such things as peer pressure, anger, boredom and defiance of authority figures.

According to the Office of Juvenile Justice and Delinquency Prevention (2002), in 2002, nationwide vandalism accounted for 43 percent of all juvenile arrests. In addition, in 2002, juveniles were involved in approximately 4 out of every 10 vandalism arrests. About half of all cases referred to the juvenile court system are handled without charges being filed, or they were simply dismissed.

Consequently, the goal of this study is to help law enforcement professionals better understand the crime of vandalism within the city of Winona by studying spatial and temporal patterns. From there, police professionals can make more informed decisions by allocating resources appropriately and implementing beneficial prevention strategies.

Methods

Preparation of Data

The Winona City Police Department (WCPD) provided records involving acts of vandalism for 2001 and 2006. The data was received in the form of Microsoft Excel Spreadsheets. The Excel files that were received included separate files for 2001 and 2006. Nearly, 1,000 records were edited so they could be used within ArcMap. For example, unwanted data such as littering and trespassing fields were deleted because they were not relevant to this study.

The original table received from the WCPD consisted of a single column entitled "Time Reported." This column included the month, day, year, and time of each reported incident. For ease and

efficiency for later analysis, separate fields were created for the month, day, year and time. In addition, another column was created, which was not part of the original data that was received by the WCPD. This column was titled "Day of Week" and was added, so as to allow for a greater aptitude for temporal analysis.

Lastly, in order for the Excel files to become operable in ArcGIS 9.1 they were converted into a database file, or DBF (dbase IV). Consequently, separate DBF files were created for both 2001 and 2006. Once the database files were prepared they were ready to be imported into ArcMap for geocoding.

Geocoding is a process which enables the user to convert a list of addresses into points on a map so they can be analyzed geographically. In this process, each point is assigned a latitude and longitude coordinate or spatial reference. In addition, this process involves using a reference layer, which is typically a street layer consisting of polylines. In this study, the reference layer was the street layer for the city of Winona. Each polyline represented a street and were given a name and an address range for the given street. Geocoding is somewhat of a complex process, but it is vitally important for crime mapping since crime records almost always have street addresses. Finally, the addresses from both the 2001 and 2006 DBF files were geocoded to the Winona city streets reference layer, which produced a visual display of vandalistic acts.

Additional data preparation was also necessary to allow for greater spatial analysis capabilities within ArcMap. For example, one of the spatial analysis objectives for this study was to determine if there was an elevated amount of vandalism occurring near establishments that primarily serve alcohol. These establishments may include bars, taverns, pubs and clubs within the City of Winona. In order to spatially analyze vandalism in relation to these types of venues; another Microsoft Excel file was created listing the establishments' names and addresses. Once again, the Excel file was created and converted into a DBF file, which was imported into ArcMap and the addresses of the establishments were geocoded.

The final step in the data preparation process consisted of gathering information regarding police beats within the city limits of Winona. This task was pretty straightforward considering the fact that there are only three beats which encompass the entire City of Winona. This information was also obtained from the WCPD, which reported there are three beats that encompass the city of Winona – the west beat, the central beat, and the east beat. In order for the police beats to be spatially analyzed, they had to be manually digitized in ArcMap. This allows for comparisons between beats to identify any significant trends between beats.

Understanding the Importance of Spatial and Temporal Analysis Relating to GIS and Crime Analysis

Historically, police departments have relied heavily on reactive law enforcement strategies to help manage criminal activity. However, with the capabilities of GIS and spatial and temporal analysis tools, many law enforcement agencies have taken a more proactive policing approach to preventing, controlling, predicting and

analyzing crime patterns. Law enforcement agencies are beginning to use these methods to examine the relationship between crime and environmental features. In addition, according to crime analyst experts such as Chainey and Ratcliffe (2005), spatial analysis is used to analyze spatial displacement when crime prevention initiatives are implemented to track if crime has actually been reduced or if it has just been displaced to another location. These spatial and temporal analysis methods can prove to be a supportive means when allocating resources to areas where they are needed the most.

Spatial Analysis Methods

This study used two common methods for identifying spatial concentrations of crime. One is the point based method and the other is the area based method. In addition, spatial statistical tools were also used for analytical purposes. All of these methods were used in this study to explore acts of vandalism in Winona for 2001 and 2006.

Point based methods work by identifying the locations of vandalism incidences with a series of points. Point based analysis helps in establishing areas of high crime density, commonly referred to as 'hot spot' locations. In order to establish 'hot spot' locations, the ArcGIS spatial analyst tool was used and the kernel density aggregation option was selected.

Kernel density aggregation works by overlaying a grid over the geographic study area, then using the kernel function to mathematically calculate the weight assignment of each cell based on the number of crimes per cell, giving the area an elevation or peak. Once a grid density map is computed showing peaks and valleys of vandalism, a smooth map of density values can be generated. In addition, kernel analysis can also be beneficial in analyzing incident patterns over time, or temporally. Density images can then be further analyzed by comparing previous weeks, months, seasons or years. This is represented as a standard contour map. Consequently, the smoothing image produced by the kernel method captures and displays hot spots and potential hot spots as areas of high density. In this particular study, the point based method will help in analyzing 'hot spot' locations concerning residential dwellings and businesses in Winona that have been victimized by vandalism.

The area based method takes crime data for a specified area such as block groups, census tracts and police beats and computes a measurement of crime intensity such as the total number of vandalism related acts for a specified area. The area based method is commonly referred to as block aggregation. In this study, block groups, bar buffers, and police beats were analyzed in relation to acts of vandalism. The results of the area based computations were revealed in the form of a choropleth map. These results can help determine spatial heterogeneity, which examines why some places are victimized by vandalism more than others. In addition, this analysis can determine where high crime areas are located and where to focus efforts for further analysis.

This study also utilized area-based methods to investigate demographic information in relation to occurrences of vandalism. The demographic information that was explored included population, income,

renter occupied dwellings, vacant dwellings and reported acts of vandalism per square mile. Also, police beats and bar buffers were analyzed in relation to acts of vandalism. Police beats were examined to determine which beats encountered the most vandalism to help prioritize resources. Bar buffer areas of 1/8 mile (one city block) and 1/4 mile (two city blocks) were established using the buffer tool available in ArcGIS 9.1. The buffer zones helped identify the severity of acts of vandalism in proximity to bars, clubs, taverns and pubs.

Spatial statistical tools were utilized for analyzing the distribution of geographic features. According to ESRI, spatial statistics differ from traditional statistics in that space and spatial relationships are an integral and implicit component of analysis often times not available through traditional statistics alone. These tools demonstrate a variety of statistical operations appropriate for analyzing geographic data (ESRI, 2004). The statistical tools that are used in this study include the mean center, average nearest neighbor, and the directional distribution or standard deviational ellipse.

The first spatial statistics tool used in this study is the mean center tool. The mean center tool is commonly used in crime analysis to detect a spatial shift or change for a particular crime in relation to time. The mean center tool functions by averaging the x and y coordinates of all geocoded point features in the study area. The output identifies the central focal point of the data. The mean center tool is utilized in this study to explore spatial and temporal changes concerning vandalism. As a result, law enforcement officials can allocate resources more efficiently by visualizing how crime has changed both spatially and temporal.

The Standard Deviational Ellipse (Directional Distribution) tool helps determine whether the distribution of vandalistic point features exhibits a directional trend. Mapping the distributional trend for a set of points can identity a relationship to particular physical features such as a string of bars or restaurants. For instance, long, narrow ellipses are indicative of a linear data pattern, while a rounder ellipse suggests that the point pattern is more evenly distributed in all directions around the mean center. The output consists of an elliptical polygon centered on the mean center for all features.

The average nearest neighbor tool is an efficient means for analyzing patterns of criminal activity. This tool can determine if vandalism-related incidents are clustered or dispersed. The average nearest neighbor tool operates by measuring the distance between each point feature centroid and its nearest neighbor's centroid location, then averaging all of the nearest neighbor distances. According to ESRI, if the average distance is less than the average for a hypothetical random distribution, the distribution of the point features being analyzed are considered clustered. If the average distance is greater than a hypothetical random distribution, the point features are considered dispersed (ESRI, 2004).

Temporal Analysis Methods

Temporal analysis is defined as the study of a specific geographic area over a period of time. Temporal analysis plays just as much of a factor in crime analysis

as spatial analysis does. As a result, this study explored traditional statistical factors with relation to time and vandalism. These factors include the reported time, the day of week, the month, the season and the year. Acts of vandalism were reported to the WCPD. Analyzing both space and time can prove to be an important factor in studying crime. According to Paul J. Brantingham, who is a criminology expert, crime tends to follow opportunity which does not stay the same over time (Brantingham and Faust, 1976). For example, because vehicles are more likely garaged at night, the opportunity for a motivated offender to steal it is greater during the day when the owner is at work or school. When crimes are high in a particular area, law enforcement professionals implement prevention programs and by using temporal analysis methods, they can evaluate their prevention strategies.

The goal of spatial and temporal investigation in this study is to help law enforcement professionals concentrate patrol efforts and develop more strategic crime prevention strategies concerning vandalism within the city of Winona.

Results for 2001 Data

Spatial Analysis Results - Point Based Methods

According to the Winona Police Department's crime statistics, there were 534 reported acts of vandalism in 2001. Of these, 475 were able to be geocoded for analysis.

409 incidents involved vandalism against residential dwellings and 66 incidences involved businesses. Point based methods were used to analyze 'hot spot' locations for residential dwellings and businesses.

As seen in Figure 1, there were five major residential 'hot spot' areas that were recognized. The most predominant spot included the downtown area between Franklin and Johnson Streets and between Levee Drive and 6th Street. The next most concentrated areas were on the east end of the city encompassing the area between 2nd and 9th Streets and between Hamilton and Wall Streets. This region had multiple vandalistic incidents reported to the same address location. Three additional 'hot spot' areas were identified, though they were less severe than the first two areas. The first was identified near Winona State University and included the area between 7th and 11th Streets and Grand and Lafayette Streets. The next 'hot spot' area was noted at the intersection of Gilmore Avenue and South Baker Street.

Figure 1. Residential crime density for 2001.

In Figure 2, this area's high concentration of vandalism was due to the multiple incidents that were reported at this particular address. The third area was located on the west end of the city. This region consisted of the area between 5th Street and Kraemer Drive. This area also had multiple incidents, reported at the same address.

In Figure 3, there were three

main ‘hot spots’ identified for acts of vandalism against businesses in the city of Winona. The greatest amounts of vandalism occurred near the downtown area between Levee Drive and 3rd Street and between Huff and Kansas Streets.

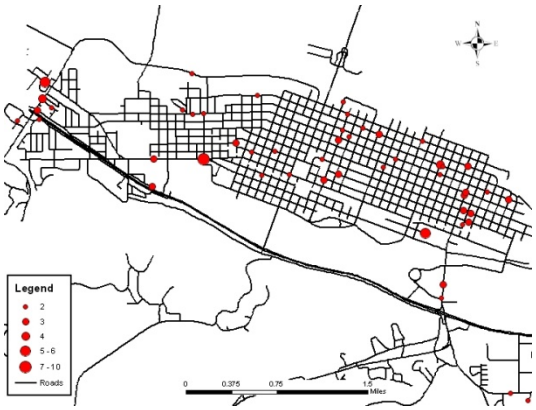

Figure 2. Multiple incidents for 2001.

Figure 3. Business density for 2001.

The second ‘hot spot’ location was recognized near the Winona Mall, located on Gilmore Avenue. This area was moderately concentrated with vandalism due to the multiple incidents which were reported at this particular address. The last ‘hot spot’ locality was identified near the west end of Winona. This area consisted of Cottonwood Drive and moved eastward to the west end of Service Drive.

Spatial Analysis Results - Area Based Methods

Area based methods were used to explore block group demographic statistics in relation to reported occurrences of vandalism. The demographic statistics that were investigated in collaboration with acts of vandalism included population, median household income, renter occupied dwellings and vacant dwellings.

The first analysis tested whether block groups that were more populated per square mile showed an increase in vandalistic occurrences per square mile. The findings revealed that as populated block groups increased, vandalistic occurrences showed the same trend. This was supported by obtaining the Pearson Correlation, which resulted in an R value of .75 ($p < .0001$).

Second, median household income statistics were explored to determine whether or not vandalism affected more affluent or less affluent block groups. The results showed that there was a significant correlation ($R = .71$ ($p<.0001$)) between block groups with above average median household income and vandalism per square mile

Third, high concentrations of renter occupied block groups were investigated to determine whether they had an effect on vandalism. The results concluded that there was a strong linear relationship ($R = .78$ ($p<.0001$)) concerning the amount of vandalism per square mile in relation to the amount of renter occupied dwellings per square mile.

The fourth analysis took into account whether or not vacant dwellings had an effect on rates of vandalism. The results concluded that there was a positive correlation between vandalism per square mile and vacant dwellings per square mile with an R value of .60 ($p<.0005$).

Area based methods were also used to investigate vandalism related occurrences in proximity to bars, clubs, taverns and clubs. The findings revealed that 184, or 38.7 percent, of acts of vandalism, occurred within one city block, or 1/8 mile, from an alcohol-related establishment. In addition, another 163, or 34.3 percent of incidents, took place 1/8 mile outside of the first bar buffer region. Therefore, 347 vandalistic acts, or 73 percent of all reported vandalism, transpired within two city blocks of an alcohol-related establishment.

Finally, area based methods were used to study vandalism in relation to police beats within the city of Winona. The findings revealed that the west beat encountered 35.4 percent of all vandalism, while the central beat encountered 28 percent and the east beat was comprised of 36.6 percent. While percentages a crossed the board were relatively similar, it is important to keep in mind that the central beat is much smaller in size than both the east beat and the west beat. Thus, the results concluded that the central beat experiences a larger amount of vandalism for its size in comparison to both the east beat and the west beat. This means that the central beat should be considered a problematic area concerning the threat of vandalism.

Statistical Based Results

The mean center tool identified the central focal point for all vandalism point features based on their X and Y coordinates. As seen in Figure 4, the mean center point location was established slightly northeast from the intersection of 9th and Washington Street.

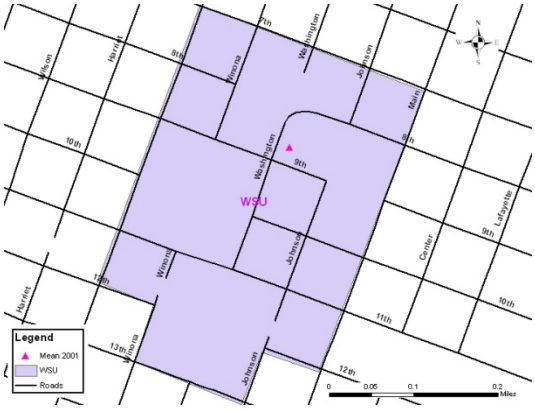

Figure 4. Mean center for 2001.

The average nearest neighbor tool was used next to detect whether or not vandalistic point features were clustered or dispersed. Furthermore, point features were separated by the month of the year and then analyzed to detect clustering or dispersion. The results concluded that there was significant clustering of points from March through December. The months of January and February consisted of dispersed point features. Since acts of vandalism were clustered from March through December, a single suspect or a group of suspects could be to blame for the clustering effect.

The last spatial statistical tool that was utilized for vandalism was known as the Standard Deviational Ellipse (Directional Distribution). This tool helped to detect spatial and temporal change concerning vandalism. As seen in Figure 5, the linear ellipse suggests that the point pattern indicates a Northwest – Southeast dispersion.

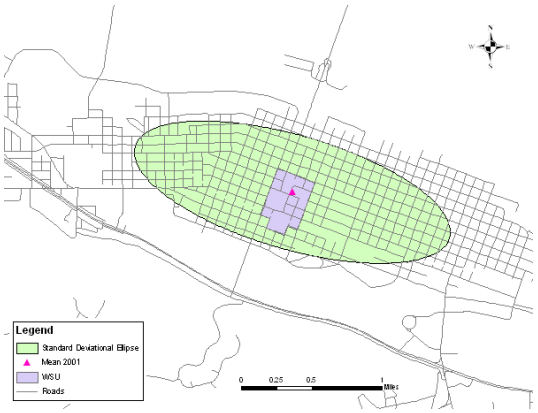

Figure 5. Standard deviational ellipse for 2001 crimes.

Temporal Analysis Results

Temporal analysis is defined as the study of a specific geographic area over a period of time. The temporal factors that were analyzed for 2001 included the reported time, the day of week, the month, the season and the year of the acts of vandalism that were reported in Winona. As seen in Figure 6, the results indicated that vandalism was most often reported between the hours of 7:00 a.m. and 6:00 p.m. The highest number of reported acts of vandalism was 49 at 5:00 p.m. The fewest reported acts of vandalism were 5 at 4:00 a.m. Furthermore, as seen in Figure 7, the reported acts of vandalism grew, starting on Monday and continuing on into the week. The highest numbers of reported occurrences were on Friday, Saturday and Sunday. In addition, the month of September had the most reported acts of vandalism with 63 reported incidences, while February had the least with 15 reported incidences. As seen in Figure 8, the months comprising the Fall seasons - September, October, November - had 157 reported acts of vandalism, which was the highest amount per season. On the contrary, the winter months - December, January, February - had the least amount of reported incidents (72).

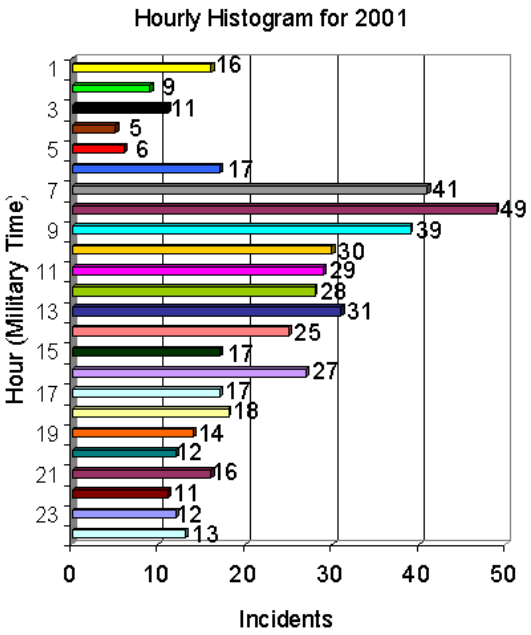

Figure 6. Hourly histogram for 2001.

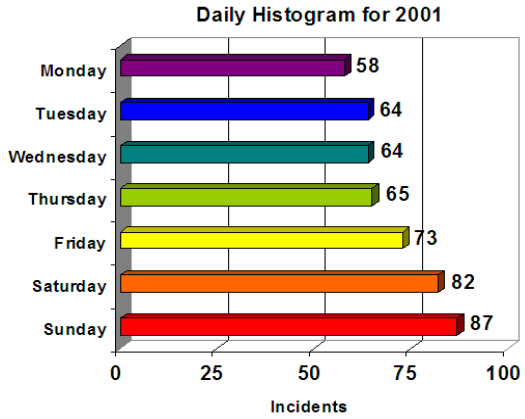

Figure 7. Daily histogram for 2001.

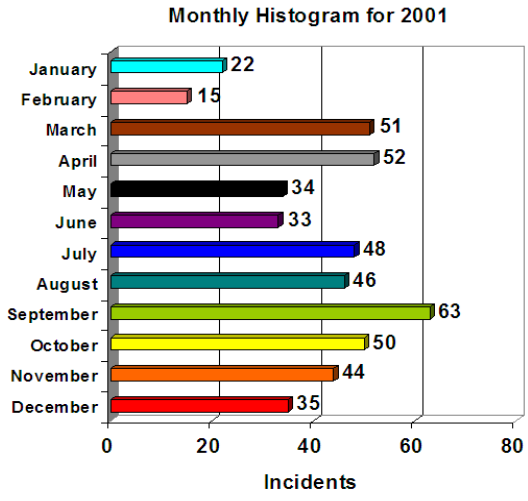

Figure 8. Monthly histogram for 2001.

Results for 2006 Data

Spatial Analysis Results - Point Based Methods

In 2006, there were 311 reported acts of vandalism in the city of Winona. Out of the 311 reported acts 304 were able to be geocoded.

There were 264 incidents involving residential dwellings and 41 incidents involving businesses. Point based methods were used to analyze vandalistic 'hot spot' locations in relation to residential dwellings and businesses.

As seen in Figure 9, there were four major residential 'hot spot' areas that were recognized in this study. The most predominant area included the downtown area and extended southeast towards the northeastern portions of Winona State University. This 'hot spot' included the area between Winona and Franklin Street and 2nd and 10th Streets. It is important to note that this highly concentrated area had several multiple incidents that were reported to the same address for several locations. The next most severely concentrated area was on the east end of the city. This'hot spot' ranged between Front and 11th Street and Zumbro Street and Mankato Avenue.

There were two additional 'hot spot' areas that were less severe than the first two areas. Both of these locations were towards the west end of the city. The first was located slightly east of Jefferson Elementary School. This 'hot spot' region consisted of the area between Hilbert and Vila Streets and 3rd and 6th Streets. The second area was located near the west end of town and was in close proximity to the JCPenny's. As seen in Figure 10, this region had several multiple incidents reported to the same address for several locations. This highly concentrated section includes the area between Sebo Street and Druey Court and from 5th Street to Kraemer Drive.

Figure 9. Residential dwelling density for 2006.

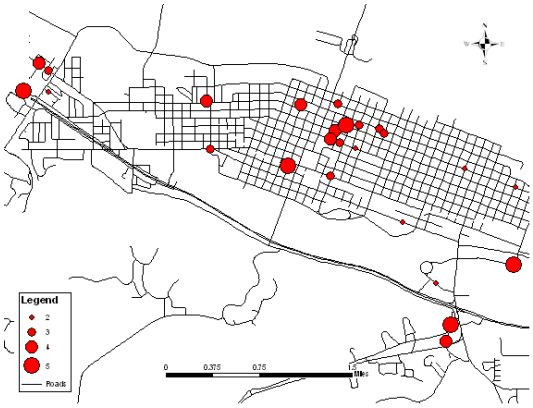

Figure 10. Multiple incidents for 2006.

As seen in Figure 11, there were three major 'hot spot' areas that included acts of vandalism against businesses. The most intense area was near the downtown area. This particular area spanned between Washington and Franklin Streets and moved southwest to 6th Street. The next two 'hot spots' were of lesser magnitude, but showed signs of above average (medium level and above) concentrations of vandalism. The first area was located on Sugar Loaf Road, near the Southeastern part of the city. This spot was victimized by multiple

incidents of vandalism. The third 'hot spot' region was identified near the Winona Mall on Gilmore Avenue.

Figure 11. Business density for 2006.

Spatial Analysis Results - Area Based Methods

Once again, the first analysis tested to see if more populated block groups per square mile showed an increase in occurrences of vandalism per square mile. In general, the findings revealed that there was in fact a significant correlation (R = .60 (p<.0005)) between populated block groups per square mile and occurrences of vandalism per square mile. Next, median household income statistics were explored to determine whether or not vandalism affected more affluent or less affluent block groups. The results showed that block groups with above average median household income also showed increased vandalistic occurrences per square mile. This was supported by a correlation coefficient, or R value of .62 (p<.0003). Third, renter occupied dwellings were examined in relation to vandalism. The findings showed a significant correlation (R = .78 (p<.0001)) between renter occupied dwellings per square mile and vandalistic incidents per square mile.

The last analysis studied whether or not vacant dwellings per block group had an effect on vandalism per block group. The results revealed that there was a significant relationship (R = .60 (p<.0005)) between vacant dwellings per square mile and acts of vandalism per square mile.

Area based methods were also used to investigate vandalism-related occurrences in proximity to bars, clubs, taverns and clubs. The finding revealed that 105, or 34.5 percent of acts of vandalism occurred within one city block, or 1/8 mile, from an alcohol-related establishment. In addition, another 107, or 35.2 percent of acts of vandalism took place 1/8 mile outside of the first bar buffer. Therefore, 212 acts of vandalism, or 69.7 percent of all vandalism, took place within approximately two city blocks of an alcohol-related establishment.

Area based methods were also used to study vandalism in relation to police beats within the city of Winona. The findings revealed that the west beat encountered 33 percent of all vandalism, while the central beat encountered 30 percent and the east beat was comprised of 37 percent. Once again, as percentages across the board were relatively similar, it is important to keep in mind that the central beat is much smaller in size than both the east beat and the west beat.

Statistical Based Methods

The mean center tool identified the central focal point for all vandalistic point features based on their X and Y coordinates. As seen in Figure 12, the mean center point was established slightly east of Johnson Street between 9th and 10th Streets.

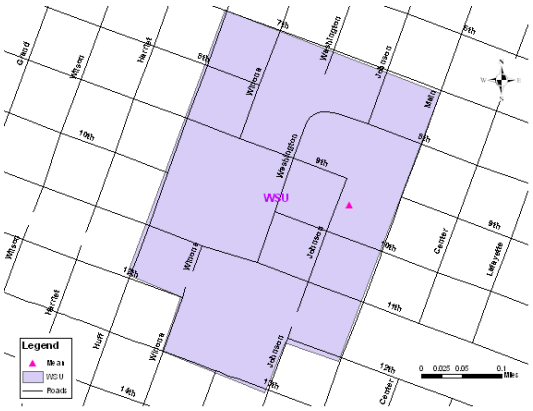

Figure 12. Mean center for 2006.

The average nearest neighbor tool was used next to detect whether or not vandalistic point features were clustered or dispersed. The point features were separated by the month of the year and then analyzed to detect clustering or dispersion. The results concluded that there was significant clustering of point features for January, March, and June through October. Months that showed signs of dispersion were February, April, May, November and December.

The last spatial statistical tool that was utilized for vandalism related spatial investigation was known as the Standard Deviational Ellipse (Directional Distribution). As seen in Figure 13, the linear ellipse suggests that the point pattern indicates a northwest – southeast dispersion.

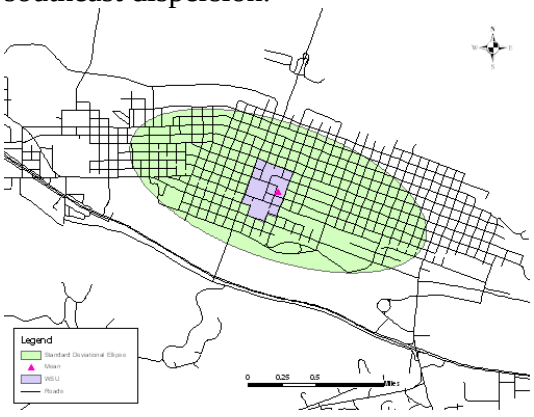

Figure 13. Standard deviational ellipse for 2006.

Temporal Analysis Results

The temporal factors that were analyzed for 2006 included the reported time, the day of week, the month, the season and the year acts of vandalism were reported in Winona. As seen in Figure 14, the results indicated that acts of vandalism were most often reported between the hours of 8:00 A.M and 1:00 P.M. The highest number of reported acts of vandalism was 31 at 9:00 a.m. The fewest reported acts of vandalism were 1 at 4:00 a.m. Furthermore, the reported acts of vandalism grew, starting on Monday and continuing on into the week. As seen in Figure 15, the highest numbers of reported occurrences were on Friday, Saturday and Sunday. In addition, the month of September had the most reported acts of vandalism with 38 reported incidences. The month of February had the least amount of reported acts of vandalism with 12 incidences. As seen in Figure 16, the months comprising the fall season - September, October, November - had 94 reported acts of vandalism, which was the highest amount per season. On the contrary, the winter months - December, January, February - had the least amount of reported incidents with 59.

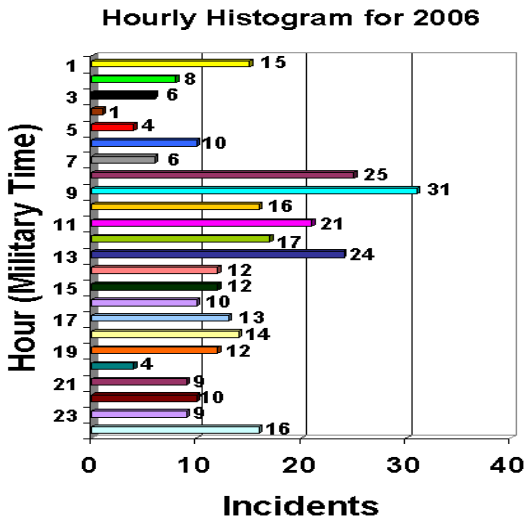

Figure 14. Hourly histogram for 2006.

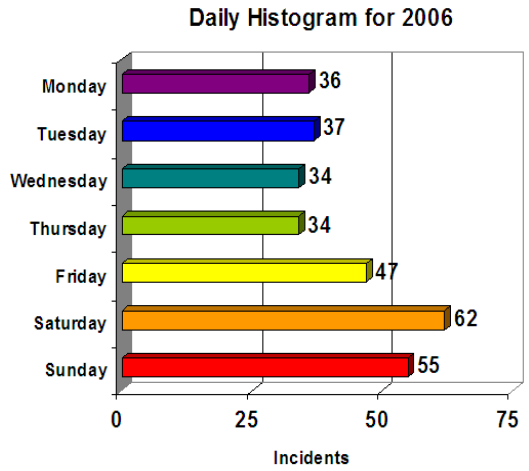

Figure 15. Daily histogram for 2006.

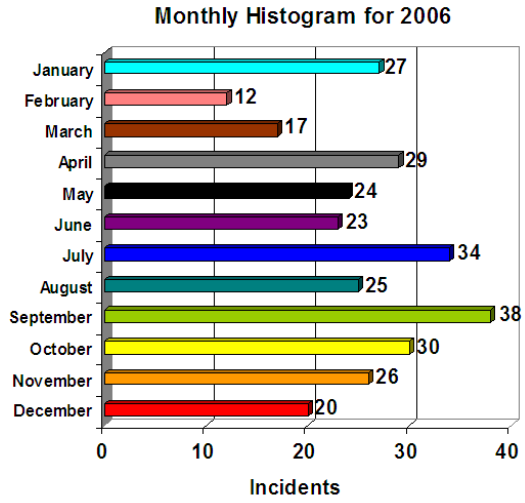

Figure 16. Monthly histogram for 2006.

Comparisons from 2001 to 2006

Point Based Comparisons

Although vandalism has decreased in Winona from 2001 to 2006, the most significant 'hot spot' areas concerning residential dwellings and vandalism remain consistent. As seen in figures 21 and 22, the three most notable 'hot spot' locations are the downtown area, the east end of the city near Mankato Avenue and the west end of the city along Pelzer Street.

There does seem to be a spatial shift involving vandalism near the downtown region. In 2001, the most highly concentrated area of vandalism in the downtown district took place near the west end between Center and Johnson Streets and 5th and 2nd Streets. However, from 2001 to 2006, the most highly concentrated areas concerning vandalism in the downtown area showed a spatial shift to the south and to the east. The concentrated movement to the south is in between the downtown area and the campus of Winona State University. The 'hot spot' shift to the east was identified between 5th and 3rd Streets and Franklin and Walnut Streets, which is slightly east of Winona State University. The spatial shift from 2001 to 2006 indicates that the large student population surrounding Winona State University along with the high number of alcohol related establishments in the downtown area may be somewhat to blame for the high concentrations of vandalism near the downtown area and the Winona State University campus.

Spatial changes concerning business related vandalism were also examined. As seen in Figures 17 and 18, the findings revealed that from 2001 to 2006 there was a significant reduction in reported act of vandalism near the west end of the city along Pelzer Street. However, high concentrations of business-related vandalism remained near the downtown area and the Winona Mall. While business-related occurrences as a whole have fallen, the total percentage of business related vandalism between 2001 and 2006 has remained consistent. For example, there were 66 business-related offenses in 2001, which accounted for 13.9 percent of all vandalistic occurrences. In 2006, there were 41 business-related offenses, which accounted for 13.5 percent of all vandalistic related occurrences.

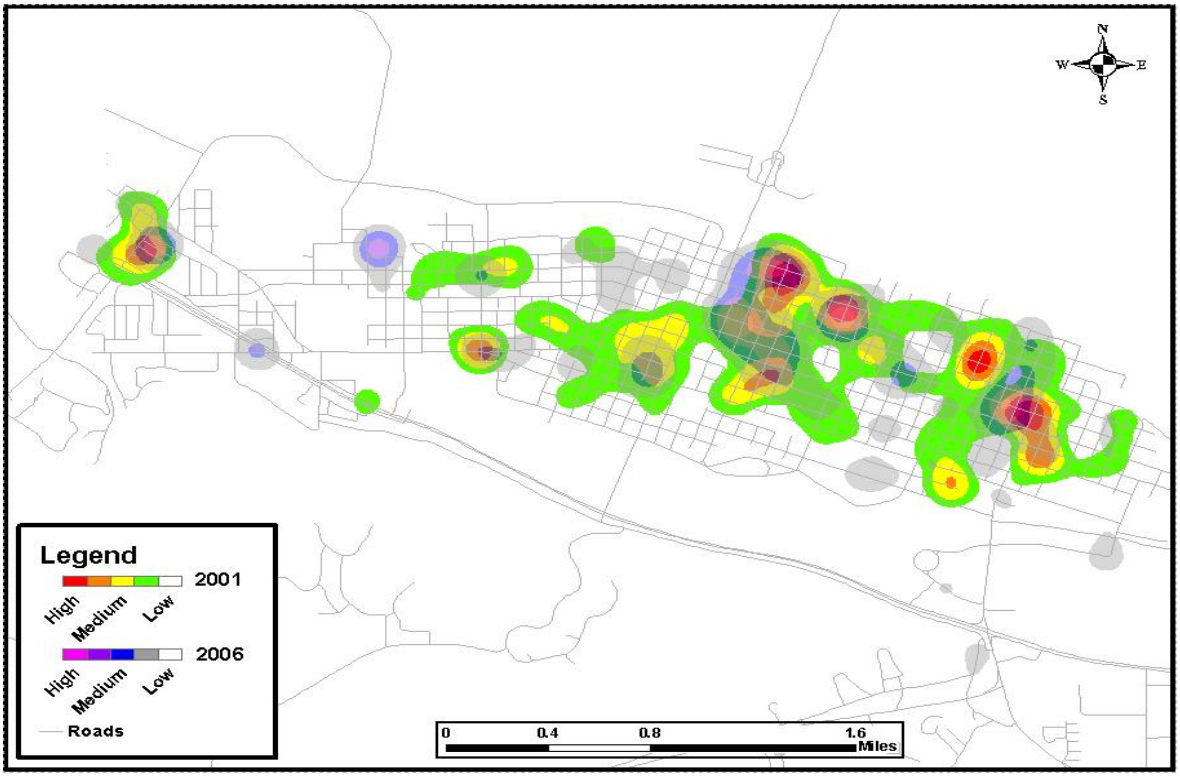

Figure 17. Residential density change detection.

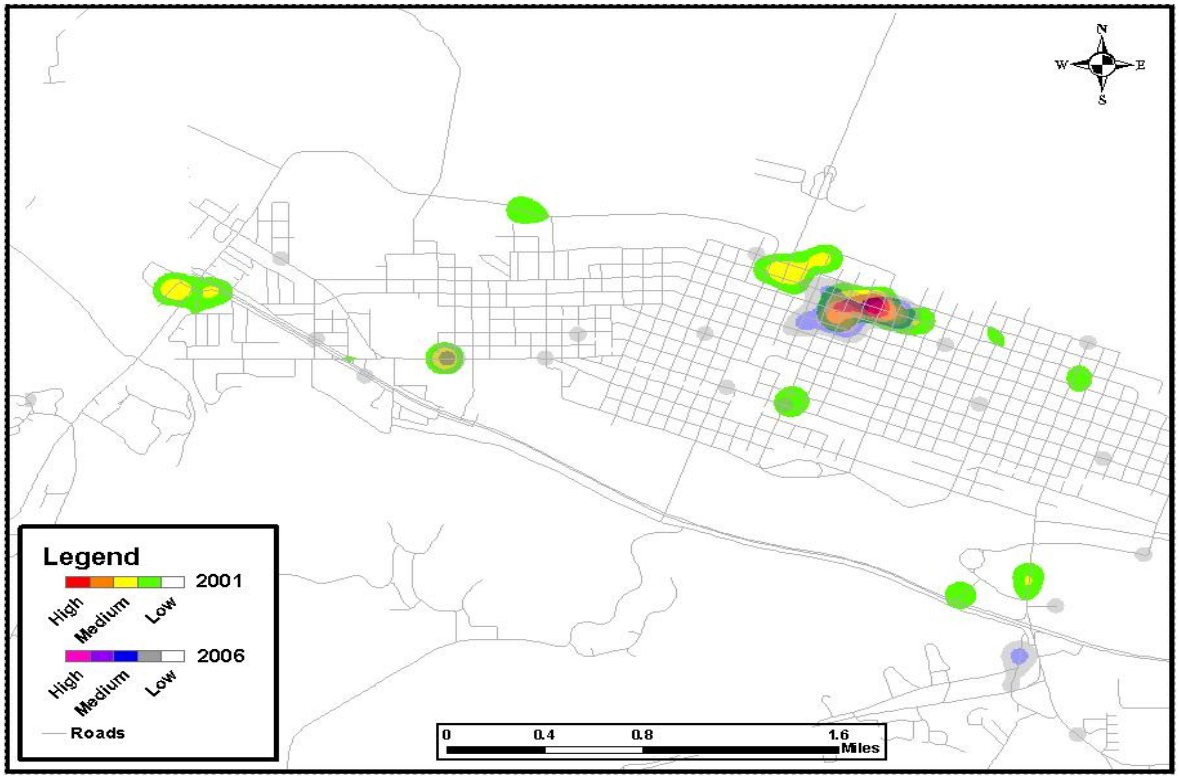

Figure 18. Business density change detection.

Area Based Comparisons

The purpose of the area based method was to explore certain demographic features in relation to vandalistic occurrences by using block group statistics. The findings for both 2001 and 2006 revealed that there was a significant relationship between vandalism per square mile and renter occupied dwellings, vacant dwellings, population and median household income per square mile. When comparing 2001 and 2006 correlation coefficient values, renter occupied dwellings not only stayed consistent, but also showed the most significant correlation with an R value of .78 ($p<.0001$) for both years. As a result, these findings suggest that areas within the city that have high concentrations of renter occupied dwellings also have elevated vandalism activity. Thus, renter occupied dwellings should be considered a significant factor contributing to the problem of vandalism in the city of Winona and need to be addressed.

Area based methods proved to be an important tool in determining whether or not alcohol related establishments foster vandalistic occurrences. In 2001, 73 percent of all vandalistic occurrences happened within two city blocks of an alcohol related establishment. By 2006, this number had decreased to 69.7 percent. However, it is important to note that there still remains a high concentration of vandalistic occurrences in close proximity to bars, clubs, taverns and pubs. Thus, these results suggest that alcohol-related establishments are a critical factor in promoting acts of vandalism. This is especially true with reference to the downtown area of Winona.

The last area based methods that were explored hoped to determine where law enforcement professionals could be most effectively utilized in helping to control vandalism. As seen in Figure 19, Winona's three police beats were spatially analyzed in relation to vandalistic activity.

Figure 19. Winona city police beats.

The findings revealed minimal changes from 2001 to 2006 concerning vandalistic activity in relation to police beats. The only minor change consisted of a slight increase involving vandalism in both the central and east beats. However, even though there were minimal changes to police beats, the central beat still possesses the most significant threat to the community and law enforcement professionals with regards to vandalism. From 2001 to 2006, the central beat has experienced a 2 percent increase in vandalism, which indicates that the central beat is gradually increasing with vandalistic threat. The central beat is relatively small in comparison to the west beat and east beat, but contains a large percentage of the total vandalistic activity and this beat shows signs of increased vandalistic threat. One of the reasons why the central beat may be victimized more frequently is because of the high number of on campus residents in the downtown area along with high renter occupied

dwellings that encompass this particular beat. In addition, the central beat is home to 17 out of the 35 bars that are located within the city of Winona.

Statistical Based Comparisons

ArcGIS 9.1 statistical tools were utilized to determine any spatial movement concerning the association of acts of vandalism over time. First, the mean centers for both 2001 and 2006 were compared. As seen in Figure 20, the results indicated that vandalism related acts over the past five years have shifted slightly in a southeastern fashion. Even though this spatial shift is minimal, it needs to be taken into consideration by law enforcement professionals and community members alike. If the mean center continues to move with southeastern momentum, resources can be allocated appropriately to help control vandalistic threat.

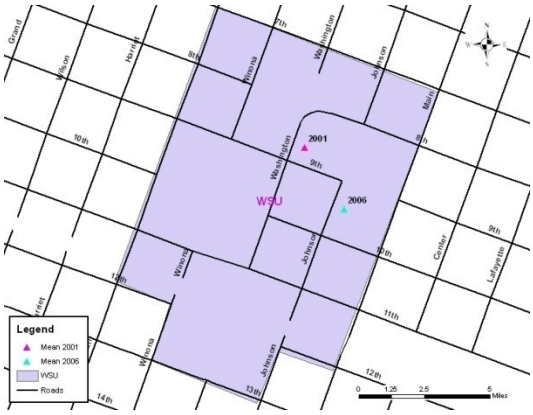

Figure 20. Mean center comparison.

Next, the standard deviational ellipsoids were explored for both 2001 and 2006 to determine a directional trend regarding spatial movement of vandalism as a whole. As seen in Figure 21, the results were similar to those of the mean center. Both the mean center and the standard deviational ellipse for 2006 showed vandalistic acts shifting towards the southeastern part of the city. Therefore the city should continue to explore vandalistic movements as a whole to determine if this trend continues in the years to come. If so, resources might be allocated more effectively and strategic preventative strategies like neighborhood watch programs could be implemented.

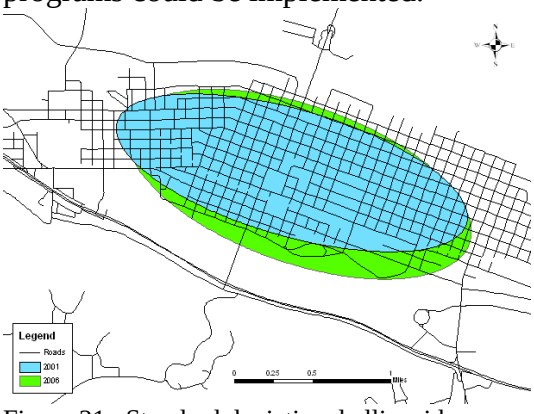

Figure 21. Standard deviational ellipsoid comparison.

Lastly, average nearest neighbor statistics were utilized to establish whether or not vandalistic point features were clustered or dispersed for each individual month for 2001 and 2006. The findings for both 2001 and 2006 revealed that the months of March, April, July, August, September, October and December all showed signs of clustering. Consequently, areas that experience significant clusters of vandalism may in fact be caused by the same person or groups of people. Thus, by analyzing clustered patterns on a regular basis, culprits could perhaps be apprehended in the early stages of their criminal patterns, which would significantly reduce the effects that vandalism causes to the city of Winona.

Temporal Analysis Comparisons

In determining a crime reduction strategy it is important to understand

how vandalism has changed spatially, but also over time as well. The temporal comparisons between 2001 and 2006 uncovered a wealth of knowledge pertaining to how occurrences of vandalism have changed or have stayed the same over time. Comparisons were made for 2001 and 2006 concerning monthly, daily and hourly reported incidents of vandalism.

First, monthly comparisons uncovered an interesting association between the two years. In both years, the month of February had the least amount of vandalistic occurrences while September had the most. In addition, while analyzing the seasons of the year, the fall months had the highest reported acts of vandalism while the winter months had the least. One of the more obvious factors that may contribute to a lesser amount of vandalism in February and the winter months is the harsh reality of the frigid temperatures in Winona during the winter. This inhibits people from staying outside for long periods of time, lowering people's ambitions and opportunity to commit vandalism. On the contrary, vandalism is the highest in September and in the fall months. This temporal pattern is most likely due to the spike in the Winona population that time of year due to the large numbers of students who attend colleges and universities in the community returning to class.

Secondly, each day of the week was analyzed to determine when vandalistic occurrences were taking place. The largest amounts of reported acts of vandalism occurred on the weekends, which consisted of Friday, Saturday and Sunday. Hourly reports of vandalism were analyzed for 2001 and 2006. The hourly analysis provided minimal findings concerning the temporal breakdown of reported acts of vandalism. The most significant findings revealed that the highest number of reported acts of vandalism occurred in the early morning hours between 7:00 a.m. and 9:00 a.m., while the fewest amounts were reported at 4:00 a.m. Increased reports of vandalism in the early morning hours were most likely due to a high number of area residents wakening up between these hours and promptly reporting the vandalistic act to their local police department. On the contrary, vandalistic incidents reported at 4:00 a.m. were low because this is a time when a large majority of people are generally sleeping.

Conclusion

It is important to note that from 2001 to 2006 the reported acts of vandalism dropped from 534 in 2001 to 311 in 2006. These figures equate to a 41.7 percent decrease in the amount of reported acts of vandalism in the city of Winona. According to Chief Frank Pomeroy of the Winona City Police Department, diminishing vandalism within the city can be attributed to several key preventative strategies that have been implemented in the past several years. For instance, in 2002, city-wide ordinances that mandate keg registrations and keg limits were put into practice. This helped in reducing the number of vandalistic acts that were commonly associated with large parties on or around college campuses. Another strategy that can be attributed to the decrease of vandalism in Winona is the Winona Transit System's Safe Ride program. Safe Ride is a free shuttle service that is made available to college students who frequent the downtown area. This seems to have helped control

the number of incidents from intoxicated students walking back to their residence through residential neighborhoods. Another notable reduction strategy that has proven to be effective involves mediation programs for convicted juvenile offenders. This plan works by giving the juvenile an opportunity to 'apologize' to the person or persons they victimized. In return, the juvenile receives a lesser punishment or the original charges are dropped or expunged from his or her record. In 2000, a landlord-tenant ordinance was enacted to control noise, loud parties and other alcohol related offenses like vandalism. This ordinance makes sure that landlords are held accountable for their property and renters. Lastly, neighborhood watch programs that were enacted in 1999, 2002 and 2003 have also been attributed to helping reduce the number of occurrences within the city.

The aforementioned preventative strategies have proven to be a step in the right direction concerning vandalism within the city of Winona. However, by analyzing spatial and temporal analysis methods, this study has revealed several key findings that could help in constructing new or improved preventative strategies.

Neighborhood Watch Groups across the country have been known to play a pivotal role in helping to reduce vandalism and other crime related incidents. One of the more significant preventative tactics would include initiating neighborhood watch groups in close proximity to vandalistic occurrences. By using point based methods, this study has identified three 'hot spot' regions that have remained consistent over the years and need immediate attention. The first area includes the downtown segment between Winona and Franklin Street and extends southward to the Winona State University campus. There is one neighborhood watch group in this existing area, but it could be beneficial to add another. Also, it may be advantageous to establish a watch group comprised of local business owners and chamber of commerce members since a large number of business related vandalism takes place in the downtown area as well. The second most notable area in need of assistance is towards the east end of town between St. Charles Street and Mankato Avenue and Front and 10th Street. The third and final 'hot spot' zone is near the west end of the city, which runs along Pelzer Street between 6th and Kraemer Street.

Also, vacant properties and abandoned buildings present local government with an assortment of problems. Vacant properties strain municipal budgets and the resources of police, fire, building and health departments. In addition, such properties quickly become breeding grounds for vandalism and other criminal activities. Area based methods revealed that there is a strong correlation between vandalistic activities and high vacant residences. It would benefit the community to take a further look into helping control or eliminate these vacancies.

Comparisons for 2001 and 2006 using area based methods also revealed a significant correlation between renter occupied dwellings per square mile and vandalism per square mile. Consequently, the city of Winona should continue to strongly enforce their landlord tenant ordinance so that rental units do not foster increased criminal behavior such as vandalism. In addition, it could be advantageous for the colleges

and universities in Winona to impose stricter penalties for off-campus students who commit unlawful behavior such as vandalism. Possible penalties could include probation, community service or even expulsion from the school.

Allocation of resources is another important factor that needs to be addressed. Statistical based comparisons involving the mean centers and the standard deviational ellipses revealed that vandalism as a whole may be moving in a southeastern direction. Consequently, law enforcement professionals should continue to monitor this spatial pattern to see if vandalistic movement remains consistent. If uniformity persists, resources could be efficiently allocated to help deter the threat of vandalism. Furthermore, average nearest neighbor statistical comparisons for 2001 and 2006 illustrated that the months consisting of March, April, July, August, September, October and December all showed signs of clustering. Thus, it would be advantageous for law enforcement professionals to analyze clustered patterns on a regular basis so that 'hot spot' regions or vandalism patterns could be established quickly. This would allow for more efficient allocation of resources, which could possibly lead to the apprehension of culprits in a timelier manner.

This study also found that it would be beneficial to concentrate law enforcement resources in the central police beat to help deter acts of vandalism. The central beat continues to be a problematic region based on this study's findings, which indicated that from 2001 to 2006 the total percentage of vandalistic incidents has risen to an all time high.

Temporal analysis findings concerning monthly, seasonal and weekly breakdowns can offer law enforcement professionals in collaboration with local community members the know-how to make more informed decisions as to how to reduce the harmful effects of vandalism within the city of Winona. To be most effective, police professionals and community members should concentrate their resources and efforts on Friday, Saturday and Sunday. In addition, it may be advantageous to develop community wide vandalism prevention campaigns in the early months of the fall season, which is the time of the year when vandalism appears to be at its highest.

It is imperative that the entire community, along with law enforcement professionals be involved in dealing with the harsh realities caused by vandalism. Collaboration between police professionals and Winona community members needs to be revitalized by the sharing of information. An efficient and effective way of distributing crime related episodes such as vandalistic occurrences is through the internet. The city of Winona has already established a GIS internet mapping site that is free and accessible to the public. However, they have yet to add crime related occurrences to their site. By doing so, citizens would have the ability to select crime types and date ranges, and produce tables and maps of incidents near their homes, landmarks such as schools and parks or within boundaries of neighborhood watch organizations. By using internet mapping services, landlords, neighborhood watch organizations and concerned citizens could more actively help in reducing vandalism and other criminal activities

within the Winona community.

Discussion and Issues of Error

Overall, there were minimal complications that were experienced throughout this project, though there were some issues that proved difficult.

The first issue dealt with the data that was provided by the WCPD. Considerable time was spent sifting through the records to obtain usable data. Some of the tasks included deleting fields that were not applicable to this project such as littering or trespassing offenses. In addition, some of the vandalistic offenses were reported from victims who came directly into the Winona Police Department at 201 W 3rd Street, or to the Winona City Police Department at 451 E 3rd St. Consequently, these reported address locations were of no use so they were deleted.

Other data complications included vague or indecipherable records. For example, various landmarks were used to identify vandalistic activities. These landmarks had to be researched to find their address location, so that they could be properly geocoded. Other records were simply too unintelligible to even use. Examples included addresses such as “W of Government Center” and “Po Box 28”.

The second issue dealt with the geocoding process. Once the correct “Range” was identified, the geocoding process allowed for a much more proficient and accurate portrayal of vandalistic occurrences.

Lastly, it is important to note that the statistical data that was used to determine correlations between vandalism and renter occupied dwellings, vacant dwellings, population and income is somewhat outdated. The data was obtained from the U.S. Census Bureau and the most recent statistics that they offer are from 1999. Thus, there may be some inconsistencies, but the demographic characteristics for Winona have not changed significantly over the past six years.

Suggestions for Future Research

Potential research endeavors concerning vandalism in Winona seem endless. Most notably, future research could get a more accurate perspective concerning vandalism in relation to vacant dwellings and rental units by geocoding the addresses instead of using block group statistics. By using geocoding principles, it would allow for a more precise and accurate analysis because rental units and vacant dwellings would be spatially identifiable. In addition, it would be interesting to investigate vandalistic occurrences in relation to various other crimes such as noise violations, curfew violations, loitering offenses, public intoxication or other criminal activities. Also, it would be fascinating to break down vandalistic occurrences for a 10-year period and explore each year individually. This would take a considerable amount of time and resources, but the findings may prove to be beneficial in helping to further understand the crime of vandalism within the City of Winona. Lastly, by analyzing 2001 and 2006 vandalistic occurrences, spatial trends indicate that vandalism as a whole is moving in a southeastern pattern. It would be interesting to investigate future trends to see if this pattern continues to stay the same or changes in the future.

Acknowledgements

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