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Geographic profiling: knowledge through prediction

Crosby, Tiffany D.

Monterey, California: Naval Postgraduate School

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GEOGRAPHIC PROFILING: KNOWLEDGE THROUGH PREDICTION

by

Tiffany D. Crosby

June 2014

Thesis Advisor: William Fox
Second Reader: Michael Freeman

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For years it has been the goal of the Intelligence Community to limit sharply or even put a stop to terrorism, be it through the prevention of attacks or apprehension of those seeking to commit such acts. While there has been some success, perhaps further progress could be made by incorporating techniques used by law enforcement into the intelligence process. Geographic profiling has been used successfully by law enforcement agencies to aid in the capture of serial criminals, and due to the similarities between the two, it is possible that geographic profiling could do the same against terrorists. In the case of the Abu Sayyaf Group in the southern islands of Sulu and Basilan in the Philippines, geographic profiling techniques were partially successful in highlighting the possible future locations or types of incidents that would next be committed by the group. The success was limited, but while it may not be the next great breakthrough in the prevention of terrorist attacks, it appears to be another layer of analysis that can be incorporated in the intelligence cycle.

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GEOGRAPHIC PROFILING: KNOWLEDGE THROUGH PREDICTION

Tiffany D. Crosby
Lieutenant, United States Navy
B.S., Eastern Michigan University, 2009

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June 2014

Author: Tiffany D. Crosby

Approved by: William Fox
Thesis Advisor

Michael Freeman
Second Reader

John Arquilla
Chair, Department of Defense Analysis

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ABSTRACT

For years, it has been the goal of the intelligence community to limit sharply or even put a stop to terrorism, be it through the prevention of attacks or apprehension of those seeking to commit such acts. While there has been some success, perhaps further progress could be made by incorporating techniques used by law enforcement into the intelligence process. Geographic profiling has been used successfully by law enforcement agencies to aid in the capture of serial criminals, and due to the similarities between the two, it is possible that geographic profiling could do the same against terrorists. In the case of the Abu Sayyaf group in the southern islands of Sulu and Basilan in the Philippines, geographic profiling techniques were partially successful in highlighting the possible future locations or types of incidents that would next be committed by the group. The success was limited, but while it may not be the next great breakthrough in the prevention of terrorist attacks, it appears to be another layer of analysis that can be incorporated into the intelligence cycle.

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LIST OF ACRONYMS AND ABBREVIATIONS

ARMM	Autonomous Region in Muslim Mindanao
ASG	Abu Sayyaf group
CGT	criminal geographic targeting
CORE	Common Operational Research Environment
CRUSH	Crime Reduction Utilizing Statistical History
CTM	Communist terrorist movements
DNA	deoxyribonucleic acid
FBI	Federal Bureau of Investigation
FTO	Foreign Terrorist Organization
GIS	geographic information systems
LE	lawless elements
MADM	multi-attribute decision making
MILF	Moro Islamic Liberation Front
MNLF	Moro National Liberation Front
NCTC	National Counterterrorism Center
NIJ	National Institute of Justice
OSC	Open Source Center
RCMP	Royal Canadian Mounted Police
TOPSIS	technique of order preference by similarity to ideal solution

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I. PREDICTING TERRORIST ACTION

A. PROBLEM STATEMENT

While it may be difficult to disrupt a terrorist network, perhaps we can improve our ability to anticipate where and when the next attack will occur. The adaptation of terrorists in order to avoid detection has limited the number of characteristics that we can search for or track. If we cannot find the terrorists directly, we must focus our efforts on another strategy. One way that terrorist networks can be exploited is through the determination of when and where the organization will make its next attack. If counterterrorism forces have an idea of when and where the terrorists will attack, they can plan accordingly in terms of surveillance and security presence, which could lead to the prevention of said attack and/or the apprehension of its perpetrators before, during, or immediately following the commission of their act. While tactics and methods may have changed, the locations of these acts of terrorism have stayed more or less consistent over time, driven by available targets and opportunities as have the individual traits of the perpetrators. These anticipatable variables may be able to yield information concerning the potential whereabouts of both the terrorists as well as the locations of their next attacks. How best might we combine these variables together in order to yield the possible locations of terrorists and/or their attacks? Is it possible that these commonalities mean that something that works well for law enforcement could be applied to intelligence and security analysis?

B. PURPOSE AND OBJECTIVES

The purpose of this thesis is to determine whether it is feasible to apply the method of geographic profiling, a method successfully used by law enforcement for hunting serial criminals, to terrorists and terrorist acts. In general, geographic profiling "is based on crime pattern, routine activity, and rational choice theories from environmental criminology, a field of study interested in the interactions between

criminals and the physical environment that surrounds them."[1] Due to the complexity of terrorist networks, the author will begin by studying the feasibility of applying geographic profiling toward anticipating the next actions of a terrorist organization and predicting when are where their next attack could occur. If successful, future efforts may move toward the illumination of terrorist networks and finally, the search for individuals within the organization. Also explored will be whether existing models of geographic profiling can be improved upon by including variables not just related to the location of the event, but to terrorists as well.

C. METHODOLOGY

This thesis will utilize data concerning terrorist attacks and input these data into established models of geographic profiling to see whether they can accurately predict where the next attack will occur. Today, there are four primary models of geographic profiling utilized by law enforcement officials: CrimeStat, Rigel Analyst, Dragnet, and Predator. For this thesis, the CrimeStat Version III program will be utilized, due to its accessibility and because additional variables can easily be included in the program. Along with using CrimeStat to conduct analysis of terrorist incidents, information about the Philippines, such as population data, terrain, roads, and built-up places will be incorporated to aid in determining whether the location where future incidents occurred made sense and could be predicted. This thesis will utilize data received from the Common Operation Research Environment (CORE) Lab concerning terrorist attacks that occurred in the Philippines and input their location data into the preexisting and combination models of geographic profiling. Not all of the data from each set will be entered because the later attacks will serve as the testing criteria for each of the models.

It is the goal of this thesis to determine whether geographic profiling software and techniques can be utilized to predict future terrorist attacks. By leaving out some of the data from the data sets, it will be possible to compare the predictions made by the various

[1] D. Kim Rossmo, Ian Laverty and Brad Moore, "Geographic Profiling for Serial Crime Investigation," in *Geographic Information Systems and Crime Analysis*, ed. Fahui Wang (Hershey, PA: Idea Group, 2005), 104.

models to the actual outcomes and determine the differences between the two in order to see which of the models made the closest prediction to the actual event (i.e., reflected in the smallest degree of difference).

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II. THE APPLICABILITY OF GEOGRAPHIC PROFILING TO TERRORIST ACTION

A. WHAT IS GEOGRAPHIC PROFILING?

Craig Bennell and Shevaun Corey describe geographic profiling as "using knowledge about the relative locations of an offender's crime sites to predict the highest probable location of his or her residence."[2] This field is relatively young, started in 1987 by D. Kim Rossmo, and is currently utilized by law enforcement agencies to prioritize suspects in criminal investigations and determine the areas where to saturate police patrols. Geographic profiling operates under the premise that the locations of crimes are not completely random but, in fact, have a "degree of underlying spatial structure" to them because there is some rationality behind the selection of their locations.[3] The primary goal of geographic profiling is the establishment of an anchor point, or the place where an offender primarily operates from, and likely the single most important place in his or her life. Anchor points can include the offender's home, his or her workplace, a home of a friend of the offender, or even a bar or restaurant. Data can be collected from previous crimes and used to create a profile of the criminal's geography. Rossmo's model operates under the following beliefs: that an offender is more likely to choose locations that are closer to his or her anchor point rather than farther away, and though the offender targets areas closer to his or her anchor point, he or she will avoid targeting locations too close to this anchor point in order to avoid being caught.[4]

From his or her focal point, an offender searches outward for the target; this search is typically modeled by some sort of distance-decay function. This distance-decay

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[2] Craig Bennell and Shevaun Corey, "Geographic Profiling of Terrorist Attacks," in *Criminal Profiling: International Theory, Research, and Practice*, ed. R.N. Kocsis (Totowa, NJ: Humana Press, 2007), 190.

[3] D. Kim Rossmo, "Place, Space, and Police Investigations: Hunting Serial Violent Criminals," *Crime Prevention Studies* 4 (1995): 222.

[4] University of Washington Department of Mathematics student team, *Yet Another Mathematical Approach to Geographic Profiling: Control #7502* (Seattle: University of Washington, 2010), 6.

function illustrates an inverse relationship between the number of incidents and the distance from an offender's anchor point.[5]

In order to construct a geographic profile, the coordinates of crime scenes are entered into a software analysis program that contains an algorithm known as the CGT (criminal geographic targeting). The CGT algorithm is based on the three-dimensional aspect of the hunt process a criminal goes through when searching for a target. As described in Geographic Profiling for Serial Crime Investigation, the algorithm "divides the hunt area (the area enclosing all of the crime sites) into a fine grid, and then calculates the probability that each individual grid point is the offender's anchor point."[6] It yields a probability graph, called a jeopardy surface, where the greater the height depicted, the greater the probability the given location is the offender's anchor point; this can then be converted into a two-dimensional map and overlaid on a map of the area.[7] Once generated, this geographic profile has a number of applications in the world of law enforcement.

Since the advent of geographic profiling, this method has helped aid in several investigations for law enforcement agencies including the Federal Bureau of Investigation (FBI), the Royal Canadian Mounted Police (RCMP), Scotland Yard, as well as agencies at the state and local levels.[8] Even though a geographic profile does not mark the exact location of the person who most likely committed the series of crimes, it does help narrow the search area and also provides another possible metric to compare a list of suspects against. An example of the success Scotland Yard has had with utilizing a geographic profile was its 1994 to 1998 search for the Mardi Gras Bomber. The bomber was responsible for 36 bombings in the London area and when a geographic profile was requested, it produced two areas where it was highly probable that the bomber resided or operated from. When the people responsible were arrested, their residence was located in

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[5] Rossmo, "Place, Space, and Police Investigations," 223.

[6] Rossmo, Laverty and Moore, "Geographic Profiling for Serial Crime Investigation," 107.

[7] Ibid., 108.

[8] D. Kim Rossmo, *Geographic Profiling* (Boca Raton, FL: CRC Press, 2000), 212.

the top 3.4% of the suspect's hunting area.[9] Geographic profiling has also helped to illuminate search areas not previously considered, as was the case of the South Side Rapist in Lafayette, LA. Following 14 rapes that occurred over a period of 11 years, the generated geographic profile highlighted a new neighborhood that served as the foundation for a hotline receiving tips. One tip matched this profile as well as a psychological profile, and surveillance of the suspect led to obtaining his deoxyribonucleic acid (DNA) and comparing this DNA to samples collected at the crime scenes resulted in a match and his arrest.[10]

Geographic profiling also has applications outside the search for and apprehension of individual perpetrators; it can also be utilized more generally for the improvement of police patrols. In Memphis, TN, city officials have seen a decrease in crime with the help of operation Blue CRUSH (Crime Reduction Utilizing Statistical History). "Blue CRUSH is a data mining approach to the analysis of location- and time-based criminal patterns and evolving trends."[11] With its help, Memphis has experienced a 16% decline in crime between 2006 and 2008. This program is able to utilize existing as well as incoming data from police patrols on a variety of information such as the location of crimes, the type of crime, day and time of crimes, and victim characteristics, which help generate a tactical crime prediction.[12] Blue CRUSH's timely incorporation of data into a multilayered map allows police patrol and unmarked cars to be placed throughout the city in hopes of catching crimes during their commission and serving as a deterrent. The program has helped Memphis reduce both drug and gang related activity as well as crime in general in the city.[13]

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[9] Rossmo, *Geographic Profiling*, 215–216.

[10] Rossmo, *Geographic Profiling*, 226.

[11] Walter C. Perry et al., "Using Predictions to Support Police Operations," in *Predictive Policing: The Role of Crime Forecasting in Law Enforcement Operations* (Santa Monica, CA: RAND, 2012), 67.

[12] Perry et al., "Using Predictions to Support Police Operations," 68.

[13] Ibid.

B. WHY SHOULD THE UNITED STATES EXPLORE EXPANDED UTILIZATION OF GEOGRAPHIC PROFILING?

The prevailing methods of counterterrorism currently in use are alone not enough to handle the task of stopping terrorists and their attacks. Terrorists do not operate out in the open; they actively seek to maintain secrecy and the element of surprise because these allow them to instill fear in their enemies and increase their likelihood of survival.[14] While current methods of counterterrorism claim some success, these terrorist organizations still exist. These methods have included counter-messaging, trying to turn the support of the local population away from the terrorists, targeting senior leaders, and seeking to reduce their numbers.[15] All of these methods have relied heavily on intelligence, but intelligence can be flawed, and in turn, negatively impact the choices made based on the collected information.

Intelligence information comes in several forms and from several sources of collection. Due to the abundance of intelligence collected not only by intelligence services but from tips and unusual or suspicious activity reports, combined with a lack of proper resources to handle the volume of information, an overload can occur.[16] Even though a large amount of intelligence is received, not every essential piece of intelligence needed to make a decision can be collected. The information, even if accurate, will not always be analyzed and disseminated in a timely manner. Sometimes, the assets needed to collect intelligence are not always available. When utilizing people to collect information, language and cultural barriers can exist that prevent these outsiders from being able to either infiltrate an organization or work with the local population. Even if able to obtain information from people on the inside in the form of defectors or informants, that intelligence could be unreliable and further set back counterterrorism efforts. The events of September 11 highlight another problem with intelligence: even if

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[14] David Charters, "Counterterrorism Intelligence: Sources, Methods, Process, and Problems," in *Democratic Responses to International Terrorism* (New York: Transnational Pub, 1990), 228–229.

[15] Martha Crenshaw, "How Terrorism Declines," *Terrorism and Political Violence 3*, no. 1 (1991), 85..

[16] D. Kim Rossmo and Keith Harries, "The Geospatial Structure of Terrorist Cells," *Justice Quarterly 28*, no. 2 (2011): 222.

the information is collected, if it is not shared among all intelligence agencies and relevant organizations, opportunities can be missed and countries can fall victim to a terrorist attack.[17] Because of these issues, perhaps it is time to incorporate new methods into the fight, methods such as geographic profiling. The information overload problem will continue to exist for the foreseeable future, but geographic profiling would allow for this abundant information to be utilized in a different manner. Kim Rossmo and Keith Harries highlight that "because of the prevalence of spatial information, however, geographic prioritization models can be useful tools in the management of information overload situations."[18] In *How Does Studying Terrorism Compare to Studying Crime*, Gary LaFree and Laura Dugan highlight how researchers of terrorism could incorporate geographic profiling techniques.

> An important strategy used by criminologists to study spatial and temporal patterns of events employs geographic mapping techniques. Just as these scholars have imbedded crime incidents into maps of countries and cities, terrorism researchers can create regional and world-wide maps depicting numbers and rates of terrorist activities around the globe.[19]

Geographic profiling offers a possible solution to the problems caused by a reliance on intelligence. The models of geographic profiling currently in use utilize for their inputs hard data points such as location and distance from a particular point. Geographic profiling also removes the uncertainty about the correctness of the information because the data is based on the location of attacks that have already occurred and that information is able to be verified. It also is able to move past cultural and language concerns because it does not rely on human agents to obtain the needed information. Finally, because the location of attacks is common knowledge, the various agencies would not have to struggle to gather information from each other, which help to reduce the reliance counterterrorism agencies have on one another.

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[17] Charters, "Counterterrorism Intelligence," 252–257.

[18] Rossmo and Harries, "The Geospatial Structure of Terrorist Cells," 222.

[19] Gary LaFree and Laura Dugan, "How Does Studying Terrorism Compare to Studying Crime?" *Terrorism and Counter-Terrorism: Criminological Perspectives 5* (2004): 68.

Apart from the possibility that geographic profiling could be utilized in aiding the prediction of where and when a terrorist organization will attack next, geographic profiling could potentially offer other applications to the military such as for incorporation into their cordon and search operations, which would aid in counterinsurgency operations.

C. SIMILARITIES BETWEEN SERIAL CRIMINALS AND TERRORISTS

In order to export the theory of geographic profiling to counterterrorism, a number of assumptions about terrorists and serial criminals need to be examined. At first glance, there may not appear to be many similarities between the two groups, but upon closer examination, the two share several commonalities. In order for a crime to occur, three requirements must be met: a motivated offender, a suitable target, and the lack of an authority's presence,[20] something both serial crimes and terrorist attacks share. Both types of offenders, serial criminals and terrorists, commit multiple offenses; the two can both have a signature, which makes it possible to determine whether or not it is the same individual or group committing a crime or attack. Deborah Schurman-Kauflin argues that another similarity shared by serial criminals, serial killers in particular, and terrorists lies in the fact that both types have a fantasy of some sort and want to see that fantasy come to life; they will then seek activities that reinforce that what they want to do is correct.[21]

Another similarity exists between the two types during the preparation phase because, as a criminal or terrorist prepares for an attack, they generally have a specific sequence of events that they follow. Michael Freeman, David Tucker, and Steffen Merten have divided the actions a terrorist or terrorist organization conducts prior to the attack into nine distinct phases: "networking, training, general planning, attack-specific recruitment, financing, operational planning, weapons procurement, logistical preparation, and operational preparation."[22] Further modeling into these nine distinct

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[20] Rossmo, Laverty and Moore, "Geographic Profiling for Serial Crime Investigation," 105.

[21] Deborah Schurman-Kauflin, *Disturbed: Terrorist Behavioral Profiles* (Sun City, AZ: Violent Crimes Institute, LLC, 2008), 89.

[22] Michael Freeman, David Tucker, and Steffen Merten, "Pathways to Terror: Finding Patterns Prior to an Attack," *Journal of Policing, Intelligence and Counter Terrorism 5*, no. 1 (2010): 76.

phases by Thompson and Fox has given priority values to these phases using multi-attribute decision making (MADM) analysis. Using Analytical Hierarchy Process as the vehicle for MADM their results showed that terrorist training, networking, planning, and operational preparation account for 65.2% of the priority value, see Table 1.

Phases	Percentage	Prioritization or Ranking
Terrorist Training	27.40%	1
Networking	16.40%	2
Planning	11.40%	3
Operational Preparation	10.00%	4
Financing	8.56%	5
Recruitment	8.00%	6
Operational Planning	7.20%	7
Weapons Procurement	6.10%	8
Logistical Preparation	4.86%	9

Table 1. The Table Shows the Final Outcome from the AHP Analysis by Fox and Thompson.[23]

Furthermore, they applied the technique of order preference by similarity to ideal solution (TOPSIS) and obtained the priorities shown in Table 2, where operational preparation, terrorist training, networking, and recruiting account for 76.46% of their priorities.[24]

[23] William P. Fox and Nicholas Thompson, "Phase Targeting of Terrorist Attacks: Simplifying Complexity with AHP and TOPSIS," *Journal of Defense Management* 4, no. 116 (2014).

[24] Fox, "Phase Targeting of Terrorist Attacks."

TOPSIS	Phases	Ranking	Percent	Cumulative Percent
0.816936	Operational Preparation	1	26.1996	26.1996
0.774866	Recruiting	2	24.85038	51.04998
0.49741	Terrorist Training	3	15.95221	67.00219
0.294915	Networking	4	9.458104	76.46029
0.268568	Weapons Procurement	5	8.613136	85.07343
0.174234	Planning	6	5.58778	90.66121
0.126706	Financing	7	4.063533	94.72474
0.086217	Operational Planning	8	2.765018	97.48976
0.078273	Logistical Preparation	9	2.510244	100
3.118124	Total			

Table 2. This Table Shows the Cumulative Percentages Generated through TOPSIS Analysis by Fox and Thompson.[25]

The two methods share terrorist training, networking, and operational preparation among their top three variables. These give us insights into the process. This information can be incorporated by security forces and intelligence analysts, who previously have been likely to determine what sort of attack a particular organization may be working toward, and be able to focus their efforts on looking for a particular set of events to occur in order to more accurately determine the timing of an attack and perhaps be able to prevent it from happening.

Finally, when narrowing serial criminals down to serial killers, the further comparison of target type can be included to illustrate their similarities because both groups tend to choose soft targets. While several terrorist organizations aim to eventually conduct a large-scale attack against an important landmark or other piece of infrastructure that would likely produce a devastating effect on an entire country, their day-to-day attacks focus more on smaller-scale efforts that target people. Much like the more commonplace attacks made by terrorists the “soft” people over the “hard” pieces of infrastructure; serial criminals tend to target those in society who are more vulnerable to attack.

[25] Ibid.

D. PREVIOUS ATTEMPTS TO APPLY GEOGRAPHIC PROFILING TO TERRORISM

Previous attempts to apply geographic profiling to terrorism are few in number, and these few attempts have yielded mixed results. Craig Bennell and Shevaun Corey examined two terrorist groups, *Action Directe*, which primarily operated in France and *The Revolutionary People's Struggle* in Greece. They chose to focus on one specific individual in each group and a series of attacks that they were tied to. The two researchers ran their collected information through geographic profiling software and in the case of *Action Directe*, were not able to accurately identify the individual's anchor point due to the offender traveling great distances to attack his targets. However, in the case of *The Revolutionary People's Struggle*, the geographic profile was able to identify the location of the individual's anchor point with a 14% hit percentage because the offender did not travel great distances.[26] Their research posited that geographic profiling has five assumptions that have to be met in order to ensure accuracy: "the profile must be based on multiple crime sites, the crimes must be linked to the same offender, the offender committing the crimes cannot be commuting into the area of criminal activity, the distribution of suitable targets must be relatively uniform around the offender's home, and the offender cannot move anchor points during his or her crime series."[27] However, terrorist attacks and their perpetrators do not always meet these five assumptions. They explain that two assumptions of the five assumptions will frequently be met and the remaining three will only sometimes be met. In the cases studied by Bennell and Covey the assumptions that will frequently be met in the terrorist context are the first two; they require multiple crimes and locations as well as all the offenses need to be tied to the same individual. The other three assumptions will only sometimes be met, but it is believed that under certain conditions, these assumptions could be met.[28] They conclude their research stating that "geographic profiling may be possible in the terrorist context,

[26] Bennell and Corey, "Geographic Profiling of Terrorist Attacks," 195–199.

[27] Ibid, 192–193.

[28] Ibid., 192–195.

but only under certain conditions."[29] However, they claim that they may have underestimated the value of geographic profiling and that it needs to be further explored.

Another effort that sought to apply geospatial information concerning terrorist cells and their eventual attacks in order to determine whether any spatial patterns exist in their behavior was headed by D. Kim Rossmo and Keith Harries. They studied the behavior of terrorist cells operating in Ankara and Istanbul, Turkey.[30] The primary goal of their research "was to develop the basis for a geographic prioritization model that could be used to help locate various elements of terrorist cells, similar to the one used in the geographic profiling of serial crime."[31] In their course of their research, they discovered that local and proximate spatial relationships exist between terrorist incidents and the location of their cells.[32] Their model was also able to demonstrate the feasibility of making a geospatial approach to studying terrorist actions. They also concluded that like criminals, in terms of geography, terrorists behave rationally. Furthermore, they state that their model could be improved upon by the inclusion of three factors: "base rate or prior probability of an active terrorist cell in a given area;" "incorporating a demographic analysis;" and incorporating more than one cell site.[33] Together, these previous efforts to apply geographic profiling or geospatial analysis to some aspect of terrorism indicate that this new approach is possible, but will require further research and work; something this thesis seeks to accomplish.

[29] Ibid., 199.

[30] Rossmo and Harries, "The Geospatial Structure of Terrorist Cells," 222.

[31] Ibid., 243.

[32] Ibid., 242.

[33] Ibid., 243–244.

III. GEOGRAPHIC PROFILING SOFTWARE AND CASE STUDY

A. GEOGRAPHIC INFORMATION SYSTEMS

According to Susan Smith and Christopher Bruce, geographic information systems (GIS) are "hardware and software that collects, stores, retrieves, manipulates, queries, analyzes, and displays spatial data. GIS is a computerized fusion of maps with underlying databases that provide information about map objects."[34] GIS generates a map and this map can be analyzed visually; however, this visual interpretation can only get someone so far and further, more complete analysis is needed, especially when large amounts of data points are being analyzed. In order to complete these more complex calculations, spatial statistics, or "mathematical technique that apply descriptive and multivariate statistics, mathematical modeling, and algorithms to spatial data," are needed and that is where CrimeStat can be utilized.[35]

B. CRIMESTAT

CrimeStat was first released in August 1999, but the edition that was utilized in this thesis is version 3.3 (CrimeStat III). CrimeStat IV (version 4.0) was released this past November but not evaluated in this thesis, as instructional material for this new version was not available until spring 2014. "CrimeStat is a Windows-based spatial statistics application developed by Ned Levine and Associates of Houston, Texas, under a grant from the NIJ" (National Institute of Justice).[36] CrimeStat is not a GIS, but it can read files from those programs and also produce results that can be read by a GIS. It takes the locations where crimes occurred and is able to perform a wide array of calculations on these coordinates.[37] All of these can be exported as various map layers that can be displayed in a GIS.

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[34] S. Smith and C. Bruce, *CrimeStat III User Workbook* (Washington, DC: National Institute of Justice, 2008), 2.

[35] Ibid., 3.

[36] Ibid., 4.

[37] Ibid.

CrimeStat is designed to help users: identify patterns in crime; identify a "target area" in which a serial offender is most like to strike next; identify and prioritize hot spots; conduct a risk analysis throughout the area of operations based on where previous incidents have occurred; and to produce a geographic profile.[38] Most of these specified goals coincide with the goals of this thesis, making CrimeStat an attractive analysis tool for use.

CrimeStat is self-described as being easy to use and its instruction manual covers its operation in just four steps: enter the data in the "data setup" screen; choose what analysis wanted along with the parameters; run the computation; close output window. An additional step is required if the resultant output is a map layer and therefore must be opened in a GIS program.[39] In order to run, one primary file consisting of X and Y coordinates is required; but another attractive element of CrimeStat is that it allows for a secondary file to be included that the primary file can be compared to in the running of certain spatial statistics. An example of this is placing the location of homicides in the primary file and poverty rates for the same area in the secondary file. Of course CrimeStat is not the only type of software available with application for geographic profiling. As previously mentioned, three other major programs exists: Rigel, Dragnet, and Predator, but "CrimeStat's virtue is collecting different methods of spatial statistical analysis into a single application that works with multiple geographic information systems," and is fairly simple to use even though the analysis it performs can be rather complex.[40]

C. THE DATA

In this thesis, the incidents of terrorism that will be analyzed came from a Stanford University dissertation by Joseph H. Felter, titled "Taking Guns to a Knife Fight: A Case for Empirical Study of Counterinsurgency" by way of the Naval Postgraduate School's Common Operational Research Environment (CORE) Lab. The

[38] Smith and Bruce, *CrimeStat III User Workbook*, 5.

[39] Ibid., 8.

[40] Ibid., 7.

data covered the time period of 2001 to 2008 in the Philippine major island of Mindanao and its surrounding smaller islands. Mindanao is the southernmost island in the Philippines and is the second largest in size. Since the Philippines achieved independence in 1946, this island in particular has experienced a large amount of terrorist activity from a number of different organizations focused on achieving either independence or autonomy from the government. The data provided includes the date of the incident, where it occurred, who it involved, what sort of incident it was, the number of casualties, and other categories of information.[41] The total number of incidents over this eight-year period was 10,990, but that number includes incidents initiated by counterinsurgency and local police forces. The removal of these incidents reduces the number of incidents to 4,601 enemy-initiated events. As there are several different terrorist groups and other organizations responsible for all of these incidents, the data will be further broken down into the four primary organizations: Communist Terrorist Movements (CTM), Lawless Elements (LE), Moro Islamic Liberation Front (MILF), and the Abu Sayyaf Group (ASG). The terrorist organization that this thesis will focus on is the Abu Sayyaf Group, as their incidents are more concentrated, rather than being dispersed throughout Mindanao, like the other organizations.

Another program utilized in this thesis was ArcMap 10.1, a component of the ArcGIS program, developed by Esri. Both CrimeStat and ArcMap were used to develop an image highlighting the locations of terrorist incidents by the ASG, perform a number of calculations, and visualize the calculations as layers of data points in ArcMap.

In CrimeStat, the data set was uploaded as an ArcGIS shapefile; the geographic area of reference the data falls in was set; the measurement parameters selected; and the type of calculation wanted chosen. The types of calculations utilized in CrimeStat included: spatial description, such as, mean center and standard distance, standard deviation ellipse, median center, center of minimum distance, nearest neighbor analysis, and hot spot analysis; and spatial modeling, to include kernel density estimate.

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[41] Joseph Felter, "Taking Guns to a Knife Fight: A Case for Empirical Study of Counterinsurgency" (PhD diss., Stanford University, 2009).

D. THE ABU SAYYAF GROUP

The Abu Sayyaf group is commonly believed to have formed sometime during the late 1980s or early 1990s following repeated perceived failures by the Moro National Liberation Front (MNLF), the first group that emerged against the Philippine state in order to achieve secession from the country and establish an Islamic state. The efforts of the MNLF and later the MILF, the first organization to break away from the MNLF and form, had resulted in the establishment of the Autonomous Region in Muslim Mindanao (ARMM). The ARMM was originally intended to be created in 1976 as a result of the Tripoli Agreement between the government and the MNLF, but a breakdown in how to implement the agreement prevented the formation of the ARMM until 1989.[42] Currently, five provinces compose the ARMM: Basilan, except for Isabela City; Sulu; Lanao del Sur; Maguindanao; and Tawi-Tawi. The establishment of the ARMM "provided a limited measure of self-rule. But the autonomous government lacked the resources to tackle the problems of the poorest region of the Philippines, and the devastation caused by years of war."[43] Throughout its existence, the ASG has operated primarily throughout the ARMM, but the majority of its attacks have occurred in the provinces of Basilan and Sulu, both areas that have served as a base of operations for the ASG.

ASG is a small organization; today it is believed to not have any more than 500 members, though no one is certain about just how many people have joined. Compared to the MNLF and the MILF, it is certainly the most violent; of the three, it is the only group that has been designated by the United States and has been included on the US State Department's list of Foreign Terrorist Organizations (FTO). Like the other two separatist groups, the ASG is committed to the creation of an independent Muslim state; however, the ASG is anti-Christian, and many of its attacks target this population. The founder of the ASG, Ustadz Abdurajak Janjalani, believed that the only way to achieve this just Islamic state is through the use of jihad and encouraged Muslims to go all the way to the

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[42] Sylvia Concepcion et al., "Breaking the Links between Economics and Conflict in Mindanao," presented at the Waging Peace conference in Manila, December 2003, 9, http://ki-volunteer.org/index.php?option=com_docman&task=doc_download&gid=2&Itemid=79.

[43] Ibid., 11.

highest level, martyrdom, to help achieve it.[44] Since its creation, the ASG has changed its method of attack, switching back and forth between bombings and kidnap for ransoms (KFR), depending on the current situation.

From 2001 to 2008, of the 4,601 enemy-initiated incidents in Mindanao, 299 were perpetrated by the Abu Sayyaf group. For the 299 incidents analyzed the breakdown of the type of incidents and how many of each type are depicted in Table 3.

Incident Type	Total Number Initiated	Percentage of Total Incidents
Abduction	27	9.030
Ambush	44	14.716
Armed Clash	2	0.669
Arson	3	1.003
Bombing	13	4.348
Disarming	1	0.334
Encounter	32	10.702
Harassment	47	15.719
Hold-Up	1	0.334
Hostage Taking	2	0.669
Jail Break	2	0.669
Kidnapping	11	3.679
Killing	3	1.003
Land Mining	8	2.676
Liquidation	13	4.348
Mutilation	1	0.334
Raid	10	3.344
Sabotage	1	0.334
Sea Jacking	1	0.334
Shooting	26	8.696
Stabbing	2	0.669
Strafing	3	1.003
Surrender (Capture)	46	15.385
Total	299	100

Table 3. ASG-Initiated incidents in Mindanao: 2001–2008

[44] Rommel C. Banlaoi, "The Abu Sayyaf Group: From Mere Banditry to Genuine Terrorism," *Southeast Asian Affairs 2006*, 251.

With so many different types of incidents being utilized by the ASG, it raises whether this organization attacked with what was convenient. With this in mind, the different incidents have also been analyzed in groups similar in type. These groupings and the new percentages are shown in Table 4.

Incident Type	Total Number Initiated	Percentage of Total Incidents
Abduction/Hostage Taking/ Kidnapping/Sea Jacking	41	13.71237458
Ambush/Armed Clash/Arson/ Bombing/ Killing/Liquidation/ Mutilation/Shooting/ Stabbing/Strafing	110	36.78929766
Encounter/Harassment	79	26.42140468
Hold-Up/Sabotage	2	0.668896321
Disarming/Surrender (Capture)	47	15.71906355
Jail Break	2	0.668896321
Land Mining	8	2.675585284
Raid	10	3.344481605

Table 4. ASG-Initiated incidents in Mindanao: 2001–2008 (Grouped)

However, not all 299 incidents were analyzed in this thesis; the 41 incidents that occurred on the island of Mindanao lie outside the geographical scope of this study. This thesis focuses on the 258 incidents that occurred on the islands of Basilan (78) and Sulu (180). These incidents will be analyzed both on a year-to-year basis as well as part of a larger group (2001–2007) in terms of both incident number and type; these results will then be compared to the actual data from 2008 in order to determine whether or not different methods of analysis aid in predicting where incidents will occur and what type of incidents will occur. The various strategies for analyzing the ASG-initiated incident data will focus on *hot spot analysis*, percent differences based on average outcomes compared to the actual outcomes, and normalization by both total number of incidents and population of each municipality.

IV. ANALYZING THE ABU SAYYAF GROUP'S ACTIVITIES

A. RESULTS AND ANALYSIS

In order to determine whether geographic profiling techniques were able to effectively indicate the location of future attacks, the incidents that occurred in 2008 were removed from calculations performed both by CrimeStat and ArcGIS software programs. The data the analysis was performed on covered the years 2001 to 2007; the results of this analysis were compared to incidents that occurred in 2008 in the same geographic areas (Basilan and Sulu). Apart from comparing the 2008 events to those that happened from 2001–2007, other comparisons will be made: year to year in both number of total incidents and type of incident; and municipality comparisons in both number and type of incidents. In order to measure the success of particular geographic profiling techniques, primarily this thesis will focus on the associated percentages generated from each portion of analysis. These percentages will either be based on either the accuracy of a particular method in forecasting where an incident will occur (what type of incident it will be) or the percent difference between the calculated average from the 2001–2007 period and the actual outcome from 2008.

The largest portion of this analysis was conducted utilizing different types of *hot spot analysis*, a tool used in identifying where crime incidents cluster. Hot spots are defined as "concentrations of incidents within a limited geographic area that appear over time."[45] Several different types of hot spot analysis methods exist, but for the purpose of this thesis point location analysis was utilized due to the sheer size of the area being studied. This type of clustering technique involves counting how many incidents occurred at each location; the locations with the highest number of incidents are identified as hot spots.[46]

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[45] Ned Levine & Associates, *CrimeStat IV: A Spatial Statistics Program for the Analysis of Crime Incident Locations Manual* (Washington, DC: National Institute of Justice, 2013), 7.1.

[46] Ibid., 7.2.

In CrimeStat, this type of hot spot analysis is called the Mode routine. With this analysis, the locations that saw the highest number of incidents will be indicated; the top locations from the years 2001–2007 will be compared to the incidents that occurred in 2008 to determine whether or not the incidents follow a pattern by continuing to occur in locations that were previously the site of an incident. Running this analysis means that the incidents will be counted, the frequency of the events calculated, and the resulting ranking of most to least frequent locations are generated in the output. Along with a ranking of locations, CrimeStat also creates a 'dbf' file that can be imported into ArcGIS and depicted for visual interpretation.

B. MICROSOFT EXCEL—ANALYZING HISTORICAL DATA FOR INCIDENT NUMBER AND TYPE

For the eight years of incident data, the information was broken out into the number of incidents that occurred in total for both Sulu and Basilan and then further broken down by how many incidents occurred in each municipality each year from 2001 to 2008. The resulting break down is depicted in Tables 5 and 6.

	Number of Incidents in Sulu Municipalities / Percentage of Year's Total Incidents															
Year	2001		2002		2003		2004		2005		2006		2007		2008	
Total Incidents Occurred	44		10		19		10		27		31		17		22	
Municipality																
Indanan	**3**	**6.82**	**4**	**40.00**	**2**	**10.53**	**0**	**0.00**	**11**	**40.74**	**6**	**19.35**	**4**	**23.53**	**1**	**4.55**
Jolo	5	11.36	0	0.00	3	15.79	1	10.00	0	0.00	14	45.16	0	0.00	0	0.00
Kalingalan Caluang	2	4.55	1	10.00	0	0.00	0	0.00	0	0.00	0	0.00	1	5.88	0	0.00
Luuk	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	4.55
Maimbung	**5**	**11.36**	**0**	**0.00**	**2**	**10.53**	**4**	**40.00**	**4**	**14.81**	**4**	**12.90**	**1**	**5.88**	**4**	**18.18**
Old Panamao	2	4.55	0	0.00	2	10.53	0	0.00	3	11.11	0	0.00	0	0.00	0	0.00
Panglima Estino	1	2.27	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	5.88	1	4.55
Parang	0	0.00	1	10.00	0	0.00	1	10.00	4	14.81	0	0.00	4	23.53	1	4.55
Patikul	**7**	**15.91**	**4**	**40.00**	**7**	**36.84**	**4**	**40.00**	**3**	**11.11**	**5**	**16.13**	**2**	**11.76**	**13**	**59.09**
Talipao	19	43.18	0	0.00	3	15.79	0	0.00	2	7.41	2	6.45	4	23.53	1	4.55

Table 5. Sulu Incidents Broken Down by Year and Municipality

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As indicated (bolded) in Table 5, there are three municipalities that either saw at least one incident either every year (Patikul), or in seven out of the eight years (88%) (Indanan and Maimbung). One other municipality, Talipao, sees an incident in six out of the eight years (75%). Together, these four municipalities outweighed the other six municipalities in Sulu; all of the municipalities that experienced attacks in five of the seven preceding years to 2008, would go on to experience an incident in 2008. Out of the eight years covered, only in 2006, did a municipality not in the previously mentioned four, Jolo, the island's capital, have the highest number/percentage of incidents. Half of the time, Patikul was either the municipality that saw the most activity or was tied for the most activity, one of those years being 2008. In attempting to make a prediction about which municipality would be likely to see an incident occur in 2008, the following observation can be made: if a municipality experiences an incident in four out of the seven years preceding 2008, the municipality has an 83% (5/6) chance of having an incident occur during 2008. It also can be observed that if a municipality experiences an incident in three or less of the years preceding 2008, that municipality has a 50% (2/4) chance of experiencing an incident; though it also appears that if a majority of events take place in the earlier years (2001–2004), the municipality is less likely to be the location of a 2008 incident.

	Number of Incidents in Basilan Municipalities / Percentage of Year's Total Incidents															
Year	2001		2002		2003		2004		2005		2006		2007		2008	
Total Incidents Occurred	27		9		8		6		4		0		9		15	
Municipality																
Isabela	**2**	**7.41**	**3**	**33.33**	**2**	**25.00**	**2**	**33.33**	**0**	**0.00**	**0**	**0.00**	**1**	**11.11**	**0**	**0.00**
Lamitan	10	37.04	0	0.00	0	0.00	1	16.67	0	0.00	0	0.00	1	11.11	1	6.67
Lantawan	4	14.81	2	22.22	3	37.50	0	0.00	0	0.00	0	0.00	1	11.11	0	0.00
Maluso	1	3.70	0	0.00	0	0.00	1	16.67	0	0.00	0	0.00	0	0.00	0	0.00
Sumisip	**5**	**18.52**	**4**	**44.44**	**1**	**12.50**	**2**	**33.33**	**3**	**75.00**	**0**	**0.00**	**0**	**0.00**	**1**	**6.67**
Tipo-Tipo	2	7.41	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	6	66.67	4	26.67
Tuburan	3	11.11	0	0.00	2	25.00	0	0.00	1	25.00	0	0.00	0	0.00	9	60.00

Table 6. Basilan Incidents Broken Down by Year and Municipality

As highlighted in Table 6, unlike the municipalities of Sulu, those of Basilan were not the sites of an incident every year or almost every year; instead, only two municipalities (bolded), Sumisip and Isabela (the capital), experienced an incident six (75%) or five (63%) years out of the eight, though it should be noted that although Isabela experienced an incident in five of the years leading up to 2008, it did not experience an incident in 2008. Unlike Sulu, where a municipality experiencing incidents in four or more of the seven years leading up to 2008 greatly increased a region's chance of having an incident in 2008, Basilan's municipalities tend to experience a 2008 incident if they experienced incidents in fewer years. For those municipalities that experienced incidents in three or less years preceding 2008, there is a 75% (3/4) chance of an incident occurring in 2008; whereas for the municipalities experiencing incidents in four or more of the seven previous years, there is only a 33% (1/3) chance of the municipality serving as the location of a 2008 incident. For these municipalities (Isabela and Lantawan), four out of three or three out of their four years in which an incident occurred fell during the 2001–2004 time period. Of note, during the year 2006, Basilan experienced zero ASG-initiated incidents.

To illustrate how Sulu and Basilan compared to one another overall, the total number of incidents of each were compared. As the total number of incidents that occurred in Sulu over the eight years outnumbered the incidents that occurred in Basilan, the percentage difference between the two islands was also calculated. The results are shown in Table 7.

Year	2001	2002	2003	2004	2005	2006	2007	2008
Total Incidents in Sulu	44	10	19	10	27	31	17	22
Total Incidents in Basilan	27	9	8	6	4	0	9	15
Total Incidents	71	19	27	16	31	31	26	37
Percentage of Events in Sulu	61.97	52.63	70.37	62.50	87.10	100.00	65.38	59.46
Percentage of Events in Basilan	38.03	47.37	29.63	37.50	12.90	0.00	34.62	40.54
Percentage Sulu Events Outnumber Basilan Events	23.94	5.26	40.74	25.00	74.19	100.00	30.77	18.92

Table 7. Sulu Incident Totals versus Basilan Incident Totals

When the total number of incidents occurring on each island is compared, as expected the total number of incidents on Basilan was less than half of the total incidents that occurred on Sulu. In all seven years leading up to 2008 Sulu experiences more incidents than Basilan, meaning the higher occurrence of incidents in 2008 in Sulu once again make sense. Overall, while Sulu incidents might outnumber the Basilan incidents two-to-one, this ratio is not maintained throughout the years. Out of the eight years, only in two (25%) of them does Sulu have more than twice the number of incidents as Sulu; however, in these two years, the difference is quite large (74.19% and 100%).

To further identify any patterns that emerged, the incidents were broken down once again by year, but this time, further subdivided by the total number of each type of incidents that occurred each year on the island. The result of this division is found in Table 8.

	Number and Incident Type on Each Island															
Year	2001		2002		2003		2004		2005		2006		2007		2008	
Island	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan
Incident Type																
Abduction	0	0	0	0	0	0	0	1	1	0	1	0	2	0	10	10
Ambush	4	1	3	1	1	1	2	1	9	2	7	0	6	1	1	1
Armed Clash	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Arson	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1
Bombing	0	0	0	0	0	1	0	0	0	0	5	0	0	0	0	1
Disarming	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Encounter	5	7	4	3	9	2	1	0	0	0	0	0	0	0	0	0
Harassment	1	4	1	0	1	0	2	0	9	0	4	0	3	6	7	1
Hold-Up	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Hostage Taking	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jailbreak	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Kidnapping	2	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0
Killing	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
Land Mining	0	0	0	0	0	1	0	0	2	0	5	0	0	0	0	0
Liquidation	1	1	0	0	0	0	1	0	0	0	7	0	0	0	1	0
Mutilation	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Raid	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sabotage	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Sea Jacking	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Shooting	4	1	0	0	5	2	0	2	1	0	0	0	3	1	2	1
Stabbing	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Strafing	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Surrender (Capture)	21	9	1	4	2	0	2	0	0	0	0	0	0	0	0	0

Table 8. Incidents by Type per Year

Several observations can be made from viewing Table 8. First, the only type of incident that occurs every year in both municipalities, with the exception of Basilan on 2006 where zero incidents occurred), was ambush. Sulu also experienced harassment every year from 2001 to 2008, though in Basilan, this type of incident occurred in only three of the eight years. During the 2001–2008, in four out of the eight years (50%), Sulu and Basilan share the most common type of incident. In 2001 surrender was most common (21 and nine); in 2003 encounter is the incident that occurred the most (nine and two); in 2002, it was encounter (four) for Sulu and surrender (four) for Basilan; in 2005, the most common incident was ambush (nine and two), though Sulu also experienced nine incidents of harassment; and in 2008, both Sulu and Basilan experienced ten abductions. In 2006, since Basilan experienced zero incidents that year, the highest numbers of incidents in Sulu were ambush and liquidation (seven). As for the other three years, while the type of incident occurred most frequently differed, the highest number of incidents was the same for both Sulu and Basilan. In 2002, Sulu experienced four encounters and Basilan four surrenders; in 2004, Sulu experienced two ambushes, harassments, and surrenders while Basilan experienced two shootings; lastly, in 2007, Sulu saw six ambushes and Basilan six incidents of harassment.

Beyond looking at which events occur most frequently and how many of each type of incident occurs, further observations can be made about when the different incident types occur. For both encounters and surrenders these types of incidents stop happening after 2004; these could go hand in hand with one another as surrender is interpreted as an ASG-initiated encounter that results in the ASG surrendering. Like encounters and surrenders, kidnapping stops occurring after 2004, but a similar incident type, abduction, takes its place from 2004 and onward to 2008, meaning that between the two, an incident occurs every year on Sulu and occasionally on Basilan. Lastly, there is one event that occurs in five out of eight years (63%) in both Sulu and Basilan, though in different years: shooting; however, the instances of shooting are sporadic throughout the eight years (2001, 2003, 2005, 2007–2008 for Sulu and 2001, 2003–2004, 2007–2008 for Basilan).

Finally, the types of incidents that occurred in 2008 were: abduction, ambush, arson, bombing (though not on Sulu), harassment, liquidation (though not on Basilan), and shooting. For Sulu, if the island experienced a particular kind of incident in three or more out of the seven years prior to 2008, there is a 63% (5/8) chance that the island would also experience the same type of incident in 2008. For the three types of incidents that occurred in three or more years but did not occur in 2008 (encounter, kidnap, and surrender/capture), all occasions of these incidents occurred during the 2001–2004 time frame. Out of the six types of incidents that occurred on Sulu during 2008, 83% (5/6) occurred in three or more previous years. As for Basilan, if a type of incident was experienced in three or more years prior to 2008; the chances are similar to those on Sulu at 66% (2/3). Like Sulu, the one incident type that occurred in more than three years yet did not occur in 2008(encounter), never happened after 2003. The same is true if you lower the number of year's threshold to two, though the likelihood of a similar type of incident occurring reduces to 50% (3/6). Out of the six types of incidents that occurred on Basilan in 2008, only 33% (2/6) occurred in three or more years; the same can be said for the incident types happening in only one out of seven years.

To further illustrate the breakdown into individual incident type, the corresponding percentages of each type of event occurring on Sulu and Basilan by year are shown in Table 9.

	Percentage of Incident Type on Each Island															
Year	2001		2002		2003		2004		2005		2006		2007		2008	
Island	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan
Incident Type																
Abduction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	3.70	0.00	3.23	0.00	11.76	0.00	45.45	66.67
Ambush	9.09	3.70	30.00	11.11	5.26	12.50	20.00	16.67	33.33	50.00	22.58	0.00	35.29	11.11	4.55	6.67
Armed Clash	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Arson	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.70	0.00	0.00	0.00	0.00	0.00	4.55	6.67
Bombing	0.00	0.00	0.00	0.00	0.00	12.50	0.00	0.00	0.00	0.00	16.13	0.00	0.00	0.00	0.00	6.67
Disarming	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Encounter	11.36	25.93	40.00	33.33	47.37	25.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Harassment	2.27	14.81	10.00	0.00	5.26	0.00	20.00	0.00	33.33	0.00	12.90	0.00	17.65	66.67	31.82	6.67
Hold-Up	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00
Hostage Taking	0.00	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jailbreak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00	0.00	11.11	0.00	0.00
Kidnapping	4.55	0.00	10.00	11.11	5.26	12.50	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Killing	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00
Land Mining	0.00	0.00	0.00	0.00	0.00	12.50	0.00	0.00	7.41	0.00	16.13	0.00	0.00	0.00	0.00	0.00
Liquidation	2.27	3.70	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	22.58	0.00	0.00	0.00	4.55	0.00
Mutilation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.88	0.00	0.00	0.00
Raid	13.64	11.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sabotage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sea Jacking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shooting	9.09	3.70	0.00	0.00	26.32	25.00	0.00	33.33	3.70	0.00	0.00	0.00	17.65	11.11	9.09	6.67
Stabbing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.76	0.00	0.00	0.00
Strafing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.45	0.00	0.00	0.00	0.00	0.00
Surrender (Capture)	47.73	33.33	10.00	44.44	10.53	0.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 9. Percentages of Incidents by Type per Year

As previously mentioned, since there was such diversity in incident type, perhaps the ASG simply utilized the most convenient method available at the time. With this in mind, the different incident types that were similar in nature were combined and analyzed in the same manner as each type separately. The number of each grouping of incidents and their percentages are displayed in Tables 10 and 11.

	Number of Incident Type on Each Island															
Year	2001		2002		2003		2004		2005		2006		2007		2008	
Island	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan
Incident Type																
Abduction/Hostage Taking/ Kidnapping/Sea Jacking	2	1	1	1	1	1	1	2	1	0	1	0	2	0	10	10
Ambush/Armed Clash/ Arson/Bombing/Killing/ Liquidation/ Mutilation/ Shooting/Stabbing/Strafing	9	3	3	1	6	4	4	3	13	3	21	0	12	2	5	4
Encounter/Harassment	6	11	5	3	10	2	3	0	9	0	4	0	3	6	7	1
Hold-Up/Sabotage	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Disarming/Surrender (Capture)	21	9	1	4	2	0	2	0	1	0	0	0	0	0	0	0
Jailbreak	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Land Mining	0	0	0	0	0	1	0	0	2	0	5	0	0	0	0	0
Raid	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 10. Incidents by Type per Year (Groupings)

	Percentage of Incident Type on Each Island															
Year	2001		2002		2003		2004		2005		2006		2007		2008	
Island	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan	Sulu	Basilan
Incident Type																
Abduction/Hostage Taking/ Kidnapping/Sea Jacking	4.55	3.70	10.00	11.11	5.26	12.50	10.00	33.33	3.70	0.00	3.23	0.00	11.76	0.00	45.45	66.67
Ambush/Armed Clash/ Arson/Bombing/ Killing/Liquidation/ Mutilation/Shooting/ Stabbing/Strafing	20.45	11.11	30.00	11.11	31.58	50.00	40.00	50.00	48.15	75.00	67.74	0.00	70.59	22.22	22.73	26.67
Encounter/Harassment	13.64	40.74	50.00	33.33	52.63	25.00	30.00	0.00	33.33	0.00	12.90	0.00	17.65	66.67	31.82	6.67
Hold-Up/Sabotage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.70	25.00	0.00	0.00	0.00	0.00	0.00	0.00
Disarming/Surrender (Capture)	47.73	33.33	10.00	44.44	10.53	0.00	20.00	0.00	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jailbreak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00	0.00	11.11	0.00	0.00
Land Mining	0.00	0.00	0.00	0.00	0.00	12.50	0.00	0.00	7.41	0.00	16.13	0.00	0.00	0.00	0.00	0.00
Raid	13.64	11.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 11. Percentages of Incidents by Year Per Type (Groupings)

Grouping the incidents together by similar type highlights that the grouping of ambush, armed clash, etc. for both Sulu and Basilan is the most prevalent grouping of incidents in four out of eight years (50%) and three out of seven years (43%), respectively. These tables highlight that certain incident types simply are not as numerous compared to others; however, in these cases, the incidents that have low percentages are also those that either stand alone or are partnered with only one other incident. As discovered in tables 8 and 9, the surrender grouping, after a few years of prevalence, quickly diminishes; the opposite can be said for the ambush, armed clash, etc. grouping. From 2001 to 2007, this group's percentage steadily climbs each year; although in 2008 its percentage is not as high as in previous years, it does make sense as these incident types occurred in all preceding years. The other groupings that occur in 2008 also follow this pattern as each of these groupings experienced a number of incidents in a majority of years. From looking at these tables, security forces would be able to see which incident types occur most frequently and therefore, be able to predict which practices and operations to focus on.

C. HOT SPOT ANALYSIS

Of the 299 incidents that were initiated by the ASG, 180 took place on the island of Sulu, 158 during the years 2001 to 2007 and 22 occurring in 2008. CrimeStat's Hot Spot Mode routine was run on the 2001 to 2007 incidents and generated locations where incidents occurred. The top locations are identified in Table 12.

Rank	Municipality (Location in Decimal Degrees)	Number of Incidents
1	Jolo (6.044251, 121.01007)	12
2	Indanan (5.99428, 120.960286)	9
	Patikul (6.043645, 121.089826)	9
3	Talipao (5.962007, 121.09313)	6
	Patikul (6.047924, 121.142882)	6
4	Indanan (5.949059, 120.952817)	5
5	Talipao (5.979516, 121.075123)	4
	Parang (5.970464, 120.910145)	4
	Jolo (6.053346, 121.006827)	4
	Maimbung (5.950357, 121.009857)	4

Table 12. Top Ten Most Frequent Locations of ASG Incidents

The resulting output from CrimeStat was imported into ArcGIS and generated the image shown in Figure 1.

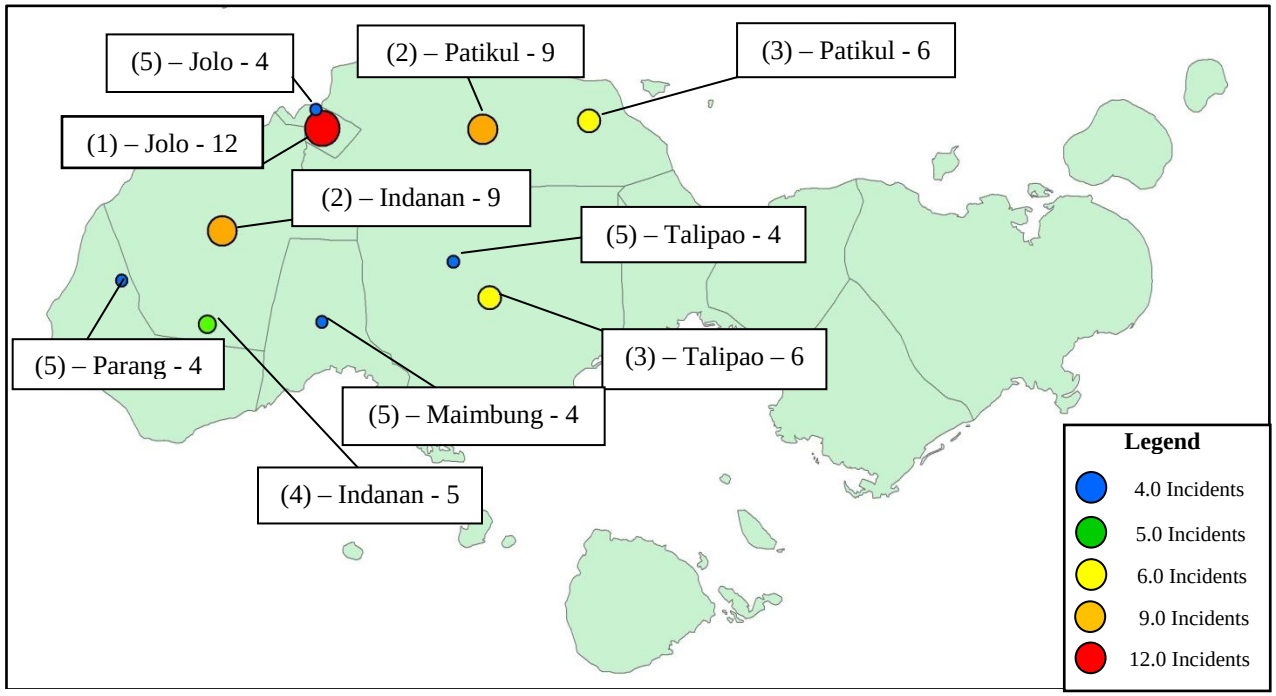

Figure 1. Top Ten Locations for Incidents on Sulu, According to CrimeStat

Of the top 10 locations for 2001–2007 incidents, only one location saw at least one incident happen in 2008; the location in Patikul (121.089826, 6.043645 decimal degrees) that was the scene of nine incidents from 2001 to 2007, saw two incidents occur in 2008. The overlay of 2008 incidents on the top ten hot spots for Sulu from 2001 to 2007 is shown in Figure 2.

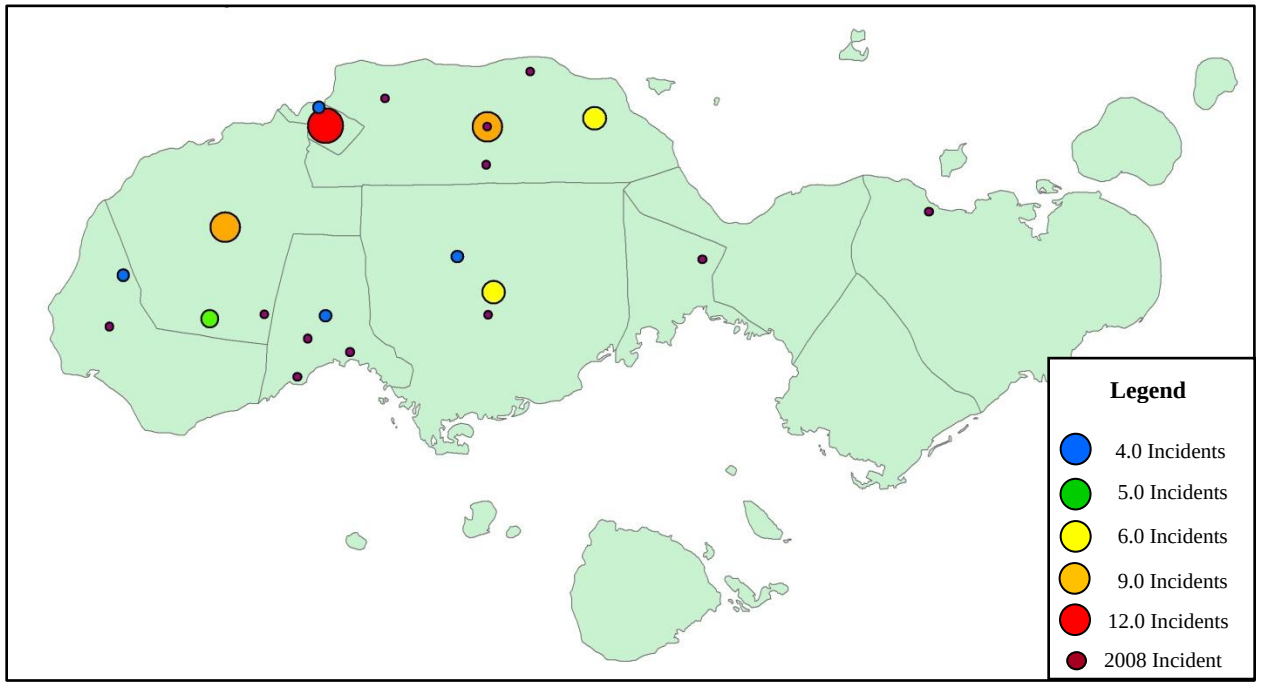

Figure 2. Sulu 2008 Incidents Compared to 2001–2007 CrimeStat Hot Spots

As shown in Figure 2, two outlying incidents occurred in 2008: one, in Luuk involved harassment by the ASG; and the other, abduction, occurred in Panglima Estino. However, these two incidents appear to be just that, outliers. The harassment that happens in Luuk is the only incident the municipality saw over the eight-year period and out of the incidents in the neighboring municipalities (Old Panamao and Kalingalan Caluang), Old Panamao was the only municipality where harassments occurred, but these incidents happened three years previously. The abduction that took place in Panglima Estino was only the third incident seen in the municipality (2001 and 2007 were the years of the other incidents) and the only abduction. However, unlike the harassment in Luuk, this abduction was the only abduction that occurred within the neighboring region. Although the incidents were rather isolated from others, in 2008, the incidents that did occur tended to be either an abduction or harassment (ten and seven out of twenty-two, respectively).

Of the 119 remaining ASG-initiated incidents, 78 took place on the island of Basilan, 63 from 2001 to 2007 and 15 during 2008. CrimeStat's Mode routine was run on this set of data and the top locations are identified in Table 13.

Rank	Municipality (Location in Decimal Degrees)	Number of Incidents Occurring in Same Location
1	Sumisip (6.467481, 121.993832)	5
2	Tuburan (6.630038, 122.239598)	4
3	Lamitan (6.648478, 122.104057)	3
	Lamitan (6.642691, 122.155193)	3
	Tipo-Tipo (6.460622, 122.153796)	3
	Sumisip (6.451078, 121.978106)	3
	Lantawan (6.646073, 121.891488)	3

Table 13. Top Seven Most Frequent Locations of ASG Incidents

The results from Basilan were input into ArcGIS and are depicted in Figure 3.

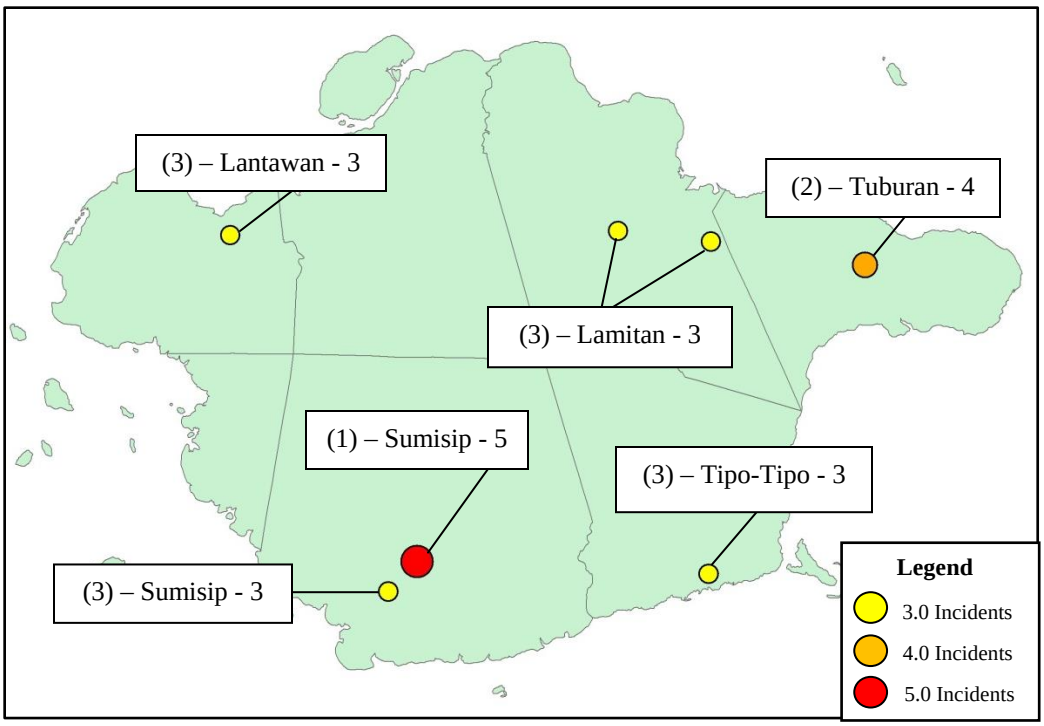

Figure 3. Top Seven Locations for Incidents on Basilan, According to CrimeStat

Just like the 2008 incidents that occurred in Sulu, one location, the location in the Basilan municipality of Lamitan (122.104057, 6.648478 Decimal Degrees) that was the site of 3 incidents during the 2001 to 2007 years, was the scene of an incident during 2008. The overlay of 2008 incidents on the top ten hot spots for Basilan from 2001 to 2007 is shown in Figure 4.

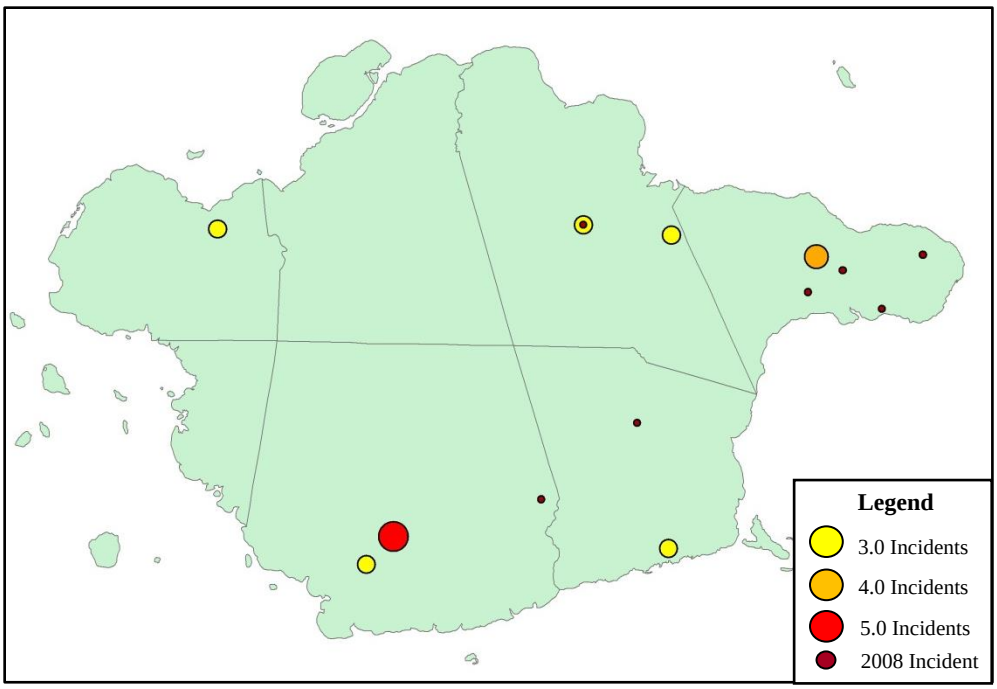

Figure 4. Basilan 2008 Incidents Compared to 2001–2007 CrimeStat Hot Spots

For both of these islands, running CrimeStat's Hot Spot Analysis routine on 2001–2007 incidents and overlaying the 2008 incidents on the resulting output reveals that only one of the identified top hot spots is the location of an incident in 2008. For Sulu this means that 8% (1/12) of 2008 locations are the same location as a top hot spot and for Basilan 14% (1/7) locations are the same location for a top hot spot. However, for Sulu, if all CrimeStat-generated Hot Spots are included, this increases the likelihood a 2008 incident location will be the same as a 2001–2007 hot spot (25% or 4/12).

In both Sulu and Basilan, most of the incidents occurred nearby other incidents during 2008, but some of the 2008 incidents appeared to be more isolated than others. Whereas in Sulu where the two outlying incidents really were quite isolated, the "isolated" incidents on Basilan (Sumisip and Tipo-Tipo) were located near other incident sites from between 2001 to 2007. The isolated incidents on Basilan differed slightly from those that occurred on Sulu. Both municipalities saw more total incidents throughout the 2001–2007 period, fourteen and eight, respectively. The 2008 incident in Sumisip was an ambush; looking back at the previous seven years, the municipality saw three other

ambushes in 2001, 2004, and 2005; only encounters outnumber the number of ambushes. The 2008 incident in Tipo-Tipo was a harassment, but not the first the municipality had seen; six harassments occurred the year before throughout the municipality. Compared to the incidents that took place on Sulu, the type of incident that occurred in both Sumisip and Tipo-Tipo was more likely to occur.

ArcGIS is also capable of conducting Hot Spot Analysis. However, unlike CrimeStat, which calculates a hot spot simply by counting how many incidents occur in the same location, ArcGIS's Hot Spot Analysis utilizes the Getis-Ord Gi* statistic:

> This tool works by looking at each feature within the context of neighboring features. A feature with a high value is interesting but may not be a statistically significant hot spot. To be a statistically significant hot spot, a feature will have a high value and be surrounded by other features with high values as well. The local sum for a feature and its neighbors is compared proportionally to the sum of all features; when the local sum is very different from the expected local sum, and when that difference is too large to be the result of random change, a statistically significant z-score results.[47]

The resulting z-scores and their associated p-values tell the user whether or not a spot has a high or low cluster spatially; the higher the z-score (positive) or the lower the z-score (negative), the more intense the clustering of either high or low values.

Both the incidents that occurred on Sulu and Basilan during the years 2001 to 2007 were run through the ArcGIS Hot Spot Analysis tool. The resulting outputs are displayed in Figures 5 and 6.

[47] Esri, "How Hot Spot Analysis (Getis-Ord Gi*) works," in *ArcGIS 10.2 Help* (1995–2013).

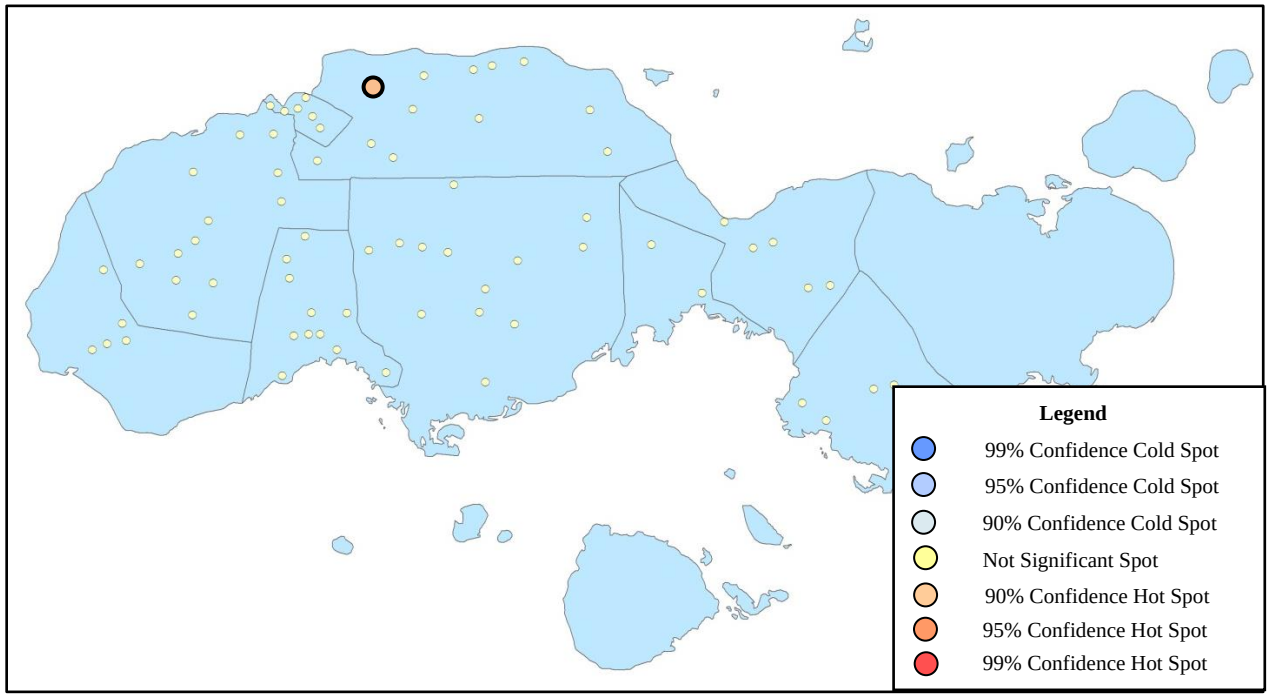

Figure 5. ArcGIS Hot Spot Analysis of 2001–2007 Abu Sayyaf Group Sulu Incidents

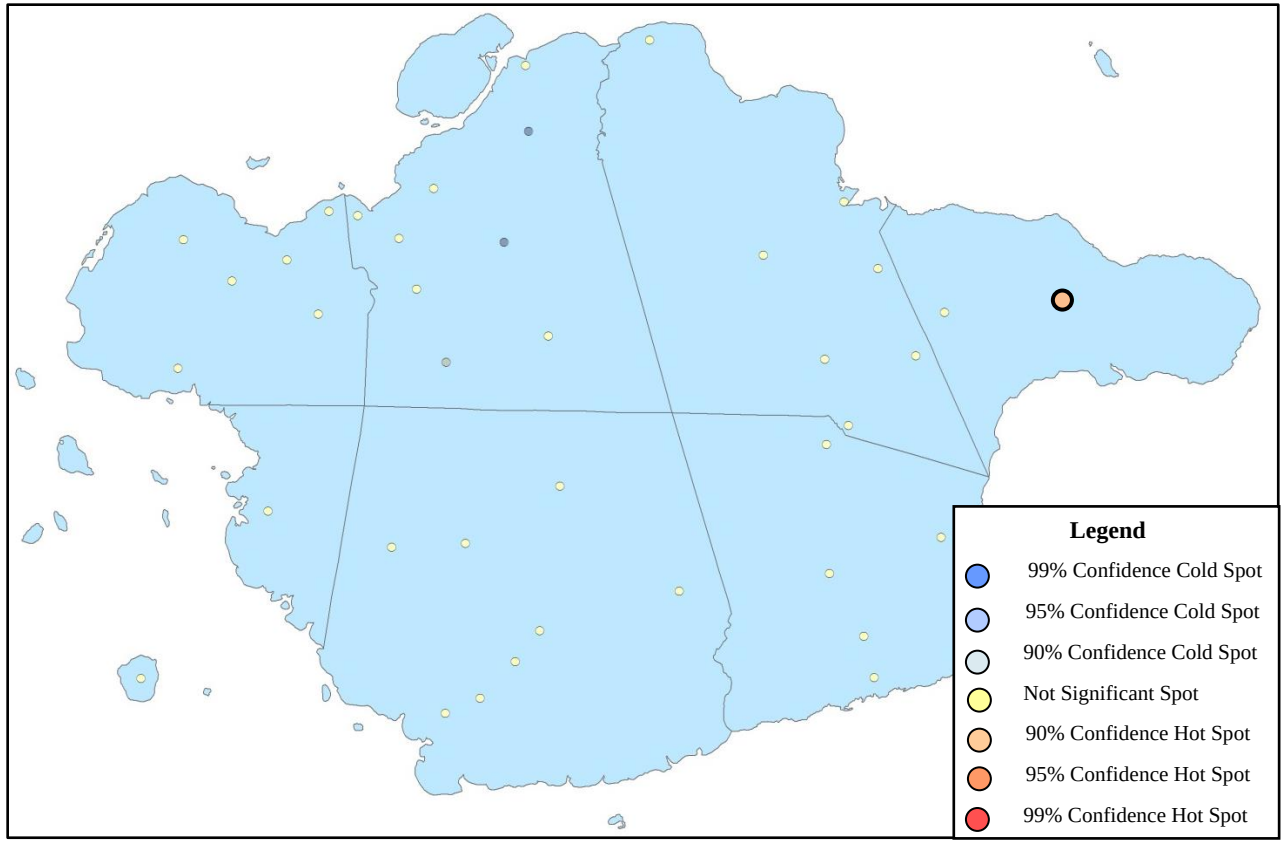

Figure 6. ArcGIS Hot Spot Analysis of 2001–2007 Abu Sayyaf Group Basilan Incidents

Just as with the CrimeStat Hot Spot Analysis Outputs, the results of the ArcGIS Hot Spot Analysis had the 2008 incident data overlayed to determine whether or not any hot or cold spot based on the data from 2001 to 2007 was the site of an incident in 2008. The resulting images are depicted in Figures 7 and 8.

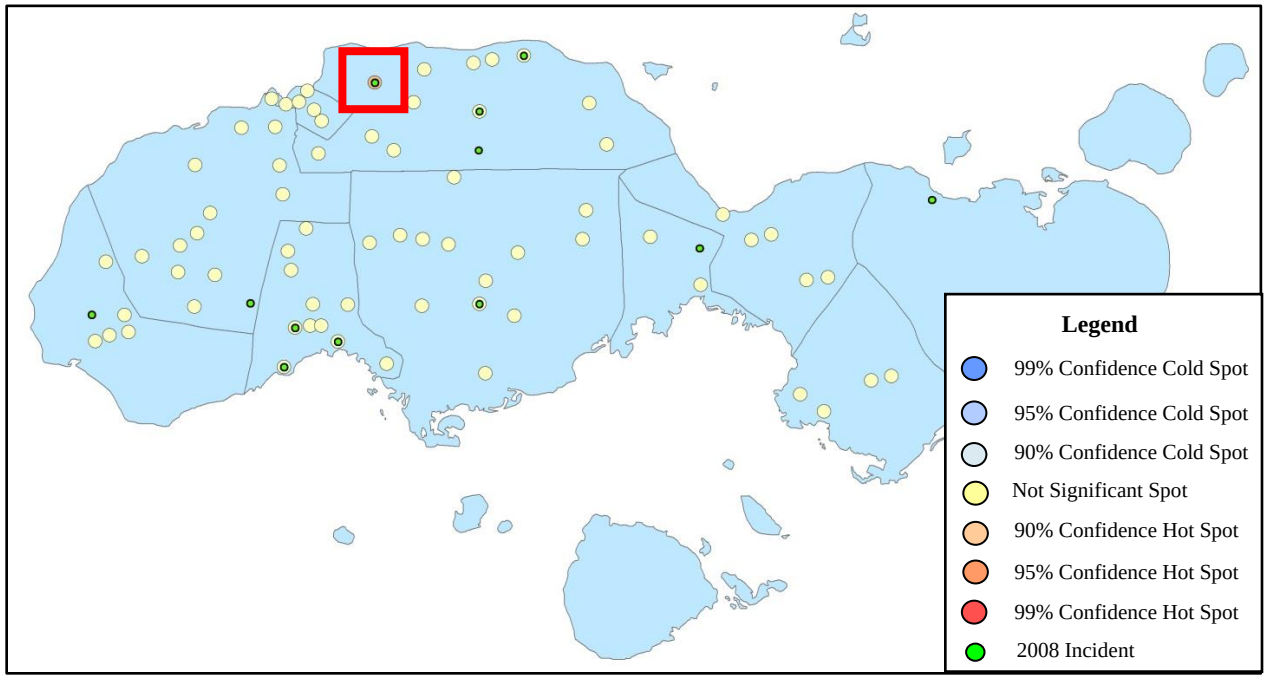

Figure 7. 2008 Incidents Overlaid on ArcGIS Hot Spot Analysis of 2001–2007 Sulu Incidents

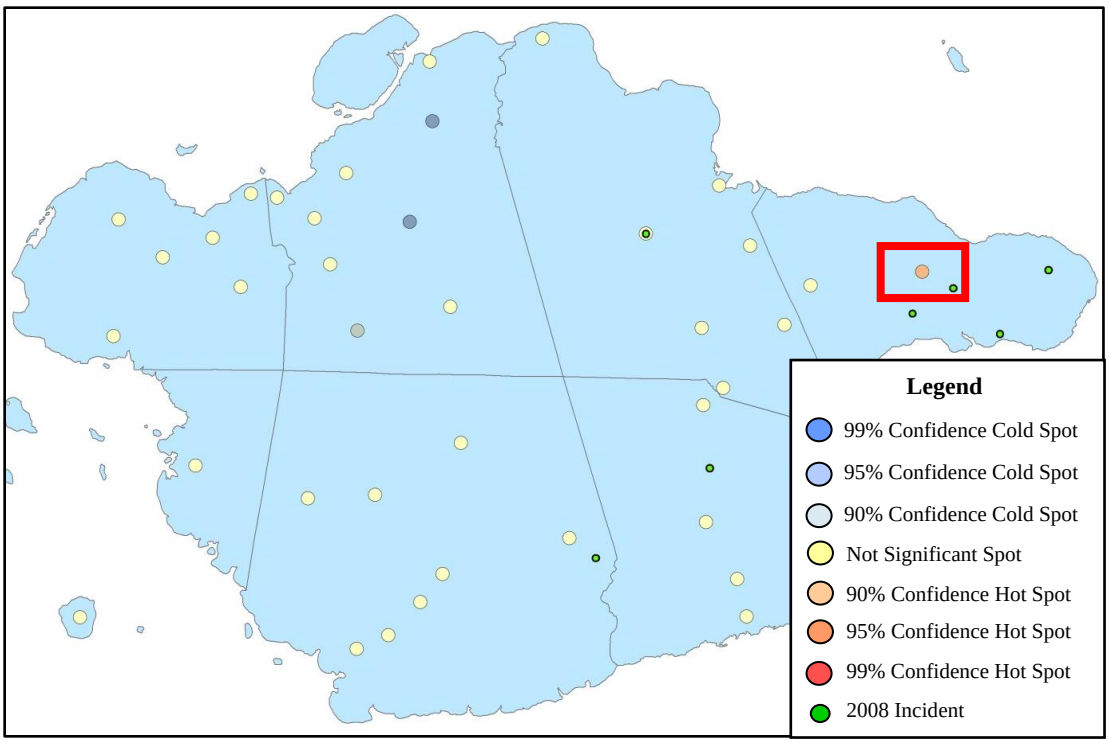

Figure 8. 2008 Incidents Overlaid on ArcGIS Hot Spot Analysis of 2001–2007 Basilan Incidents

This time only the island of Sulu has its one identified hot spot (90% Confidence) serve as a repeat location for 2008 incidents. Like the hot spot identified in CrimeStat, the ArcGIS-generated hot spot is located in the municipality of Patikul (121.039413, 6.057583 Decimal Degrees), but it is not the same hot spot, though this hot spot also is the location of two 2008 incidents. Unlike Sulu, Basilan's one identified hot spot, located in Tuburan (Coordinates: 122.239598, 6.630038 Decimal Degrees), is not the location of a 2008 incident. The only overlap occurs at a location in Lamitan (Coordinates: 122.104057, 6.648478 Decimal Degrees) that was ruled as not statistically a cold or hot spot by ArcGIS; though it is the same previously identified hot spot in CrimeStat.

Out of the 12 locations that experienced an incident on Sulu in 2008, seven (58%) of them occur in locations that were not previously the site of an attack during the 2001 to 2007 period (5/12 or 42% occurred at a previous site). Like Sulu, out of seven sites that experienced an incident in 2008 on Basilan, only one of the sites (14%) was a location that saw an incident during 2001 to 2007. Compared to having absolutely no

knowledge, these percentages, although low (especially Basilan's), give rise to the examination of more information to help predict terrorist actions.

Compared to ArcGIS, the CrimeStat software's mode routine identified more hot spots where it would be likely to see future activity. For CrimeStat both Sulu and Basilan saw one hot spot serve as the location of a 2008 incident resulting in a low percentage of successful prediction for the two cases (8% and 14%, respectively). ArcGIS's hot spot analysis identifies only one statistically significant hot spot for both Sulu and Basilan, classifying the majority of sites from 2001–2007 as either not statistically significant or as a cold spot with varying degrees of confidence. As ArcGIS only identifies one hot spot for each island, and only the hot spot in the municipality of Patikul on Sulu has an incident occur there in 2008, the islands have the resulting percentages from whether or not an identified hot spot was the site of a future incident: 100% for Sulu and 0% for Basilan; together the two average out to a 50% ability for ArcGIS hot spot analysis to accurately identify possible future locations for incidents. Again, ignoring the identified hot spots and simply looking at what percentage of locations that served as an incident site from 2001–2007 again was the site of an incident in 2008 generates the following numbers: 42% for Sulu (five locations out of twelve 2008 locations saw an incident in the preceding years) and 14% for Basilan (one location out of the seven 2008 locations saw an incident in earlier years). A summary of this information is provided in Table 14.

CrimeStat Identified Hot Spot	Did a 2008 Incident Occur at Same Location?	Number of Total 2008 Incidents	Percentage of 2008 Incidents Occurring at Identified Hot Spot	ArcGIS Identified Hot Spot	Did a 2008 Incident Occur at the Same Location?	Total Number of Hot Spots Identified in ArcGIS	Percentage of Hot Spots Serving as Location of 2008 Incident
Jolo - 12 Incidents	No	12 - Sulu	8.33	Patikul - 90% Confidence Level	Yes	1 - Sulu	100.00
Indanan - 9 Incidents	No	7 - Basilan	14.29	Tuburan - 90% Confidence Level	No	1 - Basilan	0.00
Patikul - 9 Incidents	Yes						
Talipao - 6 Incidents	No						
Patikul - 6 Incidents	No						
Indanan - 5 Incidents	No						
Talipao - 4 Incidents	No						
Parang - 4 Incidents	No						
Jolo - 4 Incidents	No						
Maimbung - 4 Incidents	No						
Sumisip - 5 Incidents	No						
Tuburan - 4 Incidents	No						
Lamitan - 3 Incidents	Yes						
Lamitan - 3 Incidents	No						
Tipo-Tipo - 3 Incidents	No						
Sumisip - 3 Incidents	No						
Lantawan - 3 Incidents	No						

Table 14. Summary of Hot Spot Analysis from CrimeStat and ArcGIS

Although the resulting percentages for successfully identifying locations for future incidents are low, they still indicate that there is some information that can be gathered from this type of analysis, and therefore, *hot spot analysis* should not be easily dismissed from the intelligence process. However, these software packages take into account neither the total number of incidents nor the population of the area being analyzed when identifying hot spots, something that would help put all the studied municipalities on an equal level; this can be accomplished by normalizing the incident data.

D. INCIDENT NORMALIZATION

Another method for interpreting the data for both Sulu and Basilan was in taking the total number of incidents that occurred in each municipality and normalizing that number by either the total number of incidents that occurred on the entire island or by the population of the municipality. The total number of incidents in each municipality and for the entire island as well as the resultant normalization value and category for both 2001 to 2007 and 2008 for the island of Sulu are shown in Table 15 and depicted in Figures 9 and 10. The different categorization levels for the normalization values are drawn out in Table 16 in order to illustrate the range each municipality falls under.

Municipality	Total Number of Incidents in Municipality: 2001 - 2007	Total Number of Incidents in Sulu: 2001 - 2007	Normalization Value 2001 - 2007	Normalization Category	Total Number of Incidents in Municipality: 2008	Total Number of Incidents in Sulu: 2008	Normalization Value 2008	Normalization Category
Indanan	30	158	0.1899	5	1	22	0.04545	2
Jolo	23		0.1456	4	0		0.000	1
Kalingalan Caluang	4		0.02532	2	0		0.000	1
Luuk	0		0.000	1	1		0.04545	2
Maimbung	20		0.1266	4	4		0.1818	3
Old Panamao	7		0.0443	3	0		0.000	1
Panglima Estino	2		0.0127	2	1		0.04545	2
Parang	10		0.06329	3	1		0.04545	2
Patikul	32		0.2025	5	13		0.5909	4
Talipao	30		0.1899	5	1		0.04545	2

Table 15. Normalization of Municipality Incidents by Total Sulu Incidents

Normalization Category	Normalization Value Range: 2001 - 2007	Category Color	Normalization Category	Normalization Value Range: 2008	Category Color
1	0.000	Blue	1	0.000	Blue
2	0.00010 – 0.02532	Green	2	0.00010 – 0.04545	Green
3	0.02533 – 0.06329	Yellow	3	0.04546 – 0.1818	Yellow
4	0.06330 – 0.1456	Orange	4	0.1819 – 0.5909	Red
5	0.1457 – 0.2025	Red			

Table 16. Normalization Category Levels

In this thesis, the normalization category that is red in color (Category 4 or 5 depending) highlights a strong or high value and the blue normalization category (Category 1) is indicative of a weak or low result.

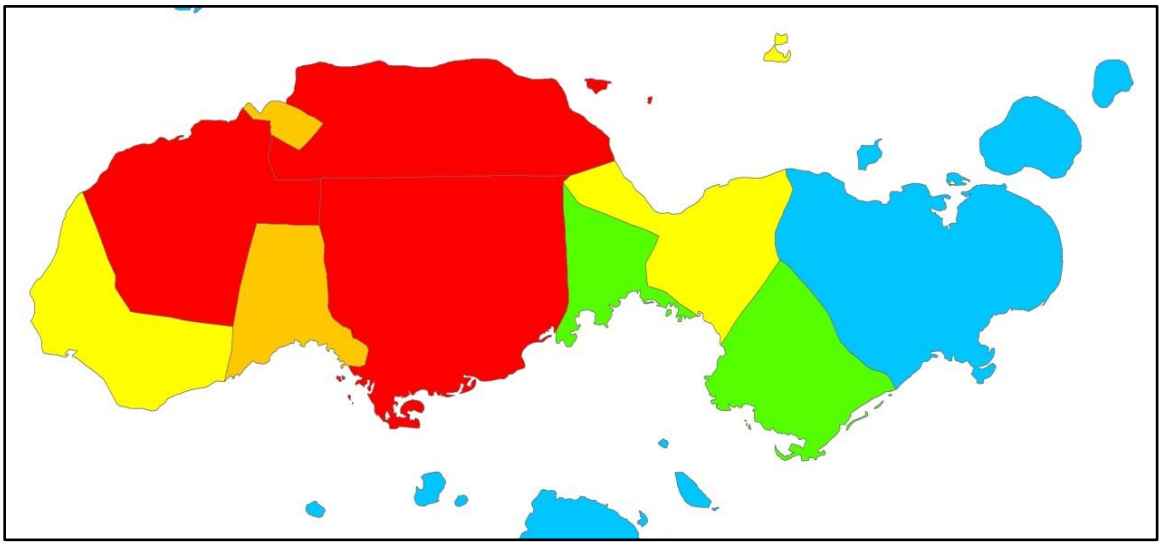

Figure 9. Normalization of Municipality Incidents by Total Sulu Incidents: 2001–2007

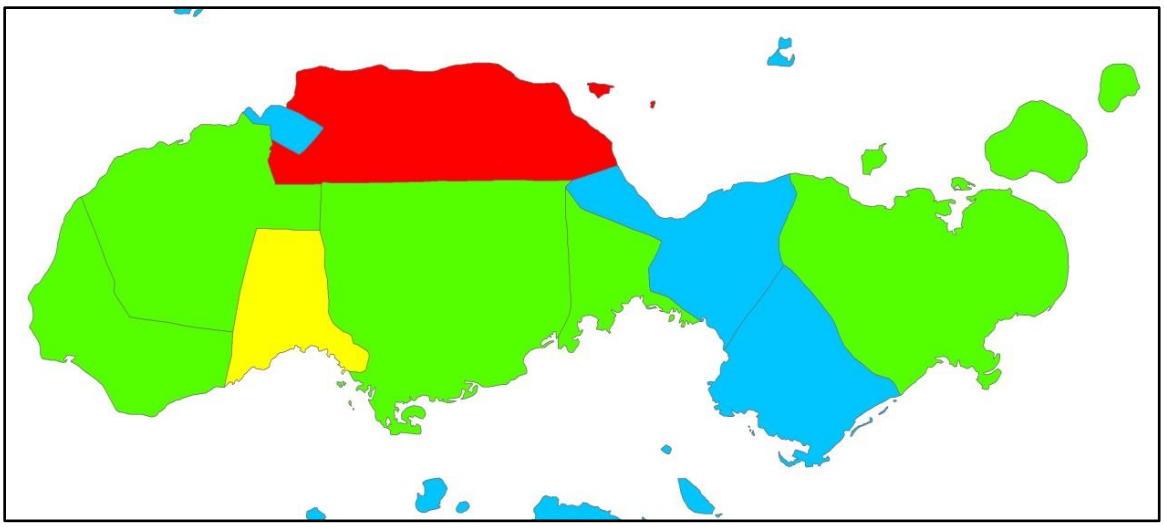

Figure 10. Normalization of Municipality Incidents by Total Sulu Incidents: 2008

Comparing the normalization values of each municipality's incidents by the island's total number of incidents from 2001 to 2007 to the values for 2008, there are two consistencies observed: Patikul and Panglima Estino. In both instances Patikul falls in the highest normalization value, which corresponds to this region experiencing the highest number of incidents in both time periods; Panglima Estino's normalization values keep the municipality solidly in category 2 in both year groupings. In both cases, these can be considered as important pieces of information for security forces; from this analysis they would identify Patikul as an area to watch closely as it sees the most activity and Panglima Estino sees consistently less activity, where perhaps they would not focus as much attention. There is only one municipality that's normalization value increases from the 2001 to 2007 time to 2008: Luuk; this municipality only experiences one incident during all eight years, which occurred in 2008, the second time frame. The other eight municipalities all decrease in normalization category, most by a level of one, though Jolo does drop from level (4) to level (1) when it experiences zero attacks in the 2008 year.

The total number of incidents in each municipality, and for the entire island as well as the resultant normalization value and category for both 2001 to 2007 and 2008 for the island of Basilan, are shown in Table 17 and depicted in Figures 11 and 12. As the

normalization values for each category have changed for the island of Basilan, new ranges are displayed in Table 18.

Municipality	Total Number of Incidents in Municipality: 2001 - 2007	Total Number of Incidents in Basilan: 2001 - 2007	Normalization Value 2001 - 2007	Normalization Category	Total Number of Incidents in Municipality: 2008	Total Number of Incidents in Basilan: 2008	Normalization Value 2008	Normalization Category
Isabela	10	63	0.1587	4	0	15	0.00000	1
Lamitan	12		0.1905	4	1		0.06667	2
Lantawan	10		0.1587	4	0		0.00000	1
Maluso	2		0.03175	2	0		0.00000	1
Sumisip	15		0.2381	5	1		0.06667	2
Tipo-Tipo	8		0.1270	3	4		0.26667	3
Tuburan	6		0.0952	3	9		0.60000	4

Table 17. Normalization of Municipality Incidents by Total Basilan Incidents

Normalization Category	Normalization Value Range: 2001 - 2007	Category Color	Normalization Category	Normalization Value Range: 2008	Category Color
1	0.000	Blue	1	0.000	Blue
2	0.00010 – 0.03175	Green	2	0.00010 – 0.06667	Green
3	0.03176 – 0.1270	Yellow	3	0.06668 – 0.2667	Yellow
4	0.1271 – 0.1905	Orange	4	0.2668 – 0.6000	Red
5	0.1906 – 0.2381	Red			

Table 18. Normalization Category Levels

Due to the small number of values utilized in determining the normalization values in 2008, there are only four normalization categories compared to the five categories from the 2001 to 2007 range.

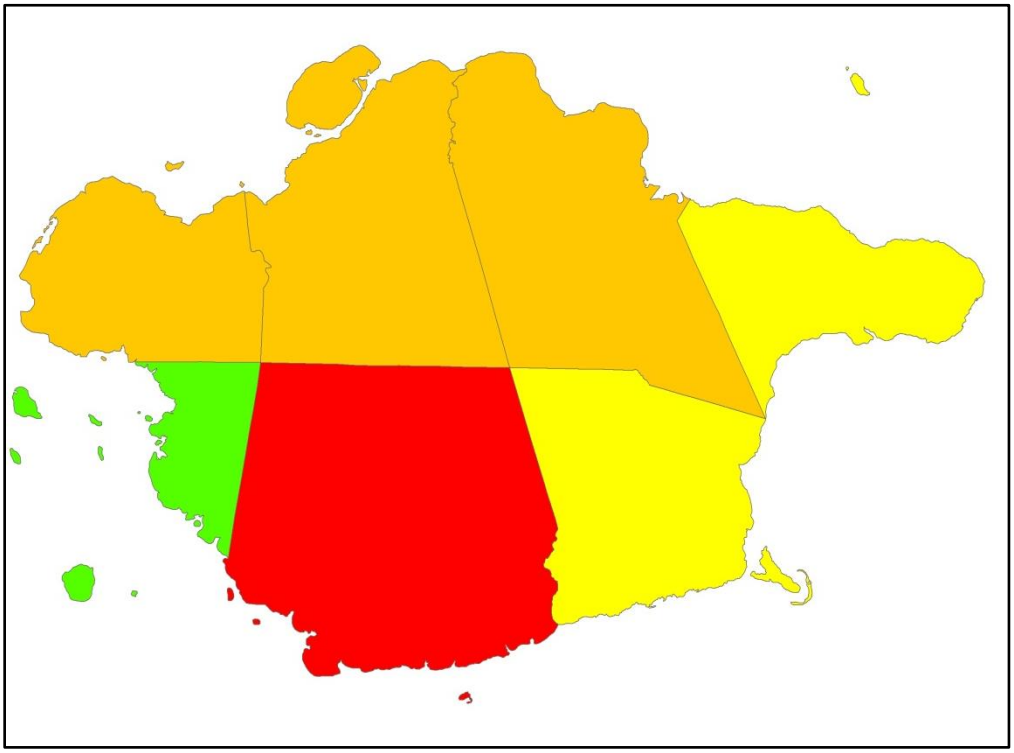

Figure 11. Normalization of Municipality Incidents by Total Basilan Incidents: 2001–2007

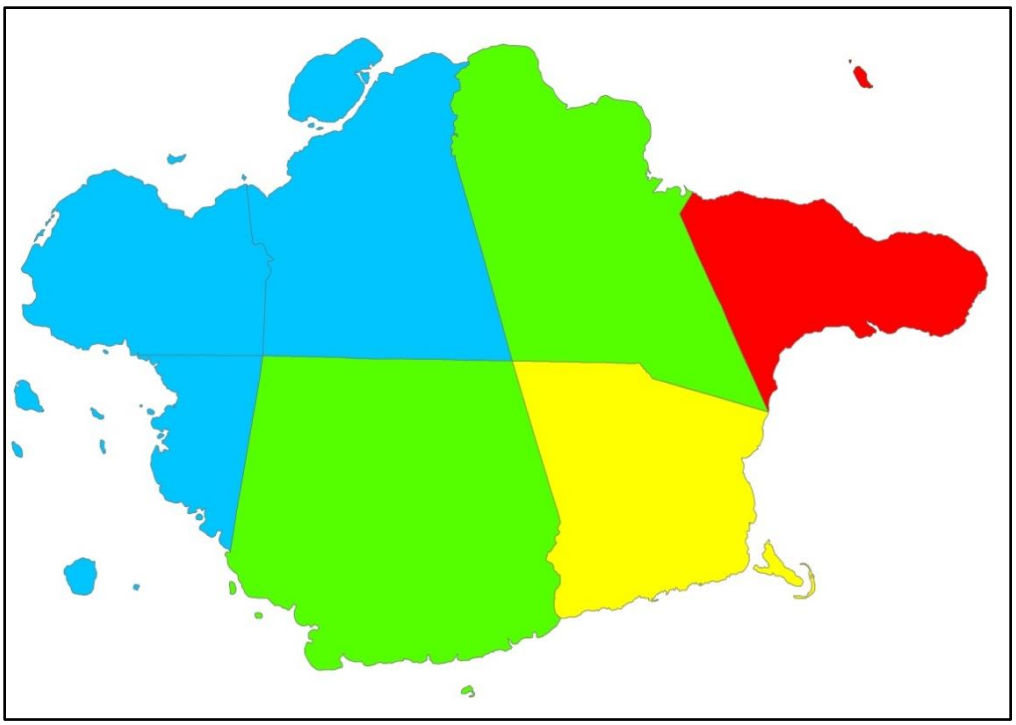

Figure 12. Normalization of Municipality Incidents by Total Basilan Incidents: 2008

For Basilan, like Sulu, the island highlights a consistency from the 2001 to 2007 value to the 2008 value: Tipo-Tipo, the municipality remains in the yellow category in both phases, the third from the bottom. Beyond this municipality, the others switch normalization categories seemingly at random.

Beyond comparing the values from the 2001–2007 time period to those that occurred in 2008, each year can be compared to the others and the average of those years. The average of the years 2001–2007 is compared to 2008 in order to determine whether any pattern from year-to-year emerges. The yearly normalization numbers for each year and the averages are displayed in Table 19.

Sulu	Number of Incidents Occurred in Municipality / Normalization by Year's Total Incidents									
Year	2001	2002	2003	2004	2005	2006	2007	Average	2008	Percent Error
Total Incidents Occurred	44	10	19	10	27	31	17	22.57143	22	2.597402597
Municipality										
Indanan	3	4	2	0	11	6	4	4.285714	1	328.57
	0.06818	0.4	0.10526	0	0.40741	0.19355	0.23529	0.201385	0.04545	343.05
Jolo	5	0	3	1	0	14	0	3.285714	0	
	0.11364	0	0.15789	0.1	0	0.45161	0	0.117592	0	
Kalingalan Caluang	2	1	0	0	0	0	1	0.571429	0	
	0.04545	0.1	0	0	0	0	0.05882	0.029183	0	
Luuk	0	0	0	0	0	0	0	0	1	100.00
	0	0	0	0	0	0	0	0	0.04545	100.00
Maimbung	5	0	2	4	4	4	1	2.857143	4	28.57
	0.11364	0	0.10526	0.4	0.14815	0.12903	0.05882	0.136415	0.18182	24.97
Old Panamao	2	0	2	0	3	0	0	1	0	
	0.04545	0	0.10526	0	0.11111	0	0	0.037404	0	
Panglima Estino	1	0	0	0	0	0	1	0.285714	1	71.43
	0.02273	0	0	0	0	0	0.05882	0.01165	0.04545	74.37
Parang	0	1	0	1	4	0	4	1.428571	1	42.86
	0	0.1	0	0.1	0.14815	0	0.23529	0.083349	0.04545	83.37
Patikul	7	4	7	4	3	5	2	4.571429	13	64.84
	0.15909	0.4	0.36842	0.4	0.11111	0.16129	0.11765	0.245366	0.59091	58.48
Talipao	19	0	3	0	2	2	4	4.285714	1	328.57
	0.43182	0	0.15789	0	0.07407	0.06452	0.23529	0.137657	0.04545	202.84

Table 19. Sulu Island-Wide and Municipality-Level Normalization Values by Year

For Sulu, the average number of incidents per year based on the 2001–2007 numbers was just over 22.5; comparing this to the total number of incidents in 2008, 22, yields a percent difference between the two of fewer than 3%, meaning that the number of incidents in 2008 follows the number of incidents one would expect to occur. However, other than providing information toward the grand picture, this result would not tell security forces where to possibly expect future attacks just that in general they should expect about twenty-two attacks to occur in a given year. While the total number of incidents for the entire island is consistent with the yearly average, the same is not true

for each municipality. The municipality with the lowest percent difference for both the total number of incidents and the normalization of those incidents by the island's total incidents is Maimbung, but even those values are high, 28.57% and 24.97%, respectively; the other municipalities' values range from 58.48% to as high as 343.05%. These resulting percentages demonstrates that like the 2001–2007 total values compared to the 2008 values, using the averages from the same time period and comparing to the 2008 values produces very little information to go on, though the total number of anticipated incidents may be able to be predicted.

Basilan	Number of Incidents Occurred in Municipality / Normalization by Year's Total Incidents									
Year	2001	2002	2003	2004	2005	2006	2007	Average	2008	Percent Error
Total Incidents Occurred	27	9	8	6	4	0	9	9	15	40
Municipality										
Isabela	2	3	2	2	0	0	1	1.428571	0	
	0.07407	0.333333	0.25	0.33333	0	0	0.11111	0.157407	0	
Lamitan	10	0	0	1	0	0	1	1.714286	1	71.43
	0.37037	0	0	0.16667	0	0	0.11111	0.092593	0.06667	38.89
Lantawan	4	2	3	0	0	0	1	1.428571	0	
	0.14815	0.222222	0.375	0	0	0	0.11111	0.122354	0	
Maluso	1	0	0	1	0	0	0	0.285714	0	
	0.03704	0	0	0.16667	0	0	0	0.029101	0	
Sumisip	5	4	1	2	3	0	0	2.142857	1	114.29
	0.18519	0.444444	0.125	0.33333	0.75	0	0	0.262566	0.06667	293.85
Tipo-Tipo	2	0	0	0	0	0	6	1.142857	4	71.43
	0.07407	0	0	0	0	0	0.66667	0.10582	0.26667	60.32
Tuburan	3	0	2	0	1	0	0	0.857143	9	90.48
	0.11111	0	0.25	0	0.25	0	0	0.087302	0.6	85.45

Table 20. Basilan Island-Wide and Municipality Level Normalization Values by Year

Like the average values for Sulu, the average values for Basilan based on total incident number and the normalization values, does not yield results that appear to be

helpful in the prediction of incident numbers in 2008, for either the island as a whole or for each municipality.

The other method of normalizing the incident number is by the population of each municipality. The total number of incidents occurring in the municipality, the population of the municipality, and the resultant value are displayed in Tables 21 and 22.

Municipality	Total Number of Incidents in Municipality: 2001-2007	Population of Municipality (2000)	Incident Number Normalized by Population
Indanan	30	53425	0.0005615
Jolo	23	87998	0.0002614
Kalingalan Caluang	4	22688	0.0001763
Luuk	0	38819	0.0000000
Maimbung	20	24982	0.0008006
Old Panamao	7	35906	0.0001950
Panglima Estino	2	21443	0.0000933
Parang	10	54994	0.0001818
Patikul	32	34396	0.0009303
Talipao	30	73015	0.0004109

Table 21. Normalization Values of Sulu Municipalities Based on 2001 to 2007 Incidents

Municipality	Total Number of Incidents in Municipality: 2001-2007	Population of Municipality (2000)	Incident Number Normalized by Population
Isabela	10	73032	0.0001369
Lamitan	12	58709	0.0002044
Lantawan	10	27487	0.0003638
Maluso	2	31054	0.0000644
Sumisip	15	51712	0.0002901
Tipo-Tipo	8	48284	0.0001657
Tuburan	6	42550	0.0001410

Table 22. Normalization Values of Basilan Municipalities Based on 2001 to 2007 Incidents

The same level of interpretation was done for the municipalities and the events that occurred in them during 2008; the results are shown in Tables 23 and 24.

Municipality	Total Number of Incidents in Municipality: 2008	Population of Municipality (2000)	Incident Number Normalized by Population
Indanan	1	53425	0.0000187
Jolo	0	87998	0.0000000
Kalingalan Caluang	0	22688	0.0000000
Luuk	1	38819	0.0000258
Maimbung	4	24982	0.0001601
Old Panamao	0	35906	0.0000000
Panglima Estino	1	21443	0.0000466
Parang	1	54994	0.0000182
Patikul	13	34396	0.0003780
Talipao	1	73015	0.0000137

Table 23. Normalization Values of Sulu Municipalities Based on 2008 Incidents

Municipality	Total Number of Incidents in Municipality: 2008	Population of Municipality (2000)	Incident Number Normalized by Population
Isabela	0	73032	0.0000000
Lamitan	1	58709	0.0000170
Lantawan	0	27487	0.0000000
Maluso	0	31054	0.0000000
Sumisip	1	51712	0.0000193
Tipo-Tipo	4	48284	0.0000828
Tuburan	9	42550	0.0002115

Table 24. Normalization Values of Basilan Municipalities Based on 2008 Incidents

In order to compare the normalization values from 2001–2007 to the values from 2008, the normalization values were divided into five categories. The categories were defined as follows in Table 25.

Normalization Category	Normalization Value Range	Category Color
1	0.00 - 0.0000999	Blue
2	0.0001000 - 0.0002614	Green
3	0.0002615 - 0.0004109	Yellow
4	0.0004110 - 0.0005615	Orange
5	0.0005616 - 0.0009303	Red

Table 25. Normalization Categories

The resulting comparison of normalization values from 2001–2007 and 2008 for both Sulu and Basilan are shown in Tables 26 and 27 and depicted in Figures 13, 14, 15, and 16.

Municipality	Normalization Value 2001 - 2007	Normalization Category	Normalization Value 2008	Normalization Category
Indanan	0.000561535	4	0.0000187	2
Jolo	0.00026137	2	0.0000000	1
Kalingalan Caluang	0.000176305	2	0.0000000	1
Luuk	0.0000000	1	0.0000258	2
Maimbung	0.000800576	5	0.0001601	4
Old Panamao	0.000194953	2	0.0000000	1
Panglima Estino	0.0000933	2	0.0000466	3
Parang	0.000181838	2	0.0000182	2
Patikul	0.000930341	5	0.0003780	5
Talipao	0.000410874	3	0.0000137	2

Table 26. Comparison of Sulu Normalization Categories

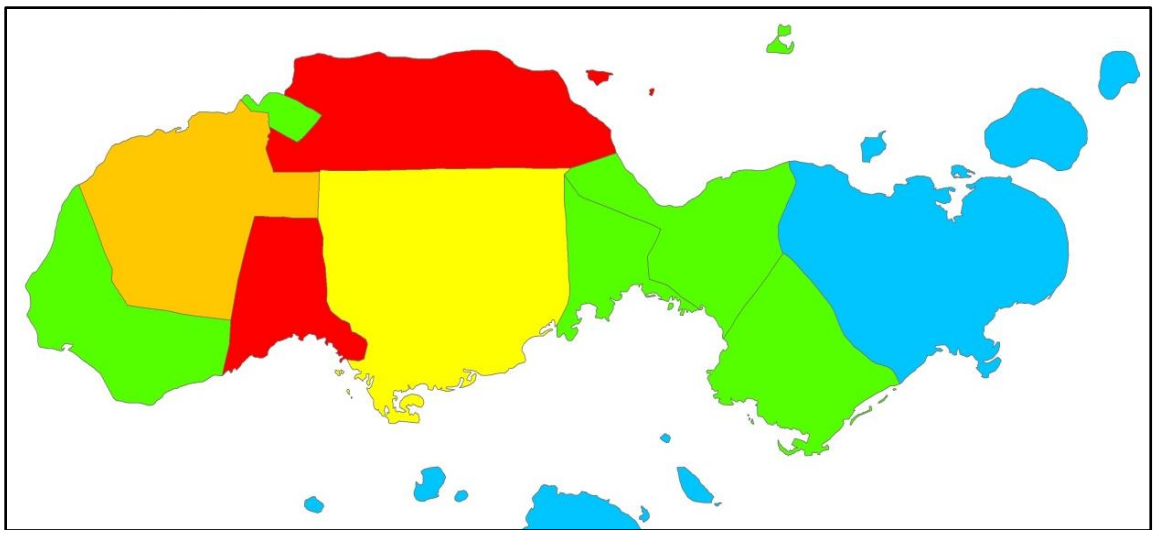

Figure 13. Sulu 2001–2007 Incidents Normalized by Municipality Population

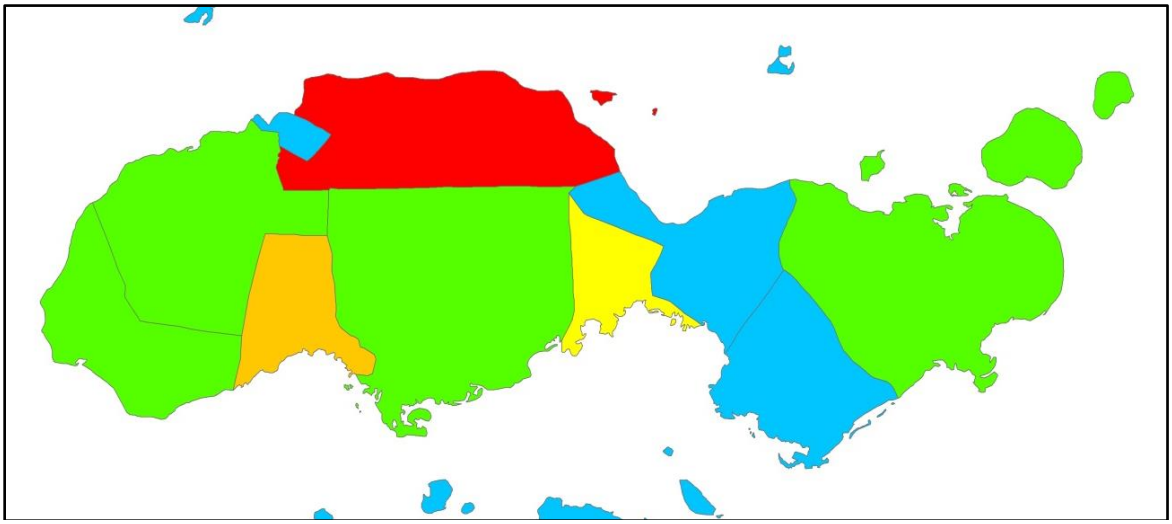

Figure 14. Sulu 2008 Incidents Normalized by Municipality Population

Municipality	Normalization Value 2001 - 2007	Normalization Category	Normalization Value 2008	Normalization Category
Isabela	0.0001369	3	0.0000000	1
Lamitan	0.0002044	4	0.0000170	2
Lantawan	0.0003638	5	0.0000000	1
Maluso	0.0000644	2	0.0000000	1
Sumisip	0.0002901	5	0.0000193	3
Tipo-Tipo	0.0001657	3	0.0000828	4
Tuburan	0.0001410	3	0.0002115	5

Table 27. Comparison of Basilan Normalization Categories

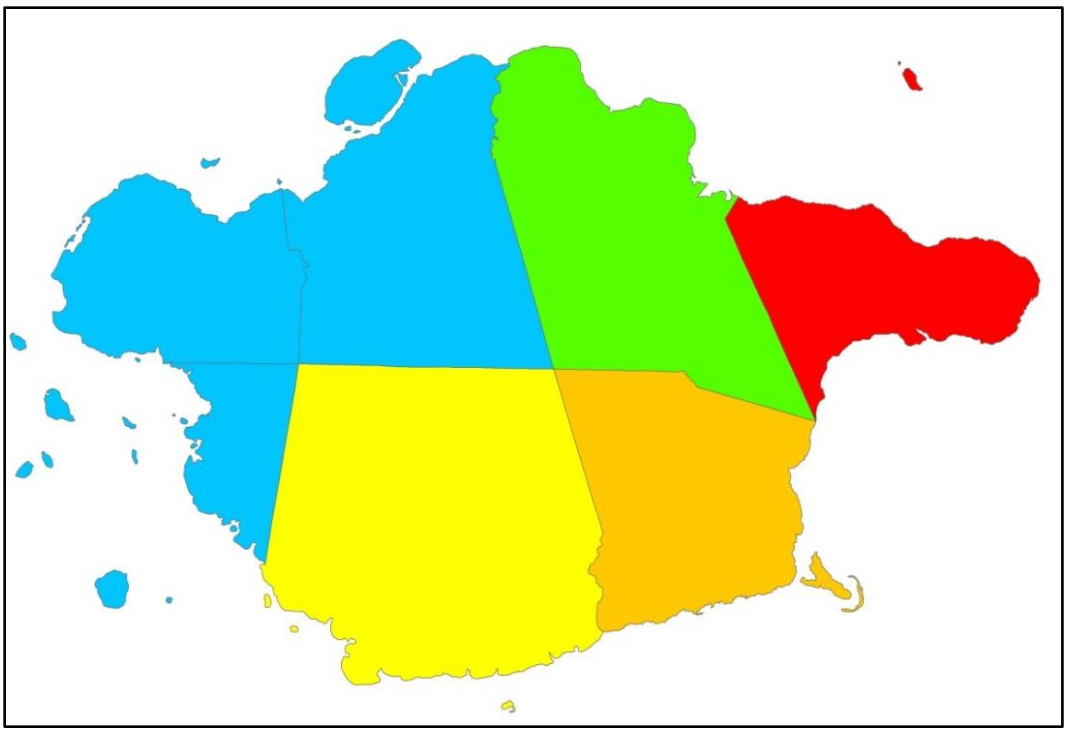

Figure 15. Basilan 2001–2007 Incidents Normalized by Municipality Population

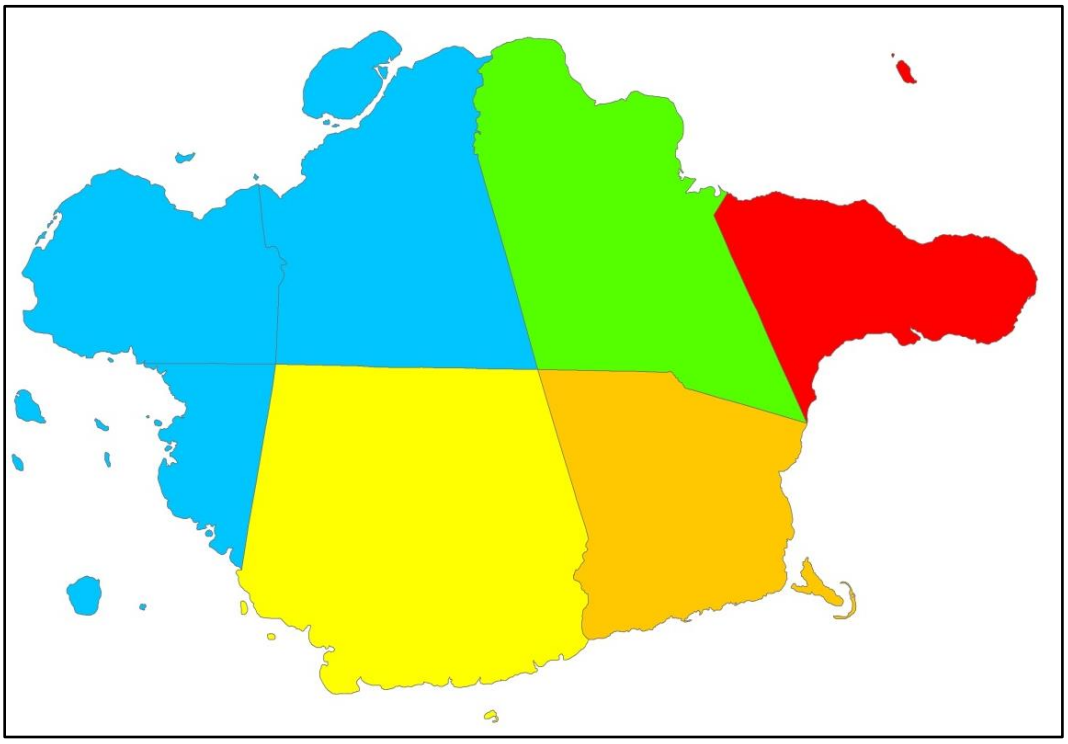

Figure 16. Basilan 2008 Incidents Normalized by Municipality Population

When the figures for each island for the 2001 to 2007 incidents are compared to the same island's figure for 2008, some consistancy is observed. For instance, for Sulu, Patikul once again remains in the highest normalization category (5) and Parang remains in the second lowest normalization category (2). Again, this is bit of information could prove useful to security forces in planning operations and patrols, for they could see where activity is consistently high and where it is lower. However, out of the eight remaining municipalities, only one changes its normalization category by more than one (Indanan – 4 to 2). As for Basilan, none of the seven municipalities maintain their original normalization category, and five out of the seven change normalization categories by two or more levels.

If the normalization values by population for each year and each municipality on both islands are averaged and compared to the actual values for 2008, like the percent errors obtained from the normalization of incidents by total incidents, these percent errors are large in number, ranging from 28.57%–328.57%.

Overall, the results of utilizing geographic profiling techniques on the incident data for Sulu and Basilan indicate potential for being useful in the determination of where future incidents could occur; however, further analysis on different pieces of data is required in order to determine whether these techniques could aid in future prediction efforts. Perhaps, with different data sets, there lies the possibility of utilizing more complex geographic profiling techniques that were not feasible with this thesis' data, which could provide more predictive information and therefore, more clear-cut results.

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V. DISCUSSION AND CONCLUSION

A. DISCUSSION

Utilizing statistical analysis, CrimeStat, and ArcGIS, the results of utilizing geographic profiling techniques yielded an assortment of results, some useful, and other results not.

From the statistical analysis conducted, the results for the two islands of Sulu and Basilan tended to contradict each other, meaning that there was not much consistency between the islands, at least when it came to predicting whether an incident would occur within a particular area in the future. While municipalities on the island of Sulu were more likely to experience a 2008 incident if they experienced an incident in more of the seven years preceding 2008, the opposite held true in Basilan where a municipality was more likely to be the location of a 2008 incident if they experienced incidents in three or fewer preceding years. In looking at the likelihood of a particular type of incident occurring in Sulu and Basilan, the two islands tend to share more in common with one another because if the island experienced a particular type of incident in three or more out of the seven preceding years, approximately two-thirds of the time, they would experience that type of incident again in 2008. For those incidents that occurred in more than three years leading up to 2008, but did not actually occur in 2008, these types of incidents all occurred in 2004 or before, never after. However, when looking at the 2008 incidents themselves, Sulu's incidents tended to follow the pattern that if a particular type of incident occurred in multiple years, it was more likely to occur again in 2008; but in Basilan only a third of the 2008 incident types occurred in three or more years. Again, inconsistencies between the two islands make it difficult to develop an actual prediction.

From CrimeStat, the Hot Spot Analysis reveals the locations that experienced the most incidents over a seven year period. However, in terms of prediction value, for both Sulu and Basilan, this analysis did not contribute much. The generated hot spots tended to not serve as the location of an incident in 2008; only fifteen percent (or less) of the hot spots saw an incident occur again in 2008. While CrimeStat's Hot Spot Analysis provides

a slight indication of where a future incident would likely occur, the Hot Spot Analysis conducted by ArcGIS does not fare much better. On both islands, the model only generates one hot spot location, more often than not; the locations of incidents from 2001 to 2007 were categorized as being not significant of a spot, though in a few instances the sites were identified as cold spots. Of the sites identified as hot spots, only on Sulu does a 2008 incident occur at the same location as a previously identified hot spot. Even when looking at the incidents as a whole, the percentage of 2008 incidents that occur in previously attacked locations, only reaches forty-two percent for Sulu and fourteen percent for Basilan, percentages that are not high enough to help serve a predictive function.

The predictive ability of incident normalization, when looking at the incidents in terms of their total numbers from 2001–2007 for each municipality and normalizing by total incident number for the entire island, provided little information. Most of the municipalities on both islands see a reduction in their normalization category, though three municipalities maintain their level and one, Tuburan, actually increases. The same basically holds true when the incidents that occurred from 2001–2007 are normalized by the 2000 population of the municipality. When the 2001–2007 incidents are averaged instead of simply being combined, a bit more information can be extracted. For both islands, the expected number of incidents in total for each island is roughly similar, though it is much better for Sulu than Basilan, meaning that authorities could at least begin to predict how many incidents in total the island should expect in a given year. Unfortunately, on the municipality level, the numbers vary on a large scale from the anticipated values, once again decreasing the predictive capability of the method.

Overall, these results do not speak highly of the predictive nature of geographic profiling techniques; however, while the resulting percentages were not very high, the fact that most of these methods of analysis produce even a result at all means that they have future application. The process intelligence analysts and law enforcement officials go through currently to predict likely locations of where terrorists and criminals attack and operate involves multiple methods, which all together aid in the determination of the most likely areas; these geographic profiling techniques provide yet another level of

analysis to help in this determination. Perhaps when added into several existing methods, information can be revealed that would have previously gone undetected.

The results of this thesis may simply highlight that for all the similarities shared between serial criminals and terrorists, the two entities are just too different from one another for a technique that works on one to work for the other. Terrorists tend to be motivated by an ideology and choose their targets in order to generate fear among the population and force the government to take action against a perceived injustice held by the terrorists, while serial criminals and serial killers or rapists in particular tend to target people who fit a certain description in order to act out anger on someone who has wronged them previously, without a further goal of soliciting a government response. Of course, the largest difference, which makes determining the location of a terrorist base of operations difficult, is that serial criminals tend to be an individual, but with a terrorist organization, it is challenging to pick out one individual so instead, the focus turns toward applying efforts meant for one person to an entire group. However, this thesis focused on the prediction of where a terrorist organization will strike next and not where they operate from; even though this is the case, due to the underlying differences between an individual committing crimes and an entire group conducting attacks, it may be enough to make the application not feasible. Once again, further analysis is required in order to determine whether this feasibility exists; from this thesis, the process appears promising.

B. LIMITATIONS

There are several limitations to this study, particularly in terms of data and its ability to be incorporated into the analysis packages. The data utilized in this thesis came from one source, meaning that potentially not all incidents were included in the data set. The data itself had so much information, in terms of numbers, that it had to be reduced down to one particular group, mostly in order to keep the incidents that occurred in the same general area so that the analysis was not conducted throughout the entire southern Philippines. The incident data, even prior to reduction, only included so much information about a particular attack, leading to confusion about what each type of

incident had occurred. Beyond the possible confusion introduced by the data itself, there were aspects of the data that did not mesh well with the programs utilized. The CrimeStat software was not able to be utilized to its fullest potential because of the data inputted into it; only one method of analysis was able to be run. Even in ArcGIS the data ran into problems when the software processes required more information than available. These issues may not have arisen if different geographic profiling software, such as Dragnet and Rigel Analyst, but as CrimeStat was the only program easily obtained; the other software packages were not used. Lastly, this thesis only focused on the one data set; there is more room for further analysis of data to be run through these programs.

C. CONCLUSIONS

The utilization of geographic profiling in the hunt for serial criminals has found success for law enforcement agencies. Although it seems difficult, there is room available for incorporation into the analysis process utilized by intelligence personnel to predict where future terrorist activity could occur. Even though this thesis analyzed a limited amount of data, it still provided key pieces of information from which observations could be made by security forces in the Philippines that have the potential to help aid in planning either operations or security patrols in regions where the Abu Sayyaf Group operates.

Geographic profiling is a newer method, meaning that as time passes, improvements will be made to existing techniques that will only help the field grow. While this thesis has not been able to show that geographic profiling techniques are the next "silver bullet" in the prediction of terrorist attacks, it has illustrated the possibilities the method offers in helping to further analysis. This thesis only provided one attempt of applying existing geographic profiling methods to terrorist incident data, future efforts to explore the possibility of geographic profiling terror attacks and terrorists need to be run on several different types of data and on several different scales of data.

These future efforts could include many possibilities; it will take time to determine what sort of data and how much data is required in order to be most compatible with the geographic profiling software utilized. First, perhaps there is an aspect of

CrimeStat that was not compatible with the data used; running the same data through different software packages could yield other results, ones that may be able to provide a more in-depth picture. Even just from the complete data set utilized in this thesis there were several different groups whose actions could be analyzed; perhaps groups such as the Moro Islamic Liberation Front and their greater number of incidents as well as their more spread out nature provide a better set of data to study. On the other hand, many current applications of geographic profiling by law enforcement agencies are restricted to city-level analysis and in running analysis over an entire island, the area was simply too large to be accurately interpreted; therefore, finding a portion of the data which is great in number and concentrated around a city or established place would enable the software to provide a better analysis of incident data. The incident data from this thesis also spanned a large period of time, eight years; again, this could have been too much for the programs utilized and because the hot spot analysis was run on a seven year period, important aspects about the data and the progression of incidents was missed. Beyond the data set studied in this thesis, there is a wealth of other incident data sets that could be analyzed in order to determine if a particular type of information is more suited for application of geographic profiling techniques. This thesis serves merely as a beginning for future and more in-depth efforts into determining whether geographic profiling is applicable to the intelligence process in the search for terrorists; however, this thesis has been able to demonstrate that, while small, at present, such a possibility does exist and needs to be further explored.

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