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An Analysis of Selected Clusters of Fires in Florida (1996 - 2018)

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An Analysis of Selected Clusters of Fires in Florida (1996 – 2018)

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Abstract

An Analysis of Selected Clusters of Fires in Florida (1996–2018). Thomas R. Hall, 2018: Dissertation, Nova Southeastern University, College of Arts, Humanities and Social Sciences, Department of Justice and Human Services. Descriptors: arson, cluster, fire, serial crime, trigger.

Hidden within the day-to-day routine responses of fire departments are possible multiple fires set by individuals in a small area with an unusual frequency. These fires may be the initial announcement of an emerging serial offender who is declaring a wound, an intolerable life situation, or is triggered by unknown events. This study sought to predict incendiary fires within a known cluster by using observable variables, both prior to and after the cluster event. This was done to further our understanding of the characteristics of clusters of intentionally lit fires. This was accomplished by examining the Florida Fire Information Reports (FFIRS) from the Florida State Fire Marshal's Division and the Augmented Criminal Information (ACISS) reports provided by the Florida Division of Investigative and Forensic Services, Bureau of Fire, Arson and Explosives Investigation from 1996 to 2018. The study surveyed 1,260,369 records from which 45 clusters comprised of 1216 individual fire events were used.

The results of this study found that illumination, the spatial density of a cluster and to a lesser extend the target of a fire were significant predictors of an incendiary event. Further, open fields and trash receptacles were found to be the most common point of origin of fire clusters.

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Chapter 1: Introduction

The Problem of Arson

Approximately 8% of fires in the United States may be arson, and intentionally set fires are the fourth leading cause of structure fires in the United States (National Fire Protection Association, 2017). Owing to the unique nature of fire investigations, this number may be a low estimate. With regard to investigating fires, the act of arson tends to destroy evidence of the crime. Many times, all the evidence an investigator has to reconstruct an incendiary event is the burn debris, eyewitness accounts, and the approximate time that the fire occurred. If a given fire is created using an accelerant like gasoline or had highly flammable materials added, the use might assist in the eventual determination that the fire was incendiary. However, the fire itself can also destroy the evidence that an accelerant was used.

Dolan, McEwan, Doley and Fritzon (2011) have reported research stating that juveniles account for up to 52% of arson arrests in the United States. Mackay, Feldburg, Ward and Marton (2012) claim that over half of those arrested for arson in the United States are juveniles. Most authoritative sources attribute over 40% of known arsons to children, and suggest that diversion programs are not being included in crime statistics (Dolen, et al., 2011). This view has some validity because most diversion programs are designed to keep the juvenile from acquiring a criminal record, and, with the consent of the local state's attorneys, they are conducted outside the purview of the court. These locally managed fire setting diversion programs are not regulated or monitored, except informally by the local county fire district. Of particular interest is that there is no known identification or systematic fact-gathering process involved in these locally run youth intervention programs. As a result,

potentially half of the fire-setters are diverted from any type of investigative accounting or overview (Dolen, et al., 2011).

Significance of the study

Fire Clusters in Context

Fires that occur within a small geographic area are known as fire clusters. The reporting structures used by the State of Florida in the past two decades have not identified clusters even when these patterns of fires are already established. The clusters may be developing or continuing at a rate not readily apparent because they are hidden in the much more frequent day-to-day routine events requiring the response of fire departments. Rarely do they become the subject of an investigation by fire investigators. In most instances, the unique characteristics of clusters have not been fully explored. However, these clusters represent the signature actions of serial fire-setters. These offenders comprise one of the least understood criminal categories, yet are responsible for property damage and other crimes far beyond that of other types of offenders, and require far more investigative effort (McCarty & McMahon, 2005; Tyler, Gannon, Lockerbie, King, Dickens & Burca, 2014).

The study of fire clusters is important because it is foundational in the development of a predictive model that would assist fire investigators. The significance of these clusters is fourfold. First, some offenders may be setting fires to announce a grievance. An extraordinary group of serial fire-setters have been identified as having a high likelihood of having experienced childhood abuse, physical abuse, or sexual abuse. Further, abuse may be a distinct type of trigger for juvenile fire setters (Root, MacKay, Henderson, Del Bove & Warling, 2008; Mackay, et al., 2012). These fires may be indictors of the harm being visited

upon the young arsonist. Identification and apprehension may lead to discovery of abuse or other crimes.

Lewis and Yarnell (1951) first identified a similar phenomenon at Bellevue Hospital. They observed that patients with lower IQs resorted to fire-setting more often than others and postulated that the two issues might be connected. Jackson (1994) followed with observations that his autistic and challenged patients who set fires may have been attempting to communicate their distress. Jackson's "no other viable option" theory for communicating this distress resonates with observations from fire investigators (Jackson, 1994). Further, in the results of a survey reported by Sugarman and Dickens (2009), both clinical psychiatrists, the researchers found that setting fires to an occupied structure was a likely indicator of the threat of future, perhaps more serious actions. In addition to occupied structures, setting fires to unoccupied structures and failing to report fires or summon help were also listed as significant indicators of future threat.

The exact trigger for a fire cluster event is unknown. It may be wholly unique to the fire-setter, with each individual having his or her own personal "on switch" to light fires. However, media triggered, copycat and environmental aspects may also be involved (Doley, Ferguson & Surette, 2013; Surette, 2011). There have been no known studies to date that looked at fire clusters in terms of external factors such as news broadcasts about fires, weather, foliage, visibility, the presence of previous animal abuse reports, or other conditions. Local crime rates have also not been included in research about fire clusters. From the perspective of the underlying psychology of fire-setting, most triggers may represent some type of emotional tipping point where setting the fire becomes a form of relief, or in the case of economic fire-setters, a money-making endeavor.

The spatial characteristics associated with clusters also could be important. Canter (in Meany, 2004) long ago described two types of serial criminals according to their journey to crime. Cantor categorized criminals as either marauders or commuters. He defined marauders as committing crimes locally while commuters traveled outside of their home base and executed their crimes in distant areas (Meany, 2004). Previously, it was believed that serial fire-setting consisted of a series of local events by an individual. This was dramatically proven incorrect by the cluster of arsons in Coatesville, Pennsylvania during 2008 and 2009 (Urbina, 2009). There were no less than 44 arsons in Coatesville and six persons were arrested. None of the offenders had any connection to each other; half lived in Coatesville and half commuted to the small Philadelphia suburb to set fires.

The United States Forest Service has researched or sponsored research about the time and space attributes associated with forest fires. Some of the most recent studies have begun to discriminate fires associated with lightning (previously thought to be the most common source of forest fires) from those created by human activity (Butry & Presteman, 2005). The spatial aspect of fires has now become a major identifying element of categorizing a forest fire as accidental or incendiary. The spatial research initiated and conducted by the Forest Service may have direct applications to fires occurring in populated areas.

One such study of fires in Detroit by Presterman, Butry and Thomas (2013) found that fires occurred more often in the poorer areas of the city. Further, the study was able to make a weak association with late-night fires and arson. As a first step, the study was significant and suggested that a useful algorithm could possibly be found to assist fire responders in planning the placement of fire stations and movement of firefighting equipment throughout the city. However, the focus of the study was fire event prediction overall, and was not necessarily

focused on incendiary fire events. Further exploration in the spatial-temporal aspects of incendiary fires is needed. Finally, the investigative effort to identify, stop, and apprehend the serial fire-setter is currently deficient in scientifically valid tools that the investigator can use.

The current research into arson is primarily found in psychological studies of the fire-setter, the etiologies or mental state (Kocsis & Cooksey, 2002). The current emphasis is on understanding the serial fire-setter, his motivations, and possible comorbid diagnoses. All of these are critically important – after the fires stop. No validated criminological theory exists that provides empirical evidence regarding serial fire-setters (Gannon & Pina, 2010). Temporal-spatial tools, target analysis, and criminological conditions, as well as previous events in the neighborhood could be fertile investigative areas. The pre-fire correlates may provide public safety officials with advance warning of an emerging serial arsonist. The post-fire correlates may assist in the identification of the fire setter. There is a possibility that an examination of pre- and post-fire correlates may allow an investigator to make inferences based on observable and quantifiable actions apparent in the fire areas.

Clusters of fires represent the most prevalent and unique signatures of a serial arsonist. Once these disparate fires are recognized and presented to the investigator, showing that they are grouped in a meaningful manner, they represent clarion events. Research has suggested that serial arsons can be expected to be closely repeated in time and location (Grubb & Nobles, 2016). That study was an important factor in the examination of clusters, and suggests that there are more clusters than are currently recognized in the fire investigation community. In this light, the little fires preceding the recognition of an arson cluster become important.

The current study sought to unwrap the common elements that characterize fire clusters. Using archival data from state-mandated fire reports, validated regression and other statistical methods, conditions before, during, and after the identified clusters were examined to find inferential signatures.

Problem Statement

Arsons occur at a rate that is likely underreported in the available statistics (Jackson, 1988). Portions of these arsons are found in the clusters of fires, which are also occurring and are reported, but with insufficient data to separate accidental from intentional fires. Gaps exist concerning our knowledge of the characteristics of serial arson events. This study will attempt to fill those gaps by examining a set of theory-driven variables that may best predict when a fire is incendiary. A potential gap exists between the number of reported arsons and the probable co-location of other fires within clusters of fires. It may be that characteristics of fire clusters are the most observable signatures of serial arson available to the researcher.

Theoretical Framework

There may be observable actions associated with fire events that occur prior to an arson fire. Concurrent with this, there may be observable criminological or population density conditions which accompany the clusters. Within the observable events and conditions, there may be distinct spatial-temporal boundaries, which highlight an arson event. There are environmental conditions within which an arson event mostly occurs, and these can be detailed and possibly associated with the fire event. The conceptual model (Figure 1) graphically displays the predictor variables (event and environmental) and highlights a possible relationship between the outcome variables (arson, accidental, and undetermined fires).

Overall Objective

The overall goal of the study was to develop a predictive model that can discriminate between arson and accidental and/or undetermined fires. Using 20 years of statewide fire reports, an examination of archival data from these mandatory reports was used to attempt to unpack fire event records to see if there are any common occurrences recorded outside of the fire itself.

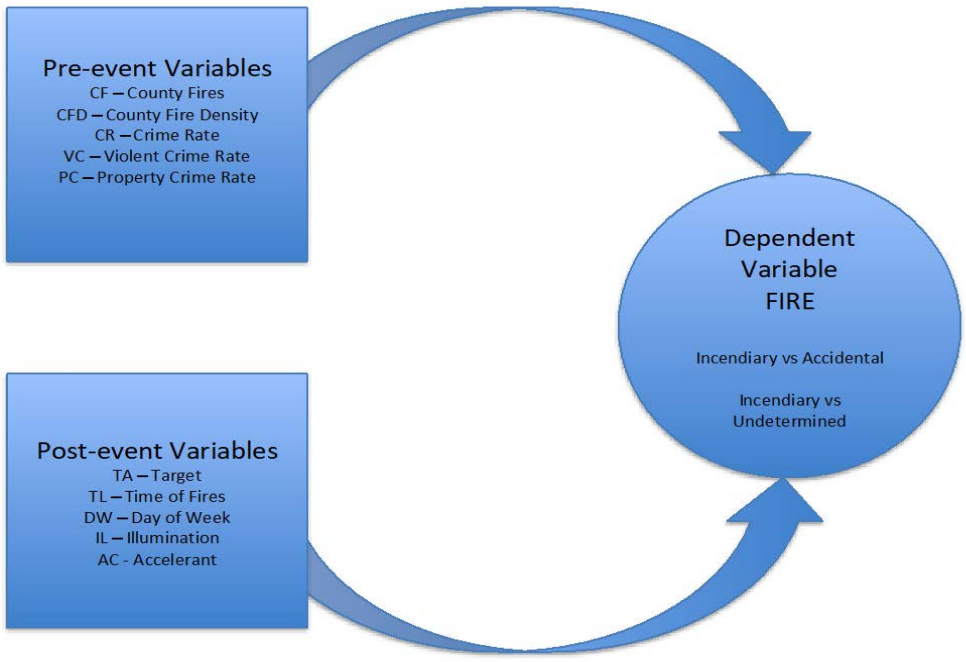

Figure 1. Conceptual Model

One goal of this study was to explore the geographic and criminological environment as viewed by the arsonist, i.e., to see the neighborhood as the arsonist sees it. There may be a distinct possibility that the landscape apparent to the arsonist is different from the view of the investigator. Such a view may be important in identifying the arsonist. This may be

accomplished by freezing the event in time and in context by capturing the fire event in spatiotemporal terms. From this it may be possible to identify the correlates of incendiary fires, which will provide new insights into the phenomenon of arson fires.

Research Questions

Research questions were chosen because of their potential support for the theoretical model depicted in Figure 1. They represent the observable, the obtainable, and possibly the important. The research questions are formulated to confirm each hypothesis at each investigative phase of a fire.

Research Question 1: What are the pre-fire variables that uniquely predict whether a fire is arson or accidental?

Hypothesis 1: There are observable spatial, environmental, and criminological events that occur which could discriminate an accidental or undetermined fire from arson.

Research Question 2: What are the post-fire variables that uniquely predict whether a fire is arson or accidental?

Hypothesis 2: There are observable spatial-temporal and target related items that remain at the fire area that could discriminate between an accidental or undetermined fire and arson.

Research Question 3: What are the pre- and post- fire variables that uniquely predict whether or not an arson fire is a member of a cluster of fires or present a unique pattern?

Hypothesis 3: There are two or more observable fire related characteristics both before and after a known arson, which could uniquely associate it with other fires in the vicinity.

Barriers and Issues

Background. There were several impediments to the completion of this study. They involved the relative failure to recognize a cluster. Reasons for this include a lack of a formal review of fires in a specific area, the disparate agencies involved in reporting fires, the nature of first responder shift work and the recognition of incendiary fires as part of an ongoing fire event.

Lack of cluster identification. The most prominent barrier to the proposed study was a lack of fire cluster identification. There is no current methodology to highlight a cluster, and there are very few serial arson clusters identified throughout the state. As best as can be determined through standard reporting structures, the Florida arson and fire statistics appear to be more accurate than national statistics from fire prevention and law enforcement communities. Part of this may be attributed to crime classification discrepancies as discussed below. However, the overall low numbers of arson clusters may simply exist because they are not reported as such. Within the data of routine fire responses, there may be fires that, for one reason or another, are not designated as arson and are not obviously correlated with other fires in the vicinity.

Another aspect of this observation is the nature of both fire and law enforcement shift work. One shift may not necessarily receive knowledge about fires or crimes from the previous shift. In the aggregate, the statistical and reporting mechanisms available to the state may not be adequate or equipped to recognize serial events in progress. Further, the legal procedural path may also preclude identification of previous bad acts by an individual prior to an arrest in a current case. To overcome this problem, counties identified with arson fires were proportionally compared to a typical level of fire responses in that area, as a base line.

Fire activity above or beyond the normal baseline was then further examined to determine whether the responses suggested a cluster.

Classification of arson. The first of two issues that need to be identified are the violent crime vs. property crime designation. An argument can be made that arson is a crime of violence and not a property crime, as it is many times categorized. However, intentionally set fires are sometimes listed as property crimes and are routinely downgraded as criminal mischief. There are wide variances in the arrest, prosecution and reporting of fires, particularly intentionally set fires. All of this may confuse a system already deficient in reporting some types of fires and the disparate agencies that have jurisdiction over the investigation of the fires. This is not limited to fires that may have criminal implications; accidental fires are also subject to reporting discrepancies throughout the system.

In the second associated issue, these discrepancies may serve to hide or alter the reported nature of clusters of fires in the same geographic vicinity. There is no single standardized fire reporting mechanism available to the state. Reporting is more aligned with jurisdiction than the event. This study examined the property crime issue and culled fire related criminal activity from available records.

Limitations and Delimitations

The study was limited to archival data. Within the State of Florida, there are three primary sources of information regarding fires. They are the Augmented Criminal Information Support System (ACISS) maintained by the Division of Investigative and Forensic Services (Bureau of Fire, Arson & Explosives Investigations), the Florida Fire Information Reporting System (FFIRS) maintained by the State Fire Marshal, and Florida crime statistics maintained and compiled by the Florida Department of Law Enforcement. All three sources are comprehensive within their design capabilities, but they also have

deficiencies not anticipated when the initial programs were started. However, this archival data does have information dating to the early 1990's. As such, all three have the potential to add both new and known information on fire clusters and the depth of data to potentially provide considerable statistical strength to inferences.

The current study is limited to this archival data for several reasons. First is the overwhelming breadth and longevity of the effort. The archival data provides the best material available to explore possible patterns and ultimately to make inferences about serial arsonists. Officials at the Divisions of Investigative and Forensic Support and the State Fire Marshal who provided access to this data reported that, to their knowledge, no previous studies had ever used this data for a purpose other than aggregating national data.

Second, the unique application of statistical operations to a large database has never before been subjected to such research. The third reason to limit the study to archival data is the distinct possibility that new and emergent observations may be made from the initial review of the information at hand. In short, at this very preliminary unpacking of the existing data, not all questions may be known.

Definition of Terms

The following terms are used within this research to identify potential aspects related to serial arsonists.

Arson. Arson is the intentional lighting of a fire which results in damage or harm to any person or property. Arson is the (act) crime of maliciously and intentionally, or recklessly starting a fire or causing an explosion (NFPA 921, 2017). This may also be referred to as an intentionally lit fire.

Arsonist. An arsonist is a person who engages in criminal fire-setting. All arsonists are fire setters; however legally, not all fire-setters are arsonists. A serial fire-setter is an individual,

regardless of age, who has set more than three fires. These arson fire sets can be further divided into mass, spree, or serial episodes. The FBI lists fire-setting motives such as: revenge, excitement, vandalism, profit, crime concealment, and extremist views (Douglas, Burgess, Burgess & Ressler, 2013).

Call for Service. A call for service is a request for a public safety department to respond to an incident, usually initiated through the county 911 systems.

Cluster. A cluster, for the purposes of this study, is a group of three or more fires connected by spatial-temporal similarities, methods, targets or location. As used in this study, a cluster represents a group of measurable events to which there was a fire department response.

Contagion. A contagion as it applies to serial fire setting is an urge or compulsion to light a fire as a result of a previously ignited fire. It is an urge or compulsion passed from an event to an individual who eventually lights a fire, regardless of size or sophistication. As presented herein, a contagion for a serial fire-setter is the fire created as a result of a trigger, for example, a spectacularly visual fire observed in person or on some type of media.

Decay. In the current paper, the term decay refers to the distance from a triggering event. Decay to extinguishment may represent a distance or a time.

Diminishment. Diminishment used in this paper is the passing of the offender from fire setting onto newer modes of criminal behavior or the cessation of fire setting altogether.

Fire Set. A fire set is the actual physical act of creating an incendiary fire. It is an act by a human created via some type of ignition device (electric, chemical or physical). It must satisfy the requirements for fire, which are the presence of a fuel, a heat source, oxygen and a continuing chemical reaction (burning). This is the essence of the fire tetrahedron.

Fire Setter. A fire setter is a human who ignites a combustible material.

Hunting grounds. Offender hunting grounds represent a concept that limits the offender to areas of familiarity such as those expressed in the Routine Activities Theory, or to specific areas that lessen the possibility that the offender will be discovered as detailed in the Rational Choice Theory (Curran & Renzetti, 2001). Both theories of offender activity by geography are found with serial fire-setters. Another possibility is the serial fire-setter who sets fires indiscriminately in the most immediate or accessible area that contains fuel and an ignition source.

Journey to Crime. Journey to crime is the distance that an offender travels from a home base to the location of the offense.

Mass Arson. Mass arson is a series of at least three fires at the same location in a short period of time. An example of a mass arson event would be (for instance) multiple fires set in school bathrooms on the same school day.

Pre-Event Correlate. That act, condition, or environmental occurrence which precedes an arson event.

Post-Event Correlate. The residue, reaction, or social response to an arson event.

Serial Arson. Serial Arson consists of a series of at least three fires in different locations over a period of time, with a cooling-off period between fires.

Spree Arson. Spree Arsons are a series of at least three fires in different locations, in a short period of time.

Trigger. A trigger, as it relates to serial fire setting is that event, emotion, or other impulse, which releases a serial fire-setter from any inhibition to light a fire. It is distinct from a tipping point because a trigger is a singular event.

Tipping Point. The tipping point as used here is the point where the serial offender actively starts to plan or acts to commit a crime. In the case of serial fire-setters, it is the point where the previous fire no longer provides the stimulus to hold the urge to set fires at bay. The tipping point is the final stage of a continuum of emotional behavior that is found in the decay of the effect of the fire.

Violent Crime versus Property Crime. Violent crime is a reportable event, as defined by the U.S. Bureau of Criminal Statistics. These are the crimes that account for the Tier 1, violent felonies. The judicial district or county tracks these crimes to determine the overall rate of risk for citizens. Arson is classified as a Tier 1 violent felony, but is also listed as a property crime, or a Tier 2 felony. The distinction is subtle, but important in the study of arsons and serial fire-setters. Because of the nature of property crimes, national reporting of crimes relegates most (if not all) property crimes to local jurisdictions.

Summary

There are administrative, investigative, and structural barriers to an accurate accounting of serial arsons. Self-reports of fire setting activity clearly indicate that a significant number of fires are not being correctly identified as intentionally set (Grant & Kim, 2007). While the reasons for this are also a result of the limitations of investigative science, there are environmental clues that are not being utilized. Clusters of fires, which occur beyond the statistical element of chance, may be the single best indicator of a serial arsonist at work.

The question at the heart of the issue is whether there are historical markers which precede fire clusters or other events that occur after the fires begin. The study of arson has been limited to the cognitive aspects of the fire-setter, typically in a clinical setting, and to investigative observations based on the type of ignition, fire set, or the target. All of these

dimensions of serial arson are important, and their study is critical to an understanding of the serial arsonist. However, observation that focuses on the local, the neighborhood, the environmental aspects that precede an arson cluster and those items that can be captured after the fires, represent a rarely explored area in fire investigations. New observations using standard reporting structures as they evolve may also offer new and unique insight into the triggering and process of serial arson clusters.

Chapter 2: Literature Review

The Nature of the Problem

The premise of this study is that serial arsonists do not erupt and suddenly appear in a neighborhood. Rather, there may be a discernable and logical progression before clusters become apparent and there may be triggers or other socio-economic conditions that precede the fires. These possible triggers and other actions may be observed, recorded and otherwise discovered by the investigator. This study seeks to place the fire clusters into a temporal-spatial and criminological context. An examination of the current programs, databases and the nature of the public safety response to fires are explored. These include the importance of clusters, the tracking of fires through both the UCR and NFIRS, and current biopsychosocial theories of firesetting.

The importance of the phenomenon of fire clusters among the greater overall fire events is that it allows a study of a small but significant subset of offenders. The serial fire-setter can cause extensive damage. Fires in a confined temporal-spatial event, or fires that occur among similar targets are the most visible and identifiable signatures of a serial fire-setter. The fires themselves are many times a matter of record, even if there is no determination of cause for the fire. This official record of the event is found in the ongoing reporting of public safety responses throughout Florida. As such, spatially or temporally similar fires may become the physical markers of a serial event. Within this study, these observable markers include; total fires within a specific area (F), total fires within the county (CF), density of the fires within the cluster (CD), the overall crime rate in the county (CR) and the subsets of overall crime rates, violent crime rate (VC) and property crime rates (PC). The post fire markers examined included; target (TA), time of fire (TL), day of week of the fire (DW), illumination at the time of first call (IL) and the use of an accelerant (AC).

Data from the United States Fire Administration (USFA) indicate that in 2015 there were 1,345,500 fires reported within the United States (Aherns, 2017). These in turn caused 3,280 deaths, approximately 15,700 injuries and $14.3 billion in property damage (Haynes, 2016; Aherns, 2017). In the five-year period from 2007-2011, approximately 13,340 citizens lost their lives to fire (USFA, 2013). Nearly 2/5 of all pre-school deaths were related to juvenile-set fires. Burning is the third leading cause of death for pre-school children (Centers for Disease Control, 2008). African-American children are twice as likely to die in fire than any other ethnic group (NFPA, 2010). Roberts (1997) found that, in Wales and England, children from a lower economic class were at significantly greater risk from fire than other children.

A study conducted by Shai and Lupinacci (2003) regarding fatality fires involving children (arguably the most vulnerable of a home's occupants) was conducted during 1982–1983 in Philadelphia using fire response reports. The researchers found that there were five statistically significant conditions that were associated with child deaths due to fire. They were: low-income neighborhoods, single parent families, presence of children under 19, the overall number of children in the neighborhood, and finally use of domiciles built prior to 1939. This became apparent when it was discovered that from 1996 to 2000, Philadelphia children were more likely to die in fire than in an automobile accident. The study found that socially, arson deaths were associated with the drug trade and domestic violence, and accidental deaths were attributed to the poor neighborhoods (Shai & Lupinacci, 2003).

Cloniger (1990) found that a possible corollary to the arson issue was that, as the value of homes fell below the insured value, abandonment of the home through arson became more prevalent. This type of activity is normally associated with economically distressed

neighborhoods. Spillman and Zak (1979) found admittedly weak correlations between the economy and arson. Their study of Nashville, Tennessee from 1963 to 1976 demonstrated a possible link between economic vitality of the community and arsons – albeit at least one business cycle distant from the initial social and economic disruption.

The Uniform Crime Report

In addition to fires which have been unaccounted for, there are other inherent problems with the Uniform Crime Reports (UCR). According to Kelling and Coles (1996), problems with the statistical use of the UCR have been apparent since the 1960's. A Congressional mandate in 1978 directed that arson be classified as the eighth index crime tracked by the federal government. This was further emphasized in the Anti-Arson Act of 1982 (Akiyama & Pfeiffer, 1984).

Jackson (1988) listed four reasons that the UCR are not accurately tracking fires within their systems. They include the unique characteristic of fire as both a property crime and a violent crime. The delayed characterization of a fire as arson results because of the forensic and investigative process needed to determine the fire was arson. Another reason is the disparity between jurisdictional investigative agencies. Finally, owing to the nature of fire investigation, a fire can be reported as suspicious in the fire agencies but there is no category for suspicious fires within the UCR. Jackson's conclusion was that the arson data within the UCR is significantly lower than that reported by the fire departments. Further, this was applicable throughout the United States. Notwithstanding national efforts to accurately detail the true number of arsons, the fact is the true number is unknown and most likely grossly underreported. To emphasize the point, in a Las Vegas, Nevada study of adolescent self-reports of fire setting, Britt (2011) found that 70.6% of the participants had a response from

the fire department, police, or school when they initiated a fire event. However, nearly one third (29.4%) of the self-reported fire events were undocumented and/or had no response.

In a study on arson detection rates in the United Kingdom, Hopkins (2009) tabulated a gap of 263,900 fires from arsons known to the Fire Rescue Service (317,100) and those arsons recorded with the police (53,200). Using data from 2003 to 2004, the results of this study, were consistent with subsequent years.

Within Florida, in 2014 there were 49,107 reported fires (Florida State Fire Marshal (SFM), 2015). Approximately 8.27% of these fires are known to be arson, with an additional 15.1% undetermined. Within the fire investigation community, an undetermined fire is an unfortunate fact and is not necessarily rare. What it portends is a gap in information regarding the classification of fires, which are either accidental or intentional. By implication, the 8.27% arson rate in Florida may be low. There are statistical, structural, and policy gaps in the overall fire reporting criteria within the state and certainly within the country. Table 1 shows the statistical disparity between the national view of the arson rate (1.78% of all fires) and the more local Florida accounting (8.27% of Florida fires). For reasons of statistical certainty, the National Fire Protection Association (NFPA) does not list undetermined fires but places them in the accidental or arson categories based on an internally developed algorithm.

Table 1

Comparison of fire in the United States and Florida, 2015

	National	**Florida**

All Fires	1,345,500	49,107
Arson	23,000 (EST) [1.71%]	4,061 [8.27%]
Undetermined	Note 1	7,414 [15.1%]

Note 1: The NFPA assigns fires of undetermined or unknown cause to a known fire category based on an algorithm developed internal to their statistical protocols. NFPA (2017).

These issues are not confined to the categorization and accounting of fire-related crimes. Other issues become apparent with the study of arson and crime in general. Hering and Bair (2014) produced a study that highlighted the lack of quality data available to geospatially and chronologically plot offender activity. However, this lack of "quality" data may have more to do with granularity than quality. Reports are made for nearly every call first responders are tasked to attend. Data included in these reports are a function of jurisdiction and specialization.

There are fires that are unreported throughout the state and some may have significance well beyond the usual moniker of "nuisance fires." Additionally, sometimes clusters of these fires that occur in a limited time within a neighborhood only become apparent after a major fire response occurs. In fact, the major conflagration may be the outcome of a practicing serial arsonist. There is a suggestion that, by the time investigators become aware of a possible arson cluster, it may already have been preceded by other fires which for one reason or another were not categorized as an intentionally lit fire. Grant and Kim (2007) confirmed this when they found that a group of diagnosed pyromaniacs engaged in fire-setting that was unknown to public safety agencies. Further, Grant and Kim offered the opinion that some of the fire-setting activity could not be construed as arson, so by inference they may not have come to the attention of public safety agencies or fire investigators.

Overall, non-fire related property crimes, violent crimes, and arsons might tend to parallel each other. That is to say, areas of high crime also experience higher incidences of arson. The property crime rate for the United States in 2014 was 2,574.1 crimes per 100,000 (U.S. Dept. of Justice, 2014). Within Florida, the property crime rate for 2014 was assessed as 2,983.9 crimes per 100,000 (Florida Department of Law Enforcement, 2016). As collected by law enforcement agencies, arsons in the United States in 2014 totaled 39,174. There are 29,953 fire departments nationally and 563 fire departments in the State of Florida (NFPA, 2016). Via the Uniform Crime Report, the FBI lists 14,750 law enforcement agencies throughout the nation (DOJ, 2014). Within Florida, there are 357 law enforcement agencies (DOJ, 2011). There were approximately 23,000 intentionally set fires in 2015 according to the National Fire Protection Association (NFPA, 2016). There is no information regarding how many fire agencies reported intentionally set fires to law enforcement or how many were included in the statistics.

De-confliction of agency circular reporting regarding fire incidents is currently an issue within the crime statistics effort, and the number of caveats and warnings posted by the FBI regarding arson statistics is an apparent recognition of the problem. Added to this is the number of undetermined fires, fires where a fire agency did not respond, and fires where a law enforcement agency did not respond or make a report, subsequently turning over reporting responsibilities to another agency. Table 2 shows the wide disparity between arsons tabulated by law enforcement and those tabulated by the fire services. Without an accurate accounting of fires, specifically those that meet the minimum definition of a cluster, no reasonable explanation of the pre-and post-event correlates is possible.

This study reviewed the data and identified previously undisclosed incendiary fires among those that were previously characterized as undetermined or accidental. Added to the overall number of fire responses, a subset of which are arsons, is the number of undetermined fires and fires for which the fire department and law enforcement agency are not trained or equipped to classify them as arson. These typically include the "nuisance" fires that occur in neighborhoods with little to no apparent explanation. It is possible that there are more fires associated with clusters than is currently known. The reporting system for fires, as currently configured, is not capable of capturing the entire gamut of fires. This is particularly true in cases of nuisance fires, which may not reach a level of concern.

Table 2

Comparison of fires in the United States as reported by Fire Agencies and Law Enforcement Agencies, 2015

	National	**Florida**
All Fires	1,345,500	49,107
Arson	23,000 (EST) [1.71%]	4,061 [8.27%]
Undetermined	Note 1	7,414 [15.1%]
Law Enforcement	39,174 [2.9%]	285 [.6%] Note 2

Note 1: The NFPA assigns a description of undetermined or unknown cause fires to a known fire category based on an algorithm developed internal to their statistical protocols. NFPA (2017).
Note 2: Florida law enforcement arson numbers are based on arrest data compiled by the Florida Department of Law Enforcement. Crime in Florida, 2015.

Background

Fire setting has a deficit of criminological theory that would support arson in all circumstances. Plainly stated, a lack of etiological theories exists that adequately describe the fire-setter (Gannon & Pina, 2010). Sparse and inaccurate theories exist

within the scope of most criminological theory that applies to fire setting offenders. Most scientific examination has taken place at the psychological level (the arsonist) with some analysis of the target selection and technique (profiling). However, no examination has been made of known external factors which either announce the arrival of a cluster of fires (the hallmark of a serial fire-setter), or show that conditions are present to trigger someone who may be predisposed to light fires. There is a deficit of empirical proof about why serial fire-setters light fires. The reasons some offenders light fires remain so varied that they may inhibit any association with a theory of crime.

Associating the target and other related activities with a reasonably accurate general theory of crime might assist in the identification of the fire-setter. With very few exceptions, all theories might sometimes apply to specific cases, but arson is difficult to generalize in its sociological setting. Fires can be observed, but are rarely placed into a social context. Cohen (1955) found no utilitarian use or rationality among various juvenile crimes. But when placed into context, the research revealed much about the offender and the social foundation of the group. The use of a contextual framework could be beneficial in attempting to understand serial fire setting. Clusters of fires that can be attributed to an individual are the important signatures. They are the most visible and forensically relevant data that can be observed and studied.

Not all prominent or available theories of crime have been examined in light of serial fire setting. While some criminal theory fits nicely with fire setting, such as the routine activities theory (Curren & Renzetti, 1994), most of these events are one-and-done type fires initiated by juveniles. Research by Sapp, Huff, Gary, Icove and Horbet (1994), and Britt (2011), suggests that in most instances fire setting is primarily a juvenile event.

According to the FBI, adults may commit arson to further a crime, conceal a crime, or for revenge (Douglas, et al., 2013). However, juvenile fire-setters may light fires for reasons beyond a specific goal. Becker, Stuewig, Herrera and McClosky (2004) suggest that much of this type of fire-setting activity may be an attempt to communicate distress or injury the child has experienced. This is consistent with other studies conducted in England (Jackson, 1994), and further evidence may suggest that adults also engage in serial fire setting in a compressed time and space in order to relieve distress or uncomfortable situations (Gannon, Ciardha, Doley and Alleyne, 2012).

However, a cluster of fires represents the serial fire-setter, who continues along a trajectory, which may become more dangerous over time. Brett, (2004) did not find support for the notion that fire-setters are inherently dangerous but he goes on to state that fire setting is poorly understood. While there have been numerous attempts to find an elusive theory of fire setting, most of these attempts have originated in observations of clinicians who are working with fire-setters. To date, none adequately address the serial fire-setter absent a comorbid psychological diagnosis.

This has led in the past to a movement to make fire setting its own psychological category typically diagnosed as pyromania or pyrophilia type disorders (APA, 2013). Other attempts to place fire setting in a continuum of criminal theory fall short (Singer & Hensley, 2004; Ciardha & Gannon, 2012). The overall problem is some type of interpretation of the fire scene, which has both meaning and can infer a possible suspect (Canter & Youngs, 2009).

Serial Firesetters. This study focused on serial firesetters through the lens of clusters of similar fires (spatially, temporally and objectively). The observable byproducts of a serial fire event were examined to create an actionable path forward for the fire investigator. The

literature suggests that serial firesetting may have meaning beyond just the target (Gannon, et.al, 2012) (Canter & Youngs, 2012). Conversely, there are suggestions that the fire is the object, not necessarily the target (Fineman, 1995). The one aspect of serial fire events that possibly differentiates them from other crimes is the consistency of action on the part of the serial fire setter. It is always fire; it is local in the case of polygon clusters and it appears to be temporally consistent. Another aspect may be the age of the offender, with juvenile firesetters out numbering adult firesetters (MacKay, et.al, 2012) (Lewis & Yarnell, 1951). Within the current literature, there are four basic attributes of serial firesetting that become apparent, they are: Consistency, Timing, Drive and Journey to Crime.

Consistency. Patterns examined in serial fire events suggest that there is some sort of consistent pattern either through the timing, the event, the target or the proximity of one fire to another.

Timing. When the fire is first reported may have significance and may also help to identify the serial firesetter. Fires set during after school hours may suggest a juvenile firesetter, while fires set over a lunch period may suggest an adult (Britt, 2011). Fires set during the Thursday – Sunday period may suggest some alcohol involvement (Hakkanen, et.al, 2004).

Drive. The drive or impulse to set fires may have both psychological and temporal roots. The serial firesetter may be driven by pressures that are outside of the immediate control of the offender (Agnew, 1992). Research suggests that impulse control disorders are a leading determinant of serial firesetting (Dell'Osso, et.al, 2006).

Journey to Crime. Notwithstanding the cluster, organized by time, place, type or target – it is the journey to crime, which may most clearly identify a serial fire event. Polygon

clustering suggests that the offender is a local resident and taking the previous three conditions (Consistency, timing and drive) into account, must travel to the cluster area. Both the relative size of the fire cluster area and the distance which the offender traveled to light the fires may be significant and an identifiable aspect of the entire pathology. Linear clusters suggest some type of mobility, such as a vehicle.

Multi-Trajectory Theory of Adult Fire setting (M-TTAF). Gannon, et al. (2012), citing a lack of reporting regarding adult fire-setters in a clinical setting, sought to *theory-knit* (italics added) a workable multifactorial framework of fire setting. Their work is psychosocially oriented. The result of this effort is the Multi-Trajectory Theory of Adult Firesetting (M-TTAF). M-TTAF becomes a sort of collection of all theories of fire setting, where childhood or juvenile events anchor a future path toward fire setting as an adult. The theory's attractiveness is its all-inclusive nature and the reasonable presumption that not all serial arsonists come from the same family, social, or psychological background. Within the context of M-TTAF, five trajectories were noted which support the overall premise of the theory. They are: antisocial cognition, grievance, fire interest, emotionally expressive (including a need for recognition), and a multi-faceted trajectory. M-TTAF relies on the Functional Analysis Theory pioneered by Jackson, Glass and Hope (1987) and the Fineman (1995) Dynamic Behavior Theory (of fire setting). All are grounded in previous work with fire-setters and attempts to develop some sort of generalizable theory about fire setting. M-TTAF also conspicuously notes the "hero" role or fires set for recognition. This area is a very understudied phenomenon; many times, these can be the result of firefighters setting fires (Geller, 2008).

M-TTAF is unique in its incorporation of childhood and adolescent events (distal factors) that create a script or predispose the fire-setter to actions when a trigger is presented (proximal events). It also allows and incorporates multiple distal factors, which can influence a fire setting response when a proximal trigger is experienced. These multiple childhood and adolescent factors combine in such a manner that they produce an adult pre-disposed to light fires under the right circumstances. Viewed in this light, a fire-setter is a psychologically and socially engineered offender in a manner similar to a burglar or rapist.

The following segments break down the issues which might lead to arson by various types of fire setters. These include:

Antisocial cognition. The antisocial fire-setter is the result of a poorly regulated response to social interactions. Vandalism is a possible outward marker of the antisocial offender and vandalism by fire or criminal mischief may be the most common public safety interaction with this person. Other typologies include, but are not limited to, crime concealment (when this is part of a repeated modus operandi) and fires set out of boredom. These fire-setters would typically exhibit conduct disorder and antisocial personality disorders in childhood or early adulthood.

Grievance. The fire-setter who is unable to socially and safely express a grievance may use fire, or a learned fire script to attempt to resolve issues. Grievance is closely aligned with antisocial thoughts and feelings and may have a component in the grievance trajectory. However, the grievance trajectory has more to do with displaced aggression than antisocial tendencies. The grievance path of fire setting includes those

who have low assertiveness and anger toward another person or possibly an institution. Grievance fire-setting trajectories include revenge and retribution themes.

Fire Interest. Unregulated fire interest has always been a component of fire-setting activities. In fact, there is evidence that the majority of children experience a stage of fire curiosity and interest, but grow out of it. In some instances, they may be referred to a juvenile fire-setter program and become one of the many "one and done" kids. Others remain focused on fire setting and it develops into an unhealthy compulsion. The fire-setting script is written at this stage of development.

Expression. Within the expressive (or as stated, the emotionally expressive) fire setter are found the clinical presentations of depression, inability to communicate, and a fire-starting script inappropriate to the circumstances. This is where Jackson et al.'s (1987) theory, known as the no other viable option theory, has prominence. Included within the Jackson–M-TTAF trajectories are the "cry for help" fires, including self-harm issues and the possibility of suicide or an attempted suicide. Yarnell (1940) may have initially observed this phenomenon. Of note, there is an empirically validated precedence for suicide and attempts at suicide among serial fire-setters. The expressive fire-setter is at war with the world and themselves (Canter & Fritzon, 1998). Separate, but included in the expressive trajectory are the firefighter (and police or public servant) arsonists, who may light fires as a result of a need for excitement or recognition.

Multi-factor. The multi-factor reason for fire setting becomes a catchall for those observed fire-setting events that do not or cannot fit into one of the previous trajectories. Included in the multi-factor trajectory are conduct disorder and impulse control diagnoses, which have some empirical basis in serial fire setting (Repo &

Virkunnen, 1997; Dell'Osso, Altamura, Allen, Marazziti & Hollander, 2006). Overall, the multi-factor trajectory is viewed as a values and attitudinal issue which supports lighting fires.

M-TTAF as a generalizable theory has only recently been empirically tested and has found partial validation (Dalhuisen, Koenraadt & Liem, 2017). The authors note many problems with this theory. However, they contend that the foundation is established via previous empirically-proven fire setting typologies. M-TTAF appears to be consistent with all the previously cited theories used in this study. The implications of M-TTAF are that the proximal events (clusters of fires) may influence fire investigations with a clear direction to the distal origins of the acts. This supports the significance of the target, as well as the other aspects of cluster investigation through time of day, day of week, and possibly other target analysis items of concern that may become apparent in the typical fire investigation.

Mechanisms of Serial Arson

The mechanisms involved in serial arson include:

Area. The location of a series of fire may be one of the most salient predictors of a serial arson event. The area may serve to announce the beginning of the event; it also defines the boundary of the fires. This may become vital in any investigation of fires, with past offender activity as possibly a distinct predictor of future crime – including arson. Areas of older homes may provide the foundation for a serial arson event. Older homes in aging neighborhoods could become targets for the practical reason that they may be neglected, damaged or even abandoned. These structures are very vulnerable to fire and many have not been updated to recent safety codes or are grandfathered to

bypass the most recent hurricane and fire codes. Gentrifying neighborhoods are also subject to examination, as the previous generation that populated the neighborhood passes on. This leaves a residue of older homes falling into probate, being sold, or abandoned. Conversely, the area of firesetting activity may have less focus on the target and more on the availability of a suitable fuel. The expansion of a fire cluster may be driven by the ability to access suitable, combustible fuels such as dried vegetation or abandoned structures.

Previous Fire Activity Levels. In theory, every area has some type of fire and crime activity level. The reports of calls for service clearly document the fire activity within any given fire district, and sometimes within the county depending on how the local fire department is organized. Each of these responses (fire, car crash, EMS, etc.) is detailed in some form, typically in Florida in the FFIRS. By examining the previous fire activity in any given area, a rhythm of fire responses may be determined. Even areas with minimal fire responses would have something, which would allow tabulation of the average fire response per unit of time. Of note, a serial arson event would appear as a spike in the normal response pattern regardless of the overall numbers of responses to the fires. The current study examines this very phenomenon. This spike may become the unique signature or at the very least the initial warning of a serial arson series in progress.

Property Crime. Crime in the neighborhood may be critical to understanding the overall mosaic of offender actions. Control Balance Theory, Social Disorganization Theory, Social Learning Theory and Strain Theory all may have a legitimate role in the social health of the neighborhood (Curren & Renzetti, 2001). Firesetting within the area may be a result of other distress or may be an adjunct to ongoing offender activities. There are some suggestions

that firesetting is a developmental activity en route to other, more violent crimes (MacDonald, 1963; Wax & Haddox, 1974). The first, most obvious activity to examine is current or previous firesetting within the neighborhood. This may not be defined as clusters of fires, but instead represent fires that are used as revenge in drug-plagued areas, insurance fraud, or other fires that occur incidental to ongoing neighborhood activities. There is some evidence that incipient serial arsonists are attracted to, and may be triggered by, local conflagrations.

Other crimes beyond those involving fire may add to the overall social disorganization, or highlight the lack of control balance within the area. In some cases, burglars will ignite something in a structure to camouflage the burglary. There are no known studies that address these actions, as they pertain to clusters. In fact, if fires occur during breaking and entering and burglary of a structure, they may present as clusters if the fire is associated with the preceding crime and if the offenders are routinely conducting B&E and burglary. Vehicle theft, which originates in the neighborhood may have some relevance to firesetting when the vehicle is discovered or recovered and is found burned up. This is not an uncommon occurrence. There are no known studies that have associated vehicle theft and later vehicle arson clusters. The reverse may also be true – although there are no known studies or examples – when a car is stolen from another area and brought to the neighborhood to be burned. The question is, why was the vehicle destroyed in that new location?

Violent Crime. Finally, abuse in its many forms, suggestive of Strain Theory (Agnew, 1992) causes triggers which can occur in any neighborhood. Child and domestic abuse are apparent in some areas and it has been suggested that economic distress may be a cause in some cases. These actions may trigger a firesetting episode as

a response to the abuse or as a plea for help (Burnett and Hatim, 2014). Domestic abuse which results in an arson is not typically associated with clusters, but with the destruction by fire of the property of the abuser. Citing Jackson, et al. (1987) the arsonist in this case is less assertive and aggrieved. For example, this can be an abused companion.

Overall Crime Rate. The overall crime rate bridges the possible gap between the designation of arson as a property crime or as a crime of violence. However, the fire is categorized, arson should be included in one of the two categories. The overall crime rate is used as a measure of overt criminal and offender activity within the county jurisdiction.

Clustering. Each fire set is unique to itself. However, those attributed to the same individual within a cluster (three or more) would seem to have some connective evidence. Possible connections could be spatial, thematic, technical or temporal. In that light, each cluster may have its own signature.

Spatial differentiation. In all of the episodic firesetting events, the spatial dimension remains one of the most enduring quantifiable aspects of the crimes. There is some evidence that serial fire-setters are neighborhood offenders and do not typically travel long distances to set fires. This is critically important, particularly in light of recent studies that have attempted to identify the home base of the arsonist through an analysis of the individual fires, which make up the cluster (Rossmo, Lu & Fang, 2012). Additionally, it is proposed that not all fires (particularly the nuisance fires) are being included in the overall spatial view. If they were included, the resolution of the offenders and their home bases would be that much more in focus.

Thematic differentiation. The target of fire-setters may have some thematic quality that might provide insight about the reason for the fires. Themes such as rage against an institution, displaced aggression against a person, or even dissatisfaction with the quality of the fire-setters' life, could be themes that might be discerned in the choice of targets.

The significance of the identification of a theme would enhance the overall effort to identify the fire-setter. Themes, if discernable, might support the theory of communication by fire, such as that proposed by Jackson, et al. (1987). Also, if a theme is apparent, it may be one that can be directly tied to an institution, an activity (such as bullying) or an antagonist.

Technical differentiation. Douglas, et al. (2013) contends that in a manner similar to serial rapists and burglars, serial fire-setters will develop a signature method of lighting fires. Sapp, et al. (1994) found that the majority of serial arsonists used common combustibles found at the fire scene and regular matches. The use of paper or wood matches may be a generational item owing to the wide use of butane lighters today. Regardless, the use of common combustibles (paper, leaves, debris) and a routinely carried and possessed fire ignition device is so common that it becomes insignificant during the fire investigation and of mild interest after an arrest. However, if the serial firesetting signature did include an accelerant or exotic fire ignition technique or device, that would certainly qualify and be of great interest to the fire investigator.

Another aspect is the relative sophistication of fire sets from the first to the most recent. Kindling Theory would support the proposition that as the serial fire-setter set more fires, they would become more efficient, creating larger and more sophisticated

fires as the offender learned the science behind them (Brett, 2004). Taken in this light, crude and simple fire sets would characterize the initial fires in a cluster. Later fires would be larger and attract more attention. There may be some empirical basis to this if nuisance fires are able to be associated with the cluster. Those initial trash can and dumpster fires may represent a fire-setter learning to set fires.

Temporal Differentiation. Fires set during a specific time within a neighborhood could be significant and might be a key indicator of the age of the fire-setter. Fires set during normal school or work hours would tend to be older fire-setters, while fires set before or after school hours are suggestive of a juvenile fire-setter (Bowling and Hatim, 2014) (Britt, 2011). Fires set during the late evening hours again might suggest an older offender or an unsupervised juvenile. Sapp, et al. (1994) found that most arsonists walked to their targets. Factors such as habitual late-night walking have been implicated in some serial fire-setter methods. Further, some neighborhood travel, such as walking the pet or simply taking a walk, may serve as reconnaissance forays to identify future targets.

A significant number of arsonists preplanned their fire-setting activities within the neighborhood and this may have been done during these neighborhood walks. There are no known studies that have examined whether there is a difference between travel to the target to reconnoiter and travel to set it on fire, or if there is a difference in the time of day such actions took place. Another dimension to the overall phenomenon of firesetting would be the time gap(s) between reconnoitering and setting the fire, but this data is not available from the state reporting system. However speculative, time compression observations might satisfy the prevailing theories of pressure building in the fire-setter to

the point of setting a fire such, as proposed in some biopsychosocial theories (Dalhuisen, Kownraadt & Liem, 2017). Such observations could also provide insight into the routine of the fire-setter, such as one who sets fires on the same time and day over an extended period, suggesting routine activity.

These patterns may have more to do with the seemingly normal life of the fire-setter, who often must maintain a job, among other things. Because of this, the fire-setter may focus on a more stable, less random attack on the target. This may be in part because the target is inanimate and is probably available to the arsonist during periods of low human activity. A serial rapist, for instance, must await the target of their crime to arrive at the attack point or area. This makes the serial rapist more dependent on the actions of the target. The fire-setter, however, may have already reconnoitered one or several future arson attacks and is merely awaiting the trigger. Further, the pre-scouted targets may all share some sort of symbolic connection known only to the fire-setter until several attacks could reveal the connection.

The time during which arsons occur is vital to an understanding of who is lighting them. The time a fire occurs can be just as important as what is set on fire. Time of fires would serve to better define the temporal rhythm of the arsonist and allow some predictive analysis. Further, the time a fire occurs may provide insight into the fire-setter trajectory. Within Florida, fires peak at 3 P.M., with a steady climb from noon and continuing into the early morning hours (Florida SFM, 2015). At present, there are no computations involving the time of incendiary fires. There are also no known studies of a comparison between arson clusters and the time of the first response.

Sapp, et al. (1994) found that 42.5% of convicted and incarcerated serial arsonists set fires after work hours. However, the data for this was derived from a convenience sample and has come under increasing scrutiny, particularly since the baseline data has been opened to the criminological community in 2015. Kelm (2016) challenged the basic FBI behavioral assumptions and found that the conclusions cannot be statistically supported.

There are also incendiary fires set at random times which may indicate impulse control issues, revenge fires set when the opportunity presents itself and fires set in schools which tend to be during school hours. Other fires can be set at times that would allude to an economic motive versus a pathological one. This would imply a Rational Choice Theory or perhaps would be more in line with Jackson's functional analysis of fire-setter motivations where the arsonist is forced to communicate via fire (Jackson, et al., 1987). Fires at night suggest either access to the target or a need to conceal the offender. If the reason is to have unrestricted access to the target, such as when the business is closed or the parking lot is empty, Rational Choice and Routine Activities must be considered. If the fire during hours of darkness is meant to conceal the identity of the arsonist, Strain Theory and Kindling Theory may be the most appropriate fit. An examination of the target location and history may reveal social abandonment in the general area, suggesting a Social Control or Control Balance Theory at work (Tittle, 1995).

Research by Hipp, Bauer, Curran and Bollen (2004) contributes to the base of knowledge as it pertains to the timing of crime in general, and property crimes in particular, in their study of seasonal aspects of different types of crime. The data set,

over 8,000 crime reports over a three-year period, have sufficient volume to provide statistical strength to the study. The study found that property crimes are predominately committed during good weather. Beyond just noting the day and time, there may be seasonal aspects for arson clusters. Clusters predominately during summer months might imply juveniles, who are on summer vacation from school.

Illumination. It is unknown whether ambient light in the area of the fires is associated with the activity of arson (Stolzenberg, D'Alessio & Flexon, 2017). Further, it is unknown whether the availability of light or a lack of light is a precondition for an incendiary event.

Day of the Week. On what day of the week a fire occurs may provide insight into the fire setter (Wheeler,2015). Fires set on Friday night or Saturday might be associated with drinking. This is consistent with studies by Wood, Sher and Rutledge (2007). Hakkanen, Puolakka and Santtil (2004) found alcohol use to be a significant factor in arsons.

Area of fire setting activity. Hunting grounds may also define the fire-setter. Many theories abound, but the most persistent is the geospatial research that defines a limited hunting ground. In this instance, it has been implied that arsonists are criminally similar to serial rapists or burglars (Canter & Fritzon, 1998) (Rossmo, 2000). However, the geospatial universe of a fire-setter is vastly different from that of other serial offenders. Depending on such elements as triggers, contagions, prime motivations and other issues, the fire-setter may light fires as close as the backyard, or as distant as the range of an automobile. Alternatively, many studies have shown that serial offenders

establish themselves in a specific area defined by range at the distant end and domicile on the near end.

There is empirical evidence that some serial offenders avoid their own neighborhood and target an area away from their own homes or residences (Rossmo, 2000; Tonkin, Woodhams, Bull & Palmer, 2011). This is done to add an element of camouflage by range and to assist in the anonymity of the offender. Fire-setters may not be limited by the hunting ground concept applied to other serial offenders. One theory is of a foraging effect. This means in essence that the offender travels to an area to seek specific targets. Further, the foraging theory provides a solution to the geospatial aspect of serial firesetting by focusing on the target, be it near or far. This appears to be more appropriate to understanding serial fire-setters than the target location. In fact, there have been instances of fire-setters traveling extended distances to participate in ongoing arsons in a given community, such as the events in Coatesville, Pennsylvania in 2008-9 (Urbina, 2009). This suburban community witnessed a series of arsons, which eventually led to the arrest of no fewer than six arsonists, one of whom was a volunteer firefighter. In short, using the foraging theory of offender activity, the serial fire-setter is much more organized and criminally prepared than would otherwise be apparent.

A significant number of arsons are accomplished using common combustibles found at the scene. This has led some to propose that arsonists are categorically disorganized. Other research suggests that fire-setters are more organized than previously thought. In fact, targeting areas with available combustibles may be part of a pattern and might imply a degree of organization. Hering and Bair (2014) attempted to geospatially identify an offender through his target, target location, and time of offense.

The study reviews the forager theories, which contend that survival instincts alone will cause offenders to vary and disperse their offending to prevent apprehension.

Alternatively, the stomping ground theories present an offender operating in familiar areas, giving the offender a geographic advantage. This study is most appropriate for serial fire-setters because the concepts of mass burglary are addressed as a function of geospatial targeting, which may resemble serial firesetting episodes. Foraging theories also partially explain the proclivity of some serial fire-setters to survey the target in advance. While this might seem to be counter-intuitive to the impulsive nature of a number of serial fire-setters, investigative records have determined that in many instances, the arsonist was aware of the target before the triggering event. In this light, serial fire-setters may be similar to burglars, who exhibit greater clustering than robbers (Hering & Bair, 2014). Of note, are the clandestine nature of burglary and firesetting – a common aspect of those crimes.

Target. While an exploration of the mechanisms involved in serial firesetting include, but are not limited to, targets, hunting grounds, foraging effects and time compression issues, the target remains the most available item to investigate after the fire. The target of arson may be one of the most definitive characteristics that identify the serial fire-setter. In a significant number of studies, the target holds special significance to the fire-setter and links the fire-setter to a past narrative that might reveal the motivation for the offending behavior (Canter & Youngs, 2012). Of all the possible data collection variables, the target remains the most personal and is most likely to be unique to each individual fire-setter (although this has never been proven). Fire-setters who light

fires for reasons of societal or institutional revenge would be expected to attack something that represents the source of their anguish.

Identification of the target would be a very necessary first step to discern the cause of the firesetting. While this study is not necessarily concerned with solving who started the fire, the examination of the target and its association with some type of grievance would be a major step toward identification of a serial arsonist who is active in a community. Cantor and Youngs (2009, 2012) propose that the arsonist is expressive and expressing a grievance through the firesetting act. Determining the "what" may have a direct link to the "whom." This study sought to examine whether this is possible on a wider scale than has been accomplished to date. The FBI study of serial arson (Sapp, et al., 1994) noted that at least 50% of serial arsonists thought they had left something at the scene of a fire, which they felt would implicate them in the fire. Objectively, this may have more to do with an over-belief in criminal arson investigations than reality. However, the target remains the most tangible residue of arson.

Type. One study divided the target of an arsonist as person-oriented or thing-oriented (Hakkanen, et al., 2004). Despite the study conclusions, ultimately the real division seemed to consist of actual live persons who were assaulted by fire or a specific object which, to the arsonist, had come to represent a person. While unstated, the assault with flammable liquids appears to be more along the lines of a weapon (used) and not pathology.

Significance. It is the target, the thing set on fire or destroyed, which might represent the fingerprint that the arsonist leaves behind at the crime scene. The significance of the target cannot be understated. The nature of the target may provide the

overall best signature for an individual arsonist. The target must provide some link to the nature of the act in the mind of the serial fire-setter. In those cases where the act and resulting fire are the point, there will still be some residual connection with the target and the arsonist. This connection may sometimes be confused or may simply be a result of psychotic thinking, but there must be some connection that compels the serial fire-setter to light "that" object on fire. However, there are instances where the target is not so much the important item, but the timing. Opportunity, in this instance, may doom a lucrative target.

Use of accelerants. The use of accelerants distinguishes the arsonist in a way no other activity could. Using an accelerant suggests a level of pre-planning. Further, use of an accelerant suggests that the fire-setter is experienced and may have an extensive firesetting history.

Devices. The use of a device – closely associated with accelerant use – may also present as a signature. Use of an incendiary device, delayed or otherwise, represents a significant clue to the arsonist identity and motivation. Further, it technically ties fires to each other in a discernable cluster.

Summary

Criminological theory has potentially considerable application to understanding fire setting. At present, there is no adequate or empirically sufficient theory to address arson clusters. For this research, theories of fire setting that may be found in other, generalizable theories were examined. All these theories have elements that may apply to the fire-setter, yet they do not adequately account for the unique nature of the serial arsonist. Each of the variables detailed in Figure 1 may have a specific tie to a specific theory of crime. The conceptual model incorporates as many variables found in current

theories of crime that can be potentially observed and recorded from a fire scene. Of note, the Multi-Trajectory Theory of Adult Firesetting (M-TTAF), as a compilation of all theories has been proposed (Gannon, Ciardha, Doley & Alleyne, 2012). However, it has not met with widespread acceptance. Gannon and Pina (2010) examined biopsychosocial aspects and noted that these theories may help explain a predisposition to lighting fires, but they may still fall short of a generalizable pattern of offending which supports the actions of the serial fire-setter.

Kindling Theory may be the most observable phenomenon, if the fires within the clusters exhibit increasing sophistication and effectiveness (Brett, 2004). This is consistent with other studies (e.g., Anderson, Berkowitz, Donnerstien, Huesmann, Johnson, Linz, Malamuth & Wartella 2016; Doley, et al., 2013) which suggest that the triggers may be other fires preceding the cluster and ending with satiation and extensive media coverage. But again, Kindling Theory has several gaps that are not fully explained by known or observed actions of the fire-setter. This includes the displacement issues.

The social environment in a neighborhood may be critical to an understanding of the clusters and who lights the fires. Control and social disintegration have not been adequately examined in light of firesetting (Rasanen, Puumalainene, Janhonen & Vaisanen, 1996). While they have not been specifically noted in previous studies of firesetting, neither have these theories been scientifically excluded (Delisi & Hochstettler, 2002; Douglas, Butry & Presterman, 2011). It is unknown whether the neighborhood environment incubates the fire-setter, or if the fire-setter emerges and takes advantage of the social disintegration found in these areas. The target also takes on vital importance,

with the type and location perhaps revealing a theme of offending which may be unique to the offender.

Chapter 3: Methodology

Background

This chapter examines the predictor variables as viewed through Hypothesis 1 and 2. There are observable, testable spatial-temporal and target-related variables that may be associated with the fires, respectively. The variables of interest are independent of each other but can directly relate to H_1 and H_2 (Salkind, 2014). Hypothesis 3 examines the result of RQ-1 and RQ-2 significant variables in order to find statistically relevant variables which are able to predict an arson fire. Chapter 3 will address the participating agency products, the analytical instruments used to process the data, procedures and research design, how the data analysis was conducted, and overall limitations in this study.

Source of the data

This study did not have any human participants but utilized existing databases and open source materials. The information was analyzed with the data obtained from archival public and open source data.

Agency provided materials

There are two primary agencies within Florida, which are statutorily mandated to collect, compile and report data from the field regarding fires and fire investigation. One is the Office of Fire Statistics (of the State Fire Marshal), which collects and reports the fire response information collected by participating county and fire districts. The other is the Bureau of Fire, Arson, and Explosives Investigations (of the Division of Investigative and Forensic Services) that reports on fire investigations, including incendiary and accidental fires and explosions. A third agency, the Florida Department of Law Enforcement (FDLE), is the state-wide central depository for UCR information, and some criminal fire activity may be reported through this pipeline to the exclusion of the

other two fire-related reporting agencies. The Augmented Criminal Investigations Support System (ACISS) was used as the ultimate and final determination of the characterization of a fire; Incendiary, Accidental or Undetermined. FFIRS determinations were used when there was no corresponding ACISS report. UCR information was used to compare statewide numbers.

Programs and Databases used in the study

Florida Fire Incident Reporting System (FFIRS). The Florida Fire Incident Reporting System (FFIRS) is the State of Florida component comparable to the National Fire Incident Reporting System (NFIRS). NFIRS is a standardized reporting protocol used to unify and consolidate the entire range of fire department responses and activities (USFA, 2018). The FFIRS/NFIRS is comprised of 11 modules. The Basic module is the minimum required data element to initiate a FFIRS report. Other modules include, but are not limited to, fire incident identification, structure fire identification, casualty (both civilian and fire service) and emergency medical services. There is also an arson module. Unless information contained in Module 1 (basic fire response) was incomplete, most information used in this study was confined to Module 1.

Augmented Criminal Information Support System (ACISS). As used in this study, ACISS is a crime-tracking management program used by the Bureau of Fire, Arson and Explosives Investigation. ACISS provides forensic and investigative information on past, current, and ongoing criminal fire investigations. Within this study, only information on the date, time, and location of the fire, as well as the determination were used. Earlier reports within ACISS did not contain zip code information. This was overcome by associating the address with a zip code.

Florida Crime Report. The Florida Crime Report is a yearly summary of all reported crimes, and the categories of crimes and closure rates by county. It is compiled and maintained by the Florida Department of Law Enforcement. It is the data submitted to the FBI, Bureau of Crime Statistics for the national Crime in the United States survey published yearly.

U.S. Navy Astronomical Almanac. The astronomical almanac used was the Multiyear Interactive Computer Almanac (1800-2050). The U.S. Naval Observatory provides this information for both civilian and military use. It includes phases of the moon, illumination of celestial bodies, and other items used in navigation.

All databases used within this study were publicly available and were comprised of archival information. All investigative information (primarily found in ACISS) was shielded and was not used. In this light, in both FFIRS and ACISS only broad categorical information was derived from the databases.

Fire Occurrence Information

Fire averages. As a matter of gross estimates, it is possible that from the period 1996 through 2018 there may have been approximately 1,200,000 fires in Florida to which various fire departments responded. This is based on a very general average from the recent Florida Fires annual report from the State Fire Marshal's Office (SFM, 2015). Additionally, it is estimated that there may be up to 90,000 arsons during that same time frame. This estimate does not include wildland fires, which are reported under a separate reporting protocol used by the National and Florida Forest Service. Of note is the apparent long-term downward trend of fires and arson. Some of this is a result of increasingly safe materials used in structures and updated local building codes coming into national fire code compliance (Ahrens, 2017). For

the purpose of this study it was estimated that there are enough fire reports to support the study and to ensure the statistical strength of the conclusions (See Table 6).

Data Preparation

Background. Elements of the data and variables were chosen based on their availability and applicability to support the hypotheses'. Each predictor variable was operationalized and utilized within the study.

RQ-1 What are the pre-fire variables that uniquely predict whether a fire is arson or accidental? The data collection plan for RQ-1 is to examine the identified fire cluster and use available data to place the event into context. The outcome variable is a fire within a designated cluster.

Pre Fire Event Predictor Variables

Fires in the vicinity (F). Beyond fires which are reported by various news agencies, some research suggests that firesetting is a visual stimulus (Fineman, 1995). As such, a possible trigger for the fire cluster might be a local fire with the attendant response, trucks, sirens and public safety activity. If this is valid, then very local fires become important as a precursor to an arson cluster. These fires (specifically a truly neighborhood event) might not break the noise-to-signal ratio for more regional reporting, and as such would not become apparent in a media search. Far more accurate is the FFIRS report generated by the responding fire agency. The overall fire rate for the county was operationalized by using all fires (F) within a specific time frame and dividing that number by the total square miles of the county. This produced a standardized fire per square mile specific to the county (CFD). This was then compared against the cluster and the corresponding spike in fire activity per square mile and used to

highlight activity that was clearly above the county norm. The CFD was derived using all fires within the same calendar year.

Cluster density (CD). Using a geospatial program, plotting clustered fire events provided both the overall limit of the event spatially and some type of coordinate (most likely based on the FFIRS and ACISS address). The conceptual model (Figure 1) would capture the serial arson event as a cluster, with the event exhibiting a spike in fire activity relative to the normal fire activity in the neighborhood or county. Further, this increase in fire activity would be relatively compact. Cluster density was operationalized as a function of fires occurring within a specific geographic area.

County Crime Rates (CR). The prevalent types of crime within the neighborhoods were also used to provide insight into possible triggers. Using FDLE data, both by zip code and (in some instances) by county, a survey of the relative number and types of crimes was determined. Reasonably, the greatest clarity regarding previous crimes in the vicinity of the fire cluster would typically be found at the local level. Based on data from FDLE, each county was examined, and the violent and property crime rates obtained. These were then combined to present an overall crime rate. The overall crime rate was the sum of both the property crime rate and the violent crime rate, i.e., CR = VC+PC. These rates were derived from the previous year's UCR.

Property Crime (PC). Property Crime was obtained from the Uniform Crime Report for the year of the fires of interest. PC = n (property crimes)/100,000. The rate was derived from the previous year's UCR.

Violent Crime (VC). Violent Crime was obtained from the Uniform Crime Report for the year of the fires of interest. VC = n (violent crimes)/100,000. This rate was derived from the previous year's UCR.

RQ-2 (What are the post-fire variables that uniquely predict whether a fire is arson or accidental?) The data collection plan is to examine the identified fire cluster and use available data to place the event at the origin and the surrounding fire activity.

Post Event Predictor Variables

Target (TA). The target is defined in accordance with Table 3. It was numerically operationalized to align with the values assigned within the table. The target was generally described as the item that burned as it was noted in the reports.

Temporal observations. (TL) Times used for fire activity will be standardized as the alarm time. This represents the first identified time that a fire event became known to the responding fire agencies. Alarm time is the earliest time that is part of the overall fire response system statewide. The fire may have been set or may have occurred minutes or even hours prior to the alarm time, but rarely is there a record of this or rarely does an investigation reveal this. Reporting from local fire districts using FFIRS does not have an actual fire time but instead they use alarm time as the first awareness of a fire event. Barring the use of a delayed incendiary device, alarm time may be the overall best indicator of a fire's actual time of occurrence, albeit delayed. This is critical to the illumination (IL) observations.

Table 3.

Numerical assignment by target.

TARGET	ASSIGNMENT	Remarks
Residential Structure	1	Structures used as living spaces.
Commercial Structure	2	
Open field	3	Includes vacant lots and other open spaces. Also, wildland fires
School, university, or other educational facility	4	Includes school property
Refuse Container	5	Includes trash cans, dumpsters, and piles of garbage in dumps or recycling facilities, etc.
Vehicle & other mobile property	6	Includes cars, buses, motorcycles or any other conveyance.
Church or place of worship	7	Includes cemeteries and other religious facilities not otherwise noted.
Other	8	All targets not covered by above

Illumination (IL). Illumination is a percentage of ambient light available from the sun (100%) or moon at the time of the first alarm. It is presented as a percentage, i.e., half-moon would equal .500, and a quarter moon would equal .250. Illumination at the time of the fire event was obtained using the Multiyear Interactive Computer Almanac from the U.S. Naval Observatory. All celestial illumination calculations were based on the available illumination at the University of Florida observatory in Bronson, Florida. This process was used to determine the amount of illumination from the moon (if the fire was after sundown or prior to sunrise) as a percentage. A value of 100% illumination is either daytime or a full moon. The time of alarm was used as the base time for the computation. This was chosen as an approximate center point in the state and the best,

most convenient location to measure the illumination. However, there was no attempt to modify illumination based on local cloud conditions or precipitation.

Day of the Week. (DW) The day of the fire event was collected and noted. Fires which occur on weekends or holidays may contribute to an understanding of the opportunity for an arsonist to light fires, suggesting routine activities theory.

Accelerant Use (AC). Accelerant use was designated as either yes (1) or no (2). Note, because of the lack of information regarding accelerant use, it was later removed from the study as a post-event variable.

RQ-3 (What are the pre- and post-fire variables that uniquely predict whether or not an arson fire is a member of a cluster of fires or presents a unique pattern?)

Pre and Post Event Predictor Variables. Those observable variables, which could be used in the study, were culled from among many other data elements that make up the ACISS and FFIRS reports. Further, illumination was determined using the U.S. Naval Observatory Celestial Almanac as detailed below.

Cluster (CL). Cluster is operationalized as those fires with a close geospatial proximity to each other. This study categorized three distinct subsets of fires; undetermined fires, accidental fires and incendiary fires. Nearly all clusters within the study contained all three categories.

Cluster Density (CD). Once the cluster is identified and plotted, and the total area of the cluster is determined in square miles, the result will be used as the denominator of the total number of fires associated with the cluster, i.e., *Total associated fires / square miles*. This is expected to produce a number which the study designates as the **cluster density** or **CD**. Likewise, the total number of fires within the county was

divided by the total county area in square miles. This produced the normal fire activity within the county. As detailed earlier, the normalized county fire density **(CFD)** was used to contrast the **CD** against the norm. This was further computed against the total area in square miles of the county and the total number of fires in the same year as the cluster's fires. Fires in clusters that extended beyond a calendar year were likewise listed and computed with fire data from the year of the individual fire within the cluster.

Classification of Fire (CF). The classification of a fire is limited to the current investigative standard of accidental, undetermined, or incendiary. Previous use of the suspicious fire classification was converted to undetermined. Table 4 depicts the numeration of the three classifications.

Table 4

Classification of Fires

Classification	Assignment	Remarks
Incendiary	1	
Accidental	2	
Undetermined	3	Includes NFIRS category, "All other causes." And previous use of "suspicious."

The all other causes designation within FFIRS does not provide any other ancillary information, which might be an accurate determination of the fire either as accidental or incendiary. The previous use of suspicious fire determinations was ceased by the Bureau of Fire, Arson and Explosives in 2007.

Procedures

Research Design. The overall study design is a quantitative design (Edmonds & Kennedy, 2013; Creswell, 2014). There are two primary datasets, which will serve to provide the foundation of all fire-related reporting within the State of Florida. They are the FFIRS fire response reports and ACCIS fire investigation reports. At the most basic level, both reporting mechanisms register a fire event at a place and time (Ashby &

Bowers, 2012). This will establish the first level of identifying a cluster (Kulldorff, 1997).

Statistical Modeling and Treatment

Logistic regression application. Using the International Business Machine SPSS Version 25, 2018 Software, the study employed a standard multiple regression to predict the ability of the pre- and post-fire correlates as depicted in the conceptual model (Figure 1) to identify conditions, which could be associated with a cluster of fires.

Data Analysis Procedure

Phase I consisted of the identification and collection of arson clusters from 1996 to 2018. This was accomplished by a concurrent review of the ACISS database and the agency-wide request for information. The agency-wide request for information through the Florida State Fire College revealed 25 known or suspected clusters. Of these, only seven were used in the study. From this, the initial groups of arson clusters (groups of three or more fires in a confined geographic area) were assembled. Further, the most common data element shared by the ACISS, FFIRS and UCR was the zip code. The tabular sequential plan for this study is detailed in Figure 3. Phase I validated the overall model and prepared the most efficient collection and treatment of the data.

Phase II will examine each separate fire to identify each of the pre- and post-fire correlates: Specifically, these items will include the target, the time, environmental conditions, and crime rates prior to the fire. Concurrently, fire event norming was accomplished using the county fire average to determine what a normal day looks like to the fire department. Using regression analysis, each aspect of the variables of interest was compared against the cluster to discern any commonality, if present. For each treatment

of each variable of interest, the appropriate mathematical test was used to measure the relative strength of the finding.

Use of ZIP Codes. Geronimus, Bound and Neidert (1996) found a weak correlation between socioeconomic conditions and the associated zip code. They also found that their use of ZIP codes to proxy a geographic area might be applicable to other social science attempts. In the immediate instance, use of zip codes served at least two functions in this study. First, it provided a minimum common geocoding element between non-communicative, non-associated databases assembled by separate agencies. Second, it served as an arbitrary geographic limit, albeit one established by postal standards – which may have nothing to do with the socio-economic condition of the community.

There are obvious problems with zip codes, principally because they are established without regard to political boundaries, such as fire districts are. Krieger, Waterman, Chen, Soobader, Subramanian and Carson (2002) found significant ZIP code bias with regard to public health research. However, in this instance within the study, the ZIP code was the most convenient common standardized coding element available. As an interim adjustment, ZIP codes were used in a Phase I survey of fires and clusters, and a further focusing of fires and clusters were examined using the geographic coordinate. In short, ZIP codes were used to get the study cluster in the vicinity, and the geo-coordinate verified that the cluster was in the same neighborhood (both practically and figuratively).

Data Analysis

Quantitative Analysis. Based on the initial research conducted by the Behavioral Science Unit of the Federal Bureau of Investigation, the baseline minimum

arson cluster was three discernable fire events (Douglas, et al., 2013). This study instead used a five-event standard. The reason for the increase in the minimum cluster size was to provide an even greater discrimination between the fires in general and those found as part of a cluster. The fire data, both FFIRS and ACCIS was compiled, and appropriate elements of the reports were input into the regression analysis. As an initial starting point, time and location was used consistent with previous studies on serial crime (Grubesic & Mack, 2008; Ashby & Bowers, 2013; Kisilevich, Mansmann, Nanni & Rinzivillo, 2016). The effort was primarily directed at finding relationships between the cluster event and other phenomena (Seifert, Goodman, King & Magolda, 2010).

Expected Results. Initially there were three expected results: Clusters would be spatially dense, activity would spike in a given period of time, and more than one predictor variable would discriminate between arson and accidental or undetermined fires.

Density. In the issue of cluster density, tighter cluster density as observed as a small spatiotemporal factor **(CD)** may potentially indicate a younger offender or an offender under great distress. Put another way, older serial arsonists are more mobile and may have a broadened area from which to light fires. Also, statistically significant populations of serial arsonists are cognitively impaired, limiting mobility.

Spikes. A spike in calls for service from fire agencies, will at least offer some element of observable arson clustering. Available research suggests that serial arsonists are somewhat predictable in their firesetting sprees before hibernating. Put another way, they will announce their presence before retreating. This announcement may be the spike in fires in a cluster based on spatial-temporal aspects (Kulldorff, 1997).

Convergence. Convergence of at least one predictive element from the pre-event correlates was an anticipated occurrence (Creswell, 2014). Something must be motivating or triggering the serial arsonist. While there may be several different types of triggers – and the psychology suggests this – at least one should become apparent.

Research Methodology

Chapter 1 highlighted the structural and systemic reporting issues involved in fires in general and possible clusters of fires in particular. Chapter 2 delineated the possible theoretical basis of firesetting as well as the inherent deficiencies in all criminological theories associated with firesetting. This chapter reviewed and provided a plan for the search for clusters of fires in an attempt to match offender actions in the firesetting environment (including the community). From this plan a generalizable criminal theory was proposed, which best describes the serial arsonist and etiology.

Data Collection

The following procedures were used to collect data, identify trends and develop corollaries based on the materials. The data collection approach was aligned with the research questions. The overall guiding procedural efforts used an existing archival database available to the public and match it against a research question.

Description of instrument and validation procedures. The predominant instrument used to identify any trends or to make inferences based on the available data was quantitative regression analysis. This included the techniques available to validate those findings. The goal was to identify trends and actions that were clearly beyond random chance, and from those identified actions conclusions were assembled in an attempt to provide new insight into serial arson and its manifestation within the larger community.

Event Norming. Each targeted county will be examined, and a standard fire activity by area (or density) will be reviewed. From this baseline, a consistent activity rate should be apparent by area. Once the examined county has been examined for a standard daily fire activity level, any events beyond the norm should become apparent and available for further study (Ashby & Bowers, 2013).

Preliminary Treatment of the Data

Sampling Method. The method to obtain the most valid fire reports consisted of a three-step process. The first step was to download the pertinent FFIRS data. The State Fire Marshal provided the entire electronic data set of collected Florida Fire Information and Reports (FFIRS) which were downloaded from the national database (NFIRS). This was comprised of all reported fires from 1998 to 2018 and were placed in a spreadsheet in 5-year increments. This comprised 1,152,745 records. Additionally, ACISS data from the Bureau of Fire, Arson and Explosions Investigations was obtained on 15 February 2019 and initially consisted of 98,877 records, with an additional 8,777 records added at the end of February 2019, for a total of 107,654 investigative records. These records consisted solely of time, date and location of fires as well as a determination of their cause (accidental, incendiary or undetermined). In total, the entire dataset of fire event information was 1,260,396 records.

The second treatment consisted of sorting incomplete records and fires that could be considered exempt. The first level was to exclude all records without a zip code or a valid zip code. Incomplete records also included those without a corresponding fire location (such as a training record sometimes found in ACISS) and records, which were listed as “metropolis.” Exempt fires included fires on the Interstate system, off-ramps, and close tributary routes because these fires would normally involve an occupied vehicle in operation, so by practical definition would not be an incendiary fire. For example, 1998 fires were closely monitored to

ensure that wildfire events that intruded into occupied neighborhoods were not part of the study pool. NFIRS had a total of 83,336 records excluded while ACISS had 69,104 records excluded.

The third step was to remove all redundant records. Redundant records are possible when there are several investigative reports made as a result of the same fire event, such as a fire investigation report for each vehicle damaged in an automobile dealership fire. Another common occurrence was multiple FFIRS event reports for the same fire, but from different responding agencies, as a result of mutual aid protocols. These redundant records were culled from the overall spreadsheet. A total of 11,702 records fell into this category. After step three, 1,096,254 candidate records remained in the FFIRS and ACISS from which to draw fire events for the study.

Data gathering methods. The remaining records were sorted using four different methods. The first sort consisted of identifying all known arsons. Known serial arson events (N=7), as provided by the agency-wide data request, were introduced into the study at this point. These records were tagged and further sorted by zip code. Within the zip code sort, repeated fire events of any determination, other than incendiary (undetermined and accidental), were highlighted at exact match addresses. The fourth level sort identified the near repeats, which were adjacent or near addresses of the initial incendiary fire.

These fire events (arsons, repeats and near repeats) were plotted on a digital map. The map was then used to identify adjacent street locations and these locations were queried against remaining records in the database. These records were also highlighted in the spreadsheet. The entire database was then queried against zip code, address and

incident number. The incident number was used to provide frequency of fire responses in the general area. Incident numbers are a sequential tabulation of a call for service. Each 911 call results in an incident number, which is carried throughout the response and listed in the FFIRS report. These are sequential numbers and they can provide insight into the pace of activity at a given fire station. Since a single fire station typically responds to fires in the same vicinity, or the area of an active cluster, the time or pace of numerous responses becomes a factor in identifying the cluster. The results were groups of fires within a common zip code that were color-coded and provided a visual marker for fire events. All fires within a group were listed sequentially by date and time.

Clusters. Clusters were obtained and plotted in total on the digital map layer. The result was a visual representation of a group of similar fires (by location, type or determination). Measuring the outward fires within the cluster and computing the total square miles of the event determined the overall area of the fire cluster. In those instances, where the cluster was less than .1 square miles, the value of .1 was assigned. A total of 10 clusters were identified under .1 square miles or 22%. From the plotted fire events, the geographic location was obtained. One additional cluster was excluded because of irregularities with the addresses and zip code mismatches. There were 45 clusters identified in this process. These 45 distinct clusters were comprised of 1,216 individual fires. The 45 identified clusters were then assembled into a spreadsheet and formed the specific fire incidents examined by this study. Appendix 1 is a profile of the clusters used in the study.

Data Analysis. Each procedural step of the analysis first used all fires (N=1216) with the associated identified cluster (N=45). A secondary analysis was conducted using

the pre-event correlates aligned with RQ-1, these included; total fires (F), fires in the county (CF), county fire density (CFD), overall county crime rate (CR), county violent crime rate (VC) and the county property crime rate (PC). The post-event correlates, aligned with RQ-2 were also analyzed which included; target (TA), time of event (TL), day of week (DW), illumination (IL) and the possible use of an accelerant (AC).

Spatial examination. Concurrent to the regression analysis, the clusters were plotted and the circumferences of the outer fires were measured. From this, the total area in square miles was determined and a variable: cluster square miles was created. The cluster of square miles was divided by the number of fires within the cluster to create a variable designated cluster density (CD). Cluster density was then used to compare the cluster density against the County Fire Density (CFD).

NSU Institutional Review Board

The Nova State University Institutional Review Board (NSU IRB) was fully consulted and all mandates and other procedural aspects were complied with. For the purposes of the NSU IRB, this study was an archival research project, with no personal identification information or any human or animal involvement. Reports used within the study consisted of public information available to the public at large. The actions of the offender are the target of the inquiry, and do not include the identity of the perpetrator. There were no licenses, requests for permission, or other necessary requirements needed to obtain access to the materials used in the process of this research study.

Chapter 4: Results

Analysis

Three specific analysis avenues were used to explore the significance of the predictor variables and ensure statistical validity. They were a test for statistical strength, correlations between the pre- and post-predictor variables, and a regression analysis (Pallant, 2013). From these separate but related analysis techniques, several variables emerged as having the ability to predict the possibility of an incendiary fire event from other fire events in a cluster.

Demographics of the Sample

Table 5 illustrates the selected demographic distribution for the entire dataset (N = 1216).

Table 5

Selected demographics used in the analysis

Fire Characteristics	**Number of cases**	**% (Within category) of cases**
Incendiary Fires	319	26.2
Accidental Fires	307	24.2
Undetermined Fires	590	49.6
Total	**1216**	**100**
Open Fields	337	26.6
Refuse Container	254	20.0
Vehicle	224	17.7
All others	401	35.7

Total	**1216**	**100**

Test for statistical strength

A power analysis was conducted to ensure that the available pool of fire events would sustain a statistical confidence of at least 95%. In effect, the total number of fires needed to ensure this was 292. The total number of fires contained in the study pool was 1216, which is 924 more fire events than the minimum required. For comparisons of the individual clusters (N=45), 41 clusters were needed to achieve the desired statistical strength.

Predictor Correlational Analysis

The variables were determined to be normally distributed. This was verified by computing the Pearson Correlation Coefficient. Table 7 is the Pre Event Correlational Analysis (N=1216) and Table 8 is the Post Event Correlational Analysis (N=1216). Both the pre-event and post-event variables were analyzed using the total fires (F) for all identified clusters.

Cluster (CL). Clusters were identified using the methodology detailed in Chapter 3.

Cluster Density (CD). Cluster density was determined by dividing the total number of identified fires within the cluster against the total area of the clusters in square miles.

County Demographics. The county demographics for the study were identified as the overall county fire rates, the subsequent density of those identified fires, the overall county crime rates, which was further broken down into the overall property and violent crime rates. Within the study, crime rates were used in the year of the identified

individual fire within the identified cluster. In this manner, crime rates had more relevance to the fires when both occurred in the same calendar year.

County Fire Rates (CFR). The county fire rate was computed using the FFIRS event number, totaled within the calendar year from 1 January to 31 December of the appropriate year of the identified fire within a cluster.

County Fire Density (CFD). County fire density was computed using the number of fires within a calendar year divided by the total square miles of the county (County Square Miles/Total Fires within calendar year).

County Crime Rates (CR). The overall county crime rate was computed by adding the property crime rate and violent crime rate per 100,000 population. This was further verified by comparing the results against the FDLE statistics.

County Property Crime Rates (PC). Property crime rates were obtained from FDLE for the individual county and compared against the 100,000 population.

County Violent Crime Rates (VC). Violent crime rates were obtained from FDLE for the individual county and compared against the 100,000 population.

Target (TA). The target was interpreted from both ACISS and FFIRS reports. Table 3 shows a numeric assignment by target. In those instances where the target was not provided, was ambiguous, or was misidentified, Category 8 (others) was used.

Temporal Observations (TL). Temporal observations were obtained from the FFIRS and ACISS reports of time and date of fire event. The time and date were exclusively obtained from the alarm time because this represented the nearest time to the actual ignition of the identified fire as was possible.

Illumination (IL). The illumination was determined by computing the amount of ambient light reflection from the moon (as the largest nighttime celestial body). In those instances, where the IL was computed at 1.00, this represents either a full moon or daytime. Because no actual site survey was conducted in this study, there is no accounting of local ambient light from businesses, residences or street lights. Nor is there a measure of the effect of cloud cover at the time of the first alarm.

Day of Week. (DW). Day of week was computed by assigning a numerical value to the specific day of the fire. For example, Sunday = 1, Monday = 2, etc.

Accelerant Use (AC). Accelerant use was originally designed to be included into the overall study. However, the actual reporting of accelerant presence was minimal, and was mostly confined to ACISS reporting. Because the presence of accelerants could not be verified with any degree of accuracy on accidental and undetermined fires, the category was removed from the final analysis.

Classification of Fire (CF). The classification of fires was limited to three determinations: accidental, undetermined, and incendiary. Table 4 (Classification of Fires) was used in this study.

Data Set Analysis

Correlation coefficients were analyzed among the five pre-event predictors (N=1216). A Bonferroni approach to control for Type I errors was used for all five variables, and all pre-event variables were statistically significant at the .01 level (2-tailed). As detailed in Table 7, three of the five correlations were statistically significant and were greater than or equal to .5 (Green & Salkind, 2014). The correlations of total Fires (F), County Fire Density (CFD) and Overall Crime Rates (CR) were lower and

were less significant. In general, the results of the pre-event correlation analysis suggest that fires that occur in areas of higher violent and property crimes tend to be correlated.

In a second analysis, correlation coefficients were analyzed among the four post-event predictors (N=1216). The Accelerant (AC) predictor was excluded. A Bonferroni approach to control for Type I errors was used for all four variables, and one post-event variable was significant at the .05 level (2-tailed) and one was significant at the .01 level (2-tailed). Time of Fire and Illumination were small coefficients (-.062 and .078, respectively). This result may suggest a weak correlation between time of the fire and the available illumination. Table 7 shows the preliminary correlational analysis of the pre-event predictors. Table 8 represents the preliminary correlational analysis of the post-event predictors.

Table 6

Pre-event Predictor Correlational Analysis (N=1216)

Predictor	**F**	**CF**	**CD**	**CR**	**VC**	**PC**
Total Fires **(F)**	__					
Fires in the County **(CF)**	.542**	__				
Cluster Density **(CD)**	.206**	.472**	__			
County Crime Overall **(CR)**	-.111**	.222**	.190**	__		
County Violent Crime **(VC)**	-.034**	.324**	.279**	.845**	__	
County Property Crime **(PC)**	-.084**	.248**	.232**	.979**	.838**	__

** Correlation is significant at the 0.01 level (2-tailed)

Table 7

Post-event Predictor Correlational Analysis (N=1216)

Predictor	**F**	**TA**	**TL**	**DW**	**IL**	**AC**
Total Fires **(F)**	--					
Target **(TA)**	.028	--				
Time **(TL)**	-.062*	-.025	--			
Day of Week **(DW)**	.027	-.037	.027	--		
Illumination **(IL)**	-.050	-.026	.015	.078**	--	
Accelerant Use **(AC)**[1]	NA	NA	NA	NA	NA	NA

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
1. Accelerant was removed as a variable because of lack of data

Regression Analysis

Multiple regression analyses' were conducted to predict the overall ability of the variable to predict and differentiate an incendiary fire from one that was accidental and undetermined. Further, the analysis was used to identify variables that could uniquely identify an incendiary fire. One analysis included the pre-event predictors (CFR, CFD, CR, PC and VC), while the second analysis included the post-event predictors (TA, TL, DW, CS, CD and IL). The regression equation with the pre-event measures was significant, R^2=.36, adjusted R^2=.36, F (5,1193) =133.5, p<.001. The post-event measures were equally as significant, R^2=.37, adjusted R^2=.36, F (6,1187) =63.0, p<.001.

Based on this analysis, both the pre- and post-event variables appeared to be a relevant predictor of an arson event.

Next, a third regression analysis was conducted with all ten predictor variables. The linear combination of the ten variables was significantly related to arson, R^2=.45, adjusted R^2=.43, F (11,301) =22.6, p<.001. The pre-event variables significantly predicted arson over and above the post-event predictors, R^2 change = .359, F (5,1193) =133.47, p<.001. The post-event predictors did not change significantly over and above the pre-event predictors, R^2 change = .01, F (6,1187) = 3.03, p=.006.

Table 8

Bivariate and Partial Correlations of the Predictors Among All Fires

Predictors	Correlation between each predictor and the total number of fires	Correlation between each predictor and the total number of fires controlling for all other predictors
County Fire Total	.544**	.532**
County Fire Density	.208	-.026
Violent Crime	-.039	-.001
Property Crime	-.089	.029
Total Crime	-.116*	-.082*
Target	.034	-.003
Time of Fire	-.063	-.015
Day of Week	.029	.023
Illumination	-.041	-.009
Cluster Square Miles	-.201*	-.083*
Cluster Density	.022*	.059*

* p<.05, ** p<.01

Of the pre/post event predictors, the county fire total was most strongly related to the determination of an arson event. Supporting this, the bivariate correlation between county fire totals (CFR) and the total fires (F), which was .544, p< .001, as well as the comparable correlation, takes into account the effects of the other four predictor variables, which was .553, p<.001. Table 8 shows the results of the bivariate and partial correlations of the predictor variables against all fires.

Spatial Analysis.

The average cluster area was 1.2 square miles (N=45). A total of 64% (N=29) of the identified clusters were under ½ square mile. With the exception of linear clusters, all other clusters had significantly greater fire events per square mile than the normalized county fire density.

Findings

RQ-1, asked what are the pre-fire variables that uniquely predict whether a fire is arson or accidental? Hypothesis 1 was that there were observable spatial, environmental and social events that occur which could discriminate between an accidental or undetermined fire and arson. The enter method for regression analysis was used to predict which observable events can uniquely discriminate an incendiary fire from an accidental or undetermined fire.

A multiple regression analysis was conducted to predict the occurrence of arson vice accidental/undetermined fires. The analysis included the pre-event correlates (Total county fires, cluster density, crime rate/100K, violent crime rate/100K and property crime rate/100K). The dependent variable was the total number of fires within

the identified clusters. The results were significant, R^2=.357, adjusted R^2=.355, F(5,1208)=134.4, p<.01. Overall the pre-event correlates could moderately predict an incendiary fire among all fires. The overall model moderately predicted the fire classification (arson, accidental/undetermined). The classification accuracy was 56.8% when the fire was arson and 62.7% for accidental/undetermined fires. The overall classification was 64.2% correct for the pre-event correlates.

In a comparison of arson versus accidental/undetermined fires, the regression coefficient for the Violent Crime Rate/100,000 was significant, b = .640, t(1208) = 3.29, p = .001. County Fire Density also significantly predicted whether a fire was arson versus accidental/undetermined, b = 25.59, t(1208) = 1.52, p = .024.

RQ-2, asked what are the post-fire variables that uniquely predict whether a fire is arson vice accidental or undetermined. Hypothesis 2 was that there were observable spatial-temporal and target-related items that remained in the fire area that could discriminate between an accidental or undetermined fire and arson.

A multiple regression analysis was conducted to predict the occurrence of arson vice accidental or undetermined fires. The analysis included the post-event correlates (Target, Time, Day of Week and Illumination). The post-event correlate of accelerant use was removed from the study due to lack of information. The dependent variable was the total number of fires within the identified clusters.

The results were more significant than the pre-event correlates overall, R^2=.032, adjusted R^2=.029, F(4,1197)= 10.05, p= .000. Overall the post-event correlates adequately predicted an incendiary fire among all fires. The overall model moderately

predicted the fire classification (arson versus accidental/undetermined) from the post-event correlates. The classification accuracy for arson was 86.8% and 88.3% for accidental/undetermined fires. The overall classification was 88.3% correct for the post-event correlates.

In a comparison of arson versus accidental or undetermined fires, the regression coefficient for the Time (time of first alert) was significant, b = -.001, t(1208) = -1.94, p = .053. Illumination also significantly predicted whether a fire was arson versus accidental/undetermined, b = - 42.8, t(1208) = -1.43, p = .153. These results suggest that arson fires are most likely to occur during nighttime in periods of reduced visibility.

RQ-3, asked what are the pre- and post-fire variables that uniquely predict whether or not arson is a member of a cluster of fires or presents a unique pattern? Hypothesis 3 demonstrated that there are two or more observable fire related characteristics both before and after a known arson, which could uniquely associate it with other fires in the vicinity.

A multiple regression analysis was conducted to predict the occurrence of arson vice accidental/undetermined fires. The analysis included the combined pre-event and post-event correlates highlighted by the RQ-1 analysis (Violent Crime Rate/100,000 and County Fire Density) and the RQ-2 analysis (Time and Illumination). The dependent variable was the total number of fires within the identified clusters.

The results were significant, R^2=.363, adjusted R^2=.360, F(6,1193)= 113.5, p= .000. The overall model moderately predicted the fire classification (arson versus accidental/undetermined) from the pre and post-event correlates. The classification accuracy was 79.0% for arson and 81.3% for accidental/undetermined. The overall classification was 81.3% correct.

In a comparison of arson versus accidental/undetermined fires, the regression coefficient for County Total Fires was significant, $b = .137$, $t(1189) = 22.8$, $p < .001$. This was closely followed by Cluster Density, which also significantly predicted whether a fire was arson versus accidental/undetermined, $b = .568$, $t(1189) = 3.0$. $p = .003$.

Chapter 5: Discussion

This research represents the first known attempt to examine the FFIRS database in general and compare it with the ACISS database in particular. The research covered decades of collected information regarding fires, where they occurred, what was burned, and when the event happened. The total number of records available to accomplish this exceeded one million responses to fires from 1998 through 2018. This has culminated in the study's attempt to put these events into a spatial-temporal context. Further, an examination of the target and the available circumstances surrounding the event has been attempted.

To ensure that the construct validity of the study remained intact, care was taken to verify and use only those data points that could be reasonably associated with fire setting. Extreme care was taken to ensure that the observations, data, and other ancillary information actually records the arson event, and further, that it is correctly interpreted so that some sort of conclusion may be made (Creswell, 2014). The use of different data sets (such as distance, time of day, etc.) provided support for robust construct validity. Tens of thousands of records were rejected if any of the data points appeared to be in error or insufficient, or if they did not match with the other portions of the record. The original proposal of this study mandated at least three fires, with at least one designated as arson, to qualify as a cluster. Because of the amount of data, this specification was changed to five fires in a cluster with at least one arson. This served to further isolate the fires into the categories of accidental, undetermined, and incendiary, with groups of fires that shared the same attributes in particular being highlighted.

County Fire Density. Any perturbation of a county normalized fire density represented a potential fire cluster indicator. As predicted, a spike in fire activity over

any given span of time tended to distinguish a cluster. As a condition of the study, fires along interstate highways or secondary highways were omitted. So the qualified county fire density as used in this study does not include vehicle fires as a result of traffic crashes.

Illumination. The amount of ambient light at the time of the first report of fire was significant. Daylight fires notwithstanding (illumination = 1.0), the greatest number of incendiary fires during nighttime hours exhibited an ambient illumination of .78 to .97. Even though this might suggest that the phase of moon has a direct correlation, this is not the measurement used in this study. Time of fire was statistically unsuited as a predictor variable, but the illumination at the time of the first report of fire was somewhat correlated with early morning fires for those fires not reported during daytime. More research is needed, specifically if the act of igniting a combustible item may need some amount of ambient light to allow the arsonist to accomplish the fire set. Without some measure of available street lights or other potential sources of illumination at the point of origin, we are left with the analysis which suggests that some amount of light substantially above total darkness is a characteristic of an incendiary fire within a cluster.

Target. Among the post-event predictors, there were moderate associations with the target. Open fields and refuse containers represented nearly 47% of the targets within the clusters. Others included vehicle and structures, but only to a statistically moderate degree overall. Upon further analysis, the target may offer a better post-event predictor. The study found a slight homogeneity between the cluster and the target. The study suggests that targets within the densest clusters remained consistent over time. There was only a statistically small deviation from the items that caught fire within each designated

cluster, suggesting that serial arsonists may attack a specific type of target and remain with that target for the duration of the event.

Thematic Discrimination. Closely associated with the target was an exploration of the thematic possibilities within the firesetting event. Overall the study found that specific themes were absent or were not captured in the available data. The data suggested that the things burned were aligned with range, convenience and combustibility rather than with any symbolic tie to the arsonist. The FFIRS, ACISS and geospatial reviews of the clusters suggested that the target was available and vulnerable, without any higher meaning.

Spatial Examination of Fire Clusters. It was found that 95.6% of all fires within a cluster were within 5 square miles, 70.5% were within 1 square mile, and 52.4% were below ½ square mile. One linear cluster had a lower computed fire density then the normalized county fire density (Blountstown Highway Cluster; .516 CD vs. Leon County normalized density of 2.08 CFD). This was the only observed instance where a cluster density was lower than the county fire density.

Geographic Constraint. Each predictor was evaluated on its own merits, and within the context of the fire event as a whole. It was determined that the best overall predictor of a possible serial arson event was the grouping of fires within a geographically constrained area. Serial arson events appear to be overwhelmingly a local phenomenon. These clusters are highly suggestive of a marauding offender. Linear clusters – or those clusters along a roadway – presented a challenge in the overall dimensions of the studies use of square miles in the computation of the cluster density (CD). These elongated clusters tended to have much lower cluster densities than the

oval, round, or hexagonal clusters. These clusters were suggestive of a commuter offender. Cluster density, regardless of the geometry or the event, represented the easiest and most obtainable information being gathered by the fire service.

The 2000-foot paradigm. After examination of the entire candidate clusters (N=45) the most coherent variables that could predict arson remained the targeting of open fields and refuse containers in a spatially condensed area. At least 64% of the identified clusters were contained within an area no more than ½ square mile. Put another way, there would not be more than 2000 feet from one fire to another for 29 of the 45 fires examined in this study. The fires were measurably within line of sight of each other. These may possibly represent journey to crime implications for fire investigators. The implication is that the possible home base of the offender may be within the line of sight of most of the fire sets.

Serial Event Sequence. Of the examined serial arson events, nearly every one was preceded by a group of fires, which were categorized as accidental or undetermined. Within the study, the 1996 FSU Cluster was exempt from this claim because only ACISS data was available. This is because the Tallahassee Fire Department implemented FFIRS the following year. This period of firesetting episodes prior to the recognition of a serial arson cluster may be significant. These previous fires could contain information of use to the field investigator. This study supports the conclusion that a delay in awareness of a serial arson event may occur on a regular basis.

Crime Rates. The next available possible pre-event predictors were the crime rates in general and the violent crime rate in particular. Both these crime rates exhibited high collinearity with both arsons and undetermined fires. Missing is the overall

economic health of the community where the fire events occurred – which might have added an important dimension to the overall ability to predict these fire events.

Day of Week. The day the week when a fire occurred within a designated cluster proved to be statistically irrelevant. This may have some impact on previous research, which implies that alcohol use would lower inhibitions to fire setting. The days when alcohol use is most prevalent are Thursday, Friday and Saturday in the United States (Wood, Sher & Rutledge, 2007). Within the designated clusters, Saturday was the most common day (N=198) at 16.3%. However, no statistically significant day of the week for fire setting was found within the parameters of this study.

Time between fires. The time between fires needs to be researched further. No statistically significant time aspect was noted in this study. However, it was not unusual for a cluster to extend 48 months in the same general vicinity. More research is needed to further develop the exact parameters of the serial temporal nature of fire setting. Longer times between fires in the same general vicinity may have helped camouflage the event, with changes in shifts, changes in firefighting crew duties, and reassignments within the fire department. The longer the time between fires, the greater the chance of a serial event being missed. A reevaluation of the temporal aspects is in order. The time between fires may be more nuanced than is currently recognized. Even with the long dwell periods between some fires, the spatial aspects remained condensed and consistent.

Accelerants. The use of accelerants in the formation of a fire was removed from the study. Though it was not apparent at the beginning, later analysis of the FFIRS and ACISS databases revealed that there was not enough information to make accelerant use a viable predictor variable. This may be a reporting issue, or the use of an accelerant

within a known serial event may be extraordinarily rare. Not enough information is currently available. However, the 1994 FBI study suggested that use of common combustibles at the scene of the fire was routine among serial arsonists (Sapp, et al., 1994). This study supports that observation.

Limitations

Current reporting instruments for fires tend to be weak and poorly maintained. FFIRS has extensive issues at the initial reporting level. Not all fire agencies in Florida participate. Further, the initial use of FFIRS was not adopted by all fire agencies and may not yet be in use in all fire districts. It was apparent during the examination of the data that this issue improved over time, and later FFIRS reporting was substantially better and more accurate than the initial reporting. Some of the information is found in non-searchable data categories – i.e., the golden nuggets of the investigation are in the narratives and not searchable. Within this study, the narratives were not available as a condition of the release of the information.

Recommendations

Much more research is needed on this subject. The application of some of the methods used to develop the analysis may be beneficial to other crimes or serial events. Additionally, there needs to be more research into the targeting schemas used by serial offenders. Because of the nature of serial fire setting, further research will benefit both the communities and those responsible for responding to these events. The study found much more consistency than anticipated. As a result, more granularity is needed to differentiate the fires within a cluster. Specific recommendations are; more precise GPS derived location data, better training for firefighters and investigators, the removal of the

"all other causes" category within NFIRS, and some type of mechanism to rapidly compare FFIRS data with ACISS at the local field office within the state.

GPS use within the FFIRS/NFIRS/ACISS reporting system. Because of the nature of serial events and the spatial aspect of firesetting, reasonably accurate geocoordinates are recommended. The most efficient incorporation of location data would be use of WGS-84 derived coordinates placed into all of the response and investigative reports. The use of addresses, while sufficient for record-keeping purposes does not assist in the investigation of serial events that occur in close proximity. Past use of the target to identify the serial offender was found insufficient based on the conclusions that the fire is the primary focus of the offender and not the item attacked. As such, an accurate location of the seat of the fire better supports the investigative process.

Better Training for Firefighters and Investigators. Both the firefighters and local investigators would benefit from enhanced training on serial fire events and their identification. The awareness of cross-shift activities would further enhance the rapid identification of a serial event in progress. Firefighters, trained in possible indicators of a serial event would further assist the investigative effort by placing the first responding units in a position to better contain, observe and protect the cluster scene than any other units or responses.

Removal of the "all others causes" category from FFIRS/NFIRS. The study found that a significant number of clusters were caused by "all other causes." The apparent overuse of this designation does not assist in the public safety of the community. Further, the use of "all other causes" does not trigger any review or open a fire response to investigative review, as the determination "undetermined" is designed to do.

Comparison of NFIRS/FFIRS and ACISS databases. Some type of reconciliation of the two reporting structures is needed. As a start, the geocoordinate appears to be the most efficient and easily installed common element between the databases. Further, some type of automatic review is recommended. The sharing or merging of the databases might be the subject of a local mutual aid agreement or might be mandated and coordinated at the state level.

Summary

The study found that a series of fire events clearly above the county normalized fire density, combined with ambient illumination above .78, with a similar target was the most consistent predictor of a serial fire event. Further, the study found that the fires had nearly a 50% probability of being contained within ½ square miles. The implication is that the most statistically common fire event occurred in an area within line-of-site of each individual fire set. The actual target of the fire event suggested that the object was the fire, and not necessarily the item set on fire.

There may be a narrative present that has been missed in the data collection protocols in use today. Certainly, there are quantifiable events, numbers, and locations that could allow for more thorough data collection. For example, information about the weather could be overlaid, and current neighborhood socio-economic status could be examined in the areas of arson clusters. But that may not be the whole story. The numbers alone do not give depth to the real meaning of arson clusters, who is lighting these fires, and perhaps the ever-elusive question of why. This research study fills an important gap in current deficiencies of what is known about arson clusters. Depending on the data, its fidelity and availability could be included with further research to form

the foundation for a predictive model of serial arson through regression analysis (Castro, 2016).

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Appendix

Cluster Profile

Appendix A: Cluster Profile

Zip Code	Cluster Designation	Event Square Miles	Event Total	Cluster Fires SqMi **CD**	County	County Square Miles	County Fires/Year of Event[1] **CFR**	Baseline Fires/SQ Mi **CFD**	Remarks
32306	Tallahassee mailbox bombing	.26	4	15.38	Leon (13)	702	129[2]	5.44	
32306	Florida State Mass Fires	.46	12	26.09	Leon (13)	702	129	5.44	Known Serial Event
33880	Eloise Cluster	.14	19	45.23	Polk (5)	2011	1486[3]	.74	
32219	Birdville Cluster	.23	29	26.06	Duval (2)	918	2130	2.32	
32401	US-98 Cluster, Springfield	2.43	12	2.47	Bay (23)	1033	405	.39	Possible Commuter
32401	School Ave. Cluster	.1	8	33.3	Bay (23)	1033	405	.39	
32401	Transmitter Road Cluster	.1	8	20.66	Bay (23)	1033	405	.39	
32401	Springfield Cluster	3.39	16	.96	Bay (23)	1033	416	.40	Possible Commuter
32164	Palm Coast Cluster	.19	17	44.73	Flagler (61)	571	465	.76	
32174	Yonge St. Cluster	.1	15	30.0	Volusia (8)	1432	1787	1.24	
32119	Palm View Cluster	.31	39	23.2	Volusia (8)	1432	1787	1.24	
32124	Tomoka Farms Rd. Cluster	2.78	21	7.55	Volusia (8)	1432	1787	1.24	
32127	Farmbrook Cluster	.1	6	60.0	Volusia (8)	1432	1317	.92	
34458	Rock Crusher Canyon Cluster	.3	18	30.0	Citrus (47)	773	591	.77	Average of two clusters in same area.
32301	Paul Russell Road Cluster	.14	8	14.25	Leon (13)	702	1526	2.18	

[1] Or average of a multiple year event
[2] FFIRS data unavailable for 1996, ACISS data used.
[3] Includes partial reports from 2018

Appendix A: Continued

Zip Code	Cluster Designation	Event Square Miles	Event Total	Cluster Fires SqMi **CD**	County	County Square Miles	County Fires/Year of Event[4] **CFR**	Baseline Fires/SQ Mi **CFD**	Remarks
32707	Castleberry Cluster	.1	21	40.0	Seminole (17)	345	1138	2.77	
32310	Blountstown Highway Cluster	20.9	54	.516	Leon (13)	702	1474	2.08	Possible Commuter
32426	Ox Bow Cluster	.48	10	5.2	Leon (13)	702	1449	2.53	
32444	Overpass Cluster	1.9	9	1.6	Jackson (25)	955	253	.26	
32444	Lynnhaven Cluster	2	31	7.75	Bay (23)	1033	316	.37	
32501	Gregory St. Cluster	.15	25	33.38	Escambia (9)	875	840	.96	
32547	Beal Parkway Cluster	.29	18	31	Okaloosa (43)	1082	712	.66	
32548	Bobolink Cluster	.1	9	22.5	Okaloosa (43)	1082	375	.35	
32669	Newberry Cluster	4.21	43	2.04	Alachua (11)	969	617	.64	Possible Commuter
32763	Saxon Cluster	.3	40	26.67	Volusia (8)	1432	1786	1.17	
32773	Sanford Cluster	.1	31	6.2	Seminole (17)	345	1138	3.28	
32901	University Blvd. Melbourne	.4	53	10.6	Brevard (19)	1557	2011	1.304	
32976	Sebastian Cluster	.96	29	6.04	Indian River (32)	617	811	2.19	
33404	W. Blue Heron Cluster	.1	34	113.3	Palm Beach (6)	2383	1749	.73	
33417	Benoist Farms Rd. Cluster	.3	24	26.65	Palm Beach (6)	2383	2659	1.12	

[4] Or average of a multiple year event

Appendix A: Continued

Zip Code	Cluster Designation	Event Square Miles	Event Total	Cluster Fires SqMi **CD**	County	County Square Miles	County Fires/Year of Event[5] **CFR**	Baseline Fires/SQ Mi **CFD**	Remarks
33431	Glades Cluster	.1	73	144.0	Palm Beach (6)	2383	1960	.82	
33916	Michigan Ave. Cluster	.2	73	91.25	Lee (18)	1212	2048	1.7	
33904	Miramar St. Cluster	.12	16	25.02	Lee (18)	1212	1959	1.6	
32114	Nova Road Cluster	.85	24	9.4	Volusia (8)	1432	1914	1.33	
32117	Moody Road Cluster	1.69	22	2.62	Putnam (22)	827	752	.91	
32205	Jacksonville Polygon	.61	48	13.1	Duval (2)	918	2742	2.98	
32209	Cleveland Road Cluster	.25	51	14.2	Duval (2)	918	2742	2.98	
32217	Powers Ave. Cluster	.72	66	15.5	Duval (2)	918	2742	2.98	
33138	NW 71st St. Cluster	1.56	28	18.6	Miami-Dade (1)	2431	6268	2.6	
33183	SW 84th St. Cluster	1.2	20	17.5	Miami-Dade (1)	2431	6268	2.6	
33194	Krome Ave. Cluster	1.61	60	7.1	Miami-Dade (1)	2431	5976	2.5	
34420	Belleview Cluster	1.26	40	5.4	Marion (14)	1663	1262	.76	Known Serial Event
34471	Pine Avenue Cluster	.23	8	34.78	Marion (14)	1663	1000	.67	Known Serial Event
34482	Ocala Parks Estate Cluster	.1	8	40	Marion (14)	1663	1239	.75	Known Serial Event

[5] Or average of a multiple year event