

# **The Fourth Tribe: A Metatheory of Environmental Criminology<sup>1</sup>**

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At the 2007 ECCA conference in London, Sir Anthony Bottoms presented three tribes of environmental criminology (what he called socio-spatial criminology). He proposed that a stronger theory could be created if there was greater collaboration between these tribes (particularly the rational choice/routine activities approach and the post-social disorganization approach). This article extends that argument and proposes a meta-theory or overarching paradigm for environmental criminology based on complex systems theory (commonly called chaos theory). The proposed new paradigm is called Ecodynamics Theory based on its underlying precepts. The article concludes with a discussion of how this paradigm could be used to further the cause of environmental criminology.

## **Introduction**

Arguably, the oldest and most extensive form of criminology falls within what is referred to, among other names, environmental criminology (Brantingham and Brantingham; 1981). Beginning with the work of Guerry (1833) and quickly thereafter Quetelet (1848/1984), the recognition that much of the explanation for the occurrence of crime falls within the realm of the community and human environment became a focus of study.

The cause of environmental criminology took probably its greatest step forward with the work of Park (1936), Burgess (Park and Burgess 1969), and Shaw and McKay (1942) at the Chicago School in the 1920s and 1930s. The development of social disorganization theory was considered by many as development of a new way of thinking about crime and criminality. Although the popularity of social disorganization as the principle criminological theory was short-lived, the work of examining criminal behavior in the community context continued.

The 1980s saw a resurgence of neighborhood research, due to the social disorganization works of Bursik (1982, 1984, 1986) and Sampson (1985), social disadvantage research such as that by William Julius Wilson (1987), and of course the now iconic “Broken Windows” (Wilson and Kelling 1982). This was a different theory, however; having to stave off criticisms of the past and adapt neighborhood research to current methods and statistical analyses.

More importantly, beginning in the 1970s with the work of Jeffery (1971) and Newman (1972), a few criminologists who were not satisfied with traditional explanations based on

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<sup>1</sup> Adapted with permission from Walker, J. T. (2007). “Advancing science and research in criminal justice/criminology: Complex systems theory and non-linear analyses.” *Justice Quarterly*, 24, 4, 55-581.

community concepts began to move to explanations based on the “human environment.”<sup>2</sup> This produced the rise of environmental criminology. The first major statement on this new paradigm (Brantingham and Brantingham 1981) began a “movement” (Bichler and Malm, 2008) of a new way of examining crime and crime patterns based more on the characteristics of place and the patterns of criminals. This paradigm also developed or adapted new methods of examining criminality, including geographic information systems, agent-based modeling, and artificial simulations.

Even with the changes and improvements in theory, methods, and analyses, criminology (including environmental criminology) is still not producing the level of understanding of criminal behavior to which we aspire and policy makers expect. In one of the most scathing criticisms from within, Sampson (2000) proposed that “[t]heories limited to time-stable factors are thus incapable of unpacking the zigzagging and temporally variable patterns of offending.” Sampson seems to be speaking directly to those who study aspects of the loosely knitted field of environmental criminology. Our current state, however, is not sufficient for the kinds of explanations that are needed. As Sampson (2000) states, “[w]hat is needed is a concerted effort to enhance the science of ecological assessment (“econometrics”) by developing systematic procedures for directly measuring social mechanisms in community context, and by developing tools to improve the quality of community-level research.”

At the 2007 ECCA conference, Sir Anthony Bottoms proposed three tribes of environmental criminology (what he called socio-spatial criminology). He argued that a stronger theory could be created if there was greater collaboration between these tribes (particularly the Rational Choice/Routine Activities approach and the post-Social Disorganization approach). This paper extends that argument and proposes a meta-theory or overarching paradigm for environmental criminology based on complex systems theory (commonly called chaos theory). I propose that criminology in general and environmental criminology specifically must move beyond research based on linear analysis to include methodologies that are more appropriate for studying complex human behavior. We must put aside strictly linear models in favor of fractal behavior, complex systems, and non-linear analysis. Even though research in environmental criminology has made advancements in explaining the incidence of crime, we must employ additional methods that allow us to better examine changes in time and space (see also Townsley 2008). We must use analyses that search large and complex data sets for associations hidden deep in the data. The argument is made here for the viability of using complex systems science to improve environmental criminology research.

The result of this argument is twofold. First, I propose a new theory based on a combination of the principles of environmental criminology and the methods of complex systems science. This new theory, called Ecodynamics Theory, would begin to examine changes in neighborhood characteristics in a time-space analysis that could overcome the limitations of previous research. Second, it is anticipated this discussion could also convince others to use complex systems with other types of environmental criminology research. This line of research could be the fourth tribe of environmental criminology.

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<sup>2</sup> It may be more appropriately stated this was a return to a study of the human environment, much closer to the explanations of human ecology in the 1920s and 1930s; although the newer research was based on a better understanding of the dynamics of the community and influenced by improvements in social science methods and statistical analyses.

## Related Literature

It is not possible within the confines of this discussion to fully present the literature on neighborhoods and crime, environmental criminology, or complex systems. Criminological research on communities spans almost 100 years, and research on complex systems includes literature from almost every field of science (Gelick 1987) and several fields of social science (Goertzel 1994). Literature related to using complex system science to examine criminal behavior is sparse, however (Young 1995, Milovanovic 1997), and using complex systems science to examine crime at the neighborhood level has only been discussed in a few professional conference papers (see Walker 1996, 1997, 2005) and Walker (2007). To support the discussion at hand, a laconic treatment these areas must suffice to show how complex systems science can be applied to neighborhood research.

## Neighborhoods and Crime Literature

Even though this line of research can be traced to the 1800s or before, it is generally accepted that examinations of communities and crime solidified with the work of the Chicago School in the 1920s. As one of the most extensive and long-running criminological theories, it has contributed to a variety of methodologies and theoretical perspectives as diverse as geographic information systems and crime mapping, social disorganization theory, and routine activities theory. This literature is too extensive to discuss fully here and is fairly well known, so the comments here will be confined to some of those studies most related to the topic at hand.

The foundation of the study of neighborhoods and crime in the U.S. is the research on social disorganization by Shaw and McKay (1942). Their research in Chicago and eight other cities in the U. S. established the relationship between neighborhood variables, social disorganization, and high levels of crime. Shaw and McKay's study spawned a number of replications and additional research that has spanned to the present. The results of those studies essentially supported the conclusions of Shaw and McKay, although there were differences in specific findings. The variables from this line of research, including homes owned, median rental price, some measure of wealth or social assistance, population turnover, and physical deterioration, have been consistently linked with crime for over 60 years.

More specific to the study of neighborhoods that could have been couched in a complex systems paradigm, Schuerman and Kobrin (1986) proposed that neighborhoods pass through a progression of three stages from low, to moderate, to high levels of crime. They termed these stages and the neighborhoods associated with them emerging, transitional, and enduring.

Schuerman and Kobrin (1986) examined the same kinds of variables used in most ecological research, including the physical, economic, and population characteristics of the areas. They used cross-lagged regression analysis to identify the temporal relationship between neighborhood characteristics and delinquency. They found that physical deterioration was most highly associated with increases in delinquency in emerging areas. As the neighborhoods declined, there were substantial increases in the number of physically deteriorated houses. This produced a sustained migration into and out of the area, creating a substantial change in the population composition. This they considered an area of transition. In enduring crime areas, where the physical condition continued to deteriorate and delinquency rose, the most significant factors shifted to economic characteristics.

The analysis of crime and neighborhood characteristics showed an inconsistent relationship (Schuerman and Kobrin 1986). In the early stages of change, structural deterioration in the neighborhood preceded rising crime. As the neighborhood continued to deteriorate and change, however, crime began to precede the onset of further deterioration. This led Schuerman and Kobrin to conclude that "... neighborhood structural components become not causes but consequences, and crime emerges as the dominant force in neighborhood change." In this instance, crime was initially a dependent variable – influenced by the ecological factors. As the neighborhoods moved toward the enduring stage, crime became an independent variable – further propelling the neighborhood toward deterioration. The speed at which change occurred also varied. In emerging neighborhoods, the speed of change in neighborhood characteristics exceeded the rate of change for crime. As crime levels reached the enduring phase, the rates of crime outpaced changes in neighborhood characteristics. These findings of Schuerman and Kobrin will be particularly important in the discussion below. One of the key problems in studying crime at the neighborhood level is that crime is often a dependent variable, independent variable, interaction variable with other independent variables, and a confounding variable within very short periods of change in neighborhoods. This created problems for traditional research such as Schuerman and Kobrin, but can be addressed in complex systems models.

Skogan (1986) also conducted research that could be supportive of using complex systems science in criminological theory. He presented a model demonstrating the recursive relationship between neighborhood characteristics and crime. Skogan found that crime appeared to initially result from the onset of increases in ecological factors and later served as a catalyst to increase levels of the ecological variables, further propelling neighborhoods into deeper disorder. This seeming incongruence between recursive and non-recursive models supports the criticism of current criminological theory's inability to properly examine cities that are not stable over time.

Both of these studies and others support an argument that modern cities present a more random pattern of growth than in previous decades. The increasing complexity of cities can be shown in how models of city growth have changed over the years. Park and Burgess (1969) proposed a model of concentric rings where the city grows in circles, with growth rings occurring immediately outside previous rings and only broken up by natural barriers such as rivers or lakes. Hoyt (1939) argued that successive sectors, where a city grows in linear sections with residential areas moving directly behind existing ones, was more appropriate to study change in modern cities. Harris and Ullman (1945) argued that multiple nuclei, essentially smaller models of concentric rings spread throughout a city, were more appropriate. Bursik (1988) proposed that following World War II, cities began to grow in more random patterns, and that social disorganization theory failed to account for this change in urban structure.

There have been many objections to the various methods of examining crime at the community level over the years, including the inability to deal with the changing nature of American neighborhoods (Bursik 1988) and using crime as an indicator of social disorganization and as a result of it (Riess and Tonry 1986). Even research that generally supported Shaw and McKay (Walker 1990) qualified the results due to the change in cities and the fact that the stability found by Shaw and McKay no longer held in modern U.S. cities. Although not as strong of an objection, there is always the question of what combination of neighborhood factors and what level of change is required to create a situation where a neighborhood moves to higher states of disorder and higher levels of crime.

Many of the objections of neighborhood research, and many expansions of it, have begun to be addressed by a group of researchers examining crime ecology. Researchers dealing with spatio-temporal elements of crime (Brantingham and Brantingham 1981), advancements in routine activities theory (Killias 2006), and the link between plant/animal ecology and criminal ecology (Felson 2006) have made substantial advancements in understanding the complexity of the urban ecosystem. This line of research is promising for increasing the efficacy of criminological research, but it is still hampered by its reliance on traditional methodologies and analysis procedures.

### **Complex Systems Science Literature**

Even more so than with the literature on crime, the history of scientific knowledge is lengthy. Arguably, it can be divided into three principle eras however: premodern, modern, and postmodern. From the beginning of time until the 17th century, most knowledge was based in religion, superstition, or myth. Those who were considered most knowledgeable were those who either practiced some kind of religion or who were particularly adept at describing their surroundings. Not much in the way of science was undertaken during this time.

In 1620, Francis Bacon published *Novum Organum*, which changed the way humans discovered and verified information. The title translates into the “New Body,” and referred to the new body of knowledge, now called modern science, that established empirical observation as the preferred method of acquiring knowledge. This new science placed careful observation and mathematical/empirical support as the bulwark of defensible ideas.

Using a paradigm of experimental methodology and linear analysis, scientists conquered much of the physical sciences. Durkheim (1895/1982) brought this Newtonian logic to the social sciences, particularly sociology, in his work on the rules of sociological method. It was to be as simple as extending the methods of the physical sciences to the study of human behavior. It was assumed that, with the right methods, we could ferret out those human characteristics that would allow social scientists to find the same order and consistency in human nature that could be found in physics or astronomy.

Research in the social sciences, including the study of crime, fell far short of the elegant precision of Newtonian laws of motion, however. This research did not fit as easily into a linear paradigm where social phenomena followed correlation patterns approaching 1 with unflinching consistency. Although the failure to fit social science and criminological research to a linear paradigm caused some social scientists to conclude that social phenomena were different from the physical sciences, most argued that we have simply not looked hard enough or in the right places for those characteristics that would consistently explain criminal behavior. As Young (1995) stated:

We thought, and most who deal in such things still think, if we are smart enough, careful enough and disciplined enough we can tease out the inviolable laws of psyche and society; we can bring the social sciences to the same maturity to which physics and chemistry had come in the two hundred years after Newton.

An exception to the linear scientific method was the work of Poincaré (1892/1993). In his work in astronomy in the 1890s, Poincaré developed an understanding of the nonlinearity of physical systems. This led him to propose that the solar system was unstable.

Despite Poincaré's efforts, Newtonian physics and Euclidean geometry would remain essentially unchallenged until the 1960s. In 1962, an American meteorologist named Edward Lorenz discovered nonlinearity in the dynamics of weather systems. It was Lorenz (1963) who determined that not all structures in the physical sciences worked in a purely linear fashion. Lorenz's ideas were accepted with some trepidation within the physical sciences.

At about this same time, the third era of knowledge began to emerge: postmodernism. This paradigm was based primarily on the works of Saussure (1966), Lacan, (1977), Foucault (1965, 1970), and Derrida (1982). Although postmodernism did not replace modern scientific thought as happened in changing from the first to the second era, it did signal a change in the philosophy and way of thinking for many people.

Lorenz's work and those of others related to complex systems science were originally called "chaos theory." This is because they argued that some systems are so complex they look like they are in chaos. Other systems, as will be described below, move from relative order to what could be described as chaos. This became a popular term, showing up in both scientific and lay books and even making its way into movies. As more people studied chaos theory and began to add to the methods, analyses, and theory, it became more accepted to call it complex systems science or a few similar terms to more accurately describe both the systems under study and the methods used to study the systems.

Heavy reliance on complicated mathematical models and a departure from traditional methodologies and theoretical designs prevented the spread of complex systems science to the social sciences for many years. It is only in the past fifteen years or so that some criminologists began to see the value of a paradigm that was less rigid and allowed for the inconsistencies inherent in human nature. It was against the backdrop of Lorenz's analyses and postmodern thought that complex systems science began to emerge within criminology. Young (1995) was one of the first people to propose using complex systems science in criminal justice and criminology. His work laid the foundation for using complex systems science in examining crime from a postmodern perspective. Others such as Arrigo (e.g. 1993, 1996), Henry and Milovanovic (1991), and Milovanovic (e.g. 1992, 1996) continued to develop a postmodern theory of crime using complex systems as the backcloth.

One of the most extensive treatments of complex systems science as it relates to crime is Milovanovic (1997). This book is a collection of essays applying complex systems science to criminology, law, and social justice. The first part of the book is most relevant for the discussion here as it outlines some of the central concepts of complex systems science as they might be utilized in criminology. Some of Young's early and unpublished thoughts on complex systems and crime can be found in two chapters in this section. Each of his chapters provides an overview of complex systems science related to post-modernism. Young shows how complex systems science and postmodernism could be used to reconceptualize various forms of violent and non-violent crime. Pepinsky adds to the discussion of violent crime in a shortened version of his "geometry of violence," which uses a complex systems paradigm to discuss violent crime. The other two sections of the book deal with postmodern explanations of the application of law and a discussion of using complex systems science through postmodernism to support social change.

Specific to using complex systems science to examine neighborhoods is a series of my previous conference papers. In 1996, I examined the propositions of social disorganization theory from a complex systems science viewpoint and suggested ways the theory could be improved using a complex systems paradigm. I expanded that paper in 1997 and presented a discussion of the foundation of complex systems science principles for use in criminological

theory. In 1999, I addressed the data requirements necessary to examine neighborhood characteristics and crime using complex systems science. In 2005, I presented an initial call for using complex systems science in examining cities and neighborhoods. Finally, in 2007, my presidential address for the Academy of Criminal Justice Sciences (Walker 2007) was a call for criminology to adopt complex systems as a new theoretical, methodological, and analytical paradigm for studying crime at the neighborhood level. These papers form the foundation of using complex systems science as the fourth tribe of environmental criminology. The elements of complex systems science and their place in environmental criminology are discussed in the next section.

### **The Fourth Tribe: Complex Systems Science in Neighborhood Research**

Complex systems science is a theoretical, methodological, and analytical paradigm that deals with the complex structure of *order* and *disorder* that is exhibited by natural and social systems. The key words here are order and disorder. Both are important in complex systems science as a research paradigm. Both order and disorder are examined through *attractors*, *bifurcations*, and the patterns of attractors and bifurcations drawn in *phase space*. The order of attractors and the likelihood of bifurcation is partially dependent on the *feedback* experienced by the system. These concepts allow the examination of systems that are far too complex for linear analysis.

These elements of complex systems can be combined with the principles of environmental criminology to represent what I believe is an advancement in the ability of environmental criminology to explain criminal behavior. This would be the fourth tribe of environmental criminology. One that takes the promising aspects described by Sir Anthony Bottoms of the rational choice/routine activities tribe and the post-social disorganization tribe and combines them with the more dynamic and robust analytical and methodological paradigm of complex systems science. This combination represents a new way of examining the crime environment.

An example of research/theory that could be drawn from the fourth tribe is described in this section of the article. The example is Ecodynamics Theory (see Walker 2007). The rationale for this name comes from the research areas from which it is derived. From environmental criminology, this theory proposes humans interact in an ecosystem (Felson, 2006) that includes many live and material entities. Criminologist must study human behavior within this ecosystem as a whole if we are truly to understand the extent of our topic. This ecosystem is quite complex, however, and not suitable for examination with traditional linear models. We must employ complex systems science, therefore, to better understand these complex and dynamic systems. Putting these two overarching paradigms together leads to an ecodynamic examination of crime, communities, and human behavior that changes the way criminologists undertake theory, methodology, and analysis.

There is also the potential to combine the elements of complex systems with other theories and research being conducted in environmental criminology to advance the understanding of the crime environment in others ways. Thus, the fourth tribe could be represented by a variety of research using complex systems to describe the crime environment (cellular automata models, agent-based models, artificial intelligence, etc.).

The remainder of this section addresses the principles of complex systems and how they could be used to explain crime at the neighborhood level. As stated above, they form the foundation of Ecodynamics Theory, but could also be used in other environmental criminology research to address neighborhood change and crime in a dynamic state.

## Phase Space

Phase space in complex systems theory is a graphical representation of what is occurring in the behavior of a system, in this case human behavior. Think of phase space like a map of a city where a person's movement is plotted. The geographic changes of the person can be plotted on the map to represent movement. Because of the need to also examine time, the map needs to be made 3-D so geography is plotted on one plane and time on another. The result is something that might resemble a bowl or sphere and the person's movement over time could be plotted in a continual line that moves horizontally for geographic changes and vertically for time changes. The bowl, which is called a *phase-space basin* in complex systems science, has advantages over strictly two-dimensional space because it allows some variation in time and space even within a single set of behaviors.

Now imagine that each set of behaviors of the person are plotted in separate basins. All activities related to normative behavior (going to school, work, shopping, etc) are plotted in one basin. All activities related to criminal behavior are plotted in another basin. All activities related to potentially criminal behavior (drinking, gambling, etc) are plotted in still another basin. The number of basins for a person could be expanded or contracted based on what was being examined. For example, it would be possible to divide the basins of criminal behavior between, drug use and burglary; or the number of basins could be increased as a person's criminal activities expanded. Plotting behavior in this way increases the understanding of human behavior and interaction similar to that of routine activities theory or environmental criminology, but it is much more complex. Because of its complexity, it requires analytical methods much stronger than linear analyses.

## Attractors

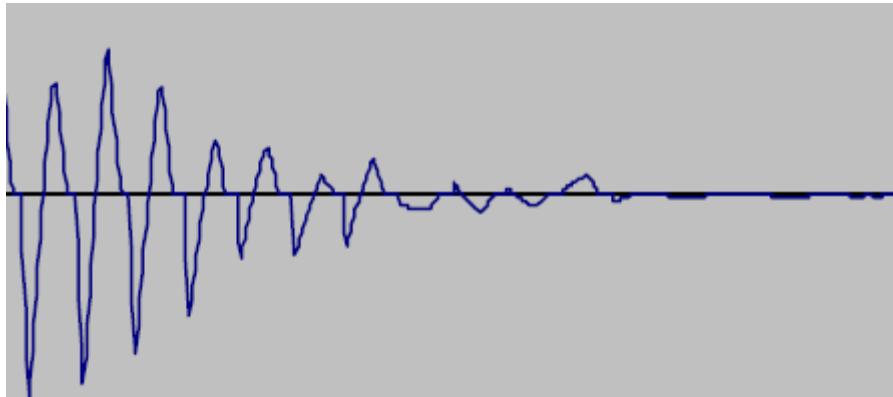
What is represented in phase-space are attractors. All systems operate in patterns. Even those systems with little or no order have certain points that bind them together. The systems that are most orderly can be represented in linear or curvilinear patterns studied with traditional scientific methods. More complex systems require different and more dialectic methods of representing them. Attractors allow this representation. For example, a person who is involved in many complex behaviors may wake up at essentially the same time every weekday. The behavior of the individual is very complex and varied; however, it is attracted to a relatively stable point. Using a criminological example, a person may be involved in burglary, drug use, and drug sales, with no observable pattern in his or her actions. If the individual is observed over time, however, a pattern of behavior may be produced that shows the person moving from burglary to get money to buy drugs, to drug use, to sales of the excess drugs bought. The person is, thus, attracted to a relatively stable pattern of what otherwise appears to be random behaviors.

Although there is disagreement concerning how many attractors exist, it is generally accepted that there are four types. They are arranged from systems exhibiting very ordered

behavior to systems that are considered in chaos because they have order that is very difficult to detect, and impossible to detect with linear analyses.

The first type of attractor is a point attractor. This is a pattern of behavior that converges in phase-space to one point (see Figure 1). An often quoted example of a point attractor is a pendulum that goes to the same point in an arc at equal intervals and then comes to rest at exactly the same point each time.

*Figure 1*  
*Graphical Representation of Movement in a Point Attractor*

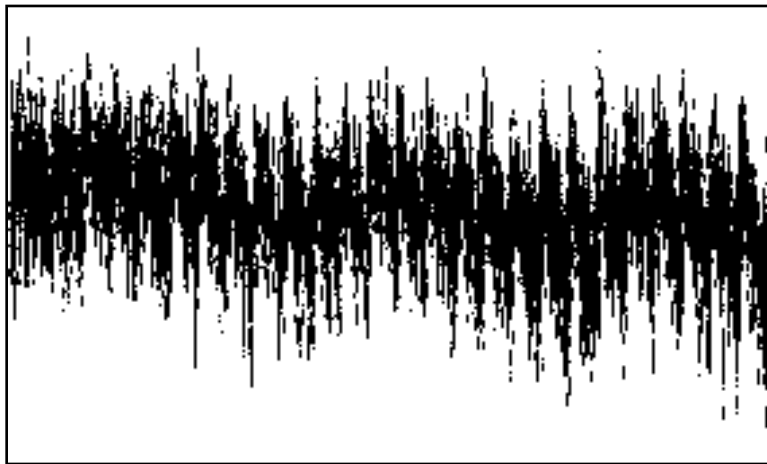


A point attractor essentially cannot exist in neighborhoods and in human behavior. There is almost never a point that characteristics in a neighborhood are at the same point at exactly the same time each year or where they return to exactly the same point when disturbed. For example, there are virtually no neighborhoods in a city that have no population turnover in the time between the decennial censuses. Although there may be very little change in a neighborhood population and it returns to the same number of households, it is unlikely that changes in population in the neighborhood would occur at exactly the same time each year or decade or that the size of a family moving into a neighborhood would exactly match the size of a family moving out. It is ironic that point attractors are rare in dynamic neighborhoods and human behavior because this is the attractor type sought after in traditional research. The goal of almost all current statistical models is a neighborhood (or person) that does exactly the same thing under the same conditions, and hopefully at the same time – a perfect correlation. It is no wonder current criminological analyses struggle; the model sought after does not exist or exists in such small numbers as to render current statistical analyses ineffective.

A limit attractor represents perhaps a more appropriate pattern for human behavior. This attractor allows unlimited variation between two extremes (see Figure 2). An example of this kind of attractor is a thermostat. Temperature is allowed to vary within certain limits. If these limits are not reached, nothing is considered abnormal and the heater or air conditioner will not turn on. Only when behavior is outside the limits does the system react. Limit attractors resist change and will work to settle back into their cycle if disturbed. For example, if the temperature moves beyond the limits of the thermostat, it will turn on the heater in an attempt to bring the system back within its boundaries. In neighborhood research, a limit attractor describes a neighborhood that is very stable and with little crime exhibited. In this kind of neighborhood, changes occur but they are limited and tend to hover within a range of values over time. For

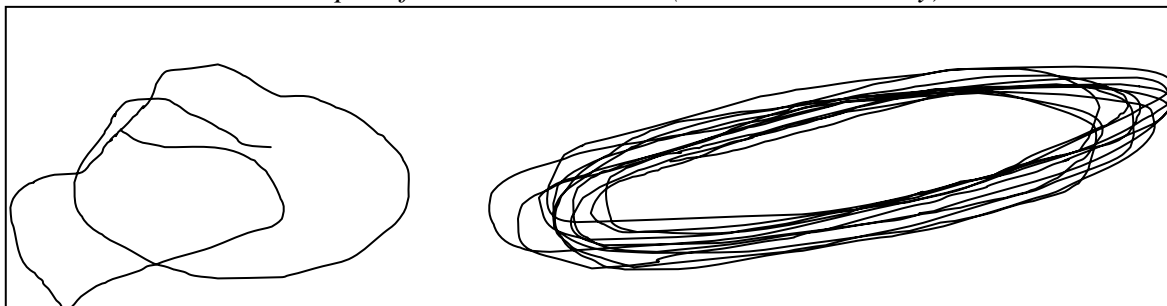
example, when interest rates are low, people in a relatively stable neighborhood may take the opportunity to sell their homes and to buy more expensive homes elsewhere. Others will buy the homes vacated in the neighborhood. When interest rates climb again, the population of the neighborhood will return to a level similar to its previous level; probably not the same population, but relatively close in number. Crime in this system will also show low levels and stability. There may be the occasional teenager who commits delinquent activities. When this occurs, the people of the neighborhood will mobilize to bring crime back within the accepted level, and the neighborhood will stabilize after that person leaves, is controlled, or ages out of crime.

*Figure 2*  
*Graphical Representation of Movement in a Limit Attractor*



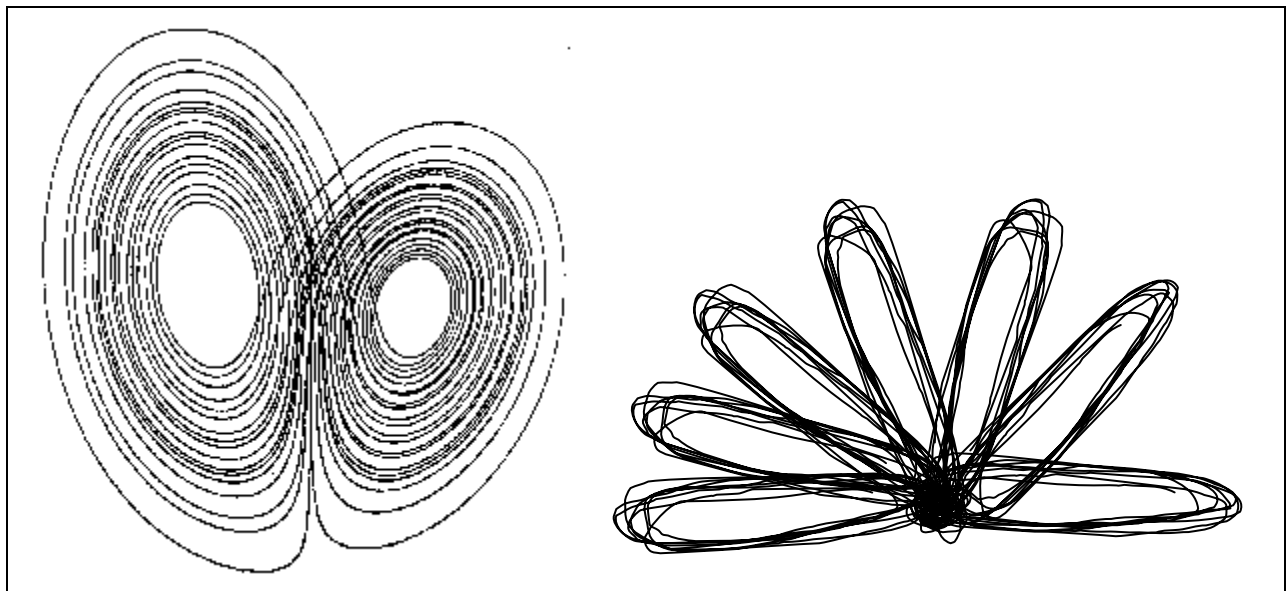
If change occurs too rapidly or at high levels, the limits of variability may be broken and a bifurcation occurs (see below). The system will then change into one where unpredictability is more the norm and behavior is more varied. This state characterizes a torus attractor. This is the point at which we may truly begin to analyze human behavior. A torus is a pattern that occupies three dimensional space but is relatively limited in variation. An example is a marble that is being propelled through a sphere. As that marble moves through the sphere, it is free to move on any side, top or bottom. In fact, the marble will probably not take the exact same path twice. After only a few revolutions, as shown on the left side of Figure 3, there appears to be no pattern; but if enough rotations of the marble are made and plotted, a pattern of behavior develops as shown on the right side of Figure 3.

*Figure 3*  
*Phase Space for a Torus Attractor (2 Dimensional Only)*



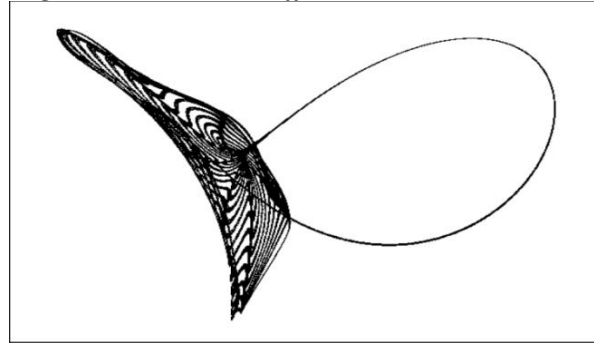
A neighborhood characterized by a torus attractor will exhibit constant change in ecological variables, but the variation will be within some boundaries and represent what one might depict as a fluid neighborhood. For example, some population turnover would occur in the neighborhood as people move in and out. This turnover would be constant and more varied than a limit attractor. The change would not be represented by “social disorganization,” flight, or abandonment, however. In terms of criminal behavior, some crimes would be committed by residents but mostly in other parts of the city, or crime might result from a small number of juveniles engaged in a limited amount of crime. While the crime in the neighborhood would be constant and varied, it would not reach levels sufficient to alarm residents and would be relatively stable over time. This is the type of neighborhood Schuerman and Kobrin (1986) characterized as “emerging crime.”

*Figure 4*  
*Multiple Basin Strange Attractor*



The next attractor is a strange attractor. Strange attractors may be of many different types. At the most ordered level, a strange attractor has two phase-space basins (two phase space plots of behavior). This type of attractor is often called a butterfly attractor because the pattern of activity in phase space takes on the appearance of a butterfly with its wings spread (See left side of Figure 4). As further bifurcations occur, the attractor may develop 4, 8, 16, 32 or more outcome basins (See right side of Figure 4). It is also important to note that the wings of an attractor do not have to be symmetrical (as shown in Figure 5); thus a person could spend more time in criminal behavior, more in non-criminal behavior, or relatively equal time in both. The time spent in each outcome basin could also vary over time or as conditions change.

*Figure 5*  
*Strange Attractor with Differential Behavior Patterns*



A strange attractor represents the point at which criminal behavior may be as equally plausible as non-criminal behavior as people begin to move freely between two or more basins of behavior. In a limit attractor, criminal behavior is an aberration that would cause the system to react to bring the behavior back within limits. For example, a teenager might be caught in some criminal behavior; at which point, the parents step in and make changes to the person's environment to restrict any future criminal behavior. In a strange attractor, however, a person may move freely and randomly between criminal and non-criminal behavior. Criminal behavior may also expand quickly into different outcome basins as the number and types of crimes begins to increase. This is the point that a neighborhood may begin a transition from an emerging crime problem to a more enduring one (Schuerman and Kobrin 1986).

If crime and neighborhood characteristics continue to change, the neighborhood could eventually be said to represent chaos. The behavior would be represented by a multiple basin ( $4n$ ,  $8n$ ,  $16n$ , or larger) attractor. This is the point Shaw and McKay (1942) called social disorganization and what Schuerman and Kobrin (1986) characterized by "enduring crime." Here, there is seemingly no pattern to behavior, especially criminal behavior. The system is unstable, and to a large extent uncontrollable. What once was minor criminal involvement can rapidly turn to many different kinds and levels of criminal behavior as the neighborhood declines and the population becomes more criminally oriented.

Not only is behavior of residents and the neighborhood not consistent in this kind of system, change within the system's characteristics can be irrational and unpredictable. In a neighborhood characterized by deep chaos, some people will move to one outcome basin while others with near identical qualities will move to another outcome basin. Some individuals will be caught and punished, which may cause them to move back to a non-criminal outcome basin; their peers may not get caught or punished and may also return to a non-criminal outcome basin. Others, both caught and not caught may operate predominately in criminal outcome basins. Others could exist in this environment and not engage in criminal behavior at all. Where the outcome basins meet, which is the attractor, it is impossible to predict what outcome basin a person will move into at any given time.

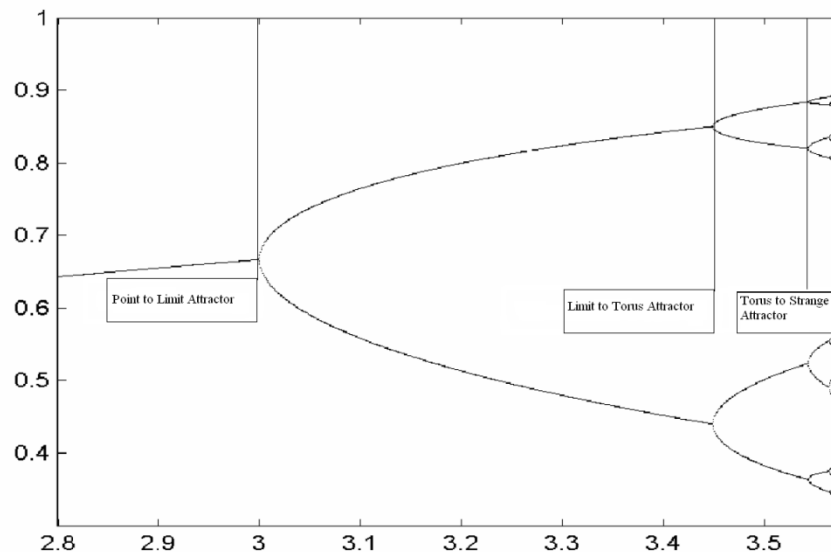
At this level of complexity and disorder, certain characteristics may feed off of others to produce even greater changes. For example, a particularly heinous crime may produce great fear among residents. That fear may result in an increase in the number of residents who move before selling their house, further increasing disorder in the neighborhood. This, in turn, produces even greater changes in the composition of residents and can substantially increase crime, cascading

the neighborhood into more and more outcome basins and levels of complexity and disorder. This will be discussed more fully below in terms of feedback mechanisms.

### Bifurcations: Moving from Order to Disorder

Complex systems often do not stay in one type of attractor. Frequently, systems exhibit increasingly complex and disordered behavior over time. These systems move from one attractor to another at very specific points as they become more disordered. The points at which a system moves from one attractor to another are called bifurcations. They are a doubling in the patterns of behavior where systems move from more to less ordered. For instance, one additional home going up for sale in a neighborhood could create a perception of “flight” among the residents. The behavior here doubles from a single set of actions (not selling homes) to two sets (selling homes and not selling homes) with potentially equal amounts of behavior. The movement from a point attractor to a strange attractor, and the associated bifurcation points are show in Figure 6.

*Figure 6*  
*Bifurcation Map*



An important concept associated with bifurcations is that they occur at exact points within a system. These points are called Feigenbaum points or values after the scientist who discovered them (see Feigenbaum, 1978). These bifurcations always occur at exactly the same Feigenbaum value. As illustrated in Figure 6, at a Feigenbaum value of 3.0, the system will bifurcate from a point attractor into a limit attractor. The system will bifurcate to a torus attractor at a Feigenbaum value of 3.4495. After this, the system will bifurcate at increasingly closer values as it moves to systems exhibiting greater amounts of disorder. This process of bifurcation at particular points has been found in many systems from the stock market to the distribution of galaxies in the universe. In fact, in all systems to which Feigenbaum values have been able to be applied, these values hold true (Young, 1995).

As shown in research spanning over a century, neighborhoods often move over time from relatively stable and low crime areas to relatively unstable and high crime areas. Research and anecdotal evidence also shows points in a neighborhood studied over time that were “critical

incidents” (Williams 1999); those instances that pushed the neighborhood to higher levels of crime. For example, there may be cases where residents are somewhat concerned about the future of the neighborhood. Home owners may begin to move to other parts of the city. Some of them are able to sell their homes quickly, but perhaps some not as quickly. At some point, though, one additional house goes up for sale, which starts a sense of desperation. Many people start putting their homes up for sale. Those who are financially able may even rent their homes. Others may sell to people who rent the homes. This dramatic change in population and in the number of home owners can push the neighborhood to a higher level of disorder and complexity. That one action, therefore, becomes a critical incident in the neighborhood. These critical incidents represent bifurcation points in neighborhood change.

Feigenbaum values and the time between bifurcations can also be shown from neighborhood change. For most neighborhoods, the first bifurcation may take a long time. A neighborhood may be quite stable for several decades because it is in a good part of the city, the homes are new, many homes are owned, etc. As the neighborhood begins to age and become more disordered, it approaches a Feigenbaum value of 3.0. In the example above, that one extra house going up for sale pushes the system beyond a Feigenbaum value of 3.0 and the system/neighborhood bifurcates and moves to a more complex attractor state. Perhaps more renters move in or people who are more socially unstable (say characterized by crime prone aged children) buy the homes. This increases the disorder in the neighborhood and increases the likelihood of crime. Before long, the neighborhood reaches a Feigenbaum value of 3.4495 and bifurcates again to an even more complex attractor. This creates more crime and more disorder, which, through feedback (see below), causes the neighborhood to bifurcate again. The neighborhood continues in this spiral toward disorder at increasing rates. It bifurcates again and again at increasingly smaller time periods as the Feigenbaum values move closer together.

The challenge of criminology, and specifically environmental criminology, is to find these bifurcation points in human behavior or in the dynamics of the neighborhood. If researchers can identify where a neighborhood is in terms of a bifurcation map, changes could possibly be made in the neighborhood that might maintain the stable state. According to complex systems theory, it is easier to maintain a system in its current state than to move it from a less ordered to a more ordered attractor state. It would be better, and easier, then, to recognize a potential bifurcation and provide feedback to keep the neighborhood at the current level of order than attempt to return it to a more ordered attractor state once it bifurcates. This is supported by the work of Schuerman and Kobrin (1986) who proposed that neighborhoods with emerging levels of crime were the most likely to be “saved” from moving to high levels of crime. Criminologists have been unable to predict these critical incidents or bifurcation points to this juncture because of the limitations of traditional analyses. Ecodynamics Theory and fourth-tribe research may be used to determine when the conditions are right for a bifurcation to occur and thus might be able to inform policy concerning where government resources would be most helpful.

## **Feedback**

The final component of complex systems is feedback. Feedback is an impulse sent to the system from its environment that the system uses to make changes to itself. It is like the feedback in an electric guitar where the sound of the guitar affects the system which, in turn, affects the

sound of the guitar, which in turn affects the system in a spiraling process of adaptation and change.

There are three types of feedback in complex systems science. These differ by the consequences of the feedback on the system. Some feedback pushes the system to more disorder, some to less disorder, and some depends on the system. It is also possible the feedback has no effect on the system.

First is positive feedback. This tends to push a system toward more unstable states. This is the kind of feedback displayed in the electric guitar where the feedback gets louder and more complex the longer it is allowed to continue. It is also the kind of feedback displayed in the systems discussed by Schuerman and Kobrin (1986) and Skogan (1986). In that research, changes in ecological variables typically preceded changes in crime. At some point, however, crime increased the rate of change in ecological variables. At still later points, crime and ecological variables combined to produce even further changes in themselves. This kind of feedback to the system of a neighborhood serves to propel it toward further disorder.

The second type of feedback is negative feedback, which tends to push a system toward a more ordered attractor, continually attempting to reduce variation and instability. An example here is a limit attractor. In this state, any movement outside the boundaries of the attractor are met by the system with attempts to move the system back within the limits and maintain the state of order. Only change sufficient to cause a bifurcation can break the system from a limit attractor.

The third type of feedback is non-linear. Non-linear feedback can either be positive or negative depending on the needs of the system, and tends to maintain the system in the present pattern of stability. Non-linear feedback is like the heart during exercise (Young, 1995). In this example, positive only feedback (promoting change to handle increased levels of activity) would cause the heart to move to a fatally high heartbeat level because it would try to adapt to the level of oxygen needed for the most stressful situations. Negative only feedback (always attempting to resist change) would prevent the rapid increase of heartbeat to compensate for new energy demands. This would also be a problem because, in response to exercise, the heart would beat slower not faster. Nonlinear feedback (positive and negative change at different times) offers a dynamic state with which to respond to such exigencies (increasing the heartbeat in response to exercise but also decreasing the heartbeat to keep from damaging the heart).

One of the frustrating but ultimately beneficial aspects of a complex systems paradigm is that change, even change in a system characterized by deep chaos, is not absolute. If it was, we could probably predict it using linear methods of analysis. Complex systems science teaches us, however, that some systems can absorb a great deal of change without moving to further disorder. In the discussion above, some neighborhoods may be able to sustain massive turnovers in population without moving to a transitional or high crime area. For example, some higher SES neighborhoods that serve as “starter homes” for socially mobile people may experience turnover rates near 100% every few years. These areas may not experience increases in crime rates, however, because of their makeup and because the mix of characteristics allow the system to absorb those kinds of changes. Within complex systems science, this relates to feedback mechanisms within the system.

Feedback as it relates to complex systems may also account for the variation in findings that have plagued neighborhood research. For example, Shannon (1982) examined social disorganization characteristics in Racine, Wisconsin in an attempt to show how “large city” characteristics also applied to smaller cities. Shannon found there was not a significant

relationship between the amount of change in the characteristics of an area and related changes in the local arrest rates. He concluded from these findings that smaller cities did not follow the same patterns of social disorganization factors as larger cities. Bursik (1988) suggested a possible reason for this is that “local community adaptations to changes in urban dynamics stabilized much earlier in Racine than in larger urban areas.” It is equally plausible, however, that Racine as a system experienced the type of feedback that caused the system to absorb changes in the neighborhood characteristics without changing the level of crime.

This phenomenon can also be shown in other neighborhood-based research. In the original work of Shaw and McKay, slight increases or decreases in population produced large changes in the delinquency rate, while large changes in population produced small and inconsistent changes in delinquency. In a replication of Shaw and McKay’s research, Walker (1990) found an opposite effect of population. In that study, population changes below the 75<sup>th</sup> percentile were not significantly associated with delinquency. Population changes in the top 25<sup>th</sup> percentile, however, were significantly associated with delinquency. The difference in these two studies supports the principle of complex systems science that small changes in certain elements may produce large changes in other elements in some systems, while the same changes or larger in the same factors will produce little or no change at all in other systems.

The importance of feedback concerns the proper reaction to changes in neighborhood characteristics related to crime. For example, the reaction of Chicago to the findings of Shaw and McKay’s work was the Chicago Area Project that poured money and resources into areas with high crime and disorder. This experiment was considered a failure however because none of the changes produced decreases in crime. If physical deterioration, poverty, and living conditions are factors that appear related to crime, then why does reducing those factors not reduce crime? The answer may lie in the way the resources are provided to the neighborhood, the timing of those resources, and the state of the system when the resources are provided. Resources, or other crime prevention efforts, operate as feedback for the system. Some systems are prepared for negative feedback, and such feedback assists in maintaining the order of the system. In other systems, feedback can do more harm than good. If positive feedback is offered to a system, or if the system was not prepared for feedback, it could cause further disorder in the system. If the system was characterized by a limit attractor state and was simply left alone it would move back within limits of acceptable levels of behavior. In still other systems, the feedback would simply be absorbed with no change to the system.

We must be careful, then, concerning when feedback is offered to the system and in what proportions. Hübler (1992) argued that feedback is only viable for systems below a 4n attractor, and that, in attempting to influence highly complex systems through feedback, the more unstable the system, the gentler must be the feedback. Heavy handed attempts to force the system to remain stable may work for limit or torus attractors, but these tactics could be ineffective or detrimental in systems with greater disorder (Hübler 1992).

For crime control, this means that in the worst neighborhoods in terms of crime and disorder, feedback and attempts to control the system will probably not be of much value. This can be shown in almost any city in the U.S., where increasing police patrols in high-crime areas often has no effect on the levels of crime. Further, introducing feedback in a system that is not prepared for it, or introducing the wrong type of feedback, could cause the system to move to higher levels of disorder. For example, a neighborhood that is close to a bifurcation because of crime could react badly to increased police patrols – in effect, the residents could believe the neighborhood is lost, which could exacerbate the problem and push the neighborhood to a higher

level of disorder. Proper timing of the right kind of feedback, however, may be an answer to crime control models. Neighborhoods that are moving from say a torus attractor to one of more disorder might be at the perfect place for feedback. Residents might be getting somewhat fearful of the future of the neighborhood, and the introduction of foot patrols or other crime control measures could be the catalyst that makes residents believe the neighborhood can be saved and make them take actions to maintain order.

### **The Role of Crime in Fourth Tribe Research**

There has always been an underlying tension between crime and research because, even though crime is almost always the dependent variable, in reality it is also an independent variable. This creates real problems for criminology because much of neighborhood research, back to Shaw and McKay (1942), saw crime as the outcome of neighborhood characteristics and disorder and also the cause of it. Possibly the greatest benefit of adopting a fourth-tribe approach to examine neighborhoods and crime is because it allows crime to change roles at different times or within the same system. Crime in Ecodynamics Theory may be a dependent variable and the subject of study; but it may also serve as a cause of additional levels of disorder through feedback, as discussed above. Instead of the differing roles of crime (even within the same system) causing problems for the analysis, however, Ecodynamics Theory embraces the nature of crime and uses it to further understand the system.

These differing outcome basins are important for the study of neighborhood change and crime because complex systems science allows the same factors to produce one outcome (non-criminal behavior) at a particular value and a different outcome (criminal behavior) even with the same value. This does not mean that the variables interact differently or with other variables. This means that the same variables, even with the same values, can produce non-criminal behavior at one point in the system and criminal behavior at another point. This is because the phase space of the system has “enough room” that two objects (characteristics or variables) can occupy the same space at the same time. When this occurs, it is possible for the objects to interact in some systems and not in others. It depends upon the kind of feedback that is being experienced by the system. This may partially account for the many cases where two brothers grow up in the same household under the same conditions but one becomes a successful businessman and the other goes to prison. This revolutionizes the way we look at neighborhood change, and is key for the use of fourth tribe theory in studying neighborhood change. In traditional analyses, the same combination and level of variables should result in the exact same outcome (a point attractor in complex systems parlance). In complex systems science, no longer must different values of variables or different combinations of variables be used to show variation between neighborhoods. Now, the same variables and values can be used to describe different outcomes in the same neighborhood.

Feedback, in effect, solves the problem of crime being both a dependent and independent variable. Initially in the system, crime is probably a dependent variable. The ecological variables come together in some form that increases the level of crime. Once the system gets sufficiently complex, however, feedback may cause crime to take on different roles, depending on the system and what is happening. For example, in some neighborhoods, crime may continue to be a dependent variable, being influenced by the ecological variables. In other neighborhoods, crime may become an independent variable, increasing the ecological variables rather than the ecological variables increasing crime. The ecological variables and crime may also reach a point

where they combine and further influence themselves to push the system/neighborhood to higher levels of disorder and higher crime. Here, crime may be a dependent variable and an independent variable (or interaction variable with other independent variables) in the same time period. This is the methodological problem Shaw and McKay (1942) were criticized for, and the situation Schuerman and Kobrin (1986) recognized but could not address with linear analyses and traditional methodology. What makes matters worse for traditional methodologies but not for Ecodynamics Theory is that, in this situation, it is easy to see there is a spiraling nature of the variables. Both crime and the other ecological variables are in a feedback loop where crime is initially influenced by the ecological variables, but then may have an influence on them, eventually reaching a point where crime and the ecological variables come together to increase the disorder of the neighborhood, and that disorder itself increases the level of crime and the ecological variables, which continues to increase the disorder and crime. This turns our methodological world upside down. We have been taught to look for intervening variables to account for different outcomes in criminological theory. The exact opposite is stressed in Ecodynamics Theory.

### **Limitations of Fourth Tribe Research**

Although an argument can be made for an immediate and beneficial use of fourth tribe theor in neighborhood research, there are problems inherent in this paradigm, as with all other theories. These problems may be overcome to a certain extent in future development of fourth tribe research.

The first problem in fourth tribe (Ecodynamics Theory) research lies in its relative infancy of application. To this point, complex systems science has mostly been limited to a mathematical ideal. It has been used to describe the weather, to describe predator prey cycles, and in contrived mathematical experiments, among others. There has been some application of complex systems science, especially in examining characteristics that lend themselves to univariate, mathematical research such as brain waves, heart patterns, and such. There has also been limited research in other areas of psychology and medicine. In those instances where a complex systems paradigm has been used, it has produced results consistent with the mathematical models, so it is reasonable to believe the same will hold true when we begin to test complex systems theory in criminology. Little research had been conducted, however, in most of the social sciences and especially in criminology, so the methods of conducting research related to social factors such as crime are rudimentary and not well tested.

There is also the problem that research using a complex systems paradigm is very data hungry. The nature of examining patterns where seemingly none exist require one to collect a large amount of data. It also requires that the data be longitudinal. In the days of limited funds for criminological research, longitudinal studies that are this revolutionary may face difficulty getting funded. This problem, however, may not be as big a detriment for community-level research as it would be for more individual level theories. Much of the research on neighborhoods and cities spans at least two iterations of the decennial census. Although this is still a limited amount of data, it is such that initial assessments of the viability of using fourth tribe principles can be tested, at least in terms of the ecological variables associated with the census. The same cannot be said for crime data; although it is also improving. The kind of crime data needed for these analyses only began to be collected in an electronic format in many cities in the 1990s. On its own, this is now probably sufficient to begin to conduct complex systems

analyses. We may need a few more years, however, before crime data and neighborhood data reach a point where they are simultaneously sufficient for these kinds of analyses.

The final problem is that this line of research is not a theory of prediction. The nature of change beyond a point attractor prevents us from knowing where the system will be at any given time. Even within ordered systems, such as a limit attractor, we can predict a general pattern of behavior of the system, but cannot predict where a characteristic of the system will be at any given point. For example, research will not be able to predict when a person will commit a crime or who will be criminal – not that we can do that now, but we still cling to the notion of being able to do so with better methods and more data. With a complex systems paradigm, the best that can be accomplished is to identify those factors that most influence the patterns and attractors and attempt to apply feedback mechanisms that will ensure the greatest possible order in the system. For neighborhood crime control, this means identifying the key parameters that drive neighborhoods to less ordered attractor states; not necessarily eliminating factors of change, but rather working with those factors to maintain a stable state of neighborhood order and crime. This is still a substantial improvement over current criminological theory, but in using fourth tribe research, we must accept from the beginning that it will not be able to identify that one thing in a person that will allow prediction of criminal behavior.

## Conclusion

The purpose of this article was to propose that there is value in changing the way we examine crime and that models based on the precepts of complex systems combined with the principles of environmental criminology offer promise in increasing our understanding of crime at the neighborhood level. Adopting the principles of complex systems into environmental criminology could represent the fourth tribe of environmental criminology; one that takes the promising aspects described by Sir Anthony Bottoms of the rational choice/routine activities tribe and the post-social disorganization tribe and combines them with the more dynamic and robust analytical and methodological paradigm of complex systems science. This new tribe would be based on the environmental criminology principle that humans interact in an ecosystem that includes many live and material entities. This ecosystem is quite complex, however, and not suitable to examination with traditional linear models. We must employ complex systems science, therefore, to begin to truly understand these complex and dynamic systems. Putting these two overarching paradigms together would lead us to an ecodynamic examination of crime, communities, and human behavior that changes the way we do theory, methodology, and analysis. This combination would move us forward from our current state to a new level of understanding of the way people, neighborhoods, and cities change over time. We could finally begin to use the scientific methods appropriate for studying human behavior – not scientific methods designed for much more ordered systems.

Of course, there is still much that needs to be accomplished to adapt complex systems theory to environmental criminology. This is not something that can be accomplished overnight. A stronger and more specific statement of the theory needs to be developed, and we need to begin to test the theory with crime data. I believe this is where we need to be going as a discipline, however, if we are to continue to advance our understanding of criminal behavior.

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