Chaos Theory, Informational Needs, and Natural Disasters

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Abstract

This study applies chaos theory to a system-wide analysis of crisis communication in a natural disaster. Specifically, we analyze crisis communication during the 1997 Red River Valley flood in Minnesota and North Dakota. This flood, among the worst in modern American history, consumed entire metropolitan areas, displacing thousands of people. The conditions and decisions leading to the disaster, and the subsequent reactions are retraced. Communication related to river crest predictions (fractals), the shock at the magnitude of the crisis (cosmology episode), novel forms of reorganizing (self-organization), and agencies that aided in establishing a renewed order (strange attractors) are evaluated. Ultimately, we argue that preexisting sensemaking structures favoring rationalized, traditional views of a complex system led officials to make inappropriately unequivocal predictions and ultimately diminished the effectiveness of the region's crisis communication and planning.

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Chaos theory has enriched many areas of inquiry by expanding the applications of the systems perspectives to the non-linear operation of large, complex systems (Butz, 1997; Frederick, 1998; Gleick, 1987; Hayles, 1990; Kiel, 1994; Matthews, White, & Long, 1999). These views also have the potential to clarify the communication dimensions of such systems, including the role of uncertainty, equivocality, and predictability. Specifically, chaos theory may elucidate how communicators characterize the behavior of such systems in their descriptions and predictions of outcomes. It may also point to the ways in which communication processes relate to systems moving in and out of chaos and order. In this study, we examine the devastating North Dakota and Minnesota floods of 1997 and the ways in which emergency management and government officials at the federal, state, and local (the cities of Fargo, Moorhead, and Grand Forks) level responded to a chaotic system, including how they communicated about risk, threat, and predictability. We argue that preexisting structures for sensemaking that favor rationalized, linear views of complex systems led officials to make inappropriately unequivocal predictions and ultimately, led to a cosmology episode, a collapse of sensemaking. This collapse during the flood, however, generated new communicative structures and relationships, understandings, and procedures in a manner consistent with self-organization. Interviews with key emergency management personnel, including members of the Federal Emergency Management Agency (FEMA), the National Weather Service, and North Dakota Emergency Management Personnel, and media and official reports are used in this case study of equivocality in risk messages regarding a chaotic system.

Initially, we outline chaos theory. Specifically, we define bifurcations, fractals, and strange attractors as key elements of our analysis. We then discuss the relevance of these concepts to crisis communication. Next, we apply these elements to the Red River Valley flood of 1997. Finally, we offer conclusions and practical implications for communicating in chaotic situations.

Chaos Theory

Meteorologist Edward Lorenz, in an effort to increase the level of predictability of complex weather phenomena, initially described chaos as a property of systems. Lorenz (1963) found that a very minor modification in weather models led to unanticipated, wildly fluctuating, and seemingly contradictory outcomes. More recently, chaos theory (CT), along with related work in the complexity sciences, catastrophe theory, and non-linear dynamic system theory, is applied broadly to the social sciences, including psychology, economics, sociology, decision-making, political science, medicine, criticism, urban development, organizational studies, and crisis communication and management (Abraham & Gilgen, 1995; Butz, 1997; Guastello, Dooley, & Goldstein, 1995; Hayles, 1990; Matthews et al., 1999; Murphy, 1996; Robertson & Combs, 1995). Chaos theory expands the systems perspectives to the behavi or of large, complex, non-linear systems, including those where social and technical elements interact in highly dynamic and casually disproportionate ways. This normal interaction within highly complex systems increases the probability that unanticipated and highly disruptive outcomes will occur (Perrow, 1984).

While a common belief is that chaos theory rejects prediction, its approach seeks order and predictability, albeit without established causal and deterministic patterns and models (Hayles, 1990). Newtonian causal logic, linear proportionality, and reductionist methods are simply viewed as inadequate for explaining the dynamic complexity of systems (Kauffman, 1993; Kiel, 1994; Matthews et al., 1999.) However, general trends and patterns regarding the behavior of chaotic systems, particularly as they are viewed holistically and as they cycle over extended periods of time, may become evident. Moreover, underlying structures and processes of order function to reconstitute stability and structure even in the face of apparent randomness (Kauffman 1993). "In fact, chaos may be the necessary precursor of a higher level of order" (Kiel, 1994, p. 4). Chaos theory, then, represents a loosely related body of concepts, including sensitive dependence on initial conditions, bifurcation, self-organization, fractals, and strange attractors, that seek to describe the behavior of non-linear systems at higher levels of complexity. Taken together, these concepts help explain both the chaotic and the organized features of complex systems.

A basic factor used to account for the behavior of complex systems is the principle of sensitive dependence on initial conditions, often called the butterfly effect (Stewart, 1989). Stewart suggests:

> The flapping of a single butterfly's wing today produces a tiny change in the state of the atmosphere. Over a period of time, what the atmosphere actually does diverges from what it would have done. So, in a month's time, a tornado that would have devastated the Indonesian coast doesn't happen. Or maybe one that wasn't going to happen, does. (p. 141)

Stewart describes complex systems in ways that emphasize their openness and sensitivity to influences, many of which cannot be measured or understood using traditional methods. The impact of even minor variance, background noise, in combination with lack of "infinite precision in the measurement of initial conditions" suggests that predictability is impossible (Matthews et al., 1999, p. 446). Kiel (1994), for example, describes the role of communication in the Shuttle Challenger disaster as an example of the butterfly effect. "The butterfly--in this case an error in communication-generated amplifying effects that had unexpected outcomes--posing a new set of problems for the space agency . . . that still lingers today" (p. 7). The absence of clear measurement of initial conditions and understanding their impact with the concomitant reduction in certainty and predictability undermine accurate and confident forecasts about the long-term behavior of systems. Such conditions, in turn, make precise, accurate, and confident communication problematic.

The systematic changes that emerge in response to a chaotic environment are referred to as bifurcation. Bifurcation represents the flashpoints of change where a system's direction, character, and/or structure are fundamentally disrupted. Bifurcations are the "abrupt, discontinuous, and divergent changes in the formal system" where the basic system equilibrium breaks down (Matthews et al., 1999, p. 445). All complex systems, even those with the appearance of stability and order, have the potential for bifurcation. Those systems with high states of exchanges and connections with their environments may be typified by higher levels of instability and periodic bifurcation. Crisis events and behaviors, also associated with environmental dependence and change, are often described in chaos theory as these points of system bifurcation (Seeger, Sellnow, & Ulmer, 1998; Murphy, 1996; Matthews et al., 1999). Two conditions associated with bifurcation points include cosmology episodes and self-organization.

Cosmology episodes occur when the crisis situation creates an overwhelming sensation on the part of observers. Chaos theory suggests that such cataclysmic moments result from a consistent misinterpretation of feedback over a period of time, leading to a radical and fundamental disruption of system equilibrium. Weick (1993) describes this process as a collapse of sensemaking, suggesting that organizations seek to make sense of crises, at least initially, by comparing them to previous events. Since crises are typically unexpected, novel, and surprising events, this dependence often results in organizations tenaciously justifying standard actions even when they fail to account for the exceptional nature of the crisis. Accepting the extraordinary nature of the crisis may not occur until the organization recognizes the situation as a cosmology episode where all existing forms of sensemaking fail to account for experiences. Weick (1993) explains:

> A cosmology episode occurs when people suddenly and deeply feel that the universe is no longer a rational, orderly system. What makes such an incident so shattering is that both the sense of what is occurring and the means to rebuild that sense collapse together. (p. 634)

Weick believes that the human reaction to cosmology episodes is illustrated by such statements as “I’ve never been here before, I have no idea where I am, and I have no idea who can help me” (pp. 634-635).

Self-organization is a phenomenon sometimes described as the outgrowth or consequence of bifurcation. It is a natural process whereby order re-emerges out of a random and chaotic state (Stewart, 1989). This reordering process is characterized by some theorists as the mirror image of chaos. Kauffman (1993), who describes self-organization as anti-chaos, argues that some very disorganized systems spontaneously solidify into a higher degree of order. Moreover, this new order appears to arise from inner guidelines and principles rather than being imposed by external forces. Thus, chaotic, complex systems have some drive or capacity for order, although the relationship between order and chaos is complex and dynamic. Through self-organization, new forms, structures, procedures, hierarchies, and understanding emerge, giving a new form to the system often at a higher level of order and complexity. This duality and seeming paradox of order/disorder, deconstruction/construction, and routine/non-routine has been proposed as useful conceptualization of organizational crisis (Seeger et al., 1998, p. 232).

The problem of predictability in chaotic systems and the principle of self-organization merge with the concept of fractals, initially described in the measurement of shorelines. Mandelbrot (1977) observed that quantitative measurements of shorelines using different scales, such as 100 meters versus 10 meters, yielded very different conclusions. Fractals, then, derive from the issue of measurement in complex systems which, according to chaos theory, is largely a function of perspective. Accordingly, quantitative methods simply do not manifest sufficient levels of precision given the complexity of such systems. Mandelbrodt (1977) coined the term fractal to describe qualitative approaches to the measurement of these complex systems. Moreover, with these qualitative perspectives on variance, it was possible to identify similarity or correspondence within system complexity. These “self-similar” structures, or fractal sets, are repeated throughout the system, exhibiting constant patterns or similar “degrees of irregularity . . . over different scales,” albeit at levels of high complexity (Gleick, 1987, p. 8). Fractals, as qualitative structures of order, have been documented in a wide array of natural and physical phenomena. This observation includes many natural and manmade structures and processes that initially appear random and chaotic such as wave patterns, plant structures, the clouds, mountain ranges, the branching structures of blood vessels, dripping faucets, and price fluctuations in commodities and stock prices (Glieck, 1987). These underlying patterns, although often not casually evident, even occur in the presence of very high variability and provide one form of order to chaotic systems. What is important about fractals for the purposes of this analysis is the self-similarity and pattern they manifest even in the face of apparent chaos. Waves, for example, exhibit a high degree of variability in terms of size, frequency, and intensity. Even within this high degree of variability, individual waves have a predictable structure and form. Thus, these fractal patterns may constitute one form of predictability in chaotic systems. Determining fractals, then, requires an inclusive and broad perspective.

The final element of chaos theory described here is the concept of strange attractor. Like self-organization and fractals, strange attractors emphasize order and pattern within chaos. An attractor is an organizing principle, an inherent shape or state of affairs to which a phenomenon will always return as it evolves even through bifurcation (Murphy, 1996). The underlying order in a chaotic system may constrain the erratic behavior and serve as a regulating force on the system. Attractors are strange in the sense that they do not operate from a fixed point or in linear ways (Butz, 1997). The point of attraction may be fragmented across space and time so that "an object in this attraction would move about unpredictably" (Butz, 1997, p. 13). Strange attractors may take the form of general and fundamental social assumptions, values, first principles, conflicting tensions and needs, or oppositional paradoxes to which a social system naturally and continually returns.

Chaos theory, then, points simultaneously to the inherent disorder, randomness, complexity, and unpredictability; and to the inherent order, pattern, and general predictability in an effort to understand the operation of large, complex systems. Such systems are described as self-organizing, indicating “that out of chaos a new stability forms. In fact, it appears that a chaotic period is necessary for a new adaptive stability to be achieved” (Butz, 1997, p. 14). The emphasis on the dual ordered/disordered nature of systems, along with the emphasis on understanding complex systems, makes chaos theory particularly useful for the study of organizational crisis (Seeger et al., 1998).

Crisis

Crisis has been examined by communication researchers from a variety of methodological, theoretical, hierarchical, and structural stances (Benoit, 1995; Coombs,1999; Seeger et al., 1998; Seeger, Sellnow, & Ulmer, 2001). Although crises take many forms, communication scholars have typically focused on crisis in organizational or political contexts. In contrast, natural disasters and crises, such as forest fires, hurricanes, earthquakes, tornadoes, and floods, have received less systematic attention. These events are typically described as large-scale community or geographically based events, precipitated primarily by natural processes that severely impact society or its sub-units (Kreps, 1984; Quarantelli, 1978). Natural disasters, however, interact with human structures and processes in highly complex and unpredictable ways that often accentuate harm (Comfort, 1989). For instance, Wenger's (1978) research suggests that natural disasters may impact the organizational power structure of a community. As a result, Dynes (1978) explains that these events provide an interesting opportunity for examining inter-organizational relations. It appears that disasters in the form of earthquakes, hurricanes, and forest fires, although natural processes, can have profound effects when combined with established human structures in communities.

Weick (1995) describes crisis as low probability-high impact events that place severe demands on sensemaking for both participants and decision-makers. Crises create high levels of threat and uncertainty, and a critical need for almost immediate, accurate information, usually provided by experts, emergency management professionals, governmental officials, or similar authority figures (Seeger et al., 1998). The stressful and uncertain conditions of crisis often precipitate maladaptive responses on the part of crisis managers and decision-makers (Gouran, Hirokawa, & Martz, 1986). In some instances, for example, managers may initially respond by discounting the severity of the crisis even in the presence of overwhelming evidence to the contrary (McGill, 1994; Seeger & Bolz, 1996). Responses may also include blanket denials of responsibility (Benoit, 1995). Weick (1995) sees expectations as "starting points" for sensemaking because they affect the "information that is selected for processing" (p. 148). Weick (1988, 1995) suggests that these expectations lead to initial responses to crisis that influence subsequent crisis-related behaviors and explanations. This influence may take the form of tenacious justifications that are difficult to deny or later back away from.

The conditions of crisis in combination with high informational needs may enhance the relative levels of uncertainty. In these cases, the sensemaking capacity of individuals seeking to manage and contain a crisis may be overwhelmed, thus enhancing crisis-related damage. Weick (1993), in an analysis of a fire-related disaster at Mann Gultch, concluded that chaotic conditions and a confused role structure within a fire-fighting crew led to a collapse of sensemaking capabilities. The fire crew suffered a “cosmology episode . . . when people suddenly and deeply feel that the universe is no longer a rational orderly system” (p. 633). Thirteen lives were lost in what has been described as the worst disaster in the history of the U.S. Forest Service. Sellnow and Ulmer (1995) argue that, even though a crisis may call for an immediate and clear response, often the more appropriate and accurate stance is one that reflects the true complexity of the situation. Thus, many crisis responses are likely to include some degree of equivocality.

The chaotic view of crisis proposed here emphasizes the inability to accurately predict or forecast the behavior of a complex and dynamic system. Moreover, the crisis event itself represents a bifurcation point where dis-equalibrium in established system operations, routines, procedures, assumptions, and other structures of system order occurs. Self-organizing processes, however, can be expected to arise following bifurcation. This self-organization is manifested and influenced through fractal sets and strange attractors, and eventually reconstitutes the system at a higher level of order and complexity.

Database

This study employs a case study method in order to develop, in rich detail, descriptions of the events, decision-making processes, and emerging organizational patterns that were evident during the most critical period of the 1997 Red River Valley floods. Information was collected in four steps. First, a series of structured interviews were conducted with the city mayors and operations managers for Fargo, North Dakota, and Moorhead, Minnesota. The county emergency manager in the city of Fargo was also interviewed. No parallel official exists in Moorhead. The interviews were structured using a critical incident approach (Hargie & Tourish, 2000; Query & Kreps, 1993). Specifically, interviewees were asked to focus their answers on the time beginning in 1997 when the river initially left its banks until it receded from the emergency dikes. City officials were asked a consistent series of questions inviting them to describe their decision-making, communication strategies, and organizational efforts related to this intense period of the flood fight. Second, the lead officials in the region representing FEMA and several other support agencies were interviewed using the same schedule of questions. All interviews were transcribed and cross-referenced. Third, media accounts of the crisis and relevant reports were collected from local and national press in order to chronicle the events during the most intense period of the flood fight. Finally, various agency reports and statements were examined, including those generated by the Army Corps of Engineers and the Federal Emergency Management Administration. Our goal was to use these sources to create as complete an understanding as possible of the complex interactions surrounding these catastrophic floods.

The 1997 Red River Valley Floods

As the volatile March snows and thaws of 1997 confronted the warmth and rain of April, the record-setting snowfall of the Red River Valley along the border of North Dakota and Minnesota began to melt. Water ran through every available channel feeding the north-flowing Red River. When the tributaries were overwhelmed, blankets of water stretching for miles began to ooze overland in a steady migration toward the Red River. None of this preliminary flooding was surprising to the city leaders of Fargo and Grand Forks, North Dakota; and Moorhead, Minnesota. For three months prior to the spring thaws, city and county leaders planned for severe flooding. The region had been hit by a record number of blizzards, leaving more snow than had ever been measured in a single winter. Moreover, the region occupies an ancient lakebed, very flat with few naturally protected areas. Flooding, a relatively common occurrence, was inevitable. What the region's leaders and residents did not understand and could not predict, however, was that the flood's severity would surpass even the most pessimistic predictions.

Snow measured 30 inches in area fields—more than twice the normal levels (McEwen, 1997). The previous record flood was established in 1897 when the Red River crested in Fargo at 39.1 feet (D. Gilmour, 1997b). Eventually, all old records would fall; entire metropolitan areas would be consumed by water; and a quarter of a million people would face the worst disaster of their lives.

In the following analysis, we, first, interpret the communication difficulties regarding predictions of crest levels as fractals. Second, we discuss two forms of bifurcation that occurred during the flood: cosmology episodes and self-organization. Finally, we identify several strange attractors that emerged to enhance communication throughout the flood.

Fractals

Despite the magnitude of snow cover and the unanticipated degree of overland flooding, regional leaders continued to rely on traditional quantitative means of water measurement and prediction. These conventional calculations depended on a series of gauges that provided specific measurements of water depths along the Red River. These precise measurements are typically effective in predicting water levels for normal spring flooding. They do not, however, sufficiently account for what Matthews et al. (1999) term initial conditions. For example, factors such as the presence of ice, damming effects, and overland flooding were not considered in the traditional measurement techniques. The traditional approach, therefore, failed to account for the chaos produced by the overwhelming enormity of the runoff interacting in unpredictable ways with a number of geographic and climatic features. The flat lakebed geography of the region, road beds, bridges, and even levees had interacted in unanticipated ways. Consequentlyt, the methods used to forecast flood levels in the region simply could not account for the extreme variance in the system with sufficient precision to predict system behavior. Emergency managers, however, continued to rely on the traditional measurement methods. In short, the methods used to forecast flood levels in the region made precise communication about the crest levels impossible. Despite the limitations in measurement, the flood-related messages coming from the region's community leaders continued to portray the National Weather Service's predictions as exact. As such, the key problem associated with fractals in this case involved the communication of excessive confidence in a measurement system that lacked the precision needed to deal with the complexity of the flood.

The region's dependence on specific measures from assorted gauges represents a bias toward "modern science's assumption that single units are microcosms from which the whole system's behavior can be deduced" (Murphy, 1996, p. 99). When floating ice jammed the north-flowing river, causing flash floods and blocking or damaging gauges, for example, measurements were distorted. Heavy rain and widely fluctuating temperatures made it impossible for predictions to keep pace with fluctuating water levels ("Ice Jam," 1997). As a result, the traditional flood prediction techniques fell victim to the warning inherent in chaos: "concentration on individual units can yield insignificant or misleading information" (Murphy, 1996, p. 99). In chaotic circumstances, qualitative measurements, such as the patterns of fractals, may provide more accurate perceptions by accounting for degrees of irregularity using an inclusive set of data points (Gleick, 1987). In stock market downturns, for example, broad patterns of self-similar regularity over extended time frames may point to eventual upturns in market trends. In this case, however, the shortcomings of depending on traditional means of measurement in response to the chaotic circumstances of the flood became increasingly clear as the crisis unfolded.

Early in April, residents along the Red River were warned to prepare for flood crests as high as 38 feet. At the onset of the crisis, the 38 feet prediction was considered generous. On April 10, neighborhoods along the river lost their final "semblance of normalcy" following a National Weather Service prediction that the crest would hit between 39 and 39.5 feet. (D. Gilmour, 1997a, p. A1). Residents and city workers scrambled around the clock to raise dike levels. Two days later, work was interrupted by news that the "predicted crest dropped from a top height of 39.5 feet to a low of 37.5 feet" due to the discovery of "a faulty automated gauge upriver" (Hilgers, 1997a, p. A1). The entire Red River Valley was said to have breathed a sigh of relief at the revised forecast. Still, residents were frustrated by the erratic forecasts.

City officials wondered aloud what would have happened if the "reading [of the faulty gauge] was actually two feet lower than reality" (MacDonald, 1997, p. C3). This faulty reading represents the first sign that the city officials' dependence on a single, traditional form of measurement was problematic. The gauges simply failed to comprehend the complexity and severity of the flood. The U.S. Geological Survey, the organization that monitors the gauges, claimed the faulty reading was an isolated incident. The National Weather Service considers the data provided by the gauges when making predictions regarding crest levels. The discrepancies in its readings were blamed on the faulty gauges. The malfunction in the gauges was said to have been caused by extreme temperatures and damage caused by floating ice chunks. Manual gauges back up the automatic versions; however, the manual gauges were inaccessible due to ice (MacDonald, 1997).

By April 14, the Fargo Operations Manager said that it was unlikely the Red River would crest again in Fargo. An unofficial crest reading of 37.61 feet, the second highest on record, was slowly dropping. The next day, all hope for a quick finish to the flood faded, however. The operation manager's prediction was based on the second faulty gauge reading in a week. Floodwaters were actually rising and were expected to climb above 38 feet (Hilgers, 1997b). With this second failure, the National Weather Service abandoned its automated gauges while maintaining its traditional focus by switching to hourly readings of available manual gauges.

On April 24, signs of bitterness and finger pointing related to the National Weather Service's forecasting effectiveness were evident. Residents insisted they could have saved the city if they had known how high the water would rise. Many accused the National Weather Service of misleading them. Grand Forks' mayor said, "I don't like to be critical, but we were told absolutely 49 feet by the weather service," and she insisted that, had the city known how high the waters would rise, the devastation "would have been preventable" (Prodis, 1997, p. A7). The mayor's reaction reveals a persistent denial of the chaos surrounding the food. Air temperature, overland flooding, and ice jams made forecasting an exact crest date and level impossible. Moreover, the traditional measurement system upon which the community leaders based their communication to residents was largely ineffective. Yet, the mayor insisted on blaming the National Weather Service for the flooding in Grand Forks. In reality, the community based its crisis planning and communication on a system of measurement that, although it had been effective for much less severe floods in the past, could not account for the complexity of the 1997 situation. The hydrologist in charge of the regional forecast center offered this retrospective defense, grounded in what was now recognized as a chaotic and increasingly dangerous situation: "We were dealing with an unprecedented flood and you're dealing with Mother Nature and you just have to roll with the punches . . . It's extremely complex and under the circumstances I think we did a very credible job" (Prodis, 1997, p. A7). Thus, the National

Weather Service emphasized the fact that the predictions it makes are always limited by the confounding variables that are present in natural disasters.

As the debate over inaccurate forecasts and preparation in Grand Forks rambled on, Fargo residents received the grim news that, had temperatures risen more quickly, flood levels would have reached 42 feet, well beyond the capacity of existing dikes. A Fargo meteorologist revealed the evidence of multiple variables in the flooding when he explained that the “difference between what happened in the two metropolitan areas was not preparation or hard work, but just plain luck” (Wheeler, 1997, p. E8).

Following the flood, an investigation of the National Weather Service’s forecasting procedures, conducted by the Pioneer Press of St. Paul, Minnesota, yielded no evidence that the agency had “bungled” its predictions (“Newspaper,” 1997, p. C1). The study found that “government officials worked at the edge of scientific knowledge and made extraordinary efforts—occasionally risking their lives—as they tried to monitor and predict the river’s behavior” (“Newspaper,” 1997, p. C1). In the end, National Weather Service officials explained that the bridges in Grand Forks created an unanticipated damming effect that forced water levels two feet higher than predicted. The interaction of human structures with natural features created higher levels of complexity and enhanced the probability of bifurcation. Interestingly, the report also indicated that the National Weather Service “never suggested its original 49-foot crest prediction was something Grand Forks residents could rely on” (“Newspaper,” 1997, p. C1). However, the agency did admit that “forecasters could have stressed the uncertainties of their prediction in stronger terms” (“Newspaper,” 1997, p. C1). In essence, two problems with fractals occurred during the flood. First, the system of measurement was too simplistic. The community relied on a data set that did not sufficiently address the anomalies of the 1997 flood. Second, both the National Weather Service and the community leaders communicated with an excessive degree of confidence regarding crest levels. Thus, the region’s flood preparation was hampered by failures regarding both the measurement procedures and the communication regarding those procedures.

It is important to note the system-wide complexity associated with natural disasters creates impediments to precise communication. Ironically, it is precise communication that the public desires and often demands. In the 1997 flood, meteorologists understood that precise communication was impossible due to the inexact science of weather forecasting. However, the demands placed upon the community leaders as they battled the flood created an unrealistic dependence upon the daily forecasts provided by the National Weather Service. This unrealistic dependence resulted in meteorologists de-emphasizing the uncertainties of their science in their communication to the public.

In retrospect, it is clear that the region's dependence upon a series of gauges to provide crest predictions created the opposite outcome: a reactive stance. Even prior to the snowmelt, residents intuitively were aware that there was more moisture in the area than had ever been recorded in history. This fact, combined with the typical measurement problems fostered by jagged slabs of ice periodically producing ice dams and unprecedented overland flooding, rendered standard measurement procedures ineffective. It was simply not possible to predict how much water would move under these conditions. Still, officials acted upon the National Weather Service's crest forecasts, displaying considerable frustration with their inevitable inaccuracy. In the end, the National Weather Service based much of its defense on the fact that it never intended for the cities to rely solely on its predictions.

City officials would have benefited from a more inclusive context for considering the measurement results. In previous floods, officials obtained a maximum crest figure from the National Weather Service and prepared accordingly. As such, city officials remained locked into a "certainty seeking mode" (Murphy, 1996, p. 102). In 1997, officials continued this strategy, despite the extreme conditions. Rather than expanding their view to include communication which took into account the variability and uncertainty caused by other contextual factors such as snowpack and temperature fluctuation, officials insisted on obtaining their information, as they had always done, from the National Weather Service's gauge estimates. A more complex conceptualization of the system and different scales of analysis incorporating qualitative assessments may have resulted in different messages regarding the flood. Their failure to view this flood as a novel instance limited their capacity to consider information from the broader context. As a result, officials remained in a reactive position based on final crest estimates (which were only available after the flood) that, in Grand Forks and areas surrounding the city limits of Fargo, resulted in residents being surprised by swiftly rising flood waters. In short, the expectation that this flood could be handled like preceding events created a tenacious justification for relying on the same gauge readings that had proven successful with much smaller floods in the past.

Bifurcation Points

As the flood situation intensified, two forms of bifurcation were apparent. First, the unparalleled rise in water levels thrust the region into a cosmology episode. Second, the community leaders engaged in an unprecedented form of self-organization to better manage their flood resistence efforts.

Cosmology episodes. On April 17, the Red River surpassed the 100-year record by climbing to 39.12 feet. The Fargo Operations Manager made reference to the chaotic situation: “We are at river stages that exceed the 1897 level. No one has ever seen this much water in the Fargo area, ever. All we can do is react” (D. Gilmour, 1997c, p. A1). In essence, the operations manager was entering a cosmology episode. Neither he nor any of his coworkers had ever experienced flood conditions in the Red River Valley that were as intense as what he was facing. He had no repertoire of strategies to follow for a flood of this magnitude. By his own admission, he was asking residents to take precautions that he could not say with certainty would protect them from the rising waters.

As the floodwaters exceeded record levels, Grand Forks officials, further down the north-flowing Red River, faced the same form of uncertainty. When the waters reached a level that exceeded both their prior experience and their confidence, Grand Forks officials called for a voluntary evacuation of low-lying areas. In an effort to facilitate an orderly evacuation, Grand Forks’ mayor said, “It’s not a panic situation, but we want each and every person in these areas to be safe” (Condon, 1997a, p. C1). This statement reveals the uncertainty and insecurity associated with cosmology episodes. Grand Forks’ dikes were built to withstand 52 feet. The prediction on April 17 was for a crest of up to 50.5 feet. Grand Forks' emergency manager showed some concern that the dikes had "never been tested at 50 feet" (Condon, 1997a, p. C1). He noted, in a relatively rare admission of the equivocality in the situation, "From an engineering standpoint, they're safe. But we have to let the people know we're dealing with an unknown" (Condon, 1997a, p. C1). The Grand Forks city manager was placed in a situation where he was asked to communicate clearly about the stability of the city's dikes. Yet, the conditions exceeded both his experience and his previous expectations. Thus, the cosmology episode that was emerging confounded not only his sense-making abilities, but also his capacity to communicate about the crisis.

The self-similar pattern of crest prediction and water levels then exceeding the predictions, followed by a higher predication and levels again exceeding the predicted crest began to emerge. Residents appeared to observe the pattern and used it to discount the accuracy of subsequent predictions. Dikes, for example, were explicitly built to exceed the official predictions because the predictions had consistently been too low. This pattern represented a dramatic shift from traditional flood management where crest predictions are used as the basis for almost all flood management activities and decisions.

A sudden shift to warm weather made forecasting crest levels for Grand Forks increasingly erratic. Water rose so quickly that the National Weather Service's forecasts "barely stayed ahead of actual river levels" (Condon, 1997b, p. A10). Water lapped at the top of the Grand Forks dikes as residents scrambled to raise them with sandbags. By April 19, water began topping the dikes in Grand Forks and its neighbor across the river, East Grand Forks. Eventually, the flood crested at 54 feet, 2 feet above the permanent dikes in Grand Forks. Water began rushing down city streets, and emergency officials called for an evacuation of both cities (Condon, 1997c). Within hours of the dikes' failing, an additional catastrophe struck downtown Grand Forks. Firefighters watched helplessly as "fires raced along some of its downtown rooftops" ("Fire Adds Hell," 1997, p. A17).

The 1997 flood represented the first time in modern history that the Red River consumed entire communities. City officials and residents had "fallen prey to positive feedback" from their previous success fighting floods (Murphy, 1996, p. 106). Thus, when the dikes began to crumble and residents were caught in a race to escape rather than to hold back the flood, the region faced a cataclysmic moment that stunned its residents. The rapid flooding of Grand Forks and the subsequent fire represented a cosmology episode for residents.

During the night of April 18, a surge of water topped the dikes in Grand Forks. Water levels were as much as two feet higher than expected. Emergency officials ordered the entire city of over 50,000 residents to evacuate to higher ground. One reporter described the scene as follows: “With sirens screaming over the river, helicopters circling overhead and National Guard trucks rumbling down the streets, the city felt like a war zone” (Condon, 1997c, p. A1). No one in the city had ever seen water flow down its main streets.

The ubiquitous feeling of helplessness in Grand Forks was further intensified when several blocks of downtown Grand Forks burst into flames. Firefighters were helpless in streets covered with up to four feet of water. Emergency officials were simply unable to get equipment to function (“Fire Adds Hell,” 1997, p. A1). The powerlessness of emergency workers and the shock of the sudden collapse of Grand Forks starkly exemplify the form of “discontinuous and divergent” events in a crisis that lead to bifurcation (Mathews et al., 1999, p. 445). Flood fighters and residents were thrust into an aberrant, bifurcated world when water began to careen over the dikes that had protected the city for decades. As water gushed into the sewer system, residents reported seeing manhole covers shooting as much as eight feet in the air. Thus, the city flooded from within. One resident expressed her feeling of bifurcation, likening reality to a dream: “It seems like a dream but it’s there. You don’t believe it’s true, but it is” (Condon, 1997d, p. A3). Clearly, events in her life had taken a turn from the expected path. She was struggling to deal the chaotic, bifurcated situation she faced. Another resident said that he was awoken by sirens and told to leave his home. He and his family were wading through sewage by the time they got out of their house. He reported that the evacuation and rising waters were more frightening than what he saw as a marine in Vietnam (Hagerty, 1997). For this resident, not even his experiences in the Vietnam War could aid in his sensemaking abilities during the flood.

When a historic section of downtown Grand Forks burst into flames, as a consequence of electrical shorts from the floodwaters, emergency workers were stunned. Fire raced from the upper stories of flooded building to flooded building while city firefighters sat by helplessly in fishing boats. The water was simply too deep for them to deliver equipment to the blaze. Residents watched in horror as black smoke rumbled through the sky above their city. In a scene reminiscent of a forest fire, airplanes and helicopters circled the city for hours, dropping water and chemicals on the flooded conflagration. “The huge fire ultimately was contained through water and chemical drops from both National Guard helicopters and airplanes” (Condon, 1997e).

Ultimately, at least eight downtown buildings were destroyed by fire. Residents had to wait for details of the damage until the floodwaters subsided. Getting close enough to investigate the damage was arduous because the water made access dangerous or impossible. City officials raced to demolish the scorched and feeble frames of the building that remained. One reporter described the bizarre situation: “While the [wrecking] crane sat 5 feet deep [in water] against 15 knots of Red River current, it began swinging at historic downtown buildings destroyed by uncontrollable fires over the weekend” (G. Gilmour, 1997, p. A1).

In the hours after the flood and during the fire, “the Fire Department and National Guard worked to rescue those trapped in rising flood waters, by boat, truck, and in a few spots in East Grand Forks, by helicopter” (“Fire Adds Hell,” 1997, p. A17). Ironically, the hazardous conditions that threatened the well being of emergency workers and residents also led to the evacuation and closing of the city’s only medical center. Patients were evacuated to a nearby air force base and to surrounding towns (Condon, 1997e).

The confusion and uncertainty associated with cosmology episodes continued even after the residents were evacuated. The 50,000 evacuated residents scattered throughout the state and region. More than 3,000 people evacuated to the air force base, “some as a temporary stopping point and some for the duration of the flood” (Condon, 1997d, p. A3). Fundamental patterns of community, work, family, and place were disrupted. “Many who found shelter at the Grand Forks Air Force Base appeared to be confused and without hope,” said George Lacher, director of the Fargo

Catholic Diocese's Queen of Peace Catholic Center. "It was just beyond belief" (Crawford, 1997, p. C3). Because the evacuated residents were facing an experience that was completely unanticipated and beyond their previous experiences, their sensemaking abilities were still severely limited in the days following the evacuation. The hopelessness described above was due, in part, to an inability to reconcile the devastating effects of the flood. The results of a city of 50,000 being completely evacuated were hard for those outside the area to imagine. "Anything you've seen on TV, it's worse" said Rick Foss, bishop of the Evangelical Lutheran Church in America's Eastern North Dakota Synod (Crawford, 1997, p. C3).

Residents sought to reestablish structure and reconnect in novel ways. Radio stations, for example, broadcast messages to family members separated by the rising water. Newspapers published personal messages, which were posted around shelters. Message boards emerged as a primary means of communication.

Two particularly dramatic examples of novel communication resources that emerged during the flood fight were an AM radio station in Fargo and the Grand Forks daily newspaper. The AM station had sufficient wattage to broadcast throughout the entire Red River Valley region. This station dedicated its format almost entirely to flood coverage during the period when the river was at flood stage. Residents were invited to call the station and broadcast their appeals for sandbagging assistance live. This communication channel allowed for the highly efficient movement of human resources throughout the flood region. The station invited city officials and representatives from support agencies to broadcast their messages at will. Despite having their press destroyed by fire and water, the Grand Forks Herald, using presses from several cities in the surrounding area, published an abbreviated edition every day throughout the flood. In addition to providing information related to the city's status, the paper dedicated considerable space to a form of bulletin board that allowed residents to inquire as to the well-being and whereabouts of friends and family. The continued publication of the Grand Forks Herald helped reestablish both a sense of community and of normalcy. Both the radio station and newspaper were recognized nationally for their commitment. The Fargo radio station was given the Peabody Award for community service. Similarly, the Grand

Forks newspaper was awarded a Pulitzer Prize for its dedication to serving the community during its time of peril.

The equivocality and uncertainty of the situation did not diminish as the water levels dropped. Residents faced an unprecedented cleanup task for which they were unprepared. When the skies quieted enough for a reporter to survey the damage from a helicopter, he described the city as "little more than a vast brown sea, with a few isolated pockets of land popping up" (Condon, 1997f, p. C1). A sewer stench hung in the air for miles surrounding the city as residents collectively wondered, "Where will all of this water go? How can it all eventually fit back into that small river bank?" (Condon, 1997f, p. C1).

One sign that the cosmology episode had not dissipated was the fact that residents were forced to follow a curfew. When residents were allowed back into their homes, they were restricted by the novel mandate of an 8:00 p.m. curfew. Individuals who violated the curfew faced fines as high as $500.00 (Nance, 1997, p. 4). Residents found their homes saturated with sewage and mud. Those residents with damage restricted to their basements considered themselves fortunate. Homes were still without water and electricity as the cleanup began. Residents assisted city officials in policing their own neighborhoods as threats and rumors of looting circulated (Nance, 1997, p. 4).

The cleanup process itself introduced residents to potential hazards with which most residents had little or no experience prior to the crisis. Public health officials played an important sensemaking role for residents during the cleanup process. When residents began the cleanup process, Grand Forks' public health director warned them that the cleanup could be hazardous. He explained that "heavy lifting, exposure to allergens or toxic gases and danger of hypothermia are just a few of the dangers lurking between you and a clean home" (Scaletta, 1997, p. 9). Most residents were forced to purge their homes of all flood-soaked belongings. Mountains of furniture, carpet, utilities, and other possessions emerged as "homeowners dumped a lifetime of possessions on the curb" (DeLage, 1997, p. 1). Scavengers meandered through as public affairs officials admonished them that the sewer water and pesticides soaking the rejected possessions made them extremely noxious.

As the tedious and extraordinary cleanup process continued, mental health officials also contributed to the sensemaking process for residents. For instance, one mental health officer explained that, after experiencing a disaster, victims go through many stages. The experience may begin with shock and numbing, moving to a heroic stage of being supportive and coming together with other victims. After a brief honeymoon stage of pledging to overcome any hardship, victims begin to feel disillusionment and anger. One clinical social worker explained that “anger is a legitimate emotion . . . to bottle that anger up is not good’” (Angeles, 1997, p. 15). Such were the reactions to events so shocking that they produced a cosmology episode in a region that is accustomed to floods. Beyond the devastating effects on sensemaking, the 1997 flood also impacted the natural structure of the agencies that coordinated the flood resistance and recovery efforts.

<u>Self-organization.</u> During the 1997 flood, city, county, and state, agencies were all forced to coordinate their efforts daily or hourly. The independence enjoyed by each agency was washed away when the flood reached catastrophic levels, bifurcating the established order of agency hierarch and creating the opportunity for a new order to emerge. The emergence of such cooperative efforts is not surprising. Chaos theory explains that crisis produces “sudden changes” in a “system’s direction, character, or structure, called bifurcations” (Murphy, 1996, p. 97). These shifts may then lead to new and potentially positive relationships. Crisis can create these opportunities for new order. The new order emerges in response to the dire circumstances of the crisis. The magnitude and duration of the 1997 flood forced agencies to align as an interdependent system in an unprecedented manner. The chaos of the flood produced the form of bonding stimulus Butz (1997) sees as essential to the formation of “a new adaptive stability” (p. 14).

The novel system that emerged during the two weeks that Fargo and Moorhead were besieged can best be characterized as one of suspended rivalries and collaboration via the reputation of neutral agencies. Interviews with agency leaders revealed that the combined efforts were not void of conflict. For the system to survive, however, underlying tensions among cities, counties, and state agencies had to be suspended momentarily. Ultimately, a tenuous new order emerged as cities, counties, and state agencies worked together for two weeks to hold back record water levels. This spontaneous system enabled the southern portion of the Red River Valley to sustain a flood fight that lasted more than three times longer and posted water levels two feet higher than anticipated. The Grand Forks community could not develop such a system because its dike assemblage failed even before the river reached its first crest. Therefore, this segment of the analysis focuses on the Fargo-Moorhead region. In the case of Fargo and Moorhead, the flood enabled a bifurcation that created an opportunity for a more cooperative order to a system that had been competitive for some time.

One form of rivalry emanated from a resentment of Fargo by some Moorhead leaders. Because the two cities are located parallel to one another across the Red River, cooperation was essential in managing their flood defenses. This location of the two communities, separated and united by the Red River, was a primary factor leading to the development of coordination. Since Fargo's population, at 87,000, is nearly triple that of Moorhead, Moorhead leaders complained of being "upstaged" by Fargo. The smaller city had difficulty garnering the media attention it needed to communicate with its residents. Moorhead's mayor said, "We're always competing with Fargo for media attention. Their [sic] being the big kid on the block obviously, nationally, attracts more media attention than we get. So it's an ongoing struggle" (personal communication, June 28, 1999). Moorhead's city manager rationalized the lack of media exposure it received during the flood this way, "Basically we had a lot less damage than Fargo. I daresay, we were probably more prepared maybe. Consequently, we were a secondary news item" (personal communication, July 12, 1999). These comments serve as convincing evidence of the tension between Moorhead and Fargo prior to the 1997 flood regarding its most threatening stages.

Much of the tension between Moorhead and Fargo was based on the immediate need of each city to use radio, television, and the newspaper to get information out to residents expediently. Simply put, Fargo received the media attention it needed while Moorhead did not. To cope with this discrepancy, Moorhead's leaders took the first step toward suspending conflict and forming a novel cooperative effort. Moorhead's mayor and city manager accepted an invitation from Fargo's mayor to attend the daily news conferences held at Fargo's city hall. Fargo's mayor said the city "took over" as the media center without a "conscious effort." He said, "we just felt that it made more sense to do it here. And then other people kept coming in, you know Moorhead came in after a while" " (personal communication, June 1999). Eventually, Fargo's mayor explained, the morning news conferences "became the central point for getting communication out to the media" (personal communication, June 1999). The common threat and immediate need to communicate through the media, in this case, was the stimulus for self-organization. The two cities created a new hierarchical order of communication. This new hierarchy served to centralize communication in Fargo's City Hall. In this manner, the need for efficiency replaced the pattern of rivalry that had been established previously.

One of the FEMA project managers in the region commended the two cities' leaders for cooperating in their news conferences to get essential information out to residents. She noted that the collaborative press conferences "really helped put people's minds at ease. They felt that they knew what was going on. They knew what the city was doing" (personal communication, June 16, 1999). In essence, Fargo and Moorhead were able to, in Kauffman's (1993) words, spontaneously solidify a new order that was far better suited to respond to the community's needs than was the previous order.

Another form of self-organization that changed a previous pattern of communication involved Fargo's relationship with the county. In the past, the county had always served as the emergency operations center. Fargo's mayor explained that this relationship was altered by what he perceived as a lack of felt urgency on the part of the county. The mayor was exasperated that, in critical stages of the flood, the county still closed its offices at 5:00 p.m. He said:

> They actually closed down. I mean, we'd call over there and nobody's there. The coordinator was gone. We'd page them, we'd call them back. We were trying to make

> decisions. We can't wait for that. We couldn't figure that out—why were they closed? (personal communication, June 1998)

This frustration resulted in the crisis system evolving from a county focus to a city focus. Self-organization in chaotic circumstances often results in a higher level of order and complexity. When the county continued to function in its previously established order, it simply could not meet the increasingly complex needs of the city. Thus, Fargo maneuvered with state agencies to self-organize into the primary agency in the flood fight.

The emergency manager for Cass County, the county surrounding Fargo, felt he was distanced from the Fargo leadership by his inability to participate with the city in pre-flood planning. He insisted that the demands of the county made it impossible for him to work as closely with Fargo as the city's leadership desired. The Cass County emergency manager reflected on this situation as follows:

> You tend to grow with somebody during the disaster if you work with them from the filing stage to the preparation stage to the actual disaster. If you start from the very beginning, you seem to have a mutual goal as you're going through it. Whereas if you come into the board or on board at the time that you're only looking for assistance or help, then there are sometimes difficulties in communications. I wouldn't say friction, but there is this communication thing because you haven't been allowed or had the ability to actually learn what they've done to date. So you don't know where they are exactly coming from. (personal communication, July 1998)

In this case, the previous relationship was not mended by the crisis. Rather, the complex needs of the city resulted in a form of order that precluded the county from playing a major role. Despite misgivings by the county emergency manager, in the end, the county was relegated to a minimal role in the management of the 1997 floods. In fact, Fargo applied for and received authorization from state government to function as an emergency operation center for the state. In essence, this move was a form of self-organization that permanently supplanted the county's previous role of managing major emergencies related to Fargo, the largest city in North Dakota.

Moorhead had no such problems coordinating efforts with its county officials. Moorhead's mayor explained that the county and city have a "joint emergency operation center" which, from the start, had "county people and city people all operating out of the same emergency center" (personal communication, July 1999). As a result of the crisis, Fargo and Moorhead were able to self-organize in a manner that enabled them to overcome the exigencies of the crisis. Although crises can be quite destructive to systems and physical structures, this example suggests that a form of self-organization can also emerge that actually enhances the quality of communication associated with the crisis.

Strange Attractors

Strange attractors may emerge in crisis situations to offer some degree of order within chaos. Thus, strange attractors allow some form of underlying order to persist throughout a chaotic event. In the case of the Red River Valley flood, two external support agencies provided a means of communication coordination that instilled a form of confidence and order.

While the National Guard's contribution to bridging communication in the spontaneous system may have been unnoticed by the public, its presence offered an unanticipated feeling of security. Butz (1997) explains that strange attractors emerge and function unpredictably. This uncertainty was clearly the present with the National Guard. Initially, several city leaders worried that the guard's presence would intensify fear by suggesting that the cities and county had lost control. Quite the opposite occurred. Fargo's city manager clarified the National Guard's contribution:

> I was surprised how many people were so happy to see the Guard directing traffic. I mean there was chaos and there was stress. When they saw those guys out there, it seemed to add a little bit of reassurance. I thought maybe it would create more stress, but no. They thought having the military there directing traffic provided a little bit of feeling good—there was some order. Another positive aspect I didn't expect. (personal communication, July 28, 1999)

Fargo's mayor observed that the National Guard "gave the appearance, maybe, that everything was okay. People just like the uniform" (personal communication, June, 1999). It is ironic that the presence of armed troops in the streets of Fargo functioned as strange attractors helping to reconstitute a sense of normalcy. Yet, by their very presence, the National Guard inspired a form of order in a chaotic situation.

FEMA also played a role of strange attractor. As the surging water began to consume homes and destroy basements, many residents were left with little knowledge of where to go or how to recover. Others remained fearful that the flood had exceeded the capacity of Fargo and Moorhead to cope with the persistent water. FEMA offered a return to order by lending credibility to city officials and by facilitating the first stages of recovery for those whose property had been damaged. For example, Moorhead's city manager mentioned that FEMA publicly endorsed some of its innovative diking techniques. Being commended by FEMA officials added credibility to the city engineers as they communicated with residents about dike maintenance and construction. Moreover, FEMA established a visible presence throughout the crisis by operating a large, central warehouse where residents could apply for financial assistance; get information and advice; pick up food and cleaning supplies at no cost; and simply rest in a dry, warm, and safe area. The expertise of FEMA's workers played a role similar to that of the National Guard, reassuring residents that the federal government had not forgotten them. FEMA also coordinated and augmented local communication efforts in a way that eased tensions and enhanced credibility for some workers. Once the flood water subsided, FEMA's role expanded to assisting flood victims whose homes had sustained damage and helping devise preventive measures for future floods. Through its presence during and after the flood, FEMA offered a form of order to a community whose confidence was deeply shaken by a natural disaster that greatly exceeded its expectations.

Ironically, Cass County's emergency manager felt further alienated from the flood-fighting process by the arrival of FEMA. He did not deny the importance of FEMA's role. Rather, he contended that FEMA's presence tended to override all other agencies, noting that "FEMA will bypass the county and a lot of times, even though they work with the state, I think many times they bypass the state" (personal communication, July 1999). This frustration is not unexpected with strange attractors. Butz (1997) explains that conflicting tensions that exist prior to a chaotic event may reemerge as a form of pre-existing order. In this case, the emergency manager experienced frustration with the city prior to the flood. FEMA's presence further reduced the role for the county in the flood recovery effort. The county was excluded from the communication between FEMA and the city. This exclusion, said the county emergency manager, made coordination difficult. Eventually, he argued, residents came to see FEMA as being "the all giver and they forget the county is still here and we have to work 365 days a year and not just during the disaster" (personal communication, July 1999). Thus, the FEMA assistance that many in the system saw as comforting and reassuring was perceived by this county worker as further evidence of a persistent unwillingness on the part of the city to work with the county. In this manner, FEMA functioned as a strange attractor that enabled the county emergency worker to return to the level of tension that existed prior to the flood. Despite its negative aura, this tension served as a form of order for the county worker. The result was a continued sense of rivalry on the part of some county employees even though attractors of location, common threat, and external support agencies had produced high levels of cooperation and coordination.

Theoretical and Practical Implications

The floods that threatened Fargo and Moorhead, and overwhelmed Grand Forks point to a number of factors concerning predictability and communication of risk, informational need during crisis, breakdown of sensemaking, and the role of strange attractors and emergent communication systems in subsequent self-organization and recovery. These factors are useful in both understanding crisis and risk-related communication in complex, non-linear systems; and in informing the practice of crisis communication.

The floods illustrate the tension between the fundamental absence of predictability in complex, non-linear systems and the continued tendency of crisis managers, even in the face of chaos, to assume that traditional methods for prediction are adequate. This tendency to see novel events according to previous experience is well documented in the crisis literature. Gouran et al.

(1986), for example, note that decision-makers at NASA assumed that the Challenger shuttle would launch successfully because it had in the past, even though the critical variable of temperature was at an entirely untested level. Weick’s (1995) concept of the selection of existing sensemaking devices for the reduction of equivocality is useful in explaining this tendency to see and communicate about novel and threatening events in routine ways. In North Dakota, this enactment through established sensemaking devices led decision-makers to communicate about the rising water in routine and unequivocal ways. The search for linear and simple order in the face of crisis and chaos many encourage managers to communicate messages reflecting more predictability than actually exists.

The crisis literature also points to informational needs of stakeholders who are threatened during times of crisis (Seeger et al., 1998). Fargo and Grand Forks residents needed specific, timely information regarding crest levels in order to determine the minimum dike level. Information during crises often has a specific functional value in terms of threat reduction and harm mitigation. Timely warning of tornadoes and hurricanes allows residents to protect themselves. Dissemination of information about tainted food or defective products allows companies to conduct recalls. In this case, the precise information needed to limit water damage, i.e., crest levels, was not available due to the chaotic behavior of the system and associated measurement problems. As noted earlier, however, emergency management personnel continued to enact the flood according to linear predictability and issued precise crest predictions. By so doing, they created the perception of certainty where it did not exist. Eventually, the self-similar pattern of inaccurate predictions became evident, subsequently reducing the credibility of forecasts, but paradoxically allowing residents to respond more effectively to the crisis. This response suggests that unequivocal statements during a crisis might be less valuable than probabilistic statements, reflecting more realistically the lack of precise predictability in any crisis situation and allowing stakeholders to make their own qualitative assessments. Ulmer and Sellnow (1997), in fact, have suggested that such equivocality may represent a more ethical stance in the face of a crisis. Emergency management personnel, therefore, may need to strike a careful balance between the two stances of certainty: a) quantitative precision, predictability, and probability; and b) qualitative patterns and estimates. The present state of understanding related to crisis communication, however, does not yet provide clear estimates for practitioners seeking that balance. In the absence of such clarity, crisis communication practitioners should err toward greater equivocality.

The Red River Valley floods also illustrate the phenomenon of a cosmology episode and the breakdown of basic sensemaking structures. Residents of Grand Forks, in particular, lost their fundamental ability to make sense of their radically altered world. Core beliefs and assumptions about security, essential convictions about the stability of institutions, and the very viability of the community were literally washed away. Perhaps this cosmology episode is most vividly illustrated by fires raging though Grand Forks' flooded downtown. While some sense of normality eventually returned after months of cleanup and rebuilding; and by telling and retelling and interpreting and reinterpreting the story, it is likely that the basic notion of normality and crisis has been fundamentally altered for those citizens who experienced the 1997 floods. The Red River, a central feature of both the Fargo and Grand Forks communities, will be seen in a much more complex way. The organized system of beliefs and values has emerged through bifurcation to a new, more complex level. The search for order and normalcy involved communication processes at a number of levels, including the media, interactions with friends and neighbors, and venues for telling and re-telling the stories of the floods. Most notably, a lasting form of self-organization resulted in the flood story being told and contemplated from the perspective of the region rather than from the singular standpoint of any given community. For example, following the 1997 flood, Minnesota, North Dakota, and Canada formed a task force to plan for the management of future floods. One of the key features of the task force's ultimate report admonished community leaders and emergency managers to avoid rivalry by maintaining the cooperative spirit that emerged in 1997. In the report, each city in the Red River Valley was advised to "to build on the trans-border relationships which developed after the 1997 flood" (D. Gilmour, 2000, p. B1). In essence, then, the 1997 flood significantly altered the way in which the region perceives itself.

Crisis scholars have also observed that crisis events often have unanticipated positive outcomes (Seeger et al., 1998). Chaos theory suggests that, following bifurcation, these systems often exhibit self-organization, leading to new relationships, structures, and understandings. During the floods, agencies from various cities, the county, state, and federal levels developed new structures for cooperation and coordination. New methods of dike construction and new understandings of the Red River system and its behavior under extreme conditions also developed. Novel insights regarding how predictions function and the role of equivocality in issuing warning were developed. These developments set the stage for both recovery and, eventually, renewal.

The strange attractors of region-wide common threat and shared hardship ultimately served to strengthen community bonds and order. In addition, FEMA and the National Guard played a role in the new organization that developed between Fargo and Moorhead. These two agencies operated in a manner that simply ignored city, county, and state boundaries. The community was addressed as a whole by these agencies. Thus, FEMA and the National Guard served to energize and enable the self-organization that fused Fargo and Moorhead into an atypically cooperative entity. Crisis managers and political leaders would be wise to recognize the potential for this secondary, but valuable, role that such outside agencies can play in uniting communities during crisis. Emergency management and crisis communication practitioners should also take note of the opportunities created during disaster to reconstitute a sense of community, identity, and civic order at a higher level of system complexity.

For both communication scholars and practitioners, some of the most interesting dimensions of the floods involved the emergence of novel communication systems. These systems of communication involved a variety of media used in highly creative ways. While the use of media in emergency management, such as warnings and announcements, is standard procedure, mass media in this case was used in a much more flexible manner. In many instances, broadcasters abandoned established formats and routines, and created more responsive and immediate channels for disseminating necessary information throughout the region. Call in radio shows became community bulletin boards, allowing families and friends to reconnect with one another. Flood managers were able to announce that specific manpower was needed at specific locations. In addition, these systems of communication provided an outlet for alternative interpretations and emotional expressions, and served a primary role in reconstituting a sense of community and normalcy. In addition, these systems of communication served to coordinate flood activity, provide an outlet for alternative interpretations and emotional expressions, helped to reconnect family and friends, and served a primary role in reconstituting a sense of community and normalcy. The results of this investigation reiterate the critical role of communication during crisis and point to the resilience of communication channels during this event. Maintaining flexible, responsive and resilient channels of communication during disasters clearly should be a priority of crisis managers. Moreover, emergency managers should understand the role of such systems in crisis logistics, in re-establishing normalcy and community, and as a force in subsequent self-organization.

Directions for Future Research

Chaos theory represents a rich framework for communication analysis and is particularly well suited for the examination of crisis in complex non-linear systems. It is important to recognize, however, that like systems theory, chaos theory is a very broad and general set of constructs. While this quality enhances its flexibility as an analytical framework, it reduces precision and, thus, may be seen as a limitation. This stance, however, is appropriate given the inherently equivocal nature of crisis. The present study points to several ways in which chaos theory can be used as a general framework for further the understanding of crisis communication. In this investigation of the Red River Valley floods, for example, both common threat and the intervention of third party agencies were identified as a strange attractors during crisis bifurcation. The conditions of crisis itself, therefore, helped reconstitute system stability and organization. Subsequent investigations should focus on describing other strange attractors involving communication that may function during crisis.

Additionally, processes of self-organization and the role of communication represent an important area of future inquiry. This study suggests that communication processes played a central role in reconstituting normalcy, relationships, and a sense of community. In may be that these communication processes themselves represent strange attractors leading to new, higher levels of system complexity following bifurcation. Communication scholars might focus specifically on the ways in which crisis creates novel communication processes with particular attention to the role of communication technologies. The internet, for example, has been used extensively to disseminate calls for aid following international disasters.

A third potential area for future inquiry involves other types of disasters. Several researchers have pointed out that the specific nature of a crisis influences its development (Seeger et al., 1998). Thus, product recalls can be expected to differ from plant explosions or transportation accidents. The same conclusions likely hold for different forms of natural disasters. Investigation of communication processes during hurricanes, tornadoes, and wild fires might serve to clarify both the similarities and differences in these events.

Finally, the question of appropriate levels of equivocality in crisis messages remains largely unanswered. Much of crisis communication literature suggests that organizations should be as open and honest as possible in their post-crisis responses in order to quickly move past the crisis (Seeger, et al, 1998). Others have suggested that some level of equivocality may represent a more responsible stance during crisis (Ulmer & Sellnow, 1997). Communication researchers should focus on clarifying how equivocality functions in crisis messages and developing guidelines for crisis managers.

Conclusion

We have argued elsewhere that crisis may be seen as “part of the natural organizational process, purging elements of the system which are outdated and inappropriate and creating new, unexpected opportunities for growth and change” (xxxxx, 1998). “Disorganization is necessary to organization and the chaos of crisis is linked to the routines of business as usual” (pp. 232-233). The Red River Valley floods vividly illustrate both the disorganization and chaos created by complex, non-linear systems and the opportunities for growth and renewal created by their self-organizing features.

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