TOWARD IMPROVED WARNINGS FOR SHORT FUSE WEATHER EVENTS
PROJECT DESCRIPTION

C.1. OBJECTIVES AND AIMS

This proposal challenges the current state of public perceptions to disaster warnings through an unusual interdisciplinary collaboration between geography and psychology. Short lead-time disasters including flash floods and tornadoes will be our focus.

Intellectual Merit. This project exemplifies the goal of disaster research by fostering interaction between disciplines and across physical and social sciences to reduce public vulnerability. By building on previous theoretical models for disaster response we introduce a new theoretical framework for understanding the broader warning process (e.g., from initial notification to long range outcomes). The project's results will make two primary contributions. First, findings will offer new knowledge and theoretical development concerning how individuals respond to warnings incorporating the richness of psychology and geography. Second, the theoretical framework introduced will provide an opportunity to develop new approaches to warning system development and public education interventions.

Broader Impacts. Findings from this project will provide new insights for improving the warning process in the United States. We will address the interaction between the hazardous environment and the individual ultimately reducing vulnerability from all hazards, both natural and human-made. The proposed effort will promote teaching, training, and learning by working with an interdisciplinary team of graduate and undergraduate students, faculty, and local, state and federal officials engaged in warning system development. Findings and progress reports will be disseminated to university classes at CU-Colorado Springs relevant to disaster mitigation across several departments including nursing, geography, sociology, and psychology. Reports from our efforts will also be made available to scholars and practitioners elsewhere through the CU Trauma Studies and Resource Center. Finally, results of this research will be shared with professionals involved in warnings and emergency management through publications and presentations for emergency managers and operational forecasters. Our recommendations will be presented to many agencies including the National Weather Service, The Public Private Warning Partnership, the U.S. Bureau of Reclamation, the Federal Emergency Management Agency, and the U.S. Army Corps of Engineers. Findings from this project may provide important information for warning systems for other hazards including hurricanes and terrorist attacks.

The proposed effort has five main objectives:

Objective 1. <u>Develop an enhanced understanding of the warning process by investigating public and private sources of warning information.</u> This project will review public perceptions of the currently available sources of warning information and evaluate how the information was, or was not, used.

Objective 2. <u>Investigate how changing demography of the U.S. influences public responses to warnings.</u> The project will test how demographic factors including socio-economic, ethnicity, age, and gender affect current public perception of and response to warnings. We will seek generalizations across types of hazards and in a variety of locales. We will obtain demographically diverse samples stratified for socio-economic status, ethnicity, age, and gender.

Objective 3. Evaluate the use and potential of new technologies for warning perceptions and responses. This project will test the range of preferences of new technologies for disseminating warnings. We will investigate the use of and perceived utility of graphical products, maps, and integrated data sources (e.g., radar, stream gauges, GIS storm tracking). For example, we will assess how these sources influence knowledge of the hazard, lead time, false alarms, confidence in the credibility of the sources, and quicker risk identification. We will study the history of local warnings and the most recent events with special attention to the spatial extent of damage. We will use text, maps, and other graphics to show the recent events and their development and movement. A small group of local advisors will evaluate our questionnaire and other products prior to distribution and for suggestions on interpretation of our results.

Objective 4. Assess the construct of "false alarms" for short-fuse weather events. The proposed effort will test the conventional wisdom that false alarms within large scale natural disasters reduce public willingness to respond to future warnings. This project will evaluate whether false alarms affect critical responses when a warning is issued. Public perception of false alarms will be evaluated to determine influence of these experiences on warning response during the current disaster.

Objective 5. Evaluate the utility of social cognitive theory as a framework for understanding the individual difference factors that predict disaster warning response. Environmental, behavioral, and psychological factors will be tested from within the social cognitive theoretical perspective to better understand the warning process. A theoretical model will be tested that integrates environmental, cognitive, and behavioral factors that predict warning outcomes. Causal relationships and reciprocal interactions will be analyzed. Specifically, we will assess coping self-efficacy perceptions for the warning response and assess the predictive power of these perceptions along with environmental factors relative to the disaster (e.g., proximity to the flood, information sources, false alarm reactions) to explain warning response outcomes.

C.2. LITERATURE REVIEW

While the meteorological and hydrological sciences have shown dramatic improvement in offering increased lead-times, better long-term models, and integrated real-time monitoring, the social science research necessary to translate the new knowledge into improved responses is missing. Few studies have explored how technological innovations, increased mobility, an increasingly information-dependent society, and population demographics affect the ability to forecast and warn citizens and emergency managers about impending short lead-time hazard events. In addition, little is known concerning how psychological and sociological factors interact to predict who may be at most risk for negative outcomes following a warning.

A new look at the ways we approach the warning process for natural hazards is overdue. The last major research on response to warnings was completed in the 1970s and 1980s (Mileti, 1975; McLuckie, 1974; Perry and Mushkatel, 1984, 1986). The early research has been cited and used extensively over the past three decades (Drabek, 2001; Mileti, 1999; Mileti and Peek, 2000; Mileti and Sorensen, 1990; Mileti, Farhar and Fitzpatrick, 1990). Some additional studies were done in the 1980s and 1990s (Lindell and Perry, 1992; Tierney, Lindell, and Perry, 2001). In recent years the Quick Response program of the Natural Hazards Research and Applications Information Center has provided funds for post-tornado and flash flood studies (Tiefenbacher et al., 2001; Schmidlin and King, 1997; Paul and Leven, 2002; Legates and Biddle, 1999; Paul, 1999). The roles of technology, communications, and population demographics deserve more careful study.

Studies of the physical aspects of forecasting in meteorology and hydrology abound and results from improved forecasts are now routinely available through a variety of channels (Doswell, Brooks and Maddox, 1996; National Weather Service Modernization Committee, 1999). However, the physical science advancements have not been accompanied by the necessary social science research to insure that warning information is most effectively issued and used (Gruntfest and Huber, 1989; Mulilis and Duvall, 1997; Schmidlin and King, 1996). Successful warnings must be taken seriously and must be responded to in a timely and effective manner. This proposal bridges our two disciplines and the physical and social elements of short fuse weather events to promote a better understanding of the warning process.

C.2.1 Multitude of Warning Sources

Recent findings show that public reliance on “official” warnings from traditional sources may be shifting to more private and informal sources (Baker, l995; Dow and Cutter, 1998; Drabek, 2001). People use new, previously unavailable, sources of information and weigh several factors into their decisions about whether, how, and when to react to hazardous conditions. Where the public seeks information and what factors they take into consideration need to be more clearly understood.

Dow and Cutter (1997, 1998) studied the warnings for the 1994 Hurricanes Fran and Bertha in South Carolina. Their event-specific studies indicate that earlier findings on warning response behavior do not account for the current context of warning responses. Specifically they found that the perceptions of the public are affected by elements that did not exist 30 years ago, including private providers of information such as The Weather Channel and a reduced reliance on top-down information from emergency managers (Dow and Cutter, 1998). Their study of “close calls” for these hurricanes found that official information is only one of many sources the public uses to make evacuation decisions. A “public” that once relied solely on the advice of emergency managers, now uses a variety of sources including The Weather Channel, the Internet, and sophisticated graphical images to make evacuation decisions (Baker, 1995; Dow and Cutter, 1998). In our 2002 Colorado wildfires study, most of our sample (N = 104) utilized a combination of information on the fires from a variety of sources (Benight and Gruntfest ,2002). Over 75% of the sample used more than one source for their information on the fire. Over 50% utilized three or more sources of information, primarily radio, Internet, phone, television, and the newspaper. Slightly over 35% used four or more sources for their information. The utilization of warning information sources becomes even more complex in short fuse disasters.

For the March, 1997 tornadoes in Arkansas, Schmidlin and King (1997) found that government warnings on the television preceded the tornado by 18 to 32 minutes and 73% of their respondents were watching television. Legates and Biddle (1999) also indicated that in the April, 1998 Oak Grove, Alabama, 85% of their study respondents became aware of the tornadoes on television. McEntire's (2001) quick response study of the March, 2000 Fort Worth, Texas tornado highlights how much time is involved from the initial official recognition of the tornado and the possible dissemination of the warnings to the public. This is particularly a problem with short lead time events where initial sighting may be the only warning the public receives. How helpful are the Doppler radar images in prompting effective public responses prior to tornadoes?

Most of the more contemporary warning research has focused on disasters with longer lead-times. As stated above, Dow and Cutter's work focused on hurricanes. Quick developing disasters have received minimal attention. Research on short lead-time events such as flash floods, tornadoes, tsunamis, fires, and landslides may provide different results. Warning systems for these types of events pose a different set of problems for forecasters, emergency managers, and the public-at-risk due to the limited lead-time. Researchers from the United States, England, and Australia also call for increased attention to short lead-time warnings (Dengler, 1998; Gruntfest and Handmer, 2000; Handmer, 2000, 2001; Penning-Rowsell et al., 2000). The cited research demonstrates that the public is utilizing more sources of warning information. Little is known about how channels of information influence effective responses in short fuse events.

New physical science knowledge does not automatically lead to improved responses. It is not enough to simply provide real-time information. The message must also be understood and used. A successful warning, including the response, depends on psychology and technology. Risk perception is a complex process (Lindell and Whitney, 2000; Sjöberg, 2000). The link between awareness and response is not necessarily direct. Successful risk perception must be meaningful to recipients and motivate risk acceptance and the adoption of risk reduction behavior. In the proposed study we will extend these results and comprehensively evaluate the types of sources utilized for disasters with short-lead times, assess the variability across different short-lead time events (e.g., tornado vs. flash flood, vs. fire), and determine the importance of psychological factors in utilization of different sources.

C2.2 False Alarms

Attitudes toward false alarms affect forecasters' and emergency managers' willingness to issue warnings. The conventional wisdom is that the public-at-risk will be desensitized by repeated warnings that do not result in a severe occurrence. This premise is related to the perception that official warnings drive public decisions and may cause a hesitation in issuing warnings. Officials from the U.S. Army Corps of Engineers, the National Weather Service, and local emergency managers all claim a fear of issuing false alarms. The belief is that false alarms severely reduce the public's willingness to respond to warnings. The 1999 National Weather Service Strategic Plan calls for a 50 per cent reduction in the number of false alarms (National Weather Service, 1999). Indeed, laboratory research has supported negative effects following false alarms (Breznitz, 1984). More recent research, however, calls into question this belief.

Many “false alarms” actually are “close calls.” Flash floods or tornadoes strike specific sections within a warning region, rather than encompassing the entire warning area. Research in Fort Collins, Colorado indicates that local officials appreciate these “close calls” as learning opportunities (Weaver, et al., 2000). Much of the available research supports this interpretation. Carsell’s (2001) research in Ventura, California after a false alarm of a dam break siren system supports the evidence that people do learn from false alarm experiences and they are *not* less willing to respond to the next warning. She found that the false alarm gave people valuable lessons how to, or not to, evacuate the area in future events. Dow and Cutter (1998) found that in 1996 the false mandatory evacuations of South Carolina for Hurricanes Bertha and Fran did not result in any negative effects. The public did not hesitate to evacuate for the second false alarm and reported that they would be willing to evacuate in the future which lends support to the drill concept.

A recent study of people nearly in the path of a deadly tornado near Siren, Wisconsin reviews a “close call” experience for people on the periphery of a tornado damage path (Tiefenbacher, et al., 2001). Their findings show people intend to learn from their “close call” and be better prepared for the next warning. Gruntfest and Carsell’s recent findings for Boulder, Colorado offer similar notions of the impacts of false alarms. More than 50 per cent said one or two flash flood false alarms would not reduce their willingness to respond to the next warning (Gruntfest , Carsell and Plush, 2002; Gruntfest and Carsell, 2000). Finally, our recent study with victims from the 2002 Colorado wildfires found that of those who indicated that they had previously experienced a “false alarm”, 68% indicated that this experience had “not at all” influenced their decision to evacuate this time. Only 15% suggested that this previous “false alarm” experience influenced their decision this time either “pretty much or very much” (Benight and Gruntfest, 2002). This literature highlights the need to investigate more in-depth the effects of false alarms on behavior. We will assess the public perception of false alarms and close calls as well as the importance of psychological difference variables in understanding these perceptions.

C.2.3 Demographic Changes in Populations

Previous warning research emphasized several demographic factors (e.g., socioeconomic status, age, education, ethnicity, and gender) in understanding warning response (Sorensen, 2000). However, limited samples combined with outdated population characteristics challenge the contemporary applicability of the results (Sorensen, 2000). The U.S. population is significantly older and more diverse than it was 25 years ago. In 2000, one in eight Americans was over 65 years old, an increase in 12 per cent from 1990 (Himes, 2001) Following this current trend one in five Americans will be age 65 or older (Himes, 2001). The Census Bureau reports significant increases in minority populations as well. People who issue warnings need to be aware of how these new demographics affect warning response. With growing possibilities for localizing warnings with GIS to streets and neighborhoods rather than to county levels, the value of being able to write warnings that are most meaningful to various segments of populations is also a growing need with tremendous benefit possibilities. This project will provide critically lacking information on disaster warning perceptions relative to current population characteristics utilizing a representative sample.

C.2.4 Technological Advances in Warning System Information Dissemination

During the past three decades the possible technological sources of information to the public has increased exponentially. Previous generations had few basic sources of disaster warning information (e.g., sirens, television, radio, personal communication). All the information was handed down from a centralized authority. Today, huge technological advances have made available graphical products, maps, and integrated data sources (e.g., radar, stream gauges, GIS storm tracking). Individuals are barraged with information from computers, cell phones, pagers, cable television, radio, and standard phones. Virtually no research exists that has assessed the utilization or practicality of these sources of information for disaster warning systems. The differential or cumulative effect of these sources on risk perception and warning response remain unknown. This proposal will assess the utilization of alternative technological information sources on the warning process helping to fill this scientific void.

How individuals utilize technological information, respond to false alarms, or cope with short lead time warnings is a complex interaction between environmental conditions, social norms, and cognitive interpretation. Social cognitive theory provides a useful theoretical approach that can augment the existing models of the warning process to help us better understand how individuals react to warnings. It provides a framework with supportive empirical bases from research on other public health behaviors to assist emergency managers in designing new warning messages as well as public education programs.

C.2.5 Social Cognitive Theory and Existing Warning Response Models

Disaster warnings aim to promote public safety behaviors to reduce human casualties and property losses (Lindell and Perry, 1992). Effective warnings motivate people to take protective actions. Therefore, understanding the various factors that differentiate those who take these protective actions from those who do not is imperative. Few studies acknowledge individual differences in responding to disaster warnings (e.g., rapid responders versus late responders) (Sorensen, 2000). Several researchers have generated models that depict the interaction between environmental information, sociological processes, and individual factors to predict warning responses (Lindell and Perry, 1992; Tobin and Montz, 1997). Sorensen (2000) provided a summary of the main factors found to influence warning responses documented by social science researchers. He classifies these factors into three main groups: 1) sender and receiver factors, 2) situational factors, and 3) social contact. He lists 32 different variables that influence warning responses. Some examples include physical cues (situational), perceived risk (receiver), education (receiver), number of communication channels (sender), and source credibility (sender).

Tobin and Montz (1997) describe a model that depicts these variables within an interactional system of environmental conditions and adaptive psychological processes. Cognitive factors such as beliefs about the threat of the hazard and perceptions of vulnerability filter environmental information and predict behavioral outcomes. The authors emphasize that humans do not function in a deterministic fashion with environmental information coming in on one side and behavior out the other. Lindell and Perry (1992) have also proposed a framework for understanding the warning process. They identify three primary components: 1) risk identification, 2) risk assessment, and 3) risk reduction. They integrate these components into a warning response model that, like Tobin and Montz, includes situational factors, the social context of the disaster, premorbid recipient or receiver characteristics all influencing the risk identification, risk assessment, and risk reduction process. This model is based on the theory of bounded rationality and the theory of norm-based behavior. Based on these theories, the authors argue that decisions to take protective action will be heavily based on social norms relative to the action combined with a decision process that maximizes the rationality of enacting the behavior given the information available.

It is beyond the scope of this project to specifically test all the different components of these various models. They are presented to highlight the conceptual overlap and emphasis on cognitive processing as one component of human response to warnings. Each of the models emphasizes, to various degrees, the importance of cognitive interpretation of the specific impending disaster as a determinant of protective action. Mileti and Sorensen (1990) refer to the receiver attributes including cognitions such as a fatalistic outlook. Tobin and Montz emphasize the cognitive filtering of information. Lindell and Perry describe the cognitive interpretive process under the heading personality characteristics and specifically refer to self-efficacy perceptions relative to warning behaviors.

Although each of these models indicate that the cognitive interpretation process is important for understanding warning response, how the cognitive processes interact with environmental information and behavior is not clearly delineated. Social cognitive theory provides a theoretical framework for understanding the interactive nature of between cognitive appraisal processes, the environment, and behavior.

Social cognitive theory provides a meta-theoretical framework that suggests cognitive appraisals, environmental conditions, and behaviors interact in a reciprocal fashion each influencing the other (i.e., triadic reciprocal determinism) (Bandura, 1986, 1997). Reciprocality, however, does not imply symmetry of influence among the factors. Under certain conditions (e.g., 150 mph winds from a tornado tearing off parts of one's house as the black swirling funnel can be seen from the window) environmental factors will be the prime determinant of behavior. However, under other conditions (e.g., one hears on the radio of a possible tornado in the area) cognitive factors will serve as powerful influence on behavior.

The natural human process of adaptation demonstrates how these cognitive factors interact with environmental information to influence behavior. Humans adapt through their ability to self-regulate (Bandura, 1997). Self-evaluation is a central part of self-regulation providing feedback on goal directed behavior (e.g., responding to a tornado warning). This self-evaluative process involves determining discrepancies between one's current state (e.g., intense sense of hopelessness) and an expected or desired outcome (e.g., getting oneself to safety) providing information for adaptation. Particularly relevant to disaster warning responses is the self-appraisal of coping self-efficacy (CSE). CSE is derived from evaluations of perceived success or failure to achieve desired outcomes during stress and is defined as the perceived capability for managing traumatic stress demands (Bandura, 1997; Benight et al., 1997). In the case of the disaster warning response, CSE would be the perceived capability for enacting the safety behavior (e.g., getting out of one's car and climbing to safety in the case of a flash flood or finding the most safe place in a home during a tornado warning).

Lindell and Perry (l992) refer to self-efficacy for protective action. They suggest that self-efficacy is synonymous with locus of control perceptions and that the concept is interesting theoretically, but has little practical utility. We disagree. We argue that locus of control perceptions are a stable trait variable with minimal predictive power when compared with context specific CSE perceptions (e.g., how capable am I to get my family out of the house safely) (Bandura, l997). In addition, the practical utility of CSE perceptions is quite significant. Public education campaigns could be specifically designed to enhance CSE perceptions for protective action. Social cognitive theory provides a wealth of research to support its utility in improving health enhancing behaviors (e.g., HIV-AIDS prevention, cardiovascular disease prevention, exercise; Bandura, l997) and also delineates methods directly applicable to emergency managers for improving CSE appraisals including the power of modeling, mastery experiences, and verbal persuasion.   Public education programs could be designed utilizing this type of approach to enhance perceptions of CSE for protective action. Improving an individual's sense of CSE for specific mitigating behavior theoretically would directly influence critical outcomes such as perseverance for enacting the protective behavior, effectiveness of the coping response, and ability to manage setbacks in achieving the outcome (Bandura, 1986, 1997). Previous research suggests that CSE perceptions are important within the trauma environment.

CSE for posttraumatic recovery has predicted a multitude of psychological and physical outcomes following a wide variety of traumas including hurricanes (Benight et al., l997; Benight, Swift, et al., l999; Benight, Ironson, et al., l999), terrorist bombings (Benight et al., 2000), fires and floods (Benight and Harper, 2002), and military combat (Solomon, et al., l99l). These studies were all focused on the recovery process following a traumatic event, rather than investigating the relationship of CSE with protective action before or during a disaster.

Our recent quick response study through the Natural Hazards and Applications Center focuses on the evacuation process for two of the 2002 wildfires of Colorado to begin to look into this question. CSE for evacuating (i.e., the perception of capability for being able to safely evacuate) during the fire was found to correlate negatively with the amount of time reported for evacuation ($r = -.34$, $p = .001$). CSE for evacuating was also found to be a significant predictor of posttraumatic stress symptoms experienced after the fire even after controlling for amount of lost resources suffered in the fire and the proximity of the fire to the home.   Although these findings are preliminary, they do provide support for investigating more thoroughly the importance of CSE perceptions within the disaster warning process.

Social cognitive theory provides a useful theoretical approach that can augment the existing models of the warning process. It provides framework with supportive empirical bases from research on other public health behaviors to assist emergency managers in designing new warning messages as well as public education programs.   This proposal will also address how CSE perceptions relative to warning behaviors relate to utilization of sources of warning information, demographic factors, technological influences, and false alarms.

C.2.6 Summary

The literature review highlighted the need for critical evaluation of current public responses to disaster warnings. This project will advance the field of disaster warnings by investigating the following five issues:

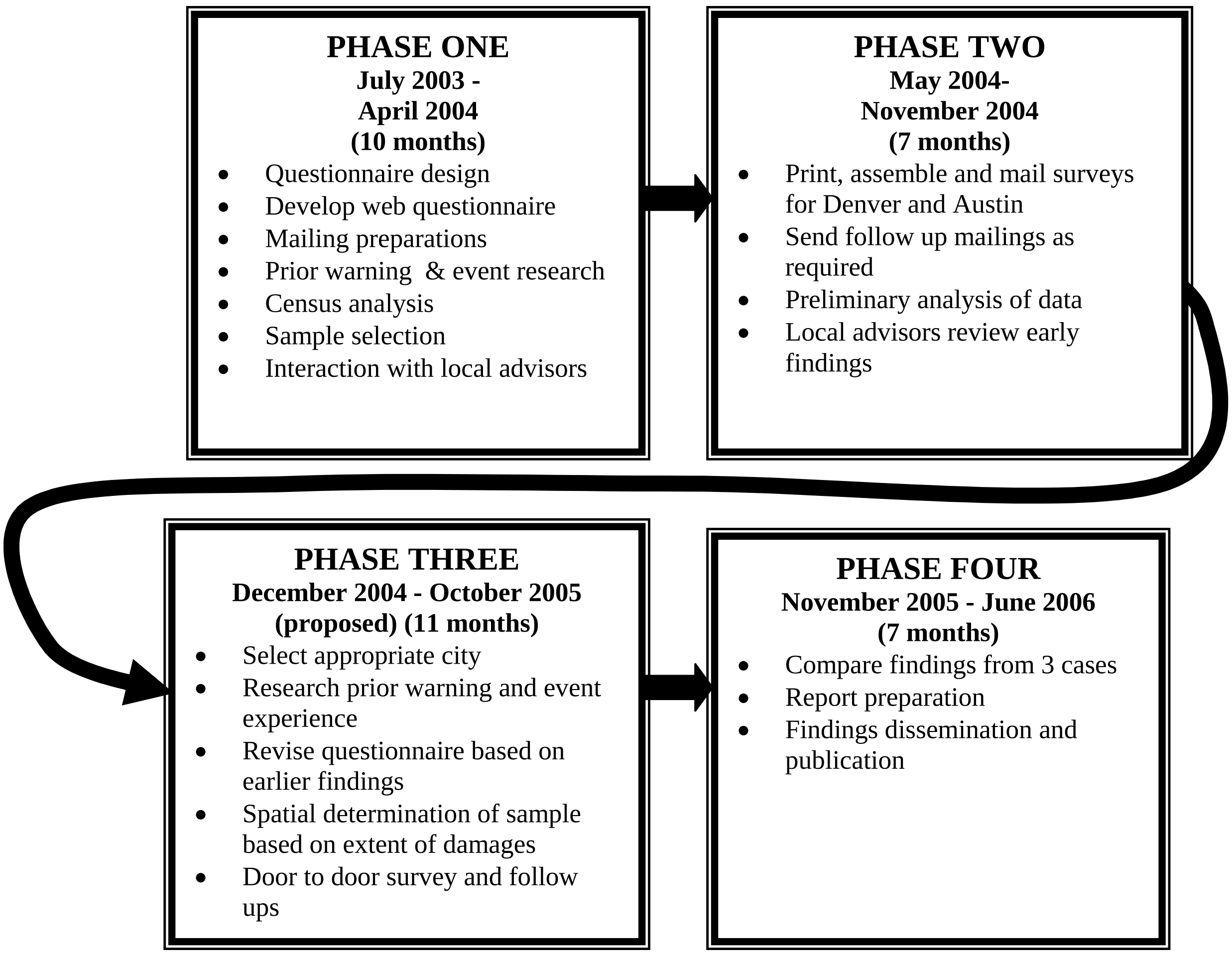
1) The role of new public and private sources of warning information for short fused disasters in public response to warnings;
2) The importance of the changing population demographic characteristics on types of warnings utilized and public responses enacted;
3) The utility of various technologies, including new graphical products for disseminating effective warnings;
4) The value of conventional wisdom about false alarms and warning lead-times on public perceptions of warnings; and,
5) The value of social cognitive theory as a framework for understanding the warning process and identifying at risk individuals.

Figure 1 shows the timing and tasks associated with the four phases of the project. Each phase is described in detail in the following sections. The research design addresses each of the five study objectives. The study will consist of three in-depth case studies. Two case studies will be mail-in/Internet surveys of urban populations (Denver, CO and Austin, TX) facing short fuse weather events conducted according to Dillman's (2000) recommended methods. These cases represent rapidly growing American cities with diverse urban populations and vulnerability to short fuse weather events including flash floods and tornadoes. The third case study will be a door-to-door survey in an urban area where a short fuse weather event occurs sometime during the project period.

Austin, Texas. Austin is a growing southwestern city of 656,562 residents vulnerable to flash flooding and tornadoes. Flash floods are the leading cause of weather related deaths in the area (Austin City Connection, 2002). On November 14, 2001, severe flooding resulted in 10 deaths and damage to over 1000 homes (Anderson, 2002). Tornadoes are also a concern for the residents of Austin. On May 27, 1997, two people were killed in Austin in a thunderstorm with tornadoes and flash flooding (National Climatic Data Center, 1998). In that same storm system, the small town of Jarrell, only 40 miles north of Austin, was hit by a tornado that killed 34 residents and destroyed an entire subdivision. Eight years prior a tornado killed one person, injured 28, and largely destroyed the town (CNN, 1997).

Denver. The Denver, Colorado metropolitan area has experienced multiple flooding events and tornadoes in the past. The city proper has a population of 554,636. Denver's location creates an optimal setting for the development of severe thunderstorms during the spring and summer months. This is often called the “Denver Cyclone" effect. These storms create cloud to ground lightning strikes, heavy rain with flooding potential, severe hail, and tornadoes. On July 11, 1990 one hailstorm caused $625 million in insured damage. (City and County of Denver, 2002). Flooding along the streams in Denver is documented by the U.S. Army Corps of Engineers and the Urban Drainage and Flood Control District. A flash flood and/or failure of one of the major dams in the metro area could create flooding of historic proportions (City and County of Denver, 2002).

Figure 1: Schedule for Research Phases



Tornadoes are often a part of these severe thunderstorms in Denver. According to the National Weather Service, 11 tornadoes have “touched-down” in Denver between 1950 and 1989. The tornado threat is highest in Denver during the months of May, June and July. On June 15, 1988, a group of tornadoes passed over the metro area, causing heavy damage in two areas of the city. On June 2, 1993, another tornado struck Denver. The intensity of these events and the potential for damages and injury should not be underestimated (City and County of Denver, 2002).

C. 3.0 RESEARCH DESIGN

C.3.1 Phase I Mail-in and Internet Survey Development

The first two case studies will be conducted according to the Dillman (2000) method for mail and Internet questionnaires. Using Dillman’s (2000) methods we can control for all four types of potential survey error. Measurement error in the study will be controlled by clear and precise questionnaire design. The questionnaires and the sample selection will be reviewed by a small (2-3 people) select advisory committee made up of officials from Denver and Austin. Kevin Stewart of the Urban Drainage and Flood Control District and Bob Glancy the National Weather Service Warning Coordination Meteorologist have both agreed to serve for Denver. For the Austin case study David Walker of the City of Austin will be asked to serve. Larry Eblen, the National Weather Service Warning Coordination Meteorologist has agreed to serve for Austin.

The advisors will be consulted in person and in emails to review the project materials. The advisors will also actively participate in the selection of the third case study, the evaluation of the findings from the mail in surveys, and the review of the draft report before the final report is prepared. Once the third community is selected a panel of local advisors will be chosen from that city to help us focus on the most important issues. The panels of advisors are essential in all three cases as a "local knowledge" base to enhance the likelihood that the most critical "local" aspects are incorporated in the study and to increase the chances that the study conclusions and recommendations will be applied in the field.

Detailed warning and disaster histories will be developed for Denver and Austin based on review of local documents, newspaper accounts and discussions with emergency managers and National Weather Service warning coordination meteorologists responsible for the two case cities. Maps will be prepared detailing the extent of historic flood and tornado warnings and events. We will evaluate current warning practices and how new technologies might enhance the systems already in place.

Specific questions directly addressing each of the five objectives of the proposal will be developed. In collaboration with the advisory committee, questions will be designed to assess new warning sources utilized, new sources of technology, experience with false alarms, attitudes toward government, previous experience with the hazard, physical understanding of the potential hazards, physical limitations, demographic characteristics, and coping self-efficacy perceptions for warning response (see Appendix A). In addition, we will assess a range of responses depending on various lead times to determine public preferences. We will also look at the implications of reactions to false alarms as they pertain to thought, preparations, and actions. Questions related to previous experience with disasters and coping self efficacy will help to understand individual differences in warning response behavior. The questionnaire will include a graphical interpretation component tailored to Denver and Austin based on existing floodplains and on flood, tornado and warning experiences. Questions will cover demographics, warning sources and perceived usefulness, (including private and public), warning experiences, and questions about perceived vulnerability, actual historical close calls and events. The questions will be drawn from surveys used in earlier research by others, recent studies in Colorado by Benight and Gruntfest (2002) and Gruntfest, et al (2002). Our earlier survey is available online web.uccs.edu/geogenvs/bouldersurvey.htm

In choosing the random samples from our two selected cities the Southern Colorado GeoData Laboratory will select appropriate samples for the project that reflect broader demographic patterns. The samples will be selected by the Southern Colorado Geodata Laboratory using floodplain maps and U.S. Census data, hazard vulnerability maps, and maps of the extent of recent flash flooding or tornadoes. A total of **3,000** households will be selected in both Denver and in Austin. Based on Dillman (2000), we expect a fifty-percent return rate for the surveys, giving us a final sample size of approximately **1,500** for each city. Spanish language questionnaires will be developed to complement the English version.

The Denver Urban Drainage and Flood Control District has a mailing list for all addresses in the floodplains. The local advisors will review the format and content of the questionnaires and the proposed samples. Revisions will be made before the finalizing the survey and the sample.

C. 3.2 Phase II Conducting the Mail-in/Internet surveys

The study follows Dillman's (2000) recommended methods for mail-in/Internet surveys. The initial pre-notice letter will be sent to inform recipients that they will be receiving a survey for an important study very soon. Within two days of mailing this letter, the main questionnaire will be sent to Denver and Austin residents. We will send a reminder/thank you postcard one week after the initial mailing to all participants. This will be followed by another full questionnaire packet to those who have not responded by the end of the third week. Finally, for those who have not responded after a month, the questionnaire will be sent by certified mail. Based on the expected 50 per cent response rate, we should have a ± 3 per cent sampling error. We anticipate differential response rates for different demographic factors (e.g. socio-economic levels) and we will enhance recruitment efforts using Dillman's approach. For example, we will reselect households with specific demographic characteristics where we are not receiving enough questionnaires and do additional mailings. Finally, in addition we will post the questionnaire on the CU Trauma Center website for people to complete if it's easier than sending their responses by mail. We will follow Dillman's recommendations for internet surveys when transferring the written questionnaire onto the internet.

Data Analysis and Sample Size Requirements. Warning perceptions and responses will be compared against each demographic and geographic factor to determine significant relationships. A map and report will be generated for each comparison. Finally, inferential comparisons using multiple regression analyses will be used to test theoretical relationships with specific outcomes (e.g. false alarm perceptions and range of responses). Descriptive statistics will be used to explore perceptions of flooding and tornado warnings and experiences among the different demographic groups (e.g., age stratifications, race, ethnicity, marital status, etc.). In addition regression modeling will be conducted to determine base predictors (e.g. age, gender, socio-economic status) of outcome variables (e.g. false alarm and vulnerability perceptions, and warning responses).

The predictive power of coping self-efficacy within the base models will be tested utilizing hierarchical regression (increment to R-square test). Sample size requirements for this study are relatively large based on the desire to be able to generalize beyond the two initial cities and to do comparisons across multiple groups within the larger samples (all three samples together) (e.g., socio-economic levels). With the proposed representative samples we should be able to detect relationships between variables as low as $r = .10$ (Milton 1996). Looking at differential relationships with subgroups (e.g. white or African Americans) we should have large enough samples to accommodate such divisions. Based on the small percentage of Native Americans (.9%) or Native Hawaiian/Pacific Islander (.1%) relative to the general population, we will not be able to make this fine distinction based on our proposed sample size. With the least significant variable partial correlation coefficient of .05, the sample requirement would be 54 participants with 11 independent variables (Milton 1996). Based on the information in Table 1, our sample sizes for cities 1 and 2 are adequate to address questions relating to both demographic and individual difference factors in predicting perceptions of warnings and short fuse weather events for the whole sample and for most sub-groups based on ethnic identification. The following table depicts these divisions for each group based on the US census data. For city 3 we will be able to address individual difference factors in predicting perceptions of warnings and short fuse weather events for the whole sample, but will have limited power to look at sub-groupings.

Table 1: Sample Size For Each Group Based on U.S. Census 2000.
Numbers add up to more than 100 % due to Census reporting method. People can belong to more than one category. N = 3,200 is 1500 for Cities 1 & 2 and 200 from city 3.

	Total population	% of population	N
Total population	**281,421,906**	**%**	**3,200**
White	211,460,626	75.1	2,403
Black or African American	34,658,190	12.3	394
American Indian and Alaska Native	2,475,956	0.9	29
Asian	10,242,998	3.6	115
Native Hawaiian and other Pacific Islander	398,835	0.1	3
Hispanic or Latino	35,305,818	12.5	400

Following the completion of the survey phase the Geodata Lab will map and analyze responses to each objective in relation to the geospatial characteristics that are predicted to affect them (e.g. age, gender, ethnicity, address). Attribute maps will be generated to illustrate responses to survey questions, demographic and other geographic characteristics. To protect privacy of respondents thematic maps (map layers) will not display specific points at addresses, but instead attributes will be rendered as continuous shaded areas interpolated from point data. The local advisory teams will review the early findings before preparations begin for the third case study.

C. 3.3 Phase III The Third Case Study

Based on the recent record, there is a strong likelihood that a major flash flood or tornado disaster will occur somewhere in the U.S. during the study period. We will use a city within the U.S. that experiences either one of these disasters as our third case. The third case will draw on the recommendations from the Denver and Austin mail-in/Internet survey. First, the city will be selected based on events that occur in 2003 and 2004. We will carefully research the warning history and documents, and we will talk with a selected group of advisors from the National Weather Service and local emergency management to comprehensively understand disaster and warning experiences.

A team of two graduate students will conduct the interviews in the post-impact city. Three hundred addresses will be randomly selected within the mapped region of the disaster. These households will be selected based on demographic characteristics so that this random sample is representative of the U.S. population. We anticipate a decline of approximately 100 households leaving our desired total of 200 respondents. The questionnaire will be revised and tailored for the new community and the door-to-door survey. We anticipate some earlier questions will be dropped and some new, more open ended questions, including map interpretations will be added.

Graduate and undergraduate students in psychology and geography will have the opportunity to work with experts in their fields and will be trained in sample selection and questionnaire development. The CU Trauma Center will organize a seminar for graduate students and upper division undergraduates in geography and psychology on the integration of these two disciplines on warning research. In addition, this research will be presented in current courses in geography and psychology. Students will gain critical research skills by conducting interviews and gathering survey data from populations exposed to natural hazards. It is anticipated that the data will serve as foundations for graduate theses.

C.3.4 Phase IV Comparison of Findings, Write-up and Dissemination of Information

The results of the three case studies will be compared to develop a comprehensive set of findings and recommendations. All the advisors from the three cities will review the initial findings and their comments will be incorporated before the final reports are developed. They will also be asked to review the written final report to assure that the recommendations are clearly and succinctly presented.

The proposed research has broad implications for future warning procedures. Results of this research will be shared with agencies actively engaged in issuing warnings including The National Weather Service, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, and with local, state, and federal emergency managers. Students and principal investigators will develop publishable journal articles and professional presentations as the findings emerge and will write a comprehensive final report. Findings will be presented in at least one scholarly session at geography and psychology professional meetings. Additionally presentations will be made at National Weather Service flash flood workshops, the American Meteorological Society annual meeting, warning decision-making workshops, and national meetings of the Emergency Managers Association. Ongoing progress of our study will be available on an interactive web page offered through the CU Trauma Studies and Resource Center. To publicize our effort we intend to link our site with state and federal agencies involved in the warning process..

Many factors operating at the same time will affect response to warnings, including types of information sources available, new technologies that may be utilized, population demographic characteristics, previous exposure to false alarms, and social cognitive factors. This study will provide an information base and understanding of how and to what extent these factors influence public response to the threat of a short fuse hazard. In revealing how these factors influence responses, this study will be a valuable tool for mitigating damage and loss of life from short fuse events. Scientific understanding of natural processes that lead to short fuse hazards has become much more sophisticated in recent years, allowing for more precise prediction of hazard events. The proposed effort takes major steps toward contributing the social science necessary for emergency managers, forecasters, and others to develop and issue effective warnings that reduce losses of lives and property utilizing the newer science and technologies.

Appendix A	**Sample Survey Variables**	
New Concepts for Warning Research	**Factors**	**Examples**
	Respondent characteristics	Coping self-efficacy, Hazard Experience
	Roles of new technology	Cellular phones, Pagers, Internet
	New sources of data	Real-time data, The Weather Channel Internet
	Public/Private relations	Perceptions of government, Reduced link between government and public
	Physical and social cues	Heavy rain, Actions of neighbors
Prior Warning Research		
	Risk factors	Risk perception, Proximity to threat Mitigation efforts
	Socioeconomic factors	Income Education
	Warning factors	Type of warning received Frequency of warning Warning source Credibility of warning source Warning message content
	Threat factors	Time to impact Knowledge of hazard Experience with hazards
(modified from Sorensen, 2000)	Demographic	Gender, Age, Socio-Economic Level, Ethnicity, Children in Household