Factors influencing individuals' decision-making during high-risk short-notice disasters: the case study of the August 21st, 2011 Goderich, Ontario tornado

by

Amber Silver

A thesis

presented to the University of Waterloo

in fulfilment of the

thesis requirement for the degree of

Master of Environmental Studies

in

Geography

Waterloo, Ontario, Canada, 2012

© Amber Silver 2012

AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

ABSTRACT

The hazards literature has identified many factors as being influential in the decision making process during high risk, short-notice disasters. Risk perception and previous disaster experience are commonly identified as two of the more influential factors in this complex process. However, few studies adequately address the complex role(s) that these factors play in self-protective decision-making during successive high-risk events. In particular, the role of previous disaster experience during subsequent events is still a matter of considerable discussion and inconsistent findings.

This thesis examines two events that occurred in August, 2011 in Goderich, Ontario: an F-3 tornado that struck the community on August 21st and a tornado warning that was posted for the region three days later on August 24th. This case study provided the opportunity to examine the roles of risk perception and previous disaster experience in the decision-making process during successive high-risk events. Semi-structured interviews (n=35) and close-ended questionnaires (n=268) were conducted to learn about the ways that individuals obtained and understood risk information, and to explore whether and how such information guided protective behaviors during the two events. The interviews were analyzed using thematic coding to identify response patterns, and the questionnaires were analyzed using IBM SPSS software.

It was found that a sizable portion of the sample population took protective actions on August 24th in ways that were inconsistent with their actions on August 21st. Also, a significant portion of respondents chose not to take any form of protective action on August 24th despite having previously experienced the damaging tornado. The findings of this research suggest that the significance of previous disaster experience in the decision-making process is highly variable and context-dependent. A second significant research finding involves the impact of the tornado on the place attachments of Goderich residents. It was found that the disaster had significant impacts, both positive and negative, on participants' sense of place. These findings have implications for both short- and long-term disaster recovery.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my advisor and role model, Jean Andrey, for all of her support and encouragement over the last two years. I would also like to thank Jean for letting me take a chance on the Goderich tornado (thus abandoning my previous research proposal, which we had spent six months developing). It was my dream to study tornadoes in southern Ontario, and Jean helped to make that dream a reality. Thank-you, Jean. For everything.

I would also like to thank my second advisor, Cathy Conrad, for all of her support over the last four years. Cathy, were it not for our talk that afternoon in the spring of 2009, I would never have known that I could study the human dimensions of hazards. You will never know the full extent of my gratitude for your all of your help and support.

Thank-you also to the moderators of various Facebook groups for helping me to recruit participants for my study. Specifically, I would like to thank the organizers of the "Goderich Ontario Tornado victims and support", the "Goderich Tornado Clean Up Hub", the "Goderich Trees Project" and the "SAVE DOWNTOWN GODERICH" Facebook pages. I would also like to publically thank Francesca Dobbyn, Richard Stewart, Luke Elliott, and Jody Armstead for their encouragement and support.

Special thanks goes out to the Goderich Public Library, whose staff generously donated their time and assistance to this project. I would also like to thank my research assistant Mitchell Avis for helping to recruit participants for this study. Thank-you also to Brian Mills, Derrick Hambly, Lindsay Matthews, and Brent Doberstein for your encouragement and support. I would also like to thank the Institute for Catastrophic Loss Reduction (ICLR) for its generous financial support of this project.

Finally, I would like to thank my husband, Allen, and my family for their continued support throughout the last six years. I could not have done this without you.

“Adversity is like a strong wind. It tears away from us all but the things that cannot be torn, so that we see ourselves as we really are.”

Arthur Golden (1997)

TABLE OF CONTENTS

CHAPTER THREE – STUDY CONTEXT AND METHODS

CHAPTER FOUR – INTERVIEW RESULTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION TO THE PROBLEM

1.1 The case study

In the late afternoon of August 21st, 2011 an isolated supercell thunderstorm intensified over Lake Huron as it approached the eastern shore. Environment Canada issued a tornado warning for this thunderstorm cell at 3:48 p.m., and approximately 12 minutes later the tornadic storm came ashore into the town of Goderich, Ontario. Based on post-storm damage assessment surveys conducted by Environment Canada, the tornado was rated an F3 on the Fujita Scale of Tornado Intensity. This made the Goderich tornado the most intense tornado to occur in southern Ontario since the Violet Hill tornado outbreak in 1996. As a result of this storm, one individual was tragically killed and another 39 people were injured. As of September, 2011 the Goderich, Ontario tornado has cost at least $75 million in insured damages.

Three days later, on August 24th 2011, atmospheric conditions were once again primed for an outbreak of severe weather. As a result of the antecedent conditions, Environment Canada issued a tornado watch early that morning for a large swatch across of southern Ontario, including the town of Goderich. By late afternoon, Environment Canada upgraded the tornado watch to a tornado warning for the township of Goderich. Although no tornadoes touched down in the Goderich area, three tornadoes were confirmed to have touched down in southern Ontario.

1.1.1 Justification of the disaster

The August 21st, 2011 Goderich tornado and the subsequent severe storm system on August 24th provided the rare opportunity to examine the roles of risk perception and previous disaster experience during two successive high-risk events in the same community. The Goderich, Ontario tornado also provided the unique opportunity to examine these influential factors from within the Canadian context. The Canadian focus of this study has value in broadening the empirical literature on natural hazards, as the vast majority of the existing literature on risk perception and disasters was written from an American perspective.

The overall objective of this research project was to identify the influential factors in the decision-making process during high-risk disasters. Four research questions were developed to meet this objective:

1. What influence do risk perception and previous disaster experience have on decision-making during high-risk events?
2. How do individuals obtain, interpret, and disseminate risk and recovery information before, during, and after disaster?
3. How did the tornado influence sense of place and place attachments of Goderich residents immediately following the disaster, and into the long-term recovery period?
4. Are the results of this research project consistent with existing studies on tornado perception and response that have been written from the American perspective?

To answer these research questions, primary data was collected through two different methods. First, 35 in-person interviews were conducted with Goderich area residents between September and November, 2011. These interviews were designed to gain an understanding of the

experiences, perspectives, and perceptions of those who were either directly or indirectly affected by the August 21st tornado. Second, questionnaires were distributed to a larger sample between December 2011 and March 2012 in order to determine the generalizability of the interview results. The questionnaire was also designed to probe respondents' experiences and perspectives on long-term recovery in the Goderich region.

1.2 Thesis format

Chapter two provides an overview of the current state of the environmental hazards literature. Although the hazards literature is extensive, the literature review emphasizes risk research as it pertains to information dissemination, perception, and response to hazardous events. Chapter three outlines the Goderich, Ontario tornado case study and the subsequent August 24th storm system that affected the region. Chapter three also outlines the research methodology, and therefore includes both the interview and the questionnaire research frameworks. Chapter four and five present the results from the interviews and the questionnaires, respectively. Chapter four includes an in-depth analysis of two respondents profiles, as well as the results from thematic analysis of the interview transcripts. Chapter five expands on insights gained from Chapter four. Each results chapter provides insights on: general weather knowledge; the August 21st tornado; the August 24th storm system; the influence of the tornado on participants' place attachments; and the role of risk communication. Particular emphasis was placed on the roles of risk perception and previous disaster experience on the decision-making process in both of these chapters.

Finally, Chapter six outlines the major research contributions of this project to the hazards literature. These contributions include: findings on the role of risk perception and previous disaster experience on the decision-making process during successive high-risk disasters; the importance of word-of-mouth communication in the days following a damaging disaster; and the nuanced influence of disaster on sense of place attachments of Goderich residents. These findings have important implications for emergency managers and decision-makers, particularly within the Canadian context.

CHAPTER TWO

REVIEW OF THE LITERATURE

2.1 Defining environmental hazards

Throughout history, environmental hazards have posed a significant threat to human beings and their welfare. Between 2000 and 2005, environmental disasters killed approximately 80,000 people per year and directly affected another 300 million by destroying their homes, causing substantial economic losses, and resulting in serious health problems (Hyndman et al., 2009). Although the terms hazard and disaster are sometimes used interchangeably, they have distinct interpretations. In the context of most geographical scholarship, an environmental hazard refers to "all the potential threats facing human society by events that originate in, and are transmitted through, the environment" (Smith and Petley, 2009: 9). A hazard becomes a disaster when the affected group is incapable of recovering without external assistance (Hyndman et al., 2009).

This definition of disaster is quite broad and would apply equally across a wide spectrum of events. As such, various institutions have developed different classification systems in an attempt to distinguish between small- and large-scale disasters (Table 2.1). The Worldwatch Institute highlights the difference between natural disasters and so-called 'unnatural disasters', defined as those events that have been made more frequent or severe due to human alteration of the environment (Abramovitz, 2001). The destruction caused by Hurricane Katrina in New

Institution	Event Classification	Definition
Worldwatch Institute	Unnatural disaster	Events made more frequent/severe due to human alteration of the environment.
CRED	Disaster Significant disaster	≥10 deaths **or** ≥100 affected ≥100 deaths **or** ≥1% population affected **or** ≥1% GDP lost.
Munich Re	Great natural catastrophe	Events that overtax local communities, making interregional or international assistance necessary.

Table 2.1: Various definitions for different scales of disaster events.

Orleans, which was exacerbated by the destruction and development of wetland habitats, is a sobering example of an unnatural disaster. The Center for Research on the Epidemiology of Disasters (CRED) at the University of Louvain, Belgium distinguishes between disasters and significant disasters. Based on their categorization, disasters are those events that result in 10 or more fatalities or affect more than 100 people, whereas significant disasters are those events that result in 100 or more fatalities, or affect more than 1% of the total national population, or result in economic damages greater than 1% of the Gross Domestic Product (Smith and Petley, 2009).

Munich Re, a reinsurer that undertakes global data collection and trend analysis of natural disasters, differentiates between disasters and 'great natural catastrophes'. Disasters are classified as great natural catastrophes only when "the ability of the region to help itself is distinctly overtaxed, making interregional or international assistance necessary" (Munich Re, 2002: 15). According to data collected by Munich Re, there has been a dramatic increase in the number of great natural catastrophes over the last fifty years. In the 1950s there was an

average of two such disasters per year, but that number had increased to approximately nine per year in the 1990s (McBean, 2004). While the data show that economic losses from these catastrophes have risen exponentially since the 1960s, these losses are concentrated in the most developed countries whereas injuries and fatalities are concentrated in the least developed countries (O'Brien et al., 2006).

2.1.1 Changing perspectives on natural hazards

Human understanding of natural hazards is often conceptualized within the literature as having 'evolved' from less sophisticated to more sophisticated over time. Smith and Petley (2009) provide a comprehensive review of the five different stages of this evolution (summarized in Table 2.2). However, this common conceptualization is lacking in several regards. First, it presents scholarly understanding of hazards as having neatly progressed through a series of stages from 'less accurate' to 'more accurate'. This reductionist approach fails to highlight the strengths and weaknesses of the different perspectives. Second, this conceptualization fails to

Period	Paradigm name	Main perspectives
'Early times'	Acts of God	Disasters are external events that occur at the discretion of an omnipresent deity (Smith, 2010)
Pre-1950	Engineering	Humans can prevent or minimize disasters by building more efficient structures (McEntire, 2005)
1950−70	Behavioral	Hazards are not external to society. Humans must adapt to or accommodate hazards, rather than relying solely on structural solutions (White, 1945)
1970−90	Development	Disasters in least developed countries occur due to marginalization, powerlessness, and impoverishment.
1990−	Complexity	There exists a complex and reciprocal relationship between the environment and human society (Warner et al., 2002)

Table 2.2: A summary of the evolution of the natural hazards paradigm presented by Smith and Petley (2010).

acknowledge that the development of each new 'paradigm' did not eliminate all prior belief systems. At the time of writing, all five hazards paradigms are present to varying degrees across different social, political, and academic institutions. For example, many tribal cultures continue to conceptualize natural hazards as 'acts of God', while many civil engineers believe the best way to reduce hazard risk is to design improved mitigation structures.

It may be useful to discuss the 'evolution' of the scholarly understanding of hazards in terms of agency and complexity. As human understanding of natural hazards expanded, the locus of control shifted from being entirely exogenous to human society (i.e., the belief that humans had no control over the frequency or severity of hazards) to increasingly endogenous. As this shift occurred, researchers and practitioners came to appreciate the increasingly complex role of human agency in determining whether a hazard will become a disaster. As a result of this shift, there has been an increasing emphasis placed on the research of societal dimensions of hazards, such as vulnerability and resilience. The process of knowledge building was not strictly linear, nor was it neatly compartmentalized into discrete stages. Instead, it has been (and continues to be) a process of defining and redefining scholarly understanding of hazards, with an increasing emphasis placed on human agency, and an increased appreciation of systems complexity.

2.2 Social dimensions of disasters

2.2.1 Vulnerability and resilience

Within the natural hazards literature, vulnerability is often broadly defined as the potential for loss from a hazardous event (Cutter, 1996). Smit and Wandel (2006: 286) provide a comprehensive definition of vulnerability as "reflective of (or a function of) the exposure and

sensitivity of a system to hazardous conditions, and the ability or capacity or resilience of the system to cope, adapt or recover from the effects of those conditions". Sensitivity refers to the degree that a community could be affected by change, and exposure refers to the potential frequency at which change could occur. Hence, vulnerability has both social and physical dimensions (Adger, 1999; Smit and Wandel, 2006). Social vulnerability is influenced by many factors, including: societal demographics, infrastructure, political and social institutions, and perception of risk (Adger, 1999; Wisner et al., 2004).

Within the last decade, there has been a notable increase in the amount of research that directly links social vulnerability with community resilience (e.g., Paton et al., 2001; Coles and Buckle, 2004; Maguire and Hagan, 2007; Folke, 2006; Berkes, 2007). In the context of disaster research, resilience refers to the ability of a community to absorb shocks and to revitalize itself if damaged (Tompkins and Adger, 2003). Berkes and Jolly (2001) explain that resilience has three defining characteristics: (1) the amount of change a system can experience and still retain the same controls on function and structure, (2) the degree to which the system is capable of self-organization, and (3) the community's ability to build and increase its capacity for learning and adaptation. Thus, resilience, adaptation, and vulnerability are all closely related concepts (Folke, 2006; Smit and Wandel, 2006).

2.2.2 Mitigation and adaptation

There are three broad potential responses to disaster risk: mitigation, adaptation, and inaction. Mitigation refers to any action taken to physically reduce the exposure of a community to a hazard. Mitigation projects often take the form of engineered structures, such as levees and

dams. Research has shown that investing $1 into the mitigation of disasters can save up to $7 in recovery costs (Abramovitz, 2001). For example, China invested over US$3 billion in flood control between 1960 and 2000, which is estimated to have prevented losses of about $US 12 billion (UN/ISDR, 2008). Mitigation efforts are most prevalent in developed countries with sufficient economic capital to support such projects.

In comparison, adaptation refers to any action taken to reduce the sensitivity of a community to a hazard. Smit et al. (2000: 225) provide a comprehensive definition of adaptation as the "adjustments in ecological-sociological-economic systems in response to actual or expected climatic stimuli, their effects or impacts". Adaptation can therefore be proactive or reactive, and it can incorporate temporal, spatial, social, and physical connotations. Adaptation policies often focus on improving education and communication, writing and enforcing zoning laws, and strengthening social networks. A notable example of successful behavioral adaptation was discovered on Simeulue island, which is located 150 kilometers off the west coast of Sumatra, after the 2004 Indian Ocean tsunami (McAdoo et al., 2006). Residents of this low-lying island immediately sought higher ground after the earthquake occurred in December 2004. Members of this community had access to traditional knowledge passed down through oral histories that warned residents to seek higher ground after an earthquake. As a result of this adaptive behavior, only five individuals lost their lives to the disaster that would ultimately cause over 230,000 fatalities (McAdoo et al., 2006).

Not all adaptations are beneficial; some actions taken to reduce vulnerability to hazards may actually increase vulnerability or reduce resilience instead. These maladaptive decisions

include "actions taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors or social groups" (Barnett and O'Neill, 2010: 211). The Farakka Dam on the Ganges River near the border between India and Bangladesh is an apt example of this concept. This Indian-build dam has profound negative consequences for downstream communities in Bangladesh by restricting water flow in the dry season and contributing to floods during the rainy reason.

2.2.3 Risk

There currently exists an ongoing debate within the risk research community about the most appropriate conceptualization of risk. The two opposing factions can be identified as objectivists and subjectivists, and each party dominates a certain area of the risk literature. Within the technical literature, risk is most often conceptualized as an objective variable identified by the statistical or probabilistic expectation of an outcome (Hansson, 2010). Objectivists conduct risk assessments to identify and quantify 'real' risk (Slovic, 1987). These risk assessments are most often completed by technical analysts to evaluate the potential for technological and environmental disasters. In comparison, social scientists tend to conceptualize risk as a social construct that is interpreted within the context of a subjective reality (Hansson, 2010). Subjectivists argue (often vehemently, e.g., Otway and Thomas, 1982) that objective risk assessments are impossible since all decisions, from the initial framing of the problem statement to the final presentation of the results, are made within a subjective reality. Slovic and Weber (2002) comment on this inherent subjectivity by describing the various ways that fatality risks associated with chemical accidents can be

conceptualized, measured, and expressed (e.g., deaths per million people in the population; deaths per facility; deaths per ton of air toxin released).

In the current study, risk will be conceptualized in terms discussed by Hansson (2010: 236) who proposed a dual risk thesis: "an accurate and reasonably complete characterization of risk must refer both to the objective facts about the physical world and to (value) statements that do not refer to objective facts about the physical world". Under this conceptualization, risk is understood to be both fact-laden and value-laden (i.e., it has both objective and subjective attributes) (Hansson, 2010). In this research framework, objective risk can be understood as the statistical likelihood of a tornado occurrence in southern Ontario, whereas subjective risk refers to risk attitudes and risk perception of individuals in this region.

2.2.4 Risk perception paradigms

Risk perception research developed rapidly in response to public opposition to the development of chemical and nuclear technologies during the 1960s (Slovic, 1987; Sjöberg, 2000). Over time, three broad models were developed for assessing the complex opinions that people had about risk (Slovic, 1987): the psychometric model; the Social Amplification of Risk Framework (SARF); and cultural theory. These three models will be briefly discussed below; for an in-depth analysis of the strengths and weaknesses of each of model, refer to Sjöberg (2000).

The psychometric model seeks to understand the cognitive faculties used to interpret and quantify risk. Specifically, explanatory scales and multivariate analysis techniques are used to

quantify risk perception (Slovic, 1987). Two factors in particular, dread risk and unknown risk, have been identified as either exaggerating or minimizing risk judgements, relative to expert analysis of 'real' risk (Gierlach et al., 2010). Dread risk refers to the destructive potential of the anticipated hazard, while unknown risk refers to the individual's controllability and predictability of the event (Gierlach et al., 2010). Proponents of the psychometric model assert that perceived risk is both quantifiable and predictable.

The second model is the Social Amplification of Risk Framework (SARF), which studies the process through which risk is interpreted and meaning is attributed to an event (Gierlach et al., 2010). SARF asserts that risk perception can be heavily influenced by the social interpretation of a particular event (such as a tornado warning). This constructed meaning is propagated across society *via* amplification stations (e.g., individuals, mass media, social networks) that repeatedly distort the perceived level of risk (Gierlach et al., 2010). If the risk is interpreted by society to be less serious than analysts have determined, then this same process of propagating risk distortion is referred to as attenuation (Gierlach et al., 2010). The degree to which perceived risk is amplified or dampened will in turn influence protective-action decisions by recipients of the distorted risk information.

The third model that is prevalent in the risk perception literature is cultural theory. Cultural theory asserts that social groups emphasize certain hazards based on the perceived relevance of that hazard to their social, political, and cultural values (Gierlach et al., 2010). Thus, risk is always interpreted within the broader social context. For example, schoolchildren in Japan may develop a distorted perception of tsunami risk after the 2011 March earthquake and

tsunami, but they may lack an appropriate conceptualization of tropical cyclone risk. Although cultural theory has been criticized for its inability to accurately predict how individuals perceive risk, it is still widely utilized within the perceptions literature.

Risk perception studies seek to understand the nature and extent of the discrepancy between the objective (actual) risk and the subjective (perceived) risk of a hazardous event. Many social scientists are particularly interested in perceived risk, as risk perception is known to influence protective action decision-making. As Slovic (1987: 281) explains:

> If successful, [risk perception] research should aid policy-makers by improving communication between them and the public, by directing educational efforts, and by predicting public responses to new technologies, events, and new risk management strategies.

2.2.5 Common themes in risk perception

Many factors, both internal and external, can influence risk perception, including: gender, ethnicity, age, socio-economic status, cultural values, social memory, and access to mass media (e.g., Gierlach et al., 2010; Paton et al., 2008; Sheridan, 2007; Sjöberg, 2000). As such, there can be significant differences in the ways individuals perceive and respond to risk information. However, while risk perception is both a highly dynamic and personal construct, recent studies have found several consistencies in the way that many people interpret risk information. The first tendency is for people to have an optimism bias, whereby individuals perceive themselves as being less at risk than other people (Paton et al., 2008; Gierlach et al., 2010). This bias is found in numerous studies from different disciplines, including research on every day risks

(Sjöberg, 2000), weather warnings (Silver and Conrad, 2010), volcanic eruptions (Paton et al., 2008), tropical cyclones (Hanson, 2003), and life choices (Weinstein, 1980).

A second theme involves the difference between voluntary versus involuntary risks. Through his research on acceptable risk-benefit trade-offs, Starr discovered that individuals are far more likely to accept voluntary risks than involuntary risks (Starr, 1969). He found that individuals will accept risks from voluntary activities that are approximately 1000 times greater than they would accept from involuntary activities (Slovic, 1987). For example, many individuals feel comfortable driving above the posted speed limit, but experience significant anxiety during air travel. Building upon Starr's work, Slovic (1987) identified two variables that influence risk attitudes: dread risk and unknown risk. Dread risk and unknown risk form the foundation of the psychometric model of risk perception discussed previously. Dread risk is defined as the "perceived lack of control, dread, catastrophic potential, fatal consequences, and the inequitable distribution of risks and benefits" (Slovic, 1987: 283). Risks that could result in awful outcomes, such as nuclear technology or air travel, are dread risks. The second variable identified by Slovic (1987: 283) is unknown risk, defined as "hazards judged to be unobservable, unknown, new, and delayed in their manifestation of harm". Stem cell research and certain medical technologies would rate high on the unknown risk scale. Situations that rate very high on either the dread risk or the unknown risk scale (or both) are often perceived to be high-risk.

A third common theme in risk perception research was established by the cultural theory of risk perception. It was found that individuals who are deferential to authority are more likely

to support seemingly high-risk research, such as nuclear technology (Wildavsky and Dake, 1990). This finding is consistent with a political culture of hierarchy, and has been supported by recent research examining the differences in cultural risk perception between American citizens and Japanese citizens (Gierlach et al., 2010).

The fourth theme relates to the exposure of individuals to mass media. Some research suggests that an overabundance of risk information can contribute to a heightened perception of risk. For example, after the widely televised events of September 11th, 2001, people avoided flying by commercial airplanes out of an exaggerated fear of another terrorist attack (Gierlach et al., 2010). In contrast, other researchers have found no apparent relationship between the exposure to mass media and the distortion of risk perception (Sjöberg, 2000). The relationship between these two variables is still a subject of considerable discussion (Sjöberg, 2000).

2.3 Decision-making in high-risk situations

2.3.1 The role of risk perception in decision-making

There are numerous characteristics, both exogenous and endogenous, which could potentially affect individual decision-making, either directly or indirectly, in risky situations. Prospect theory asserts that problem framing can control individual decision-making in high-risk situations (Kahneman and Tversky, 1979). Prospect theory also purports that problem-related characteristics directly influence individual risk behaviour. Sitkin and Pablo (1992) were particularly critical of prospect theory, which they charge as overlooking risk propensity as an influencing factor in decision-making. In an effort to clarify the 'fragmented and oversimplified' model of prospect theory, Sitkin and Pablo (1992) identified nine key

Level	Characteristic Name	Description
Individual-	Risk preference	Certain individuals enjoy the challenges associated with risk-taking more than others.
	Risk perception	The subjective and often intuitive evaluation of risk by individuals.
	Risk propensity	The innate tendency of an individual to be either risk averse or risk seeking.
Organizational-	Group composition	Decisions made by a group can influence individual-level decision making.
	Cultural risk values	Certain organizations prefer certainty over uncertainty and risk avoidance over risk-seeking.
	Leader risk orientation	The risk preferences of a group leader can either encourage or discourage risk taking by group members.
	Organizational control systems	If risk taking is rewarded or encouraged, individuals may be more prone to risky behavior than if risk taking is punished or discouraged.
Problem-	Problem familiarity	Previous experience with risk taking and familiarity with high-risk situations may cause risk seeking behavior that other, less experienced individuals would avoid.
	Problem framing	The way that the situation is presented (i.e., either in terms of potential gains or potential losses, or as an opportunity or a problem) will influence either risk-taking will be sought or avoided.

Table 2.3: Nine key characteristics identified and summarized by Sitkin and Pablo (1992) as being influential in the decision-making process during high-risk situations.

characteristics that influence decision-making in high-risk situations (Table 2.3). These variables were organized into three broad categories: individual-, organizational-, and problem-related characteristics. Individual-level characteristics that affected decision-making included risk preferences, risk perception, and risk propensity. Organizational-level characteristics included group composition, cultural risk values, leader risk orientation, and organizational

control systems. Problem-related characteristics included problem familiarity and problem framing. Of these factors, Sitkin and Pablo (1992) argued that risk propensity and risk perception are the two key characteristics that influence decision-making, particularly in high-risk situations.

Based on this research, Sitkin and Pablo (1992) developed the model of the determinants of risky decision-making behaviour, a theoretical framework for the study of decision making in high-risk situations. This conceptual model highlighted the critical role of risk propensity and risk perception as mediators in the decision-making process. In subsequent research, risk perception has been identified as the more influential of these mediating variables on individual decision making in risky situations (Sitkin and Weingart, 1995; Keil et al., 2000; Wong, 2005; Williams, 2007; Williams and Noyes 2007). Although the reconceptualized model of the determinants of risk behavior proposed by Sitkin and Pablo (1992) and later updated by Sitkin and Weingart (1995) has been criticized for omitting influential variables (such as self-efficacy) and for its inability to conceptualize interactions between variables, it is still widely credited for highlighting the important role of risk propensity and risk perception in the decision-making process (e.g., Pennings and Grossman, 2008).

2.3.2 Multi-level influences on decision making in high-risk situations

As discussed previously, there are numerous individual-, family-, and community-level characteristics that may influence decision-making in high stress/high risk situations. Much of the existing research in the hazards literature focuses on the influence of individual-level characteristics (e.g., gender, age, socioeconomic status, or risk propensity) on the decision

making process. There has also been considerable research conducted to examine the influence of neighborhood- and community-level factors on individual behavior during crises. However, few studies in the hazards literature adequately explore the interconnected, multi-level nature of the decision-making process (notable exceptions include: Burningham et al., 2008; Norris et al., 2008; Paton et al., 2008; Pennings and Grossman, 2008).

It is widely acknowledged that community- and institutional-level factors influence individual- and family-level decision-making in high-risk situations. For instance, the presence or absence of tornado sirens and tornado shelters in a community can affect individual risk perception and protective actions taken during a tornado warning. But can individual-level factors aggregate up to the community- or national-level? In sudden onset disasters, most people make protective action decisions as individuals or as family groups, although individuals may seek risk confirmation from trusted friends or neighbors before taking action (Sherman-Morris, 2010). However, environmental disasters rarely affect only individuals; instead, disasters most often occur within a neighborhood- or community-level context (Norris et al., 2008). In a study of flood disasters in Kentucky, Norris et al. (1994) documented community-wide adverse psychological effects that greatly affected the quality of life of residents and eroded their social networks. Given that individual decision-making may be influenced (either directly or indirectly) by the broader social context, and the social context is, in turn, influenced by individuals, it is counter-productive to rigidly separate these factors when studying behavior in high-risk situations.

In their study on the role of risk attitudes and risk perceptions on decision-making, Pennings and Grossman (2008) argued that drivers of individual-level decision-making can aggregate to influence community-level response toward disaster. The aggregation of all behaviors of all individual decision-makers within a community is referred to as *behavioral outcome space* (Pennings and Grossman, 2008). The authors also asserted that behavioral outcome space must be effectively managed during a disaster by maintaining open communication, and by shaping risk attitudes and risk perceptions (Pennings and Grossman, 2008). The tendency for individual-level behavior to aggregate to the community level is also supported by research on criminal violence (Sampson and Lauritsen, 1994), domestic violence (Koenig et al., 2003), and community resilience (Norris et al., 2008).

The dynamic interplay between the various individual- and community-level factors that influence decision-making has important implications for community-level disaster risk reduction policies. Consider public education campaigns, which are an example of the community-level influence on the individual decision-making process in high-risk situations (Paton et al., 2008). Recent research has shown that top-down education campaigns, which identify knowledge gaps within the community and then attempt to eliminate these gaps by providing relevant risk information to individuals, are largely unsuccessful (Burningham et al., 2008). Ironically, these education campaigns may actually increase social vulnerability through a process called risk compensation (Paton et al., 2008). Risk compensation occurs because "individuals maintain a balance between perceived level of safety proffered by their environment and their perceived risk. Any positive shift in perceived environmental safety is accompanied by a reduction in their perceived risk" (Paton et al., 2008: 182). Thus, top-down

education campaigns that make individuals feel more secure may cause a reduction in their preparedness.

If individuals perceive and respond to risk information differently, how then do emergency managers create effective policies at the community level to positively influence decision-making? Although protective action decisions are made at the individual-level, risk information is almost always interpreted in the context of local knowledge; social interaction also plays an important role in this process (Paton et al., 2008). Recent research on flood awareness (Burningham et al., 2008), climate change (Ford et al. 2007; Pearce et al. 2009), and volcanic eruptions (Paton et al., 2008) has recognized the need to engage community members in honest, two-way communication whenever community-level policy is developed. Numerous reasons have been supplied by researchers to support this recommendation, including: (1) Policy written without community consultation often does not take into account local needs or community concerns. These policies may increase social vulnerability by undermining social networks, increasing conflict, and reducing flexibility, (2) Externally-imposed policies are often met with resistance and resentment by community members, which often leads to the failure of the policy due to low participation and support, and (3) Community members have a wealth of local knowledge which can be used to supplement and support risk reduction policies. Thus, emergency managers can create flexible and effective policies intended to improve individual decision-making by actively engaging the entire community.

Identifying public awareness of (and concerns regarding) local disaster risk, and improving perception of these risks is one participatory adaptation method that could potentially reduce

social vulnerability. As Gierlach et al. (2010:1548) explain: "Because levels of perceived risk are associated with self-protective behaviors, understanding how to meaningfully communicate risk information can lead to more accurate and timely behavioral changes rather than decisions based inappropriately on fear". However, it is important to balance risk perception studies with risk assessments. An over-emphasis on the public perception of risk can lead to the creation of ineffective and redundant hazard policies. Conversely, researchers who only focus on the objective analysis of risk have no understanding of how individuals and communities receive, interpret, and respond to risk information. Thus, researchers must address both the subjective and objective attributes of risk in order for social vulnerability to be effectively reduced.

2.4 Tornadoes

2.4.1 Physical characteristics and risk

Tornadoes are among the most potentially destructive storms on Earth. Broadly defined, a tornado is the violently rotating column of air that extends from the base of a cumulonimbus cloud to the ground. These phenomena are "capable of creating incredible amounts of damage and significant numbers of fatalities and are, from a meteorological and climatological perspective, one of nature's most challenging perils" (Etkin et al., 2001: 915). The challenging nature of tornadoes is a function of their rapid onset and development, their unpredictable behavior, and their complex, multi-scale impacts.

Although tornadoes can occur at any time of the day or night, they typically occur in the late afternoon or early evening when the atmosphere is made unstable from intense daytime heating. Tornadoes can occur anywhere in the world given the appropriate conditions, but

tornado frequency varies significantly across the globe. Tornado activity within the United States accounts for almost 90% of all tornadic activity worldwide (Grazulis, 2001). The United States experiences approximately 1000 tornadoes each year, which result in an annual average of 65 deaths and 1100 non-fatal injuries (Comstock and Mallonee, 2005). Canada accounts for approximately 5% of all tornadic activity worldwide with an average of 80-100 tornadoes occurring each year. The majority of these tornadoes occur in southern Ontario, which is the northern most extent of North America's "Tornado Alley".

The high frequency of tornadoes in North America is a function of the atmospheric mechanics necessary for the development of these storms. Severe thunderstorms most readily develop when warm, moist air collides with cool, dry air, which results in atmospheric instability. In North America, warm, moist air is drawn up from the Gulf of Mexico and cool, dry air is drawn down from Canada; when these conflicting air masses meet, the development of supercell thunderstorms is possible (Hyndman et al., 2009). In addition to destructive tornadoes, mesoscale convective storms are also capable of producing torrential rainfall and large hail. Hailstones in particular are capable of damaging agricultural crops, vehicles, and buildings, and they can cause serious injury to livestock or people. It is estimated that damage from hailstones in the United States alone averages over $1.2 billion USD annually (NOAA, 2011).

The dominant classification scheme used in tornado research is the Fujita Scale of Tornado Intensity, which was developed in 1971 by Tetsuya "Ted" Fujita of the University of Chicago (Table 2.4). The F-scale classifies tornadoes based on the damage they produce, as determined

by post-storm damage surveys (Grazulis, 2001). Thus, wind speed is inferred from damage done rather than directly measured. Tornadoes are capable of causing incredible destruction as they can produce wind speeds in excess of 500 kph. This is especially relevant considering tornadoes produce both vertical and horizontal winds; vertical wind speeds in excess of 160 kph can counteract the force of gravity, causing objects to become airborne (Grazulis, 2001). In these powerful storms, debris becomes dangerous projectiles capable of impaling buildings and vehicles, and causing significant injury or death. In 2007, an Enhanced Fujita Scale (EF-scale) was introduced in an attempt to more accurately align wind speed estimates with reported damage (Table 2.4). Placement on the EF-Scale involves expert judgment of eight levels of damage to 28 indicators, including: homes and other buildings, towers, poles, and trees (SPC, 2004).

2.4.2 Tornado forecasts and warnings

Due to their rapid onset and development and their unpredictable behaviour, tornadic storms

FUJITA SCALE		**ENHANCED FUJITA SCALE**		
F-number	**Wind Speed (kph)**	**EF-number**	**Wind Speed (kph)**	**Typical Damage**
F0	64 - 116	EF-0	105 - 137	Light damage
F1	117 - 180	EF-1	138 - 178	Moderate damage
F2	181 - 253	EF-2	179 - 218	Considerable damage
F3	254 - 322	EF-3	219 - 266	Severe damage
F4	333 - 418	EF-4	267 - 322	Devastating damage
F5	419 - 512	EF-5	> 322	Incredible damage

Table 2.4: The Fujita Scale and the Enhanced Fujita Scale. Note that wind speed estimates are based on three-second gusts estimated at the point of damage. Modified from SPC (2004).

are one of the most challenging weather phenomena to accurately predict. The National Weather Service (NWS) in the United States began issuing official watches and warnings for tornadoes in the 1950s (Grazulis, 2001). The average tornado warning lead-time has since improved significantly due to advancements in forecasting technology, as well as recent improvements in the scientific understanding of tornadogenesis. For example, the average warning lead-time was 0-3 minutes in the 1970s, whereas current average lead-time for tornadic storms is 13 minutes (Stensrud et al., 2009; Stalker et al., 2011). The increased time between when a tornado warning is issued and when a tornadic storm impacts a community has significant implications for individual- and community-level disaster response.

Although the accurate and timely posting of tornado watches and warnings is a significant factor in reducing deaths and injuries due to tornadoes, other factors have emerged in the literature as being equally significant, including: the ability to receive and understand official watches and warnings; access to suitable shelters; situational awareness of appropriate protective actions; and an accurate perception of tornado risk (Hammer and Schmidlin, 2002; Comstock and Mallonee, 2005; Sherman-Morris, 2005; Donner, 2007; Ashley et al., 2008; Blanchard-Boehm and Cook, 2009; Schmidlin et al., 2009; Sherman-Morris, 2010). These factors greatly influence individual- and community-level decision-making during tornado warnings and other high-risk events, and remain largely independent of a forecast centre's ability to produce timely and accurate weather forecasts.

2.4.3 Sources of severe weather information

It has been well established that most individuals in North America receive warning information from mass media sources, with television, outdoor warning sirens, and radio frequently cited as the most common public warning mediums (Hammer and Schmidlin, 2002; Comstock and Mallonee, 2005; Sherman-Morris, 2005; Blanchard-Boehm and Cook, 2009; Schmidlin et al., 2009). Television in particular can be highly effective at tornado warning dissemination. For example, news outlets have the ability to interrupt regularly scheduled television programs to disseminate urgent warning information during periods of hazardous weather. Television weathercasters may tailor their severe weather coverage to include graphics of storm track and intensity, as well as images of the storm and its aftermath. This motivating information is unavailable from other popular warning mediums, such as tornado sirens or radio stations. Frequent viewers of television newscasts may also perceive camaraderie between themselves and their weather forecaster; this perceived bond between the viewing public and their weathercaster is referred to as a parasocial relationship. It has been shown that viewers who develop a parasocial relationship with their weathercaster are more likely to follow his or her protective action advice during outbreaks of severe weather (Sherman-Morris, 2005).

Although television, outdoor warning sirens, and radio remain the most commonly accessed modes of tornado warning dissemination, there is an emergent literature that examines the usefulness of social media as a source of disaster response and recovery information. Social media refers to those web-based and mobile services that allow end-users to generate and share content, and to browse other users' generated content (Hyvärinen and Saltikoff, 2010). Facebook and Twitter (with over 800 million and 140 million users, respectively) are two

examples of highly popular social networking services, both of which may be accessed through the Internet and mobile phone applications.

Social media has several advantages over traditional media as a crisis communications tool. First, social media can be rapidly and continuously updated by numerous end-users throughout a severe weather event. These updates can provide critical information that would otherwise be unavailable to weather forecasters and emergency management personnel located outside of the impact area. Second, information can propagate rapidly on social media websites, reaching thousands (sometimes millions) of users within a relatively short timeframe. Many social networking websites also allow users to share or search for content using hashtags or keywords, which further increases the accessibility of user-generated content. A common and legitimate criticism of social networking websites is that it can be difficult to evaluate the credibility and validity of user-generated content (Jefferson, 2006; Kaplan and Haenlein, 2010; Hyvarinen and Saltikoff, 2010). Gossip and misinformation (either intentional or unintentional) are common on social networking websites, and it can be a challenge for end-users to differentiate between this content and more credible information. This represents a potential source of vulnerability for those individuals who may rely on social media sources when seeking weather information.

2.4.4 Social vulnerability and public response to tornadoes

Due to their rapidity of onset and potential destructiveness, tornadoes represent a significant risk to human beings. As with other disasters, social vulnerability to tornadoes is influenced by many variables, including: timing and rapidity of onset, public response to tornadoes, socio-

economic status, previous experience with the hazard (either personal, or within the broader social context), and risk perception. These variables can also influence an individual's decision-making process during tornadic events. Thus, it is important to understand the dynamic relationship(s) between these variables when trying to deconstruct a tornado disaster.

The timing and rapidity of tornado onset has several important implications for social vulnerability to these severe storms. First, the ideal warning lead-time is known to vary between different publics. While individuals may only need several minutes to seek appropriate shelter, school administrators and hospital staff may need significantly longer to evacuate their facilities (Ewald and Guyer, 2002). Interestingly, recent research suggests that longer warning lead-times do not always translate into lower risk, as reflected by mortality and injury rates (Doswell, 1999; Simmons and Sutter, 2008; Simmons and Sutter, 2009). Longer warning lead times may be less effective because they convey a sense of competency and preparedness that may result in a reduction of perceived risk (Doswell, 1999). This classic example of risk compensation may cause individuals to be less motivated to take appropriate protective actions.

The timing of a tornado event can also influence social vulnerability. Individuals are more likely to receive a tornado warning if it is issued during the time when people are awake and media sources are readily accessible. It is also much easier to visually assess an approaching storm during the daytime than at night. The ability to visually assess a storm has been shown to be an influential factor in the decision to take protective actions (Hammer and Schmidlin, 2002; Comstock and Mallonee, 2005; Sherman-Morris, 2010). Recent research has shown that

mortality associated with nocturnal tornadoes has not shared the same rate of decline over the past century as those tornadoes occurring between sunrise and sunset (Ashley et al., 2008). Tornadoes that occur when people are typically at work, school, or in transit also represent a challenge, as these individuals may not have access to suitable shelter, or they may lack an emergency action plan.

Public response to tornado watches and warnings can also substantially influence social vulnerability during these high-risk events. A 'protective action' refers to the full range of actions taken to reduce the risk of injury or death, and to minimize the damage sustained to property. The National Oceanic and Atmospheric Administration in the United States recommends a list of protective actions to take during a tornado warning (NOAA, 2010). The safest place to take shelter during a tornado is an underground room, such as a basement or a storm cellar. If underground shelter is not available, then it is recommended that individuals shelter in an interior room or a hallway on the lowest level of a sturdy building. Individuals who are caught outdoors or who live in mobile homes are advised to go to the nearest sturdy building to take shelter immediately. It is also strongly recommended that individuals shelter *in situ* for the duration of the severe weather event. Other examples of protective actions that are often taken before severe weather arrives include: securing loose items, such as lawn furniture, and closing windows and doors.

Socio-economic status influences vulnerability to tornadoes in many ways, both directly and indirectly. Individuals in a low income bracket are more likely to reside in inadequate structures, such as mobile homes. Mobile homes are notoriously vulnerable to even the

weakest tornadic winds, and offer no significant protection during these severe storms (Sutter and Simmons, 2010). Recent research has shown that individuals in mobile homes are 12 times more likely to receive serious injuries and 35 times more likely to be killed by a tornado than those individuals in well-built wood-framed houses (Daley et al., 2005; Schmidlin et al., 2009). Socio-economic status can also affect the technology to which an individual has frequent and reliable access. It has been well established that communications technologies (e.g., televisions, radios, computers with Internet access, and cell phones) play an important role in the dissemination of warning information during tornado events (e.g., Hammer and Schmidlin, 2002; Comstock and Mallonee, 2005; Sherman-Morris, 2005; Sherman-Morris, 2010). Socio-economic status can also influence the range of available protective actions. For example, individuals with higher incomes may be able to afford technologies that would assist in taking protective actions, such as weather radios, weather-related cell phone applications, motor vehicles, and personal storm shelters.

Risk perception can also greatly affect individual-level vulnerability during tornado emergencies. As previously discussed, risk perception has been shown to be the most influential factor in the decision-making process during times of crisis (Sitkin and Pablo, 1992; Sitkin and Weingart, 1995; Pennings and Grossman, 2008). Risk perception of tornadoes is influenced by numerous variables, including previous experience with damaging tornadoes, access to weather information, and personal attributes (e.g., age, gender, education). Recent research is divided on the influence of previous hazard experience on risk perception and decision-making during subsequent events (Drobot et al., 2007). Some researchers assert that previous experience with tornadoes will positively impact protective action decision-making in

subsequent events (e.g., Comstock and Mallonee, 2005; Mileti and Sorensen, 1987; Hammer and Schmidlin, 2002). However, other research has shown that previous experience with damaging tornadoes does not necessarily influence individuals to be any more likely to make appropriate protective-action decisions during subsequent events (e.g., de Man and Simpson-Housley, 1987; Liu et al., 1996; Balluz et al., 2000; Donner, 2007; Schmidlin et al., 2009). Therefore, any new research that examines the influence of two or more successive tornado events on a community could greatly contribute to the academic understanding of risk perception and protective action decision-making during tornadic events.

CHAPTER THREE

STUDY CONTEXT AND METHODS

3.1 Introduction to the research problem

3.1.1 Tornadoes in southern Ontario

Southern Ontario is one of Canada's most active regions for severe weather. A wide variety of weather-related hazards occur in the province annually, including: blizzards, floods, severe thunderstorms, and tornadoes. An average of 80 tornadoes occur in Canada each year, which result in an annual average of 2 deaths, 20 injuries, and tens of millions of dollars in damages (Environment Canada, 2011b; Cao and Cai, 2011; Cao and Cai, 2008). The Canadian region at the highest risk of tornadoes is southern Ontario (Etkin et al., 2001; Natural Resources Canada, 2009; Conrad, 2009). Based on assessments of tornado frequency, intensity, and tract, it has been determined that an F3 tornado affects southern Ontario every five years (Banik et al., 2007); less intense tornadoes affect southern Ontario every year (Figure 3.1). Given that southern Ontario accounts for approximately 35% of Canada's total population (McGillivrary, 2010), the tornado hazard in this region poses a significant risk to millions of Canadians (Figure 3.2)

The average number of reported tornadoes in Ontario has increased since the 1970s (Banik et al., 2007). As with similar trends in the United States, this apparent increase is at least partly the result of an observation bias. As population density, forecasting accuracy, and public awareness have increased, so too has the number of reported tornadoes (Banik et al., 2007). In

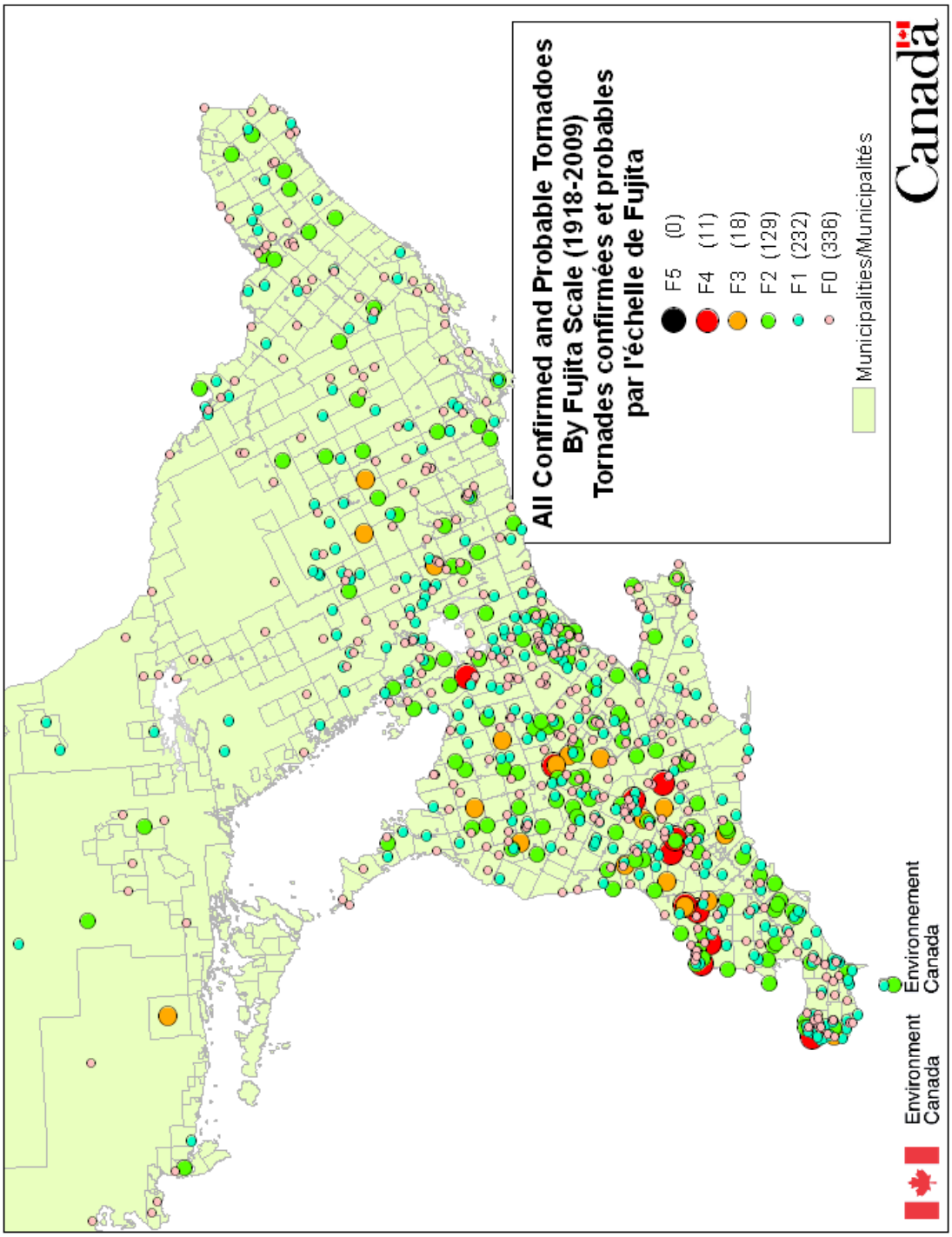
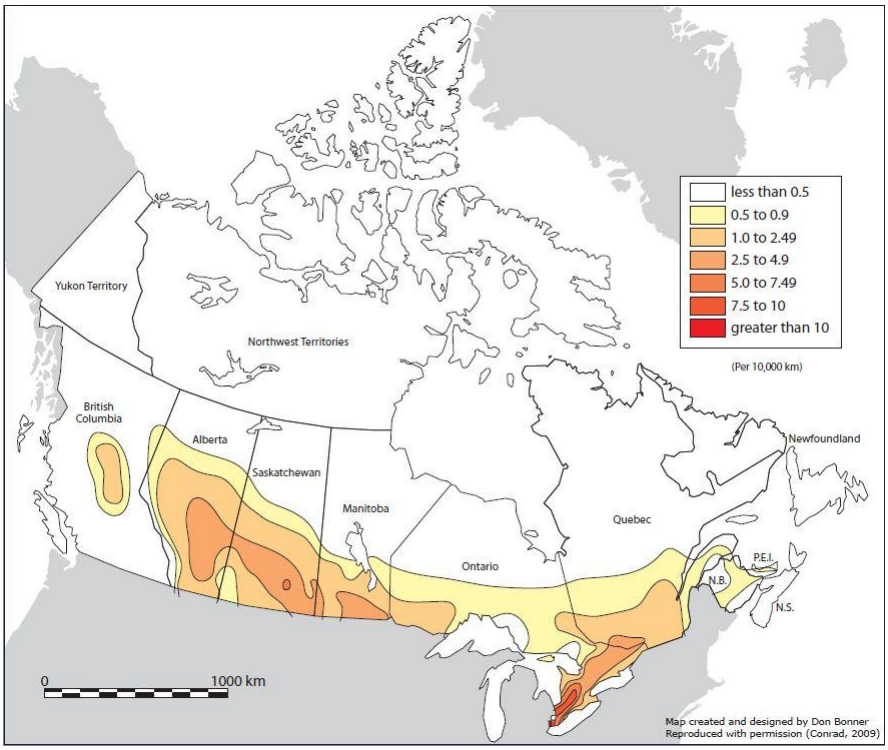


Figure 3.1: The location of all confirmed and probable tornadoes that occurred in southern Ontario from 1918-2009 (Source: Environment Canada, nd.)

a)



b)

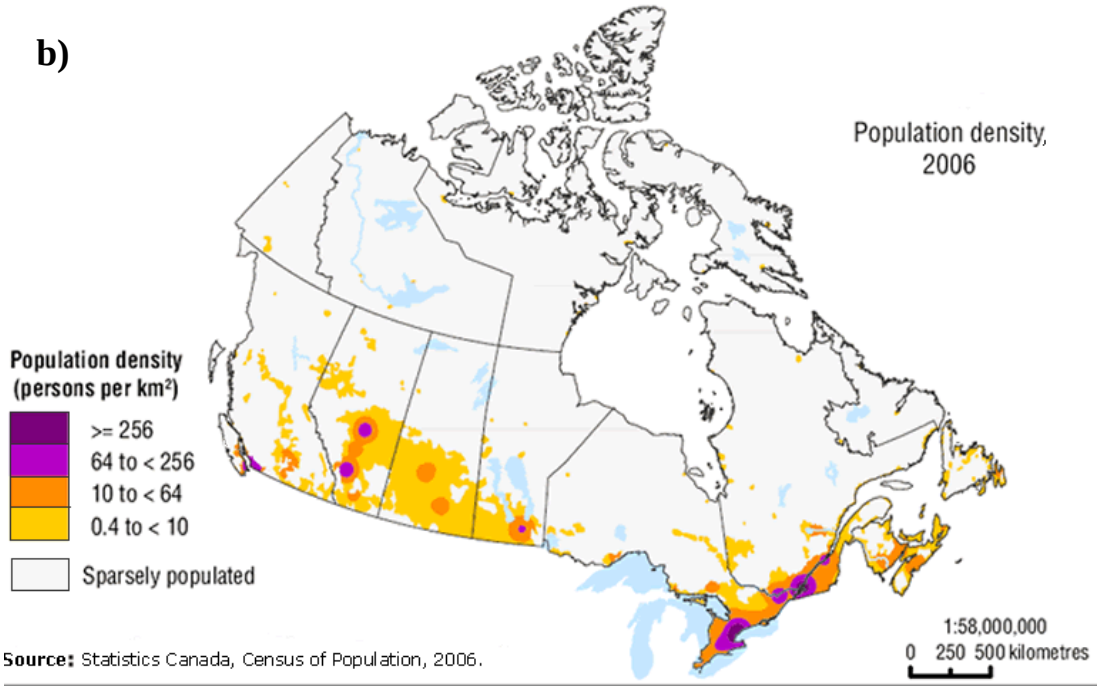


Figure 3.2: **a)** The geographic distribution of tornadoes in Canada (Source: Conrad, 2009, used with permission). **b)** The population density of Canada (Source: Statistics Canada, 2006).

actuality, tornado frequency in Ontario has been highly variable over the last three decades, with the 1980s being particularly active in Ontario, whereas the 1990s was a period of reduced tornado activity. However, recent research has found that tornadic activity in southern Ontario may be increasing for the first time in sixty years independent of the observation bias discussed previously (Cao and Cai, 2011). As tornadic activity is variable, so too are tornadic damages. Several notable tornado outbreaks have occurred in this region over the last three decades, including significant events in 1985, 2005, and 2009 (Environment Canada, 2011c). The 1985 Barrie tornado outbreak in southern Ontario, which resulted in 12 fatalities, 155 injuries, and approximately $250 million in damages, remains one of Canada's worst natural disasters (Allen, 1986).

Despite the existing tornado risk in southern Ontario, there has been very little research published that investigates how individuals in this region obtain, interpret, and respond to severe weather information. The purpose of this thesis research is to address this knowledge gap by determining how the publics in southern Ontario understand risk information pertaining to tornado warnings, and how these individuals make protective action decisions during these high-risk, short-notice disasters. To achieve this objective, this research project examines two events that occurred in August, 2011 in Goderich, Ontario: an F3 tornado that impacted the community on August 21st and a tornado warning that was posted for the region three days later on August 24th. Semi-structured interviews (n=35) and close-ended questionnaires (n=268) were conducted to examine how individuals obtained, interpreted, and responded to risk information, and to assess how the experience of a damaging tornado on August 21st affected perception and response to a tornado warning on August 24th.

Figure 3.3: Goderich, Ontario (Harris, 2012)

3.1.2 Goderich, Ontario

Goderich is a small town with a declining population of 7521 residents located on the shore of Lake Huron in Huron-Perth county of Ontario, Canada (Figure 3.3). The town spans a total land area of 7.91 km^2, with a population density of 950.8 persons/km^2 (Statistics Canada, 2012b). The downtown core of Goderich is an octagonal traffic circle, which is referred to as the Courthouse Square or locally as "The Square". The Square houses a number of businesses, including four banking institutions, two art galleries, the Hotel Bedford, and numerous specialty stores. The Huron County Courthouse, which provides family, criminal, and court services for the region, is located at the center of The Square. Many other public and municipal buildings are also located in or are adjacent to The Square, such as the Ontario

Provincial Police station, Goderich Public Library, Goderich & District Chamber of Commerce, Canada Post, and the Goderich Town Hall. As a regional service center, Goderich provides many retail, municipal, and economic functions for its surrounding communities.

3.1.3 The August 21st Goderich, Ontario tornado

Goderich experienced several periods of unsettled weather throughout the early afternoon on August 21st, with rain, hail, and wind affecting the town shortly after noon. At 2:02 pm on August 21st, 2011 a severe thunderstorm watch was posted for Huron-Perth Counties by Environment Canada. Although there was not a separate tornado watch posted at this time, the possibility of a tornado was mentioned in the text of the severe thunderstorm watch. Approximately one hour later, an isolated supercell thunderstorm moved over Lake Huron and intensified as it approached the town of Goderich. At this time, Doppler radar showed an organized severe thunderstorm with a characteristic "hook echo" (Figure 3.4), which is indicative of intense rotation associated with tornadoes. At 3:48 pm on August 21st, Environment Canada issued a tornado warning for Goderich, Ontario, as well as most of the surrounding area and southern Lake Huron (Environment Canada, 2011a) .

Approximately 10 minutes after the tornado warning was issued by Environment Canada, the storm came ashore into the town of Goderich. The tornado stayed on the ground for two minutes; during this time, it traveled 20 kilometers in a southeasterly direction, leaving behind a damage path between 200 meters and 1.5 kilometers wide (Stockton, 2011; Environment Canada, 2011c). As a result of the tornado, one individual lost his life and at least 39 others were injured, five of whom required urgent medical assistance. Based on a damage assessment

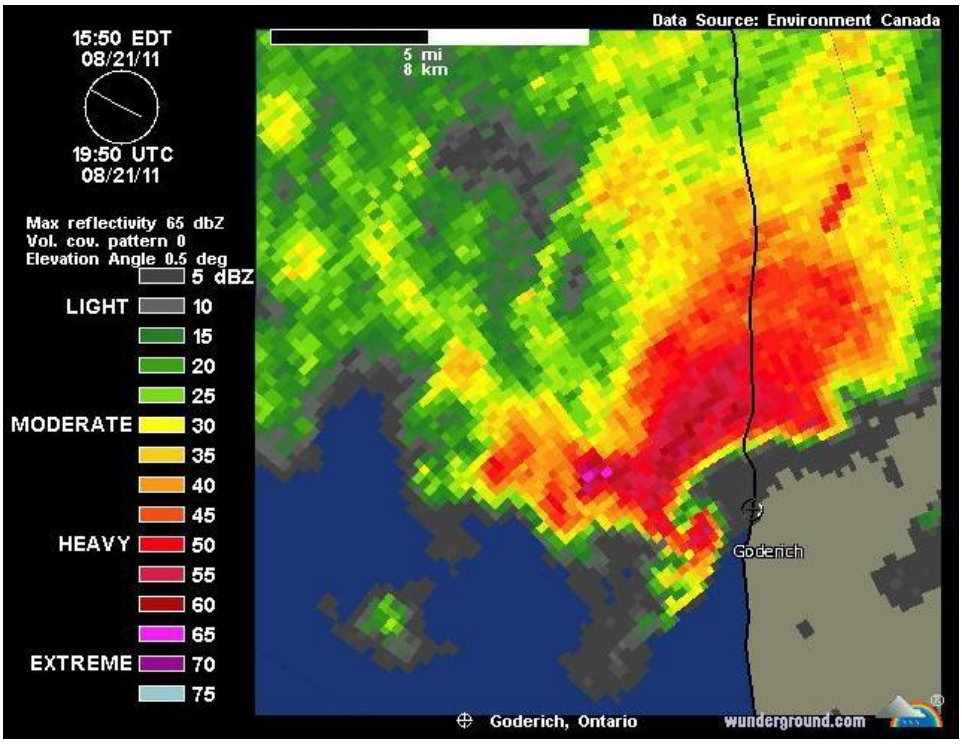


Figure 3.4: Radar reflectivity of the tornado-warned storm as it approached Goderich, Ontario on August 21st, 2011. Note the characteristic "hook echo" in the lower-middle of the figure. (Source: Wunderground.com, 2011. Used with permission).

survey conducted the following day, Environment Canada classified the tornado as an F3, with maximum wind speeds of 280 km/hr. Shortly after the storm had passed, Goderich Mayor Deb Shewfelt declared a state of emergency, and on Monday, August 22nd Premier Dalton McGuinty told the press that the province had enacted its emergency plan to assist Goderich residents with recovery.

The August 21st Goderich tornado was the strongest tornado to affect southern Ontario in 15 years. The storm damage in Goderich was extensive, particularly in the downtown core around the Courthouse Square. Due to damaged lines in the area, natural gas service was cut off to

about 3,300 customers around 10:00 pm that evening. Many buildings received serious structural damage, including residential and commercial buildings, the Sifto Salt Mine, and the Goderich Courthouse. A number of buildings were destroyed by the tornado, including the Victoria Street United Church, while others were damaged beyond repair and were subsequently approved for demolition. As of September 21st, 2011, the Goderich tornado has cost at least $75 million dollars in insured damages (IBC, 2011).

3.1.4 The August 24th severe storm system

Early in the day on August 24th, 2011 both Environment Canada and the Storm Prediction Center (SPC) in the United States recognized that several atmospheric conditions necessary for the development of severe thunderstorms would converge over southern Ontario and the upper mid-west. By early morning, Environment Canada had issued a tornado watch for large portions of southern Ontario, including the town of Goderich. The text of the watch indicated that severe thunderstorms with heavy rains, damaging winds, large hail, and destructive tornadoes were possible. Throughout the day, Environment Canada extended the tornado watch to encompass most of southern Ontario. By late afternoon, numerous severe thunderstorm cells began to develop and track across southern Ontario. In response, Environment Canada upgraded the tornado watch to a tornado warning for the Goderich region at 6:30 pm on August 24th. Although no tornadoes were reported in Goderich, this storm system did cause heavy rainfall and strong winds in the region. The storm system was also responsible for three confirmed tornadoes in southern Ontario: an F1 tornado touched down in Nairn and in Cambridge, while an F0 tornado occurred in Neustadt (Environment Canada, 2011c).

3.2 Research procedure

3.2.1 Previous research on perception of and response to natural hazards

The vast majority of the existing research on the perception of natural hazards has taken the form of close-ended surveys distributed to a random sample (e.g., de Man and Simpson-Housley, 1987; Sherman-Morris, 2005; Hammer and Schmidlin, 2002; Sheridan, 2007; Zhang et al., 2007; Schmidlin et al., 2009; Sherman-Morris, 2010). Although fewer studies have been conducted using in-person interviews (e.g., Wong and Yan, 2002; Donner, 2007; Burningham et al., 2008) or focus groups (e.g., Zeigler et al., 1996; Moore et al., 2004; Tekeli-Yeşil et al., 2010), qualitative methods can also be highly effective in hazards research. According to McGuirk and O'Neill (2010) there are four types of knowledge that can be accessed through social science research: attributes, behaviors, attitudes, and beliefs. Attributes and behaviors are well suited for quantitative methods, but attitudes and beliefs are more subtle and nuanced. These forms of information are best accessed through qualitative methods that engage and encourage participants to divulge information beyond the surface level (McGuirk and O'Neill, 2010). Thus, a blended methods approach (i.e., a research framework that incorporates both interviews and questionnaires) can be highly effective when studying experiences and perceptions of natural hazards (e.g., Murphy et al., 2005).

3.3 Methods of data collection

3.3.1 Interview script

The interview script was developed to investigate several themes related to the research objectives, including: general weather knowledge; usage of current communications technologies; and perceptions of and responses to the tornado hazard. Many questions that

appeared in the interview script were drawn from previous studies that examined tornado perception and response in the United States (e.g., Donner, 2007; Sherman-Morris, 2010; Comstock and Mallonee, 2005; Hammer and Schmidlin, 2002; Schmidlin et al., 2009). Once the interview script was completed in draft form, it was sent to several hazards researchers for feedback on clarity and completeness. Based on the feedback received from these individuals, the interview script was edited to add several questions on general weather knowledge and cell phone usage. The final interview script was organized into five sections:

SECTION A: General Weather Questions

The questions in this section were intended to gain an understanding of how respondents obtained and utilized weather products, such as forecasts and weather warnings. Respondents were asked where and how often they obtained weather information, and about what motivates them to check the weather on a typical day. Questions in this section also probed respondents' understandings of weather forecasts and warnings. For example, respondents were asked to explain the difference between a weather watch and a weather warning in their own words. Finally, respondents were asked to describe the best way(s) for forecast centers to warn them about impending severe weather (e.g., television broadcast, text message, or radio broadcast).

SECTION B: August 21st, 2011 Goderich Tornado

Questions in this section were designed to investigate respondent's experiences and attitudes throughout the day on August 21st, 2011. Respondents were first asked several questions that required them to reflect on their whereabouts and activities prior to the tornado's impact. Respondents were then asked questions about their situational awareness throughout the day

(e.g., "When did you first notice the inclement weather?" and "Were you aware that Environment Canada has issued a severe thunderstorm watch for Huron-Perth at 2:02 pm on August 21st?"). Finally, respondents were asked about their experiences and actions during and immediately after the tornado. Specifically, questions in this section probed respondents' protective-action decisions during the tornado event, and their experiences in the hours that followed. The term 'protective action' was defined for participants as any sort of action that they took to prevent injury to themselves or others, or to minimize damages (such as going to the basement, shutting or opening windows, or hiding in a bathtub).

SECTION C: August 24th, 2011 Severe Storm System

The severe storm system that affected southern Ontario on August 24th provided the opportunity to investigate how previous experience with a damaging tornado influenced protective-action decision-making during a subsequent event. The questions in this section were intended to probe respondents' experiences, perceptions, and behaviors throughout the day on August 24th. As these interview questions were intended to examine the differences and similarities in perceptions and behaviors between these two events, many of the questions were comparative in nature (e.g., "Did you take protective action for this storm that was different than what you did on August 21st?"). Other questions probed respondents' general perceptions of their community during the day on August 24th.

SECTION D: Cell phone and Social Media Usage

One of the primary thrusts of this research project was to understand how individuals obtained, interpreted, and disseminated important information before, during, and after a short-notice

disaster. Questions in this section were designed to investigate how individuals used current communications technologies (e.g., social media, mobile phones, and the Internet) on August 21st and August 24th. Specifically, respondents were asked to describe how they used their mobile phones and social media to communicate with friends and family during and after each of these two events. Respondents were also probed to determine what role these communications technologies played in the short- and long-term recovery process.

SECTION E: Demographics

The final section of the interview script contained questions regarding respondent demographics. The purpose of these questions was to gather information on relevant characteristics (e.g., gender, age, income, level of education) known to influence vulnerability, risk perception, risk propensity, and decision-making. These questions were asked with the intention of comparing answers between respondents.

3.3.2 Interview Recruitment

One of the primary goals of this research project was to determine the role(s) that current communications technologies (e.g., social media, mass media, cellular phones) played in the warning and response process during the Goderich tornado. To that end, a non-probability purposive sample was thought to be an appropriate sampling method for this research. Respondents were invited to participate in the project through advertisements placed on Facebook groups associated with the Goderich tornado. Specifically, recruitment scripts were posted to the 'Goderich Ontario Tornado victims and support', 'Save Downtown Goderich', and 'Goderich Tornado Clean-up Hub' Facebook groups. A recruitment script was also posted on

the 'Ontario Storms Site' message board, a forum for storm spotters and severe weather enthusiasts in southern Ontario. To further raise interest in and awareness of the project, the student researcher was also interviewed by a number of local media outlets, including: 104.9 The Beach (local radio station), the Goderich Signal Star (local print newspaper), and Huron Bullet News (local community news website).

3.3.3 Pre-project Goderich community meeting

On Monday, October 3rd a pre-project community meeting was held at the Goderich public library. This meeting was arranged through and advertised on several Facebook groups, most notably the 'Goderich Tornado victims and support' group. The community meeting provided the opportunity to discuss the research project with Goderich residents. There were two notable outcomes of this meeting: first, the attendees were able to provide feedback on the interview script, and on issues facing the community since the August 21st tornado. Second, the community meeting served to further raise interest in and awareness of the research project. Several attendees of the community meeting went on to participate in the research project themselves, and/or to encourage affected individuals in the community to contact the student researcher.

3.3.4 Interview process

All interviews conducted as a part of this research project took the form of semi-structured conversations that followed a script, but still allowed for flexibility and spontaneity of inquiry (Dunn, 2010). The interviews began on October 4th, 2011 and finished on November 17th, 2011; during this period, a total of 35 participants were interviewed. Interviews varied in

length from less than 25 minutes to over 80 minutes, with most interviews lasting approximately 45 minutes. The interviews were held at a time and a location that was convenient and accessible for both the student researcher and the participants. Most interviews took place at the Goderich Public Library, located in downtown Goderich. Other interviews took place at public offices, or, in exceptional circumstances, by telephone (n=3).

3.3.5 Questionnaires

Due to considerable community interest in this thesis research, it was decided by mid-November, 2011 to develop and distribute a close-ended questionnaire. The main purpose of the questionnaire was to determine the extent to which insights from the interviews were generalizable to a larger population. A secondary purpose was to provide the residents of Goderich with a quick and simple opportunity to share their experiences during and after the August 21st tornado. The questionnaire was developed based on the suggestions of Dillman et al. (2009) and McGuirk and O'Neill (2010). The general structure of the questionnaire was similar to that of the interview script, but several questions were added based on insights gained from the interviews. These additional questions probed such topics as trust in issued forecasts; damages to businesses; and community meetings. An additional section was also added to explore respondent's experiences and perceptions throughout the long-term recovery period. This section contained 19 questions that explored sense of place, place attachments, and feelings of loss due to the disaster.

3.3.6 Questionnaire recruitment

As with the in-person interviews, several methods were used to advertise the questionnaire. First, an on-line version of the questionnaire was created using Surveymonkey.com. The on-line survey went live on December 27th, 2011 and remained available until March 15th, 2012. A recruitment script for the on-line survey was posted to the Facebook groups that had been previously used to advertise for the interviews. Second, paper copies of the questionnaire were printed and left at the Goderich Public Library by a visible display that contained information on the research project. Individuals who completed these questionnaires were able to place them in a sealed envelope and leave them at the library for pick-up. Finally, an undergraduate student researcher conducted a systematic random sample through a door-to-door survey during two weekends in February 2012. In this random sample, every fifth residential home on 12 randomly selected streets was visited to solicit participation in the study. If no one was home at the time of the visit, the student researcher left an information letter that explained the research project and provided the hyperlink to the on-line questionnaire.

3.4 Data analysis

The interviews were first transcribed and then analyzed for content using thematic analysis to observe response patterns in the interview transcripts. The results of the questionnaire were downloaded from Surveymonkey.com and formatted for analysis in the Statistical Package for the Social Sciences (SPSS) software. SPSS was used to determine percent frequencies and means, and to document relationships between variables and across respondent groups using cross-tabulation. Statistical significance was determined using Chi-Square analysis. More information about the data and data analysis is presented in the next chapter.

CHAPTER FOUR

INTERVIEW RESULTS

A total of 35 interviews were conducted with Goderich area residents from October to November, 2011. The purpose of these interviews was to gain insight into the different perspectives and experiences of those Goderich area residents and visitors who were either directly or indirectly affected by the August 21st tornado. The interviews were also designed to gain an understanding of the complex factors that motivated protective behaviours on August 21st and August 24th, such as risk perception, self-efficacy, and previous disaster experience.

This chapter will begin with a brief overview of the socio-demographics of the interview participants, as well as an in-depth examination of two respondent profiles. The in-depth analysis of the respondent profiles is intended to illustrate the diverse range of experiences and perspectives reported among the interview participants. The remainder of the chapter will focus on the results of the thematic analysis of the interview transcripts. These results will be presented under the same headings that appeared in the interview script (e.g., general weather knowledge; the August 21st tornado; and the August 24th storm system). Additional sections have been added to explore relevant trends that frequently appeared throughout the interview process (e.g., risk communication, risk perception, and long-term recovery). The chapter will conclude with a brief discussion on the similarities and differences between the interview results and the questionnaire results.

In full compliance with the University of Waterloo's Office of Research Ethnics (ORE) guidelines for research involving human subjects, all results will be presented with the participants' full confidentiality and anonymity in mind. To that end, no personally identifying information will be provided, either in the two results chapters or in the subsequent discussion chapter. All of the written quotations will include a pseudonym and age of the speaker. This information is provided for contextual purposes only, and cannot be used to identify any of the participants in this study.

4.1 Participant demographics

A total of 35 participants were interviewed between October 4th and November 17th, 2011. This sample size is consistent with several other research projects on severe weather perception and response that utilized in-person interviews and focus groups in their methodology (e.g., Moore et al., 2004; Zeigler et al., 1996; Donner 2007). The sample was composed of 20 females and 15 males, which is a more balanced gender ratio than was present in the questionnaire sample. This discrepancy may be partially explained by the request of three participants to be interviewed with their opposite-sex partners. The remaining socio-demographic characteristics of the interview participants (outlined below) are reasonably similar to those of the questionnaire respondents.

The ages of the participants ranged from 20 to 74 years old, with the median age being 47 years. In terms of employment status, most participants were employed either full- or part-time before August 21st, 2011. Five individuals indicated that they were unemployed, and five respondents were outside of the workforce (either retired or student status). The occupations of

the interview participants were diverse, and included positions from a wide range of industries (e.g., health care and social sciences, educational services, construction, business services, finance and real estate, retail trade, and tourism). The gross household income for participants ranged from less than $20,000 to over $150,000 annually, with a median value of $70,000. The majority of interview respondents indicated that they have lived in the Goderich area for over five years, with many participants having lived in Goderich for most of their lives.

4.2 Respondent profiles

In order to gain an understanding of the diverse range of experiences and behaviours cited among the participants, two of the interviewees were selected for in-depth analysis. These two respondents were chosen to be profiled because they are illustrative of the larger sample set, both in terms of their socio-demographic characteristics and in their experiences during and after the August 21st tornado. Meet Abigail and William.

4.2.1 Profile 1: Abigail

Abigail is a 28-year-old university graduate who has lived in the Goderich region for most of her life. Prior to the August 21st tornado, Abigail would have described herself as not being particularly interested in the weather. In general, she would only check the forecast if there was a special reason for her to do so (such as an outdoor event or a trip), and she could go days without really thinking about the weather. Although Abigail had a general understanding of the different products published by Environment Canada, she acknowledged that she was not very interested in pursuing weather information.

On August 21st, 2011, Abigail was enjoying one of the last days of summer with her sister and her fiancé. It was a quiet Sunday afternoon, and Abigail decided that she was in the mood to bake something. An inspection of her cupboards revealed that she was out of several ingredients, so she grabbed her car keys and headed to the grocery store. By the time she had found her items and gone through the checkout, Abigail noticed that the sunny morning had turned dark. The wind had picked up, and it had started to hail. Although the stormy weather was inconvenient, Abigail did not pay it much attention as she got into her car and headed home. After all, as a life-long Goderich resident, Abigail was used to severe weather blowing in off of the lake.

Around the time that Abigail returned home, the stormy weather had passed and the sun was shining again. By 3:30 p.m. that afternoon, Abigail was at home with her sister and her fiancé as her pastries baked in the oven. Together, they chatted about nothing in particular–what to have for supper, what to do next weekend–while Abigail cleaned up. Suddenly, all of the power went out in the house. Abigail glanced outside and noted that it was cloudy but otherwise calm. Surprised by the sudden power loss and irritated at the potential loss of her pastries, Abigail complained to her fiancé. However, before he could do anything to investigate the cause of the power loss, it began to rain. The sudden onset of heavy rain was surprising, and together Abigail, her fiancé, and her sister went to watch the weather on the porch.

Before they could reach the front door, the storm had intensified. The sky was dark, and heavy wind and hail accompanied the first flash of lightning. As they stared in astonishment at the

intensity of the storm, the large trees that lined their street began to bend in the wind. Leaves and branches ripped off and went flying, and larger tree limbs followed in rapid succession. As the skies continued to darken, Abigail looked at her fiancé and her sister nervously. After a brief discussion, they decided to take shelter together, and, with the roar of the storm following them, they headed to the basement. Before they could reach the bottom of the basement steps, they were met with an eerie quiet. Unsure whether the storm was truly over, they waited for a few minutes. Abigail's fiancé was the first to go back upstairs, and within several moments his voice called down to them:

"You should come out and look at this".

Abigail recalled being shocked at the destruction that had occurred in the few moments since they had been upstairs. One of the living room windows had been blown out, and glass and bits of debris littered the floor. Two 40-foot tall trees in her backyard, a spruce and a birch, had been uprooted by the wind and had fallen over. One of the trees pinned down a section of the fence that separated Abigail's yard from her neighbour's, but the rest of the fence was nowhere to be seen. Pieces of debris, including lawn furniture, uprooted vegetation, and housing materials, were scattered everywhere.

In the hours following the storm, Abigail and her fiancé checked on family members and neighbours to make sure that they were all right. Abigail recalled the anxiety she felt as a result of the patchy cell-phone service immediately following the tornado, which made her unable to contact family members by telephone. In response to this connectivity issue,

Abigail's fiancé traveled around town by bicycle to ensure that family members were safe. After all of their loved ones had been contacted and accounted for, Abigail and her fiancé went into the streets. As she remarked, they “kind of wandered around, like zombies”. Abigail remembered her neighbours running up and down the street, and hearing people call to each other, "Have you checked this house? Has anyone checked this house yet?" Several hours later, Abigail and her fiancé came across a first responder whom they asked for information on the extent of the storm. The first responder replied, "I think it's the whole town".

That evening, Abigail and her fiancé went to her mother-in-law's home in the south part of town, an area that was comparatively less damaged by the tornado. Here Abigail was able to access the Internet and cable television, which she used to connect with Environment Canada and the Weather Network, respectively. Once cellular service was restored to the area, which Abigail remembers as having occurred that same evening, she was also able to send and receive text messages to friends and family in other areas of the country. Most of the information regarding the storm and post-disaster recovery that Abigail received in the following days came from the television and from Facebook, which she frequently accessed following the disaster.

Abigail would describe her experiences on Wednesday, August 24th as hectic. As soon as the tornado watch was posted for the Goderich region, Abigail began to receive text messages, telephone calls, and Facebook messages from friends and family across the country. As she recalls, “As soon as [the tornado watch] got posted, my phone was beeping like crazy". Although she acknowledges that there was an increased awareness of the weather among

Goderich residents that afternoon, Abigail was not anxious about the possibility of a second tornado. In fact, when her mother-in-law suggested that the family spend the day in the basement, Abigail and her fiancé laughed at the idea. However, when the sky got dark and it began to get windy that afternoon, Abigail described herself as feeling 'extremely panicked'. At this point, Abigail and her family decided to go down to the basement, despite not having received news that the tornado watch had been upgraded to a tornado warning. The family stayed in the basement until they could hear the wind and the rain begin to abate, which was only a few moments. After that, they went back upstairs and returned to their previous activities.

4.2.2 Profile 2: William

William is a 44-year-old family man who has lived and worked in the Goderich region for most of his life. As a member of the law enforcement sector, William acknowledges that much of his weather awareness is related to his job. As he explained, the weather influences the operational needs of his department; thus, he must have an accurate and up-to-date understanding of any potentially inclement weather in order to plan for public events, such as concerts or rallies, and to address any hazardous issues, such as unsafe roads. In his personal life, William does not tend to actively check the weather, although he passively obtains weather information through a variety of sources, including the television and the radio.

On August 21st, 2011, William was enjoying a day off from work. He and his wife had decided to run some errands that morning, so they left for London around 10:00 a.m. As William recalls, the drive to London was pleasant, with high clouds and intermittent sun. On

their way back to Goderich that afternoon, he and his wife stopped in at an apple orchard along Highway 8. They chatted with other customers as they gathered their produce and waited to pay for their items. The wind picked up as they waited in line, and by the time they were ready to make their purchase, it had begun to rain. Shortly thereafter, the rain changed to hail and everyone hurried to the nearby buildings for shelter. As William recalls, the hail lasted approximately 10 to 15 seconds, although the heavy rain lasted quite a bit longer. Once the rain eased up, he and his wife paid for their produce and headed for their car. They were in a hurry to make it to The Square before the shops closed at 4:00 p.m., as they needed to pick up a few last-minute items for dinner that evening. The drive to the Square was short, and William pulled into a parking spot right across from the Burger Bar at approximately 3:45 p.m. As he got out of the car, he noticed that the sky was cloudy but it was otherwise calm. Together, William and his wife entered the specialty market at approximately 3:50 p.m.

The market was quiet so close to closing time on a Sunday afternoon. William and his wife chatted with the owner as they browsed the shop for their items. The large storefront windows provided a clear view of the Courthouse Square, and William noticed that it had grown dark in the short time that they had been inside. Suddenly, the lights inside the store began to flicker. William and his wife made their way to the cash register at the back of the store, eager to pay for their items in case the electricity went out. Before they reached the register, the sound of the wind abruptly picking up caused William to pause and glance toward the front of the store. Through the windows, he could see the big trees in the Courtyard begin to sway in the wind. Then, heavy rain began to fall at the same time as the electricity went out in the store.

At first, William was intrigued by the intensity of the wind and rain. As a long time Goderich area resident, he was used to storms blowing in off of the lake. Thus, when the rain became mixed with hail, William did not think anything was out of the ordinary. But then, the storm began to rapidly intensify into something that was unlike anything William had ever experienced. The wind began to howl and the large trees in the Courtyard Square began to bend, at first in one direction and then in the opposite direction. As William watched, the large gazebo that was directly across the road from the store was lifted off of its foundation slightly, and then it completely collapsed. Immediately thereafter, trees began to fall over 'like bowling pins', one after the other. William remembers his wife saying matter-of-factly, "It's a tornado".

At once, everyone began to back away from the large storefront windows as trees continued to fall in the Square. William remembers that his biggest concern in that moment was protecting his wife; he was particularly worried about the glass windows shattering and injuring her. As they continued to back up, the ceiling began to buckle above them and tiles began to drop to the floor. At that moment, the storeowner told everyone to get to the back of the building. As they all hurried past the archway into the back of the store, the backdoor blew open under the force of the wind. William recalled taking shelter between the backdoor and a large freezer that went all the way to the ceiling. He remembers thinking that they would be protected between these two structures if the roof caved in on them. From his vantage point, William had a clear view of the storefront windows. As he recalls, it was as though a snow squall had suddenly blown up and reduced the visibility to zero.

William and the others stayed in the back of the store for only a few moments before the storm began to subside. It was at that point that William got his first glimpse of the damage caused by the storm. As he recalled, "It's just complete devastation, it looked like a bomb had gone off". After the shock of their experience began to wear off, William's wife became frantic over the whereabouts of their children. Immediately, William called their home phone. No answer. Then he tried to call his daughter's cell phone. No answer. William remembers thinking to himself that he could not comfort his wife, that he could not say to her 'Don't worry, everything will be fine' because he knew, by looking outside, that their children might not be okay. It was not until William returned home that he was able to confirm that both of his children were all right.

Once he was certain that his children were safe, William immediately switched over to his role as a first responder. Leaving his wife to handle the task of contacting friends and family, William quickly got dressed and headed back to the Courthouse Square. One of his top priorities in the coming hours was to cordon off the downtown core and evacuate everyone out of the area. The reasons for this were two-fold: first, the buildings in and around the Square had sustained serious structural damages. Second, numerous natural gas lines had been ruptured by the storm, and the smell of gas filled the Square. Another priority was to establish a 'safe space' for individuals to go for shelter and information; the decision was made to contact the Knights of Columbus center and, if it was operational, to get it open for the public as soon as possible.

By August 24th, 2011, William was still deeply involved in the post-tornado recovery process; as a result, he learned about the tornado watch very soon after it was posted that morning. William was home for much of the day on August 24th with the television tuned in to weather and news updates. William remembers numerous times when the news was interrupted to give the latest updates on the weather system. Although William understood the hyper-vigilance, he felt that it might create a sense of paranoia and fear among the local viewership. Later in the afternoon, when the weather began to look foreboding, William asked his children go into the basement with his parents while he watched the weather conditions from the top of the stairs. He waited until he felt that the weather had eased up slightly, and then called for them to come back upstairs. William was hesitant to insist that his children stay in the basement for the duration of the storm; on one hand, their safety was his top priority, but on the other hand he did not want to frighten them unnecessarily.

4.2.3 Comparison of the two profiles

Together, Abigail and William represent many of the experiences commonly reported by the interview participants. Both of these participants experienced the severe storm on August 21st, and both took protective action without knowing that Environment Canada had issued a tornado warning. Instead, Abigail and William decided to take shelter as a result of the disturbing audio-visual stimuli (e.g., strong wind, heavy rain and hail, and seeing trees bending in the wind) that they witnessed. After the tornado had passed, the first concern of both participants was to contact their family to ensure that everyone was okay. They both experienced a significant amount of anxiety as a result of being unable to communicate with loved ones by telephone or text message in the hour after the tornado.

Abigail and William both recalled a significant amount of discussion by friends and family about the tornado warning on August 24th. However, both participants thought that the hyper-vigilance was overdone. This is interesting, given that they had experienced a damaging tornado just three days prior. Abigail and William also indicated that they were not overly concerned about the tornado watch, and that they thought it was highly unlikely a second tornado would impact the town. Neither Abigail nor William took protective action on August 24th as a result of the Environment Canada tornado watch or warning; instead, they took protective action (or, in William's case, asked his children to take protective action) when they thought the weather began to look threatening outside. Both respondents only sheltered for a few minutes before they came back upstairs.

Since her experiences on August 21st and August 24th, Abigail admits that her perspectives on weather in the Goderich region have changed. Prior to August 21st, Abigail did not believe it was even possible for a tornado to impact the town. In fact, Abigail recalled being taught in her high school geography class that any tornadic system coming in off of the lake would be forced to rise over Goderich once it came in contact with the steep bluffs that separate the town from Lake Huron. Since her experiences in August 2011, Abigail acknowledges that she is more aware of the weather and that she tends to check the forecast more often than previously, especially if severe weather has been forecasted for her region.

Like Abigail, William was also familiar with the local belief that the bluffs would protect Goderich from a tornado. However, unlike Abigail, William acknowledges that he is not likely to be any more cautious than he was before his experiences on August 21st. William believes

that he is by no means unique in this regard, and he predicts that, as time moves on, 'numbness' will settle in on the town as individuals return to their old behaviours (such as downplaying weather warnings). As he explains, "Some people may change, but a lot of people will still go down to the beach to watch the storms come in. It's just the way it is".

4.3 Thematic Analysis

4.3.1 General weather knowledge

Most participants check the weather forecast for pragmatic reasons (e.g., deciding clothing or planning a trip). A few respondents check the weather multiple times per day, but most of these individuals self-identified as 'weather enthusiasts'. Average weather consumers tend to check the Environment Canada website, the Weather Network television station, or the local radio station for weather information. Weather enthusiasts tend to be more aware of higher-level weather products, such as radar and operational analysis charts. Weather enthusiasts are also more likely to access a variety of weather products and websites (including accuweather.com and wunderground.com) to assist with their weather related decision-making.

Most participants had a general understanding of the difference between a weather watch and a weather warning. Many people indicated that a weather watch was 'less severe' than a warning, and that a weather warning was 'more imminent'. As Violet (25-years-old) explained:

> "Um, a watch is just to, you know, be aware that there's something that could be going through. A warning is a little bit more severe, I do believe . . . A watch is just, you know, 'Pay attention', and a warning is 'Now it's coming so just be careful'."

A few interviewees were able to fully define both terms, but ten respondents were unable to differentiate between the two. Several participants also acknowledged that they did not realize that Environment Canada issued both watches and warnings. The majority of participants said

that they were very familiar with the weather patterns in the Goderich region, and most agreed that they were used to severe weather blowing in off of the lake:

> "When you live on the lake, you know, when fronts come across, it's not a big deal. In fact, in this town a lot of times, if you know there's a good storm coming, people will go down to the lake to watch the storm come across . . . We all do it." (William, 44-years-old)

Most participants also agreed that they were more aware of winter severe weather than summer severe weather. Many people cited the snow squalls common in the Goderich region as the reason for this differential awareness.

Participants were also asked about the best way(s) to disseminate a weather warning to a community. Although there were many different suggestions (e.g., radio broadcast, television broadcast, cell phone "app" notification), most people said that a text message or an automated telephone call would be their most preferred method of warning communication. As William (44-years-old) explained:

> "So many people carry cell phones . . . There's nothing else that in today's society anybody carries with them, because everything else you've got to turn on, go seek out. If it's a computer, you gotta turn it on or go look for it. If it's a radio, you've gotta either be in your car with the radio on or, you know, in a building with that. And TV, you gotta wait for a time [that the weather is] gonna be on. A cell phone is with you no matter where you go. No matter what phone it is, [a text message] will come."

Several participants said that they wanted the town to install warning sirens to communicate future weather warnings. This finding is interesting given that the question did not stipulate what type of weather warning was to be communicated. Finally, no one indicated that a weather radio was his or her preferred method of warning communication. This is unsurprising, given that only eight individuals knew about Environment Canada's weather radio program, and only two have a weather radio on their property.

4.3.2 August 21st, 2011 tornado

Most of the interview participants were in the Goderich region on August 21st, 2011. Since it was one of the last Sundays of the summer, many people were either at home or at their cottages outside of town. A few people indicated that they had to work or run errands that afternoon, and several people were out of town on vacation. Most people who were in Goderich said that they first noticed the inclement weather early in the day when a storm system, which brought rain, hail, and high winds, blew through the area. Everyone who experienced this storm agreed that they paid it little attention since they were used to inclement weather blowing in off of the lake. Accordingly, only a few of the participants paid any attention to the weather when the rain started again just before 4:00 p.m. that afternoon:

> "So when the hail starts, we're going 'Oh look at that, here comes the hail', which is no big deal, 'cause 20 minutes earlier there had been some hail." (William, 44-years-old)

> "We had a small thunderstorm around lunchtime and, um, that—I just thought that day was going to be that type of a day . . . so [when the tornado came] I thought "Oh it's just another small storm of heavy rain." (Jerome, 49-years-old)

> "I would say there were like three storm systems that rolled through. Uh, one first thing in the morning and then it stopped, and then another one, I'm gonna say early afternoon, and then it stopped. Uh, and then, and then when the tornado one came in you just thought, 'Okay, here, here comes another one'." (John, 60-years-old)

> "It was kind of a . . . crummy day, I think. It had been raining, but nothing about it struck me as unusual. Not in the summer time. We get storms off the bank all the time." (Jaide, 55-years-old)

Only a few participants indicated that they checked the weather forecast that afternoon, and only two people said it was in response to the inclement weather. Unsurprisingly, only one individual was aware of the tornado warning when it was posted by Environment Canada at 3:48 p.m. that afternoon. Jerome was in his basement when his weather radio began to broadcast the tornado warning. He did not believe that the warning could be correct, so he

went outside to visually assess the weather. It was at that point that he saw the tornado coming in off of the lake, and he immediately sought shelter inside:

> "I left the radio turned on accidentally . . . when I came upstairs, the weather radio sounded and . . . I went over to it and pressed the button and it said tornado warning for Goderich and, uh, I thought it was a mistake at first, I didn't realize anything was going on and just went outside to have a look. That's what I saw [the tornado]." (Jerome, 49-years-old)

Most people agreed that the weather went from overcast to threatening in a matter of moments. In terms of protective behaviours, most of the participants who were in Goderich took shelter from the storm. Commonly reported shelter locations included basements and interior hallways. It is important to reiterate that most people who took shelter that afternoon were not aware of the tornado warning, and only a few participants suspected that the storm might be tornadic. When asked why they decided to take protective action during the storm, the participants overwhelmingly agreed that they saw or heard something that was unusual or threatening:

> "When I looked out [the deck] doors, I could tell that it was beyond—the wind and the way the trees were moving—um, it was beyond just a 'bad storm'" (Jaide, 55-years-old)

> "It was very reactive because—just sort of everything, you know? We've had hail before, we've had lots of wind. I mean I—we experienced the storm that we had 15 years, 16 years ago now. Um, I mean I remember that. So, uh . . . it was a gut instinct" (Amanda, 40-49 years old)

> "We probably weren't thinking 'tornado', um, my instinct was just hearing glass break with children, I just picked him up and ran . . . it was reactive" (Allen, 30-years-old)

Although only one interview participant reported seeing the funnel cloud, several respondents did remember hearing the tornado:

> "We could hear it coming and it was loud and you can hear it. . . it got really, really, really loud and the wind picked up and the leaves started flying off the trees and everybody got in the house and got to the basement" (Valerie, 45-years-old).

> "I don't recall seeing the tornado, but I do recall hearing it. That freight train noise they talk about . . . There was no mistaking it. I'd never heard it before in my life, but I knew exactly what it was." (Ruth, 40-years-old)

> "I thought it was the hail breaking through the windows, initially. . . [then] you hear the freight train and your ears pop as it goes overtop" (Allen, 30-years-old).

> "It's not a freight train, it's a jet engine. That's-- you know, they have that old tornado sound, like freight train going through the room. Well I was on an airplane last week and it's a jet engine, that's the noise that it was." (Amanda, 40-45 years old)

A few of the participants who were in Goderich during the storm did not take protective action. Reasons for not taking protective action were polarized: either people did not feel threatened by the weather or the storm came on too quickly for them to take shelter. Sarah, for example, was unable to get out of her car before the storm overtook her. She was waiting in a parking lot for her husband (a self-identified weather enthusiast, who had previously remarked that the storm looked tornadic on radar) when the weather turned violent. She remembered watching debris from the Volvo plant going up in the air, and she wondered whether she had time to run into the store for shelter. Before she could get out of the car, golf ball sized hail began hammering her vehicle; the precipitation was so intense that she was unable to see the front door of the store just several meters away. Knowing that it was too dangerous to get out of the car, Sarah huddled down until the rain and hail stopped several moments later. In comparison, Morgan, a 53-year-old husband and father, did not take protective action because he did not feel threatened by the storm. He had previously experienced a high wind event, locally dubbed the '95 cyclone, and he felt that the weather on August 21st was less threatening than that storm:

> "It didn't feel that threatening right there. It was a heavy hailstorm and that was about it . . . We didn't take shelter even during the cyclone, we had a barbeque going and we just kept on barbequing right through."

After the storm had passed, the primary concern for most participants was to contact their families. Many people reported experiencing cell phone connectivity and reception issues in the hours immediately following the tornado. Many people experienced a significant amount of anxiety if they were unable to immediately reach their loved ones, and three participants recalled feeling extreme panic when they were unable to contact their children. After Sarah recovered from her near-miss in the parking lot, she was overwhelmed with intense anxiety for her son:

> 'We were trying to get home quickly to our son . . . and then I started going, 'My goodness—how's—I hope [Jacob's] okay', and [my husband's] like, 'Don't panic, stop panicking.' And I was just like— and then I started to panic more for my son, but first it was worry and then it got a little more panicky 'cause the closer we got to the lake, the worse the destruction was getting. And [my son] was working opposite the salt mine down at the harbour." (Sarah, 47-years-old)

If they were unable to contact their loved ones by telephone, many people decided to physically check on their family, either on foot, by bicycle, or by car. However, most participants agreed that it was difficult to get around town as most of the roads were blocked by fallen trees or downed telephone lines. These accessibility issues further contributed to participants' anxiety and frustration.

After participants' had contacted their loves ones, many people went out into the streets to talk to neighbours and to assess the damage. Although it was upsetting to see the full extent of the devastation, most participants felt that this was a highly cathartic experience, and that talking to neighbours helped to alleviate the shock and grief that they all were feeling. Aileen (53-years-old) and her husband began walking around their neighbourhood soon after the storm. Although she admits that it was painful to see the damage, Aileen believes that the socializing that took place after the storm was an important first-step in the healing process for those involved:

> "We walked around trying to take in what in fact had happened. And in a way it was an important way of connecting with our community and still hugging people and making sure people were okay . . . and at that point, people were really quite in shock. People were just sort of walking around taking it in. Really, literally, with tears in our eyes." (Aileen, 53-years-old)

4.3.3 August 24th storm system

Three days after the tornado impacted Goderich, atmospheric conditions were primed for another outbreak of severe weather across southern Ontario. Although many residents were without electricity and many others were occupied with recovery efforts, almost all of the participants agreed that they learned about the tornado watch shortly after it was posted that morning. Participants were notified of the watch through a variety of mediums, including: word of mouth (most common), text messages, phone calls, Facebook, Twitter, and the local radio station. A couple of participants said that they were first notified of the tornado watch by friends and family who lived in different parts of the country.

Although some participants reported feeling highly anxious when they learned about the tornado watch, others initially dismissed it as overly cautious behaviour on the part of Environment Canada. As Gordon (36-years-old) explained, people in Goderich were either frightened or apathetic when the tornado watch was posted:

> "There were two schools [of thought] far as I saw. There were the people who say 'Lightning can't strike twice', and I was in the other school that said, 'We just saw this happen, we know that these kinds of systems can go through here. . . why wouldn't it happen again?'."

Accordingly, although most people reported that their friends and neighbours were hyper-vigilant and anxious throughout the day on August 24th, many participants personally experienced low levels of anxiety. As Robin, a 20-year-old technician explained, the thought of a second tornado impacting the town seemed too unlikely to consider seriously: "It would

just be too wild of a circumstance to actually happen. So that was my initial reaction, I wasn't really too concerned about it".

In terms of protective behaviors, a few participants did take extra precautions when the tornado watch was posted on August 24th. For example, several participants chose to spend the day with friends or family who had a basement. Many parents reported that they asked their children to stay at home with them that day, and two parents said that they sent their children to stay with relatives who lived outside of the tornado watched area. Other examples of proactive protective behaviors included moving valuable items and family pets down to the basement, and remaining updated on the latest weather information. However, while some participants took extra precautions upon hearing about the tornado watch, most participants just carried on with their day. Many people expressed confidence in their own ability to assess the weather and to take shelter if necessary.

As the day progressed and the weather in the Goderich region began to deteriorate, many people began to feel very highly anxious and uncertain. When the tornado watch was upgraded to a tornado warning, many participants reported taking some form of protective action. Valerie (45-years-old) was in the midst of clearing out her office when she received word about the tornado warning: “So we ran into the building and said, 'They’re saying it’s a warning now, we need to get out, we need to take cover.' And everybody bolted. Everybody. Every employee that was there bolted like we couldn’t get out of that building fast enough".

While several participants took protective action because of the tornado warning, most agreed that they took action when the weather began to look threatening outside. As Abigail (28-years-old) recalls, "I wasn't too worried about [the tornado watch] . . . When it did get dark and windy, I was extremely panicked and that, uhm, I was like 'I'm going to the basement'".

While many participants reported taking protective action during the storm, these protective actions were not necessarily appropriate or effective at reducing their vulnerability. For example, a few people said that the only protective action they took was to shut windows and doors when the tornado warning was posted. Several participants who were at work that afternoon decided to drive home to be with their families after learning about the tornado warning. A few participants who were at home said that they moved closer to their basement door when the weather started to look threatening outside. Finally, almost all of participants who took shelter agreed that they only sheltered for a few moments during the height of the severe weather−not for the duration of the tornado warning.

4.3.4 Risk communication

In the hours following the August 21st tornado, many participants experienced cell phone connectivity and reception issues. This led to a great deal of anxiety and frustration for those individuals who relied on cellular phones to contact friends and family. Many participants also reported that their cell phones quickly lost battery power and, without access to electricity, many participants had to carefully ration their cell phone usage. This proved to be a challenge, as cell phones were the primary mode of communication for many people. A few participants received hefty long distance and roaming charges as a result of their cell phone usage

following the tornado. Kyle, a 53-year-old tourist who has been visiting Goderich for over 25 years, received substantial roaming charges on his cell phone bill:

> "[After the tornado], the phone's ringing and ringing, and you gotta answer it 'cause if you don't answer it, [the caller] will think something's really bad. And yet when you do, you know, your 0.70 cents a minute is just chuggin' away."

By August 24th, most individuals reported that they were able to freely use their cell phones, although several people had to charge their devices at a friend or family member's house. Many participants used their cell phones as a means of getting information on August 24th. Specifically, people used their cell phones to communicate with friends and family, and those with 3G coverage used their devices to access the Internet.

Although social media was not used by participants to obtain or interpret warning information in the hour leading up to the August 21st tornado, it played a substantial role in post-disaster recovery. Specifically, Facebook played a major role in coordinating volunteer groups, providing information and support, and organizing various disaster aid campaigns. Within hours of the tornado, the first Facebook group "Goderich Ontario Tornado victims and support" was established. Within twelve hours, it had over 7000 followers, and within two weeks there were over 5000 comments posted to the group (United Way, 2012). In the days and weeks that followed, other thematic Facebook groups appeared, including "Goderich Tornado Clean Up Hub", a group dedicated to organizing volunteer efforts, "SAVE DOWNTOWN GODERICH", a group intended to unite Goderich residents, and "Goderich Trees Project", a non-profit grassroots campaign intended to help re-tree private properties.

Many of the participants spoke about the role that Facebook played in their warning communication and post-disaster recovery:

> "Facebook, um, was huge, just because my friends would constantly update with prevalent information." (Adam, 24-years-old)
>
> "[Any information] that I needed was coming through that [Goderich Ontario Tornado victims and support] website. They were updating it multiple times a day at the beginning." (Ruth, 40-years-old)
>
> "There was a number of Facebook groups that were established to bring people up-to-date and tell people's stories, and, you know, talk about where help is needed, and things like that. So we did frequent those sites in the days following." (Michael, 42-years-old)
>
> "I got most [information] off of Facebook, actually. Half of what people were saying, um, and then providing links and stuff, and then I would just follow the links from Facebook." (Breanna, 31-years-old)

However, there were also several participants who criticised the way that information was disseminated through social media. Robin (20-years-old) is an avid social networker who accesses Facebook and Twitter many times per day. At first, he was happy to see so much information being disseminated through Facebook groups. But, as time went on, he began to become frustrated with what he felt was poor information management:

> "I mean, I felt like it was ridiculous, to be honest with you. I think there was a lot of different things that could have been done better in order to help . . . streamline the flow of information . . . I felt like, uh, you know, if there had been some sort of plan beforehand to utilize social media, that it could have done a world more good than it did."

Similarly, Jackie (57-years-old) wished that someone from the town had been designated to help keep information up-to-date on the various Facebook groups:

> "All the information was hugely out of date all the time. Um, there were lots of social media—especially Facebook—um, postings that could have happened. There were lots of questions and, and wrong information coming out on Facebook through those groups. And if they'd had somebody official from the town who could post to it, [they could have alleviated those issues]."

Although Robin and Jackie had serious concerns with information management following the August 21st tornado, they both agreed that social media had the potential to be a highly effective communications medium.

Finally, many participants agreed that they heavily relied on non-electronic forms of communication in the hours and days following the August 21st tornado. Specifically, word of mouth was commonly cited as one of the most important ways that individuals obtained and interpreted risk and recovery information. Other examples of non-electronic forms of communication include: the local newspaper, a flyer campaign that was initiated by the town, and community meetings. Non-electronic forms of communication were essential in the immediate recovery process for two reasons: first, many individuals were without electricity and therefore they could not easily access information disseminated through mass media (e.g., Internet, television, radio). Second, in-person communication helped to alleviate the stress that many people experienced when they tried to tease out information from electronic mediums, such as news articles and television reports.

4.3.5 Long-term recovery

The August 21st tornado has continued to have substantial emotional impacts on the interview participants well into the long-term recovery period. These impacts are both positive and negative, and they occurred regardless of the amount of damage sustained to participants' personal property. The negative impacts reported by participants were diverse. Many people spoke with sadness about the damage sustained to the historic downtown, and several participants expressed scepticism about the ability of the town to maintain its historic charm:

> "It's strange, dealing with the new normal now . . . Staples in the community, like physical institutions, uh like the church that was recently knocked down. Not having that landmark there is actually demoralizing." (Adam, 24-years-old)

> "I just find it really angering to go around and look at these buildings that have been so severely damaged and just left to die a slow death when, um, uh, there could've been some fast action taken at the time to prevent them—to uh, prevent that amount of damage from happening." (Morgan, 53-years-old)

> "I hate to say it, but I think there'll be some good blood and bad blood that will happen after this because, you know, everybody's going to have their own image of what they think things ought to look like." (Kyle, 53-years-old)

Many participants were also distraught over the loss of greenery and beautiful spaces in the Goderich area:

> "I live in the forest. Because the only time I cried, truthfully, after the tornado—you get so... it does something to your soul, to be in this place when it's so smashed. And part of the thing that is missing is that—it was the trees . . . After the tornado, it just, it was wrong. Everything, like the landscape looked wrong, it felt wrong, everything was wrong." (Meaghan, 47-years-old)

> "I think the fact that we couldn't get to the Square for a long time kind of gave me and everybody some time to heal and kind of get used to what has happened to our town . . . I mean, we knew it was bad but [when] you walked around it saw it... that was the next hurdle. Getting used to looking at things that didn't look good anymore." (Jaide, 55-years-old)

> "It's heartbreaking to see these old buildings go . . . It's really sad to see that. And it's sad to go to Harbour Park, which had all these beautiful magnificent trees and it's just…it's just bare field now. It's really sad." (Amanda, 40-45 years old)

Several participants expressed feelings of guilt or resentment towards other members of the community. The guilt was commonly reported by those participants who were comparatively less affected by the tornado. These individuals felt remorseful when they were able to resume their normal lives, while others in the community–many of whom were friends and neighbours–had their lives irreparably altered. Those individuals who expressed feelings of

resentment commonly directed their frustrated at those people who refused to 'move on' from their experiences:

> "[People] said to me, 'You know I'm tired of all this hoopla about this tornado. You know, I just I'm tired of hearing stories about it, I'm tired of listening to people about it, I just like it to move on'. And that's people [whose] houses weren't affected. They were inconvenienced, not having hydro for four or five days, but after a week they were tired of listening to other people talk about their stories." (William, 44-years-old)

Others expressed resentment towards their public officials and towards "rubber-neckers" who came from outside of the community to gawk at the destruction:

> "There were some really horrible people who came into town from wherever and wandered around and spent hours wandering around and standing in the way of people trying to get their belongings out of what was left of their homes or trying to get trees moved. And they're just standing there taking pictures of people's houses." (Valerie, 45-years-old)

In terms of the positive impacts, participants overwhelmingly agreed that the tornado fostered a sense of community and belonging among Goderich residents:

> "I think there was a tremendously powerful, uh, sense of community and helping. Incredible that it was. That you could not run into someone, someone even that you knew remotely, who wouldn't say, "Are you guys okay?" There was huge spirit in that regard [and] huge outpourings of generosity from people in the community." (Aileen, 53-years-old)

> "That [disaster] has changed this community forever. Period. For the better. Because now we understand what 'community' really means." (Meaghan, 47-years-old)

> "There was obviously, you know, the disappointment, the devastation, but at the same there, there was a real sense of community. Of people just coming together and helping each other out." (Adam, 24-years-old)

> "[Friends] wanted to come to support us . . .that was really helpful. We have friends we didn't—haven't heard from in 20 years contact us by email, sometimes by phone. Um, they'd heard about this in Goderich, "Were we affected?" That was really helpful for us." (Jenny, 64-years-old)

Although some participants had issues with various aspects of the recovery process (e.g., communication from public officials; inability to access property in the downtown area; quality and frequency of updates from traditional media; issues related to property insurance), almost everyone agreed that the community was now closer as a result of their shared experiences.

4.3.6 Comparison of the interviews and questionnaires

The results from the thematic analysis of the interviews were consistent with the results from the larger sample questionnaire. As previously discussed, the socio-demographics of the interview participants were reasonably similar to those of the questionnaire respondents. Additionally, the experiences and perspectives reported by interview participants on August 21st, August 24th, and during the long-term recovery period were corroborated by the questionnaire results. With this in mind, the stories and perspectives that were shared in this chapter should be carried forward in order to contextualize the questionnaire results.

CHAPTER FIVE

QUESTIONNAIRE RESULTS

A total of 304 questionnaires were received by the closing date of March 15th, 2012. Of these, 268 questionnaires had been completed and were included in the data analysis. This sample size is comparable to that of several other studies conducted on public perception of and response to severe weather (e.g., Comstock and Mallonee, 2005; Silver and Conrad, 2010; Zhang et al., 2007; Balluz et al., 2000; Sherman-Morris, 2005; de Man and Simpson-Housley, 1987; Wong and Yan, 2002; Hammer and Schmidlin, 2002). As the number of responses varied per question from 122 to 268 (since not all respondents answered every section of the questionnaire), the denominator for all of the percentages stated in this chapter was determined based on the number of responses to each question. Based on this sample size, the percentages that are reported in this chapter can be extrapolated to the general population of Goderich at a 95% confidence level with a margin of error between 1.2 to 5.8%. To further ensure generalizability of the results, the socio-demographics of the questionnaire respondents were compared to Statistics Canada's 2006 Community Profile for Goderich, and were found to be similar (Table 5.1).

5.1 General weather questions

At the beginning of the questionnaire, respondents were asked a series of questions about how often they accessed specific weather sources. In general, women tended to check the weather more often than men for all mediums. The local radio station was the most commonly

	Stats. Canada (2006)	Thesis Survey
Age (median)	45.6	40-49
Gender (% female)	53	66[1]
Education (% with high school diploma)	27	22
Education (% with university or college diploma)	36	36
Income (median)	$63,965	$50,000 - $74,999
Employment status (% employed)	57	74
Mobility status (% Goderich resident >5 years)	62	60

Table 5.1: Demographic characteristics of the questionnaire respondents, in comparison to the 2006 Statistics Canada community profile for Goderich, Ontario. Although the 2011 census has since been released, it does not contain the demographic information listed above.

[1]Although females are over represented in this study, it is common for women to respond to questionnaires more often than men (e.g., Sax et al., 2003; Underwood et al., 2000).

accessed source, with 47% of respondents using this medium at least once per day. The Environment Canada website, the Weather Network website, and the Weather Network television channel were all accessed by approximately 25% of respondents at least once per day. Cell phone applications were the least accessed medium, with 50% of respondents rarely or never using this service. Examples of other sources of weather information included visually assessing the weather and national news outlets. A substantial proportion of respondents (30-35%) indicated that they "rarely or never" checked the weather sources mentioned in the questionnaire.

When asked how often they check the weather, 50% of respondents indicated that they checked the weather regularly, while 38% of respondents indicated that they only checked the weather when there was a special reason for them to do so (e.g., when planning a trip). The vast majority of respondents (84%) indicated that they checked the weather more often than usual if

severe weather had been forecasted. Sixty-seven percent of respondents also indicated that they tried to avoid traveling if there was a weather warning posted for their area. In terms of trust, most respondents indicated that they trusted the forecasts issued by Environment Canada (63%), the local news (58%), and the Weather Network (51%).

When asked the best way to disseminate weather warning information to individual end users, the majority of respondents (33%) indicated that an outdoor warning siren would be the most effective medium. This finding is interesting, given that the question did not specify the type of weather warning to be communicated. Other respondents indicated that an automated text message (19%) or telephone call (15%) would be their most preferred method. Although 25% of respondents indicated that they had reliable access to an Environment Canada weather radio, only five respondents indicated that the weather radio would be their preferred method of warning communication. Seven respondents indicated that they could not choose one "best" method for communicating a warning, but rather that multiple methods should be used to communicate severe weather information.

5.2 August 21st, 2011 Goderich, Ontario tornado

Eighty-one percent of respondents (n=218) were in the Goderich region on Sunday, August 21st, 2011. Of these individuals, 55% indicated that they had not paid much attention to the weather in the hour leading up to the tornado. Accordingly, although Environment Canada issued a tornado warning for Goderich at 3:48 pm, only 12 respondents (4.5%) received the warning before the storm reached the town. In terms of the tornado's impacts, nine respondents indicated that someone in their household had been injured during the tornado, and

two respondents indicated that someone in their household had required medical attention as a result of their injuries. Twenty-three percent of respondents said that their home sustained some degree of damage as a result of the tornado on August 21st, with 15 respondents indicating that their home had sustained serious structural damages.

5.2.1 Protective action decision-making

When asked about protective action decisions, only 35% of respondents indicated that they took any form of protective action during the tornado. The majority of these individuals decided to take protective action as a result of hearing or seeing something unusual, such as hearing the wind, rain, and/or hail become very intense (n=63), seeing objects flying around outside (n=38), or seeing trees bending in the wind (n=48) (Figure 5.1). Examples of other cues that motivated protective action included unusual animal behavior (n=5) and hearing the "freight train" noise often associated with tornadoes (n=7). As one individual noted:

> I was on the phone and it went dead, then I heard a loud sound like a train coming right for us. My husband heard it too, and he came in from outside and yelled to get in the basement. (Female, aged 60 or older)

Most individuals indicated that it was some combination of these audio-visual cues that led them to take protective action, not one factor in particular. Only eight of these individuals had heard about the tornado warning issued by Environment Canada, and all of these respondents indicated that the tornado warning was not the only factor that influenced their protective action decisions. Rather, each of these respondents indicated that their decision to take protective action was at least equally motivated by hearing or seeing something unusual. This finding is consistent with several previous studies that found that most individuals who receive

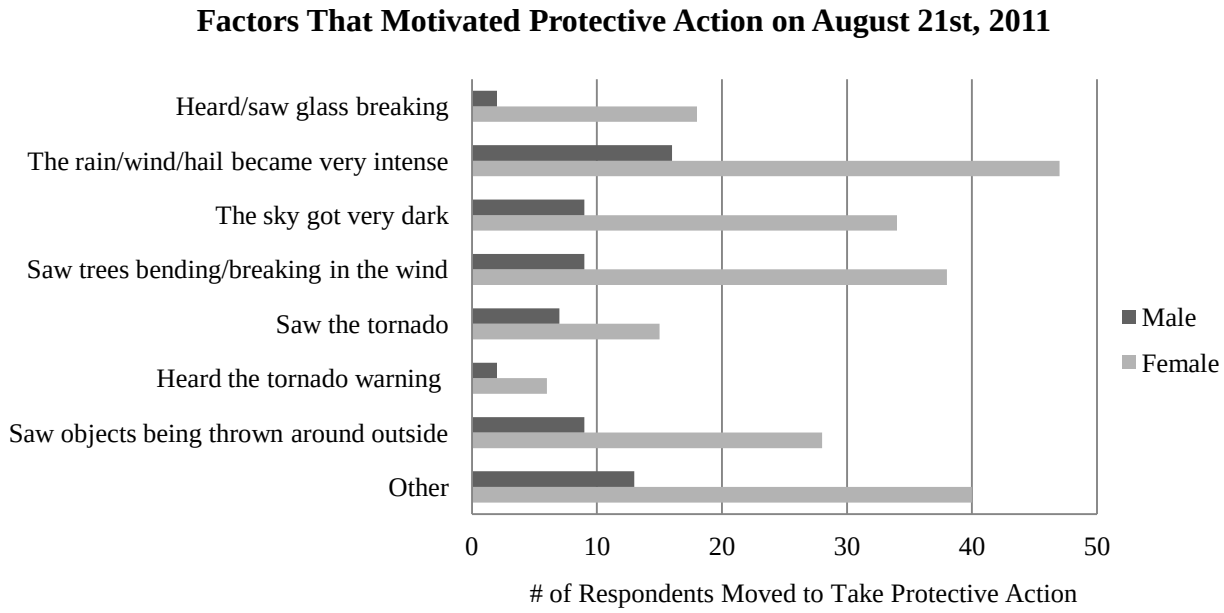


Figure 5.1: Respondents were asked to indicate those factors (not mutually exclusive) that motivated their protective action decisions during the August 21st tornado.

a weather warning seek to confirm risk for themselves before taking protective action (e.g., Hammer and Schmidlin, 2002; Sherman-Morris, 2010). Of the 136 respondents who did not take protective action during the storm, one-half (51%) indicated that they did not realize there was a tornado on the ground. Other common reasons for not taking protective action include (not mutually exclusive): it happened too quickly to do anything (n=46) and the weather did not appear to be that severe (n=23). Eleven respondents indicated that they were unable to take shelter for a variety of reasons (e.g., because they were at work or because they were in a vehicle), while seven respondents said that they would have taken shelter but that they had no where safe to go. Only one person indicated that she chose not to take shelter because she wanted to see the tornado.

Many different factors have been identified in the literature as being influential in the decision-making process during severe weather events (e.g., gender, age, education, previous disaster experience, awareness of tornado warnings, and risk perception). However, none of these factors significantly influenced protective action decision-making during the August 21st Goderich, Ontario tornado (as determined using Chi-Square analysis). In terms of gender, only 33% of the males (n=18) and 36% of the females (n=54) took some form of protective action. Similarly, neither the age nor the education of respondents significantly influenced protective action decision-making during the tornado, although those with post-secondary education were slightly more likely to take protective action (Table 5.2). Awareness of the tornado warning also did not significantly increase the likelihood of taking protective actions, as only seven of the 12 respondents who knew about the tornado warning took protective action. Respondents' existing perceptions of tornado risk were equally unrevealing about protective decisions during the tornado.

Percentage of each age group that took protective action		**Percentage of each education level that took protective action**	
Less than 20	100[1]	Elementary school	24
20-29	22	High school diploma	25
30-39	35	Trade of technical certificate	39
40-49	41	College diploma/program	39
50-59	36	University degree(s)	36
60 or older	36		

Table 5.2: Age and education breakdown for those individuals who indicated that they took protective action during the August 21st, 2011 tornado.

[1]Although 100% of 18 and 19 year-olds took protective action, there were only three individuals in this age group.

Participants were asked whether they had believed (prior to August 21st, 2011) that a tornado could affect the Goderich region. Only 27% of those individuals who believed that a tornado could not affect Goderich took some form of protective action during the tornado. However, only 22% (n=13) of those individuals who believed that tornadoes could affect Goderich took some form of protective action during the tornado. Thus, more accurate risk perception (i.e., the belief that a tornado, however improbable, could potentially affect their community) was not correlated with an increased likelihood of taking protective actions.

In summary, only 35% of respondents took any form of protective action during the August 21st tornado. Individuals typically chose to take protective action based on audio-visual cues that indicated that dangerous weather may be approaching (e.g., wind/rain/hail becoming very intense or trees bending in the wind). Most individuals (especially women) indicated that many different cues moved them to take action during the storm. This finding is consistent with previous studies that found that many individuals seek to confirm risk through a variety of sources before taking protective action. In terms of factors associated with shelter-seeking behavior, there were no demographic variables from the overall sample that were significantly correlated with protective-action decision making during the Goderich tornado.

5.2.2 Post -tornado recovery

In the hours following the tornado, the vast majority of respondents (89%) attempted to contact friends and family by telephone or by text message. Many of these individuals (79%) reported that they frequently used their cellular phones to communicate with others during this time. Over one-half (62%) of the individuals who used their mobile phones after the tornado

experienced service interruptions and dropped calls. In addition to calling friends and family, most respondents (88%) physically checked on their friends and neighbours to see if they were okay; one-third of respondents reported purposefully going around police barricades in order to check on loved ones or property. Many individuals also spent time talking to people in the streets (84%) and walking around to assess the storm damage (87%).

In the days and weeks following the tornado, one-half of respondents indicated that they felt starved for information. Many respondents (47%) had a difficult time getting information electronically because they had no power, and approximately one-half (54%) of respondents relied heavily on non-electronic forms of communication (e.g., word of mouth, flyers, the local newspaper, and town hall meetings) to obtain post-disaster recovery information. In terms of satisfaction with the information that was being received, most individuals felt that the local radio station (73%) and the local newspaper (61%) did a good job of providing information during the post-disaster recovery phase. In terms of public satisfaction with first responders, the vast majority of respondents (93%) agreed that police, paramedics, and firefighters did an good job in the immediate aftermath of the tornado.

Participants had mixed opinions about the performance of their public officials, with almost half of the respondents (45%) indicating that there had been insufficient communication from community leaders in the days following the disaster. Similarly, 46% of respondents felt that post-disaster community meetings did not have enough two-way communication between residents and their public officials. However, 70% of respondents felt that the post-disaster community meetings were useful, and that they provided residents with the opportunity to

meaningfully connect with their public officials. Overall, 72% of respondents indicated that public officials did a good job in the immediate aftermath of the tornado.

5.3 August 24th, 2011 storm system

In an effort to understand how previous disaster experience can affect risk perception and protective-action decision making during subsequent severe weather events, respondents were also asked a series of questions regarding their experiences on August 24th, 2011. As mentioned previously, Environment Canada had issued tornado watches for much of southern Ontario in the morning of August 24th. By 6:30 p.m. that afternoon, Environment Canada had upgraded the tornado watch to a tornado warning for the Goderich region. In general, respondents felt that there was a high degree of situational awareness among Goderich residents on August 24th, 2011. The majority of respondents (74%) indicated that they had learned about the tornado watch soon after it was posted, and 81% of respondents felt that people were talking about the weather all day. Most respondents (68%) indicated that they checked the weather more often than usual, and 74% of respondents recall community members being hyper-vigilant about the weather for most of the day.

Although these results indicate that there was a high degree of situational awareness among respondents (which was motivated by their prior experience with a damaging tornado), this awareness did not necessarily translate into either improved risk perception or precautionary behavior. One-third of the respondents felt that most people overreacted when the tornado watch was posted, and 25% of respondents were not concerned about the tornado watch because they did not believe a second tornado would hit Goderich. In addition, 33% of

Response Pattern	# of Respondents (%)
Took protective action on both Aug. 21st and Aug. 24th	40 (26%)
Took protective action on Aug. 21st, but not on Aug. 24th	18 (12%)
Did not take protective action on either Aug. 21st or Aug. 24th	48 (32%)
Did not take action on Aug. 21st, but took protective action on Aug. 24th	45 (30%)

Table 5.3: Comparison of protective action decisions made on August 21st and August 24th for those individuals who experienced both events (n=191).

respondents did not take any form of protective action when Environment Canada upgraded the tornado watch to a tornado warning at 6:30 p.m. Of these individuals, 75% planned to take protective action if the weather became severe, and 62% felt confident in their own ability to determine whether to take protective action. These results suggest that, despite their recent experience with a damaging tornado, a significant portion of respondents trusted their own risk judgements above the recommendations outlined in the Environment Canada tornado warning.

Additional support for this finding can be found by examining the differences in protective action decisions made by those respondents who experienced both events (Table 5.3). While 26% of these respondents indicated that they took protective action on both August 21st and August 24th, a significant proportion (32%) did not take protective action on either day. Perhaps more interesting are those individuals who indicated that they took protective action on August 21st but not on August 24th. However, it is important to note that 30% of the respondents who experienced both events made more appropriate protective action decisions on August 24th. Thus, previous disaster experience seemed to positively influence protective-action decisions for some individuals. These findings suggest that the importance of previous

disaster experience in the decision-making process during subsequent events is highly variable and context-dependent.

5.4 Long-term recovery period

A section was added to the end of the questionnaire to explore how residents were recovering four months after the tornado. Two broad themes strongly emerged in this section: the positive impact of the disaster on residents' sense of community, and the negative impact of the disaster on residents' place attachments.

5.4.1 Positive impacts on sense of community

Respondents overwhelmingly agreed that they felt more connected to their community as a result of their experiences in August, 2011. Seventy-nine percent of respondents agreed that they felt the community was closer now than it had been before the tornado, and almost half of respondents (46%) agreed that they were now closer with their friends and neighbours. There was also a healthy amount of optimism expressed by the majority of questionnaire respondents. For example, 73% of respondents felt that the disaster represented an opportunity for the town of Goderich, and 79% felt that the disaster brought the best in people. Sixty-four percent of respondents also felt that they could personally help their community to recover from the disaster. When asked about their satisfaction with the recovery process over the last four months, 65% of respondents felt that their public officials had done a good job since the disaster.

5.4.2 Negative impacts on place attachments

Although the majority of respondents agreed that the disaster has had a positive impact on the sense of community in Goderich, most participants also responded strongly to questions that probed negative impacts to their town. A significant portion of participants expressed concern over the future development in the downtown core. For example, 77% of respondents worry that Goderich has permanently lost some of its historic charm, and almost half of respondents (48%) worry that any new development will not be as charming or beautiful as the buildings that were lost. When asked about long-term recovery, only half (48%) of respondents felt that Goderich could truly recover from the tornado. Similarly, 71% of respondents were concerned that affected business owners will not want to rebuild after the disaster.

While many respondents expressed optimism about Goderich's future, many also expressed conflicting emotions of disbelief, guilt, and worry. For example, over half of respondents (61%) expressed worry that people outside of the community will forget about Goderich even though resident's still need recovery assistance. Many respondents (69%) said that they still could not believe that the disaster had happened to their town, and a small percentage (18%) wanted people to move on and stop talking about the tornado so much. Interestingly, almost half (45%) of the respondents said that they felt guilty because they were not affected by the storm as badly as others in their community.

Participants also responded very strongly to questions about their attachments to the physical landmarks in Goderich. Eighty-two percent of respondents said that they felt sad whenever they visited the Courthouse Square, and respondents overwhelmingly agreed (95%) that the

landscape of downtown Goderich feels 'barren'. Many individuals mentioned the loss of green space as the reason for their feelings of sadness and detachment. For example, 94% of respondents strongly agreed that the Courthouse Square does not feel same without all of the trees. When asked how they respond to these feelings of loss and sadness, one-fourth of respondents (24%) said that they avoid going into the hardest hit areas because it still makes them feel uncomfortable.

To summarize, participants responded strongly to questions that involved the long-term impacts of the tornado on both the physical and social aspects of their community. Two broad themes involving individuals' sense of community and place attachments clearly emerged throughout this section. Specifically, most individuals agreed that the tornado has brought residents closer together in the months following the disaster. Many respondents also expressed a healthy amount of optimism about the future wellbeing of their town. However, participants also responded very strongly to questions that probed the tornado's impacts on their physical community. Many people expressed intense feelings of sadness at the loss of the greenery and the historic landmarks in their town. Others expressed feelings of worry and uncertainty about the ability of their community to recover from the tornado. These results show that respondents' place attachments have been significantly affected, both positively and negatively, by the August 21st tornado.

CHAPTER SIX

DISCUSSION AND CONCLUSIONS

The August 21st tornado and the subsequent severe weather system on August 24th provided the opportunity to examine the roles of risk perception and previous disaster experience on the decision-making process during successive high-risk events. This study also provides several other valuable insights, including the ways that individuals obtain, interpret, and disseminate risk and recovery information; and the impacts (both positive and negative) of a high-risk short-notice disaster on place attachments.

6.1 Influential factors in the decision-making process

Prior to August 21st, 2011 many participants believed that a tornado could never affect Goderich, either because it was physically impossible or because it was so statistically unlikely as to be effectively impossible. Additionally, only a few participants were aware that Environment Canada had issued a tornado warning at 3:48 p.m. Considering these factors, it is not surprising that only a small proportion of individuals suspected that the August 21st storm might be tornadic. However, most people who were in the immediate Goderich area took protective action during the storm on August 21st. When asked about the factors that motivated them to take shelter that afternoon, participants overwhelmingly agreed that they took protective action in response to threatening or unusual sights and sounds. Thus, response on August 21st was highly reactive.

On August 24th, many participants reported that friends and family were hyper-vigilant about the weather conditions after the tornado watch had been posted that morning. However, most participants felt that this hyper-vigilance was unnecessary (although understandable) as it was unlikely that a second tornado would impact their community. Accordingly, almost half of the respondents did not take any form of protective action on August 24th. This finding contradicts several earlier studies that found that previous disaster experience positively influenced protective behaviours during subsequent events (e.g., Comstock and Mallonee, 2005; Mileti and Sorensen, 1987). In particular, Comstock and Mallonee (2005) found that individuals who had previously experienced a damaging tornado were more likely to take protective action if they were given sufficient warning and if they had access to adequate shelter. Residents of Goderich were given over six hours of notification before the tornado watch was upgraded to a tornado warning on August 24th, but less than half of participants took protective action at this time.

Interestingly, those participants who took protective action on August 24th reported two distinct types of protective behaviours: proactive and reactive. Those who took proactive protective actions typically did so upon hearing about the tornado watch. These actions included moving valuable possessions into the basement and securing loose items such as lawn furniture. However, most participants waited to take self-protective action until after they heard that a tornado warning had been issued (less common) or when the weather began to look threatening outside (more common). Thus, while more people reported taking protective action on August 24th, a similar proportion of respondents demonstrated self-protective behaviours during both storms. When asked why they chose not to take shelter, most people agreed that they did not

believe that a tornado was a serious threat. This finding is consistent with several previous studies that examined protective behaviours during tornado warnings (e.g., Hammer and Schmidlin, 2002; Sherman-Morris, 2010).

Although risk perception was low prior to August 21st, afterwards there was very little observed improvement in perception of tornado risk among most respondents. This finding contradicts several previous studies that found that personal experience with a damaging tornado is likely to increase perception of tornado risk (e.g., Mileti and Sorensen, 1987; Comstock and Mallonee, 2005). Ironically, several people decided not to take protective action on August 24th as a direct result of their experiences on August 21st. Specifically, participants said that weather conditions on August 24th did not seem as threatening as they had on August 21st. For this reason, they perceived risk to be low (and chose not to take protective action) despite the tornado watch/warning issued by Environment Canada. This appears to be the first study to directly link previous disaster experience with a reduction in protective behaviours during a successive event.

However, this is not to suggest that none of the respondents reported improvements in protective action decision-making as a result of their experiences on August 21st. On the contrary, approximately one-third of respondents took protective action on August 24th when they had not done so on August 21st. Although many of these actions were proactive and did not necessarily involve appropriate self-protective behaviours, these results do suggest that previous disaster experience may positively influence protective actions (or at least situational awareness) for some people during successive events.

To summarize, neither risk perception nor previous disaster experience was significantly correlated with protective action decisions made on either August 21st or August 24th. In terms of socio-demographics, age and having post-secondary education were slightly correlated with improved protective action decisions, but gender, income, employment status, and mobility status were not. Additionally, individuals who were aware of the Environment Canada tornado warning were not significantly more likely to take self-protective action than those who were not aware of the tornado warning on either August 21st of August 24th. The only factor that consistently led to protective action decision-making on both days was the observation of unusual or threatening conditions (e.g., intense wind, rain, or hail). These findings are unexpected and contradict the existing literature.

A substantial proportion of the literature on tornado risk perception and response cites different (and often contradictory) factors as being influential in the decision-making process (Table 6.1). Sitkin and Pablo (1992) found that risk perception and risk propensity (i.e., the innate tendency of an individual to be either risk averse or risk seeking) affected decision-making during high-risk situations. Much of the existing literature on hazards focuses on risk perception as the primary factor in the decision-making process; comparatively less emphasis has been placed on examining risk propensity as a motivating factor during high-risk short-notice disasters. Given the conflicting and often contradictory findings of tornado risk perception and response studies, it may be useful to examine the role of risk propensity on decision-making during tornado events. If risk propensity is found to be a significant factor in

Author (Year)	Factors positively associated with protective action decision-making
Balluz et al. (2003)	• Having at least a high school education. • Having a basement • Living in the tornado path and receiving tornado warning • Having heard tornado sirens • Having an emergency action plan
Sherman-Morris (2010)	• Age and gender (female) • Hearing the tornado siren • Talking to other individuals • Perception of tornado as threat
Comstock and Mallonee (2005)	• Previous disaster experience • Adequate warning lead time • Access to suitable shelter
Hammer and Schmidlin (2002)	• Television reports advised protective actions • Perception of tornado as a threat • Confirmation seeking
Sherman-Morris (2005)	• Gender (female) • Trust in weather forecaster (parasocial relationship)
Schmidlin et al. (2009)	• Perception of tornado as threat • Knowledge of suitable shelter • Mobile home located on private lot • Gender (male) • Presence of children in household • Having a high school diploma • No reference to "God's will" in the interview
de Man and Simpson-Housley (1987)	• Gender (female) • Education
Murphy et al. (2005)	• Previous disaster experience • Gender (female)

Table 6.1: Summary of factors that were found to significantly influence protective behaviours during tornado events in the United States.

high-risk short-notice disasters, this would have substantial implications for the transferability of previous disaster research conducted in the United States to a Canadian context.

6.2 The use and dissemination of risk and recovery information

Most respondents learned about the tornado watch on August 24th through mass media sources, such as television, the Internet, and the radio. This finding is widely supported by previous research on warning communication (e.g., Schmidlin et al., 2009; Hammer and Schmidlin, 2002; Comstock and Mallonee, 2005; Sherman-Morris, 2005). Additionally, numerous respondents reported that they first heard about the warning from a telephone call or a text message on their mobile phone. A recent study on tornado warning dissemination and response on a university campus found that cell phones are increasingly important for tornado warning dissemination (Sherman-Morris, 2010).

Existing research is divided on the role of mass media and risk perception. While some research has found no apparent relationship between access to mass media and distorted risk perception, other research has found that an overabundance of risk information can contribute to a heightened perception of risk (Sjöberg, 2000). The present study found a clear connection between access to mass media and distorted risk perception of some respondents. Several respondents commented on the role of mass media in eliciting anxiety and hyper-vigilance on August 24th. Specifically, respondents mentioned the emotional interviews with Goderich residents and the constant barrage of weather information on August 24th as having contributed to a sense of anxiety and fear.

The largest discrepancy regarding risk communication between the current study and previous research involves the role of tornado sirens in warning dissemination. Numerous studies conducted in the United States cite tornado warning sirens as a major source of warning

information among respondents, and several studies cite tornado warning sirens as one of the primary factors that motivated protective action (e.g., Comstock and Mallonee, 2005; Hammer and Schmidlin, 2002; Schmidlin et al., 2009; Balluz et al., 2000). Only a few towns in Canada have a tornado warning system, and Goderich is not among them; thus, tornado warning sirens did not play any role in the dissemination of warning information for Goderich residents.

Finally, in-person communication was mentioned by many participants as having played an important role in the dissemination of risk and recovery information. For example, many respondents first learned of the tornado watch issued on August 24th by word-of-mouth. After learning about the tornado watch, many people then sought additional information from traditional media. Personal communication with family and friends was commonly mentioned as having played an important role in risk confirmation, as well as the decision to take self-protective action. The influential role of personal communication in confirmation seeking and protective action decision-making by participants is supported by previous studies on risk communication and tornadoes (e.g., Sherman-Morris, 2010; Hammer and Schmidlin, 2002). Lastly, the majority of respondents agreed that in-person communication was essential in the hours and days following the tornado when many people were unable to access traditional media due to issues of connectivity and reception with electronic devices.

6.3 Influence of the Goderich tornado on place attachments

Place is one of the most pivotal concepts in geography. It is a meaningful yet ambiguous term that combines location (physical location in space), locale (objects that make up the place), and sense of place (feelings and impressions generated by a place) (Cresswell, 2009). An

individual's sense of place is constructed by their personality, their life histories, their values, and their interactions with that place (Kaltenborn, 1998). Recent research has examined the influence of abrupt environmental change on place attachments. Albrecht coined the term 'solastalgia' (an amalgam of the words nostalgia and solace) to refer to the "loss of, or the inability to derive solace from, the present state of one's home environment" (Albrecht, 2006: 35). Albrecht has suggested numerous potential causes of solastalgia, including human-induced causes (e.g., war, terrorism, climate change) and natural causes (e.g., natural disasters).

However, despite the connection between natural disasters and place attachments, there has been very little empirical research published that examines the influence of disasters on sense of place. Two notable exceptions include research conducted by Miller and Rivera (2007) and Chamlee-Wright and Storr (2009), which investigated place orientation and community recovery in New Orleans following Hurricane Katrina. However, both of these studies (as well as Albrecht's work on solastalgia) focus on the negative impacts of disaster on place (e.g., displacement, disruption, and loss), and fail to adequately explore the positive impacts that may also occur as a result of disaster (e.g., sense of community, social cohesion, and collective efficacy).

The results of this research project showed a clear connection between the Goderich tornado and participants' place attachments. As anticipated, many residents expressed feelings of loss, sadness, worry, and grief as a result of the salient changes to their familiar places. However, it was also found that many participants experienced profound positive outcomes as a result of their shared experiences during and after the August 21st tornado. Previous research has found

that survivors may experience a temporary surge in unity and optimism following a disaster (e.g., Ehrenreich and McQuade, 2001; Miller and Rivera, 2007; Moore et al., 2004). This observed trend usually only lasts through the response and relief stages of disaster recovery (Moore et al., 2004). However, Goderich residents reported strong feelings of social cohesion and optimism well into the reconstruction phase four months later. This longevity may be explained by the small size of Goderich compared to previous studies conducted in the United States (e.g., Moore et al., 2004; Miller and Rivera, 2007).

6.4 Reflections on research method

The conclusions of this study are based on data collected from 35 interviews and 268 questionnaires conducted between September 2011 and March 2012. To improve generalizability of future research, several revisions to the research method could be suggested. The largest limitation of this research project involves the selection of interview and questionnaire participants. As individuals self-selected to participate and because the recruitment script was predominately disseminated through the Internet, selection bias is a potential factor. Although measures were taken (as outlined in Chapter 3) to minimize any potential selection bias in the sample, future research may benefit from a probability sampling framework and a larger sample size.

Future researchers may also benefit from incorporating a 'quick response' methodology into their research framework. Although data collection for the current study was initiated immediately upon receiving ethics approval from the University of Waterloo's Office of Research Ethics, this still left a four week gap between the tornado and the first interview. It

has been well established in the literature that disaster survivors often experience "memory decay", and that a quick-response methodology is important to maximize respondent recall of experiences and decisions made before, during, and after the event (e.g., Donner, 2007).

6.5 Conclusion

The August 21st tornado and the subsequent severe weather system on August 24th provided the opportunity to examine the roles of risk perception and previous disaster experience on the decision-making process during successive high-risk events. The results show that a sizable portion of the sample population took protective actions on August 24th in ways that were inconsistent with their actions on August 21st. Also, a significant portion of respondents chose not to take any form of protective action on August 24th despite having previously experienced the damaging tornado. The findings of this research suggest that the significance of previous disaster experience in the decision-making process is highly variable and context-dependent.

Current communications technologies (including social media and cell phones) played an important role in post-disaster recovery following the August 21st tornado. Social media was particularly effective in disseminating information and organizing recovery efforts. Respondents also used cell phones in many capacities (e.g., to access the Internet, to send and receive text messages, and to make telephone calls) as a means of obtaining and disseminating important information. However, cell phone connectivity and reception issues contributed to anxiety and heightened vulnerability for some participants. As a result, word-of-mouth communication was consistently cited as having played an important role in the immediate recovery process.

Key insights from this research project that may be of relevance to emergency managers and public officials include the challenges associated with effectively communicating risk information to "stormy cultures" (i.e., those people who have substantial experience with inclement weather), as well as the nuanced impacts of the Goderich tornado on residents' sense of place attachments. Many individuals trusted their own risk judgements more than the risk information disseminated by Environment Canada. A possible avenue of future research would be to determine ways of effectively communicating warning information (including appropriate protective actions) to those individuals who express maladaptive self-efficacy. One suggestion would be to create a holistic approach for disseminating risk information that includes both situational awareness information (e.g., southern Ontario as Canada's "tornado alley") and details on effective protective actions to take during tornado warnings. This information should be targeted at both those individuals who are unaware of the existing tornado risk, as well as those individuals who express maladaptive levels of self-efficacy.

Finally, emergency managers and public officials should be aware of the nuanced impacts the Goderich tornado had on residents' sense of place. While many individuals reported feeling an increased sense of community and social cohesion, others expressed strong feelings of loss, sadness, and guilt. All of these factors can influence individual- and community-level resilience well into the long-term recovery period. It is essential for emergency managers and decision-makers to consider these conflicting emotions when developing long-term recovery plans, and in preparing for any potential future disasters.

APPENDIX A: INTERVIEW SCRIPT

SECTION A: General Weather Questions

1. Where do you typically obtain weather information, such as forecasts and weather warnings?

2. Can you tell me about what motivates you to check the weather forecast?
    a. [**PROBE**: How often do you check the forecast? Does your frequency change if severe weather has been forecast for your area?]

3. Were you aware that Environment Canada issues two different types of severe weather products: weather watches and weather warnings?
    a. [**PROBE**: If yes, where do you obtain information on weather watches and warnings specifically?]
    b. **[PROBE**: If yes, in your own words could you explain the difference between a weather watch and a weather warning?]

4. Are you aware of Environment Canada's Weatherradio program?
    a. [**PROBE**: If yes, do you own a Weatherradio?]

5. There are many different sources of weather information, including (but not limited to) television and radio forecasts, Internet websites, and cell phone apps. There are also many different types of forecasts, including daily forecasts, severe weather forecasts, and marine forecasts. Keeping in mind the variability of weather information available, can you give me a sense of what kind of weather information (and in what format) would best suit your needs?
    a. [**PROBE**: What is the best way for officials to warn you about impending severe weather? *(e.g., television, e-mail, SMS, social media website, radio broadcast, government website)*

SECTION B: August 21st, 2011 Tornado Event

The following questions pertain to the tornado touchdown in Goderich on August 21st, 2011 at 4:00 pm.

6. Can you remember when you first noticed the inclement weather?

7. Can you tell me about what you were doing between 3:00 pm and 4:00 pm on Sunday August 21st in the hour leading up to the tornado touchdown?
    a. [**PROBE**: Where were you? Were you alone or were you with other people?]

8. Were you aware that Environment Canada had issued a severe thunderstorm watch for Huron-Perth at 2:02 pm on August 21st?
    a. [**PROBE**: If yes, where did you hear about this watch? What did you do upon hearing about the watch?]

9. Were you aware that Environment Canada had issued a tornado warning for Huron-Perth at 3:48 pm on August 21st?
    a. [**PROBE**: If yes, where did you hear about this warning? Did you do anything upon hearing about the warning?]

10. Did you take protective action during the storm on August 21st (such as going to a basement)?
    a. [**PROBE**: If yes, when did you decide to take protective action? What action did you take? Can you describe what factor(s) influenced your decision? If you were with others, what did they do?]
    b. [**PROBE**: If no, why not? Can you describe what factor(s) influenced your decision? If you were with others, what did they do?]

11. Can you tell me about what you did in the hours after the storm had passed?
    a. [**PROBE**: Did you contact any friends or family? Did you check on neighbors? Did you leave your home to survey damage or did you stay put?]

12. In the hours and days following the disaster, how did you remain updated on the latest recovery efforts?
    a. [**PROBE**: Did you attend community meetings at the Knights of Columbus Community Center?]

13. Can you give me a sense about how this storm impacted you and your household?
    a. [**PROBE**: Was there any damage to your home or property caused by this storm? Was anyone in your household injured?]

SECTION C: August 24th, 2011 Severe Storm System

Three days after the August 21st tornado, a second system moved through southern Ontario, causing a widespread tornado watch to be posted early in the afternoon, followed by a tornado warning for much of southern Ontario in the late afternoon.

14. Do you remember where you were on August 24th?
    a. **[PROBE:** If yes, did you know about the tornado watch and warning? How did you find out about it?]

15. Can you describe your experiences on that day as the storm system approached?
    a. [**PROBE**: Where were you? Who were you with? Can you give me a sense of what was going on in Goderich?]

16. Did you take protective action for this storm?
    a. [**PROBE**: Was this different than what you did on August 21st? Can you elaborate why?]

SECTION D: Cell phone and Social Media Usage

The following questions pertain to the use of cell phones and social media to obtain and disseminate severe weather information.

17. Do you have a cell phone?
    a. [**PROBE**: If yes, what type of phone is it?] **If no, skip to Question 27.**

18. Which of the following features do you use on your cell phone:
    a. Internet browser
    b. E-mail
    c. Weather Apps
    d. SMS
    e. Social networking website/apps (e.g., Facebook/Twitter)
    f. Other [Please explain: _____]

19. Do you use your phone to obtain weather information?
    a. [**PROBE**: If yes, how so? If yes, how often?]

20. Did you use your cell phone to obtain weather information or to contact friends/family in the hours before the August 21st tornado?
    a. [**PROBE**: If yes, please explain. Did you use your cell phone to contact friends/family or obtain information before the August 24th storm? Have you used your cell phone to contact friends/family in any other severe storms?]

21. Did you use your cell phone to get information or to contact friends/family after the August 21st tornado?
    a. [**PROBE**: If yes, please explain. Did you use your cell phone to contact friends/family or obtain information after the August 24th storm?]

22. Did you experience any service interruptions with your mobile device before, during, or immediately after the August 21st tornado?
    a. [**PROBE**: If yes, what was the nature of the service interruption? How did this service interruption affect you?]

23. Are you a member of any social media website, such as Facebook, Twitter, Google+, or Internet messaging boards?
    a. [**PROBE**: If yes, how often do you access these websites? If yes, what do you do on these websites?]

24. Have you used social media websites, such as Facebook or Twitter, in relation to the August 21st tornado or the August 24th tornado watches/warnings in southern Ontario?
    a. [**PROBE**: If yes, which website(s)? Can you describe how you used these websites?]

25. Were you satisfied with the way(s) that social media provided important information in the hour(s) before the storm?
    a. [**PROBE**: If yes, please explain. If no, what could have been improved?]

26. Were you satisfied with social media's role in facilitating recovery efforts after the storm?]
    a. [**PROBE**: If yes, please explain. If no, what could have been improved?]

27. There have been some complaints on social media websites about "rubberneckers" coming to Goderich after the tornado. A "rubbernecker" is defined as those individuals who travel to an area impacted by a storm to see the impacts. These individuals rarely assist with clean-up, and often get in the way of recovery efforts. Did you personally notice an influx of "rubberneckers" into Goderich after the storm?
    a. [**PROBE**: If yes, can you elaborate? If yes, did they inconvenience you personally?]

Is there anything else you would like to share with me regarding your experience on August 21st, the recovery and clean-up process in the days and weeks following, or the second tornado warning on August 24th?

SECTION E: DEMOGRAPHICS

Now I would like to ask you a few demographic questions about yourself. The purpose of these questions is to place your answers in the broader social context. Please remember that these questions are optional, and you may skip any question(s) that you do not wish to answer.

28. What is your age group?
    a. < 20
    b. 20 – 29
    c. 30 – 39
    d. 40 – 49
    e. 50 – 59
    f. 60 – 69
    g. 70+

29. Is your permanent address located in the Goderich region?
    a. [**PROBE**: If yes, how long have you lived here? How long have you lived in southern Ontario? If no, where is your permanent address located?]

30. What is your highest level(s) of education completed?
    a. Elementary school
    b. High school
    c. Trade or technical certificate/program
    d. College diploma/program
    e. University degree(s)
    f. Professional designation(s)
    g. Other: _____

31. What was your employment status prior to the time at which the tornado hit?
    a. Employed [**PROBE**: What type of work do you do?]
    b. Retired
    c. Student
    d. Unemployed
    e. Other (Please specify): _____

32. Would you mind providing me with a general sense of your household income in 2010?

APPENDIX B: QUESTIONNAIRE

SECTION A: WEATHER PRODUCTS

The purpose of the following questions is to determine how you use and understand weather products, such as forecasts and warnings.

1. In a <u>typical</u> summer week, how often do you access the following to learn about the weather?

	More than once a day	Once a day	A few times a week	Once a week	Rarely / Never
Environment Canada website (including Exeter RADAR)					
Weather Network (website)					
Weather Network (TV)					
Local television station					
Local radio station					
Cell phone "app"					
Talk to people					
Other (please specify):					

2. If an Environment Canada weather warning was issued for your area, what would be the best way to make this information available to you? ***(select one)***

- ☐ Telephone call (either landline or cell phone)
- ☐ Text message
- ☐ Television broadcast
- ☐ Radio broadcast
- ☐ Cell phone pop-up notification
- ☐ Posted message on a website
- ☐ Outdoor warning siren
- ☐ Other (please specify): _____

3. I have reliable access to an Environment Canada Weather Radio.

- ☐ Yes
- ☐ No
- ☐ I'm not sure

4. I have enough food, water, and supplies to last me 72 hours in the event of an emergency.

- ☐ Yes
- ☐ No
- ☐ I'm not sure

5. Please select the response that best describes the ways that you use weather information and experience weather events.

Question	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	N/A
I usually pay more attention to severe winter weather than severe summer weather.						
I don't check the weather regularly unless there is a special reason for me to do so (e.g., planning a trip)						
I am familiar with weather patterns in the Goderich region.						
I trust Environment Canada forecasts						
I trust Weather Network forecasts.						
I trust local news sources for weather information.						
I don't feel that the weather affects me very much.						
I think some people are too obsessed with checking the weather.						
I check the weather because I find it interesting.						
I check the weather more often if it's supposed to storm.						
I try to avoid traveling if there is a weather warning posted for my area.						

SECTION B: AUGUST 21ST GODERICH, ONTARIO TORNADO

Please answer the questions in this section if you were in the Goderich region on August 21st, 2011. If you were not in the Goderich region on August 21st, 2011, please move to **SECTION E: DAMAGES AND INJURIES.**

1. The following questions pertain to the tornado that touched down in Goderich on August 21st, 2011. Please select the response that best describes what you did or thought during and immediately after the tornado.

Question	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	N/A
I didn't pay much attention to the weather in the hour leading up to the tornado.						
I never thought a tornado could affect Goderich.						
I had thought that the bluffs would cause any tornado coming in off the lake to skip over the town.						
After the storm had passed I called and/or texted family members to make sure that they were okay.						
After the storm had passed, I went out into the street to assess the damage						
After the storm had passed, I checked on friends and neighbors to see if they were alright.						
After the storm had passed, I spent time talking to people in the street.						
I frequently used my cell phone to communicate with others after the tornado.						
I experienced service interruptions with my cell phone in the hours after the tornado.						

2. Did you know about the tornado warning that was posted for Goderich <u>before</u> the tornado hit? *(please select one)*

- ☐ Yes, I heard about the tornado warning when it was posted.
- ☐ No, I didn't know about the tornado warning until afterward.

3. Did you purposefully go around police barricades to check on loved ones or property? *(please select one)*

- ☐ Yes
- ☐ No
- ☐ I'm not sure

4. Did you take any form of protective action (such as sheltering in a basement or shutting windows) on August 21st? *(please select one)*

- ☐ Yes (go to **SECTION C: TAKING PROTECTIVE ACTION**)
- ☐ No (go to **SECTION D: NO PROTECTIVE ACTION TAKEN**)

SECTION C: TAKING PROTECTIVE ACTION

A 'protective action' is any sort of action that you take to prevent injury to yourself or others, or to minimize damages. Examples of protective actions that one may take in a tornado include: going to the basement, shutting or opening windows, or hiding in a bathtub.

1. Why did you take protective action during the storm on August 21st? *(select all that apply)*

- ☐ I saw objects (e.g., lawn furniture, tree branches) being thrown around outside.
- ☐ I heard about the tornado warning issued by Environment Canada.
- ☐ I saw the tornado.
- ☐ I saw trees bending in the wind.
- ☐ The sky got very dark.
- ☐ The rain/hail/wind became very intense.
- ☐ I could hear or see glass breaking.
- ☐ Other people in my household were taking shelter, so I went with them.
- ☐ I was told to take shelter by someone else (e.g., boss, police officer, parent/guardian)
- ☐ I don't know what exactly motivated me to take protective action from the storm.
- ☐ Other (please specify): _____

PLEASE GO TO: **SECTION E: DAMAGES AND INJURIES**

SECTION D: NO PROTECTIVE ACTION

A 'protective action' is any sort of action that you take to prevent injury to yourself or others, or to minimize damages. Examples of protective actions that one may take in a tornado include: going to the basement, shutting or opening windows, or hiding in a bathtub.

1. Why didn't you take any protective action during the storm on August 21st? *(select all that apply)*

- ☐ The weather didn't seem that severe.
- ☐ I didn't know that there was a tornado.
- ☐ It happened too quickly to do anything.
- ☐ No one else was taking protective action.
- ☐ I had no where safe to go.
- ☐ I was not in Goderich at the time of the tornado
- ☐ Other (please specify): _____

PLEASE GO TO: **SECTION E: DAMAGES AND INJURIES**

SECTION E: DAMAGES AND INJURIES

The purpose of these questions is to gain an understanding of how the storm impacted you and your household.

1. Was anyone in your household injured during the tornado? *(select all that apply)*

- ☐ Yes, someone received serious injuries (requiring medical attention)
- ☐ Yes, someone received minor injuries (not requiring medical attention)
- ☐ No, no one was injured.

2. Did your home or property receive any damages as a result of the tornado? *(select all that apply)*

- ☐ Yes, my home sustained serious structural damages.
- ☐ Yes, my home sustained minor structural damages.
- ☐ Yes, my property sustained damages (such as fallen trees).
- ☐ No, my home and property were not damaged as a result of the tornado.

3. Did your home sustain any damages as a result of the heavy rain on August 24th? *(select all that apply)*

- ☐ Yes, my home sustained serious structural damages.
- ☐ Yes, my home sustained minor structural damages.
- ☐ Yes, my property sustained damages (such as fallen trees).
- ☐ No, my home and property were not damaged as a result of the storm on August 24th.

4. Do you own or rent a business in the Goderich region?

- ☐ Yes (please go to **SECTION F: DAMAGES TO BUSINESSES**)
- ☐ No (please go to **SECTION G: AUGUST 24TH STORM**)

SECTION F: DAMAGES TO BUSINESSES

The purpose of these questions is to gain a sense of the amount of property damage sustained to businesses on August 21st and on August 24th.

1. Did your business or business property sustain any damages as a result of the tornado on August 21st? *(select all that apply)*

- ☐ Yes, my business sustained serious structural damages.
- ☐ Yes, my business sustained minor structural damages.
- ☐ Yes, my business property sustained damages (such as fallen trees)
- ☐ No, my business was not damaged as a result of the tornado.

2. Did your business or business property sustain any damages as a result of the heavy rain on August 24th? *(select all that apply)*

- ☐ Yes, my business sustained serious structural damages.
- ☐ Yes, my business sustained minor structural damages.
- ☐ Yes, my business property sustained damages (such as fallen trees)
- ☐ No, my business was not damaged as a result of the storm on August 24th.

PLEASE GO TO: SECTION G: AUGUST 24TH STORM

SECTION G: AUGUST 24TH STORM

Three days after the August 21st tornado, a second system moved through southern Ontario, causing a widespread tornado watch to be posted early in the afternoon, followed by a tornado warning for much of southern Ontario in the late afternoon.

1. The following questions pertain to the severe storm that affected Goderich on August 24th, 2011. Please select the response that best describes your actions and/or perceptions on this day.

Question	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	N/A
I learned about the tornado watch very soon after it was posted.						
People were talking about the weather all day.						
I checked the weather more often than usual that day.						
I remember people being hyper-vigilant about the weather most of the day.						
I think that many people overreacted when the tornado watch was posted.						
I wasn't worried about the tornado watch because I thought it was unlikely that a second tornado would hit Goderich.						
I took protective action after Environment Canada upgraded the tornado watch to a tornado warning						
I planned to take protective action if the weather started looking bad outside.						
I felt confident in my ability to determine for myself whether I needed to take protective action.						

PLEASE GO TO: SECTION H: IMMEDIATE RECOVERY PERIOD

SECTION H: IMMEDIATE RECOVERY PERIOD

1. The following questions pertain to the short-term recovery period following the tornado that touched down in Goderich on August 21st, 2011. Please select the response that best describes your actions and/or perceptions during this time period.

Question	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	N/A
I felt starved for information in the days and weeks following the tornado.						
I had no idea that a tornado hit Goderich until someone told me.						
I got most of my information from word-of-mouth sources in the days and weeks following the tornado.						
Local radio stations did a good job of providing coverage of the post-disaster recovery.						
Local newspapers did a good job of providing information during the post-disaster recovery phase.						
Gossip was a serious problem in the days following the tornado.						
I felt that there was insufficient communication from public officials.						
I was angry or frustrated with the "rubberneckers" coming into the community after the storm.						
I had a difficult time getting information electronically (e.g., Internet, television, cell phone) because I had no power.						
I heavily relied on non-electronic forms of communication (e.g., word of mouth, flyers, newspaper, town meetings) to get information immediately following the disaster.						
Overall I felt that first responders (police, paramedics, fire fighters) did a good job in the immediate aftermath of the tornado.						
Overall I felt that public officials did a good job in immediate aftermath of the tornado.						

PLEASE GO TO: SECTION I: COMMUNITY MEETINGS

SECTION I: COMMUNITY MEETINGS

The following questions pertain to your level of satisfaction with any community meetings that you had attended in the days and weeks following the disaster. **If you did not attend any community meetings, you may skip this section.**

Question	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	N/A
I thought that the community meetings were informative.						
I thought that the community meetings gave people the opportunity to meaningfully connect with their public officials.						
I felt that the community meetings did not have enough two-way communication.						
I thought that community meetings were a waste of time.						
I was satisfied with the information I received at community meetings.						
I felt that the services and products offered at community meetings (e.g., hot food, free toiletries) were important.						

SECTION J: LONG-TERM RECOVERY PERIOD

The following questions pertain to the progress of disaster recovery in the last four months. Please select the response that best describes your actions and/or perceptions during this time period.

Question	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	N/A
I feel that the community is closer now than before the disaster.						
I worry that Goderich has permanently lost some of its historic charm.						
It makes me sad to visit the Square						
The landscape of downtown Goderich feels barren.						
I sometimes feel guilty because I wasn't affected by the storm as badly as others in the community.						
I believe that the disaster represents an opportunity for Goderich.						
I worry that any new development will not be as charming or beautiful as the buildings that we lost.						
The Square just doesn't feel the same without all of the trees.						
I avoid going into the hardest hit areas because it made me feel uncomfortable.						

Question (continued)	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	N/A
I don't feel as connected with my community as I did before the disaster.						
I feel that the disaster has brought out the best in people.						
I don't know if Goderich can ever truly recover from the tornado.						
I am closer with my friends and neighbors because of the tornado.						
I worry that affected business owners won't want to rebuild after the disaster.						
I feel like there is nothing I can do to help my community to recover from this disaster.						
I worry that people outside of the community will forget about yes, even though we still need recovery assistance.						
I still can't believe that this disaster happened to our town.						
I wish people would stop talking about the tornado so much.						
Overall, I felt that public officials did a good job in the four months since the disaster.						

1. Did you connect with your community using social media (e.g., Facebook, Twitter) in the days and weeks following the disaster?

- ☐ Yes
- ☐ No
- ☐ I'm not sure

SECTION K: DEMOGRAPHICS

The purpose of these questions is to place your answers to this questionnaire within the broader social context. Please remember that these questions are optional, and you may skip any that you do not wish to answer.

1. What is your gender?

- ☐ Male
- ☐ Female
- ☐ Other (please specify): _____

2. What is your age group?

- ☐ Less than 20
- ☐ 20-29
- ☐ 30-39
- ☐ 40-49
- ☐ 50-59
- ☐ 60 or older

3. What is your highest level(s) of education completed? *(select all that apply)*

- ☐ Elementary school
- ☐ High school
- ☐ Trade or technical certificate program
- ☐ College diploma/program
- ☐ University degree(s)
- ☐ Professional designation(s)

4. How much total combined income (before taxes) did all members of your household (aged 18+) earn in 2011?

- ☐ Less than $20,000
- ☐ $20,000 to $34,999
- ☐ $35,000 to $49,999
- ☐ $50,000 to $74,999
- ☐ $75,000 to $99,999
- ☐ $100,000 to $149,999
- ☐ $150,000 or more

5. Which of the following categories best describes your employment status prior to the time the tornado hit?

- ☐ Employed
- ☐ Not employed
- ☐ Student
- ☐ Retired
- ☐ Disabled, or not able to work

6. Which of the following best describes your living arrangement? *(please select one)*

- ☐ Goderich has been my primary residence for less than 5 years
- ☐ Goderich has been my primary residence for more than 5 years
- ☐ I have vacationed or spent summers in Goderich for less than 5 years
- ☐ I have vacationed or spent summers in Goderich for more than 5 years
- ☐ I do not live in Goderich
- ☐ Other (please specify): _____

7. Where did you learn about this research project? *(select all that apply)*

- ☐ Student researcher
- ☐ Facebook posting
- ☐ Other Internet posting
- ☐ Goderich Signal Star article
- ☐ Other newspaper article
- ☐ 104.9 The Beach
- ☐ Word of mouth
- ☐ Other (please specify): _____

8. Were you previously interviewed as a part of this project?

- ☐ Yes
- ☐ No
- ☐ I'm not sure.

References

Abramovitz JN. 2001. Unnatural Disasters. Worldwatch Paper #158. Washington, DC: Worldwatch Institute. 62 pp.

Adger WN. 1999. Social vulnerability to climate change and extremes in coastal Vietnam, *World Development* 27(2): 249-269.

Albrecht G. 2006. Solastalgia: environmental damage has made it possible to be homesick without leaving home. *Alternatives Journal* 32 (4/5): 34-36.

Allen DE. 1986. Tornado Damage in the Barrie/Orangeville Area, Ontario, May 1985. Building Research Note 240: National Research Council of Canada. 23 pp.

Ashley WS, Krmenec AJ, and Schwantes R. 2008. Vulnerability due to nocturnal tornadoes. *Weather and Forecasting* 23: 795-807.

Balluz L, Schieve L, Holmes T, Kiezak, S, and Malilay J. 2000. Predictors for person's response to a tornado warning: Arkansas, 1 March 1997. *Disasters* 24 (1): 71-77.

Banik SS, Hong HP, and Kopp GA. 2007. Tornado hazards assessment for southern Ontario. *Canadian Journal of Civil Engineering* 34: 830-842.

Barnett J and O'Neill S. 2010. Maladaptation. *Global Environmental Change* 20: 211-213.

Berkes F. 2007. Understanding uncertainty and reducing vulnerability: lessons from resilience thinking. *Natural Hazards* 41: 283-295

Berkes F and Jolly D. 2001. Adapting to climate change: socio-ecological resilience in a Canadian west arctic community. *Conservation Ecology* 5(2): 18.

Blanchard-Boehm RD and Cook MJ. 2004. Risk communication and public education in Edmonton, Alberta, Canada, on the 10th anniversary of the 'Black Friday' tornado. *International Research in Geographical and Environmental Education* 13: 38-54.

Burningham K, Fielding J, and Thrush D. 2008. 'It'll never happen to me': understanding public awareness of local flood risk. *Disasters* 32 (2): 216-238.

Burton I, Kates RW, and White GF. 1993. The Environment as Hazard, 2nd Edition. The Guilford Press: New York. 290 pp.

Cao Z and Cai H. 2008. Tornado frequency and its large-scale environments over Ontario, Canada. *The Open Atmospheric Science Journal* 2: 256-260

Cao Z and Cai H. 2011. Detection of tornado frequency trend over Ontario, Canada. *The Open Atmospheric Science Journal* 5: 27-31

Chamlee-Wright E and Storr VH. 2009. "There's no place like New Orleans": sense of place and community recovery in the Ninth Ward after Hurricane Katrina. *Journal of Urban Affairs* 31(5): 615-634

Coles E and Buckle P. 2004. Developing community resilience as a foundation for effective disaster recovery. *The Australian Journal of Emergency Management* 19(4): 6-15

Comstock RD and Mallonee S. 2005. Comparing reactions to two severe tornadoes in one Oklahoma community. *Disasters* 29 (3): 277-287.

Conrad C. 2009. Severe and Hazardous Weather in Canada: the Geography of Extreme Events. Oxford University Press: Toronto. 205 pp.

Cresswell, T. 2009. Place. *International Encyclopedia of Human Geography* 8: 169-177.

Cutter SL. 1996. Vulnerability to environmental hazards. *Progress in Human Geography* 20(4): 529-539

Daley WR, Brown S, Archer P, Kruger E, Jordan F, Batts D, and Mallonee S. 2005. Risk of tornado-related death and injury in Oklahoma, May 3, 1999. *American Journal of Epidemiology* 161: 1144-1150.

de Man A and Simpson-Housley P. 1987. Factors in the perception of tornado hazard: an exploratory study. *Social Behavior and Personality* 15 (1): 13-19.

Dillman DA, Smyth JD, and Christian LM. 2009. Internet, Mail, and Mixed-Mode Surveys: The Tailored Design Method. John Wiley & Sons Inc: New Jersey.

Donner WR. 2007. An integrated model of risk perception and protective action: public response to tornado warnings. Doctoral dissertation, Department of Sociology: University of Delaware. 212 pp.

Doswell C. 1999. Are warning lead times the most important issue in tornado events? *Weatherzine* 17: Internet posting. Accessed on-line on 18 April 2012 at: *http://sciencepolicy.colorado.edu/zine/archives/1-29/17/editorial.html*

Drobot SD, Benight C, and Gruntfest EC. 2007. Risk factors for driving into flooded roads. *Environmental Hazards* 7: 227-234.

Dunn K. 2010. Chapter 6: Interviewing. In I Hay (ed) *Qualitative Research Methods in Human Geography*, 3rd Edition. Oxford University Press: New York. 101-138.

Ehrenreich JH and McQuaide S. 2001. Coping with disasters: a guidebook to psychosocial intervention (revised edition). Centre for Psychology and Society: State University of New York. Accessed on-line on 12 July at: *http://www.mhwwb.org.*

Environment Canada. 2011a. Public Weather Warnings for Canada. Accessed on-line on 30 April at: *http://www.weatheroffice.gc.ca/warnings/warnings_e.html*

Environment Canada. 2011b. Summer hazards. Accessed on-line on 1 May, 2012 at: *http://www.ec.gc.ca/meteo-weather/default.asp?lang=En&n=6C5D4990-1*

Environment Canada. 2011c. News Releases: Ontario Weather Review. Accessed on-line on 09 April 2011 at: *http://www.ec.gc.ca/*

Etkin D, Brun SE, Shabbar A, and Joe P. 2001. Tornado Climatology of Canada Revisited: Tornado Activity During Different Phases of ENSO. *International Journal of Climatology* 21 (8): 915-938.

Ewald R and Guyer JL. 2002. The ideal lead-time for tornado warnings−a look from the customer's perspective. Publications, Agencies, and Staff of the U.S. Department of Commerce, Paper 39. 5 pp.

Folke C. 2006. Resilience: The emergency of a perspective for social-ecological systems analyses. *Global Environmental Change* 16: 253-267.

Ford J, Pearce T, Smit B, Wandel J, Allurut M, Shappa K, Ittusujurat H, and Qrunnut K. 2007. Reducing vulnerability to climate change in the Arctic: The case of Nunavut, Canada. *Arctic* 60(2): 150-166.

Gierlach E, Belsher BE, and Beutler LE. 2010. Cross-cultural differences in risk perceptions of disasters. *Risk Analysis* 30(10): 1539-1549.

Grazulis, TP. 2001. The Tornado: Nature's Ultimate Windstorm. Oklahoma University Press: Norman.

Hammer B and Schmidlin TW. 2002. Response to warnings during the 3 May 1999 Oklahoma City Tornado: reasons and relative injury rates. *Weather and Forecasting* 17: 577-581.

Hanson R. 2003. Actual versus perceived risk of hurricanes in Nova Scotia. Undergraduate honours thesis, Department of Geography, Saint Mary's University, Halifax, NS.

Hansson SO. 2010. Risk: objective or subjective, facts or values. *Journal of Risk Research* 13 (2): 231-238.

Harris R. 2012. Map of Goderich, Ontario. Commissioned for this thesis project, and used with permission.

Hyndman D, Hyndman D, and Catto N. 2009. *Natural Hazards and Disasters* 1st Canadian ed. Thomson Brooks/Cole: Toronto. 526 pp.

Hyvärinen O and Saltikoff E. 2010. Social media as a source of meteorological observations. *Monthly Weather Review* 138: 3175–3184.

Insurance Bureau of Canada (IBC). 2011. Media releases: Goderich tornado costs $75 million in insured damage. Accessed on-line on 9 May, 2012 at: *http://www.ibc.ca/en/media_centre/news_releases/2011/09-21-2011.asp*

Jefferson TL. 2006. Using the internet to communicate during a crisis. *The Journal of Information and Knowledge Management Systems* 36 (2): 139-142.

Kahneman D and Tversky A. 1979. Prospect theory: an analysis of decision under risk. *Ecibinetruca* 47: 263-291.

Kaltenborn, B.P. 1998. Effects of sense of place on responses to environmental impacts. A study among residents in Svalbard in the Norwegian high Arctic. *Applied Geography* 18 (2): 169-189.

Kaplan AM and Haelein M. 2010. Users of the world, unite! The challenges and opportunities of social media. *Business Horizons* 53: 59-68.

Keil M, Wallace L, Turk D, Dixon-Randall G, and Nulden U. 2000. An investigation of risk perception and risk propensity on the decision to continue a software development project. *The Journal of Systems and Software* 53: 145-157.

Koenig MA, Ahmed S, Hossain MB, and Mozumder ABM. 2003. Women's status and domestic violence in rural Bangladesh: individual- and community-level effects. *Demography* 40 (2): 269-288.

Liu S, Quenemoen LE, Malilay J, Noji E, Sinks T, and Mendlein J. 1996. Assessment of a severe-weather warning system and disaster preparedness, Calhoun County, Alabama, 1994. *American Journal of Public Health* 86(1): 87-89.

Maguire B and Hagan P. 2007. Disasters and communities: understanding social resilience. *The Australian Journal of Emergency Management* 22(2): 16-20.

McAdoo BG, Dengler L, Prasetya G and Titov V. 2006. Smong: How an oral history saved thousands on Indonesia's Simeulue Island during the December 2004 and March 2005 tsunamis. *Earthquake Spectra* 22 (53): 661-669.

McBean G. 2004. Climate change and extreme weather: a basis for action. *Natural Hazards* 31: 177-190.

McEntire DA. 2005. Why vulnerability matters: exploring the merit of an inclusive disaster reduction concept. *Disaster Prevention and Management* 14 (2): 206-222.

McGillivray, B. 2010. Canada: A Nation of Regions, 2nd Edition. Oxford University Press: Don Mills. 386 pp.

McGuirk PM and O'Neill P. 2010. Chapter 10: Using Questionnaires in Qualitative Human Geography. In I Hay (ed) *Qualitative Research Methods in Human Geography*, 3rd Edition. Oxford University Press: New York. 191-216.

Mileti DS and Sorensen JH. 1987. Natural hazards and precautionary behaviour. In ND Weinstein (ed) *Taking Care: Understanding and Encouraging Self-Protective Behavior*. Cambridge University Press: New York, 189-207.

Miller DS and Rivera JD. 2007. Landscapes of disaster and place orientation in the aftermath of Hurricane Katrina. In DL Brunsma, D Overfelt, and JS Picou (eds) The Sociology of Katrina: Perspectives on a Modern Catastrophe. Rowman & Littlefield Publishers: Maryland, USA: 141-154.

Moore S, Daniel M, Linnan L, Campbell M, Benedict S, and Meier A. 2004. After Hurricane Floyd passed: Investigating the social determinants of disaster preparedness and recovery. *Family and Community Health* 27(3): 204-217.

Murphy B, Falkiner L, McBean G, Dolan H, and Kovacs P. 2005. Enhancing local level emergency management: the influence of disaster experience and the role of households and neighbourhoods. Institute for Catastrophic Loss Reduction Paper Series No. 43. 74 pp.

Munich Re. 2002. Topics – Annual Review: Natural Catastrophes 2002. Munich Reinsurance Group: Munich, Germany. 44 pp.

National Oceanic and Atmospheric Administration (NOAA). 2010. Thunderstorms, tornadoes, and lightning: nature's most violent storms. A preparedness guide. Accessed on-line on 8 August 2012 at: *http://www.nws.noaa.gov*

National Oceanic and Atmospheric Administration (NOAA). 2011. NOAA Economics of Hail. Accessed on-line on 03 June 2011 at: *http://www.economics.noaa.gov*

Natural Resources Canada. 2009. The atlas of Canada: major tornadoes. Accessed on-line on 2 May, 2012 at: *http://atlas.nrcan.gc.ca/*

Norris FH, Phifer J, and Kaniasty K. 1994. Individual and community reactions to the Kentucky floods: Findings from a longitudinal study of older adults. In R Ursano, B McCaughey, and C Fullerton *(eds)* Individual and Community Responses to Trauma and Disaster: The Structure of Human Chaos. Cambridge: Cambridge University Press. 378-400.

Norris FH, Stevens SP, Pfefferbaum B, Wyche KF, and Pfefferbaum RL. 2008. Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. *American Journal of Community Psychology* 41: 127-150.

O'Brien G, O'Keefe P, Rose J, and Wisner, B. 2006. Climate change and disaster management. *Disaster* 30(1): 64-80.

Otway H and Thomas K. 1982. Reflections of risk perception and policy. *Risk Analysis* 2 (2): 69-82.

Paton D, Millar M, and Johnston D. 2001. Community resilience to volcanic hazard consequences. *Natural Hazards* 24: 157-169.

Paton D, Smith L, Daly M, and Johnston D. 2008. Risk perception and volcanic hazard mitigation: individual and social perspectives. *Journal of Volcanology and Geothermal Research* 172: 179-188.

Pearce TD, Ford JD, Laidler GJ, Smit B, Duerden F, Allarut M, Andrachuk M, Baryluk S, Dialla A, Elee P, Goose A, Ikummaq T, Joamie E, Kataoyak F, Loring E, Meakin S, Nickels S, Shappa K, Shirley J, and Wandel J. 2009. Community collaboration and climate change research in the Canadian Arctic. *Polar Research* 28: 10-27.

Pennings JME and Grossman DB. 2008. Responding to crises and disasters: the role of risk attitudes and risk perceptions. *Disasters* 32 (2): 434-448.

Sampson RJ and Lauritsen JL. 1994. Violent victimization and offending: individual-, situational-, and community-level risk factors. In AJ Reiss Jr. and JA Roth *(eds)* Understanding and Preventing Violence: Volume 3 Social Influences. National Academy Press: Washington, D.C.: 1-115.

Sax LJ, Gilmartin SK, and Bryant AN. 2003. Assessing response rates and nonresponse bias in web and paper surveys. *Research in Higher Education* 44 (4): 409-432

Schmidlin TW, Hammer BO, Ono Y, and King PS. 2009. Tornado shelter-seeking behaviour and tornado shelter options among mobile home residents in the United States. *Natural Hazards* 48: 191-201.

Sheridan SC. 2007. A survey of public perception and response to heat warnings across four North American cities: an evaluation of municipal effectiveness. *International Journal of Biometeorology* 52: 3-15.

Sherman-Morris K. 2005. Tornadoes, television and trust–a closer look at the influence of the local weathercaster during severe weather. *Environmental Hazards* 6: 201-210.

Sherman-Morris K. 2010. Tornado warning dissemination and response at a university campus. *Natural Hazards* 52 (3): 623-638.

Silver A and Conrad C. 2010. Public perception of and response to severe weather warnings in Nova Scotia, Canada. Meteorological Applications 17(2): 173-179.

Simmons K and Sutter D. 2008. Tornado warnings, lead times, and tornado causalities: an empirical investigation. *Weather and Forecasting* 23: 246-258

Simmons K and Sutter D. 2009. False alarms, tornado warnings, and tornado causalities. *Weather, Climate, and Society* 1: 38-53

Sitkin SB and Pablo AL. 1992. Reconceptualizing the determinants of risk behavior. *The Academy of Management Review* 17 (1): 9-38.

Sitkin SB and Weingart LR. 1995. Determinants of risky decision-making behavior: A test of the mediating role of risk perceptions and propensity. *The Academy of Management Journal* 38 (6): 1573-1592.

Sjöberg L. 2000. Factors in risk perception. *Risk Analysis* 20 (1): 1-11

Slovic P. 1987. Perception of risk. *Science* 236 (4799): 280-285.

Slovic P and Weber EU. 2002. Perception of risk posed by extreme events. Paper presentation at the conference *Risk Management Strategies in an Uncertain World*, Palisades, New York. April 12-13.

Smit B, Burton I, Klein RJT, and Wandel J. 2000. An anatomy of adaptation to climate change and variability. *Climatic Change* 45: 223-251.

Smit B and Wandel J. 2006. Adaptation, adaptive capacity and vulnerability. *Global Environmental Change* 16: 282-292.

Smith K. 2010. Natural hazards - the Acts of God paradigm. Available on-line at: *http://www.libraryindex.com/pages/3352/Natural-Hazards.html*

Smith K and Petley DN. 2009. *Environmental Hazards: Assessing risk and reducing disaster*. Routledge: New York. 383 pp.

Stalker SL, Lazrus H, Kuhlman K, Peppler R, and Klockow K. 2011. Public response to the 10 May 2010 Norman, Oklahoma tornado. On-line report. Accessed from the Center for Analysis and Prediction of Storms: University of Oklahoma on 14 May 2012 at: http://*www.caps.ou.edu/reu/reu10/papers/Stalker.pdf*

Starr C. 1969. Social benefit versus technological risk. What is our society willing to pay for safety? *Science* 165: 1232−1238.

Stensrud DJ, Xue M, Wicker, LJ, Kelleher KE, Foster MP, Schaefer JT, Schneider RS, Benjamin SG, Weygandt SS, Ferree JT, and Tuell JP. 2009. Convective-scale warn on forecast: a vision for 2020. *Bulletin of the American Meteorological Society* 90: 1487.

Statistics Canada. 2006a. Population density of Canada (map). Accessed on-line on 12 June 2012 at: *http://atlas.nrcan.gc.ca*

Statistics Canada. 2006b. Community profile for Goderich, Ontario. Accessed 15 June 2012 at: *http://www.statcan.gc.ca*

Statistics Canada. 2011. Community profile for Goderich, Ontario. Accessed 15 June 2012 at: *http://www.statcan.gc.ca*

Stockton A. 2011. F3 tornado aftermath in Goderich: like a war zone. Accessed on 2 May, 2012 at: *http://www.theweathernetwork.com/archive/*

Storm Prediction Center (SPC). 2004. A recommendation for an Enhanced Fujita Scale (EF-scale). Accessed on-line on 01 June, 2011 at: *http://www.spc.noaa.gov/efscale/ef-ttu.pdf*

Sutter D and Simmons KM. 2010. Tornado fatalities and mobile homes in the United States. *Natural Hazards* 53: 125-137

Tekeli-Yeşil S, Dedeoğlu N, Tanner M, Braun-Fahrlaender C, and Obrist B. 2010. Individual preparedness and mitigation actions for a predicted earthquake in Istanbul. *Disasters* 34(4): 910-930.

Tompkins EL and Adger WN. 2003. Building resilience to climate change through adaptive management of natural resources. Tyndall Centre Working Paper #27. 23 pp.

Underwood D, Kim H, and Matier M. 2000. To mail or to Web: Comparisons of survey response rates and respondent characteristics. Paper presented at the 40th Annual Forum of the Association for Institutional Research, Cincinnati, Ohio, May 21–24.

United Nations International Strategy for Disaster Reduction (UN/ISDR). 2008. Climate change and disaster risk reduction. UN/ISDR Briefing Note #01. Geneva, Switzerland: United Nations. 12 pp.

United Way (of Bruce Grey). 2012. Goderich Ontario tornado - August 21st, 2011 post disaster response brief. Published by Community Connection in association with Huron County. Available on-line at: *http://www.unitedwayofbrucegrey.com/community-library*

Warner J, Waalewijn P, and Hilhorst D. 2002. Public participation for disaster-prone watersheds: time for multi-stakeholder platforms? *Water and Climate Dialogue Thematic Paper 6.* Wageningen: Wageningen University.

Weinstein ND. 1980. Unrealistic optimism about future life events. *Journal of Personality and Social Psychology* 39 (5): 806-820.

White GF. 1945. Human Adjustment to Floods. Department of Geography Research Paper no. 29. Chicago: The University of Chicago.

Wildavsky A and Dake K. 1990. Theories of risk perception: Who fears what and why? *Daedalus* 119 (4): 41-60.

Williams DJ. 2007. Chapter 4: Risk and decision making. In Cook M, Noyes J, and Masakowski Y (eds) Decision Making in Complex Environments, Ashgate Publishing Company: Burlington, Vermont.

Williams DJ and Noyes JM. 2007. How does our perception of risk influence decision-making? Implications for the design of risk information. *Theoretical Issues in Ergonomics Science* 8 (1): 1-35.

Wisner B, Blaikie P, Cannon T, and Davis I. 2004. At risk: natural hazards, people's vulnerability and disasters, 2nd Edition. Routledge: London. 471 pp.

Wong KFE. 2005. The role of risk in making decisions under escalation situations. *Applied Psychology: An International Review* 54(4): 584-607.

Wong, TF and Yan YY. 2002. Perceptions of severe weather warnings in Hong Kong. *Meteorological Applications* 9: 377-382.

Wunderground.com. 2011. Radar reflectivity for Goderich, Ontario on August 21st, 2011 (used with permission). Accessed on-line on 8 May 2012 at: *http://www.wunderground.com/radar/*

Zeigler DJ, Brunn SD, and Johnson JH. 1996. Focusing on Hurricane Andrew through the eyes of the victims. *Area* 28(2): 124-129.

Zhang F, Morss RE, Sippel JA, Beckman TK, Clements NC, Hampshire NL, Harvey JN, Hernandez JM, Morgan ZC, Mosier RM, Wang S, and Winkley SD. 2007. An in-person survey investigating public perceptions of and responses to Hurricane Rita forecasts along the Texas Coast. *Weather and Forecasting* 22: 1177-1190.