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Science or Fiction: The Persistence of Disaster Myths in Hollywood Films

Jennifer J. Haney*

Bloomsburg University of Pennsylvania

Claire Havice

University of Wisconsin-Madison

and

Jerry T. Mitchell

University of South Carolina

Email: jhaney@bloomu.edu

Hollywood continues to be both profitable and successful in attracting audiences to witness displays of death and destruction on the silver screen. Tornadoes, earthquakes, tsunami hazards, and climate change are among the most recent hazards portrayed in disaster films. The purpose of our research was to systematically collect and analyze physical, social, and temporal data from twelve disaster films to build upon past studies examining the portrayal of disaster. Our findings indicate a clear shift from those identified in earlier studies, with disaster myths (e.g. the importance of death tolls; technology as the only solution) appearing more than previously. Further, current trends in the disaster film genre indicate a shift toward unpredictable, widespread events and a defenseless humanity.

Keywords: Disaster film, myth, popular culture.

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Science or Fiction: The Persistence of Disaster Myths in Hollywood Films

The story is the same, humans pitted against nature or threats of their own making, but Hollywood routinely finds a way to put a new spin on the subject. For example, the 2017 film *Geostorm* centers on a network of satellites that control the world's climate. The technology soon turns on its creator and begins to attack Earth, creating a worldwide storm with the ability to wipe out all of humanity. Although many of these film blockbusters lack scientific accuracy, Hollywood's fascination with the disaster film genre has not waned; these films continue to be lucrative and attract viewers by the thousands.

Few people directly experience a disaster in their lifetime and may instead rely on the spectacular images of destruction and chaos portrayed in disaster films like *San Andreas* (2015) and *The Day After Tomorrow* (2004) to shape their perceptions of risk. This is problematic as fictional accounts of disaster may lead to incorrect information and confusion over which protective actions to take in a disaster. As such, people relying on Hollywood to shape their risk perception may lead to real world consequences and increased losses from disasters. (Bahk and Neuwirth 2000; Dunn et al. 2016; Liverman and Sherman 1985; Mitchell et al. 2000; Quarantelli 1980; Sjoberg and Engelberg 2010).

The purpose of our research was to systematically collect and analyze physical, social, and temporal data from disaster films to build upon past studies that examined the portrayal of disaster in popular films. The first research done on disaster films was conducted by Quarantelli (1985) which produced the first empirical data on disaster films. This was followed up by Jones (1993) who examined popular disaster myths in cinema. More recently, researchers from the University of South Carolina (Mitchell et al. 2000) established a framework based on Quarantelli's film selection criteria, as well as the myths identified by Jones. For our research, we chose to place greater emphasis on Quarantelli's original findings while continuing to use Mitchell et al.'s updated methodology.

Our objectives were to determine the frequency of myths in film and to find examples within that contradict appropriate responses from the affected populations. Myths are perpetuated heavily throughout the films, often alongside the facts, which creates a unique challenge for viewers to distinguish between Hollywood's creative liberties and reality.

LITERATURE REVIEW

Arguably, popular culture is more important today than ever before with the diffusion and use of technologies like social media and smartphones that allow people around the globe to connect with each other. While these tools have undoubtedly made information widely accessible and communication simpler and more convenient, they also can make us less aware of the hazards all around us. Challenges posed by social media include the

spread of misinformation and rumors, information distribution and reception, and difficulty navigating posts to find relevant content (Liu et al. 2019; Starbird et al. 2014; Wang and Zhuang 2017; 2018). Popular culture penetrates our lives to the point where it is both intimate and familiar, yet we are unaware of its effect. Couch (2000) argues that:

[P]opular culture greatly influences our norms, beliefs, and subsequent actions about everything, including disasters. It helps us frame disasters, give them meaning, and make them understandable, intelligible, and perhaps controllable. It gives us the cultural tools and collective visions through which meaning is constructed and blame assigned. It tells us how we are supposed to act under duress and how we supposedly do (p. 25).

The popular culture of disaster encompasses not just disaster films but a variety of material and non-material items including disaster songs, poems, graffiti, comics and cartoons, disaster novels, and folk legends and beliefs about disasters (Quarantelli and Davis 2011; Webb 2006). Given the multitude of popular culture products that center on disaster, it is important to consider their ability to convey harmful myths, inaccuracies, and stereotypes that may have a negative impact on individual preparedness and response measures. This is particularly the case for both disaster films and novels, two of the most common popular culture products. There are five disaster myths that have been identified (Jones 1993) and applied to the disaster film genre by Mitchell et al. (2000): (1) dramatic high energy events not necessarily significant in global terms; (2) large scale impacts rather than small events; (3) using death tolls as the most reliable statistic; (4) the unpredictability of natural events and powerlessness of humans; and (5) the technocratic approach as the most valued solution. A framework was developed utilizing temporal, social, and physical characteristics to identify the presence of these myths, inaccuracies, and stereotypes in disaster films (Quarantelli 1985). To add to the confusion surrounding the popular culture of disasters, real events are often represented, making it increasingly difficult for audiences to differentiate between fact and fiction.

While disaster films perpetuate myths about human responses to disaster and suggest that widespread panic characterized by high levels of crime, looting, and anti-social behavior follows an event, research has shown that rarely are these behaviors observed in disasters (Clarke 2002; Fischer 2008; Liverman and Sherman 1985; Quarantelli 1960; 1985; Quarantelli and Dynes 1972; 1973; Tierney 2003; Tierney, Bevc, and Kuligowski 2006; Wenger et al. 1975). Instead studies have shown that after disaster, pro-social behavior marked by altruism, community support, and cooperation prevails (Drabek 1986; Dynes 1970; Fritz 1961; Rodríguez, Trainor, and Quarantelli 2006; Tierney, Lindell, and Perry 2001). Vulnerable populations are often invisible in disaster films or if present, serve to promote negative stereotypes about race, ethnicity, social class, and gender (Quarantelli 1985). Recent research also highlights the absence of lesbian, gay, bisexual, and transgender (LGBT) characters in the disaster film genre (McKinnon 2017).

The majority of myths perpetuated in disaster films center on the human or social

responses to the events; however, one area that is often overlooked is geography. Many Hollywood blockbusters like *San Andreas* and *2012* imply that the damages from devastating earthquakes, volcanoes, and tsunami hazards are spatially concentrated in only large, developed and economically advantaged cities such as San Francisco and Los Angeles. According to the United Nations Office for Disaster Risk Reduction (2014), “By 2050, 70% of the world’s population will live in urban areas. As cities continue to grow, exposure of lives, livelihoods, and economic, social, and environmental assets is set to increase exponentially.” While numerous studies have suggested the most vulnerable urban inhabitants are the poor and politically marginalized, less glamorous locations like Port-au-Prince, Haiti and Banda Aceh, Indonesia rarely find their way into disaster films (Blaikie et al. 1994; Centre for Research on the Epidemiology of Disasters [CRED] 2016; Cutter, Boruff, and Shirley 2003; Pelling 2003; 2011). Over 450,000 people died as a result of disasters in these two locations due to a combination of geography, geology, poor quality construction, a lack of education, and a lower socioeconomic status (CRED 2016).

There is a geographic pattern to disaster mortality in the United States, although it is not what the disaster film genre would have us believe. Chronic hazards like heat and severe weather (both winter and summer) rather than acute hazards such as earthquakes and floods account for the majority of hazard-related fatalities there. In addition, the places most prone to deaths from hazards are located in the South and Intermountain regions. Clusters of high mortality from hazards were observed in the upper Great Plains, the lower Mississippi Valley, the Mountain West, parts of west Texas, and in the Florida Panhandle (Borden and Cutter 2008).

Recent efforts undertaken by government agencies and research institutions highlight the growing importance of debunking disaster myths perpetuated by popular culture and disaster subcultures. Moore (1964:195) introduced this latter concept, referring to “those adjustments, actual and potential, social, psychological, and physical, which are used by residents of such areas to cope with disasters which have struck or which tradition indicates may strike in the future”.

For example, the Southern California Earthquake Center at the University of Southern California created the Earthquake Country Alliance (ECA) in 2003 whose mission is to “support and coordinate efforts which improve earthquake and tsunami resilience” (Southern California Earthquake Center 2018). Known for organizing the Great California ShakeOut earthquake exercise, the ECA has a number of useful resources on their website that promote their mission. One of the latest additions to their website is entitled “San Andreas: Hollywood Fantasy is Not California Reality”, a page that aims to separate fact from fiction by educating individuals about earthquake science and the safety messages conveyed in the film. The National Weather Service (NWS) took a similar approach and added a “Severe Weather Facts and Myths” section to their website in an effort to combat misinformation and improve public safety in hazard-prone areas (NWS 2017). A study by Von Burg (2012) highlighted efforts undertaken by a combination of scientific organizations and environmental advocacy groups to address

the scientific credibility of the events portrayed in *The Day After Tomorrow*. Individually, the Woods Hole Oceanographic Institute, the National Snow and Ice Data Center, the Union of Concerned Scientists, Greenpeace International, and the Natural Resources Defense Council all published information on their websites aimed at correcting the film's flawed science regarding the likely effects of global climate change.

The fact that government organizations, research centers, and the scientific community must constantly work to correct erroneous information that is conveyed in popular film underscores the importance that popular culture potentially has on human behavior. Sadly, this effort must continue as Perkowitz (2007) argues that television, film, and magazines account for Americans' main source of scientific information rather than scientific articles and reports. It is necessary to understand the implications that popular culture has on disaster knowledge, risk perception, and behavior in society. By doing so, we may in fact improve disaster response efforts, reduce vulnerability, and increase resilience to future events (Alexander 2007; Bahk and Neukirk 2000; Mitchell et al. 2000; Nogami 2018; Webb 2006; 2018).

The Climate of Hollywood is Changing

Tinseltown has not grown tired of the disaster storyline, but a new trend has emerged in the disaster film genre that focuses on the impacts of global climate change. Climate fiction (or "cli-fi") encompasses both novels and films, with *The Day After Tomorrow* hailed as the most popular feature film to date on the subject matter. This marks a shift in the disaster film genre away from the acute, high consequence-low probability hazard events portrayed in 1990s films like *Dante's Peak* (1997) and *Deep Impact* (1998) to chronic threats that suggest that human behavior is to blame for nature's fury. Keane (2006: 96) argues that *The Day After Tomorrow* is particularly notable because of its "relatively serious approach to the subject matter and subsequent spectacle". In an effort to distance the film from a comparison to the terrorism events of 9/11 in the United States, director Roland Emmerich set his sights on global catastrophe. However, unlike his previous film *Independence Day* (1996), which spared no city from annihilation, Emmerich was sensitive to the impacts of those tragic events as he not only featured New York City as a prime location within the film, but also used the Statue of Liberty as a symbol to portray the resilience of the city in the face of calamity.

Despite the fundamental shift in the choice of hazard, like with all Hollywood disaster films, a primary goal of *The Day After Tomorrow* was to tell a compelling story with striking visual imagery. Unfortunately, accurate science is simply not a requirement to achieve blockbuster status (Christensen 2019; Kirby 2003; 2008; 2011; 2014; Perkowitz 2007; Svoboda 2016). This can have negative impacts on scientific literacy and public perceptions of science thus influencing attitudes and behaviors (Kirby 2014; Perkowitz 2007). There have been numerous studies examining the influence of *The Day After Tomorrow* on public attitudes and perceptions of climate change among viewers in the United States (Leiserowitz 2004), Germany (Reusswig, Schwarzkopf, and Pohlenz 2004),

and the United Kingdom (Balmford et al. 2004; Lowe et al. 2006). While the results stressed a range of cultural, social, and political factors influencing perceptions of risk and climate change in audiences, the film did not serve to generate a change in behavior. Further, Sakellari's (2015) analysis of three climate change films, *The Day After Tomorrow*, *An Inconvenient Truth*, and *The Age of Stupid*, indicate that they were unsuccessful in altering people's attitudes and behavior given their fearful framing of climate change and failure to establish the issue of trust in climate change communication. All of the aforementioned studies did however increase awareness about the potential impacts of climate change.

Representations of Science in Popular Film

Research suggests that popular films significantly influence individual's views by shaping, refining, or strengthening cultural meanings of science (Kirby 2014). The use of popular films in the classroom has received mixed reviews. Some scholars argue that using popular fictional disaster films like *Twister*, *The Day After Tomorrow*, and *The Perfect Storm* can be helpful in teaching scientific concepts and correcting misinformation in addition to sparking student interest in science and technology-related course content (Barnett and Kafka 2007; Blickenstaff 2011; Kendra, Siebeneck, and Andrew 2018; Laprise and Winrich 2010; Monfredo 2010; Perkowitz 2007; Yow 2014). Given that teens in the United States (and likely some elsewhere) are averaging nine hours of screen time per day (Tsukayama 2015), Barnett and Kafka (2007) argue that it would be beneficial for students to learn how to critically evaluate visual media in introductory college science courses. Barnett and Kafka (2007) incorporated film clips from *The Core* (2003) and *Red Planet* (2003) in an interdisciplinary, introductory science course to assist students in understanding scientific concepts and engage students in discussion of scientific plausibility. Students reported that the films and film clips kept them interested and contributed to a better understanding of course concepts.

Others disagree with the effectiveness of fictional films as pedagogical tools in the sciences. Barnett et al. (2006) argue that the primary purpose of fictional films and other forms of popular visual media are to entertain rather than educate an audience. However, studies suggest that even though individuals are aware of the filmmakers' intention, viewing can change one's perception or understanding of science (Bahk 2001; Pappas et al. 2003; Tomes 2000). For example, Barnett et al. (2006) found that students who watched *The Core* showed numerous misunderstandings of Earth science concepts compared to students who did not watch the film. Moreover, the authors emphasize that just a single viewing of the film can negatively affect student perceptions and understanding of scientific phenomena.

The Day After Tomorrow and *The Core* are the most frequently cited popular fictional disaster films that communicate scores of scientific inaccuracies (Keane 2006; Perkowitz 2007). *The Day After Tomorrow* is often criticized for the aggrandized and accelerated collapse of the Thermohaline Circulation (THC), which in reality would occur over

several decades rather than days (Keane 2006; Perkowitz 2007). Further the film shows the scientifically impossible: hurricanes and tropical storms with central eyes developing over landmasses (Perkowitz 2007). In a similar vein, *The Core* abandons all scientific accuracy and plausibility subsequent to a description of Earth's internal layers (Perkowitz 2007). Explanations and examples of microwave radiation and the electromagnetic field as contributors to the disaster are among the erroneous information presented in this fictional film.

In addition to scientific content, studies show that the depiction of scientists in popular films also can influence public perceptions. Overwhelmingly, scientists have been portrayed negatively in fictional films with the mad scientist and the powerless scientist prevailing among the identified stereotypes (Kirby 2017). Kirby argues that these myths are recurrent because audiences are trained to spot scientific characters with the help of visual cues like the white lab coat, glasses, and disheveled appearance. However, over the last 25 years, real life scientists have become more involved with Hollywood by serving as consultants on major films and television series like *Contagion* (2011) and *Breaking Bad* (2008-13), which suggests that audiences are demanding more scientific realism (Frank 2003; Kirby 2003; 2011; 2017).

METHODS

Continuing where previous research had left off (Mitchell et al. 2000), we followed an established selection criteria and consequently identified 12 suitable films released between 2000 and 2016, including *The Perfect Storm* (2000), *The Core* (2003), *The Day After Tomorrow* (2004), *Poseidon* (2006), *2012* (2009), *Contagion* (2011), *Aftershock* (2012), *The Impossible* (2012), *Into the Storm* (2014), *San Andreas* (2015), *The 33* (2015), and *Deepwater Horizon* (2016). The selected films are United States' productions that place the disaster in the spotlight. In addition, following Quarantelli's (1985) definition for a disaster film, they are not categorized as war, terrorism, science fiction, comedy, or satire films. Each film was reviewed by three to five individuals who were responsible for documenting the duration of disaster impact time periods (Quarantelli 1985) and the presence of hazard myths (Jones 1993). The five myths include the following: (1) dramatic high energy events not necessarily significant in global terms; (2) large scale impacts rather than small events; (3) using death tolls as the most reliable statistic; (4) the unpredictability of natural events and powerlessness of humans; and (5) the technocratic approach as the most valued solution. Unique social and physical characteristics, such as preparedness and magnitude of impact, associated with each time period also were accounted for during the review (Table 1). Social characteristics include preparedness and warning (pre-impact), inventory and emergency response (trans-impact), and restoration and recovery (post-impact). Physical characteristics include the nature of hazard(s) and forewarning cues (pre-impact), magnitude of impact and scope of damage (trans-impact), and residential effects and controllability (post-impact). Individual

findings were then evaluated, discussed, and confirmed as a group, then compared to past findings.

Table 1. Disaster Characteristics by Time Period (Quarantelli 1985)

Period	Physical Aspects	Social Aspects
Pre-Impact	Nature of hazard Forewarning cues	Preparedness Warning
Trans-Impact	Magnitude of impact Scope of damage	Inventory Emergency response
Post-Impact	Residual effects Controllability	Restoration Recovery

RESULTS AND DISCUSSION

Myths

Myth frequency was calculated from data collected for Mitchell et al.'s (2000) work, then compared with our findings. The data reveal that more myths are being perpetuated in film than before. We noted a substantive change in myth frequency, over 20%, present in three of the five myths. Every film contained a minimum of two myths, with an average of three (Table 2). Only one film, *Poseidon*, depicted all five myths. Limitations of the study include a lack of quantitative data on impact periods from the Quarantelli (1985) and Mitchell et al. (2000) studies. When comparing the impact periods to past findings, we focused on qualitative data.

Table 2. Disaster Myths Present in Selected Films, 2000-2016

Film	Myth 1	Myth 2	Myth 3	Myth 4	Myth 5
The Perfect Storm	V			V	
The Core		V		V	V
The Day After Tomorrow		V		V	V
Poseidon	V	V	V	V	V
2012		V	V	V	V
Contagion		V	V	V	V
Aftershock	V	V		V	
The Impossible	V	V		V	
Into the Storm	V	V		V	V
San Andreas	V	V		V	V
The 33	V			V	V
Deepwater Horizon	V	V			
Myth Frequency in Selected Films, 2000-2016	67%	83%	25%	92%	67%
Myth Frequency in Selected Films, 1990-1999	73%	55%	45%	64%	55%

Note: Myth 1: Dramatic high energy events not necessarily significant in global terms; Myth 2: Large scale impacts rather than small events; Myth 3: Using death tolls as the most reliable statistic; Myth 4: The unpredictability of natural events and powerlessness of humans; Myth 5: The technocratic approach as the most valued solution. Data for Myth Frequency in Selected Films, 1990-1999 were obtained from Mitchell et al. (2000).

Myth 1: Dramatic high energy events not necessarily significant in global terms

This myth is present in 67% of the films, as the majority of disasters occur on a local or regional scale. Half of the films that perpetuate this myth are based on real life events, such as the 2010 Deepwater Horizon explosion and subsequent oil spill (*Deepwater Horizon*), 2004 Indian Ocean earthquake and tsunami (*The Impossible*), and 1991 Perfect Storm (*The Perfect Storm*). Although the films focus on a small-scale, the impact of the actual events were much farther reaching. A good example of this is *Deepwater Horizon*, as the film chooses to focus primarily on the crew. However, completely absent from the film are the health, economic, and environmental consequences of the oil spill associated with those both directly and indirectly exposed. Since the Mitchell et al. (2000) study, Myth 1 has decreased in frequency by 6% as more films focus on global issues such as climate change and pandemics. This decrease is likely motivated by real events such as the 2009 H1N1 pandemic (also known as swine flu) that preceded *Contagion* (2011), a biological disaster movie about a virus quickly leading to pandemic.

Myth 2: Large scale impacts rather than small events

Although the geographic extent of the disasters tends to be on the smaller side, the events themselves are large-scale, as Myth 2 occurs in 83% of films. One example of a large-scale event that is becoming increasingly present in film is climate change. One consequence of global warming is noted in *The Day After Tomorrow*, as the North Atlantic Current becomes disrupted and causes a new ice age. Surprisingly, there is a bit of truth behind the story and it has led to a nearly annual resurgence of *The Day After Tomorrow* being referenced in articles published by the media and academics alike (Mack 2018; Tyrell 2017). While it is unlikely for the events portrayed in *The Day After Tomorrow* to occur as they are presented, warming does alter ocean circulation and cause more extreme weather. Since the Mitchell et al. (2000) study, the frequency of Myth 2 increased by 29%.

Myth 3: Using death tolls as the most reliable statistic

This myth appears in less than 50% of the films. In the majority of the selected films, physical metrics, such as the Saffir-Simpson and Enhanced-Fujita scales, replaced the death toll as the supposed most reliable statistic. Despite this shift, we observed a high number of reported and on-screen deaths. The frequency of Myth 3 fell by 20% since the Mitchell et al. (2000) study, as death tolls were replaced with physical metrics. The film *Into the Storm* had on-screen deaths, but an official death toll was never reported. Instead the severity of the disaster is measured by hail size, wind speed, distance traveled, the Enhanced-Fujita scale, and by comparison to other extreme, record-breaking events. Only two films, *Contagion* and *2012*, report the death toll. The film *Poseidon*, which also perpetuated this myth, did not rely on a death toll. However, death was the primary method of measuring the impact of the disaster. Out of all the passengers onboard the

cruise ship, only six survive—and they are all white. In *2012*, almost everyone, except the extremely wealthy and powerful, perish. One film, however, took a different approach to death, as *Contagion* took the lives of the young and old, the rich and poor, and even medical professionals. Unlike *Poseidon* and *2012*, no amount of quick thinking and money could guarantee survival.

Myth 4: The unpredictability of natural events and powerlessness of humans

This myth has been manifested in many ways, ranging from prayers for divine intervention to subtly placed religious iconography and a total disregard for warnings. The unpredictability of disasters and the powerlessness of humans has become a core theme within the genre, as Myth 4 takes place in 92% of films reviewed. As expected with an influx of films prioritizing widespread devastation, the unpredictability of disasters and powerlessness of humans became more common. Since the Mitchell et al. (2000) study, we have seen Myth 4 increase in frequency by 28%. In *The 33* we observed miners sign the cross before entering the mine, paying their respects to a statue of Saint Anne (the patron saint of miners), rosaries hanging from the personnel carrier vehicle, and a priest accompanying the miners into the mine. In some films, a warning was available before the disaster occurred. Occasionally this was presented as no more than a forewarning that something was not quite right, but in other instances an actual siren or alert sounded to indicate danger was imminent. Even in these instances where the best possible warning was given, we see that people did not always take them seriously. This is seen in the film *Aftershock*, as the funicular operator states that, “Every ten years we have tsunami warnings and it never happens.” Both *Into the Storm* and *The Perfect Storm* showed hazardous conditions early on, but the disasters were far more devastating than forecasted. In all three of these films, it should be noted that the disaster was far more severe than previous events.

Myth 5: The technocratic approach as the most valued solution

This myth occurs at a frequency of 67%, as the majority of disasters require technology in order to be resolved. The use of technology to address disasters has become slightly more common since the Mitchell et al. (2000) study, as Myth 5 increased by 12%. The film *2012* relied entirely on technology to identify and confirm the hazard, then later reappears as a solution to the disaster. Technology provided the means to guarantee the survival of over 400,000 individuals during an event which would have otherwise led to the extinction of humanity. In *The 33*, which is based on a true story, scientists and engineers rally to rescue the trapped miners using various technological methods. Technology kept the miners alive and boosted morale while they were trapped, as supplies such as food, water, and iPods were sent into the mine through a small drilled opening. Geologic mapping allowed rescuers to determine the safest path to drill, and to do so accurately, to ensure the best chance of survival. In the end, everyone was rescued

by pulling each miner up to the surface inside a metal capsule. Without the use of technology, it was implied that the miners would likely perish due to the structural weaknesses in the mine.

Impact Periods

The findings from our research indicate a clear shift from the average duration of each period identified in earlier studies (Mitchell et al. 2000; Quarantelli 1985). Previously the longest period was the pre-impact, which serves to establish characters and develop the story. Now the trans-impact period is over twice as long as the pre-impact, with high-intensity action scenes given priority (see Table 3). In one instance, the time periods were presented out of chronological order. *Contagion* began with the trans-impact period and ended in the pre-impact period. In every impact period the physical aspects of the disaster were more likely to be depicted than the social aspects. All twelve films contain natural hazards, with the exception of *Deepwater Horizon* in which the disaster is caused by a human-induced, technological hazard.

Table 3. Films Reviewed and Impact Periods in Minutes, 2000-2016

Film	Pre-Impact	Trans-Impact	Post-Impact
The Perfect Storm	75	41	6
The Core	47	70	9
The Day After Tomorrow	8	106	1
Poseidon	16	81	0
2012	44	102	2
Contagion	1	101	0
Aftershock	35	54	0
The Impossible	13	20	69
Into the Storm	25	55	3
San Andreas	30	72	3
The 33	16	106	5
Deepwater Horizon	50	40	8

Pre-Impact

The average duration of this period is 30 minutes. Half of the films that were reviewed featured geophysical hazards, making it the most commonly portrayed hazard in the study. Forewarning cues ranged from persons having a sense of impending doom, unfortunate coincidences, and physical indicators of irregularity such as unusual weather phenomenon and unexplained animal behavior. Despite these pre-existing concerns, which were present in all but one film, *Aftershock*, preparedness was virtually non-existent. Films such as *2012* and *The Core* reveal an effort by governments to restrict the flow of information, leaving much of the population uninformed and unprepared. Warnings often are given too late, and in four films, *2012*, *The Core*, *The Day After Tomorrow*, and *San Andreas*, they are only available to authority figures such as scientists, politicians, and the wealthy. Humans are neither responsible for nor able to prevent, prepare for, or mitigate the impacts. This is consistent with the lack of

preparedness seen in the films. Only two films, *San Andreas* and *Into the Storm*, demonstrate preparedness. In *San Andreas*, earthquake preparedness is integrated into a lecture by California Institute of Technology faculty. The residents of the fictional small town of Silverton, Oklahoma, seen in *Into the Storm*, are conscious of the weather and subtle changes, such as moisture droplets close to the updrafts that are indicative of potentially hazardous conditions. This awareness empowers individuals to take the necessary actions to protect themselves in dangerous situations, whether it be an earthquake or a tornado.

Trans-Impact

The average duration of this period is 71 minutes, making it the longest period. Magnitude of impact was reported 50% of the time, and it was most frequently reported using physical metrics such as the Enhanced-Fujita scale. Death toll was occasionally communicated, but only twice, in *2012* and *Contagion*, was it relied on to communicate the magnitude of the disaster. Regional and global events occur at roughly the same frequency, and multiple hazards are seen in the majority of films. In addition, every single film reviewed showcased limited ethnic, gender, and/or age diversity.

Ethnic diversity is severely limited in the study. For example, the middle and upper-class white population was the focus in every film except for *The 33*. The four films that contain worldwide disasters, *The Core*, *The Day After Tomorrow*, *2012*, and *Contagion*, featured the most ethnic diversity. African American characters appear most frequently, followed by Latino, Indian, and Asian Americans. Every Indian and Asian American character, and the majority of African Americans, are depicted as scientists or engineers. The roles of African American characters in *The Day After Tomorrow*, *Into the Storm*, *Poseidon*, and *2012* include high school students, a high school principal, a ship captain, the President of the United States, the First Lady of the United States, and the First Daughter of the United States, who is also an art expert. While our findings show that the majority of African American males were generally represented in powerful positions, some negative depictions of racial ethnicities can still be detected which is consistent with McGreavy and Lindenfeld's (2014) analysis of three climate change films where stereotypes about gender, race and ethnicity, and sexuality were pervasive. For instance, McGreavy and Lindenfeld (2014) found that white males were consistently portrayed as authority figures while African American males were depicted as less empowered. Similarly, in *The 33*, *San Andreas*, *Aftershock*, and *Contagion*, some Latinos are portrayed as corrupt, criminals, and drug addicts. Homelessness is only represented once, as an African American male in *The Day After Tomorrow*.

Films with gender balance embrace female characters in both major and minor roles. This is evident in *The Impossible*, *Contagion*, and *San Andreas*, as each film follows at least one main female character and numerous supporting female characters who often

are engaged in response or recovery. In contrast, *The Core*, *The Day After Tomorrow*, *Poseidon*, *Into the Storm*, *Deepwater Horizon*, 2012, and *Aftershock* present female characters as damsels-in-distress, despite their age or profession. Similarly, *The 33*, *Deepwater Horizon*, and *The Perfect Storm* emphasize gender roles: the men go away to work (in a mine, on an offshore oil rig, and at sea) while the women wait for them to return home. When strong female characters are represented, they're often disregarded by their male counterparts. Most commonly, warnings given by strong female characters go unheeded in *The Perfect Storm*, *The Core*, *Aftershock*, and *Into the Storm*.

When there is a relatively wide age range present, it almost always excludes the elderly. If elderly people are represented, they do not engage the leading characters and are effectively invisible. Children of all ages were seen in the selected films, including newborns in *Aftershock*. In two films, *Aftershock* and *Contagion*, we even see the remains of children.

The only social diversity we can note in this period is that of emergency response, which ranges from a hacker in *The Core*, the crew of an offshore supply vessel in *Deepwater Horizon*, and the Royal Air Force in *The Day After Tomorrow*. When the magnitude was described in the trans-impact period, it was reported via the Saffir-Simpson, Richter, or Enhanced-Fujita scale, as well as through the wave height, attack rate, wind speed, frequency, or death toll.

Post-Impact

The average duration of this period is nine minutes. Three of the selected films, *Aftershock*, *Contagion*, and *Poseidon*, did not follow the temporal framework and lacked a post-impact period. Of the nine films that do contain a post-impact period, each highlights the residual effects of the disaster. Most scenes depict significant structural damage, highlighted by debris and an almost unrecognizable landscape. Historic landmarks, including the Golden Gate Bridge, are often destroyed in these large-scale events, as depicted in films such as *The Core* and *San Andreas*. As Dodds (2008) explained:

In 'disaster movies', namely *Independence Day* (1996) and other terrorism-based films such as *The Siege* (1998), it is iconic buildings and cities that feature predominantly. Buildings such as the White House and the Capitol Building, alongside cities such as New York (*Executive Decision* 1996, *The Siege* 1998) and Los Angeles (*Collateral Damage* 2001), prefigure, because domestic and international audiences recognize these as landmarks that implicitly help to explain the scale of the threat facing the United States. The buildings themselves not only represent symbols of American power, but also values such as liberty, democracy, and freedom (p. 235).

Controllability is referenced in one-third of the films reviewed, but only two films describe actions that must be taken to prevent or mitigate similar events in the future. Restoration is the least frequently mentioned action in the period. In two of the films, *Into the Storm* and *San Andreas*, a commitment to rebuild is made. Neither film, however, divulges any details as to how and when restoration will begin. After the initial response, recovery efforts follow and community leaders, first responders, and volunteers are most often depicted during these scenes, with *2012* being the exception. The post-impact period, which was absent in 25% of the films, focuses primarily on the immediate and residual effects. These effects are most often depicted through scenes of devastation, which are seen in *The Day After Tomorrow*, *2012*, *The Impossible*, *Into the Storm*, and *San Andreas*. In *The 33* and *Deepwater Horizon*, holding the responsible companies accountable for the disasters in court was the only way to ensure controllability, but unfortunately this did not happen. Recovery was short-term only, as first responders, such as firefighters and the National Guard, attempted to locate and provide aid to those in need. The residents of the communities destroyed in *San Andreas* and *Into the Storm* were committed to rebuilding, though there was no discernable plan or timeline for how this would be achieved. The post-impact period remained the shortest period, which is consistent with the Quarantelli (1985) and Mitchell et al. (2000) findings. The exception was *The Impossible*, a true story based on a family's survival in the aftermath of the 2004 Indian Ocean tsunami. The majority of this film's run time, over one hour, occurred during the post-impact period.

CONCLUSION

Current trends in the disaster film genre indicate a shift towards unpredictable, widespread events that leave humans utterly powerless. As the demand for attention-grabbing disasters continues, the divide between perceived and actual risk widens. Misinformation is often muddled in with the facts. This is especially concerning as popular culture is known to influence disaster behavior. The movie *San Andreas* was unique compared to the other films as there was a major education campaign by the producers to promote earthquake preparedness. "Drop, cover, and hold on" is regarded as the proper action to take during an earthquake to protect oneself and was emphasized throughout the film. Unfortunately, there is also a reference to the "Triangle of Life", a discredited survival strategy criticized by both the American Red Cross (ARC) and United States Geological Survey (Lopes 2004; United States Geological Survey [USGS] n.d.). Despite these myths and some inaccuracies, popular films do have the potential to positively influence effective disaster behavior (Mettler 2017). Films that offer a believable story and realistic scenes, such as *Contagion*, become almost indistinguishable from events occurring off-screen (Goldberg 2014). If a viewer is unable to differentiate between fact and fiction, however, their own actions in a disaster may put lives at unnecessary risk.

Our analysis of impact-periods has implications for future work, particularly how they relate to the perception of mitigation, preparedness, response, and recovery activities. Future research detailing repetition of human behavior in the face of disasters can serve to address existing gaps in the emergency management and disaster preparedness literature. Next steps for this research should include a study of human subjects to assess existing hazard knowledge and their perception of hazards after viewing a selection of disaster films. In addition to the recommendation made by Mitchell et al. (2000) to update the framework to include made-for-television films in the selection criteria, we propose the inclusion of original streaming movies due to their growing popularity. Moving forward with this research, we anticipate the opportunity to determine the practical implications of myths and impact-periods in disaster films. While budgets continue to shrink, there are fewer resources remaining for the communication of risk and hazards. As noted by Dunn et al. (2016), hazards education and communication is necessary to address the gap between actual and perceived risk. With fewer practitioners able to devote resources towards education, and funding for K-12 education on equally shaky ground, the question of how we educate society about the hazards all around us persists (Mitchell 2009; Mitchell, Borden, and Schmidtlein 2008). For emergency managers, who may or may not be aware of the misinformation that is increasingly propagated in film, a lack of awareness could lead to unintended consequences for preparedness and response activities.

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References

- Alexander, David E. 2007. "Misconception as a Barrier to Teaching about Disasters." *Prehospital and Disaster Medicine* 22(2): 95-103.
- Bahk, C. Moh. 2001. "Drench Effects of Media Portrayal of Fatal Virus Disease on Health Locus of Control Beliefs." *Health Communication* 13(2): 187-204.
- Bahk, C. Moh and Kurt Neuwirth. 2000. "Impact of Movie Depictions of Volcanic Disaster on Risk Perception and Judgments." *International Journal of Mass Emergencies and Disasters* 18(1): 63-84.
- Balmford, Andrew, Andrea Manica, Lesley Airey, Linda Birkin, Amy Oliver, and Judith Schleicher. 2004. "Hollywood, Climate Change and the Public." *Science* 305(5691): 1713.
- Barnett, Michael and Alan Kafka. 2007. "Using Science Fiction Movie Scenes to Support Critical Analysis of Science." *Journal of College Science Teaching* 36(4): 31-5.

- Barnett, Michael, Heather Wagner, Anne Gatling, Janice Anderson, Meredith Houle, and Alan Kafka. 2006. "The Impact of Science Fiction Film on Student Understanding of Science." *Journal of Science Education and Technology* 15(2): 179-91.
- Blaikie, Piers, Terry Cannon, Ian Davis, and Ben Wisner. 1994. *At Risk: Natural Hazards, People's Vulnerability, and Disasters*. London, UK: Routledge.
- Blickenstaff, Jacob Clark. 2011. "I'll Bring the Popcorn!" *The Science Teacher* 78(6): 42-6.
- Borden, Kevin and Susan L. Cutter. 2008. "Spatial Patterns of Natural Hazards Mortality in the United States." *International Journal of Health Geographics* 7: Art. 64. doi:10.1186/1476-072X-7-64.
- Centre for Research on the Epidemiology of Disasters (CRED) and the United Nations Office for Disaster Risk Reduction (UNISDR). 2016. "Poverty and Death: Disaster Mortality- 1996-2015." Centre for Research on the Epidemiology of Disasters, Brussels, Belgium. Retrieved June 4, 2018. (<http://cred.be/sites/default/files/CredCrunch44.pdf>).
- Christensen, Jen. 2019. "Cli-fi (climate fiction) on the big screen changes minds about real climate change." *Cable News Network (CNN)*, February 8.
- Clarke, Lee. 2002. "Panic: Myth or Reality?" *Contexts* 1(3): 21-6.
- Couch, Stephen. 2000. "The Cultural Scene of Disasters: Conceptualizing the Field of Disasters and Popular Culture." *International Journal of Mass Emergencies and Disasters* 18(1): 21-37.
- Cutter, Susan L., Bryan Boruff, and Lynn Shirley. 2003. "Social Vulnerability to Environmental Hazards." *Social Science Quarterly* 84(2): 242-61.
- Dodds, Klaus. 2008. "Screening Terror: Hollywood, the United States and the Construction of Danger." *Critical Studies on Terrorism* 1(2): 227-43.
- Dunn, Peter T., Alicia Y.E. Ahn, Ann Bostrom, and John E. Vidale. 2016. "Perceptions of Earthquake Early Warnings on the US West Coast." *International Journal of Disaster Risk Reduction* 20: 112-22.
- Drabek, Thomas E. 1986. *Human System Responses to Disaster: An Inventory of Sociological Findings*. New York, NY: Springer-Verlag.
- Dynes, Russell R. 1970. *Organized Behavior in Disaster*. Lexington, MA: Heath Lexington.
- Fischer, Henry W. 2008. *Response to Disaster: Fact Versus Fiction & Its Perpetuation – The Sociology of Disaster*. 3rd ed. New York, NY: University Press of America.
- Frank, Scott. 2003. "Reel Reality: Science Consultants in Hollywood." *Science as Culture* 12(4): 427-69.
- Fritz, Charles E. 1961. "Disasters." Pp. 651-94 in *Contemporary Social Problems*, edited by Robert K. Merton and Robert A. Nisbet, New York, NY: Harcourt.
- Goldberg, Jonah. 2014. "Ebola is Much Less Scary than Hollywood's 'Contagion.' Or is it?" *Los Angeles Times*, October 13.
- Jones, David. 1993. "Environmental Hazards: The Challenge of Change: Environmental Hazards in the 1990s: Problems, Paradigms and Prospects." *Geography* 78(2): 161-5.
- Keane, Stephen. 2006. *Disaster Movies: The Cinema of Catastrophe*. New York, NY: Columbia University.

- Kendra, James, Laura K. Siebeneck, and Simon A. Andrew. 2018. "Disaster Movies in the Classroom: Pedagogical Value and Teaching Methods." *International Journal of Mass Emergencies and Disasters* 36(3): 220-37.
- Kirby, David A. 2003. "Scientists on the Set: Science Consultants and Communication of Science in Visual Fiction." *Public Understanding of Science* 12(3): 261-78.
- . 2008. "Cinematic Science." Pp. 41-56 in *Handbook of Public Communication of Science and Technology*, edited by Massimiano Bucchi and Brian Trench. London, UK: Routledge.
- . 2011. *Lab Coats in Hollywood: Science, Scientists, and Cinema*. Cambridge, MA: The MIT Press.
- . 2014. "Science and Technology in Film: Themes and Representations." Pp. 97-112 in *Routledge Handbook of Public Communication of Science and Technology*, 2nd ed., edited by Massimiano Bucchi and Brian Trench. London, UK: Routledge.
- . 2017. "The Changing Popular Images of Science." Pp. 291-300 in *The Oxford Handbook of the Science of Science Communication*, edited by Kathleen Hall Jamieson, Dan M. Kahan, and Dietram A. Scheufele. New York, NY: Oxford University.
- Leiserowitz, Anthony A. 2004. "Before and After the Day after Tomorrow: A U.S. Study of Climate Change Risk Perception." *Environment* 46(9): 22-37.
- Laprise, Shari and Chuck Winrich. 2010. "The Impact of Science Fiction Films on Student Interest in Science." *Journal of College Science Teaching* 40(2): 45-9.
- Liu, Xiaohui, Bandana Kar, Chaoyang Zhang and David M. Cochran. 2019. "Assessing relevance of tweets for risk communication." *International Journal of Digital Earth* 12(7): 781-801.
- Liverman, Diana and Douglas J. Sherman. 1985. "Natural Hazards in Novels and Films: Implications for Hazard Perception and Behavior." Pp. 86-95 in *Geography, the Media, and Popular Culture*, edited by Jacquelin Burgess and John R. Gold. New York, NY: Routledge.
- Lopes, Rocky. 2004. "American Red Cross Response to "Triangle of Life" by Doug Copp." Community Disaster Education, American Red Cross National Headquarters. Retrieved December 4, 2019. (<http://www2.bpaonline.org/Emergencyprep/arc-on-doug-copp.html>).
- Lowe, Thomas, Katrina Brown, Suraje Dessai, Miguel de Franca Doria, Kat Haynes, and Katherine Vincent. 2006. "Does Tomorrow Ever Come? Disaster Narrative and Public Perceptions of Climate Change." *Public Understanding of Science* 15(4): 435-57.
- Mack, Eric. 2018. "Some of the Science Behind The Ridiculous Movie 'The Day After Tomorrow' Is Now Coming True." *Forbes*, April 11.
- McGreavy, Bridie and Laura Lindenfeld. 2014. "Entertaining Our Way to Engagement? Climate Change Films and Sustainable Development Values." *International Journal of Sustainable Development* 17(2): 123-36.

- McKinnon, Scott. 2017. "Straight Disasters: The (Hetero) sexual Geographies of Hollywood Disaster Movies." *GeoJournal* 82(3): 503-15.
- Mettler, Katie. 2017. "How a Boy Saved his Drowning Brother's Life — with Help from the Rock's 'San Andreas'." *The Washington Post*, August 25.
- Mitchell, Jerry T. 2009. "Hazards Education and Academic Standards in the Southeast United States." *International Research in Geographical and Environmental Education* 18(2): 134-48.
- Mitchell, Jerry T., Deborah S.K. Thomas, Arleen A. Hill, and Susan L. Cutter. 2000. "Catastrophe in Reel Life versus Real Life: Perpetuating Disaster Myth through Hollywood Films." *International Journal of Mass Emergencies and Disasters* 18(3): 383-402.
- Mitchell, Jerry T., Kevin A. Borden, and Mathew C. Schmidtlein. 2008. "Teaching Hazards Geography and Geographic Information Systems: A Middle School Level Experience." *International Research in Geographical and Environmental Education* 17(2): 170-88.
- Monfredo, William. 2010. "Twisted Film, or: How I Learned to Stop the Movie and Teach the Truth." *Journal of Geography* 109(3): 130-40.
- Moore, Harry E. 1964. *...and the Winds Blew*. Austin, TX: Hogg Foundation for Mental Health, University of Texas.
- National Weather Service (NWS). 2017. "Severe Weather Facts and Myths." National Weather Service, Silver Spring, Maryland. Retrieved July 4, 2018 (<https://www.weather.gov/media/top/myths.pdf>).
- Nogami, Tatsuya. 2018. "Disaster Myths among Disaster Response Professionals and the Source of such Misconceptions." *Journal of Contingencies and Crisis Management* 26(4): 491-8.
- Pelling, Mark. 2003. *The Vulnerability of Cities: Natural Disasters and Social Resilience*. London, UK: Routledge.
- . 2011. "The Vulnerability of Cities to Disasters and Climate Change: A Conceptual Framework." Pp. 549-58 in *Coping with Global Environmental Change, Disasters, and Security: Threats, Challenges, Vulnerabilities, and Risks*, edited by Hans Gunter Brauch, Ursula Oswald Spring, Czeslaw Mesjasz, John Grin, Patricia Kameri-Mbote, Bechir, Chourou, Paul Dunay, and Jorn Birkmann. Berlin, GER: Springer.
- Perkowitz, Sidney. 2007. *Hollywood Science: Movies, Science, and the End of the World*. New York, NY: Columbia University Press.
- Quarantelli, E.L. 1960. "Images of Withdrawal Behavior in Disasters: Some Basic Misconceptions." *Social Problems* 8(1): 68-79.
- . 1980. "The Study of Disaster Movies: Research Problems, Findings, and Implications." Preliminary Paper #64. Disaster Research Center, Newark, DE.
- . 1985. "Realities and Mythologies in Disaster Films." *Communications* 11(1): 31-44.

- Quarantelli, E. L. and Ian Davis. 2011. *An Exploratory Research Agenda for Studying the Popular Culture of Disasters (PCD): Its Characteristics, Conditions, and Consequences*. Newark, DE: Disaster Research Center.
- Quarantelli, E.L. and Russell R. Dynes. 1972. "When Disaster Strikes (It Isn't Much Like What You've Heard and Read About)." *Psychology Today* 5(9): 66-70.
- . 1973. "Images of Disaster Behavior: Myths and Consequences." Preliminary paper #5. Disaster Research Center, Newark, DE.
- Pappas, Georgios, Savvas Seitaridis, Nikolaos Akritidis, and Epaminondas Tsianos. 2003. "Infectious Diseases in Cinema: Virus Hunters and Killer Microbes." *Clinical Infectious Diseases* 37(7): 939-42.
- Rodríguez, Havidán, Joseph Trainor, and E. L. Quarantelli. 2006. "Rising to the Challenges of a Catastrophe: The Emergent and Prosocial Behavior following Hurricane Katrina." *Annals of the American Academy of Political and Social Science* 604(1): 82-101.
- Reusswig, Fritz, Julia Schwarzkopf, and Philipp Pohlenz. 2004. "Double Impact, the Climate BlockBuster 'The Day after Tomorrow' and Its Impact on the German Cinema Public." PIK Report No. 92. Telegrafenberg, GER: Potsdam Institute for Climate Impact Research. Retrieved June 25, 2018 (<http://www.pik-potsdam.de/research/publications/pikreports/.files/pr92.pdf>).
- Sakellari, Maria. 2015. "Cinematic Climate Change, a Promising Perspective on Climate Change Communication." *Public Understanding of Science* 24(7): 827-41.
- Sjoberg, Lennart and Elisabeth Engelberg. 2010. "Risk Perception and Movies: A Study of Availability as a Factor in Risk Perception." *Risk Analysis* 30(1): 95-106.
- Southern California Earthquake Center. 2018. *Earthquake Country Alliance*. Retrieved July 2, 2018 (<https://www.earthquakecountry.org/sanandreas/>).
- Starbird, Kate, Jim Maddock, Mania Orand, Peg Achterman, and Robert M. Mason. 2014. "Rumors, False Flags, and Digital Vigilantes: Misinformation on Twitter after the 2013 Boston Marathon Bombing." Pp 654-62 in *iConference 2014 Proceedings*. Grandville, MI: iSchools. doi:10.9776/14308.
- Svoboda, Michael. 2016. "Cli-fi on the screen(s): patterns in the representations of climate change in fictional films." *Wiley Interdisciplinary Reviews: Climate Change* 7(1): 43-64.
- Tierney, Kathleen J. 2003. "Disaster Beliefs and Institutional Interests: Recycling Disaster Myths in the Aftermath of 9-11." Pp. 33-51 in *Research in Social Problems and Public Policy*, vol. 11, edited by Lee Clarke. New York, NY: Elsevier Science.
- Tierney, Kathleen, Christine Bevc, and Erica Kuligowski. 2006. "Metaphors Matter: Disaster Myths, Media Frames, and their Consequences in Hurricane Katrina." *The Annals of the American Academy of Political and Social Science* 604(1): 57-81.
- Tierney, Kathleen, Michael K. Lindell, and Ronald W. Perry. 2001. *Facing the Unexpected: Disaster Preparedness and Response in the United States*. Washington, DC: Joseph Henry Press.

- Tomes, Nancy. 2000. "The Making of a Germ Panic, Then and Now." *American Journal of Public Health* 90(2): 191-8.
- Tsukayama, Hayley. 2015. "Teens Spend Nearly Nine Hours Every Day Consuming Media." *The Washington Post*, November 3.
- Tyrell, Kelly April. 2017. "Abrupt Climate Change could Follow Collapse of Earth's Oceanic Conveyor Belt." *University of Wisconsin-Madison News*, January 4.
- United Nations Office for Disaster Risk Reduction (UNISDR). 2014. *Urban Risk Reduction and Resilience*. UNISDR, Geneva, Switzerland. Retrieved July 27, 2018 (http://www.unisdr.org/files/37966_finalwp3.pdf).
- United States Geological Survey (USGS). N.d. "What is the "Triangle of Life" and is it Legitimate?" United States Geological Survey, Reston, VA. Retrieved December 4, 2019. (https://www.usgs.gov/faqs/what-triangle-life-and-it-legitimate?qt-news_science_products=4#qt-news_science_products).
- Von Burg, Ron. 2012. "Decades Away or the Day After Tomorrow? Rhetoric, Film, and the Global Warming Debate." *Critical Studies in Media Communication* 29(1): 7-26.
- Wang, Bairong and Jun Zhuang. 2017. "Crisis information distribution on Twitter: a content analysis of tweets during Hurricane Sandy." *Natural Hazards* 89(1): 161-81.
- . 2018. "Rumor response, debunking response, and decision makings of misinformed Twitter users during disasters." *Natural Hazards* 93(3): 1145-62.
- Webb, Gary R. 2006. "The Popular Culture of Disaster: Exploring a New Dimension of Disaster Research." Pp. 430-40 in *Handbook of Disaster Research*, edited by Havidan Rodríguez, E.L. Quarantelli, and Russell R. Dynes. New York, NY: Springer.
- . 2018. "The Cultural Turn in Disaster Research: Understanding Resilience and Vulnerability through the Lens of Culture." Pp. 109-21 in *Handbook of Disaster Research*, 2nd ed., edited by Havidan Rodríguez, William Donner, and Joseph E. Trainor. New York, NY: Springer.
- Wenger, Dennis E., James D. Dykes, Thomas D. Sebok, and Joan L. Neff. 1975. "It's a Matter of Myths: An Empirical Examination of Individual Insight into Disaster Response." *Mass Emergencies* 1(1): 33-46.
- Yow, Donald M. 2014. "Teaching Introductory Weather and Climate Using Popular Movies." *Journal of Geoscience Education* 62(1): 118-25.