Urban Fire / Urban Conflagration

Synopsis

Trend analysis[62,63] demonstrates a decline in the incidents of fire and fire death in the United States (U.S.), which may explain why a survey of articles found few selections on the topic of urban conflagration[64] in the U.S. Current conflagration research focuses on the challenges of developing nations. Articles that focused on the U.S. tend to do so from a historical perspective.

While articles from the past five years agree that the U.S. does not have a strong risk of conflagration from traditional causes, literature demonstrates that urban areas might be at an increased risk of urban fires caused by natural and man-made hazards. The literature review examines the nexus of urban fire and hurricanes (i.e., Superstorm Sandy), earthquakes, and the Wildland Urban Interface. The final theme evaluated was literature demonstrating that lighter building materials and modern furniture means hotter, faster fires and a need for a change in firefighting tactics.

Literature Review – Urban Fire/Urban Conflagration Viewed as Unlikely, but When Combined with Other Hazards May Become a More Frequent Occurrence

Introduction

Event Description

For purposes of this assessment, urban[65] fire/urban conflagration is defined as a fire, other than a wildfire, occurring within the U.S., with major building-to-building flame spread over some distance.[66,67]

Event Background

An Overview of Fire Frequency and Consequences

Historically, the U.S. fire rate, on a per capita basis, has been higher than most of the industrialized world.[68] From 1979 to 2007, the fire death rate in the U.S. declined by 66 percent

[62] USFA. Fire Death Rate Trends: An International Perspective. (2011). Topical Fire Report Series, Volume 12 (Issue 8). Pg. 4. Figure 3. Retrieved from http://www.usfa.fema.gov/downloads/pdf/statistics/v12i8.pdf

[63] National Fire Protection Association (NFPA). (March 2015). Trends and Patterns of U.S. Fire Losses in 2013. Pgs. 1-2 (Figures 1 and 2) and Pg. 6 (Figures 8 and 9). Retrieved March 24, 2015, from http://www.nfpa.org/research/reports-and-statistics/fires-in-the-us/overall-fire-problem/trends-and-patterns-of-us-fire-losses.

[64] As noted in the Event Background, for SNRA purposes, Urban Fire/Urban Conflagration is defined as a fire, other than a wildfire, occurring within the U.S. resulting in ten or more reported fatalities, a declaration of emergency, or a request for international assistance.

[65] For purposes of this qualitative assessment a precise definition of urban is not necessary. As a point of reference, the NFPA uses the U.S. Census Bureau's definition for Urban: An area with at least 1000 people per square mile. Similarly, suburban is defined as an area with between 500 people and 1000 people per square mile.

[66] NFPA Fire Protection Handbook, 19th edition. Quincy, MA: NFPA, 2003. Of note, conflagration is not defined in the NFPA 2014 standards glossary.

[67] Historically, conflagrations implied city-wide fires or at least multiple city blocks. In more recent years, fire professionals have used the term more loosely to imply major fires that spread from building-to-building. Merriam-Webster's Dictionary defines conflagration as a large disastrous fire.

[68] USFA. Fire Death Rate Trends: An International Perspective. (2011). *Topical Fire Report Series*, Volume 12(Issue 8). Pg. 1. Retrieved from http://www.usfa.fema.gov/downloads/pdf/statistics/v12i8.pdf.

and the U.S. moved from having the third highest death rate in 1979 to the tenth highest death rate in 2007 out of twenty-four industrialized nations.[69]

In 2013, the most recent year of completed and published statistics from the National Fire Protection Association (NFPA),[70] there were 1,240,000 fires, 3,240 civilian deaths, 15,925 civilian injuries, and $11.5 billion in property damage caused by fires.[71,72]

Over the years, there has been little change in the proportion of fires, deaths, injuries, and dollar loss by the type of property involved. In terms of numbers of fires, the largest category continues to be outside fires (46 percent) in fields, vacant lots, trash, and wild spaces. Vehicle fires comprise another 15 percent of reported fires. While there are many of these two kinds of fires, they are not the source of most fire damage or deaths. Structure fires accounted for 86 percent of fire deaths, 76 percent of injuries, and 82 percent of dollar loss of all U.S. fires in 2013.[73] Residential properties in particular, account for the largest percentage of deaths from all fires in 2013 (85 percent),[74] with the majority of these in one- and two-family dwellings.[75] Residential and nonresidential structure fires together comprise 39 percent of all fires, with residential structure fires outnumbering nonresidential structure fires by over three to one.[76] From 1980-2013 there were twenty-two residential fires with ten or more fatalities, none of which occurred between the period of 2009-2013.[77]

The NFPA threshold for their annual Catastrophic Multiple-Death Fire Report is "fires or explosions in homes or apartments that result in five or more fire-related deaths, or fires or explosions in all other structures and outside of structures, such as wildfires and vehicle fires that claim three or more lives".[78] The NFPA's 2013 report documented 10 residential fires resulting in five or more fire-related deaths, and six non-residential structural fires with three or more fire-related deaths.[79,80]

The NFPA also documents "large-loss" fires on an annual basis, which they define as losses in excess of $10 million.[81,82] In 2013, there were 17 structure fires, resulting in a total property loss of $387.7 million. Only three of these fires were residential structures, accounting for $76.9 million in losses. The majority of large-loss fires, in both frequency and dollars lost, occur in

[69] USFA (2011). Pg. 1.
[70] The USFA's latest statistics are based on 2011 data. The USFA Statistics page directs users to view the NFPA's website for more statistics on U.S. Fire Loss.
[71] Karter, Jr., M. (2014). Fire Loss in the United States During 2013. Retrieved March 2015, from http://www.nfpa.org/research/reports-and-statistics/fires-in-the-us/overall-fire-problem/fire-loss-in-the-united-states
[72] Direct property damage figures do not include indirect losses, like business interruption.
[73] Karter (2014). pp iii-vi.
[74] Karter (2014). p 10. Non-residential, structure fires account for only 1% of deaths.
[75] Karter (2014). p 45.
[76] Karter (2014). pp iii-vi.
[77] Home Fires with Ten or More Fatalities, 1980-2013. (2014, August 1). Retrieved March 24, 2015, from http://www.nfpa.org/research/reports-and-statistics/fires-in-the-us/multiple-death-fires/homes-fires-with-ten-or-more-fatalities
[78] Since this analysis is focused on non-wildfires, the numbers cited in the narrative account for only structural fires.
[79] Badger, S. (2014, September). Catastrophic Multiple-Death Fires in 2013. Retrieved March 2015, from http://www.nfpa.org/research/reports-and-statistics/fires-in-the-us/multiple-death-fires/catastrophic-multiple-death-fires
[80] The NFPA's non-residential figures include fires caused by Industrial Accidents. For SNRA purposes, Industrial Accidents are evaluated as a separate hazard.
[81] Badger, S. (2014, November). Large-Loss Fires in the United States. Retrieved March 24, 2015, from http://www.nfpa.org/research/reports-and-statistics/fires-in-the-us/large-property-loss/large-loss-fires-in-the-united-states
[82] The SNRA economic threshold for a "national-level" event is $100 million.

non-residential structures such as manufacturing properties, properties under construction, or other commercial properties.[83,84]

While residential fires in single and two-family homes account for the majority of deaths from all fires, including multiple-fatality fires,[85,86] the rare fires causing ten or more fatalities are disproportionately concentrated in multiple-family dwellings such as apartment buildings, group homes, and non-residential structures (e.g., nightclubs, hotels).[87]

Fire Risks Vary by Region

The risks and consequences of urban fires and conflagration are directly related to the condition and infrastructure of the built environment, and is affected by issues such as zoning and transportation networks. Typically, older Northeast, Southeast and Rust Belt urban areas are more susceptible to conflagration than other areas due to the age and construction of the built environment and condition of water distribution services. Newer Southwest and Western urban areas have addressed many of the "historic errors" of urban development, and addressed conflagration concerns through enhanced building codes with aggressive requirements for fire resistance, roof coverings, and built-in fire protection systems; wider transportation infrastructure to prevent horizontal fire spread via radiation; and, up-to-date water storage and distribution systems (e.g., more storage capacity, larger distribution mains, strategically placed hydrants, looping and redundancy, inspection, maintenance, testing). Increasingly, communities encroaching on the wildland are at risk for conflagration because typical construction methods in those areas consist of combustible materials and closely spaced buildings.

Federal, State and Local Government Firefighting Responsibilities

State, Local, Tribal, and Territorial Responsibilities

Firefighting is an inherently local responsibility. Local fire resources often receive assistance from other fire departments/agencies through established mechanisms identified in local mutual aid agreements.[88]

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[83] Badger, S. (2014, November). Six of these structure fires occurred in manufacturing properties: a fertilizer plant, an egg processing plant, an oil reprocessing plant, a steel mill arc-furnace building, a plastics laminate plant, and an aluminum die-cast plant. These six fires resulted in total losses of $202.6 million. Four more fires occurred in special properties. Two of the properties were apartment buildings under construction and two were a highway tunnel and a highway interchange that were severely damaged following separate vehicle crashes. The combined loss of these four fires was $52.7 million. Another three fires occurred in residential properties, one each in a single-family home, a high-rise apartment building, and a cluster of rental cabins. The combined losses for these fires totaled $76.9 million. Of the final four structure fires, two occurred in restaurants and resulted in a combined loss of $25 million. The third and fourth fires occurred in a warehouse and a high school, and produced losses of $20 million and $10.5 million, respectively.

[84] The NFPA's non-residential figures include fires caused by Industrial Accidents. For SNRA purposes, Industrial Accidents are evaluated as a separate hazard.

[85] USFA (2013, July). Multiple-fatality fires in residential buildings (2009-2011). USFA Topical Fire Report Series 15(6). Retrieved January 2014 from http://www.usfa.fema.gov/downloads/pdf/statistics/v14i6.pdf.

[86] This is also true of total economic loss and the proportion of the most costly fires, which are generally wildfires destroying residential properties across large geographic areas. See the SNRA Wildfire Assessment for details.

[87] While the characteristics of all fires and multiple-fatality (two or more) fires, and the overall small relative proportion of total fatalities from the 10+ fatality fires, come from USFA and NFPA sources as cited, this judgment on the relative proportions of structure fires for the 10+ fatality fires is based solely on the data in Appendix 1-Table 1. These data come from the U.S. Government-funded international disaster database EM-DAT, but not from the USFA.

[88] This paragraph is directly from Emergency Support Function (ESF) #4 – Firefighting Annex, 2013. See: http://www.fema.gov/media-library/assets/documents/32180

There are roughly 1.1 million active firefighters in the U.S., of which just under three-fourths (73%) are volunteer firefighters. Nearly half of the volunteers serve in communities with less than 2,500 people.[89] In 2006, these organizations reported:

- 11% of the Nation's estimated 32,000 fire departments can handle a technical rescue with Emergency Medical Services (EMS) at a structural collapse of a building with 50 occupants with local trained personnel. Only communities of 500,000 or more people had a majority of departments report that they were both responsible for such an incident and had enough local specially trained personnel.
- 24% of fire departments can handle a wildland/urban interface fire affecting 500 acres with local trained personnel. Another 49% said this was within their responsibility, but they would need specially trained people from outside their local area. 27% said such incidents were outside of their responsibility.[90]

Further assistance can be obtained through an established intrastate mutual aid system. If additional assistance is required, firefighting resources can be requested from other jurisdictions through processes established under mutual aid agreements, state-to-state or regional compacts, or other agreements. If the governor of the affected state declares an emergency, firefighting resources may be requested through the Emergency Management Assistance Compact (EMAC). If the President declares an emergency or major disaster under the Stafford Act, firefighting resources may also be requested through Emergency Support Function (ESF) #4. Using existing authorities and agreements, ESF #4 can mobilize wildland and structure firefighting resources from across the country and from several foreign countries through the national firefighting mobilization system to incidents anywhere in the U.S.[91]

As a result of community risk analysis and budget limitations, municipal fire services generally are not resourced for conflagrations. Major urban fire services may be an exception, but likely are limited to command and control of a single large-scale event. Multiple events could compromise service delivery. Participation in joint fire suppression automatic or mutual aid compacts is voluntary. Depending on local services provided (e.g., fire-based emergency medical services), life safety and rescue may take priority over fire suppression and deplete resources that would normally be committed to fire control.[92]

Shortages of critical firefighting resources are adjudicated at the lowest jurisdictional level. Many firefighting agencies provide additional functions such as emergency medical services, technical rescue, and hazardous materials response. During a Federal response, these resources may support multiple ESFs in support of different core capabilities.[93]

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[89] USFA/NFPA. (2006). *Four Years Later – A Second Needs Assessment of the U.S. Fire Service*. Report No. FA-303. United States Fire Administration, Emmitsburg, Maryland. Retrieved from http://www.usfa.dhs.gov/downloads/pdf/publications/fa-303-508.pdf

[90] USFA/NFPA (2006).

[91] This paragraph is directly from Emergency Support Function (ESF) #4 – Firefighting Annex, 2013. See: http://www.fema.gov/media-library/assets/documents/32180

[92] This paragraph was pulled from the 2011 SNRA Risk Summary Sheet.

[93] This paragraph is directly from Emergency Support Function (ESF) #4 – Firefighting Annex, 2013. See: http://www.fema.gov/media-library/assets/documents/32180

Federal Government

Within the National Response Framework the United States Forest Service (USFS) is the coordinator and primary agency for ESF #4, Firefighting. The mission of ESF #4 includes coordinating Federal firefighting activities and providing resource support to rural and urban firefighting operations. The United States Fire Administration (USFA) plays a support and advisory role for the urban environment.[94]

In addition to the USFS and USFA, the Department of Commerce, Department of Defense, Department of State, Department of the Interior, Army Corps of Engineers, Environmental Protection Agency, and United States Coast Guard all have responsibilities under ESF #4. Federal Government agency actions are described in ESF #4, pages 4-6.[95]

Literature Review

Urban Conflagration in the U.S. Mostly Viewed Through Historical Lenses

Recent articles and studies evaluating urban conflagration within the U.S. examine the topic from an historic perspective.

William M. Shields's article, "Urban Conflagrations in the United States", explores the history of the Great Fires in the 18th, 19th, and earliest part of the 20th centuries and identifies the technological and social causes of conflagrations in U.S. cities.[96,97] Shields identifies the lessons learned and risk mitigation efforts taken after the fires to address the causes, and in doing so, explains how such mitigation efforts, combined with technological improvements and social and political changes, eventually eliminated the city-destroying fires. He asserts that by the 1920s, all "major sources of conflagration risk" had been reduced, and U.S. cities "felt confident that they were no longer at serious risk" of citywide fires.[98]

It is unclear if the document was peer reviewed, but the article is well footnoted and was recently referenced by a joint Resilient Cities initiative involving the University of Cambridge (see footnote 23). The primary reason to include it in this literature review is to demonstrate what appears to be the de facto assumption that conflagrations, at least for the U.S., are an issue of the past. In fact, in framing the term "conflagrations", Shields calls them "devastating fires" suffered by American cities from earliest colonial times until the early part of the 20th century.[99]

George Bankoff's book, *Flammable Cities: Urban Conflagration and the Making of the Modern World*, published by the University of Wisconsin Press, takes a broader view both in scope of the cities studied as well as the time frame. [100] *Flammable Cities: Urban Conflagration and the*

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[94] Emergency Support Function (ESF) #4 – Firefighting Annex, 2013. See: http://www.fema.gov/media-library/assets/documents/32180

[95] ESF #4 – Firefighting Annex, 2013. See: http://www.fema.gov/media-library/assets/documents/32180

[96] Shields, W. M., Ph.D. (c.2009-2010) "Urban Conflagrations in the United States." Retrieved March 2015 from http://www.tvsfpe.org/_images/conflagrations.pdf.

[97] Shields' article previously (June 2013) resided on the U.S. Department of Energy's (DOE) website at this link: http://www.hss.energy.gov/nuclearsafety/nfsp/fire/workshop2010/shields/conflagrations.pdf. The article is not dated, however, the latest citation in the article is from 2009 and the DOE web link indicates it was used at a DOE workshop in 2010, therefore it is was likely written between 2009-2012. The article does not provide a publication source – appearing to be a 'White Paper', and thus likely has not been peer reviewed. It was cited by a November 2013 paper, "Building Resilient Cities: From Risk Assessment to Redevelopment," published jointly by Ceres, The Next Practice, and the University of Cambridge Programme for Sustainability Leadership.

[98] Shields (c.2009-2010) P 16.

[99] Shields (c. 2009-2010) P 1.

[100] Bankoff, G. (2012). Flammable cities urban conflagration and the making of the modern world. Madison: University of Wisconsin Press.

Making of the Modern World provides a series of essays examining the role of conflagrations in planning and building the world's cities. It covers 18 cities and regions across the world from the 17th to the 21st centuries. The essays are grouped into three parts: Part I: Cities as Fire Regimes; Part II: Fire as Risk and as Catalyst of Change; and Part III: The Politics of Fire. Part III addresses conflagrations in the 20th and 21st centuries, and may provide relevant findings for the current risk evaluation.

In the introduction, Bankoff acknowledges that "most wealthy countries today" view fire as an "occasional and isolated threat".[101] The book suggests that this may not be an accurate view of reality: "The Flammable cities of the past may prove to be the forebears of the flammable cities of the future, and the much touted "fire gap" more a temporal phenomenon than a spatial one."[102] This argument is largely focused on the urban slums in developing countries. However, the book includes an essay studying the case of Cleveland in the 1960s and 1970s (with references to Detroit and Los Angeles), and points out that even in modern, developed cities, fire "has continued to be a weapon of the weak, used to throw the social order into disarray and register protests that would otherwise go unheard, as well as a tool of elites, used to manipulate the urban poor and to reconfigure physical social space in the city to serve their own interests." [103]

Recent examples of civil unrest that involved acts of arson include the November 2005 French Riots[104], the August 2011 London Riots[105], and most recently, the riots in Ferguson, Missouri in November 2014.[106] A 2014 study by the Cambridge Centre for Risk Studies asserts there has been an increase in civil unrest around the globe and in the U.S., citing examples such as the Arab Spring movement (2010-2013) and the Occupy movement (2011-2012), and that it is likely to continue, in part due to the amplifying effect of social media.[107] The focus Bankoff's book, and likely publication date, did not allow for more in-depth exploration of this latter point.[108]

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[101] Bankoff (2012). Introduction.
[102] Bankoff (2012). Introduction.
[103] Bankoff (2012).
[104] "The rioters . . . caused over €200 million in damage as they torched nearly 9000 cars and dozens of buildings, daycare centers, and schools. The French police arrested close to 2900 rioters; 126 police and firefighters were injured, and there was one fatality." – Sahlins, P. (2006, October 24). Civil Unrest in the French Suburbs, November 2005. Retrieved March 2015 from http://riotsfrance.ssrc.org.
[105] The United Kingdom's Home Office reports 266 recorded crimes of arson during the August 2011 riots. An Overview of Recorded Crimes and Arrests Resulting from Disorder Events in August 2011. (2011, January 1). Retrieved March 2015 from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/116257/overview-disorder-aug2011.pdf.
[106] More than a dozen buildings were set on fire the night of November 25, 2014, in protest against a grand jury's decision. Retrieved March 2015 from http://abcnews.go.com/US/additional-national-guardsmen-headed-ferguson-fires-burn-city/story?id=27157986.
[107] Bowman, G.; Caccioli, F.; Coburn, A.W.; Hartley, R.; Kelly, S.; Ralph, D.; Ruffle, S.J.; Wallace, J.; 2014, Millennial Uprising Social Unrest Scenario; Cambridge Risk
Framework Series; Centre for Risk Studies, University of Cambridge. Retrieved March 2015 from http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=9&ved=0CFkQFjAI&url=http%3A%2F%2Fcambridgeriskframework.com%2Fgetdocument%2F22&ei=P0sPVcfGHJP9oQSYkIKgCg&usg=AFQjCNHkzJQi_94TE5Gn6rf46VPO73RChA&sig2=6KFs2UiHsfpQ37wh7MqS1g&bvm=bv.88528373,d.cGU .
[108] Flammable Cities was published in January 2012. The London Riots had occurred only five months earlier, and while the Arab Spring Movement and Occupy Movement had been underway for two years, there was likely insufficient research at the time of their drafting to make a stronger case.

Urban Fires as a Consequence of Natural Disasters

Superstorm Sandy

The fires in Breezy Point, Queens, New York caused by Superstorm Sandy on October 29, 2012 were called a conflagration by major media outlets and trade journals.[109,110,111,112] The images of the fire damage were called one of the "most shocking photographs taken in the wake of Hurricane Sandy's rampage."[113] The response to the fire was complicated by not only the high-winds that caused the fire to climb higher than 60 feet and jump houses easily, but also the severe flooding that slowed access to the area and prevented use of fire hydrants.[114] 135 homes were destroyed by fire.[115] That there were no fatalities or serious injuries, particularly to the firefighters, was called miraculous.

The New York Fire Department (FDNY) Assistant Chief Joseph Pfeifer[116] was the Incident Commander for the Breezy Point fire and in 2013 he wrote a detailed account of the incident for Fire Engineering Magazine.[117] He introduces the topic of conflagration and provides background on the early "Great Fires" of New York City, as well as the recent great fires: the 9/11 World Trade Center fires and the 2006 Greenpoint Terminal Market fire in Brooklyn. Chief Pfeifer was present at both of these incidents, which makes his account of the Breezy Point fire all the more valuable.

Pfeifer's article provides a detailed narrative of what happened that night, describing the evolution of the fire, the complications of fighting the fire based on the conditions, and the strategy and tactics used to attack the fire, including a "three-pronged attack that combined flanking strategies with direct tactics to contain the fire".[118] Pfeiffer puts into context the importance of the FDNY's preparedness efforts (the previous summer they ran tabletop exercises on hurricanes in several communities including the Rockaways), and draws out lessons learned for Incident Commanders. One of his primary themes is that a "major characteristic of complex disasters is the presence of novelty" (events not seen before).[119] Novelty slows down decision-

[109] For example: Dolnick, S. and Kilgannon, C.(2012, October 30). Wind-Driven Flames Reduce Scores of Homes to Embers in Queens Enclave. The New York Times. Retrieved March 2015 from http://www.nytimes.com/2012/10/31/nyregion/wind-driven-flames-burn-scores-of-homes-in-queens-enclave.html?_r=0.

[110] Tangel, A. (2013, October 29). Breezy Point looks back a year after Superstorm Sandy. Los Angeles Times. Retrieved March 2015 from http://articles.latimes.com/2013/oct/29/nation/la-na-breezy-point-20131030.

[111] Also references at Footnote 43 and 47.

[112] There are varying opinions as to whether these fires were conflagrations in the strictest, historical understanding of the term. However, this assessment uses a broader definition of the term to ensure the full spectrum of the risk is evaluated.

[113] Breezy Point Inferno: Photo that Captures the Horror of Queens. (2012, October 31). The Week. Retrieved March 2015 from http://www.theweek.co.uk/us/hurricane-sandy/49854/breezy-point-inferno-photo-captures-horror-queens.

[114] Tangel (2013, October 29).

[115] Tangel (2013, October 29).

[116] Pfeifer is currently the Chief of Counterterrorism and Emergency Preparedness for FDNY. During his career he has commanded some of the largest fires and emergencies in New York City's history: he was the first chief at the World Trade Center attack on the morning of September 11, 2001, played a major command role during Hurricane Sandy in 2012, served as an Incident Commander at the Metro North commuter train Derailment in 2013, and assisted in developing the Ebola response in New York City in 2014. Pfeifer is a Senior Fellow of the Program on Crisis Leadership at Harvard Kennedy School and has presented in several of the program's Executive Education programs, including Leadership in Crises and China Crisis Management. He is also Senior Fellow at the Combating Terrorism Center at West Point and has spoken about crisis leadership and disaster management at Harvard University, Columbia University, Wharton, the Naval Postgraduate School, the United States Military Academy, the Federal Bureau of Investigation (FBI), and Tsinghua University in Beijing, China. He holds a Masters in Public Administration from Harvard University's Kennedy School, a Masters in Security Studies from the Naval Postgraduate School, and a Masters in Theology from Immaculate Conception. He writes frequently and is published in various books and journals.

[117] Pfeifer, J. (2013, May). Conflagration in Breezy Point, Queens. Fire Engineering, 61-67.

[118] Pfeifer, J. (2013, May). P 64.

[119] Pfeifer, J. (2013, May). P 63.

making, and Pfeiffer recommends that in such cases, the commanders must "narrow the focus of units to achieve specific missions".[120]

That same night, there were four other simultaneous multiple-structure incidents in the Queens borough of New York City. Chief Robert Maynes, the Queens Borough Commander, was the incident commander for the Belle Harbor fire where 29 homes, two businesses and three garages were burned. In an article[121] that evaluates FDNY's overall Incident Management response[122] (not just fire related) to Superstorm Sandy, Kat Sonia Thomson[123] highlights Chief Maynes' approach because he drew upon his experience with wildland fires to design his attack strategy to the Belle Harbor fire. Chief Maynes worked on the Idaho East Zone Complex Wildland fire in 2006, and when assessing the Belle Harbor fire, realized the fire was "mimicking the behavior of a wind-driven wildfire."[124] He determined he could not rely on the typical structure-by-structure approach and instead used wildland fire tactics (i.e., approach the "head of the fire" when it is safe to do so and focus limited resources in a "flanking action").

Thomson's article provides suggestions for additional areas of study to ensure future improvements to the use of an All-Hazards Incident Management Team (IMT) in large incidents. However, the primary point of her article is to draw connections between wildland and structural fires and show how both communities can learn from one another. She argues that the "instance of multiple-structure, wind-driven conflagration is becoming far too common to continue to ignore," and that both communities should "work together to collect, analyze and implement a new typology of conflagration operations that incorporates concepts from wildland and structural operations."[125]

Professor Charles Jennings of the John Jay College of Criminal Justice, The City University of New York, provides a more scholarly account of the fires caused by Superstorm Sandy in an article for Fire Safety Science News, an international newsletter from the International Association for Fire Safety Science.[126] It was published only four months after the incident, and thus is primarily a narrative record of the event, similar to the other literature reviewed, albeit with more precision of language and perhaps a more neutral perspective. A key observation in his article is that fire caused by hurricanes has "received scant attention in the scholarly fire engineering community and even in the trade press," and that a "casual review of scholarly indexes shows scarcely any mention of the topic".[127]

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[120] Pfeifer, J. (2013, May). P 63.
[121] Thomson, K. (2013, July). When a Hurricane Becomes a Wildfire. Wildfire Magazine, 14-18.
[122] Thomson explains the FDNY implemented the use of the All-Hazards Incident Management Team (IMT) and Incident Command System (ICS) after its value was demonstrated by wildland firefighters deployed to assist FDNY in the aftermath of 9/11. In addition to the structural changes and training the IMT approach required, FDNY regularly deployed its teams to support other hazards around the country, including hurricanes and wildland fires.
[123] Kat Sonia Thomson, BA Urban Studies, MPA, Ph.D. Candidate, has worked in wildland fire and aviation operations since 1998, and currently serves as an Air Attack Officer for the Government of Alberta. In the off-season, she consults on structural fire department operations and performance management in New York City.
[124] Thomson, K. (2013, July). P 15.
[125] Thomson, K. (2013, July). P 18.
[126] Jennings, C. (2013). Fires During the 2012 Hurricane Sandy in Queens, New York: A First Report. Fire Safety Science News, (Newsletter No. 34), 26-28. Retrieved March 2015 from http://www.iafss.org/portal/wp-content/uploads/No-34-Fire-Safety-Science-News-March-2013.pdf
[127] Jennings, C. (2013). P 26.

Earthquakes

Earthquake-induced conflagrations are a recognized hazard. A 2008 U.S. Geological Survey report describe these events in the following way:

> Fire following earthquake refers to series of events or stochastic process initiated by a large earthquake. Fires occur following all earthquakes that significantly shake a human settlement, but are generally only a very significant problem in a large metropolitan area predominantly comprised of densely spaced wood buildings. In such circumstances, the multiple simultaneous ignitions can lead to catastrophic conflagrations that are by far the dominant agent of damage for that event. Regions of high seismicity with large metropolitan area predominantly comprised of densely spaced wood buildings include Japan, New Zealand, parts of Southeast Asia and western North America. A large earthquake such as a M7.8 event on the San Andreas fault in southern California (or comparable events in northern California, Puget Sound, or the Lower Mainland of British Columbia) combines all the requisite factors for major conflagrations that, depending on circumstances, can be of uniquely catastrophic proportions.[128]

The report notes "the two largest peace-time urban conflagrations in history have been fires following earthquakes – 1906 San Francisco and 1923 Tokyo, the latter resulting in the great majority of the 140,000 fatalities".[129]

On October 17, 1989, the San Francisco Bay Area was hit by a M6.9 earthquake that killed 67 people and caused more than $5 billion in damages.[130] In contrast to the 1906 San Francisco earthquake, fire was a minor factor.[131] There was one major fire in the Marina District: approximately eight apartment buildings were destroyed on one street.[132] The remaining fire losses were two homes and one auto repair shop.[133] A National Institute of Standards and Technology (NIST) study of the earthquake found that a number of factors might have contributed to the low fire-rate[134]:

- There was low wind. Had there been wind, the researchers found, it was quite possible the Marina District fire could have developed into a multi-block conflagration.
- It rained shortly before the earthquake, resulting in high moisture in the ground and wild lands. Downed power lines in the Santa Cruz Mountains served as ignition sources and some minor fires occur. They were able to be managed locally, "But had the hills been dry and/or a strong wind been present, a different result could well have occurred."

The study found that the fire services for the affected communities "were left in a condition where it is doubtful that they could have halted a serious spreading fire."[135] Fire services were

[128] Scawthorn, C. (2008). Fire Following Earthquake: The ShakeOut Scenario Supplemental Study. Prepared for U.S. Geological Survey and California Geological Survey, by SPA Risk, LLC. (Berkeley, CA). P 6.
[129] Scawthorn, C. (2008). P 7.
[130] U.S. Geological Survey. October 17, 1989 Loma Prieta Earthquake webpage: http://earthquake.usgs.gov/regional/nca/1989/
[131] Nelson, H. (1990). "Performance of Fire Protection Systems". Chapter 6 of Performance of Structures During the Loma Prieta Earthquake of October 17, 1989. Edited by Lew, H. U.S. Department of Commerce, National Institute of Standards and Technology. P 6-2. Retrieved April 2015 from http://www.nist.gov/customcf/get_pdf.cfm?pub_id=908823.
[132] Nelson, H. (1990). P. 6-1.
[133] Nelson, H. (1990). P. 6-1.
[134] Nelson, H. (1990). P. 6-1.
[135] Nelson, H. (1990). P. 6-1.

overwhelmed responding to search and rescue efforts, communications were disrupted or overtaxed, and significant underground breakage of water mains eliminated the principal source of firefighting water.[136]

Five years later and further south, a M6.7 earthquake struck the San Fernando Valley region of Los Angeles. The Northridge earthquake killed 60 people and more than 9,000 were injured.[137] From the initial main shock at 4:31AM to midnight, there were approximately 110 earthquake related fires.[138] A NIST sponsored study of the fires following the Northridge earthquake found that:

- More than 70% occurred in single- or multiple-family residences;
- The major cause of ignition was electric arcing as the result of a short circuit, although gas flame from an appliance is also a recurring source of ignition; and
- Where identification could be made, escaping natural gas (presumably from a broken gas line) is the single most common ignition material.[139]

Other consequences that inhibited firefighting:

- Several instances of significant communications impairment
- The earthquake caused approximately 1,400 water system leaks, and pump stations and storage tanks also sustained damage. This resulted in a lack of water pressure at hydrants in certain portions of San Fernando Valley, and the Los Angeles Fire Department (LAFD) resorted to using water tankers and drafting from alternative sources.[140]

The NIST study determined that while a significant number of fires occurred in the hours after the earthquake, the resources of the Los Angeles region were sufficient to deal with the fires, as well as the other earthquake emergencies. However, the study indicates if the fires had turned into a conflagration the diminished water supply would not have been sufficient to address it.[141]

While these studies identify valuable lessons learned, they are based on the last major earthquakes to strike the U.S. mainland, which occurred over 20 years ago. Not surprisingly, several of the studies cited in this section are older than those usually selected for the literature review.[142] While there is value in understanding the history of earthquake caused fires, they are less reliable sources for assessing risk. Current firefighting capabilities and technology have evolved significantly in twenty years. Federal, state, and local preparedness and capabilities for catastrophic events has improved since the terrorist attacks of September 11, 2001.[143]

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[136] Nelson, H. (1990). P. 6-2.
[137] Scawthorn, C. (2008). P 10.
[138] Scawthorn, C., Cowell, A., and Borden, F. (1998, March). EQE Fire-related aspects of the Northridge Earthquake. Prepared for the U.S. Department of Commerce, National Institute of Standards and Technology, Building and Fire Research Laboratory. International, Inc. (San Francisco, CA) P iv.
[139] Scawthorn, C., Cowell, A., and Borden, F. (1998, March). P v.
[140] Scawthorn, C., Cowell, A., and Borden, F. (1998, March). P v-vi.
[141] Scawthorn, C., Cowell, A., and Borden, F. (1998, March). P vi.
[142] The target range for this Literature Review is publications from the past five years (2010-2015).
[143] Examples of improvements include: interoperable communications, situational awareness standard operating procedures, Incident Command Systems, exercises, training, and enhanced equipment.

Simultaneously, there are factors that may increase the risk of fires following earthquakes including:

- Recent severe droughts in the west have significantly depleted water supplies. The inability to quickly access water, will lead to more conflagrations.
- Increased drilling near populous areas and more refineries and tank farms; "When strongly shaken, oil refineries and tank farms have typically had large fires which have burned for days."[144]
- Wildland Urban Interface – as discussed below, increased development in wildland areas has led to an increased number of significant fires and conflagrations. They are also further exacerbated by extreme drought conditions.

Wildland Urban Interface

One of the most common topics found during this literature review was Wildland Urban Interface (WUI). Nine of the 25 costliest fires in U.S. history, in terms of property loss, were forest, wildland or WUI fires.[145] Over 46 million homes in 70,000 communities are said to be at risk of WUI fires.[146] The Natural Resource Conservation service estimates that since 1990, the U.S. has converted 3 acres per minute, 4,000 acres per day and close to 2 million acres per year of wildlands to WUI.[147,148] The International Association of Wildland Fire reports that the number of structures lost to WUI fires has "grown significantly over the past 20 years."[149] A number of factors contribute to the trend: "increased development in rural areas, fuel management policies, and climate change, all of which are projected to continue for the foreseeable future."[150]

The SNRA addresses wildfires as a stand-alone topic, separate from Urban Fire/Urban Conflagration. Increasingly however, wildfires move into populated areas and cause extensive damage. The NFPA defines WUI as: "The presence of structures in locations in which the [authority having jurisdiction] determines that topographical features, vegetation fuel types, local weather conditions, and prevailing winds result in the potential for ignition of the structures within the area from flames and firebrands of a wildland fire." Or more simply: "The location where humans and their development meet or are intermixed with wildland fuels."[151]

A 2010 article in the International Journal of Wildland Fire, written by experts from NIST and the National Oceanic and Atmospheric Administration (NOAA), assessed the current approaches

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[144] Scawthorn, C. (2008). P 10.

[145] Almand, K. (2014, September 3). Interface Investigation: The need for a closer look at how structures burn in the wildland/urban interface. National Fire Protection Association Journal. September-October 2014. Retrieved April 2015 from http://www.nfpa.org/newsandpublications/nfpa-journal/2014/september-october-2014/columns/research

[146] Bailey, D. (2013) WUI Fact Sheet, International Association of Wildland Fire and International Code Council. Retrieved April 2015: http://www.iawfonline.org/pdf/WUI_Fact_Sheet_08012013.pdf

[147] Bailey, D. (2013).

[148] Bailey, D. (2013) reference is a useful WUI fire fact sheet and provides many more statistics on WUI fires.

[149] Almand, K. (2014, September 3).

[150] Almand, K. (2014, September 3).

[151] Both definitions are found in the 2014 NFPA Glossary. NFPA. "NFPA Glossary of Terms: 2014 Edition". (2014, September). Retrieved March 2015 from http://www.nfpa.org/got

and research needs for the WUI fire problem.[152] The study asserts that the WUI fire problem is a structure ignition problem and the best approach to reducing the severity of the problem is to reduce the potential for structure ignition.[153] The paper provides "an overview of the WUI fire problem, a short review of current approaches to addressing the WUI fire problem and reducing structure ignitions, a discussion and assessment of further needs, and an overview of the ongoing work at the National Institute of Standards and Technology (NIST) to address some of the research needs".[154]

As of 2010, the authors stated there is no standardized method of risk assessment that can be applied nationwide to WUI communities in the U.S. They review and evaluate the limitations of several narrowly tailored risk assessment methodologies. A section on residential fuels, the definition of which includes both structures and vegetation, points out that most of the focus is on vegetation-to-structure fire spread. They believe this is valid for WUI communities with sufficiently low housing density, however, insufficient for medium to high housing density areas. Citing analysis of four separate WUI fires, structure-to-structure fire spread played a key role in the overall fire behavior. They assess that existing guidelines (as of 2010) for homeowners to mitigate WUI fire risk were developed for lower housing-densities and may not be applicable for the medium to high housing density areas.[155]

A more recent article in the NFPA Journal by Kathleen H. Almand, suggests that there is still a need for better research.[156] The article reviews current efforts underway to address WUI fire:

- The NFPA reorganized its technical committees to better address the WUI fire problem.
- NIST, USFS and the Insurance Institute for Business & Home Safety are actively pursuing research programs to better understand the spread of fire from the wildland to structures.
- The Fire Protection Research Foundation, a foundation that supports the NFPA mission, issued a report in March 2015, Pathways for Building Fire Spread at the Wildland Urban Interface.[157] The purpose of the report is to serve as a bridge between emerging research and NFPA's codes and standards so that their prevention and protection strategies reflect the new and growing understanding of WUI firespread.[158]

Lighter Building Materials, Modern Furniture Means Hotter, Faster Fires and a Change in Fire Fighting Strategies

As one would expect, many articles in the fire trade journals are focused on the nuts and bolts of daily firefighting. An interesting theme within the past five years of literature is the impact that

[152] Mell, W., Manzello, S., Maranghides, A., Butry, D., and Rehm, R. The Wildland-Urban Interface Fire Problem – Current Approaches and Research Needs. (2010). P 238. International Journal of Wildland Fire. Vol 19. Retrieved April 2015 from http://www.firescience.gov/projects/07-1-5-08/project/07-1-5-08_Mell_etal_WUIresearch_needs_ijwf2010.pdf

[153] Mell, W., Manzello, S., et. al. (2010). P 238. Which cites: Cohen JD (2008) The wildland–urban interface fire problem. *Forest History Today* (Fall), 20–26.

[154] Mell, W., Manzello, S., et. al. (2010). P 238.

[155] Mell, W., Manzello, S., et. (2010). P 242.

[156] Almand, K. (2014, September 3).

[157] Gollner, M., Hakes, R., Caton, S., and Kohler, K. (2015, March). Pathways for Building Fire Spread at the Wildland Urban Interface. Department of Fire Protection Engineering, University of Maryland. (College Park, MD), produced for Fire Protection Research Foundation. Retrieved April 2015 from http://www.nfpa.org/research/fire-protection-research-foundation/reports-and-proceedings/for-emergency-responders/fire-prevention-and-administration/pathways-for-building-fire-spread-at-the-wildland-urban-interface,

[158] Almand, K. (2014, September 3).

newer buildings and furniture have on fires.[159,160] The articles provide some scientific explanations for how fire acts differently in buildings constructed prior to the 1960s (with solid wood) as compared to those built since. While the newer engineered products provide a supposedly stronger structure for less material and money, under the high-heat conditions a fire produces, the structures fail much more rapidly and the fire escalates more quickly and thus the firefighting strategies must be altered depending on the type of building. The articles also suggested there was a lack of consideration for the implications of fire prevention in the construction of these homes. No articles were found that connected new buildings to an increased risk of conflagration, however, urbanization trends in the U.S. – particularly when older homes, which tend to be spaced more closely together than suburban areas, are torn down or gutted and replaced with new materials – may increase the risk of fires with the potential to spread.

Similarly, an NFPA Journal article from January 2015 highlights new research from Fire Science that suggests tactical changes should be made in how firefighters approach fires.[161] Some of this is based on finally having solid scientific data on how structure fires work, but the other reason for the suggested changes are to recognize that the 'fuel sources' in the modern home are extremely different that those fifty years ago when most firefighting tactical standards were developed. One experiment, which can be watched on YouTube, captured the significant difference in how fire behaved in a room with older versus newer furniture. The room filled with legacy furniture takes nearly thirty minutes to reach flashover, but the modern room reaches flashover in just three minutes, 40 seconds. Since the average response time for home structure fires is close to six minutes, it means firefighters are dealing with much more intense fires than their counterparts 50 years ago.

Conclusion

While articles from the past five years appear in agreement that the U.S. does not have a strong or even moderate risk of conflagration from traditional causes, there may be an increasing risk of urban fires caused by other hazards.

Flammable Cities, makes the case that urban fires, even in so-called "first world" countries, may see a resurgence in future years, as people resort to leveraging fire as a political tool. Whether the incidents in France, London, and Ferguson, Missouri are evidence of an emerging trend or an anomaly remains to be seen, and perhaps could be evaluated in future risk assessments.

On the nexus of fires and natural disasters, earthquakes and fires are well-studied due to the 1906 San Francisco Earthquake and associated conflagration[162], however, hurricanes and conflagrations, as Jennings' points out, is less studied. In both cases, firefighters' access to the blaze and access to water for fire suppression appear to be major challenges in keeping a fire from spreading. It should be noted that there was only one scholarly journal found on the topic of

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[159] Naum, C. (2015, January). Building Construction for Today's Fire Service: Newer buildings & occupancies present increasing challenges. Firehouse Magazine. P 74.
[160] Earls, A. (2009, July). Lightweight Construction. NFPA Journal. (July-August 2009 Edition). Retrieved March 2015 from http://www.nfpa.org/newsandpublications/nfpa-journal/2009/july-august-2009/features/lightweight-construction,
[161] Roman, Jesse. (2015, January). New Fires, New Tactics. NFPA Journal. January-February 2015. Retrieved April 2015 from http://www.nfpa.org/newsandpublications/nfpa-journal/2015/january-february-2015/features/fire-tactics.
[162] See draft 2011 Risk Summary Sheet on Urban Conflagration.

Superstorm Sandy and the fires.[163,164] The incidents are fairly recent, thus studies may be ongoing and as Thomson and Jennings' articles indicate, there is a need for deeper analysis.

Though the 1989 and 1994 earthquakes did not result in conflagrations, they provided useful insights into the challenges of fighting fires caused by earthquakes. The literature reviewed, however, is limited in providing a useful risk assessment for today's environment due to changes in technology, equipment, and capabilities over the past twenty years. Alternatively, certain factors like climate change, extreme drought, more oil and gas drilling, and more refineries may exacerbate fires. This means that fires that were controllable in 1989 and 1994 may no longer be able to be suppressed.

There is general agreement among experts that "WUI fires will continue to be a serious and costly issue".[165] The NFPA even made it a priority in their current strategic plan. All indications are that the WUI will continue to grow as more and more people move into wildland areas. Current drought conditions in the west, and the potential for climate change to further exacerbate drought and other severe weather will provide more fuel and ignition sources for the fire. Thus the research is focused on mitigation and suppression techniques. This research and the NFPA's updated standards should help reduce the size and consequence of WUI fires, even as the frequency is likely to stay the same or increase.

Finally changes in building materials and furnishings are producing hotter and faster fires, making a structure-to-structure fire spread more likely if outdated firefighting techniques are used. The firefighting community seems to be aware of the need for changes; standards and training are being updated. While the fires may be more intense, there is reason to believe the tactics to mitigate that intensity will be successful.

All of these changes and increased risk factors require urban firefighters to be equipped with the skills necessary to handle the complex challenges of today's fires.

[163] Searches conducted via USFA's online library, NFPA's website and general internet searches, including Google Scholar.

[164] While there were numerous additional trade magazine articles about Superstorm Sandy and the associated fires, only one scholarly journal was found in a search of the USFA's Library catalogue. The article appeared in The Crisis Journal and was solely an interview with Joseph Pfeiffer. It did not contain any references to academic literature. Since Joseph Pfeiffer's article from Fire Engineering magazine had already been reviewed for this Literature Review, it was not included as a separate source for purposes of the Literature Review. Pfeiffer does cite additional lessons learned in the interview. Should further research on this topic be required, this article should be reviewed. Citation for the article: Christo Motz, (2013). How the FDNY responded to Hurricane Sandy. The Crisis Journal (Vol 8 (3)).

[165] Mell, W., Manzello, S. . . . (2010). P 248.

Table 13: Incidents of Fires with 10 or More Fatalities from 1970-2013[166],[167]

Start	End	Location	Name	Killed	Tot. Affected	Est. Dmge (US$ Million)	EM-DAT DisNo	CPI	Dmge. $2011 (US$ Million)
9/6/1970	9/6/1970	Ohio	Nursing Home	31			1970-0011	5.797	
12/1/1970	12/1/1970			28			1970-0130	5.797	
3/2/1971	3/2/1971	Woodbine		25	61		1971-0122	5.554	
6/24/1973	6/24/1973	New Orleans	Nightclubs	30			1973-0064	5.066	
6/30/1974	6/30/1974	New York	Nightclub	24			1974-0067	4.563	
10/24/1976	10/24/1976	Bronx, New York	Nightclub	25			1976-0080	3.953	
10/1/1976	10/1/1976	Fremont (Nebraska)	Nursing Homes	20			1976-0081	3.953	
6/1/1977	6/1/1977			42			1977-0237	3.712	
2/7/1978	2/7/1978	Beverly Hills, Southgate ...	Supper Club Fire	164	100		1978-0248	3.450	
5/28/1978	5/28/1978	Beverly Hills	Beverly Hills Country Club	16			1978-0150	3.450	
1/1/1979	1/1/1979	Sante Fé		28			1979-0120	3.098	
11/21/1980	11/21/1980	Las Vegas	Hotel	84	726		1980-0024	2.730	
12/4/1980	1/1/1981	New York	Hotel 'Stouffers Inn'	26			1981-0020	2.475	
12/24/1989	12/24/1989	Johnson City (Tennessee)	Retirement home	16			1989-0342	1.814	
1/1/1989	1/1/1989	Near Remer (Minnesota)	House	10			1989-0406	1.814	
3/25/1990	3/25/1990	New-York	Night club 'Happy Land'	87			1990-0432	1.721	
4/19/1993	4/19/1993	Waco		78			1993-0449	1.557	
3/16/1993	3/16/1993	Chicago	Hotel	16			1993-0127	1.557	
3/5/1993	3/5/1993	Los Angeles	Apartment complex	10			1993-0152	1.557	
11/21/1996	11/21/1996	San Juan	Building	29	90	12.1	1996-0332	1.434	17.3
3/1/2001	3/1/2001	Oak Orchard (Delaware Sta ...	House	11			2001-0004	1.270	
2/20/2003	2/20/2003	West Warwick (Rhode Isl. ...	Nightclub	100	150		2003-0095	1.222	
2/26/2003	2/26/2003	Hartford (Connecticut)	Nursing home' Greenwood	11	120		2003-0108	1.222	
11/26/2006	11/27/2006	Anderson (Missouri)	Hall for mentally disabled people	10	19		2006-0637	1.116	
7/3/2007	8/3/2007	Bronx (New York)	Home	10			2007-0118	1.085	
3/4/2008	3/4/2008	Pennsylvania	House	10	2		2008-0143	1.045	

[166] EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be, Université Catholique de Louvain, Brussels (Belgium) [official citation]. EM-DAT is maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at the School of Public Health of the Université Catholique de Louvain located in Brussels, Belgium (http://www.emdat.be/frequently-asked-questions), and is supported by the Office of US Foreign Disaster Assistance (OFDA) of USAID (http://transition.usaid.gov/our_work/humanitarian_assistance/disaster_assistance/).
[167] Accessed March 2015. Verified no further fire incidents available in EM-DAT through 2013.