Strategic National-level Risk Assessment (SNRA): Terms of Reference

I. Policy Mandate

The Presidential Policy Directive - 8 (PPD-8) Implementation Plan mandates, as part of the development of the National Preparedness Goal (NPG), that "The Secretary of Homeland Security shall conduct a strategic, national-level risk assessment[1] to identify the relevant risk factors that guide where core capabilities are needed and develop a list of the capabilities and associated performance objectives for all threats and hazards that will measure progress toward their achievement." This document describes how the PPD-8 Implementation Team intends to meet that requirement.

II. Decision Statement

The Strategic National-level Risk Assessment (SNRA) will support the identification of core capabilities necessary for National preparedness and decisions as to what level, and against what considerations, those capabilities are needed.

III. Scope

The SNRA will focus on those threats and hazards identified in PPD-8, considering the range of natural hazards (including (b)(5), potential industrial accidents, and acts of terrorism, including (b)(5).[2] It will be designed to assess the risks of those events and incidents which create consequences that rise to a strategic, national level of impact.[3]

The assessment will focus on estimating risk[4] over the next three to five years, in support of the overall need to take a future-oriented look at core capability development. In doing so, the assessment may also qualitatively identify future trends, drivers, and conditions that may impact homeland security preparedness needs beyond the five year period.

IV. Timeframe

The initial SNRA will be conducted over a four-week period. The results of the initial assessment will be used to help refine core capabilities for the publication of the NPG on September 25, 2011. The SNRA will be designed to support the follow-on execution of a more detailed national-level risk assessment to be conducted as part of the National Preparedness System (NPS) in FY 2012, and will also be designed to support integration with regional, State, and local risk assessments.

V. Execution Elements

The Secretary of Homeland Security has the lead for conducting the SNRA. The Federal Emergency Management Agency and National Protection and Programs Directorate will provide leadership on the execution of the assessment on the Secretary's behalf, in coordination with DHS Office of Intelligence & Analysis (I&A) and DHS Office of Policy and other involved parties. The Director of National Intelligence will facilitate coordination across the intelligence community and, in coordination with the Attorney General, engage the law enforcement community to provide all relevant and appropriate terrorism-related intelligence information for the development of the risk assessment. The FBI will serve as the primary interface for purpose of conducting the risk assessment on behalf of the Attorney General. Other Departments and Agencies will provide information, analysis, and expertise to support the conduct of the SNRA as required. Additional members of the homeland security community (i.e appropriate State, local, tribal, territorial officials as well as private sector and non-governmental organizations) will be engaged during the conduct of the SNRA consistent with overall PPD-8

(b)(5)

Strategic National-level Risk Assessment (SNRA): Terms of Reference

I. Policy Mandate

The Presidential Policy Directive - 8 (PPD-8) Implementation Plan mandates, as part of the development of the National Preparedness Goal (NPG), that "The Secretary of Homeland Security shall conduct a strategic, national-level risk assessment[1] to identify the relevant risk factors that guide where core capabilities are needed and develop a list of the capabilities and associated performance objectives for all threats and hazards that will measure progress toward their achievement." This document describes how the PPD-8 Implementation Team intends to meet that requirement.

II. Decision Statement

The Strategic National-level Risk Assessment (SNRA) will support the identification of core capabilities necessary for National preparedness and decisions as to what level, and against what considerations, those capabilities are needed.

III. Scope

The SNRA will focus on those threats and hazards identified in PPD-8, considering the range of natural hazards (including pandemics), potential industrial accidents, and acts of terrorism, including cyber acts with hostile intent.[2] It will be designed to assess the risks of those events and incidents which create consequences that rise to a strategic, national level of impact.[3]

The assessment will focus on estimating risk[4] over the next three to five years, in support of the overall need to take a future-oriented look at core capability development. In doing so, the assessment may also qualitatively identify future trends, drivers, and conditions that may impact homeland security preparedness needs beyond the five year period.

IV. Timeframe

The initial SNRA will be conducted over a four-week period. The results of the initial assessment will be used to help refine core capabilities for the publication of the NPG on September 25, 2011. The SNRA will be designed to support the follow-on execution of a more detailed national-level risk assessment to be conducted as part of the National Preparedness System (NPS) in FY 2012, and will also be designed to support integration with regional, State, and local risk assessments.

V. Execution Elements

The Secretary of Homeland Security has the lead for conducting the SNRA. The Federal Emergency Management Agency and National Protection and Programs Directorate will provide leadership on the execution of the assessment on the Secretary's behalf, in coordination with DHS Office of Intelligence & Analysis (I&A) and DHS Office of Policy and other involved parties. The Director of National Intelligence will facilitate coordination across the intelligence community and, in coordination with the Attorney General, engage the law enforcement community to provide all relevant and appropriate terrorism-related intelligence information for the development of the risk assessment. The FBI will serve as the primary interface for purpose of conducting the risk assessment on behalf of the Attorney General. Other Departments and Agencies will provide information, analysis, and expertise to support the conduct of the SNRA as required. Additional members of the homeland security community (i.e appropriate State, local, tribal, territorial officials as well as private sector and non-governmental organizations) will be engaged during the conduct of the SNRA consistent with overall PPD-8

[1] Risk assessment is defined in the *DHS Risk Lexicon* as the "product or process which collects information and assigns values to risks for the purpose of informing priorities, developing or comparing courses of action, and informing decision making."

[2] For the purposes of this assessment, terrorism and cyber attacks will be grouped into a single category referred to as Adversarial/ Human Caused threats.

[3] One of the key initial stages of the SNRA will be to define thresholds and categories for what define a strategic, national level of impact. These events and incidents will be generally catastrophic in nature.

[4] Risk is defined in the *DHS Risk Lexicon* as "potential for an unwanted outcome resulting from an incident, event, or occurrence, as determined by its likelihood and the associated consequences."

What's missing?

Technical Appendix

May 2015

Homeland Security

PRE-DECISIONAL DRAFT

~~NOT FOR PUBLIC DISTRIBUTION OR RELEASE~~

Strategic National Risk Assessment 2015

Technical Appendix

May 2015

Homeland Security

PRE-DECISIONAL DRAFT

NOT FOR PUBLIC DISTRIBUTION OR RELEASE

Table of Contents

Table of Contents

Section 4: Data Sources in the SNRA

The SNRA project team used the data sources presented in Table 2 below during the development of the 2011 SNRA, and the update in 2015.

Table 2: SNRA Data Sources

(b)(5)

Threat/Hazard	Frequency	Fatalities and Injuries/Illnesses	Direct Economic Loss	Social Displacement

Section 4: Data Sources in the SNRA

The SNRA project team used the data sources presented in Table 2 below during the development of the 2011 SNRA, and the update in 2015.

Table 2: SNRA Data Sources

Threat/Hazard	Frequency	Fatalities and Injuries/Illnesses	Direct Economic Loss	Social Displacement
Animal Disease	USDA Economic Research Service modeling & DHS/OHA and DHS/S&T subject matter expertise			Subject matter expert estimates via DHS Centers of Excellence
Drought	Historic data compiled from NOAA National Climactic Data Center (NCDC)			SNRA project team assumption of zero displaced
Earthquake	Historic data compiled from the Center for Science and Technology Policy Research at University of Colorado-Boulder & FEMA HAZUS modeling			Historic data from EM-DAT disaster database
Flood	Historic data compiled from NOAA National Climactic Data Center (NCDC) and FEMA HAZUS modeling			Historic data from EM-DAT disaster database
Human Pandemic Outbreak	CDC analysis of historic record	CDC subject matter expertise	SNRA project analysis using CDC modeling	SNRA project team assumption of zero displaced
Hurricane	Historic data compiled from NOAA, the Center for Science and Technology Policy Research at University of Colorado-Boulder & FEMA HAZUS modeling			Historic data from EM-DAT disaster database
Space Weather	Expert estimates from the literature (range)	Epidemiological studies of 2003 East Coast Blackout	Expert estimates from the literature (range)	Subject matter expert estimates via DHS Centers of Excellence
Tornado	Historic data compiled from the NOAA/National Weather Service (NWS) Storm Prediction Center (SPC)			Not assessed
Wildfire	Historic data compiled from Spatial Hazard Events and Losses Database for the United States (SHELDUS) – University of South Carolina			Historic data from EM-DAT international disaster database
Winter Storm	Historic data compiled from NOAA National Climactic Data Center (NCDC)			Not assessed
Biological Food Contamination	CDC Foodborne Outbreak Online Database (FOOD) and FDA / USDA subject matter expertise		Open source historic examples	Subject matter expert estimates via DHS Centers of Excellence
Chemical Substance Spill or Release	DOT Pipeline & Hazardous Materials Safety Administration (PHMSA) and EPA Risk Management Program (RMP) incident databases			
Combustible/ Flammable Cargo Accident (Rail)	DOT Pipeline & Hazardous Materials Safety Administration (PHMSA) incident database			
Dam Failure	Historic data compiled by DHS Dams Sector		U.S. Bureau of Reclamation modeling	Subject matter expert estimates via DHS Centers of Excellence
Radiological Substance Release	U.S. Nuclear Regulatory Commission (NRC) license renewal applications			Subject matter expert estimates via DHS Centers of Excellence
Transportation System Failure	Historic data compiled by Structures Group, Cambridge University Department of Engineering			SNRA project team assumption of zero displaced
CBRN Terrorism Attacks	DHS/S&T Integrated Terrorism Risk Assessment (ITRA)			Subject matter expert estimates via DHS Centers of Excellence
Armed Assault	Historic data published by FBI		SNRA project team analysis based upon historic data	SNRA project team assumption of zero displaced

Detailed Findings

(b)(5)

Detailed Findings

The results of the SNRA include a comparison of risks for potential incidents in terms of the likelihood (estimated as a frequency, i.e., number of events per year) and impacts of threats and hazards, as well as an analysis of the uncertainty associated with those incidents.

The assessment finds that a wide range of threats and hazards pose a significant risk to the Nation, affirming the need for an all threats/hazards, capability-based approach to preparedness planning. Many events are estimated to have the potential to happen more than once every 10 years, meaning that it is likely that the Nation's preparedness will be tested in this decade.

Key findings are discussed below.

High Risk Events

Of the non-CBRN attack[7] events, the national-level events that are estimated to have generally high risk across many impact categories in the SNRA are pandemic influenza outbreaks and hurricanes (see Table 3 above). Space weather may pose comparable or greater risk to hurricanes on some impact axes, but this is highly uncertain.

To identify these high risk events, the results for each type of risk (estimated as an annualized loss) were considered independently and not aggregated. Events which were estimated to have high risk in each impact category, taking into account uncertainty and the quality of the underlying data, were identified. The events identified above are those which were identified as high risk across the majority of impact types.

- Pandemic influenza is estimated to be the highest risk event of all the non-adversarial events in the SNRA for fatality, illness/injury, and psychological distress risk, and is near the top for direct economic risk. At the best estimate, it has more fatality and injury/illness risk than every other natural hazard or accident in the SNRA combined. It is estimated to have no social displacement risk and relatively low environmental risk.
- Hurricanes are the highest direct economic risk at the best estimate, with the possible exception of space weather. Hurricanes also present the highest social displacement risks to the Nation of all the non-adversarial events included in the SNRA, coupled with relatively high psychological distress and environmental risks. Though not amongst the largest fatality and injury/illness risks within this set, hurricanes do carry some risk in these dimensions.
- The risks to the Nation posed by space weather are clouded with uncertainty.[8] However, the SNRA cannot rule out the possibility that space weather may rank with hurricanes in the top tier of direct economic and social displacement risks to the Nation.

When considering the high risk events listed above, it is important to consider that many hazards have the potential to be catastrophic, and many additional natural and accidental hazard national-level events in the SNRA pose significant risk to the Nation.

---

[7] Classified data and analyses suitable for the comparison of chemical, biological, radiological, and nuclear (CBRN) terrorist attack threats within the fully quantitative framework of the SNRA may be found in the classified SNRA Technical Report.

[8] Technical experts are strongly divided between experts who believe that a severe solar storm would most likely shut down the electric grid for days, and others who believe that it would most likely shut down large portions of the grid for months to years. As there is little middle ground between them, low and high impact estimates for this event in the SNRA represent not the endpoints of a range bounding a best estimate, but two alternate best estimates with the uncertainty being over which set of experts is correct. See the Space Weather risk summary sheet.

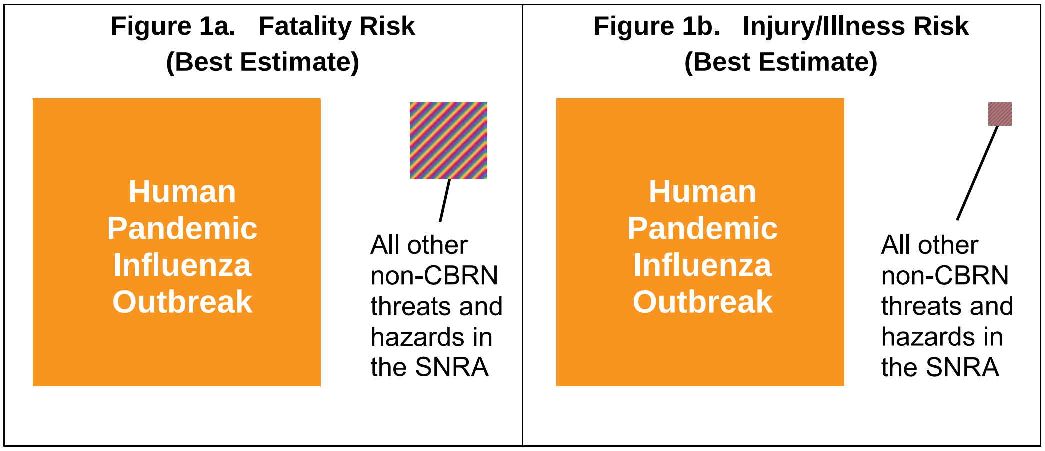


Figure 1: Dominance of Human Pandemic Influenza Outbreak Over All Other Non-CBRN Hazards - Fatality Risk and Injury/Illness Risk

Figure 2 depicts the best estimates of the fatality and direct economic risk for the SNRA's quantitatively assessed natural hazards and accidents, as measured by the product of the best estimates of frequency and fatalities given occurrence (Figure 2a, fatality risk) or the product of the best estimates of frequency and direct economic impacts given occurrence (Figure 2b, direct economic risk). Although it is not the one largest or dominant contributor to direct economic risk among national-level events as it is for human fatality and illness/injury risk, the pandemic influenza outbreak scenario ranks with the most catastrophic natural disaster events assessed in the SNRA.

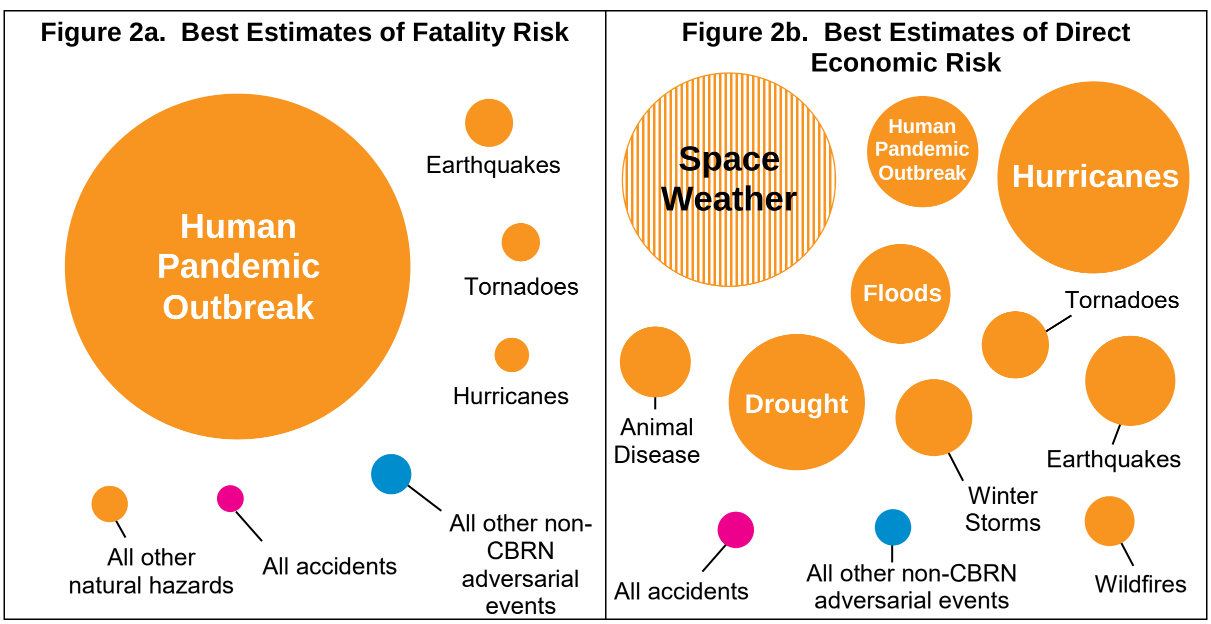


Figure 2: Best Estimates of Risk in the Unclassified SNRA Events

When interpreting Figure 2, it is important to remember that there is significant uncertainty in the frequencies and impacts associated with many events assessed in the SNRA.

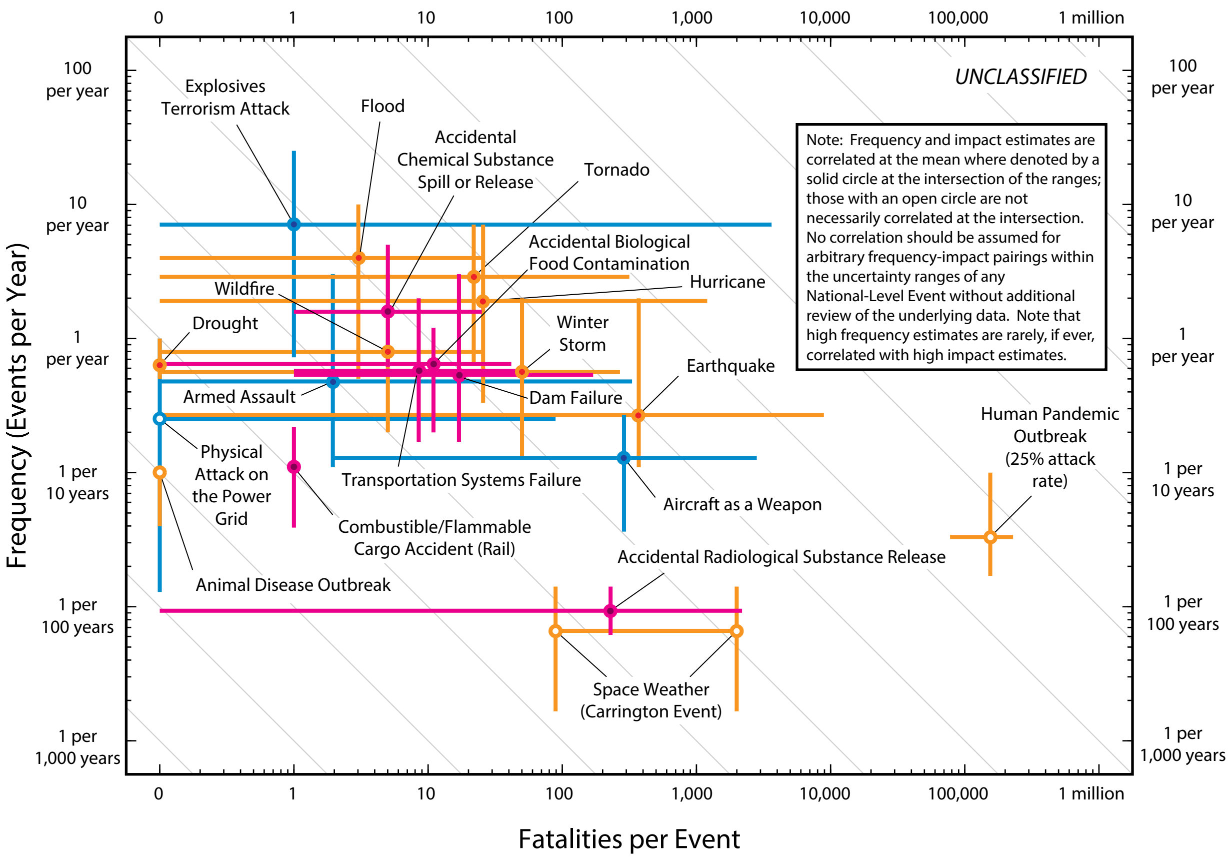
6a

Significant Risks May Be Masked By Limited Data

In the course of conducting the SNRA, a number of events were not assessed because of limited quantitative data availability. The SNRA is therefore unable to comment on the relative risk associated with these events, some of which are qualitatively believed to have potential for significant impact. These are seen in tables 2 and 3 of the 2015 SNRA Findings document.

Fatality Risk

Fatality risk was estimated for each national-level event by multiplying the best estimate of the frequency by the best estimate of the resulting injuries/illnesses given occurrence. Figure 3 presents a visual depiction of fatality risk across the SNRA-assessed accidental, natural, and non-CBRN adversarial hazard events.



Legend:

Natural Hazards
Technological Hazards
Adversarial Threats

Events Not Displayed:

- Cyber Attacks
- Antibiotic Resistance
- Oil Spill
- Heat Wave
- CBRN Terrorism Attacks
- Non-Influenza Human Diseases
- Industrial Accident (Fire/Explosion)
- Migrant Surge/Mass Migration
- Tsunami
- Plant Disease
- Pipeline Failure
- Volcanic Eruption

Figure 3: Fatality Risk

Note that all comparative statements are made within the set of natural and accidental hazards, and conventional-attack adversarial threats, which were analyzed at an unclassified level for the 2015 SNRA. Classified data and analyses suitable for the comparison of chemical, biological,

(b)(5)

Physical Attack on the Power Grid

A malicious actor causes physical damage to an aspect of the power grid, resulting in a loss of power in one or more metropolitan areas for three or more hours. [i]

Category	Description	Metric	Low[ii]	Best[iii]	High[iv]
Health and Safety	Fatalities	Number of Fatalities	0[v]	0[vi]	90[vii]
	Injuries and Illnesses	Number of Injuries or Illnesses	0[viii]	2[ix]	400[x]
Economic	Direct Economic Loss	U.S. Dollars	$15 million	$46 million	$5.7 billion
Social	Displacement	People Displaced from Homes ≥ 2 Days	0[xi]	0[xii]	0[xiii]
Psychological	Psychological Distress	Qualitative Bins	TBD	TBD	TBD
Environmental	Environmental Impact	Qualitative Bins	*De Minimus*[xiv]		
LIKELIHOOD	Frequency of Events[xv]	Number per Year	0.013[xvi]	1 every four years[xvii]	1 to 3 per year[xviii]

[i] Some studies have chosen to examine a nationwide or near-nationwide power outage in the continental United States for at least six months. However, experts differ on how realistic this scenario could be. Because of the uncertainty regarding feasibility of a nationwide power outage, the scenario included here is scoped to a significant but reasonable event.

[ii] For the Physical Attack on the Power Grid event, low, best, and high impact estimates are correlated across impact axes because they represent three physical scenarios (such correlation should not be assumed for other SNRA events). Note that the low, best, and high estimates of likelihood are not correlated to these scenarios: they represent the low estimate, best estimate, and high estimate of the overall frequency of any scenario within the scope of the event (any of the three impact scenarios defining the SNRA's reported range and any other scenario meeting the thresholds which define the scope of the Physical Attack on the Power Grid event).

The low impact estimates assume a successful attack on the grid infrastructure that causes physical damage, but which does not result in a power outage with significant impacts. This outcome could be because the grid is able to offload power and prevent a power outage or disruption, or because there is an outage of 3 or more hours which occurs at night (critical facilities and industries are assumed to have backup power sufficient for several hours).

[iii] The best impact estimates assume a successful attack on the grid infrastructure that causes physical damage and a power outage to a broad metropolitan area in the continental U.S. at daytime, with the power outage lasting 3 hours. The best estimate duration is based on the lengths of the accidental outages discussed in the Event Background section. In order to estimate the impacts of an outage for the best estimate scenario, this assessment assumes the size of the population affected is 2,138,460. This population size represents the median population size for the 50 largest metropolitan urban areas as captured in the 2010 census.

[iv] The high impact estimates assume a successful attack on the grid infrastructure that causes physical damage and a power outage to a broad metropolitan area in the continental U.S., similar to the best estimate. However, the outage lasts for one day, resulting in net impacts to the Nation similar to those of the Northeast Blackout in August 2003.

[v] Zero by assumption.

[vi] Scaled from high estimate in proportion to total person-days without power.

[vii] Injuries and fatalities from power grid failures generally result from heat stroke and respiratory ailments, which can occur when outages occur during the summer months. However, it is difficult, if not impossible, to directly tie heat stroke victims to a power outage. Determining the role of heat (versus other concurrent factors) in a death can be complicated, and different jurisdictions use different criteria for considering deaths heat related. For the high

(b)(5)

Space Weather[xix]

The Sun emits bursts of electromagnetic radiation and energetic particles causing utility outages and damage to infrastructure in the United States, resulting in direct economic losses greater than $1 billion.

Data Summary

Category	Description	Metric	Low	Best[xx]	High
Health and Safety	Fatalities	Number of Fatalities	90[xxi]	N/A[xx]	2,000[xxii]
	Injuries and Illnesses	Number of Injuries or Illnesses	400[xxiii]	N/A[xx]	10,000[xxiv]
Economic	Direct Economic Loss	U.S. Dollars	$5.7 Billion[xxv]	N/A[xx]	$2 Trillion[xxvi]
Social	Social Displacement	People Displaced from Homes ≥ 2 Days	0	N/A[xx]	40 million[xxvii]
Psychological	Psychological Distress	Qualitative Bins	See Discussion		
Environmental	Environmental Impact	Qualitative Bins[xxviii]	*De minimus* (Best); Moderate (Second Best)[xxix]		

Likelihood[xxx]	Metric	Low	Best	High
Frequency of Events	Number per Year[xxxi]	1/600 years	1/150 years	1/70 years

---

[xix] The term "space weather" describes phenomena taking place in the near-Earth environment, primarily due to influences of the solar magnetic field. The largest space weather events are geomagnetic "storms" that are caused by huge magnetic eruptions from the Sun called "coronal mass ejections" or CMEs. Such eruptions are usually accompanied by bursts of X-ray photons ("solar flares") and energetic particles that can have prompt effects on the Earth's atmosphere.

[xx] Best estimates for fatalities, injuries and illnesses, direct economic loss, and social displacement were not calculated for this event.

[xxi] The low estimate for fatalities is informed by the excess fatalities in New York City attributed to the loss of electric power in the 2003 Northeast Blackout (Anderson et al (2012)) and not directly caused by the space weather itself. This event is used as a proxy for the low economic consequence scenario because it is cited by the electric industry (NERC (2012)) as a model for a scenario of electric grid collapse caused by a solar storm not resulting in permanent transformer damage (i.e. the grid shuts down and is able to be restarted within days). The scope of the study was limited to the 8 million residents of New York City out of the 50 million who lost power nationwide.

[xxii] SNRA project team assumption based upon extrapolation of the 2003 East Coast Blackout (50 million people assumed out of power for average of 1 day) to the Lloyd's high estimate scenario of 40 million people out of power from 16 days to up to two years (Lloyd's (2013)). Because of the multiple uncertainties involved, the SNRA project team made the assumption of one month average outage having disruptive effects (i.e. the 16 days plus two weeks in addition) for a scaling estimate of 1.2 billion person-days, or 24 times that of the East Coast Blackout. This factor was applied to the 90 fatalities of the low estimate, for a lower-bound estimation of a true high estimate of 2,000 fatalities (rounded to one significant figure). Although the initial health impacts of a large-scale, sudden blackout may subside in initial days as affected populations adapt to life without power, the exhaustion of fuel and lifeline resources and impacted supply chains for critical goods may result in significantly compounded total population health impacts days or weeks into the blackout. The SNRA high estimate thus almost certainly represents a substantial under-representation of the true numbers of fatalities which may be expected from a catastrophic, multi-state extended power outage disaster. However, the SNRA project team judged that it would be more misleading and unrepresentative of the uncertainties in potential impacts of a space weather event to report no high estimate at all, rather than reporting a high estimate that itself is deeply uncertain.

[xxiii] The low estimate for injuries and illnesses is informed by the excess hospitalizations for complications of respiratory illnesses in New York City for August 14-15 attributed to the loss of electric power in the 2003 Northeast Blackout (Lin et al (2011)) minus the three fatalities due to respiratory illness of Anderson et al (2012), on the assumption that these deaths were most likely pronounced in hospital. This epidemiological study examined hospitalizations for respiratory, cardiovascular, and renal diseases: only respiratory diseases showed statistically significant

(b)(5)

Human Pandemic Outbreak

A severe outbreak of pandemic influenza with a 25% gross clinical attack rate spreads across the U.S. populace.

Table A. Pandemic: SNRA Data Summary

Category	Description	Metric	Low	Best	High
Health and Safety	Fatalities	Number of Fatalities[a]	77,000	154,000	230,000
	Injuries and Illnesses	Number of Injuries or Illnesses[b]	62 Million	77 Million	110 Million
Economic	Direct Economic Loss	U.S. Dollars (2011)[c]	$71 Billion	$110 Billion	$180 Billion
	Indirect Economic Loss	U.S. Dollars (2011)	N/A		
Social	Social Displacement	People Displaced from Home ≥ 2 Days	0[d]		
Psychological	Psychological Distress	Qualitative Bins	See text		
Environmental	Environmental Impact	Qualitative Bins[e]	Low[f]		

LIKELIHOOD	Frequency of Events	Number per Year	See Table B

Table B. Conditional and Absolute Likelihood Ranges for Pandemic Relative Severity

				Low	Best	High
Frequency of All Influenza Pandemics Absolute Likelihood (Number Per Year)[g]				0.017	0.033	0.10
Conditional Likelihood of Severity, Given Pandemic Occurrence	Mild	Low	0.10	0.0017	0.0033	0.010
		High	0.30	0.0051	0.0099	0.030
	Middle	Low	0.50	0.0085	0.0165	0.050
		High	0.80	0.0136	0.0264	0.080
	Severe/ Worst Case	Low	0.10	0.0017	0.0033	0.010
		High	0.10	0.0017	0.0033	0.010
				Absolute Likelihood by Relative Severity		

[a] Fatality low, best, and high estimates were calculated using an attack rate of 25%, a U.S. population of 307 million, and a case fatality rate of 0.1%–0.3% (best: 0.2%). Reed et al (2013, January). Novel framework for assessing epidemiologic effects of influenza epidemics and pandemics; and Technical Appendix. *Emerging Infectious Diseases* 19(1) 85–91, at http://wwwnc.cdc.gov/eid/article/19/1/12-0124_article; Technical Appendix at http://wwwnc.cdc.gov/eid/article/19/1/12-0124-techapp1.pdf (retrieved June 2013).

[b] Illness low, best, and high estimates correspond to a U.S. population of 307 million and attack rates of 20%, 25%, and 35% respectively.

[c] Sum of estimated hospitalization costs, business interruption from workdays lost, and one year's lost spending per fatality. See Direct Economic Impact for details.

(b)(5)

Winter Storm

A winter storm event occurs resulting in direct economic losses of $1 billion or greater.[510]

Category	Description	Metric	Low	Best	High
Health and Safety	Fatalities	Number of Fatalities	0[511]	50[512]	270[513]
	Injuries and Illnesses	Number of Injuries or Illnesses[514]	0	1,700	14,000
Economic	Direct Economic Loss	U.S. Dollars[515]	$1 Billion	$3.1 Billion	$9 Billion
	Indirect Economic Loss	U.S. Dollars	N/A		
Social	Social Displacement	People Displaced from Home ≥ 2 Days	N/A		
Psychological	Psychological Distress	Qualitative Bins	N/A		
Environmental	Environmental Impact	Qualitative Bins	N/A		
LIKELIHOOD	Frequency of Events	Number of Events per Year	0.125	0.56	2

Event Background[516]

The Strategic National Risk Assessment (SNRA) Winter Storm national-level event was originally developed by the DHS Office of Policy for the 2012–13 Homeland Security National Risk Characterization (HSNRC) project.[517] The original HSNRC data and analysis were expanded and revised for the 2015 SNRA by project staff from Argonne National Laboratory and the Federal Emergency Management Agency (FEMA).

---

510 For the purposes of the SNRA, the Winter Storm event includes snow storms, ice storms, freezes and other periods of extremely and exceptionally cold temperatures, and heavy snowfalls, but excludes snowmelt induced flooding which is counted in the SNRA Flood event.

511 Minimum fatalities of the 19 billion dollar winter storm events in Table 21.

512 Average number of fatalities in the 19 winter storm events in Table 21.

513 Highest number of fatalities in the 19 winter storm events in Table 21.

514 Estimated from NCDC Billion Dollar Disaster List, which does not report injuries or illnesses, by applying injury/fatality ratios from NCDC StormData events corresponding to the winter storm events of the primary data set. See Injuries for details.

515 Low, average, and high reported direct economic loss of the 19 winter storm events in Table 21, converted from reported (2014) dollars to 2011 dollars.

516 This section is substantially adapted from National Weather Service (2008, June), *Winter storms: the deceptive killers*, at http://www.nws.noaa.gov/om/winter/resources/Winter_Storms2008.pdf; National Weather Service (2003), *All about winter storms*; at https://web.archive.org/web/20040214012848/http://www.nws.noaa.gov/om/brochures/wintstm.htm (retrieved January 2014); Chapter 7, Federal Emergency Management Agency (1997), Multi-Hazard Identification and Risk Assessment (MHIRA): A Cornerstone of the National Mitigation Strategy: FEMA Mitigation Directorate, at https://www.fema.gov/media-library/assets/documents/7251?id=2214 (retrieved April 2013); and Federal Emergency Management Agency (2013, April 26). Emergency preparedness: secondary hazards associated with severe winter weather. Trend analysis, Lessons Learned Information Sharing (LLIS), at https://www.llis.dhs.gov/content/emergency-preparedness-secondary-hazards-associated-severe-winter-weather (retrieved January 2014).

517 The HSNRC was a collaborative effort of the DHS analytic enterprise to expand the 2011 SNRA risk knowledge base to additional threats and hazards, and to adapt the SNRA to the information needs of DHS strategic planning. The HSNRC title for this event is Extreme Cold/Winter Weather.

(b)(5)

Drought

A drought occurs in the U.S. resulting in direct economic losses greater than $1 billion.

Category	Description	Metric	Low	Best	High
Health and Safety	Fatalities	Number of Fatalities	0[546]		
	Injuries and Illnesses	Number of Injuries or Illnesses			
Economic	Direct Economic Loss	U.S. Dollars[547]	$2 Billion	$8.7 Billion	$38 Billion
Social	Social Displacement	People Displaced from Home ≥ 2 Days	0[548]		
Psychological	Psychological Distress	Qualitative Bins	0[549]		
Environmental	Environmental Impact	Qualitative Bins	N/A		
Likelihood	Frequency of Events	Number of Events per Year[550]	0.50	0.63	1.0

This table shows the minimum, average, and maximum values for frequencies and consequences associated with the direct impacts of national-level droughts.[551] The event set evaluated was from 1980 to 2014 and contained a total of 22 droughts that met the $1 billion threshold. This analysis did not specifically include consideration for climate scenarios often associated with drought events (e.g. heat waves, reduction in precipitation and snowpack).

Event Background

The Strategic National Risk Assessment (SNRA) Drought National-level Event was originally developed by the DHS Office of Policy for the 2012-13 Homeland Security National Risk Characterization (HSNRC) project, a cooperative effort of the DHS analytic enterprise, to expand the 2011 SNRA risk knowledge base to additional threats and hazards relevant to

[546] There are no significant human health implications resulting from a drought in the United States. To avoid double counting of impacts between hazard events, for drought and heat wave incidents which overlapped in time or which were reported together in historical data sets the SNRA counted human fatalities and injuries under the Heat Wave event, while direct economic losses were counted under the Drought event. As both property damage (e.g. damage to physical infrastructure) and crop damage were reported by the primary data sources used for these events in the 2015 SNRA as combined totals, this raises the possibility of over-reporting the direct economic losses for Drought. Non-crop damages to physical infrastructure by heat events can be substantial. However, previous DHS analysis conducted for the 2013 Homeland Security National Risk Characterization (HSNRC) Drought National-level Event indicated that these property damage costs were generally insignificant in comparison to the economic value of lost crops which were orders of magnitude greater.

[547] Low, best, and high estimates for direct economic loss are the historical minimum, average, and maximum for the event set. Adjusted from 2014 dollars of NCDC source to 2011 dollars for comparison with existing SNRA events.

[548] See text for further description.

[549] No reported human health or displacement impacts. (The SNRA Psychological Distress Index is calculated from fatality, injury/illness, and displacement estimates. For Drought/Heat Wave events, non-economic impacts were reported under the Heat Wave event.)

[550] Historical lowest, average, and maximum number of events per year (calculated from interarrival times).

[551] Direct economic loss data was gathered from the National Oceanic and Atmospheric Administration (NOAA)'s National Climatic Data Center (NCDC).

Strategic National Risk Assessment

Supplement:

SNRA 2011 Unclassified Documentation of Findings

Homeland Security

PRE-DECISIONAL DRAFT

~~NOT FOR PUBLIC DISTRIBUTION OR RELEASE~~

Strategic National Risk Assessment

Supplement:

SNRA 2011 Unclassified Documentation of Findings

Homeland Security

PRE-DECISIONAL DRAFT

NOT FOR PUBLIC DISTRIBUTION OR RELEASE

Contents

Report

Reference Appendices

Contents

Report

Reference Appendices

(b)(5)

Flood

A flood occurs within the U.S. resulting in direct economic losses greater than $100 Million.

Data Summary

Table 1 shows the minimum, average, and maximum values for frequencies and consequences of national level floods. Note that the low and high likelihoods do not correspond to the low and high consequences. In addition, low and high consequences are not necessarily correlated with each other between different consequence categories.

Description	Metric	Low	Best	High
Fatalities	Number of Fatalities[1]	0	3	25
Injuries and Illnesses	Number of Injuries or Illnesses[1]	0	95	4,520
Direct Economic Loss	U.S. Dollars[1]	$104 Million	$740 Million	$16 Billion
Social Displacement	Displaced from Homes ≥ 2 Days[2]	150	29,000	200,000
Psychological Distress	Qualitative Bins	See text		
Environmental Impact	Qualitative Bins[3]	Moderate[4]		
Frequency of Events	Number per Year[5]	0.5	4	10

Table 1

Event Background

Floods are one of the most common hazards in the United States. Their effects can be local, impacting a neighborhood or community, or large, affecting entire river basins and multiple states.[6] For the purpose of the SNRA, a national-level flood is defined as a flood producing direct economic loss in excess of $100 million dollars. Economic loss reported here is a combination of property and crop damage. A 13 year time period, from Jan-1-1993 to Dec-31-2005, was used to estimate the interarrival rates/frequencies and consequences for floods exceeding the $100 million threshold. A full list of aggregated flood events used for this report is located in Table 2. Table 1 reports the maximum, average, and minimum frequency with which such floods occurred in the United States, and the maximum, average and minimum consequences for fatalities, injuries, and direct economic losses associated with floods in the set.

This flood risk summary is based on aggregating flood losses reported by NOAA's National Climactic Data Center (NCDC).[7] Modern flood reporting by NOAA relies on many individual reports that assess damages in a specific area of responsibility. A large scale flood, for example, can result in dozens or hundreds of damage entries that assess damages for specific geographic regions. The reason for this is that damage estimates are recorded by individuals with specific areas of responsibility. As flooding passes down the Mississippi, for example, the affected areas can pass from region to region. To capture the transient and distributed nature of flood events, individual flood loss estimates were aggregated based on proximity and time. Flood damage reports that occur within 100 miles of one another and within plus or minus one calendar day are aggregated into composite flood events. The composite flood events above the $100 million threshold are used for reporting of national level event statistics in Tables 1 and 2 of this report. All hurricanes were removed from flood events to avoid over reporting flooding captured in the hurricane risk summary sheet.

Low, average and high consequence estimates were developed in the following manner. For fatalities, injuries and economic loss, the low estimate is the smallest consequence for events that exceed $100 million. For event frequency, the low estimate is the lowest number of events recorded in a year. The average frequency is the expected number of events in a given year. Similarly, the average for fatalities, injuries/illness, and economic damage are the expected value for each given the occurrence of a national level flood. The maximum frequency is the maximum number of national-level floods recorded in a single year. The maximum for fatalities, injuries/illness, and economic damage is the greatest value produced by a single storm in each consequence category.

It is important to note that the frequency estimates reported here differ from probabilities. The frequency of a national-level flood can be greater than one, while a probability cannot. Additionally, while the average estimates for consequences and frequency are correlated and approximate the average annual loss when multiplied together, the maximum and minimum historical values for consequence and frequency are uncorrelated and do not have meaning when multiplied together.

Economic flood damages were inflated to a 2011 dollar value using average changes in the Consumer Price Index. The historical maximum for fatalities was the Great October Flood of 1998 in West Texas with an estimated 25 deaths. Several floods within the time period exceeded $100 million in economic damages without any reported loss of life or injury. In total, 37 floods exceeding the $100 million threshold are aggregated in the findings of this report. For economic loss, $104 million[8] (5/8/1993: Heavy rain in parts of Oklahoma, Arkansas, and Texas) is the smallest historic loss that meets the $100 million threshold. Twenty three historic events exceeding the economic threshold did not record any fatalities. The greatest gap between flood events occurs between 1998 and 2000. This two year time lapse between national level events results in an interarrival frequency of 0.5, or $1/t_{max}$.

Social Displacement

For the purposes of the SNRA, social displacement was defined as the number of people forced to leave home for a period of two days or longer. Note that there are limitations to this measure of social displacement, as the significant differences between temporary evacuations and permanent displacement due to property destruction are not captured.

To estimate social displacement for the SNRA, U.S. flood event data from EM-DAT was used to approximate the number of people forced to leave home for two days or greater. EM-DAT, an Emergency Events Database maintained by the World Health Organization Collaborating Centre for Research on the Epidemiology of Disasters with support from USAID,[9] provides estimates of the "total number affected" by disaster events. Data on "total number affected" for U.S. flood events from 1970-2011 listed in EM-DAT as causing $100M or greater in damages are listed in Table 3. This data covers a longer historic time period than the flood data used for the economic analysis and the EM-DAT events listed may not match the events listed in Table 2 exactly due to differences in damage reporting between the two databases.[10] The low, high, and average of the "total affected" data in Table 3 are used as the social displacement estimates for floods in the SNRA.

The "total affected" measure includes the number of people needing immediate assistance, which can include displacements and evacuations; the number of people needing immediate assistance for shelter; and the number of people injured. Because EM-DAT includes injuries in the "total affected" measure, there is potential for double-counting between the SNRA injury and displacement estimates for this event. However, displacement due to floods is typically significantly greater than the number of injuries, so using EM-DAT's "total affected" measure was judged to provide an estimate of social displacement of sufficient precision for the SNRA. Note that the low estimate may be biased low due to incomplete reporting of displacement and evacuations in EM-DAT.

[1] Low, best, and high estimates for fatalities, injuries and illnesses, and direct economic loss are the historical minimum, average, and maximum for each consequence type in the event set. Extremal events for one consequence type may but generally do not correspond to those for other consequence types.
[2] Low, average, and high reported "total affected" for floods causing greater than $100M in economic damage as recorded in the EM-DAT database during the time period 1970-2011. See Social Displacement section in this summary sheet for details.
[3] The United States Environmental Protection Agency (EPA) convened an ad hoc group of environmental experts representing the fields of environmental science, ecological risk, toxicology, and disaster field operations management to estimate environmental consequences for this event. The comments and rankings presented in this Risk Summary Sheet have not undergone review by the EPA and only represent the opinions of the group. Estimates pertain to the potential for adverse effects on living organisms associated with pollution of the environment; they are grouped into high, moderate, low, and de minimus (none) categories. Experts provided both first and second choice categories, allowing the experts to express uncertainty in their judgments as well as reflect the range of potential effects that might result depending on the specifics of the event. The first choice represents the 'best' estimate.
[4] Floods were given a best estimate of 'Moderate'. The experts assessed that flooding of agricultural areas is a typical impact. The severity of the impact depends upon whether there is release of contaminants from urban areas.
[5] Historical lowest, average, and maximum number of events per year (calculated from interarrival times).
[6] FEMA.gov: Flood, March 2011. http://www.fema.gov/hazard/flood/.
[7] NOAA NCDC Storm Events Database, available by ftp from http://www.ncdc.noaa.gov/stormevents/ftp.jsp (current URL: database downloaded by SNRA project team from NCDC for analysis September 2011, URL updated 3/16/2013).

[8] 5/8/1993: Heavy rain in parts of Oklahoma, Arkansas, and Texas.
[9] 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 U.S. Foreign Disaster Assistance (OFDA) of USAID (http://transition.usaid.gov/our_work/humanitarian_assistance/disaster_assistance/). See Criteria and Definition, http://www.emdat.be/criteria-and-definition, EMDAT Data Entry Procedures, at http://www.emdat.be/source-entry , and EMDAT Glossary, at http://www.emdat.be/glossary/ for details of criteria, thresholds, and methodology for the EM-DAT database.
[10] The historical flood incidents in Table 4 were paired with corresponding historical incidents in Table 3 for the purpose of determining a unique set of records with all consequence numbers, where available, for the SNRA core data set (Appendix K). However, this identification occurred after 2011, and Table K2 was not included in the SNRA data or documentation reviewed by FEMA and the interagency, or in classified (full) versions of the SNRA Technical Report.

(b)(5)

Hurricane

A tropical storm or hurricane impacts the U.S. resulting in direct economic losses of greater than $100 Million.

Data Summary

In the following table, note that the low and high likelihoods do not correspond to the low and high consequences. In addition, low and high consequences are not necessarily correlated with each other between different consequence categories.

Description	Metric	Low	Best	High
Fatalities	Number of Fatalities[1]	0	26	1,200
Injuries and Illnesses	Number of Injuries or Illnesses[1]	0	650	30,000
Direct Economic Loss	U.S. Dollars[1]	$100 Million	$5.7 Billion	$92 Billion
Social Displacement	Displaced from Homes ≥ 2 Days[2]	140	520,000	5 Million
Psychological Distress	Qualitative Bins	See text		
Environmental Impact	Qualitative Bins[3]	High[4]		
Frequency of Events	Number per Year[5]	0.33	1.9	7

Table 1

Event Background

For the purpose of the SNRA, a national-level hurricane is defined as a hurricane producing direct economic loss in excess of $100 million dollars. Economic damages reported here are a combination of coastal flooding and wind damage generated by hurricanes and tropical storms. A 40 year time period, from 1970 to 2010, was used to estimate the interarrival rates/ frequencies and consequences for hurricanes exceeding the $100 million threshold. While accurate hurricane damages have been recorded since before 1900, mitigation and evacuation strategies have significantly changed since the turn of the 20th century, substantially lowering hurricane consequences. To capture a representative subset for current hurricane consequences, only storms recorded after 1970 were used for this report. Table 1 reports the maximum, average, and minimum frequency with which such hurricanes occurred in the United States, and the maximum, average and minimum consequences for fatalities, injuries, and direct economic losses associated with hurricanes in the set. A list of all hurricanes with accompanying economic consequences and fatalities is shown in Table 2.

Low, average and high estimates were developed in the following manner from the normalized consequence estimates and historic record. For fatalities, injuries and direct economic loss, the low estimate is the smallest consequence for events that exceed $100 million. For event frequency, the low estimate is derived from the greatest time gap, t_{max}, between years with national level events. The average frequency is the expected number of events in a given year. Similarly, the average for fatalities, injuries/illness, and direct economic loss are the expected value for each measure given the occurrence of a national level hurricane. The maximum frequency is the maximum number of national level hurricanes recorded in a single year. The maximum for fatalities, injuries/illness, and direct economic loss is the greatest value produced by a single storm in each consequence category.

It is important to note that the frequency estimates reported here differ from probabilities. The frequency of a national-level hurricane can be greater than one, while a probability cannot. Additionally, while the average estimates for consequences and frequency are correlated and approximate the average annual loss when multiplied together, the maximum and minimum historical values for consequence and frequency are uncorrelated and do not have meaning when multiplied together.

Fatalities

Fatality estimates are based directly on the historic record (Blake, Landsea, & Gibney, August 2011). The historical maximum for fatalities was Katrina in 2005 with an estimated 1,200 deaths.[6] Several storms within the 40 year time period exceeded $100 million in economic damages without causing any loss of life. While several storms have zero recorded fatalities, fatality estimates were not always available for events with less than 25 fatalities. In the case where records were not available, fatality estimates were apportioned as percentages of yearly hurricane fatalities based on economic damages. The average of all national level hurricanes was then used to produce the historical average of 26 fatalities per storm. The table of national level hurricanes, Table 2, contains a total of 2016 fatalities from 78 distinct events.

Injuries and Illnesses

Injury/illness estimates were produced for each hurricane based on a linear model relating fatalities to injuries and illness. The model is derived from Hurricane Andrew in 1992 (CDC, 1993). A model was needed because accurate injury and illness estimates were not readily available for most hurricanes. Fatality, injury and illness statistics are available for regional hospitals and mobile clinics, but these reports do not provide comprehensive estimates for hurricane related injuries. Evacuees can travel hundreds of miles (Faul, Weller, & Jones, September 2011) before receiving medical attention creating a difficult task when accounting for the number of storm related injuries. The CDC, however, has published injury/illness and fatality estimates for 19 parishes during Hurricane Andrew (CDC, 1993) that the SNRA project team used to model a multiplier for estimating total injuries. There were approximately 25 injuries to every fatality within the study group. The multiplier was applied to the fatality estimates to obtain injury/illness estimates for hurricane consequences.

Economic Loss

To provide an accurate assessment for current year planning, historic economic damage estimates have been updated to a 2011 base year. Economic and health & safety consequences, derived directly from historic record, are updated based on changes in populations, building structures, and infrastructure. These damage estimates are published by ICAT and available via the internet.[7] A full description of methods used in economic loss normalization is documented by Pielke (Pielke Jr., Gratz, Landsea, Collins, Saunders, & Musulin, 2008). In total, 78 hurricanes exceeding the $100 million threshold are aggregated in the findings of this report. These estimates potentially contain indirect economic losses. There is not a clear disambiguation for economic loss estimates as there is no readily available record for each loss estimate. Due to this ambiguity, economic loss estimates have the potential to be biased high by as much as 20 percent.

For economic loss, $100 million (1993 Hurricane Emily) is the smallest normalized historic loss that meets the $100 million threshold. Twelve historic events exceeding the economic threshold did not result in any fatalities and, consequently, were not estimated to cause any injuries/illness resulting in a minimum for both fatalities and injuries/illness of zero. The greatest gap occurs between 1985 and 1988. This three year time lapse between national level events results in an interarrival frequency of 0.33, or $1/t_{max}$.

The average economic consequence is $5.7 billion per event. On average, 26 fatalities occur per event with an average of 650 injuries per event. The average time between national level events is approximately six months, resulting in 1.9 events expected per year. An estimate of the average annual loss for each consequence type (e.g., fatalities per year or economic loss per year) can be obtained by multiplying the average frequency by the average consequence in a category. The average annual fatality and economic losses for the set of 78 historic events analyzed are approximately 26 fatalities per year and approximately $5.7 billion per year.

[1] Low, best, and high estimates for fatalities, injuries and illnesses, and direct economic loss are the historical minimum, average, and maximum for each consequence type in the event set. Extremal events for one consequence type may but generally do not correspond to those for other consequence types.
[2] Low, average, and high reported "total affected" for hurricanes causing greater than $100M in economic damage as recorded in the EM-DAT database during the time period 1970-2011. See Social Displacement section in this summary sheet for details.
[3] The United States Environmental Protection Agency (EPA) convened an ad hoc group of environmental experts representing the fields of environmental science, ecological risk, toxicology, and disaster field operations management to estimate environmental consequences for this event. The comments and rankings presented in this Risk Summary Sheet have not undergone review by the EPA and only represent the opinions of the group. Estimates pertain to the potential for adverse effects on living organisms associated with pollution of the environment; they are grouped into high, moderate, low, and de minimus (none) categories. Experts provided both first and second choice categories, allowing the experts to express uncertainty in their judgments as well as reflect the range of potential effects that might result depending on the specifics of the event. The first choice represents the 'best' estimate.
[4] Hurricanes were given a best estimate of 'High', with a second best estimate of 'Moderate'. The experts assessed that hurricanes can cause ecological impacts, beach erosion, nutrient loading, chemical contamination, salt water intrusion into fresh water bodies, and removal of plants leading to erosion. Large areas can experience impacts.
[5] Historical low, average, and maximum number of events per year (calculated from interarrival times).

[6] Note that fatality and economic damage estimates can differ across sources, including official U.S. Government sources, depending upon different definitions of what is counted. The fatality estimate of 1,200 for Hurricane Katrina was the latest official estimate of the National Hurricane Service for fatalities directly caused by the hurricane as of August 2011, as reported in the primary source used for fatality data by the SNRA (Blake and Landsea, p. 5). Counts of all fatalities including indirect fatalities can total 1,833, the current official estimate for all fatalities, or higher.
[7] ICAT damage estimates are available at http://www.icatdamageestimator.com. Accessed September 16, 2011.

(b)(5)

Wildfire

A wildfire occurs within the U.S. resulting in direct economic losses greater than $100 Million.

Data Summary

In the following table, note that the low and high likelihoods do not correspond to the low and high consequences. In addition, low and high consequences are not necessarily correlated with each other between different consequence categories.

Description	Metric	Low	Best	High
Fatalities	Number of Fatalities	0	5	25
Injuries and Illnesses	Number of Injuries or Illnesses	0	63	187
Direct Economic Loss	U.S. Dollars	$104 Million	$900 Million	$2.8 Billion
Social Displacement	Displaced from Homes ≥ 2 Days	770	110,000	640,000
Psychological Distress	Qualitative Bins	See text		
Environmental Impact	Qualitative Bins[1]	High[2]		
Frequency of Events	Number per Year	0.2	0.8	3

Event Background

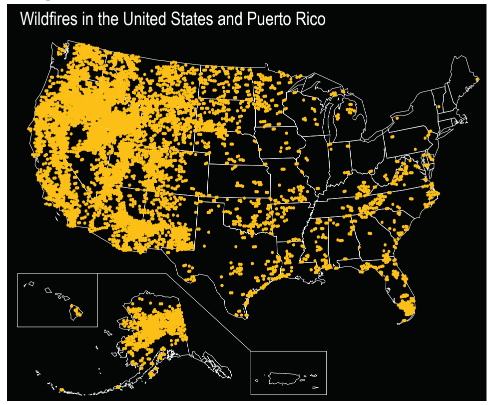
Since 1970, wildfires have destroyed more than 10,000 homes and 20,000 other structures across the nation. Fire suppression has cost government agencies in excess of $20 billion and the insurance industry $6 billion in restitution.[3] Severe wildfire events have the potential to create great economic losses—from hundreds of millions of dollars to the three California wildfires in 1991, 1993, and 2003, each of which caused damages greater than $2 billion.[4]

Wildfires are a frequent event in the United States: some 1,570,000 wildfires were reported for the 20 year period 1990-2009, consuming a total of 94,000,000 acres[5] and 110 human lives.[6] Only a small proportion of these are large enough to overwhelm local fire-fighting capabilities.[7] Although the vast majority of large wildfires occur in sparsely populated regions of the United States—a disproportionate share of the very largest wildfires by acres burned occur in Alaska[8]—it is at the "wildland/urban interface," where the wilderness meets new urban and suburban areas of high population densities, that the wildfires of greatest destructiveness in terms of human life and economic damage occur.[9] Overall, although wildfire frequency has decreased in the last 200 years, the severity of wildfires has increased, and the overall risk to life and property of wildfires in the U.S. is increasing.[10] In particular, the frequency and economic costs of the very largest wildfires considered here show a sharp increase around 1990.[11]

For even the most catastrophic wildfires in the United States, the numbers of dead and injured tend to be relatively small. No wildfire causing human deaths on a catastrophic scale in the United States has occurred since 1918, when a brush fire engulfed 38 towns across Minnesota, killing 450 people.[12] Since then, the largest death tolls have not numbered more than 30 from a single incident—for the majority of massive wildfires in recent decades, potentially affected populations receive sufficient advanced warning that no human deaths occur.

The health risk of wildfires is largely dependent on the population in the impacted area as well as the speed and intensity with which the fire moves through those areas.[13] Wildfires can increase eye and respiratory illnesses related to fire-induced air pollution. Wildfires can also result in direct and indirect deaths caused by direct contact with the wildfire or wildfire product (e.g., smoke or superheated air) or from indirect contact with a wildfire product (e.g., smoke that caused poor visibility resulting in a car crash).[14]

Figure 1. Wildfires Greater than 250 Acres, 1980-2003[15]



Assumptions

The estimates provided above are based on historical examples of major wildfires in the United States. The dataset that was considered comprises all wildfires with reported total economic damage of $100 million or greater (in 2011 dollars) which occurred from 1990 to 2009.[16]

Fatalities and Injuries

The SNRA project team used the following assumptions to estimate health and safety consequences caused by a wildfire event:

- In order to produce the summary figures in the "Data Summary," all "Low," "Best," and "High," estimates for human deaths and injuries are calculated from the dataset of catastrophic wildfires selected according to the economic cutoff of $100M minimum (see Table 1). The set chosen by this economic measure captured the range of the scenarios most catastrophic in numbers of dead and injured for all historical wildfires in the United States since 1990. To compute "Low", "Best", and "High" estimates for fatalities and injuries the historical low, average, and high values of the 1990-2009 dataset were used.
- The best-estimate frequency is the average frequency of occurrence of this set of wildfires in the selected twenty-year period. The low frequency is the inverse of the longest time interval between wildfires in this set (in days, measured from fire begin day); the high frequency is the greatest number of fires which occurred in one year (four, in 2006).

Economic Loss

The SNRA project team used the following assumptions to estimate economic consequences caused by a wildfire event:

- Since total monetary losses appeared more representative of the geographic spread of wildfires and the relative difficulty of fighting them than the number of dead and injured, the former were used to select a set of national-level events having the capability to overwhelm local emergency response efforts.
- All "Low," "Best," and "High," estimates are calculated from historical data of property damage and crop damage, comprising all U.S. wildfires between 1990 and 2009 meeting a cutoff of $100 million dollars total cost adjusted to 2011 dollars (Table 1).[17] As the frequency and severity in economic consequences caused by large wildfires were seen to have sharply increased after 1990, the dataset was restricted to this date range to be more representative of present-day conditions.
- Estimates of total losses for wildfires can vary greatly between sources. One of the reasons for this is that different types of economic cost—the cost of suppressing the fire, private property damage, crop damage, costs incurred for environmental remediation, and the indirect business-interruption costs due

---

[1] The United States Environmental Protection Agency (EPA) convened an ad hoc group of environmental experts representing the fields of environmental science, ecological risk, toxicology, and disaster field operations management to estimate environmental consequences for this event. The comments and rankings presented in this Risk Summary Sheet have not undergone review by the EPA and only represent the opinions of the group. Estimates pertain to the potential for adverse effects on living organisms associated with pollution of the environment; they are grouped into high, moderate, low, and de minimus (none) categories.
[2] Experts provided both first and second choice categories, allowing the experts to express uncertainty in their judgments as well as reflect the range of potential effects that might result depending on the specifics of the event. The first choice represents the 'Best' estimate.
[3] Zane et al. for National Center for Environmental Health. 2007. Wildfire-related deaths—Texas, March 12-20, 2006. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5630a1.htm.
[4] See Table 1.
[5] As compiled from National Interagency Fire Center, Total Wildland Fires and Acres (1960-2009), http://www.nifc.gov/fireInfo/fireInfo_stats_totalFires.html.
[6] As compiled from the SHELDUS database http://webra.cas.sc.edu/hvriapps/sheldus_setup/sheldus_login.aspx.
[7] Brush, Grass, and Forest Fires. Ahrens, Marty, 2010, National Fire Protection Association, pp 11, 15: http://www.nfpa.org/assets/files//PDF/OS.BrushGrassForest.pdf; analysis of SHELDUS database.
[8] National Interagency Fire Center, 1997-2009 Large Fires (100,000+ acres), http://www.nifc.gov/fireInfo/fireInfo_stats_lgFires.html.
[9] Fires in the wildland/urban interface, U.S. Fire Administration 2002, at http://www.usfa.dhs.gov/downloads/pdf/tfrs/v2i16.pdf; quoting Ainsworth et al, Natural History of Fire and Flood Cycles, University of California-Santa Barbara 1955, and 'History of fire', National Park Service.
[10] Wildfire hazards – a national threat. Fact sheet 2006-3015, U.S. Geological Survey, Department of the Interior, 2006; available at http://pubs.usgs.gov/fs/2006/3015/2006-3015.pdf.
[11] Analysis of SHELDUS database.
[12] National Interagency Fire Center, Historically significant wildland fires: http://www.nifc.gov/fireInfo/fireInfo_stats_histSigFires.html.

[13] U.S. Climate Change Science Program. 2008. Analyses of the effects of global change on human health and welfare and human systems: A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Gamble J.L. ed, Ebi et al authors, U.S. EPA.
[14] Zane et al. for National Center for Environmental Health. 2007. Wildfire-related deaths—Texas, March 12-20, 2006. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5630a1.htm.
[15] Wildfire Hazards – A National Threat. U.S. Geological Survey fact sheet 2006-3015, Feb 2006, available at http://pubs.usgs.gov/fs/2006/3015/2006-3015.pdf .
[16] As compiled from the SHELDUS database, http://webra.cas.sc.edu/hvriapps/sheldus_setup/sheldus_login.aspx. SHELDUS breaks down wildfire events into separate counties, and sometimes breaks down single wildfires in the same location into separate fires with overlapping date ranges, dividing casualty and damages between them to avoid double counting. Where this was obviously done (fires reported by counties in the same state having the same time range, or reported in the same city with overlapping or continuously adjacent time ranges) the separately reported portions of a single fire event were consolidated into single events.
All wildfires (after consolidation) above the $100 million threshold in 2011 dollars (a CPI multiplier of 1.0464 was used to convert the December 2009 values given in SHELDUS to May 2011) from 1970 follow after these endnotes. As noted in the "Assumptions" section, only the data points from 1990 on were used for analysis.
[17] Available at http://webra.cas.sc.edu/hvriapps/sheldus_setup/sheldus_login.aspx.

(b)(5)

Tornado

A tornado event (either a single tornado or a cluster of tornadoes that form during a single storm system) occurs in the United States resulting in direct economic losses of or greater than $100 Million. The methodology for determining clusters can be found below.

Data Summary[1,2]

Description	Metric	Low	Best	High
Fatalities	Number of Fatalities[3]	0	22	316
Injuries	Number of Injuries or Illnesses[3]	0	247	3125
Direct Economic Loss	U.S. Dollars[3]	$103 Million[4]	$450 Million	$4.7 Billion
Frequency of Events	Number per Unit of Time[5]	0.63 per Annum	2.9 per Annum	7 per Annum

Event Description

The most destructive and deadly tornadoes occur from supercells – which are rotating thunderstorms with a well-defined radar circulation called a mesocyclone (supercells can also produce damaging hail, severe non-tornadic winds, unusually frequent lightning, and flash floods).[6] Although tornadoes appear throughout the world, the continental United States is subjected to more tornado events than any other country. On average, there are 1,300 tornadoes that hit the United States each year, of which an average of 140 (or approximately 10%) are significant (rated as EF2 or higher on the enhanced Fujita scale).[7] Tornadoes are more common in the United States than in any other country because of the interactions between cold fronts coming from Canada that collide with warm fronts that hit the central United States via the Gulf of Mexico. This collision generally centers over the central and southeastern portions of the United States, and there is a higher frequency of tornadoes that strike these regions. Nevertheless, tornadoes occurred in all 50 states, the District of Columbia[8] and Puerto Rico between 1996 and 2011.

For the purposes of the Strategic National Risk Assessment, the SNRA team analyzed tornado events that resulted in $100 million or more in economic damage. From 1996 to 2011, there were 46 tornado events that met this criterion. Of these 46 events, 44 were outbreaks that included more than one tornado. These outbreaks were determined using a clustering method to aggregate the fatality, injury and economic consequences of tornadoes that occurred within one day and 150 miles of at least one other tornado.

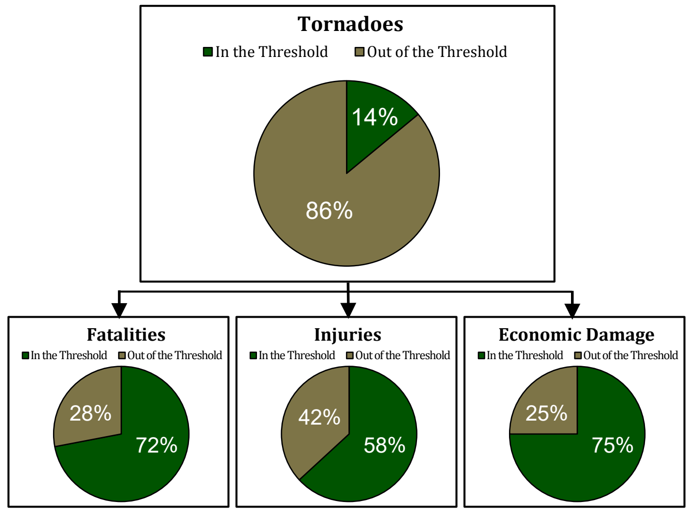
The economic threshold highlights 46 events during the time frame. Figure 1 outlines data on the tornado events that met the criteria of the $100 million threshold.

Methodology

Note that the tornadoes captured by this threshold represent only 14% of all tornadoes in the data set. However, those 14% of tornadoes are responsible for 72% of all fatalities, 58% of all injuries and 75% of all economic damage from all tornadoes during the 1996 – 2011 timeframe (see Figure 1).

When appropriate (i.e., when temporal and spatial criteria were met) individual tornadoes were clustered into multi-tornadic outbreak events. This was done because DHS is responsible for responding to a single destructive event, without separating out damage that comes from different tornadoes. The SNRA team chose to cluster tornadoes using spatial and temporal clustering, as this facilitated analysis on the aggregated total of fatalities, injuries and economic damage caused by tornadoes in a storm system, not just an individual storm. Through the use of this threshold, the SNRA team was able to capture the most damaging and dangerous storms from the data set.

Figure 1. Percentage of tornadoes in the data set that meet the threshold and the proportion of associated consequences within and outside of the threshold



In order to cluster the tornadoes, the team created a model that clusters tornado events if certain criteria are met. The data set has been programmed to cluster tornadoes if they meet the following two conditions: 1) the events fall within a one day window[9,10] and 2) the events are located within 150 miles of another event.[11]

It is important to note that the SNRA team elected to not make the Enhanced Fujita (EF) Scale (formerly known as the Fujita (F) Scale) rating a threshold for clustering. A powerful storm (EF4 – EF5) could hit a forest or a field, causing relatively little damage. At the same time, a weak storm (EF0 – EF2) could cause significant economic damage or loss of life if it struck a densely populated area. Due to the inconsistency, the SNRA team felt it was important to include all tornadoes regardless of the EF scale rankings in the data set.

During this risk assessment, temporally and spatially associated events were identified as "tornado clusters." There are two main reasons why the SNRA team created a model to cluster tornadoes as opposed to relying on external sources:

- A specific definition of a tornado cluster (also referred to as a tornado outbreak) is not available for guidance in the meteorological literature. There is an ongoing debate in the field regarding the definition of an outbreak, as storm systems can spawn tornadoes over a broad array of time and space.[12] Without a concrete definition, the SNRA team determined that it needed to create the clustering model internally.
- Since the historical data in the data set is arranged by individual tornadoes, and it does not group tornadoes by storm system, the entire data set had to be clustered before tornado clusters could be identified. Without the historical data on storm cells and their production of tornadoes, the decision was made to infer when tornadoes were associated with one another through the time and distance conditions.

The specific spatial and temporal parameters in the clustering algorithm were calibrated using publically available news and weather reports published on days of tornado outbreaks. Before clustering the data, the SNRA team checked its main data source, the National Weather Service's (NWS) Storm Prediction Center (SPC) database, for consistency. Several adjustments were incorporated in the SNRA data set:

[1] The data reported in this table represent historical U.S. tornado data. The SNRA project team used historical data from the Storm Prediction Center (SPC) online database. The SPC is a division of the National Weather Service (NWS), which is a part of the National Oceanographic and Atmospheric Administration (NOAA).
[2] Social displacement, psychological distress, and environmental impacts of tornado outbreaks were not assessed for the Tornado event. Expert elicitations and research for these metrics were completed during the main project phase of the SNRA (summer-fall 2011) before the tornado event was added in 2012. These measures will be assessed in the next iteration of the SNRA.
[3] Low, best, and high estimates for fatalities, injuries and illnesses, and direct economic loss come from the low, average, and high values of the set of events meeting a $100 million threshold of direct economic cost. This set came from the National Weather Service's Storm Prediction Center database on tornadoes ranging from 1996 - 2011. For further details see Assumptions sections below.
[4] This is the low estimate when the $100 million threshold is applied.
[5] Frequency estimates correspond to the inverse of the number of years of the longest interval between accident events (low), the mean frequency of the accident events (best), and the greatest number of accidents within one year (high) of the set described in note 3 above.
[6] (Edwards, The Online Tornado FAQ, 2012)
[7] This is based on number of tornadoes per year from 1996 – 2011. All calculations are taken from the SPC database.
[8] On September 24, 2001, a tornado originated in Virginia and passed through Washington DC. The individual entry for DC was removed during data consolidation. The tornado ID number is 11594 (entry in the NOAA SPC database is 2001 – 451).
[9] All units of time have been converted to central standard time (CST).
[10] The day window accounts for a 47 hour and 59 minute span of time. For example, a day window would associate a tornado that struck at 00:00 on January 1, 2011 and one that struck at 23:59 on January 2, 2011.
[11] An event was spatially associated with a previous event if it comes within 150 miles of the path taken by the previous event.
[12] Available definitions that are spatially precise may be nebulous in time, or vice versa. Moreover, many historical attempts to define the term "tornado outbreak" have failed to account for the spatial outliers, far removed from tornado clusters but within the same time domain. (Edwards, Thompson, Crosble, & Hart, 2004)

(b)(5)

Table K.2: SNRA Core Data

Record Type	Event Group	NLE	Place	State	Event Start	Comments/Identifiers	SNRA Fatalities	SNRA Inj/Ill	SNRA Displaced	EFF	SNRA Psych.Distress	SNRA Direct Economic Damage	Event End	Observation Period Start	Observation Period End	Observation Period (years)	Incident Likelihood	Source
Scenario	Natural	Animal Disease					0	0	1,000	1.0	500	$15,200,000,000					0.1	See RSS
Scenario	Natural	Human Pandemic					250,000	77,000,000	0	1.0	78,250,000	$170,000,000,000					0.033	See RSS
Scenario	Natural	Tsunami					300	300	14,700	1.0	9,150	$1,530,000,000					0.0057	See RSS
Scenario	Natural	Volcanic Eruption					515	17,000	130,000	1.0	84,575	$8,300,000,000					0.002	See RSS
Incident	Natural	Earthquake	San Francisco	CA	4/18/1906	Assumption 1% annual mitigation	8,896	209,056		1.1	278,890	$104,905,367,626		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	El Centro	CA	6/22/1915	Assumption 1% annual mitigation	13	306		1.1	408	$131,076,352		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	San Jacinto/Riverside County	CA	4/21/1918	Assumption 1% annual mitigation	0	0		1.1	0	$193,990,095		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Mona Passage	PR	10/11/1918	Assumption 1% annual mitigation	138	3,243		1.1	4,326	$1,943,953,812		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Santa Barbara	CA	6/29/1925	Assumption 1% annual mitigation	44	1,034		1.1	1,379	$1,371,950,746		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Long Beach	CA	3/11/1933	Assumption 1% annual mitigation	358	8,413		1.1	11,223	$7,565,220,534		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Helena	MT	10/19/1935	Assumption 1% annual mitigation	5	118		1.1	157	$960,000,000		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Helena	MT	10/31/1935	Assumption 1% annual mitigation	3	71		1.1	94	$512,380,253		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	El Centro/Imperial Valley	CA	5/19/1940	Assumption 1% annual mitigation	6	141		1.1	188	$392,000,000		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Puget Sound/Olympia	WA	4/13/1949	Assumption 1% annual mitigation	24	564		1.1	752	$3,403,585,667		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Terminal Island	CA	11/18/1949	Assumption 1% annual mitigation	0	0		1.1	0	$414,893,442		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Terminal Island	CA	8/15/1951	Assumption 1% annual mitigation	0	0		1.1	0	$109,913,608		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Kern County/Bakersfield	CA	7/21/1952	Assumption 1% annual mitigation	26	611		1.1	815	$1,820,696,601		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Kern County/Bakersfield	CA	8/22/1952	Assumption 1% annual mitigation	4	94		1.1	125	$662,071,491		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Hebgen Lake	MT	8/18/1959	Assumption 1% annual mitigation	54	1,269		1.1	1,693	$706,863,603		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Prince William Sound/Anchorage	AK	3/28/1964	Assumption 1% annual mitigation	220	5,170		1.1	6,897	$11,213,495,628		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Seattle	WA	4/29/1965	Assumption 1% annual mitigation	9	212		1.1	282	$299,194,941		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Santa Rosa	CA	10/2/1969	Assumption 1% annual mitigation	2	47		1.1	63	$120,000,000		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	San Fernando	CA	2/9/1971	Assumption 1% annual mitigation	81	1,904		1.1	2,539	$5,083,948,997		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Imperial Valley	CA	10/15/1979	Assumption 1% annual mitigation	0	0		1.1	0	$129,806,214		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Whittier/Los Angeles	CA	10/1/1987	Assumption 1% annual mitigation	9	212	9,000	1.1	5,232	$795,888,336		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Loma Prieta/San Francisco	CA	10/18/1989	Assumption 1% annual mitigation	60	1,410	32,500	1.1	19,756	$10,485,000,000		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Ferndale/Fortuna/Petrolia	CA	4/25/1992	Assumption 1% annual mitigation	0	0		1.1	0	$106,971,740		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Landers/Yucca Valley	CA	6/28/1992	Assumption 1% annual mitigation	3	71	750	1.1	507	$202,144,394		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Northridge/Los Angeles	CA	1/17/1994	Assumption 1% annual mitigation	62	1,457	120,000	1.1	67,944	$78,235,199,499		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Seattle/Tacoma/Olympia	WA	2/28/2001	Assumption 1% annual mitigation	1	24	400	1.1	251	$2,378,245,427		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Earthquake	Paso Robles/San Simeon	CA	12/22/2003	Assumption 1% annual mitigation	2	47	160	1.1	151	$328,283,332		1/1/1906	7/15/2011	105.53	0.0095	See RSS
Incident	Natural	Flood			3/27/1993	Flooding in SC and TN.	3	0		1.0	15	$238,068,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			5/8/1993	Heavy rain in parts of OK, AR, and TX.	5	0		1.0	25	$103,635,700		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			5/8/1993	Extensive flooding, South Central Kansas.	0	0		1.0	0	$157,000,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			5/8/1993	Flooding in OK.	0	0	31,000	1.0	15,500	$157,000,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			8/31/1993	Great Flood of 93.	0	0		1.0	0	$15,700,000,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			9/24/1993	Steady rains in and around Springfield MO.	1	0		1.0	5	$119,013,850		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			8/18/1994	Heavy rains, flash floods in PA and NY.	3	6		1.0	21	$111,766,500		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			10/16/1994	Texas flooding.	15	0	14,070	1.0	7,110	$399,146,400		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			1/10/1995	Flooding, Kern, Los Angeles, San Diego CA.	0	0		1.0	0	$166,135,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			3/1/1995	Flooding from Kern to Tulare CA.	0	0		1.0	0	$168,072,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			3/10/1995	Salinas River flooding in Monterey County CA.	0	0		1.0	0	$447,000,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			1/18/1996	Rain, snow melt caused flooding from VA to NY.	22	1		1.0	111	$475,800,480		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			2/6/1996	Northern Oregon river flooding.	7	0	24,900	1.0	12,485	$576,000,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			7/17/1996	Record breaking rainfall over Illinois.	0	0		1.0	0	$111,888,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			7/19/1996	Heavy thunderstorms in PA.	2	1		1.0	11	$326,160,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			1/1/1997	Melting snow, heavy rain in Southern Oregon.	0	0	18,100	1.0	9,050	$126,900,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			1/1/1997	Damages in CA from Sierra Nevada rain, snow melt.	3	52	125,000	1.0	62,567	$1,635,600,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			3/1/1997	Flooding from excessive rain in KY, OH, and WV.	10	3		1.0	53	$153,368,520		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			3/1/1997	Record 24 hour rainfall in Jefferson County, KY.	2	0		1.0	10	$296,100,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			4/8/1997	Sheyenne River flooding in ND.	0	0	50,400	1.0	25,200	$5,428,500,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			6/20/1997	Flash floods in MN and WI.	0	6		1.0	6	$141,751,530		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			7/28/1997	Heavy rains, flash floods in CO.	5	40	424	1.0	277	$289,162,800		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			8/11/1997	Hail, wind, torrential rain Lakewood, Denver CO.	0	0		1.0	0	$180,480,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			2/4/1998	Slow moving Nor'easter battered eastern VA.	0	0		1.0	0	$104,250,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			2/23/1998	Powerful Pacific storm, southern and central CA.	5	3		1.0	28	$152,316,200		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			3/8/1998	Slow moving system dumped much rain on AL.	4	0	18,000	1.0	9,020	$165,389,150		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			3/8/1998	Gulf storm dumped up to 14 inches of rain, AL, GA.	1	1		1.0	6	$543,490,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			3/10/1998	Nearly six inches of rain, multiple counties FL.	0	0		1.0	0	$510,130,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			6/1/1998	Agricultural damage from Sierra Nevada snow melt.	0	0		1.0	0	$139,556,000		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			6/26/1998	Sustained flooding, parts of East Central OH.	10	0	14,000	1.0	7,050	$281,502,800		1/1/1993	12/31/2005	13.00	0.0769	See RSS
Incident	Natural	Flood			8/5/1998	Slow moving thunderstorms moved through WI.	2	5		1.0	15	$114,410,900		1/1/1993	12/31/2005	13.00	0.0769	See RSS

(b)(5)

[redacted]

APPENDIX O: SNRA 2011 PUBLIC FINDINGS REPORT

The Strategic National Risk Assessment in Support of PPD 8: A Comprehensive Risk-Based Approach toward a Secure and Resilient Nation

December 2011

Overview

The Strategic National Risk Assessment (SNRA) was executed in support of Presidential Policy Directive 8 (PPD-8), which calls for creation of a National Preparedness Goal, a National Preparedness System, and a National Preparedness Report. Specifically, national preparedness is to be based on core capabilities that support "strengthening the security and resilience of the United States through systematic preparation for the threats that pose the greatest risk[1] to the security of the Nation, including acts of terrorism, cyber attacks, pandemics, and catastrophic natural disasters."

As part of the effort to develop the National Preparedness Goal and identify core capabilities, the Secretary of Homeland Security led an effort to conduct a strategic national risk assessment to help identify the types of incidents that pose the greatest threat to the Nation's homeland security. Representatives from the offices of the Director of National Intelligence and the Attorney General, as well as other members of the Federal interagency, supported this effort. The assessment was used:

- To identify high risk factors that supported development of the core capabilities and capability targets in the National Preparedness Goal;
- To support the development of collaborative thinking about strategic needs across prevention, protection, mitigation, response, and recovery requirements, and;
- To promote the ability for all levels of Government to share common understanding and awareness of National threats and hazards and resulting risks so that they are ready to act and can do so independently but collaboratively.

The subsequent pages provide an overview of the unclassified findings and the analytic approach used to conduct the SNRA. It should be emphasized, however, that although the initial version of the SNRA is a significant step toward the establishment of a new homeland security risk baseline, it contains data limitations and assumptions that will require additional study, review, and revision as the National Preparedness System is developed. These limitations are discussed below, and future iterations of the assessment are expected to reflect an enhanced methodology and improved data sets.

Strategic National Risk Assessment Scope

To inform homeland security preparedness and resilience activities, the SNRA evaluated the risk from known threats and hazards that have the potential to significantly impact the Nation's homeland security. These threats and hazards were grouped into a series of national-level events with the potential to test the Nation's preparedness.

[1] The DHS Lexicon defines risk as the potential for an unwanted outcome resulting from an incident, event, or occurrence, as determined by its likelihood and the associated consequences. Accessed at: http://www.dhs.gov/xlibrary/assets/dhs-risk-lexicon-2010.pdf

WORKING
DRAFT

Strategic National Risk Assessment 2015

SNRA Working Papers

May 2015

Homeland Security

PRE-DECISIONAL DRAFT

~~Not for Public Distribution or Release~~

WORKING DRAFT

Strategic National Risk Assessment 2015

SNRA Working Papers

May 2015

Homeland Security

PRE-DECISIONAL DRAFT

Not for Public Distribution or Release

Table of Contents

(b)(5)

Table of Contents

(b)(5)

Electric Grid Failure (Natural / Accidental)

Event Description

Electric Power Grid Failure: A significant regional power-grid failure that extends beyond the geographic area of the initiating incident, which is due to natural disaster/hazards, equipment failure, distribution/transmission failure/disruptions, or public appeals to reduce usage (brown-to blackouts).

Event Background

Electric Power Grid Failures are common. Significant ones are often associated with large-scale natural hazards, such as hurricanes, earthquakes, solar storms, and major winter storms. In addition to the natural physical effects of the events and the damage on the generation, transmission, and distribution equipment, the power grid is designed to fail "safely," which is to say, the control systems and operating protocols will intentionally shut down undamaged elements of the grid if sudden changes in supply and demand make the grid unstable. The Electric Power Grid Failure scenarios under evaluation are those that are attributable to the physical destruction of natural disasters, equipment failure, distribution/transmission disruptions and public appeals to reduce usage.

There is no single interconnected national grid for the U.S. Instead, the continental U.S. is served by four separate grids, which cannot be impacted by the failure of their neighbors, though it is feasible for events to impact more than one of the grids within the U.S.

The four separate networks are:

- The Western Interconnection, which serves those contiguous states west of the Rockies as well as their Canadian neighbors and portions of Northwestern Mexico;
- The Electric Reliability Council of Texas, which serves only the state of Texas,
- The Eastern Interconnection which serves all states (and Canadian Provinces) east of the Rockies and South of the Great Lakes and New York, and
- The Quebec Interconnection, which serves New York, New England, and Canadian provinces east of Manitoba.

The Eastern Interconnection is actually made up of four interconnected but separately managed grids, allowing some cascading failures within this large, heavily populated area.

No scenario exists for a national U.S. power grid failure, except apocalyptic events that may make power restoration issues seem minor.

A quantitative analysis of data provided by the National Protection and Programs Directorate (NPPD) regarding electric power grid outages from 2005 through 2014 was performed using those reported outages caused by 16 natural, equipment and public appeals for reduction of usage categories. Adversarial and Space Weather outages were not addressed in this analysis, but are covered elsewhere in the Strategic National Risk Assessment Summary; however, the resulting economic impacts may be comparable.

Over 10 years that cover the reported events, it is understood that more events occurred but only the reported events that resulted in outages were considered. These events led to significant

(b)(5)

Migrant Surge / Mass Migration

Synopsis

This survey of recent mass migration surge events and a review of associated research literature indicate there is a strong likelihood of future surges to the U.S. Such surges are caused by complex structural factors that render 'quick solutions' unlikely. This paper provides an overview of the "Why," "Who," and "How" of migration, including the dangers migrants encounter in their journey, an overview of the recent history of migration, examples of recent surges, and a brief overview of the roles and responsibilities of various U.S. Government agencies related to mass migration.

The literature review is grouped into two themes: (1) the 2014 Central American surge of unaccompanied children, and (2) push factors are intensifying and are likely to increase the frequency of surges.

Literature Review – Risk of Mass Migration Likely Increasing

Introduction

Event Description

Mass Migration is defined as a concentrated flow, or surge, of migrants into the United States primarily along maritime and land borders, regardless of method of entry or reason for migrating.[168] This assessment is inclusive of both legal and illegal (undocumented) migration attempts. It is focused on the short-term impacts to the United States in handling a surge of migrants, that is, primarily the increased resources and capabilities needed to manage a surge.[169] It does not attempt to assess the long-term impacts of legal or illegal immigration. This assessment also does not consider repatriation efforts even in events where repatriation and mass migration may be comingled concerns.

Event Background

Why People Migrate

Marc Rosenblum[170] and Kate Brick's 2011 study, *U.S. Immigration Policy and Mexican/Central American Migration Flows: Then and Now*, explains "why people move, who and how many people migrate, and how they choose where to go, depends on a combination of structural factors that are difficult for governments to control and on the policy environment in which migration decision making occurs."[171]

---

[168] Methods for entry and the reasons/intent for gaining entry are discussed in the event background.

[169] For example, maritime and land-based border patrol and search and rescue services, law enforcement and immigration courts services, and providing shelter, clothing, food, medical treatment, and other health and welfare services.

[170] Marc R. Rosenblum also co-edited the Oxford Handbook of the Politics of International Migration published June 2012. This resource was not reviewed due to its length and the fact that the scope of the book covers more than just migration to the U.S. It is, however, a notable contribution to the literature of Mass Migration.

[171] Rosenblum, Marc R. and Kate Brick. *U.S. Immigration Policy and Mexican/Central Migration Flows: Then and Now. Washington, DC: Migration Policy Institute*. 2011.

(b)(5)

(b)(5)

Emerging Infectious Diseases Other Than Influenza

Summary

Emerging Infectious Diseases (EIDs) with pandemic potential represents a major worldwide risk to global health security. Though there is no single universally agreed upon definition, EIDs can be understood either as new recognized diseases or "re-emerging" or "resurgent diseases" which are known and may have been previously controlled but are now reappearing with increasing occurrence, or threaten to increase over previously endemic or new population or geographic area. This also includes pathogens that have developed new attributes such as increase resistance or virulence. Of most concern are EIDs which have possible global pandemic risk where limited or no readily available therapeutic counter-measures are available. Leaving governments to rely on enhanced mass public health infection control practices such as protective travel and commercial restrictions, closing schools, or in worst case scenarios enforced quarantine for the affected population. If it is scientifically proven that a particular EID resulted from an accidental or deliberate release, then it could be anticipated that the U.S. government, private critical health care infrastructure stakeholders, as well as foreign governments will take countermeasures commensurate with the nature and scope of such a threat. Such a scenario may result in additional and unforeseen geopolitical consequences depending on the scale and scope of the event or incident.

Not including influenza outbreaks such as H1N1, examples of recent notable EIDs have included: Ebola; Severe Acute Respiratory Syndrome (SARS); Middle East Respiratory Syndrome (MERS). Combined, these EIDs resulted in the loss of millions of lives and billions of dollars. Causal factors include: microbial adaptation and evolution; demographic migration; new technology and industry; increased economic development and changing land use; greater contact between people and animals; international travel and trade; and the lack of adequate global public health infrastructure to carry out surveillance and control measures. Added to this list is the potential for bio-engineered EIDs resulting from future military conflict or terrorism. In addition to the human and economic toll, the Ebola epidemic in West Africa is very instructive of the risk that EIDs have to destabilize governance processes, ferment social unrest, overstress critical national health infrastructures, and restrict international commerce and travel.

Discussion

An emerging infectious diseases (EIDs) is defined as "infectious disease that is newly recognized as occurring in humans; one that has been recognized before but is newly appearing in a different population or geographic area than previously affected; one that is newly affecting many more individuals; and/or one that has developed new attributes."[452] New and naturally occurring attributes can include changes in mode of transmission, incubation periods, severity of morbidity and mortality rates, etc. Additionally, there is the risk of man-made bio-engineering to be

[452] Institute of Medicine IOM, *Microbial Threats to Health: Emergence, Detection and Response*, 2003; and Fineberg and Wilson, "Emerging Infectious Diseases," International Risk Governance Council (IRGC), 2010.

(b)(5)

Threat and Hazard Identification and Risk Assessment: Capability Target Visualizations

Introduction

The SNRA provides a strategic view of risk to support the collective understanding of the full range of threats, hazards, and challenges facing the Nation. With this in mind, the SNRA project team analyzed the Threat and Hazard Identification and Risk Assessments (THIRA) received from jurisdictional partners to gain a better understanding of what capabilities requirements jurisdictions have identified and for which they are currently planning. The SNRA project team intends on comparing the effects identified across a broad range of risks from the SNRA, against the capabilities requirements identified in the jurisdictional THIRAs, to identify any correlations between national-level risk assessment and reported jurisdictional requirements. The following depicts the outputs from the THIRA analysis. The crosswalk between effects identified in the SNRA and jurisdictional capability requirements was not accomplished during the 2015 SNRA project and should be considered for future iterations of the SNRA.

Background

The THIRA is a four-step common risk assessment process that helps the whole community understand its risks and estimate capability requirements. FEMA) Regions and jurisdictions identify risks in Step 1 of the THIRA process and map their risks to core capabilities to develop capability targets which define success. Capability targets provide a glimpse of the impacts regions and jurisdictions are preparing for across the Nation.

Analysis

The following graphs depict representative targets* in terms of absolute capability for selected core capabilities. Each core capability graph depicts a sample subset of capability targets on a logarithmic scale and incorporates isoclines to show increasing levels of absolute capability requirements. Taken together, these graphs demonstrate the range of jurisdictional planning to deliver core capabilities across a wide range of threats and hazards.

**Representative targets depict a sample subset of submitted 2013 THIRA targets, as not all targets included comparable elements for analysis.*

Fatality Management Services

Figure 6 represents the range of 2013 THIRA targets that focused on initiating fatality management services within a set period of time. While the number of fatalities varied widely, most jurisdictions defined their success as initiating fatality management within 24 to 72 hours. Figure 1 shows a majority of the represented targets included impacts of 10,000 fatalities or fewer, while a smaller subset suggested potential impacts of higher magnitudes. Several of

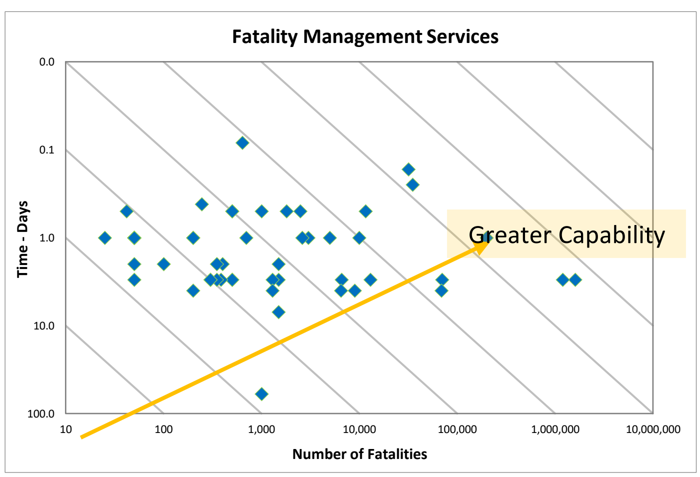


Figure 7: Fatality Management Services

(b)(5)

the targets with higher fatality impacts also identified time frames of 24 to 72 hours, indicating that these targets require greater capability to be successful.

Mass Care Services

A majority of Mass Care Services targets indicated jurisdictions' desires to achieve their targets within 72 hours or fewer; however, a third of representative capability targets included a range of 5 days to 8 weeks as sheltering objectives can vary widely depending on requirements. Likewise, the range of people requiring sheltering services ranged from several dozen to several million, indicating that jurisdictions are planning for a wide scale of impacts. The variation in Mass Care Services targets is likely due to the wide range of sheltering impacts identified in Step 3 of the THIRA process, as impacts are linked to the size and complexity of threat and hazard scenarios identified in Step 1 of the THIRA process.

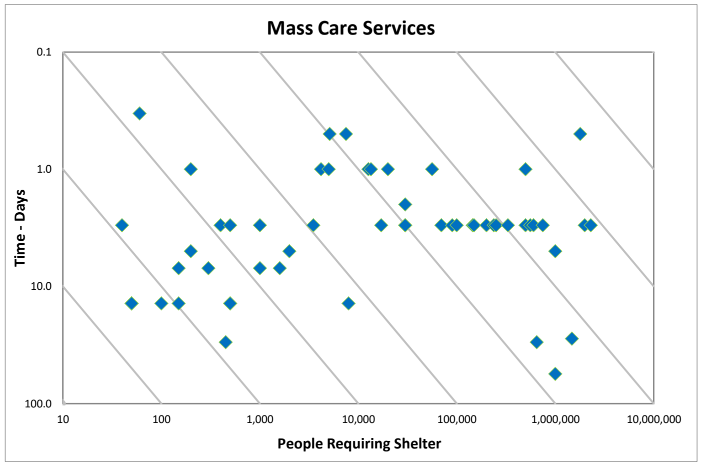


Figure 8: Mass Care Services

Public Health and Medical Services

Figure 8 shows that approximately half of the represented Public Health and Medical Services targets included impacts of 10,000 to 100,000 people requiring treatment. The Public Health and Medical Services targets are correlated to time parameters, as they depict that the time required to achieve success increases with the number of people requiring treatment. Several targets requiring the most capability to be successful included longer-term actions, such as providing prophylaxis and treatment for an epidemic.

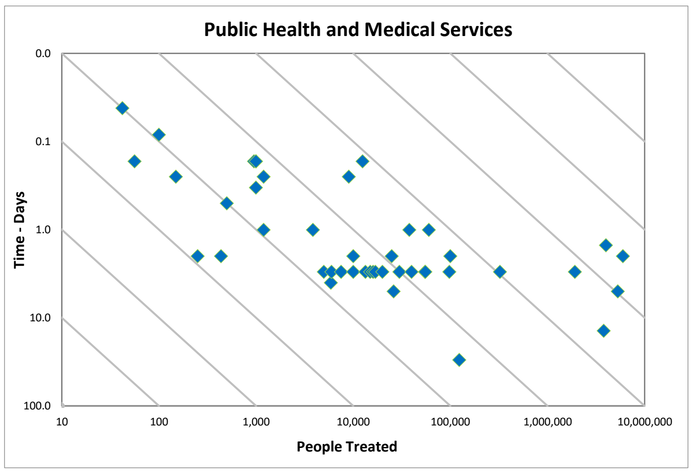


Figure 9: Public Health and Medical Services

Housing

Similar to the wide range of targets to deliver Mass Care Services, Figure 4 depicts a wide variation in Housing targets to meet long-term housing

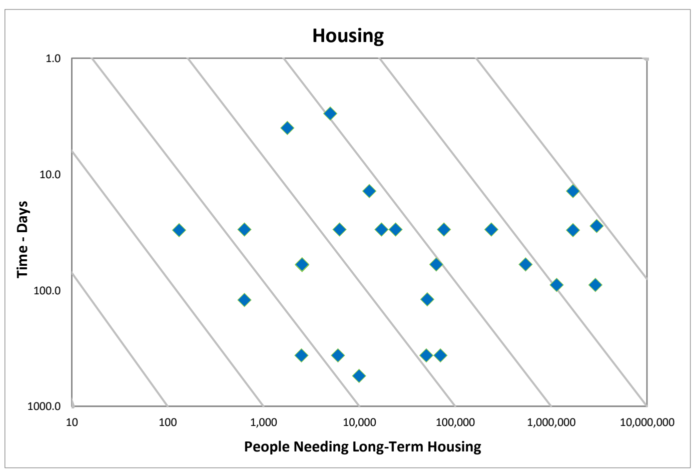


Figure 10: Housing

Strategic National Risk Assessment 2015

Findings

May 2015

Homeland Security

PRE-DECISIONAL DRAFT

~~NOT FOR PUBLIC DISTRIBUTION OR RELEASE~~

Strategic National Risk Assessment 2015

Findings

May 2015

Homeland Security

PRE-DECISIONAL DRAFT

NOT FOR PUBLIC DISTRIBUTION OR RELEASE

Table of Contents

Table of Contents

Overview

The SNRA is a process implemented by the Federal Government to identify the threats and hazards that pose the greatest risk to the Nation[9] and provide necessary context for those threats and hazards to support national preparedness planning. The SNRA informs and supports the National Preparedness Goal, the National Preparedness System, which is based on "*Identifying and Assessing Risk*"[10], the National Preparedness Report (NPR)[11], and other efforts throughout the whole community to enhance security and resiliency. Whole community partners use risk assessments to inform efforts to build and sustain capabilities, including planning, training, and exercises.

(b)(5)

The 2015 SNRA process reviewed the national risk environment and included the following:

[redacted]

(b)(5)

The SNRA findings include:

[redacted]

(b)(5)

[redacted]

Overview

The SNRA is a process implemented by the Federal Government to identify the threats and hazards that pose the greatest risk to the Nation[9] and provide necessary context for those threats and hazards to support national preparedness planning. The SNRA informs and supports the National Preparedness Goal, the National Preparedness System, which is based on "*Identifying and Assessing Risk*"[10], the National Preparedness Report (NPR)[11], and other efforts throughout the whole community to enhance security and resiliency. Whole community partners use risk assessments to inform efforts to build and sustain capabilities, including planning, training, and exercises.

The 2015 SNRA process reviewed the national risk environment and included the following:

- A revisit and refresh of the 2011 SNRA analysis and findings;
- Expansion of the quantitative evidence base of the 2011 SNRA, which included additional threats and hazards;
- An examination of the potential impacts of climate change upon national preparedness;
- A review of evolving threats to the Nation; and
- Qualitative analysis of additional threats and hazards.

The SNRA findings include:

- Natural hazards, including hurricanes, earthquakes, tornadoes, droughts, wildfires, winter storms, and floods, present a significant and varied risk across the country.
- A virulent strain of pandemic influenza could kill hundreds of thousands of Americans, affect millions more, and result in economic loss. Additional human and animal infectious diseases, including those previously undiscovered, may present significant risks.
- Technological and accidental hazards, such as transportation system failures, dam failures, or chemical substance spills or releases, have the potential to cause extensive fatalities and have severe economic impacts, and the likelihood of occurrence may increase due to aging infrastructure.
- Damage to the electric grid from a space weather event or a deliberate attack could cause cascading impacts through other infrastructure systems, with the potential for loss of life and economic disruption.

[9] The scope of the 2015 SNRA approximately coincides with the space of homeland security contingent risks, with some exceptions, notably including climate change.
[10] Whole community partners currently identify and assess risk through the THIRA process at the jurisdictional level and the SNRA identifies and assess risk at the national-level. Jurisdictional partners include states, territories, tribal governments and urban areas. FEMA Regions also conduct the THIRA process on an annual basis.
[11] The intent of the NPR is to provide the Nation—not just the Federal Government—with practical insights on core capabilities that can inform decisions about program priorities, resource allocation, and community actions.

(b)(5)

[redacted]

(b)(5)

The threat and hazard identification process of the SNRA highlighted a number of additional threats and hazards, including:

[redacted]

While the SNRA represents a significant step toward understanding the Nation's threats and hazards, it contains data limitations and assumptions that will require additional study, review, and revision.

- Terrorist organizations or affiliates may seek to acquire, build, and use weapons of mass destruction. Conventional terrorist attacks, including those by "lone actors" employing physical threats such as explosives, and armed attacks, present a continued risk to the Nation.

The threat and hazard identification process of the SNRA highlighted a number of additional threats and hazards, including:

- Natural hazards including heat waves, plant disease, tsunamis, volcanic eruptions, antibiotic resistance and other emerging infectious diseases;
- Technological/accidental hazards including combustible/flammable cargo rail accidents, industrial accidents resulting in fires/explosions, migrant surges, catastrophic oil spills, and pipeline failures;
- Cross-cutting hazards such as electric grid failures from natural and accidental causes, and fires resulting in urban conflagration; and
- Cyber-attacks, which could have their own catastrophic impacts and could initiate other hazards, such as power grid failures, financial system failures, and data breaches that amplify the potential impact of cyber-attacks.

While the SNRA represents a significant step toward understanding the Nation's threats and hazards, it contains data limitations and assumptions that will require additional study, review, and revision.

Threat/Hazard Type	Threat/Hazard Description and Impact Threshold
Earthquake	An earthquake occurs within the U.S. resulting in direct economic losses greater than $100 million
Flood	A flood occurs within the U.S. resulting in direct economic losses greater than $100 million
Human Pandemic Outbreak***	(b)(5) [redacted]
Hurricane	A tropical storm or hurricane impacts the U.S. resulting in direct economic losses of greater than $100 million
Space Weather***	(b)(5) [redacted]
(b)(5) [redacted]	
Wildfire	A wildfire occurs within the U.S. resulting in direct economic losses greater than $100 million
(b)(5) [redacted]	
Technological / Accidental	
Biological Food Contamination	Accidental conditions where introduction of a biological agent (e.g., *Salmonella*, *E. coli*, botulinum toxin) into the food supply results in 100 hospitalizations or greater and a multistate response
Chemical Substance Spill or Release	Accidental conditions where a release of a large volume of a chemical acutely toxic to human beings (a toxic inhalation hazard, or TIH) from a chemical plant, storage facility, or transportation mode results in either one or more off-site fatalities, or one or more fatalities (either on- or off-site) with off-site evacuations or sheltering-in-place
Dam Failure	Accidental conditions where dam failure and inundation in the U.S. result in one fatality or greater
Radiological Substance Release	Accidental conditions where reactor core damage in the U.S. causes release of radiation
(b)(5) [redacted]	

(b)(5) [redacted]

Threat/Hazard Type	Threat/Hazard Description and Impact Threshold
Earthquake	An earthquake occurs within the U.S. resulting in direct economic losses greater than $100 million
Flood	A flood occurs within the U.S. resulting in direct economic losses greater than $100 million
Human Pandemic Outbreak***	A severe outbreak of pandemic influenza with a 25 percent gross clinical attack rate spreads across the U.S. populace
Hurricane	A tropical storm or hurricane impacts the U.S. resulting in direct economic losses of greater than $100 million
Space Weather***	The sun emits bursts of electromagnetic radiation and energetic particles causing utility outages and damage to infrastructure in the U.S., resulting in direct economic losses greater than $1 billion
Tornado**	A single tornado or a tornado outbreak occurs in the U.S. resulting in direct economic losses greater than $100 million
Wildfire	A wildfire occurs within the U.S. resulting in direct economic losses greater than $100 million
Winter Storm*	A winter storm event occurs within the U.S. resulting in direct economic losses of $1 billion or greater
Technological / Accidental	
Biological Food Contamination	Accidental conditions where introduction of a biological agent (e.g., *Salmonella*, *E. coli*, botulinum toxin) into the food supply results in 100 hospitalizations or greater and a multistate response
Chemical Substance Spill or Release	Accidental conditions where a release of a large volume of a chemical acutely toxic to human beings (a toxic inhalation hazard, or TIH) from a chemical plant, storage facility, or transportation mode results in either one or more off-site fatalities, or one or more fatalities (either on- or off-site) with off-site evacuations or sheltering-in-place
Dam Failure	Accidental conditions where dam failure and inundation in the U.S. result in one fatality or greater
Radiological Substance Release	Accidental conditions where reactor core damage in the U.S. causes release of radiation
Transportation System Failure*	Accidental conditions where a bridge failure occurs within the U.S., resulting in one fatality or greater[20]

hundreds of millions occur every year in the Nation. Space weather events are also constant occurrences: a higher threshold was required to capture events surpassing the "100-year storm," which the electric power industry has suggested would cause direct economic loss in the billions of dollars, at minimum.

[20] The scope of the Transportation System Failure hazard is determined by the data that was actually used as the basis for the quantitative estimates of likelihood and impacts. The unclassified data available for the 2015 SNRA consisted of bridge failure data.

(b)(5)

Drivers and Evolving Threats

[redacted]

(b)(5)

[redacted]

Drivers and Evolving Threats

The 2015 SNRA included research on evolving threats, building off of previous Federal Emergency Management Agency (FEMA) strategic foresight research and additional U.S. Government reviews of evolving threats relevant to national preparedness. Certain threats and hazards frequently appeared in documents across governmental, intergovernmental, non-profit, and academic sources as potentially growing issues of concern for the U.S. as a whole and the world in the near-term and long-term. Of these, the SNRA analysis identified the following trends as having the strongest evidence for impacting national preparedness in the future.

Demographic Shifts in the U.S. and Potential Future Challenges

Over the next four decades, the U.S. population may undergo significant demographic changes that will have ramifications for the country economically, politically, and socially. Internal migratory shifts will shape the country demographically and could have wide ranging ramifications, as more Americans are living in metropolitan and coastal regions.[30] Changes to the climate and sea level rise could make homes and businesses congregated along coastal areas more prone to flooding. In addition, more concentrated populations could make evacuations more difficult, strain access to medical resources, and increase stress on aging critical infrastructure.[31]

Food and Water Insecurity

Climate change, global population growth, and economic development have the potential to create water and food insecurity in the coming decades. Food and water insecurity have the possibility of affecting the U.S. domestically and its relationships with numerous countries. Over the course of the next 10 years, many countries important to U.S. national security will experience water problems causing instability in those regions of the world. [32] As demand for these critical resources grow, global supplies may be insufficient to meet the demand.

Homegrown Violent Extremists

The terrorist threat to the Nation remains significant and continues to evolve. Individuals (lone offenders) and small groups acting on their own initiative are a tenacious threat and difficult to counter.[33] In recent years, the adept use of media by new groups has created unprecedented opportunities for their organizations to reach potential recruits and influence people.[34] Social media and the Internet have the potential to play a critical role in the immediate future in

---

[30] Federal Emergency Management Agency, *Strategic Foresight Initiative*, January 2012, p. 8.

[31] Federal Emergency Management Agency, "U.S. Demographic Shifts: Long-term Trends and Drivers and Their Implications for Emergency Management, *Strategic Foresight Initiative White Papers*, May 2011, p. 5, http://www.fema.gov/media-library/assets/documents/103600.

[32] National Intelligence Council, *Global Water Security*, February 2, 2012, p. iii.

[33] Department of Homeland Security, *2014 Quadrennial Homeland Security Review*, p. 18.

[34] Nicholas J. Rasmussen, Current Terrorist Threat to the United States, Testimony before the Senate Select Committee on Intelligence, February 12, 2015.

(b)(5)

(b)(5)

Climate Change and National Preparedness

Scientific evidence indicates the climate is changing and significant economic, social, and environmental impacts are expected as a result. Climate change is an increasingly significant factor in assessing and managing risks and vulnerabilities to extreme events. Over the past 50 years, much of the U.S. experienced increases in prolonged periods of excessively high temperatures, heavy precipitation, and, in some regions, severe floods and droughts.[37] The best available scientific data indicates these trends will continue and will likely have further cascading effects on human health, infrastructure, and the economy.[38]

Primary Impacts

The impacts of climate change will vary across the Nation, but the following are examples of critical anticipated shifts in the frequency, intensity, and/or geographic range of natural hazards:

- Increasing heavy precipitation events will contribute to flash floods and urban floods.[39]
- Average global sea level has risen by approximately eight inches since reliable record keeping began in 1880 and is projected to rise another one to four feet by 2100.[40]
- Western forests in the U.S. will be more frequently affected by large and intense fires.[41]
- The frequency and intensity of heat waves will continue to increase.[42]
- Higher temperatures cause faster evaporation rates, which may lead to drought conditions even when there is no decrease in precipitation.[43]
- Over the last three to five decades, the heaviest rainfall events have become heavier and more frequent,[44] and these are projected to continue in most of the U.S.;[45] and
- Although many contributing factors make hurricanes difficult to predict, most models project an overall increase in the frequency of the strongest (Category 4 and 5) hurricanes by the end of the century.[46]

Due to the complexity of climatological forecasting and the myriad anticipated impacts, some uncertainty remains about the magnitude and types of future changes to natural hazards. It is clear, however, that increasing frequency, intensity, and impacts of hazards due to climate

---

[37] NCA3 Highlights," *Climate Change Impacts in the United States: The Third National Climate Assessment: Highlights"* http://nca2014.globalchange.gov/Highlights, Pg. 24
[38] NCA3 Highlights, Pgs. 12–14
[39] U.S. Third National Climate Assessment (NCA3), "*Climate Change Impacts in the United States The Third National Climate Assessment*," U.S. Global Change Research Program, May 2014 http://nca2014.globalchange.gov/report, Pg. 75
[40] NCA3, Pg. 66
[41] NCA3, Pg. 192
[42] NCA3, Pg. 64
[43] NCA3 Highlights, Pg. 24
[44] NCA3 Highlights, Pg. 25
[45] NCA3, Pg. 37
[46] NCA3, Pg. 41

Threats and Hazards of Greatest Concern by Whole Community Partners

(b)(5)

[redacted]

(b)(5)

[redacted]

Threats and Hazards of Greatest Concern by Whole Community Partners

The SNRA also supports the integration of other risk assessment efforts, including the THIRA processes occurring at multiple jurisdictional levels.[54] THIRAs from 2012 through 2014 were reviewed to identify the threats and hazards of greatest concern to urban areas, states, territories, and tribes across the Nation. The 2014 THIRA analysis highlighted five threats and hazards frequently selected by a wide range of urban areas, states, tribal nations, and territories: Flood, Utility Interruption, Hazmat Release—Chemical, Cyber Attack, and Explosive Devices (see Figure 1). Flood, the most frequently identified hazard, was included by 64 percent of all contributing jurisdictions as a hazard of greatest concern.

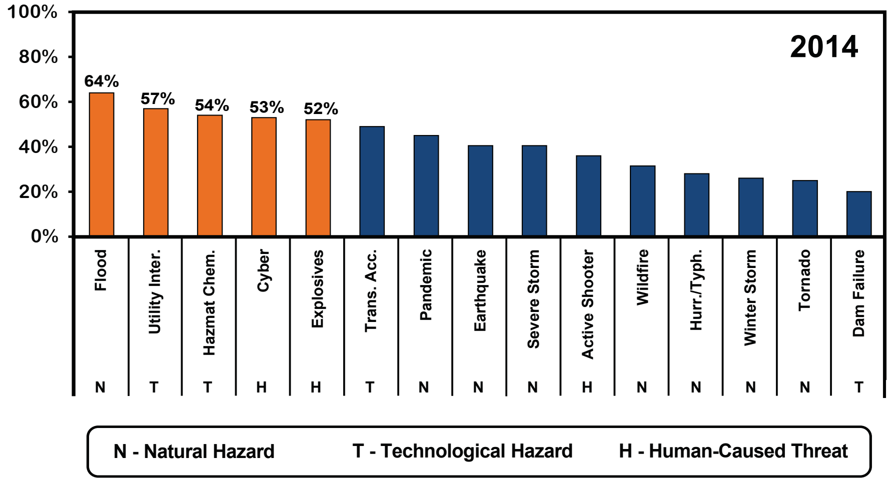


Figure 1: Most Frequently Identified Threats and Hazards in 2014 Jurisdictional THIRAs[55]

Year-over-year analysis indicates that the top five threats and hazards of greatest concern across jurisdictions remained largely consistent from 2012 through 2014, though in a slightly different order each year. In addition to the top five, other frequently identified threats and hazards throughout the three THIRA iterations include transportation accidents, human pandemic, and earthquakes. This reinforces that jurisdictions' perception of risk has not changed much since 2012. The 2015 SNRA participants reviewed this data to identify potential national-level risks not previously identified in the 2011 SNRA.

Figure 2 depicts the top 25 threats and hazards identified by all reporting jurisdictions across all groups (i.e., natural, technological, and human-caused) by year for 2012 and 2013.

[54] The THIRA process is completed by urban areas, states, tribal nations, territories, and the FEMA Regions.

[55] While these findings do show trends across several different perspectives, they are not intended to create a ranking of threats and hazards. Likewise, they are not intended to be representative of all possible threats and hazards within the jurisdictions, as many jurisdictions utilize varying approaches to selecting threats and hazards for inclusion in their THIRAs.

Final Notes

The SNRA process provides a broad analysis of the risks from the varied threats and hazards faced by the Nation. This assessment finds that a wide range of threats and hazards pose a significant threat to the Nation, affirming the need for an all-threats/hazards, capability-based approach to preparedness. The SNRA is designed to inform prioritization and tradeoff decisions by enabling the analysis of which capabilities are likely to have an impact at reducing identified high-risk events. Using the SNRA, the whole community can better understand which scenarios are more likely to impact them, what the consequences would be, and what risks merit special attention.

The SNRA process will continue to be implemented in support of the National Preparedness Goal, the National Preparedness System, and the all-hazards, capability-based planning approach to national risk management. Although the development and update of the SNRA are important steps, further analysis through the implementation of regional- and community-level risk assessments will help communities better understand their risks and form a foundation for their own security and resilience. The Nation's preparedness is dependent on whole community partners understanding the risks they face across all levels of government. In conjunction with local, regional/metropolitan state, tribal, territorial, insular area, and Federal partners, the SNRA process will be further implemented and refined in order to serve as a unifying national risk profile helping to facilitate preparedness efforts across the Nation.

Final Notes

The SNRA process provides a broad analysis of the risks from the varied threats and hazards faced by the Nation. This assessment finds that a wide range of threats and hazards pose a significant threat to the Nation, affirming the need for an all-threats/hazards, capability-based approach to preparedness. The SNRA is designed to inform prioritization and tradeoff decisions by enabling the analysis of which capabilities are likely to have an impact at reducing identified high-risk events. Using the SNRA, the whole community can better understand which scenarios are more likely to impact them, what the consequences would be, and what risks merit special attention.

The SNRA process will continue to be implemented in support of the National Preparedness Goal, the National Preparedness System, and the all-hazards, capability-based planning approach to national risk management. Although the development and update of the SNRA are important steps, further analysis through the implementation of regional- and community-level risk assessments will help communities better understand their risks and form a foundation for their own security and resilience. The Nation's preparedness is dependent on whole community partners understanding the risks they face across all levels of government. In conjunction with local, regional/metropolitan state, tribal, territorial, insular area, and Federal partners, the SNRA process will be further implemented and refined in order to serve as a unifying national risk profile helping to facilitate preparedness efforts across the Nation.