Severe Weather

Profiling Hazard Event

Introduction

Hazards induced by weather events, such as floods, tornadoes, deadly lightning strikes, winter storms, and extreme heat or cold, claim the lives of around 500 Americans annually. Some 90% of all presidentially declared disasters are weather related, leading to nearly $14 billion in damage. According to the Congressional Research Service, tornadoes, severe thunderstorms, and related weather events have caused an average of nearly 57 percent of all insured catastrophe losses in the United States in any given year since 1953. Routine weather events in the U.S., such as rain and cooler-than-average days, can add up to an annual economic impact of as much as $485 billon. Weather events affect economic activity in every state and every sector. However, much of the risk can be mitigated through weather awareness and preparedness.
Source: Lazo, J.K., Lawson, M., Larsen, P.H., and D.M. Waldman. (2011, June). U.S. Economic Sensitivity to Weather Variability. *Bulletin of the American Meteorological Society*, 92(6).

For the purpose of this mitigation plan, the term severe weather is used to represent a broad range of weather phenomena in Utah which include:

- Convective Weather
    - Lightning
    - Straight-line Winds
    - Hail
    - Tornadoes
- Winter Storms and Extreme Cold
- Synoptic Wind Events
- Avalanches

1999 Salt Lake Tornado

Severe weather events are the most deadly type of natural disaster in Utah. More people have died in avalanches in Utah than by any other natural hazard. Between 1958 and 2013 avalanches killed 110 people accounting for 52% of severe weather related deaths. Since 1950 lightning has killed 65 people and injured another 155 people. Lighting deaths accounted for 31 % of severe weather related deaths.

Convective Weather – Lightning

Each year in the United States, lightning causes an average of 55 deaths, and many more people are left with devastating and permanent disabilities. Additionally, lightning causes billions of dollars in losses each year, with costs associated to fires and airline operating costs and passenger delays. In Utah, lightning has claimed the lives of 64 people since 1950, more than any other thunderstorm-related hazard.

Each bolt of lightning can reach over five miles in length, soar to temperatures of approximately 50,000 degrees Fahrenheit, and contain 100 million electrical volts. At any given moment, there are 1,800 thunderstorms in progress somewhere on the earth. This amounts to 16 million storms each year! Lightning detection systems in the United States monitor an average of 25 million strokes of cloud-to-ground lightning every year!

In a thunderstorm, ice particles exist which vary in size from small ice crystals to larger hailstones. In the rising and sinking motions within the storm, collisions between the particles occur. This causes a separation of electrical charges. Positively charged ice crystals rise to the top of the thunderstorm, and negatively charged ice particles and hailstones drop to the middle and lower parts of the storm. A moving thunderstorm gathers another pool of positively charged particles along the ground that travel with the storm. As the differences in charges continue to increase, positively charged particles rise up taller objects such as trees, houses, and telephone poles.

The negatively charged area in the storm will send out a charge toward the ground called a stepped leader. It is invisible to the human eye, and moves in steps of less than a second toward the ground. When it gets close to the ground, it is attracted by the positively charged objects, and a channel develops. You see the electrical transfer in this channel as lightning. There may be several return strokes of electricity within the established channel that you will see as flickering lightning. Not all lightning forms in the negatively charged area low in the thunderstorm. Some lightning originates in the cirrus anvil at the top of the thunderstorm. This area carries a large positive charge. Lightning from this area is called positive lightning and is particularly dangerous, as it frequently strikes miles away from the rain core, either ahead, or behind, the thunderstorm.

The lightning channel heats rapidly to 50,000 degrees Fahrenheit. The rapid expansion, then contraction of air in the lightning channel causes the thunder. Since light travels faster than sound in the atmosphere, the sound will be heard after the lightning. If you see lightning and hear thunder at the same time, that lightning is in your neighborhood!

Lightning: A visible electrical discharge produced by a thunderstorm. The discharge may occur within or between clouds, between the cloud and the air, or between a cloud and the ground.

Lightning Channel: The irregular path through the air along which a lightning discharge occurs.

Lightning Discharge: The series of electrical processes by which charge is transferred along a channel of high ion density between electrical charge centers of opposite signs.

Lightning Stroke: A series of repeated electrical discharges comprising a single lightning discharge.

Thunder: The sound caused by the rapid expansion, then contraction, of air in the lightning channel.

Table 2G-1 Lightning deaths by County from 1950 to May 2013 - Alphabetically.

Cache	2	Morgan	1	Wasatch	2
Carbon	3	Piute	1	Wayne	1
Daggett	1	Rich	1	Weber	2
Davis	1	Salt Lake	8		
Duchesne	5	San Juan	6		
Emery	2	Sanpete	3		
Garfield	6	Summit	7		
Grand	4	Tooele	2		
Iron	1	Uintah	2		
Juab	2	Utah	2	**TOTAL**	**65**

Table 2G-2 Lightning injuries by county from 1950 to August 2012 - Alphabetically.

Beaver	2	Morgan	2	Utah	12
Cache	7	Piute	1	Wasatch	3
Carbon	6	Salt Lake	44	Washington	4
Daggett	1	San Juan	3	Wayne	1
Davis	3	Sanpete	1	Weber	5
Duchesne	11	Sevier	3		
Emery	7	Summit	17		
Garfield	6	Tooele	10		
Grand	3	Uintah	3	**Total**	**155**

Convective Weather – Straight-line Winds

Straight-line winds produced by thunderstorms are any winds not associated with the rotation of a tornado. Straight-line winds are responsible for most thunderstorm wind damage, and speeds can exceed 125 mph.

Downburst: A strong downdraft current of air from a cumulonimbus cloud, often associated with intense thunderstorms. Downdrafts may produce damaging winds at the surface. A downburst can cause damage equivalent to a strong tornado.

Microburst: A convective downdraft with an affected outflow area of less than 2½ miles wide and peak winds lasting less than 5 minutes. Microbursts may induce dangerous horizontal and/or vertical wind shears, which can adversely affect aircraft performance and cause property damage.

Dry Microburst: A microburst with little or no precipitation reaching the ground. At the ground, the only visible sign might be a dust plume or a ring of blowing dust beneath a local area.

Convective Weather – Hail

Hail is created when strong, rising currents of air within a storm (called updrafts) carry water droplets to a height where they freeze. As ice particles grow in size, they become too heavy to be supported by the updraft, and fall to the ground. Hail causes more than $1 billion in crop and property damage each year.

Hail: Showery precipitation in the form of irregular pellets or balls of ice, more than 5 mm in diameter, falling from a cumulonimbus cloud.

Convective Weather – Tornadoes

Although tornadoes occur in many parts of the world, they are found most frequently in the United States. In an average year, 1,200 tornadoes cause 60-65 fatalities, 1,500 injuries, and $1.1 billion in damage nationwide.

To determine a tornado's EF-rating, 28 Damage Indicators (which have a description of the typical construction for that category of indicator) and corresponding Degree of Damage (DOD) are used. The EF-scale table and supporting information can be found at http://www.spc.noaa.gov/efscale/ef-scale.html.

Tornadoes may appear nearly transparent until dust and debris are picked up or a cloud forms within the funnel. The average tornado moves from southwest to northeast, but tornadoes can move in any direction and can suddenly change their direction of motion. The average forward speed of a tornado is 30 mph, but may vary from nearly stationary to 70 mph. The strongest tornadoes have rotating winds of more than 200 mph. Tornadoes can occur at any time of day, any day of the year, although in Utah, tornadoes are most likely to occur during the spring and summer months.

Tornado: A violently rotating column of air, usually pendant to a cumulonimbus, with circulation reaching the ground. It nearly always starts as a funnel cloud and may be accompanied by a loud roaring noise. On a local scale, it is the most destructive of all atmospheric phenomena.

Funnel Cloud: A condensation funnel extending from the base of a towering cumulonimbus, associated with a rotating column of air that is not in contact with the ground.

Winter Storms and Extreme Cold

In an average year, winter weather is directly or indirectly involved in 400,000 vehicular accidents in the United States, leading to 1,300 fatalities. Add to that loss of life due to avalanches and exposure to cold, plus billions of dollars in economic losses, and it is clear that winter weather is a significant threat. Economic costs of snow arise from snow removal, road closures that cause lost retail trade, wages, and tax revenue, flight cancellations and delays, damage to utilities, flooding from snowmelt, and cost to agriculture and timber.

Ice storms can bring down trees and topple utility poles and communication towers, and disrupt communications and power for days while utility companies repair extensive damage. Even small accumulations of ice can be extremely dangerous to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces. The 5-year running average for insured winter storm losses from 2006-2010 was almost $1.7 billion per year (in 2010 dollars).
Source: Munich Re. (2011). *TOPICS GEO: Natural Catastrophes 2010 (U.S. Version).* Munchen, Germany: Munchener Ruckversicherungs-Gesellschaft, 40-43.

Winter storms are considered to be deceptive killers because most deaths are indirectly related to the storm. Fatalities occur in traffic accidents on icy roads, from heart attacks while shoveling snow, and from hypothermia due to prolonged exposure to cold. Of fatalities related to ice and snow, about 70% occur in automobiles, while about 25% are a result of people caught out in the storm. The majority of fatalities are males over 40 years old. Of deaths related to exposure to cold, 50% are people over 60 years old, and over 75% are males. About 20% of fatalities occur inside the home.

Blizzard: Sustained wind or frequent gusts of 35 miles an hour or greater and considerable falling and/or blowing snow, reducing visibility to less than ¼ mile and prevailing for a period of 3 hours or longer.

Blowing Snow: Wind-driven snow that reduces surface visibility. Blowing snow can be falling snow, or snow that has already accumulated, but is picked up and blown by strong winds. Blowing snow is usually accompanied by drifting snow.

Ice Storm: An ice storm is used to describe occasions when damaging accumulations of ice are observed or expected during freezing rain situations.

Lake Effect Snow: Snow showers that are created when cold, dry air passes over a large, warmer lake, and picks up moisture and heat.

Frostbite: Human tissue damage caused by exposure to intense cold. Frostbite causes a loss of feeling and a white or pale appearance in extremities, such as fingers, toes, ear lobes, or the tip of the nose.

Hypothermia: A rapid, progressive mental and physical collapse that accompanies the lowering of body temperature. The warning signs of hypothermia include low body temperature, uncontrollable shivering, memory loss, disorientation, incoherence, slurred speech, drowsiness, and apparent exhaustion.

Table 2G-3 Blizzard and Snowstorms by cost above $150,000
1964 to 2012
(Not corrected for inflation)

Hazard Begin Date	County	Injuries	Fatalities	Property Damage	Remarks
02/08/1962	Millard, Sanpete	0	0	$500,000	Rain and snow melt
03/29/1967	Statewide	0	0	$500,000	Wind and snow
03/21/1973	Box Elder, Weber	0	0	$500,000	Heavy wet snow
03/25/1975	Statewide	0	0	$517,857	Heavy snowstorms
10/18/1984	Salt Lake	20	0	$500,000	Snow
12/18/1990	Statewide	45	7	$500,000	Heavy snow
12/21/1990	Statewide	5	1	$5,000,000	Extreme cold
12/29/1990	Statewide	0	0	$500,000	Extreme cold
01/06/1993	Davis, Juab, Salt Lake, Tooele, Utah, Weber	18	1	$5,000,000	Heavy snow
10/24/1996	Statewide	20	0	$1,000,000	Winter storm
01/11/1997	Statewide	50	3	$40,000,000	Blizzard
02/26/1997	Statewide	20	0	$500,000	Heavy snow
03/02/1997	Statewide	30	0	$500,000	Heavy snow
03/31/1997	Statewide	60	3	$2,000,000	Winter storm
02/21/1998	Statewide	40	0	$900,000	Winter storm
11/08/1998	Statewide	10	0	$500,000	Winter storm
11/22/2001	Statewide	0	0	$560,000	Winter storm
11/24/2001	Statewide	1	0	$600,000	Winter storm
01/27/2002	Statewide	40	0	$720,000	Winter storm
11/21/2003	Statewide	0	0	$550,000	Winter storm
12/25/2003	Statewide	0	0	$1,500,000	Winter storm

"*Hazards & Vulnerability Research Institute (2011). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org*
Data reflects Hazard Events until 2009.

Synoptic Wind Events

High wind speeds created by gradient winds, downslope winds, and gap winds, can produce catastrophic damage. They also pose a health hazard, and can even be life threatening.

Gradient High Winds: High winds covering a large area, due to synoptic-scale, extra-tropical low pressure systems.

Gap Winds: Strong winds channeled through gaps in mountain ranges.

Downslope Winds: Winds generated as a deep layer of air is forced over a barrier. In these events, winds accelerate down the mountain and form a wave at the base of the terrain, with the strongest winds expected in the wave region.

Wasatch Downslope Windstorm Event of November 30 - December 1, 2011

A strong and destructive downslope windstorm impacted the northern Wasatch Front on November 30 to December 1, 2011, with maximum recorded wind gusts of 102 mph in Centerville, 92 mph in West Bountiful, 86 mph in Farmington, and numerous other reports in the 60 to 80 mph range. Damage from this windstorm was substantial and widespread, with the most extensive damage occurring between North Salt Lake and South Ogden. UDOT reported that 11 semitrailers were knocked over along I-15, which eventually led them to close the road to semis for several hours. In Fruit Heights, a steeple was blown off the roof of a church. Hundreds of trees, power lines, and light poles were knocked over, and some of these caused additional damage when they landed on houses, cars, and other property. The winds were strong enough to shatter windows in some locations, as well as bend or uproot many metal road signs. In the area of the strongest winds, almost all homes experienced damage to roofs, fences, and siding. Flying debris caused a few injuries, but there were no fatalities associated with the wind. Monetary damage to infrastructure was calculated to be $4.35 million, almost all of which occurred in Davis County. Private insured losses were around $64 million.

Avalanches

Avalanches are a rapid down-slope movement of snow, ice, and debris. Snow avalanches are a significant mountain hazard in Utah, and nationally account for more deaths each year than earthquakes. Avalanches are the result of snow accumulation on a steep slope and can be triggered by ground shaking, sound, or a person. Avalanches consist of a starting zone, a track, and a run-out zone. The starting zone is where the ice or snow breaks loose and starts to slide. The track is the grade or channel down which an avalanche travels. The run-out zone is where an avalanche stops and deposits the snow.

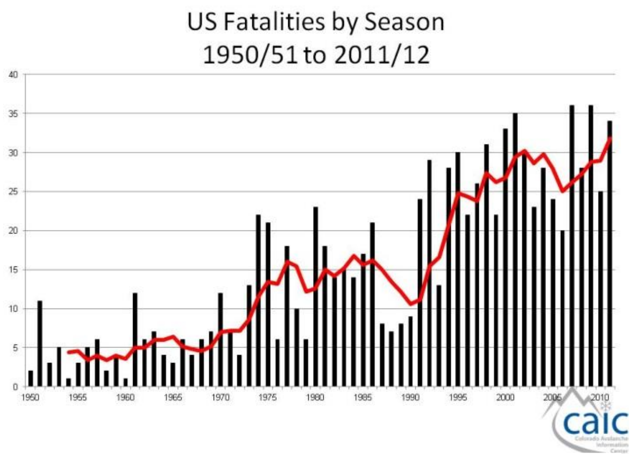
The two main factors affecting avalanche activity include weather and terrain; large, frequent storms combined with steep slopes result in avalanche danger. Additional factors that contribute to slope stability are the amount of snow, rate of accumulation, moisture content, snow crystal types, and the wind speed and direction. In Utah, the months of January through April have the highest avalanche risk.

Topography plays a vital role in avalanche dynamics. Slope angles between 30 to 45 degrees are optimal for avalanches, with 38 degrees being the most idyllic. The risk of avalanches decreases on slope angles below 30 degrees.

Types of Avalanches Common in Utah

Dry or slab avalanche: occurs when a cohesive slab of snow fractures as a unit and slides on top of weaker snow, breaking apart as it slides. Slab avalanches occur when additional weight is added quickly to the snow pack, overloading a buried, weaker layer. Dry snow avalanches usually travel between 60-80 miles per hour, reaching this speed within 5 seconds of the fracture, resulting in the deadliest form of snow avalanche.

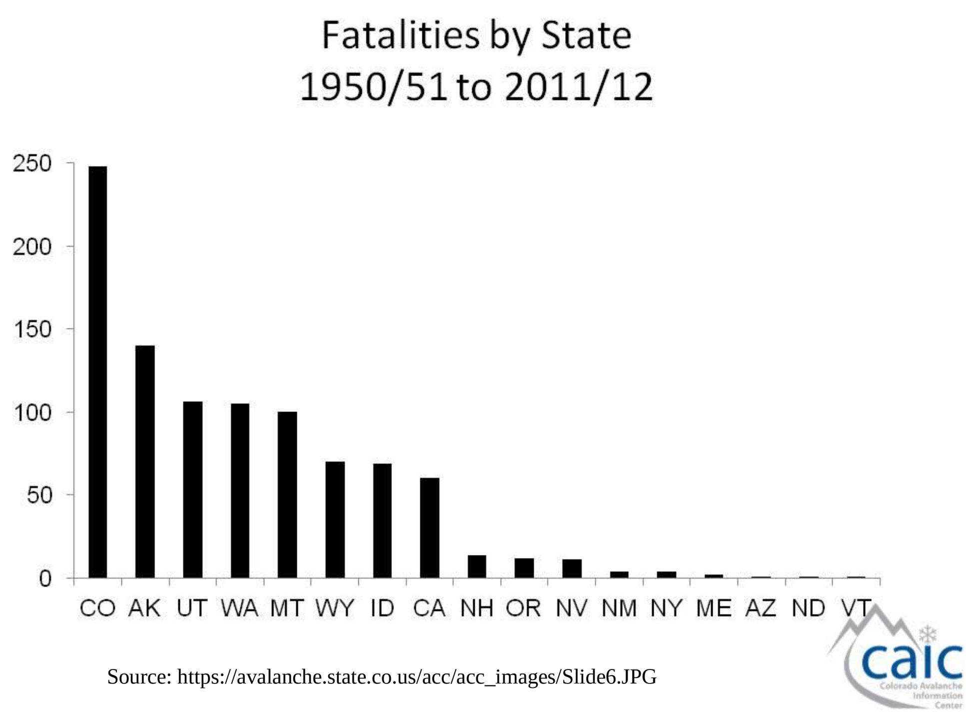
Figure 2G-1



Source: https://avalanche.state.co.us/acc/acc_images/Slide9.JPG

Wet avalanche: occurs when percolating water dissolves the bonds between the snow grains in a pre-existing snow pack, decreasing the strength of the buried weak layer. Strong sun or warm temperatures can melt the snow and create wet avalanches. Wet avalanches usually travel about 20 miles per hour.

Figure 2G-2



Source: https://avalanche.state.co.us/acc/acc_images/Slide6.JPG

Figure 2G-3

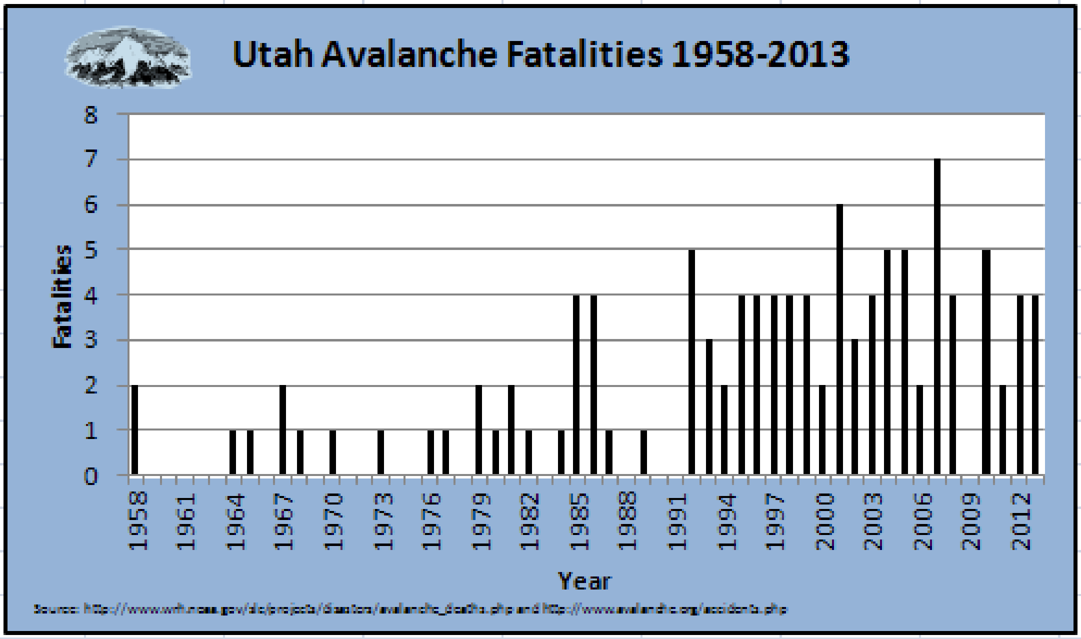
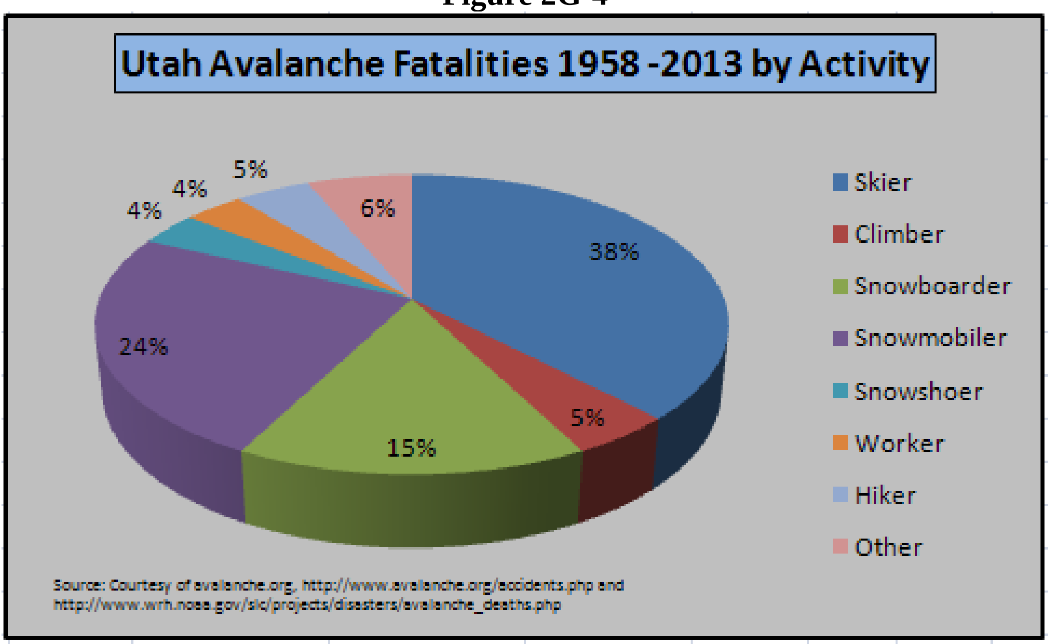


Table 2G-4 Avalanche Fatalities in Utah 1958-2013 by Activity

	Skier	Climber	Snow-boarder	Snow-mobiler	Snowshoer	Worker	Hiker	Other
1958 -2013	42	5	17	27	4	4	5	7
2004-2013	8	0	7	18	0	1	0	0
2009-2013	3	0	3	8	0	1	0	0

* Courtesy of avalanche.org, http://www.avalanche.org/accidents.php and http://www.wrh.noaa.gov/slc/projects/disasters/avalanche_deaths.php

Figure 2G-4



Hail Storms

Hailstones are large pieces of ice that fall from powerful thunderstorms. Hail forms when strong updrafts within the convection cell of a cumulonimbus cloud carry water droplets upward, causing them to freeze. Once the droplet freezes, it collides with other liquid droplets that freeze on contact. These rise and fall cycles continue until the hailstone becomes too heavy and falls from the cloud.

Table 2G-5 Hail Storms by cost $50,000 and above
1964 to 2012
(Not corrected for inflation)

HAZARD BEGIN DATE	COUNTY	INJURIES	FATALITIES	PROPERTY DAMAGE	REMARKS
09/05/1965	Statewide	11	1	$50,000.00	Lightning, Hail, Heavy Rain, and Flooding
07/22/1968	Salt Lake	1	1	$50,000	Heavy Rain, Hail and Flooding
05/23/1970	Salt Lake, Davis, Weber	35	0	$500,000	Wind and Hail
08/13/1978	Box Elder, Davis, Weber, Salt Lake	0	0	$50,000	High Wind, Hail, Heavy Rain
07/17/1985	Sevier	0	0	$50,000	Flood/Hail
07/21/1987	Statewide	8	0	$556,100	Hail
08/04/1991	Salt Lake, Utah	43	0	$50,000	Hail
10/05/1994	Salt Lake	0	0	$550,000	Hail
07/26/1996	Iron	0	0	$50,000	Hail
08/26/1998	Utah, Cache, Box Elder	0	0	$310,000	Hail
08/06/2009	Uintah, Daggett	0	0	$200,000	Hail

"Hazards & Vulnerability Research Institute (2011). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from www.sheldus.org
*Data reflects Hazard Events until 2009.

Tornadoes

A tornado is a violently rotating column of air extending from a thunderstorm to the ground. Tornados often occur at the edge of an updraft or within the air coming down from a thunderstorm. Tornadoes can rotate at wind speeds of 250 miles per hour or more, causing a damage zone up to 50 miles in length and 1 mile wide. Most tornados have winds less than 112 miles per hour and zones of damage less than 100 feet wide.

Table 2G-6 Number of Observed Tornadoes per County by Alphabetical Order

Beaver	6	Iron	5	Sevier	4
Box Elder	11	Juab	1	Summit	0
Cache	4	Kane	0	Tooele	5
Carbon	1	Millard	4	Uintah	6
Daggett	1	Morgan	1	Utah	9
Davis	11	Piute	1	Wasatch	0
Duchesne	4	Rich	3	Washington	2
Emory	8	Salt Lake	15	Wayne	8
Garfield	1	San Juan	0	Weber	6
Grand	5	Sanpete	10	**TOTAL**	**132***

*Three of the above tornadoes were counted twice because they traveled across county borders.
Courtesy of the National Weather Services.

Number of injuries
2 people on July 8, 1989
1 male on August 14, 1968
1 female on April 19, 1970
1 male on April 23, 1990
2 people on June 2, 1993
1 female on May 29, 1996
5 people (or more) on August 20, 1998
80 people (or more) on August 11, 1999
1 female on September 3, 1999

Plastic cup logged in storefront sign as a result of the August 11, 1999 tornado.

Number of deaths
1 male on August 11, 1999
1 female on July 6, 1884

Stated monetary damage by tornadoes:

1,200	June 1, 1955
5,000	June 16, 1955
20,000	June 3, 1963
2,000	August 28, 1964
10,000	April 17, 1966
15,000	November 2, 1967
50,000	August 14, 1968

5,000	May 29, 1987
3,000	May29, 1988
25,000	September 17, 1989
8,000	April 4, 1993
50,000	May 3, 1993
15,000	June 2, 1993
500,000	May 29, 1996
170,000,000+	August 11, 1999
100,000+	September 3, 1999
500	March 23, 2000
100,000	May 25, 2000
1,500	September 23, 2002
2,000,000	September 8, 2002
100,000	March 8, 2002
100,000	March 23, 2004
173,011,200+	**Total**

1999 Salt Lake Tornado damage

Utah's Strongest Tornadoes
(Category based on old Fujita Scale, see below)

F2	January 22, 1943	Young Ward
F2	June 3, 1963	Bountiful
F2	November 2, 1967	Emery
F2	August 14, 1968	West Weber
F2	May 29, 1987	Lewiston
F3	August 11, 1993	Uinta Mountains
F2	August 11, 1999	Salt Lake City
F2	September 8, 2002	Manti

Scale
Enhanced Fujita Scale (EF Scale): A set of wind estimates (not measurements) based on damage, used to estimate tornado strength. Today, tornadoes are classified by wind damage using the EF Scale. The National Weather Service has used the EF Scale since 2007. This scale assigns numbers from 0 through 5, with higher numbers indicating stronger winds and increased damage (see Table 2G-7).

Table 2G-7 Enhanced Fujita Scale

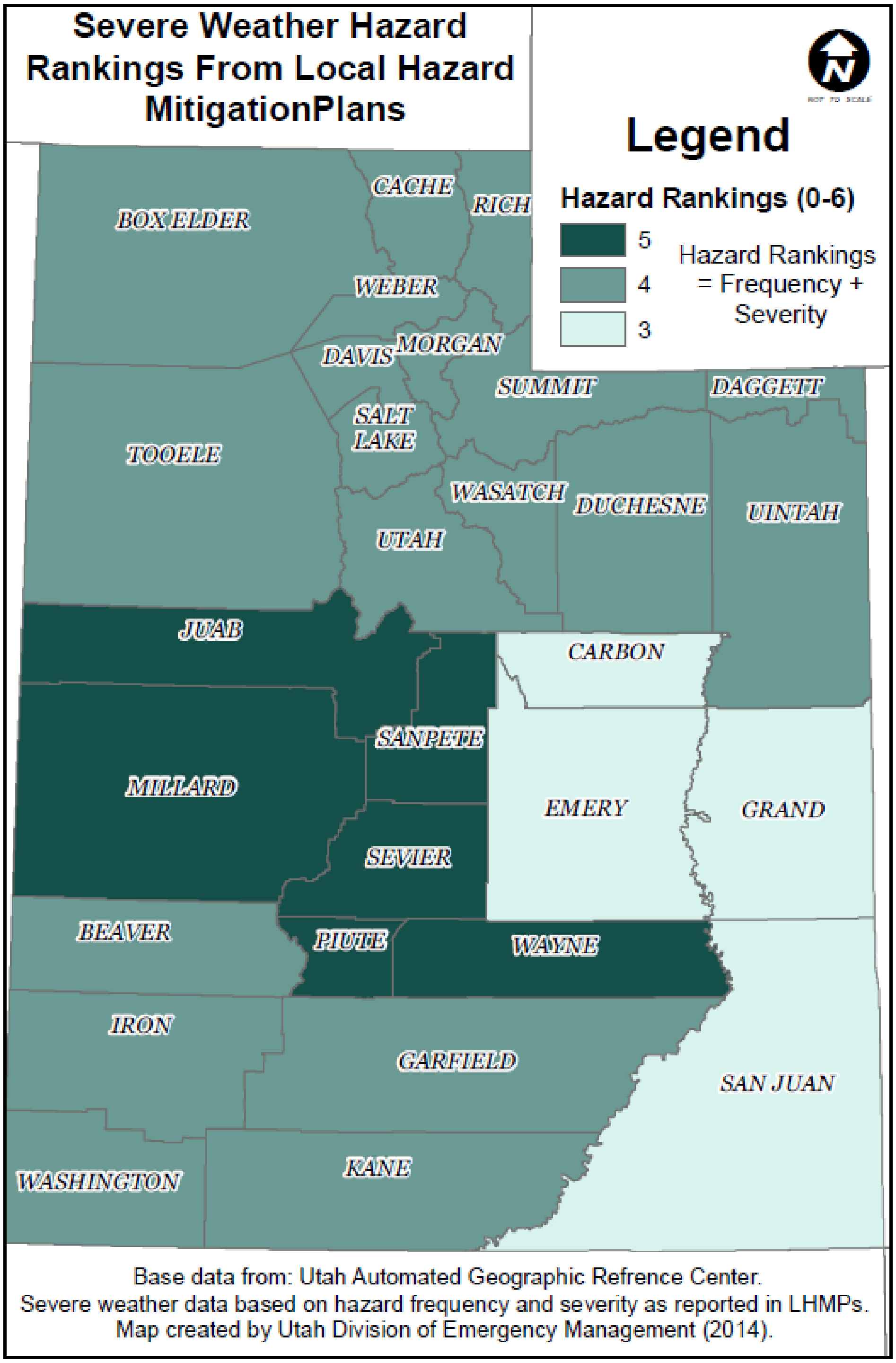
Category	Wind Speed
EF0	(65-85 mph)
EF1	(86-110 mph)
EF2	(111-135 mph)
EF3	(136-165 mph)
EF4	(166-200 mph)
EF5	(>200 mph)

Assessing Vulnerability by Jurisdiction

Assessing vulnerability and determining which counties (if any) are more vulnerable to severe weather is very problematic. Using past events to help predict the future is somewhat useful. For example, Salt Lake County has had the largest number of severe weather deaths attributed to lightning; one could assume that this trend will continue into the future. However, this is not a certainty. No one knows where the next bolt of lightning will strike. Additionally, Salt Lake County contains the state's largest population, which has little to do with the highest number of fatalities. San Juan County has the next largest number of fatalities due to lightning, but is one of Utah's least populated counties. Just 23 of Utah's 29 counties have experienced a lighting death, 25 of 29 counties have experienced a tornado, and all 29 counties have experienced hailstorms, blizzard, heavy snow, and downbursts.

As shown in Figure 2G-5, an assessment of the LHMPs was conducted which examined how each jurisdiction ranked the frequency and severity of each identified hazard. A map was created that combines the frequency and severity ranking for every county. This map shows the vulnerability of severe weather for every county based on the reporting in LHMPs. This does not show actual vulnerability, but how each county perceives their vulnerability to severe weather. The blocks of the same rankings indicate that the counties in each AOG reported the same rankings as the blocks are identical to the AOG boundaries. In the future DEM will work with the planning entities to obtain how they actually perceive their vulnerability to severe weather.

Figure 2G-5 Severe Weather Hazard Rankings from LHMPs



Estimating Potential Losses by Jurisdiction

It is virtually impossible to estimate potential losses by jurisdiction for severe weather. Several factors limit determining potential losses, including:

- Lack of research on location
- Most hazards are tied to weather and cannot be predicted with a location
- Limited GIS data is available for the one hazard that can be mapped (avalanche)
- The entire state shares nearly the same risk

Severe weather hazards can do extensive damage to property and crops, but (with the exception of avalanche) can occur at almost any time in any area of the State.

Avalanches typically do very little property damage as they often occur in forested or alpine areas outside of the human built environment. However, numerous residents of the state are still killed each year by avalanches, and the cost of search and rescue or body recovery is burdening county governments, typically tasked with the search and rescue effort.

When considering dollar losses as a function of potential losses, and therefore jurisdictional vulnerability, a key variable is the value of the human built environment and population. For that reason, the more populous counties along the Wasatch Front (including Salt Lake, Davis, Weber, Tooele, and Utah County) experience greater vulnerability.

Development Trend Impacts

Based on the limited analysis displayed in Figure 2G-6, the 50 fastest growing cities in Utah are scattered throughout the low, medium, and high vulnerability categories. While avalanches are limited to the steeper terrain of the mountain slopes, other storms associated with severe weather can impact highly populated and less populated areas alike. The greatest number of observed tornadoes is in Salt Lake County, which also happens to be the most populated county. Several ski resorts have been expanding and adding additional structures, which increase the potential of being damaged in avalanches. As Utah continues to grow, more homes, businesses, facilities and people will be vulnerable to risks associated with severe weather, but these risks remain more equally distributed when compared to other hazards like landslides or earthquakes.

Assessing Vulnerability by State Facilities

With the exception of avalanches and tornadoes, weather-related hazards typically cause very little damage to state owned facilities. The August 1999 tornado in Salt Lake City tracked just east of the state capitol doing extensive damage to several of the state owned buildings in the capitol complex, breaking windows and downing trees. All of the state owned facilities share an equal risk of being struck by a tornado or experiencing damage due to severe weather. However, thanks to updated hazards building codes that incorporate advances in science and engineering, newer buildings are becoming more resistant to the forces of severe weather.

Very few buildings exist in known avalanche slide paths and extensive research has found no case where a state owned facility was damaged by an avalanche. Avalanches do periodically block mountain roads, limiting access to ski resorts and detouring critical transportation routes.

Estimating Potential Losses by State Facilities

As the State remains vulnerable to severe weather, State-owned facilities are equally at risk to incur damages due to hazard occurrences. However, the State's resources, both monetary and fixed assets, depend heavily upon these facilities and their continuity. As of 2013, Utah owns at least 8,375 facilities with a current value of $24.5 billion. To some extent, all of these facilities are vulnerable to severe weather. The extent to which this risk is present has to do with location, construction type, height, and age.

Table 2G-8 is a total of all State-owned facilities in each county and their total insured value. The counties with the greatest number of state-owned facilities and the highest insured values possess a greater chance of sustaining damage and putting the continuity of state operations at risk if severe weather strikes, among them Salt Lake County, Utah County, Weber County, Davis County, and Cache County.

Table 2G-8 Total Number of State-Owned Facilities and Insured Value

County Name	Count Facilities	Insured Value of Facilities
Beaver	56	$60,697,658
Box Elder	175	$434,406,361
Cache	686	$1,688,388,391
Carbon	168	$222,748,804
Daggett	32	$15,277,535
Davis	408	$1,831,072,477
Duchesne	134	$225,864,192
Emery	150	$113,694,932
Garfield	83	$58,463,721
Grand	103	$87,296,597
Iron	275	$602,622,203
Juab	72	$75,072,027
Kane	87	$57,883,825
Millard	108	$169,518,737
Morgan	87	$73,587,960
Piute	37	$20,245,856
Rich	80	$27,297,843
Salt Lake	2741	$10,715,737,803
San Juan	156	$180,032,267
Sanpete	215	$453,868,556
Sevier	163	$213,094,416
Summit	179	$321,610,021
Tooele	138	$368,636,952
Uintah	173	$92,893,199
Utah	800	$3,272,078,538
Wasatch	198	$202,611,272
Washington	313	$886,829,863
Wayne	42	$17,633,297
Weber	516	$2,035,817,177
Overall Total	**8375**	**$24,524,982,480**

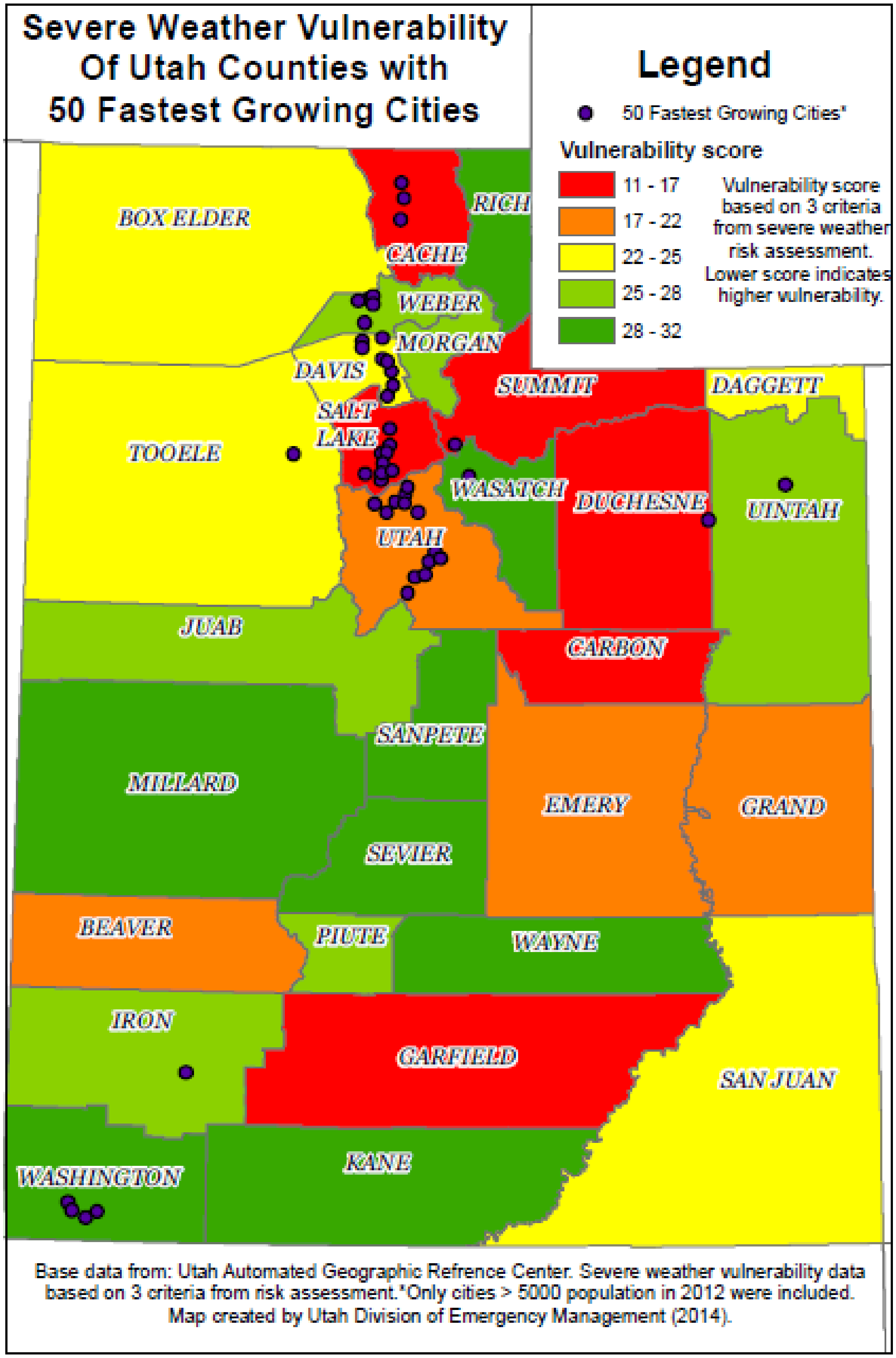
Table 2G-9 Severe Weather Vulnerability of Utah Counties*

Rank	County	Vulnerability Score
1	Salt Lake	11
2	Duchesne	13
3	Cache	15
3	Summit	15
4	Carbon	16
4	Garfield	16
5	Emery	19
6	Beaver	21
6	Grand	21
6	Utah	21
7	Davis	23
7	San Juan	23
7	Tooele	23
8	Box Elder	24
8	Daggett	24
9	Juab	27
9	Morgan	27
9	Weber	27
10	Iron	28
10	Piute	28
10	Uintah	28
11	Kane	29
11	Rich	29
11	Sanpete	29
11	Wasatch	29
12	Millard	30
12	Sevier	30
12	Washington	30
13	Wayne	32

*Based on lightning and tornado data from severe weather risk assessment (limited data).

Figure 2G-6 below combines the vulnerability scores by county from the analysis of Table 2G-9 with the population growth rate in Utah by county. Many of the fastest growing cities fall within counties with particularly high vulnerability to the threats of severe weather, such as Salt Lake, Cache, and Utah counties, indicating that a larger population is moving into areas of the state with a greater amount of risk. This analysis may help the state determine where mitigation measures may be most crucial moving forward.

Figure 2G-6 Severe Weather Vulnerability of Utah Counties with 50 Fastest Growing Cities



Vulnerability Analysis

A vulnerability analysis was performed based on the 3 criteria contained in Tables 2G-1, 2G-2, and 2G-6 (lightning deaths, injuries, and observed tornados by county, respectively). Each county was given a ranking from 1 to 29 for each criteria based on the frequency of which they experienced each given hazard. The numbers for each hazard were then combined and ordered to determine a county's vulnerability score, with the lowest numbers indicating the highest overall vulnerability. For example, if a county ranked first in every category, it would receive a vulnerability ranking of 3. Counties with the same vulnerability score receive the same ranking number.

Table 2G-9 and Figure 2G-6 list the results of the analysis. It is important to note that this analysis does not represent the likelihood of severe weather impacting a county, but the vulnerability of a county to severe weather based on the 3 criteria. The severe weather analysis is extremely limited as it includes only lightning and tornado data. For a more complete analysis, further county data on avalanches, hail storms, wind events, and blizzards is needed.

The vulnerability analysis shows a scattering of severe weather vulnerability across the state, with the highest vulnerability cluster near northern Utah. Severe weather can strike anywhere in the state at any time and any place there are people there is vulnerability. More data on the hazards identified in severe weather is necessary to gain a better understanding of the state's severe weather vulnerability.