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IA 7 – Severe Weather

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1 Purpose

- The purpose of this annex is to provide a framework for the coordination of state resources to help ensure the safety of life and property following a severe weather event.
- This annex identifies the major response and recovery activities undertaken by the listed state and adjunct agencies in response to a severe weather event.
- More specific information on severe weather as a hazard in Oregon can be found in the Natural Hazards Mitigation Plan located at:
  - http://www.oregonshowcase.org/index.cfm?mode=stateplan&page=part3

2 Policies

- Activation
  - Procedures in this annex will be implemented as outlined in the Oregon Emergency Operations Plan, Basic Plan.
  - Procedures in this annex may be automatically implemented under the following conditions:
    - When determined necessary by OEM.
    - When any area in Oregon experiences a severe weather event.
- This annex identifies the major response and recovery activities undertaken by state and adjunct agencies in response to a severe weather event.

3 Situation and Assumptions

[TO BE DEVELOPED]

4 Concept of Operations

- In accordance with the Emergency Operations Plan for the State of Oregon, the Emergency Coordination Center (ECC) will likely be fully activated.
- Tasking priorities for state resources will be determined in conjunction with local officials and approved by the State ECC.
- Oregon Emergency Management will have the lead on coordination of resources requested from local officials.
- Requested equipment, materials, supplies and personnel will be secured through State resources and/or mutual aid agreements, or purchasing.
- State supporting agencies will respond to the ECC as required to provide response and recovery resources to local governments upon assignment from the ECC Operations Officer.

5 Roles and Responsibilities

5.1 Primary Agency:

[TO BE DEVELOPED]

5.2 Supporting Agencies

[TO BE DEVELOPED]

5.3 Adjunct Agencies

[TO BE DEVELOPED]

6 Hazard Specific Information – Severe Weather

For the purpose of this annex, phenomena associated with certain weather-generated events are grouped as atmospheric hazards. The individual hazards included are:

- Thunderstorm and lightning
- Windstorm
- Snow avalanche
- Tornado
- Hailstorm
- Severe winter storm

Each atmospheric hazard may have its own natural characteristics, areal extent, time of year it is most likely to occur, severity, and associated risk. While these characteristics allow identification of each hazard, many atmospheric hazards are interrelated. In most cases, a natural disaster or event involves multiple hazards: severe thunderstorms spawn tornadoes; wind is a factor in thunderstorms, severe winter storms and hailstorms; snowfall from a severe winter storm can prompt avalanches.

Because several atmospheric hazards may occur concurrently, it may be difficult to attribute damage to any one hazard or to assess the risk a particular hazard poses. On the other hand, mitigation efforts directed to a specific hazard often have beneficial effects on related hazards.

Although atmospheric hazards are presented separately from geologic and hydrologic hazards, they may be related to these natural events and often to technological hazards, as well. Earthquakes cause snow avalanches, landslides, subsidence, and dam failures; severe winter storms can trigger floods and utility failures.

6.1 Thunderstorm and Lighting

6.1.1 Definition

Thunderstorms and lightning are generated by atmospheric imbalance and turbulence due to the combination of certain atmospheric conditions:

- Sufficient moisture to form clouds and rain;
- Unstable warm air that can rise rapidly into the atmosphere;
- Upward lift of air currents caused by colliding cold and warm weather fronts, sea breezes, or mountains.

Thunderstorms are composed of lightning and rainfall, and can intensify into a severe thunderstorm with damaging hail, high winds, tornadoes, and flash flooding. The National Weather Service classifies a thunderstorm as severe if its winds reach or exceed 58 mph, produces a tornado, or drops surface hail at least 0.75 in. in diameter.

Compared with other atmospheric hazards, individual thunderstorms affect relatively small geographical areas; the typical thunderstorm is 15 miles in diameter and lasts an average of 30 minutes at a single location. However, weather monitoring reports indicate that coherent thunderstorm systems can travel intact for distances in excess of 600 mi.

6.1.2 Life Cycle of a Thunderstorm

Developing Stage

- Towering cumulus cloud indicates rising air.
- Usually little if any rain during this stage.

- Lasts about 10 minutes.
- Occasional lightning during this stage.

Mature Stage

- Most likely time for hail, heavy rain, frequent lightning, strong winds, and tornadoes.
- Storm occasionally has a black or dark green appearance.
- Lasts an average of 10 to 20 minutes but could last much longer.

Dissipating Stage

- Rainfall decreases in intensity.
- Some thunderstorms produce a burst of strong winds during this stage.
- Lightning remains a danger during this stage.

6.1.3 Lighting

The action of rising and descending air within a thunderstorm separates positive and negative charges. Water and ice particles also affect the distribution of electrical charge. Lightning results from the buildup and discharge of electrical energy between positively and negatively charged areas. The rapid heating and cooling of air near the lightning channel causes a shock wave that result in thunder.

Most lightning occurs within the cloud or between the cloud and ground. Many fires in the western United States are started by lightning. In the past decade, over 15,000 lightning-induced fires nationwide have resulted in several hundred million dollars a year in damage and the loss of 2 million acres of forest.

6.1.4 Frequency

It is estimated that 100,000 thunderstorms that occur each year in the United States, only about 10 percent are classified as severe.

6.1.5 Territory at Risk

Thunderstorms are most likely to happen in the spring and summer months and during the afternoon and evening hours but can occur anywhere, year-round and at all hours. The chances of being struck by lightning are estimated to be 1 in 600,000.

6.2 Tornado

6.2.1 Definition

A tornado is a rapidly rotating vortex or funnel of air extending groundward from a cumulonimbus cloud. Tornadoes have been known to lift and move huge objects, destroy and move whole buildings long distances, and siphon large volumes from bodies of water.

Tornadoes occur in spring when warm, moist air collides with cold air resulting in winds rotating at very high speeds in a counter clockwise direction. Approximately 1,000 tornadoes are spawned by thunderstorms each year nationwide.

6.2.2 Frequency

Tornado events are rare in Oregon. Between 1950 and 1995, there were 50 tornadoes recorded, most rated F0 (light damage) or F1 (moderate damage) on the Fujita scale. The Fujita scale assigns numerical values based on wind speeds and categorizes tornadoes from 0 to 5. There is no record of death or injury due to a tornado in Oregon.

Table 1 Oregon Tornadoes 1950 – 1995

County	Date	Scale Value
Baker County	SEP 16, 1975	F1
	MAY 11, 1995	F0
Clackamas County	APR 12, 1957	F1
	OCT 26, 1984	F0
Clatsop County	OCT 20, 1966	F0
	OCT 03, 1967	F1
	FEB 13, 1994	F0
Columbia County	NOV 10, 1965	F0
	AUG 16, 1978	F1
Curry County	MAR 22, 1983	F0
Deschutes County	JUN 22, 1983	F0
	AUG 22, 1989	F1
Gilliam County	APR 12, 1957	F0
Harney County	MAR 11, 1995	F0
Jefferson County	JULY 16, 1993	F0
Klamath County	MAY 19, 1962	F1

County	Date	Scale Value
	MAY 30, 1995	F0
Lake County	SEP 21, 1973	F0
Lane County	DEC 06, 1951	F1
	AUG 18, 1975	F1
	MAY 14, 1984	F0
	NOV 24, 1989	F1
Lincoln County	NOV 02, 1984	F0
Linn County	MAR 22, 1994	F0
Malheur County	AUG 25, 1966	F1
	JUN 21, 1967	F0
	JUN 21, 1967	F0
	APR 23, 1974	F1
Marion County	MAR 08, 1960	F1
	NOV 12, 1991	F0
Morrow County	APR 12, 1957	F0
Multnomah County	APR 05, 1972	F1
	APR 09, 1991	F0
	NOV 12, 1991	F1
Tillamook County	DEC 12, 1975	F1
Umatilla County	MAY 01, 1991	F0
	JULY 09, 1995	F0
Union County	JUN 21, 1983	F0
Wallowa County	JUN 11, 1968	F2
	JUN 23, 1969	F1
	JULY 22, 1992	F0
Wasco County	MAY 11, 1970	F0
Washington County	OCT 22, 1954	F0
	JUN 23, 1966	F0
	OCT 13, 1968	F0
	NOV 12, 1991	F1
	DEC 08, 1993	F2

County	Date	Scale Value
Yamhill County	MAY 25, 1971	F0
	APR 18, 1984	F0
	DEC 08, 1993	F2

6.2.3 Territory at Risk

Tornadoes can basically strike anywhere. However they tend to follow the path of least resistance. People living in valleys, which normally are the most highly developed areas, have the greatest exposure.

6.2.4 Effects

Big tornadoes can lift and move very heavy objects for a long distance. Tornadoes can generate a tremendous amount of debris, which can become airborne shrapnel causing additional damage. Tornadoes are almost always accompanied by heavy precipitations. Other hazards that accompany weather systems that produce tornadoes include rainstorms, windstorms, large hail, and lightning.

6.2.5 Predictability

The National Weather Service evaluates each major tornado to determine the accuracy of its predictions and identifications based on weather data obtained from radar and other sources, local tornado spotters, emergency operations personnel, law enforcement agencies, and the general public. The NWS goal is to improve its ability to warn affected populations.

6.3 Windstorm

6.3.1 Definition

Wind is defined as the motion of the air relative to the earth=s surface. The horizontal component of the three-dimensional flow and the near-surface wind phenomenon are the most significant aspects of the hazard. Extreme windstorm events are associated with severe thunderstorms and accompanying mesoscale offspring such as tornadoes and downbursts. Wind speeds vary from zero at ground level to 200 mph in the upper atmospheric jet stream at 6 to 8 mi above the earth surface.

6.3.2 Frequency

All official wind observations in Oregon have been at valley locations where both the surface friction and the blocking action of the mountain ranges substantially decrease the speed of surface winds. Even the more exposed areas of the coast are lacking in any continuous set of wind records. From unofficial, but reliable, observations it is reasonable to assume that gusts well above 100 mph occur several times each year across the higher ridges of the Coast and Cascades Ranges and at the most exposed coastal points. At the most exposed Coast Range ridges, it is estimated that wind gusts of up to 150 mph and sustained speeds of 110 mph will occur every 5 to 10 years.

Following are some of the most significant windstorms on record in Oregon:

- January 9, 1880: Portland, sustained south wind speeds of 60 mph. Elsewhere, south winds were reported as high as 65 mph with gusts to 80 mph.

- January 20, 1921: Astoria, unofficially, reported wind gusts up to 130 mph. Hurricane-force winds were reported along the entire Oregon and Washington coasts. The very strong winds were also reported in the Willamette Valley.

- April 21-22, 1931:Strong northeast winds caused widespread damage, particularly across northern Oregon.

- Nov. 10-11, 1951: Sustained southerly to southwesterly winds of 40 to 60 mph occurred over nearly the entire state, with gusts of 75 to 80 mph at many locations.

- December 4, 1951: This storm reached its greatest intensity along the coast, where unofficial observations reported sustained wind speeds between 60 and 100 mph, while inland valley locations reported sustained wind speeds up to 75 mph.

- Dec. 21-23, 1955: High winds were felt across most of the state. North Bend reported sustained wind speeds of 70 mph with gusts to 90 mph. Dallesport, Washington, located across the Columbia River from The Dalles, reported sustained winds of 66 mph. Pendleton reported 61 mph sustained winds speeds with gusts to 69 mph.

- Nov. 3, 1958: Sustained wind speeds of 51 mph with gusts to 70 mph were reported at the Portland airport.

- Oct. 12, 1962: The Columbus Day Storm was the most destructive wind storm to ever occur in Oregon, both in loss of life and property damage. Damage was the most severe in the Willamette Valley. Monetary losses in the state were placed at 175 to 200 million dollars.

  There were 38 fatalities and many more injuries. Hundreds of thousands of homes were without power for several hours, with many power outages lasting 2 to 3 weeks. More than 50,000 homes were seriously damaged, with nearly 100 completely destroyed. Agriculture took a devastating blow as entire fruit and nut orchards were destroyed. Scores of livestock were killed as barns collapsed.

- March 27, 1963: This storm was most intense along the coast, where wind gusts from several observations made on unofficial instruments were in excess of 100 mph. Wind speeds were diminished as the storm moved inland, but they were still capable of causing widespread destruction.

- October 2, 1967: This storm brought the highest winds recorded since the Columbus Day storm of 1962 to much of western, central, and northeastern Oregon. Wind speeds of 100 to 115 mph were unofficially recorded along the Oregon coast. There was one fatality and about 15 persons were seriously injured.

- March 25-26, 1971: An intense Pacific storm center moved into northwestern Washington, bringing damaging winds across most of Oregon during the early part of the 26th. Peak wind gusts varied around the state from 50-84 mph.

- Nov. 13-15, 1981: The strongest wind storm since the Columbus Day storm of 1962 struck the Pacific Northwest. The first storm was Friday, November 13, and early Saturday, November 14, when an intense low-pressure area tracked northward 150 to 200 miles west of the Oregon coast. The second storm was Sunday, November 15, when a low pressure area following a track similar to the first storm caused strong winds over the area again. These winds occurred as people were still recovering from the effects of the first storm. Wind gusts as high as 75 mph and 62 mph were observed at Brookings and Medford, respectively. North Bend recorded gusts to 92 mph, the strongest official wind gust of the storm. Other significant recorded wind gusts were: Eugene 58 mph, Salem and Portland both with 71 mph.

  Eleven people were killed and $50 million in damage were reported as a result of the two wind storms.

- Dec 12, 1995: Record low barometric pressure reading for the state of Oregon occurred with this storm.

6.3.3 Territory at Risk

Extreme winds other than tornadoes are experienced in all regions of Oregon. Areas experiencing the highest wind speeds are North and Central coast, under the influence of winter low-pressure systems in the Gulf of Alaska and North Pacific Ocean, and Columbia River Gorge, during cold fronts, when cold air masses funnel down through the canyon. One particular location, Crown Point, located about 20 miles east of Portland; easterly winds with a 24-hour average of more than 53 mph with gusts in excess of 120 mph have been observed.

Additional wind hazards occur on a localized level due to downslope windstorms along mountainous terrains. These regional phenomena, known as foehn-type winds, result in winds exceeding 100 mph, but they are of short duration and affect relatively small geographic areas.

A majority of the destructive surface winds in Oregon are from the southwest. Under certain conditions, very strong east winds may occur, but these are usually limited to small areas in the vicinity of the Columbia River Gorge or other low mountain passes.

The more frequent and widespread strong winds from the southwest are associated with storms moving onto the coast from the Pacific Ocean. If the winds are from the west, they are often stronger on the coast than in the interior valleys due to the north-south orientation of the Coast Range and Cascades. These mountain ranges obstruct and slow down the westerly surface winds.

The most destructive winds are those which blow from the south, parallel to the major mountain ranges. The Columbus Day Storm of 1962 was a classic example of a south wind storm. The storm developed off the coast of California and moved from the southwest then turned, coming directly from the south and toward the south Oregon coast.

6.3.4 Effects

The damaging effects of windstorms may extend for distances in excess of 100 miles from the center of the storm activity. Isolated wind phenomena in the mountainous regions have more localized effects.

Near-surface winds and associated pressure effects, positive, negative, and internal, exert pressure on structure walls, doors, windows, and roofs, causing the structural components to fail. Positive wind pressure is a direct and frontal assault on a structure, pushing walls, doors, and windows inward. Negative pressure affects the sides and roof where passing currents create lift and suction forces that act to pull building components and surfaces outward. The effects of winds are magnified in the upper levels of multi-storey structures. As positive and negative forces impact and remove the building protective envelope (i.e., doors, windows, walls), internal pressures rise and result in roof or leeward building component failures and considerable structural damage.

Debris carried along by extreme winds can directly contribute to loss of life and indirectly to the failure of protective building envelope components. Upon impact, wind-driven debris can rupture a building, allowing more significant positive and internal pressures.

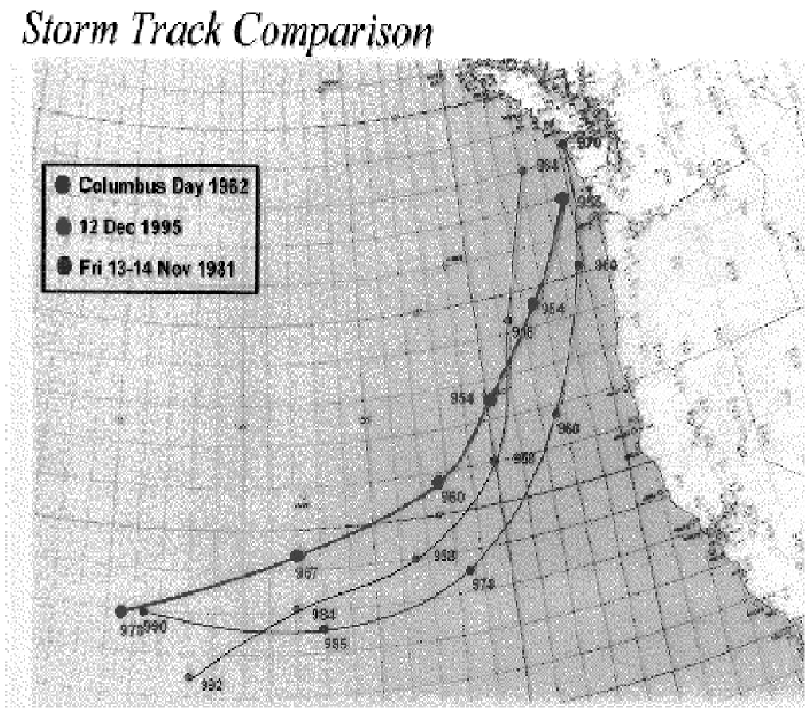
When severe wind or ice storms strike a community, downed trees, power lines, and damaged property are major hindrances to response and recovery. Severely damaged trees often must be removed in a hurry to allow passage of emergency response vehicles, and sometimes only several weeks or months following a storm does the amount of damage and loss of trees become apparent.

6.3.5 Predictability

Powerful winter storms that strike the U.S. West Coast often occur in series. Forecasting the development of oceanic storms is still a challenge, largely because there are fewer weather observations at sea than over land.

Research is being conducted on wind engineering, particularly on windstorms and how wind pressures cause damage to various types of structures. This will allow for evaluation of the weak points of existing buildings, enabling owners to take appropriate corrective actions to make buildings safer.

Figure 1 Paths of the three most significant windstorms recorded in Oregon



6.4 Hailstorm

6.4.1 Definition

Hailstorms develop from severe thunderstorms. The strong rising currents of air within a storm carry water droplets to a height where freezing occurs. Ice particles grow in size, finally becoming too heavy to be supported by the updraft and fall to the ground. Large hailstones fall at speeds faster than 100 mph.

The size of hailstones is a direct function of the severity of the storm. The stronger the updraft wind, the longer hail is kept in suspension in the thunderclouds. A hailstorm is an outgrowth of a severe thunderstorm in which the balls or irregularly shaped lumps of ice greater than 0.75 in (1.9 cm) in diameter fall with rain.

6.4.2 Frequency

Limited data available on the probability and frequency of occurrence of hailstorms in Oregon shows that areas in the Northeast Oregon experience hailstorms more frequently than the rest of the state. However hailstorms do not usually occur more than two or three days a year anywhere in Oregon. They are generally not very strong, although there have been cases when hailstorms in Oregon were similar to the type of hail storm more often experienced in the Midwest.

One such significant hailstorm occurred Morrow and Umatilla Counties in the summer of 1995. A ferocious, freak hailstorm early one Sunday afternoon devastated crops, shattered windows and pelted cars throughout Hermiston, west Umatilla County and parts of Morrow County. Total crop damage in Umatilla and Morrow counties came to about $30 million. Houses and cars also were damaged. Final property damages are not available, but early estimates were around $30 million.

Another significant hailstorm occurred in Medford area on September 4, 1997. The storm battered some orchards with hail the size of marbles or larger and destroyed 20 percent of the Rogue Valley's pear crop, according to industry specialists. It carved two swaths through the valley, sweeping north from Colver Road to Old Stage Road and toward Jacksonville. Another wave of hail hammered orchards along North Phoenix Road to Foothill. Heavy golf ball size hail was also reported in the Carpenter Hill Road Area and between Phoenix and Talent. Estimated damage from this storm was around $10 million.

6.4.3 Territory at Risk

Thunderstorms affect relatively small areas when compared with hurricanes and winter storms. The typical thunderstorm is 15 miles in diameter and lasts an average of 30 minutes. The areal extent and severity of the hailstorm hazard is not necessarily coincident with maximum thunderstorm or tornado activity.

6.4.4 Effects

The development of hailstorms from thunderstorm events can cause major property and crop damage. Long-stemmed vegetation is particularly vulnerable to damage by hail. Severe hailstorms can also cause considerable damage to buildings and automobiles, but rarely results in loss of life.

6.4.5 Predictability

Efforts to predict hailstorms and reduce damage are generally similar to those associated with thunderstorms. Weather monitoring and warning system modernization and improvements will make it possible to more efficiently forecast and protect from thunderstorms and hailstorm development.

6.5 Snow Avalanche

6.5.1 Definition

A snow avalanche is a mass of rapidly moving snow that slides down a mountainside. The flow can be composed of ice, water, soil, rock, and trees. Snow avalanches are natural processes, occurring perhaps 1,000,000 times per year, world-wide.

The slope failure associated with an avalanche is caused by several factors, but is primarily due to large accumulations of snow on steep slopes. Snow is deposited in successive layers as the winter progresses. These layers may have dissimilar physical properties. An avalanche occurs when one layer slides on another, or the whole snow cover slides on the ground. Natural or human-induced snow avalanches most often result from structural weaknesses within the snowpack.

An avalanche may be dry or wet, according to whether free water is present in the snow. It may be of loose snow, when the avalanche starts at a single point or a slab avalanche which occurs when an area of more cohesive snow separates form the surrounding snow and slide out. In practice, any snow slide big enough to carry a person down is important.

6.5.2 Effects

Typically, avalanches have localized impacts and individually do not affect large numbers of people. However, of all the deaths caused by natural hazards, the total number of deaths attributable to snow avalanches is exceeded only by those associated with floods and lightning. The chart below presents the number of deaths in the United States due to snow avalanches for the last approximately fifty years. Oregon is present in the report with eight fatalities.

The sliding snow or ice mass in an avalanche moves at high velocities. It can shear trees; completely cover entire communities and highway routes, and level buildings. The primary threat is loss of life of back country skiers, climbers, and snowmobilers.

More people are at risk due to the increased popularity of winter climbing and hill walking along with the growth of interest in ski touring and off piste skiing. Injuries and fatalities can be reduced with outreach on avalanche danger.

Figure 2 Composition of a Snow Avalanche

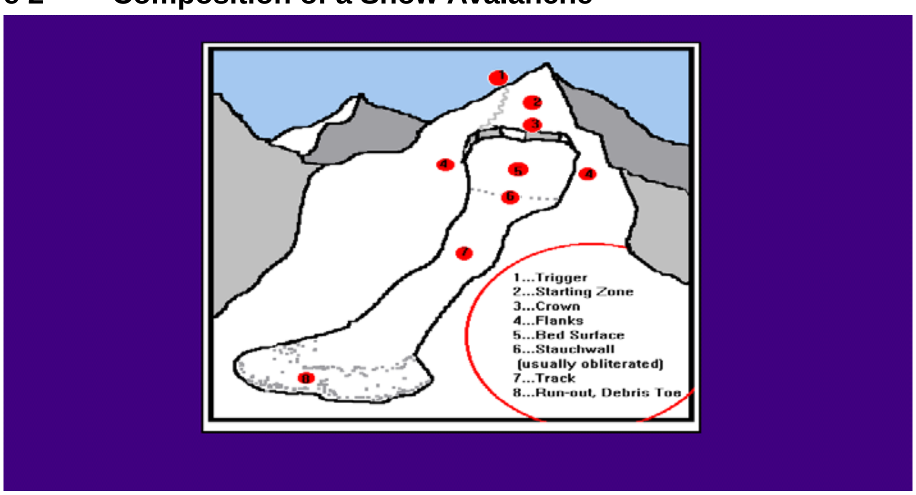
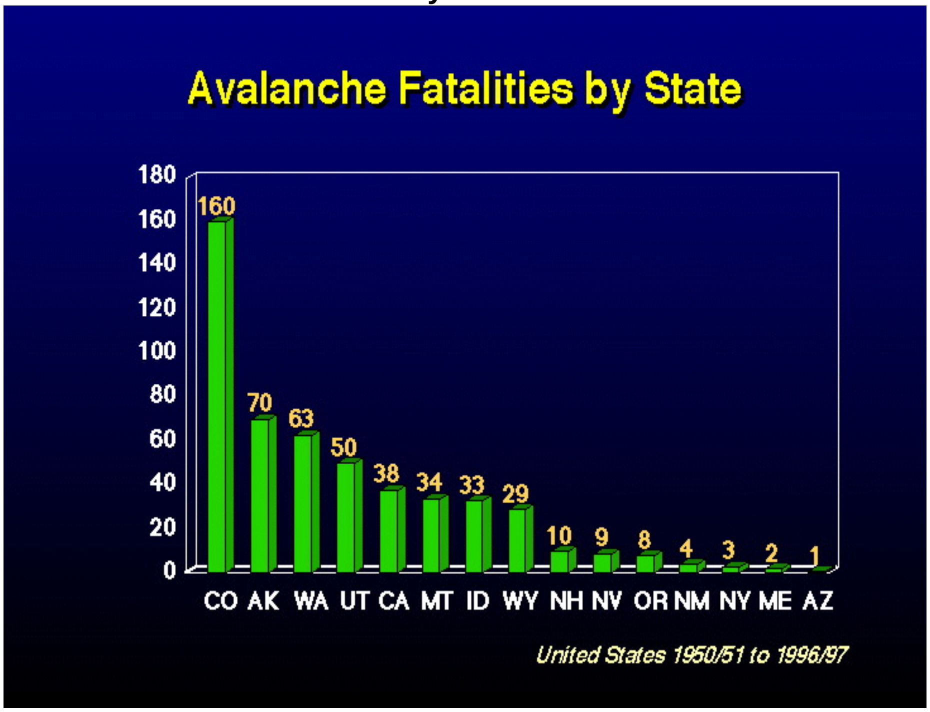


Figure 3 Avalanche Fatalities by State



Most avalanche accidents are caused by slab avalanches which are triggered by the victim or a member of the victim's party. However, any avalanche may cause injury or death and even small slides may be dangerous.

6.5.3 Territory at Risk

Most avalanches that occur each year are in remote, unpopulated mountainous areas, along recognized avalanche paths in previously identified hazard zones. Avalanches can happen wherever there is snow lying on ground of sufficient angle. In recent years there have been accidents in most Oregon mountain areas.

6.5.4 Predictability

GIS can be used by the avalanche industry as a platform to collect, store and analyze the various types of avalanche influencing factors which make up a particular avalanche hazard.

GIS could be used as a tool by the avalanche industry to analyze the components of avalanche hazard forecasting. The flexibility of such a platform has the potential to include virtually every type of avalanche influencing characteristic.

7 Supporting Documents

None at this time.

8 Appendices

None at this time.