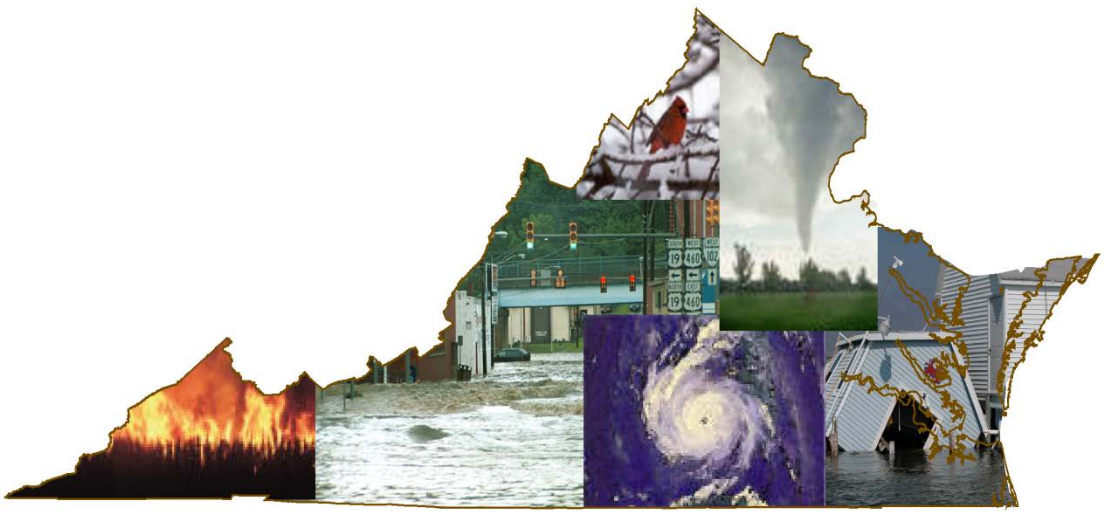
COMMONWEALTH OF VIRGINIA

Hazard Mitigation Plan



Chapter 3
Hazard Identification and Risk Assessment (HIRA)

Appendix 3.9 – Winter Weather

SECTION 3.9

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Section 3.9: Winter Weather

Description

City of Alexandria
February 2010
Source: EPA Michael Reynolds

The winter season brings a variety of natural hazards including blizzards, snowstorms, ice, sleet, freezing rain, and extremely cold temperatures. Each of these winter weather events can occur throughout the state, although the western and northern parts of the state experience winter weather much more frequently. For example, weather station data from 1960 to 2000 shows nearly all monitoring stations experiencing a day with 12" of snow. However, in southeast Virginia events approaching this magnitude may occur only once every decade.

Virginia's biggest winter weather threat comes from a storm pattern known as a Northeaster or "Nor'easter". These large storms usually originate to the south, and travel northward along the Atlantic coast. Warm, moist air from the ocean combined with cold air from the north can produce significant snowstorms throughout the mid-Atlantic and Northeast coast states. Depending on the specifics of each storm, the event may result primarily in rain, snow, or some combination thereof. Strong winds also characterize Nor'easters, often resulting in coastal flooding and erosion. The combination of heavy frozen precipitation and strong winds is destructive and often damaging to trees and utility lines. Nor'easters may occur from November through April, but are usually at their worst in January, February, and March.

Some of the historic winter weather extremes in Virginia include:

- Lowest temperature of -30°F, recorded on January 21, 1985 at the Mountain Lake Biological Station in Giles County.
- Greatest 1-day snowfall of 34 inches, recorded on February 6, 2010 at the Lincoln weather station near Purcellville, Virginia.
- Highest single storm snowfall of 48 inches, recorded January 6-7, 1996 at Big Meadows.
- Greatest monthly snowfall of 54 inches during February 1899 recorded in Warrenton.
- Greatest seasonal snowfall of 124.2 inches during the 1995-1996 winter season, recorded in Wise County.
- Major winter storms typically affect large areas of the nation. During the 1990s, winter storms in Virginia resulted in more localities qualifying for major disaster declarations than any other hazard.

Extreme Cold

Regardless of precipitation, excessively cold temperatures also pose occasional threats to the Commonwealth. While wind chill advisories are issued nearly every year, life-threatening excessive cold is a rare occurrence, and the impact of such events depends on the preparedness of individual households and heating fuel/energy providers.

Definitions of extreme cold can vary dramatically across the state and country. Jurisdictions in the eastern part of the state that do not receive frequent winter weather might consider a day below 32ºF as "extreme", while jurisdictions in the Blue Ridge or Piedmont area would have a different threshold for defining extreme cold.

The Central Shenandoah Valley, the New River Valley, and the Northern Shenandoah Valley regional plans identified extreme cold as a high hazard. Three other plans ranked this hazard as low, and the remaining 19 did not rank extreme cold. Section 3.6 includes the overall rankings for the local plans. Due to the limited impacts to population and infrastructure, this hazard was not analyzed in detail as part of this plan.

Historic Occurrence

VDEM's webpage has a winter weather history for Virginia containing events dating as far back as 1772.[1] At a regional level, the Regional Snowfall Index (RSI) provides a useful methodology for classifying snowstorms based on societal impact. The RSI is an evolution of the Northeast Snowfall Impact Scale (NESIS) which NCDC began producing in 2005. NESIS focused on the impact of storms in the Northeast, while the RSI divides the United States into six easternmost climate regions (Northern Rockies and Plains, Upper Midwest, South, Ohio Valley, Northeast, and Southeast) and develops a separate index for each of those regions based on region-specific parameters and population impact considerations[2]. Virginia is part of the Southeast region. The RSI values range from 1 to 18+ or "notable" to "extreme"[3]. Researchers at the NCDC have calculated the scores for high-impact storms dating back to the 1900's.[4] Listed below are a few of the significant winter storms affecting Virginia in recent decades:

- March 5 – 9, 1962: The "Ash Wednesday Storm" was a Nor'easter that brought heavy snowfall to interior portions of the state, as well as flooding and shoreline erosion. Snowfalls of 20 inches or more were reported in Harrisonburg, Lexington, Staunton, and
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[1] Virginia Department of Emergency Management. "Winter Weather: Virginia Winters." http://www.vaemergency.gov/news/history/winter
[2] Squires et al., "Regional Snowfall Impact Scale." http://www1.ncdc.noaa.gov/pub/data/cmb/snow-and-ice/rsi/regional-snowfall-impact-scale-27th-iips-v3a.pdf
[3] National Climatic Data Center. "Regional Snowfall Index (RSI) Overview." Retrieved from http://www.ncdc.noaa.gov/snow-and-ice/rsi/nesis on November 12, 2012.
[4] RSI scores for the Southeast region are available at: http://www.ncdc.noaa.gov/snow-and-ice/rsi/nesis

in Rockingham County. Virginia Beach and Hampton experienced flooding, wind damage and erosion due to high waves.

- January 1977: The "Bicentennial Winter" was described as the coldest season seen on the East Coast since before the founding of the republic. The tidal Potomac froze solid enough that people could skate across it near the Memorial Bridge. January's average temperature was 25.4°F in Washington D.C., the coldest seen there since 1856. The prolonged cold wave led to oil and natural gas shortages.

- February 10 – 11, 1983: The "Blizzard of 1983" blanketed a large portion of the state with deep snow. Accumulations between 15 and 20 inches were reported in Augusta County, Harrisonburg, Lexington, Rockbridge County, Lynchburg, Roanoke County, and Richmond. Strong winds caused even higher snowdrifts. The storm cost the state an estimated $9 million in snow removal. This storm scored an 11.946 on the southeast region RSI scale, which is described as a "crippling" event; the storm affected not only Virginia, but also many other Mid-Atlantic and Northeast states.

- March 13 – 14, 1993: The "Storm of the Century" affected nearly the entire East Coast, costing billions of dollars in damage and snow removal. Its effects in Virginia were less significant than other historic storms, but it affected more communities, ranging from the Chesapeake Bay through central Virginia, and was quite severe in Southwest Virginia. This storm is the second highest –ranked event on the southeast regions RSI scale at 20.572 on the southeast region RSI scale, which is described as an "extreme: event. (FEMA disaster #3112).

- January – March 1994: The "Ice Storms of 1994" coated portions of Virginia with 1 to 4 inches of ice, due to freezing rain and sleet. Approximately 10 to 20% of trees in some jurisdictions were damaged, as well as many utility lines. (FEMA disasters #1014 and 1021).

- January 6 – 13, 1996: The "Great Furlough Storm", so named due to a Congressional budget impasse, was one of the most widespread, heavy snowfalls in Virginia in recent times. Snow fell in excess of 10 inches throughout almost the entire state, with snowfalls in excess of 20 inches throughout central and western Virginia. The event consisted of two back-to-back heavy snowfalls, leaving snow on the ground for an extended period. Eventual thawing combined with heavy rain caused severe flooding. As of this writing, this event is the highest-ranked event on the southeast region RSI scale at 20.994. (FEMA disaster #1086).

- December 23, 1998: "The Christmas Ice Storm" struck central and southeast Virginia on Wednesday the 23rd and lasted until Christmas Day. Accumulations of up to an inch of ice brought down trees and power lines. Approximately 400,000 customers were without

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power on Christmas Eve, and some people remained without power for as many as ten days[5].

- January 23 – 26, 2000: This Nor'easter brought snowfalls between 5 and 20 inches to the eastern half of Virginia, which does not frequently receive such snow depths. Heavy winds created blizzard conditions and created snowdrifts between 4 and 5 feet in some areas. Significant flooding and erosion affected coastal areas including the Grandview area of Hampton. This event was rated a 7.229 on the southeast region RSI scale, or "major." A subsequent storm with significant ice accumulations occurred on January 30, leading Governor Gilmore to declare a state of emergency. (FEMA disaster #1318).

- February 13 – 17, 2003: The most significant storm of the 2003-04 winter season impacted most of the state. Three rounds of precipitation resulted in 20 to 36 inches of snow across far northern Virginia. This decreased to between 7 and 12 inches of snow and sleet in the central part of the state and to several inches of sleet and/or 1/4 to 1/2 inch of ice accretion in the south. A 24-hour snowfall of 16.7 inches at Ronald Reagan National Airport was the fifth highest on record. Flooding and mudslides occurred in Southwest and Northern Virginia as a result of this storm. This event scored a 5.933 on the southeast region RSI scale, described as "significant." (FEMA disaster #1458)

- December 26, 2004: The "Day after Christmas Ice and Winter Storm" brought a narrow band of snowfall to Virginia's eastern shore and southeast Virginia. Snow depths of up to a foot accumulated in York County, Accomack County, Northampton County, Isle of Wright County, Newport News, and Poquoson.

- February 11 – 12, 2004: A winter storm brought significant snow across to northern and central Virginia; accumulations in most of the state ranged from 5 to 8 inches. Northern Virginia and Washington DC received 10 to 15 inches. Nearly 300,000 customers in northern Virginia were without power due to downed trees and power lines.

- December 18 – 21, 2009: A nor'easter that formed over the Gulf of Mexico developed into a winter storm affecting much of the East Coast. This event was rated a 12.776 on the southeast region RSI scale, or "crippling." This snowstorm resulted in a federally declared disaster. Buchanan, Virginia reported 27 inches of snow on December 19, 2009.

- February 4 – 7, 2010: A nor'easter affecting northern Virginia was rated an 8.103 on the southeast region RSI scale, or "major." This snowstorm was a federally declared disaster. The Lincoln weather station near Purcellville, Virginia in Loudoun County reported 34 inches of snow on February 6, 2010.

[5] Virginia Department of Emergency Management. "Winter Weather: Virginia Winters." http://www.vaemergency.gov/news/history/winter

Risk Assessment

Probability

The probability of future winter weather events is usually determined empirically based on the historical frequency of occurrence of such events. The NCDC Storm Events database records winter weather events and damages dating back to 1993, but it does not systematically document the magnitude or intensity of each event. Long-term weather station observation data provides more detailed information on event magnitude (as measured by snowfall depth, precipitation types, and temperature) but does not provide any information regarding historical impacts. Other sources of information relating to winter weather climatology include the Southeast Regional Climate Center, the Oregon State University's PRISM Group, as well as a variety of other national, regional, and local organizations.

Rather than using existing climatology information, independent analyses of weather station data were performed to estimate the probability of specific winter weather occurrences. While some of the "ready-to-use" data sources may be sufficient for planning purposes, they are typically limited to certain standard climate normal products. In this plan, independent analyses were used to illustrate the usage of the raw weather station data, and to stimulate interest in using weather station data for other purposes.

The winter weather analysis from the previous version of this plan has been retained, as it still presents a reasonable assessment of the relative probability of winter weather conditions across the state. While more recent raw data is available from the NCDC, the distribution format has changed, and the processing methods used to analyze the data will require modifications to produce similar analysis outputs in the future.

Using daily weather station data involves decisions about which weather stations to include in the analysis and how to handle data gaps. In deciding which weather stations to use, the location, period of record, and data variables reported are the key factors. Virginia stations with substantially complete data from 1960 through 2000 were chosen for this analysis. Small interruptions or gaps exist in these stations' data records, which may indicate periods when the station was not operational. Entire years with no data were removed from consideration when conducting the analyses in this report, but smaller data gaps were ignored. As a result, the statistics generated from this data may slightly underestimate the frequency or intensity of winter weather phenomena. More involved techniques may improve this area of the analysis, if desired.

To assess the probability and intensity of winter storm events, weather station data was downloaded from the NCDC archives.[6] A selection of cooperative (COOP) weather stations operating between 1960 and 2000 was loaded into a Microsoft Access database in order to determine the annual frequency of occurrence of certain conditions. The daily station data

[6] Currently hosted at: http://hurricane.ncdc.noaa.gov/CDO/cdo

variables relevant to this investigation include 24-hour snowfall depth, minimum temperature, and daily weather type codes.

The NCDC archives, and specifically the Daily Surface Data records (DS3200 / 3210 / 3205 / 3206) provide data in comma-delimited text files, which must be transformed in order to create a database table a single daily record. This transformation was accomplished using a macro written with Visual Basic for Applications in Access. This macro converts the data from its original format, with all days of a month in one record, to a format containing only one day per record. With the daily data thus transformed, a second macro calculated and reported the annual frequency of occurrence for user-specified conditions. For example, the annual frequency of occurrence of "at least 3 days with snowfall of at least 3 inches" may be calculated. This result estimates the probability that a given year would contain at least 3 days with 3 inches of snowfall. The macro can compute the frequency for any number of days and any depth of snow. It also has the capability to calculate the average number of days with a specified snow depth.

Figures 3.9-2 through 3.9-7 are a selection of results from CGIT's analysis of the daily snowfall and temperature weather station data. These figures illustrate a general trend towards more frequent and more intense winter weather at higher elevations and at higher latitudes. In these figures, the station-specific statistics have been used as the basis for a seamless statewide estimate based on multiple linear regressions between the weather statistics (dependent variable) and elevation and latitude (independent variables).

In addition to the frequency and depth of snowfall, the effects of winter weather on Virginia's residents are particularly severe when winter storms bring freezing rain, sleet, and ice/snow mixtures. The broad network of COOP weather stations used to estimate snowfall frequency and depth does not provide sufficient information to identify these different types of precipitation. "Precipitation type" classifications have been recorded by a smaller set of weather stations for many years, which are located primarily at major airports around the state. These classifications, reported on an hourly and/or daily basis, can be used to identify the dominant type of precipitation during the period of observation.

"Precipitation type" data (NCDC DSI-3200 element "DYSW") was downloaded and processed in a manner similar to the snowfall and temperature data. Many specific weather types were aggregated into simpler categories during this process. Only a few stations with substantially complete monitoring from 1984 through 2007 were considered for this investigation; these results are presented in Figure 3.9-1. The spatial distribution of the selected weather stations is not broad enough to depict the dominant weather types on a state-wide level. As noted previously in this section, these analyses are subject to some errors due to incomplete reporting; more thorough handling of gaps in the period of record could produce results that are more reliable. However, this simple analysis is sufficient for depicting the general nature of winter weather in Virginia. A more detailed analysis could also be performed using hourly precipitation type codes; but as with the daily codes, not all stations report this data.

Figure 3.9-1: Daily Reporting of Winter Precipitation Types

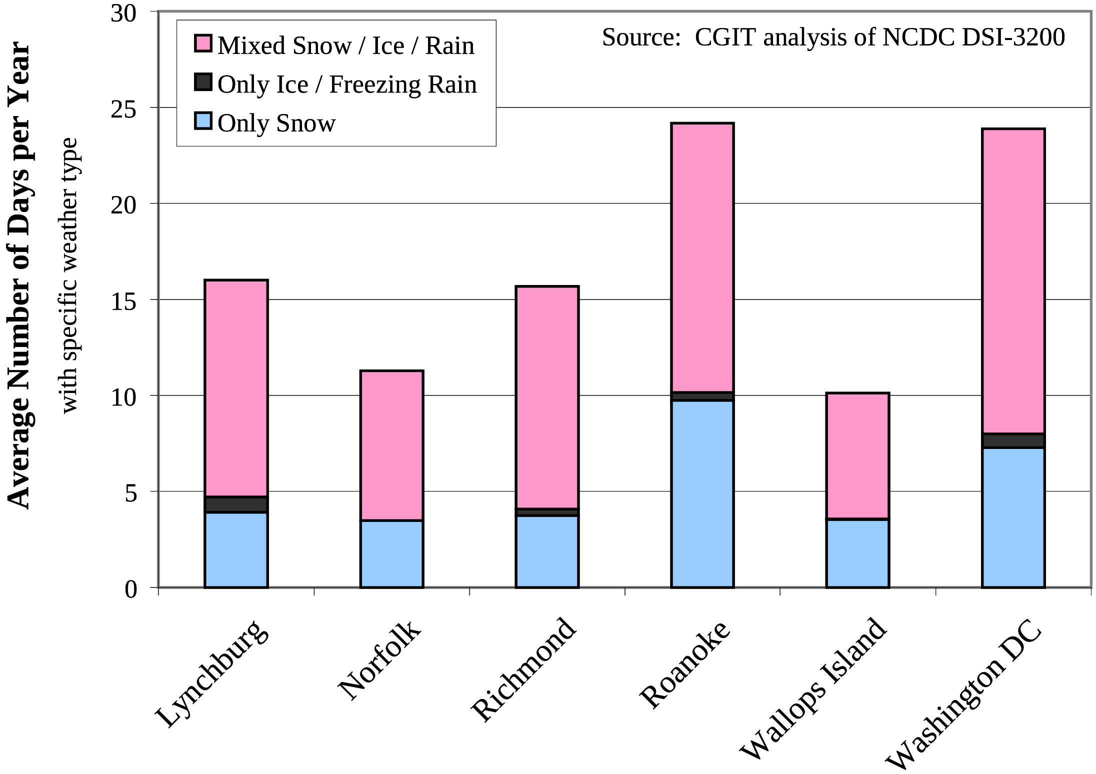
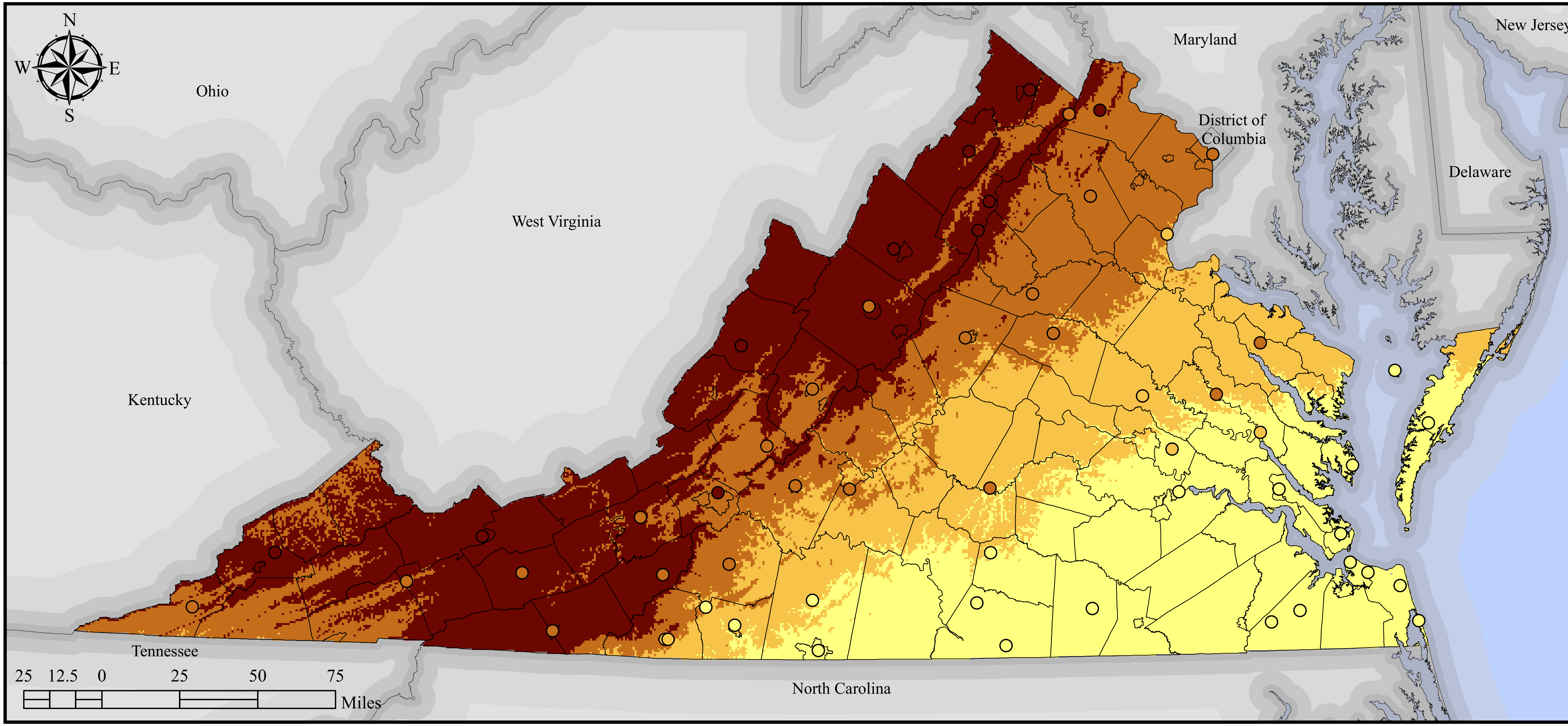


Figure 3.9-2: Average number of days with at least 3 inches of snow



PROJECTION: *VA Lambert Conformal Conic*
North American Datum 1983

DATA SOURCES:

CGIT analysis of NCDC data
VGIN Jurisdictional Boundaries
ESRI State Boundaries

LEGEND:

Avg. Number of Days per Year

- 1.5 or lower
- 1.51 - 2.0
- 2.01 - 3.0
- 3.01 - 6.72

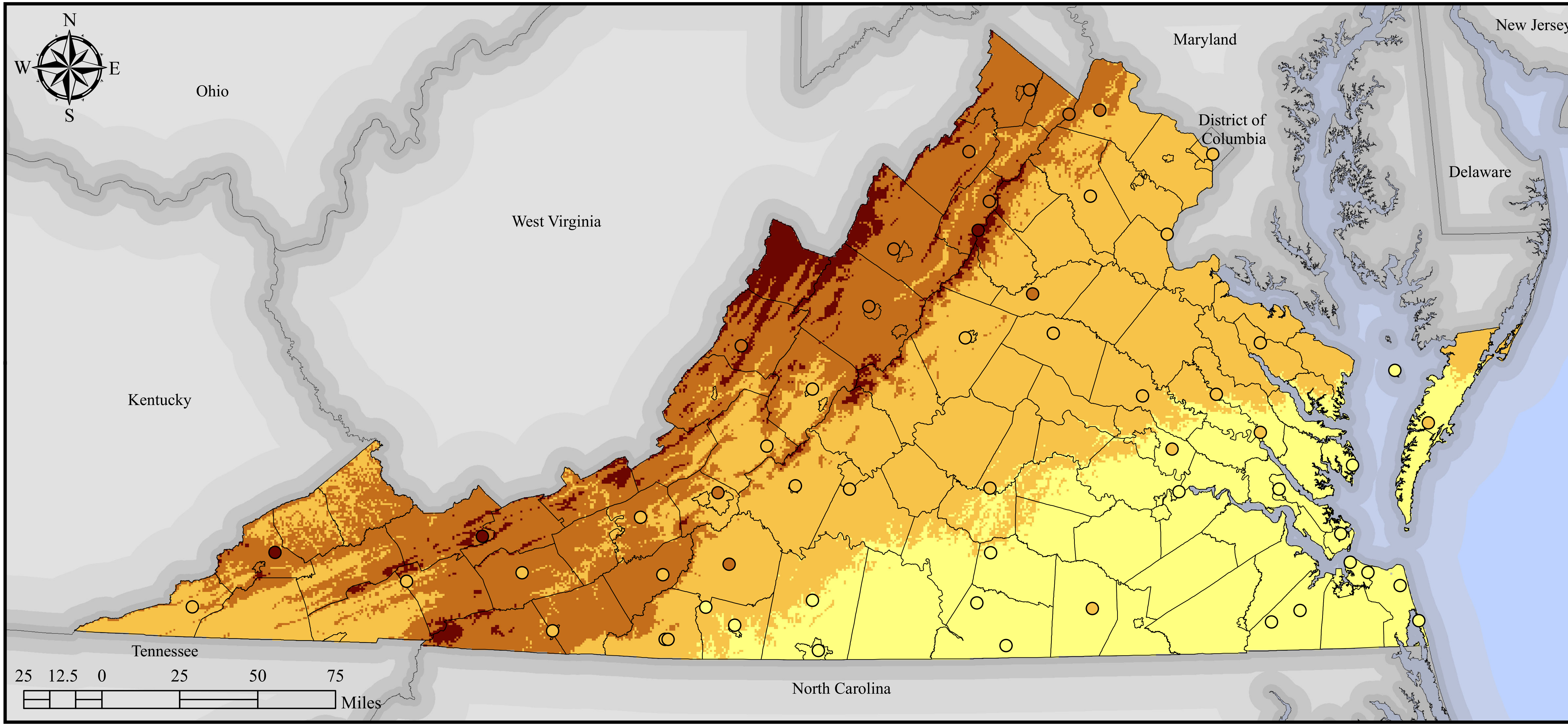
HAZARD IDENTIFICATION:

Winter weather statistics were estimated from daily NCDC weather station reports from 1960 - 2000; the values at the weather stations are symbolized with small round dots, and a statewide regression fit depicts the overall trend in the weather station statistics.

These results depict general trends, and local conditions may vary widely.

DISCLAIMER: Majority of available hazard data is intended to be used at national or regional scales. The purpose of the data sets are to give general indication of areas that may be susceptible to hazards. In order to identify potential risk in the Commonwealth available data has been used beyond the original intent.

Figure 3.9-3: Frequency of 3 or more days with at least 3 inches of snow



DATA SOURCES:

CGIT analysis of NCDC data
VGIN Jurisdictional Boundaries
ESRI State Boundaries

PROJECTION: *VA Lambert Conformal Conic*
North American Datum 1983

LEGEND:

Avg. Annual Frequency

- 0 - 0.25
- 0.251 - 0.5
- 0.51 - 0.75
- 0.751 - 1

HAZARD IDENTIFICATION:

Winter weather statistics were estimated from daily NCDC weather station reports from 1960 - 2000; the values at the weather stations are symbolized with small round dots, and a statewide regression fit depicts the overall trend in the weather station statistics. Average annual frequency ranges from zero to one: zero means that the condition never occurs in a year, one means that it always occurs in a year. These results depict general trends, and local conditions may vary widely.

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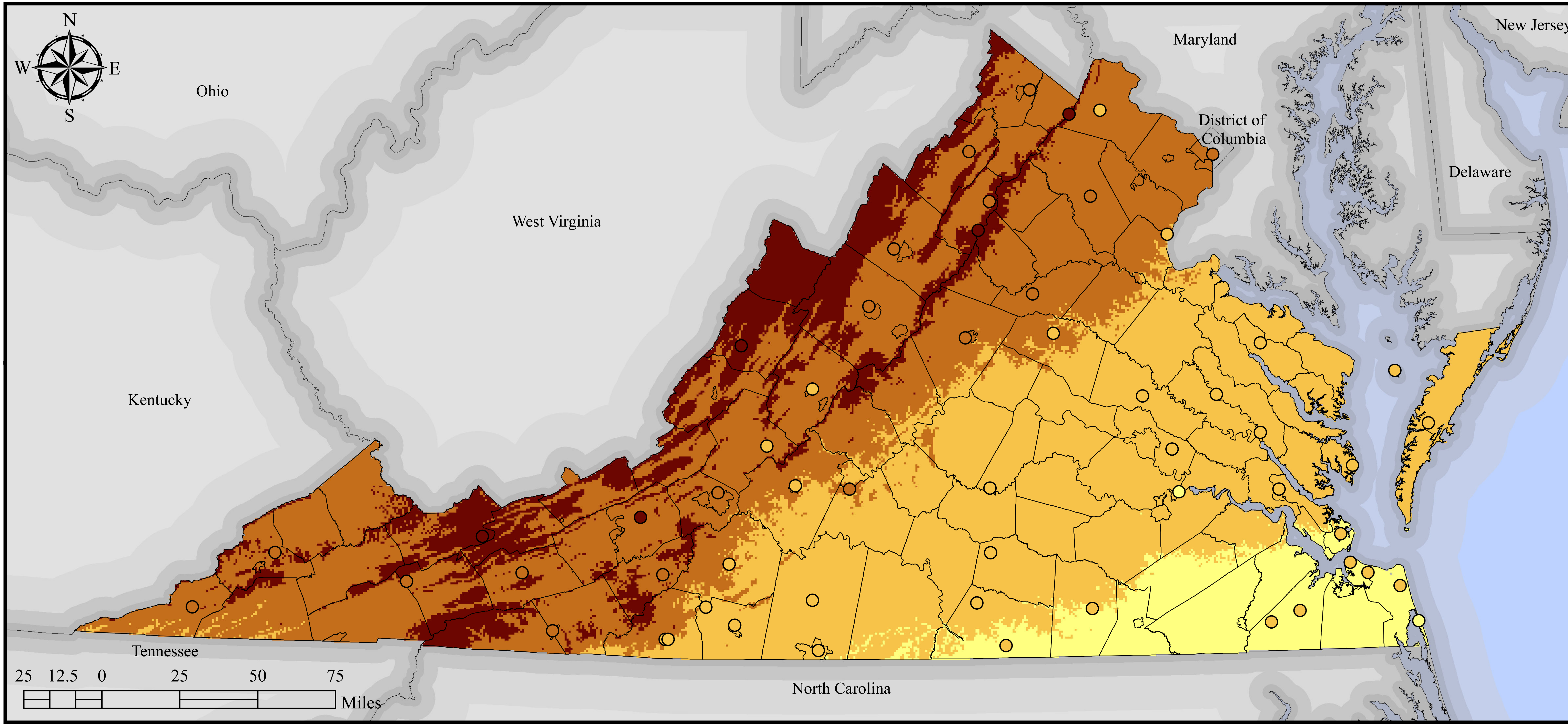
Figure 3.9-4: Average number of days entirely at or below 32 F



DATA SOURCES:

CGIT analysis of NCDC data
VGIN Jurisdictional Boundaries
ESRI State Boundaries

LEGEND:

Avg. Number of Days per Year

- 3 or lower
- 3.1 - 9
- 9.1 - 18
- 18.1 - 40

HAZARD IDENTIFICATION:

Winter weather statistics were estimated from daily NCDC weather station reports from 1960 - 2000; the values at the weather stations are symbolized with small round dots, and a statewide regression fit depicts the overall trend in the weather station statistics.

These results depict general trends, and local conditions may vary widely.

PROJECTION: *VA Lambert Conformal Conic*
North American Datum 1983

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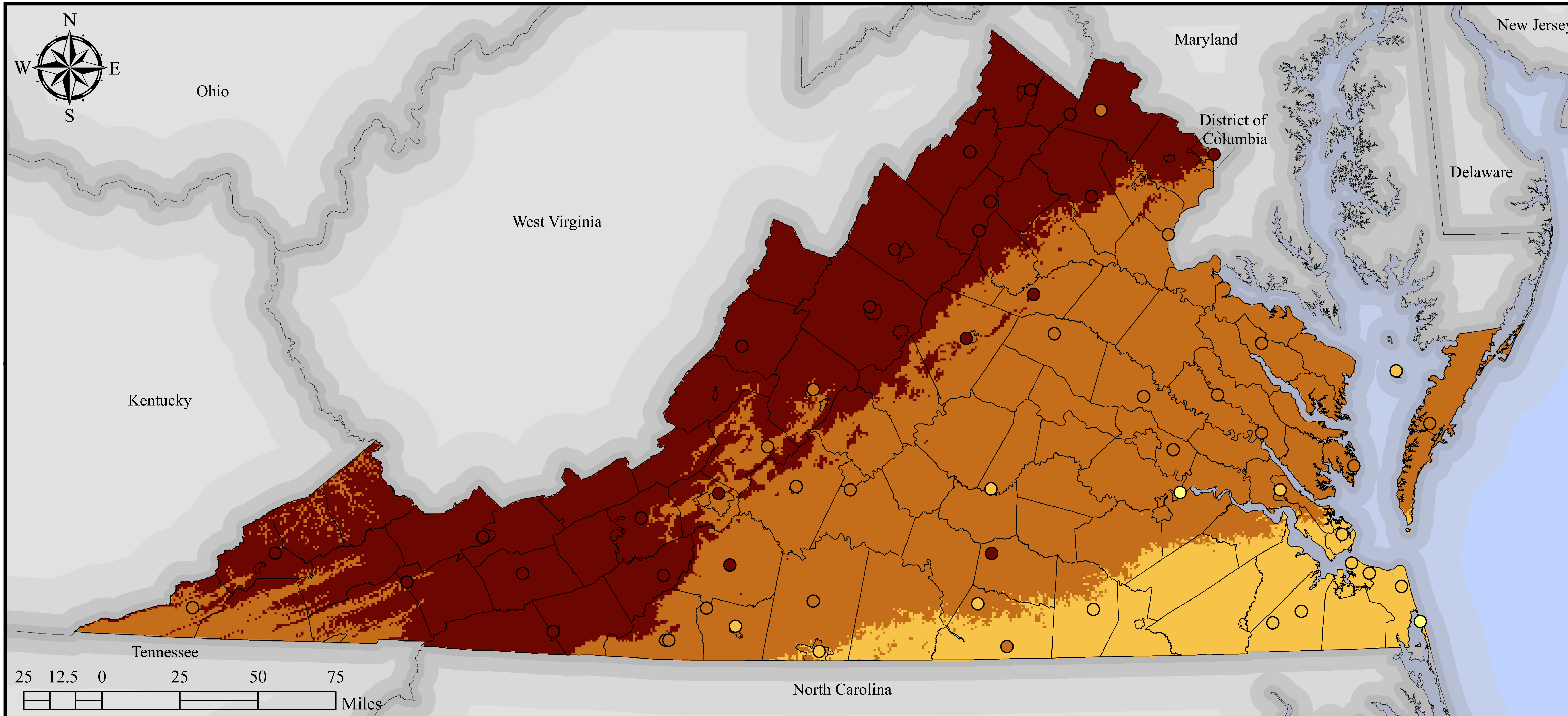
Figure 3.9-5: Frequency of 5 or more days entirely at or below 32 F



Center for Geospatial Information Technology

VIRGINIA DEPARTMENT OF EMERGENCY MANAGEMENT

PROJECTION: *VA Lambert Conformal Conic*
North American Datum 1983

DATA SOURCES:

CGIT analysis of NCDC data
VGIN Jurisdictional Boundaries
ESRI State Boundaries

LEGEND:

Avg. Annual Frequency

- 0 - 0.25
- 0.251 - 0.5
- 0.51 - 0.75
- 0.751 - 1

HAZARD IDENTIFICATION:

Winter weather statistics were estimated from daily NCDC weather station reports from 1960 - 2000; the values at the weather stations are symbolized with small round dots, and a statewide regression fit depicts the overall trend in the weather station statistics. Average annual frequency ranges from zero to one: zero means that the condition never occurs in a year, one means that it always occurs in a year. These results depict general trends, and local conditions may vary widely.

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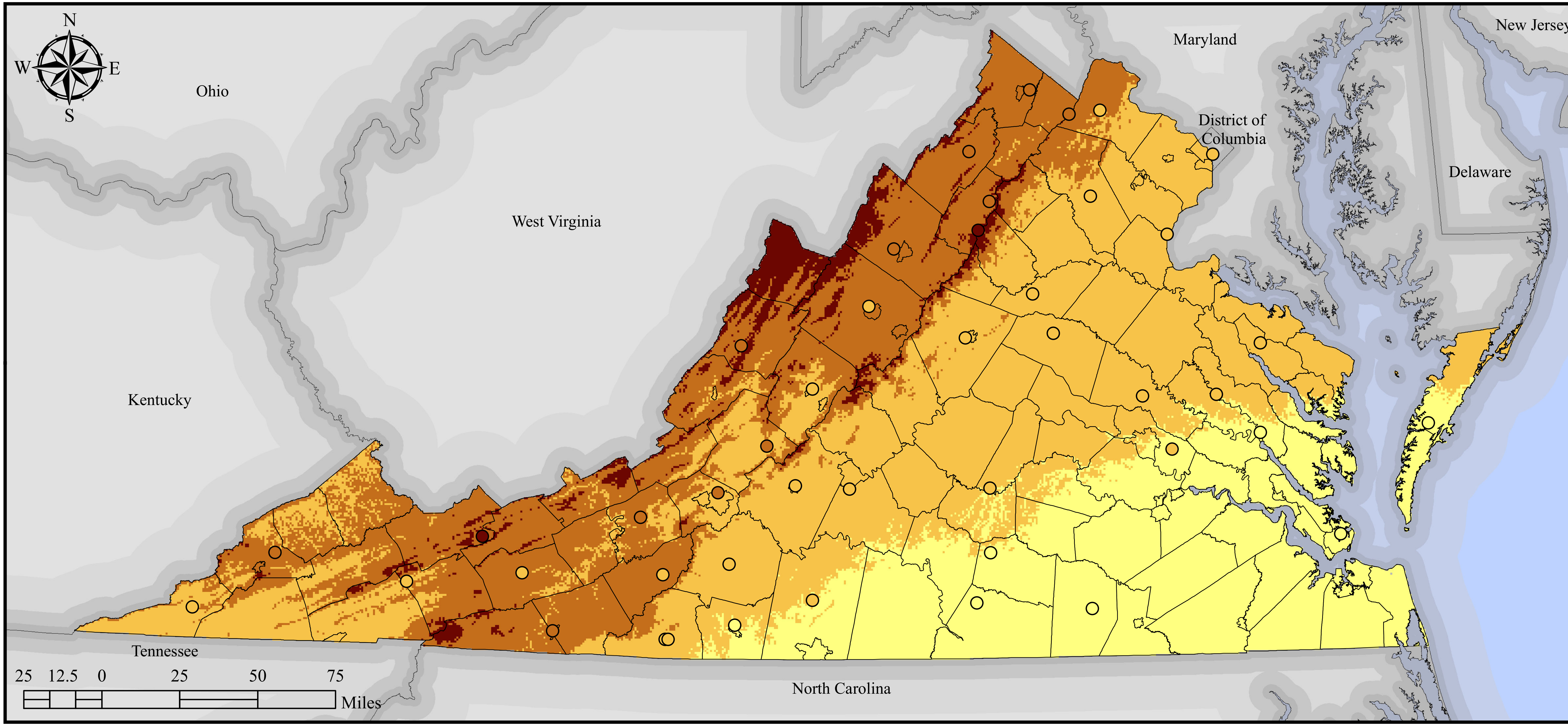
Figure 3.9-6: Average number of days with at least 6 inches of snow



Center for Geospatial Information Technology

VIRGINIA DEPARTMENT OF EMERGENCY MANAGEMENT

PROJECTION: *VA Lambert Conformal Conic*
North American Datum 1983

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DATA SOURCES:

CGIT analysis of NCDC data
VGIN Jurisdictional Boundaries
ESRI State Boundaries

LEGEND:

Avg. Number of Days per Year

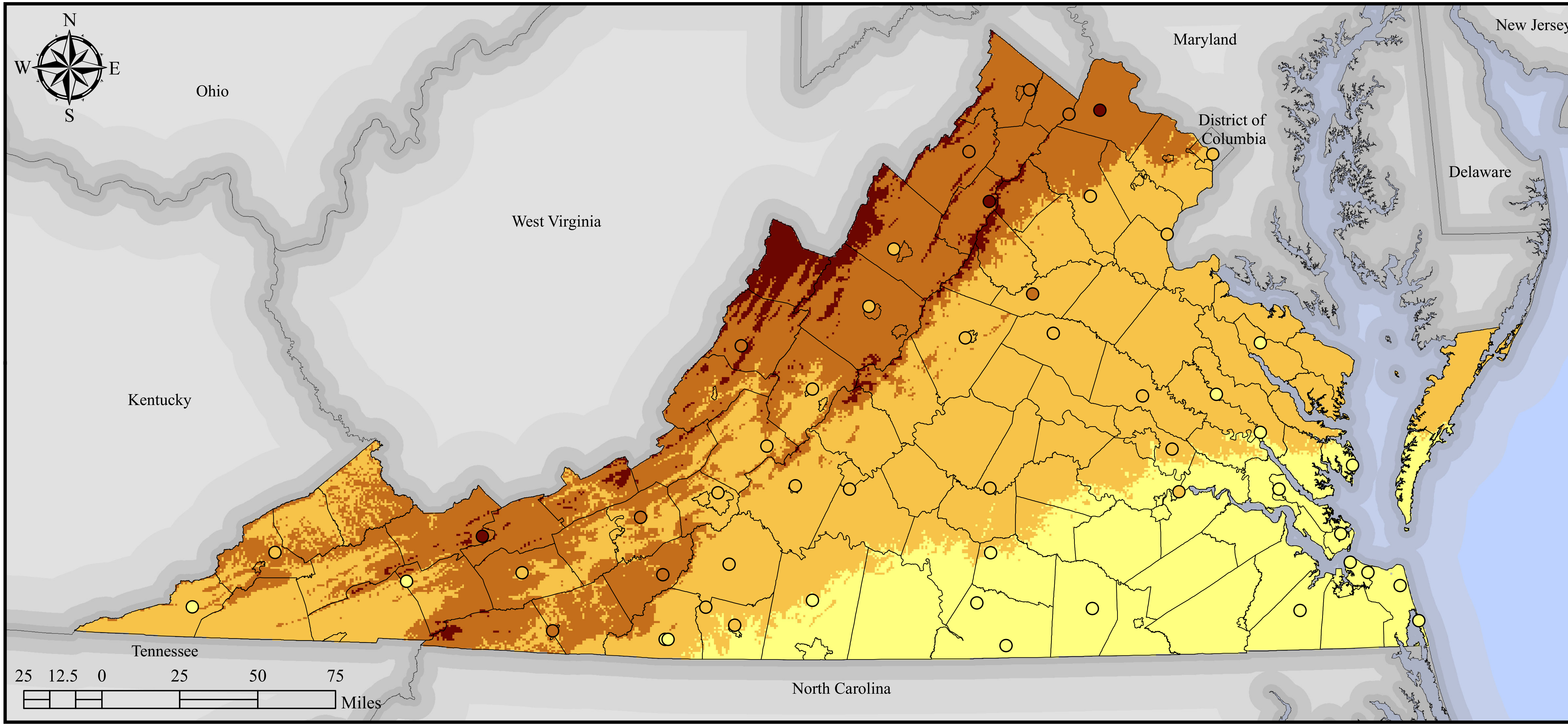
- 0.5 or lower
- 0.51 - 1.0
- 1.01 - 1.5
- 1.51 - 2.3

HAZARD IDENTIFICATION:

Winter weather statistics were estimated from daily NCDC weather station reports from 1960 - 2000; the values at the weather stations are symbolized with small round dots, and a statewide regression fit depicts the overall trend in the weather station statistics.

These results depict general trends, and local conditions may vary widely.

Figure 3.9-7: Frequency of 1 or more days with at least 12 inches of snow



Center for Geospatial Information Technology

VIRGINIA DEPARTMENT OF EMERGENCY MANAGEMENT

PROJECTION: *VA Lambert Conformal Conic*
North American Datum 1983

DISCLAIMER: Majority of available hazard data is intended to be used at national or regional scales. The purpose of the data sets are to give general indication of areas that may be susceptible to hazards. In order to identify potential risk in the Commonwealth available data has been used beyond the original intent.

DATA SOURCES:

CGIT analysis of NCDC data
VGIN Jurisdictional Boundaries
ESRI State Boundaries

LEGEND:

Avg. Annual Frequency

- 0 - 0.05
- 0.051 - 0.15
- 0.151 - 0.25
- 0.251 - 0.4

HAZARD IDENTIFICATION:

Winter weather statistics were estimated from daily NCDC weather station reports from 1960 - 2000; the values at the weather stations are symbolized with small round dots, and a statewide regression fit depicts the overall trend in the weather station statistics. Average annual frequency ranges from zero to one: zero means that the condition never occurs in a year, one means that it always occurs in a year. These results depict general trends, and local conditions may vary widely.

Impact and Vulnerability

Winter storm vulnerability is a factor of individual, property, and societal elements. At the individual level, the potential for exposure to extreme cold, falling on ice-covered walkways, and automobile accidents is heightened during winter weather events. Potential personal property damage due to winter storms includes tree damage, water pipe breakage, structural failure due to snow loads, and injury to livestock and other animals. Societal damages include disruption of utility distribution networks and transportation systems, as well as lost business and decreased productivity. The vulnerability to these individual, property, and societal damages varies based on specific factors; for example, proactive measures such as tree maintenance and utility system winterization can minimize property vulnerability. Localities experiencing winter storms on a regular basis are typically less vulnerable than localities that rarely experience winter weather.

The impacts of winter storms are primarily measured in terms of the financial cost associated with managing and recovering from them. The relationship between winter storm event magnitude and actual financial impact is difficult to model. Factors such as event timing and human perception complicate the relationship between overall magnitude and subsequent impact. Winter storms involving ice formation or accumulation are typically much more damaging than events consisting purely of snow.

The primary source of data providing some measurement of winter storm impacts is the NCDC Storm Events database. This data only dates back to the 1990's, though, and is not always complete or consistent. A comprehensive analysis of weather station data, NCDC damages, and other relevant GIS data could possibly produce an intensity-damage relationship between winter weather occurrences and resultant damages. However, given the complexity of such an analysis, and the relatively short period of time for which NCDC has recorded winter storm damage estimates, this type of analysis has not been undertaken as part of this plan.

The Southeast Regional Climate Center released a technical paper from the University of Virginia Climatology Office in May of 1993 titled "Frequency of Weather Related Tree Damage in Virginia". This report analyzed tree damage reported in NOAA's Storm Data publication from 1959-1991, noting damages due to a variety of weather events, including severe winter weather. Among other findings, the analysis found that while more snow events occurred in western and northern jurisdictions, tree damages were reported throughout the state.[7]

The branches of government most often affected by winter storms include the Virginia Department of Transportation (VDOT), and in some cases, local public work departments. Roadway treatment operations often commence prior to the actual onset of a winter storm, and continue for as long as necessary in a prioritized manner. Theoretically, a database of historical response costs could provide some insight into winter storm impacts. However, since the public demand for roadway treatment and response is almost never fully met, such data on historical

[7] University of Virginia Climatology Office. "Frequency of Weather Related Tree Damage in the State of Virginia." Southeast Regional Climate Center Technical Paper Series, May 1993. Copy obtained from the University of Virginia Climatology Office.

roadway treatment operations in response to winter storms may be more indicative of budget constraints than of relative storm magnitude.

Risk

While the annual probability of winter weather conditions can be estimated, data on the total financial impact of these events is not complete. Risk, strictly defined as probability multiplied by impact, cannot be fully estimated for winter storm due to the lack of accepted intensity-damage models for winter storm events. Therefore, projected annualized dollar losses cannot be estimated.

However, a rough estimate of financial impact can be developed based on the NCDC Storm Events database, although such an estimate is subject to the biases and inconsistencies present in that data. In the 19 years from 1993 through 2011, NCDC reports a statewide annual average of about $3.4 million per year (all dollars expressed in inflation-adjusted 2011 dollars). However, the available historic winter storm descriptions indicate that the total societal cost of these storms is much higher, as these estimates do not include road-clearing costs, lost productivity, energy costs, etc.

The winter weather frequency data shows a strong trend toward more winter weather occurring in areas at higher latitudes and at higher elevations. The mountainous western portion of the state and the furthest northern portions of the state experience winter weather more often and with greater severity. However, all portions of the state are subject to winter weather events. While the magnitude of damages from winter storm are perhaps not typically as great as extreme flooding or a severe earthquake, winter storms occur much more frequently and usually over broader areas. In addition, storm events with relatively low intensity can nevertheless cause significant impacts, especially in areas unaccustomed to such events.

Winter weather hazard zones were developed from the snowfall frequency results. This scoring system, as shown in Table 3.9-1, is used to identify facilities "at risk", and to identify the jurisdictions exposed to the greatest winter weather hazards.

Table 3.9-1: Winter weather parameters

Winter Weather Hazard Zone	Average Annual Number of Days with at least 3 inches of snow
Low	<1.5 days
Medium-Low	1.5-2 days
Medium-High	2-3 days
High	>3

State Facility Risk

State facilities were intersected with the average annual number of days with at least three inches of snowfall layer. Annualized loss was not calculated due to the lack of established winter weather probabilities.

The total number of facilities located in the potential damage zones is summarized in Table 3.9-2. Approximately 22% of the state facilitates are located in an area with a high winter weather hazard, three or more days with more than three inches of snow.

Table 3.9-2: State Facilities at risk for Winter Weather

Winter Weather Hazard Zone	Number of State Facilities	Building Value at Risk
Low	4,174	$8,406,563,068
Medium-Low	2,338	$2,487,618,303
Medium-High	3,675	$7,276,778,974
High	2,806	$4,458,408,529
Total	**12,993**	**$22,629,368,874**

The results of this analysis indicate 2,806 buildings are in a high hazard zone for winter weather. Those 2,806 buildings can be divided between 78 different agencies in Virginia. The top five of those agencies have been listed in Table 3.9-3, by building value. The agencies listed represent approximately 28% of the buildings and 75% of total building value for the Commonwealth that is within a high hazard zone, three or more days with more than three inches of snow.

Table 3.9-3: The top five agencies in a high hazard zone

Agency	Number of Buildings in High Hazard	Building Value in High Hazard
Virginia Polytechnic Inst. and State University	459	$1,693,705,068
James Madison University	216	$1,270,740,898
UVA at Wise	47	$198,034,716
Woodrow Wilson Rehabilitation Center	36	$99,691,999
Western State Hospital	20	$92,654,952
Total	**778**	**$3,354,827,633**

Critical Facility Risk

Risk for critical facilities was determined by the same parameters used above in state facilities; these results are presented in table 3.9-4. The critical facilities lacked data for building values, so these totals could not be determined. Annualized loss was not calculated due to the lack of established winter weather probabilities.

Table 3.9-4: Critical facilities at risk for winter weather.

Winter Weather Risk	Law Enforcement	Transportation	Public Health	Emergency Response	Education	Total
Low	243	22	434	945	1,121	**2,765**
Medium-Low	81	9	77	372	239	**778**
Medium-High	172	12	365	902	1,197	**2,648**
High	166	13	199	620	484	**1,482**
Total	**662**	**56**	**1,075**	**2,839**	**3,041**	**7,673**

Winter Weather Risk to Energy Pipelines

Winter weather may impact pipelines in one of two ways. First, ground motion due to frost heave can put pressure on brittle pipelines possibly resulting in breakage. Second, snow and ice accumulations may damage the control mechanisms that support pipeline operations, or may damage regional power or telecommunication systems necessary for routine pipeline operations.

Jurisdictional Risk

The hazard ranking for winter weather is based on damages reported in the NCDC Storm Events database and a generalized geographic extent rating developed from the weather station data. Annualized crop and property damages received a low (1) ranking due to the small or infrequent amounts of damages as compared to the other hazards. These parameters in the winter weather risk assessment are illustrated in Figure 3.9-8, along with the total ranking. In general, the trends in low temperatures, snowfall, and other winter precipitation types all tend to indicate the same geographic areas experiencing more frequent winter weather. The highest winter weather risk is in western and northern Virginia, with generally decreasing risk towards the southeast.

The jurisdictions with a "high" winter weather risk include:

- Clarke County
- Augusta County
- Frederick County
- Loudoun County
- Rockingham County
- Warren County
- City of Harrisonburg
- Highland County
- Page County
- Shenandoah County
- Fauquier County
- Rappahannock County
- Greene County
- City of Waynesboro
- City of Staunton

- City of Winchester
- Washington County
- Prince William County
- Fairfax County
- City of Roanoke
- Montgomery County
- City of Alexandria
- Arlington County
- Carroll County
- Wise County
- City of Norton
- Pulaski County
- Smyth County
- City of Galax
- Tazewell County
- City of Radford
- Craig County
- Wythe County

Local Plan Risk Assessment

Local plans were reviewed for spatial data sources used, historical occurrences, hazard probabilities, vulnerability, loss estimations, and land use and development trends. When available, this information supplements the text and figures of each of the sections in this revision.

All twenty-five of the local plans assigned winter weather a hazard rank and gave a general description of winter weather and impacts for their region. Two plans discussed steep slopes and the impact of roads and infrastructure. Some plans developed relative risk hazard zones for snowfall and ice potential. Nine plans summarized NCDC data that was used to derive annualized loss values (Table 3.9-5). The annualized loss values used by the local plans are very similar to the summarized data used in the statewide ranking.

Table 3.9-5: Local plan winter weather annualized loss

PDC/Jurisdiction	Winter Weather Annualized Loss
Commonwealth RC (Virginia's Heartland)	$6,052,175
Southside Hampton Roads PDC	$1,183,529
Richmond-Crater	$512,755
Northern Virginia RC	$394,977
Lower Peninsula	$189,488
Rappahannock-Rapidan RC	$167,864
Southampton County	$31,737
West Piedmont	$22,239
City of Franklin	Negligible (< $1,000)

Comparison with Local Ranking

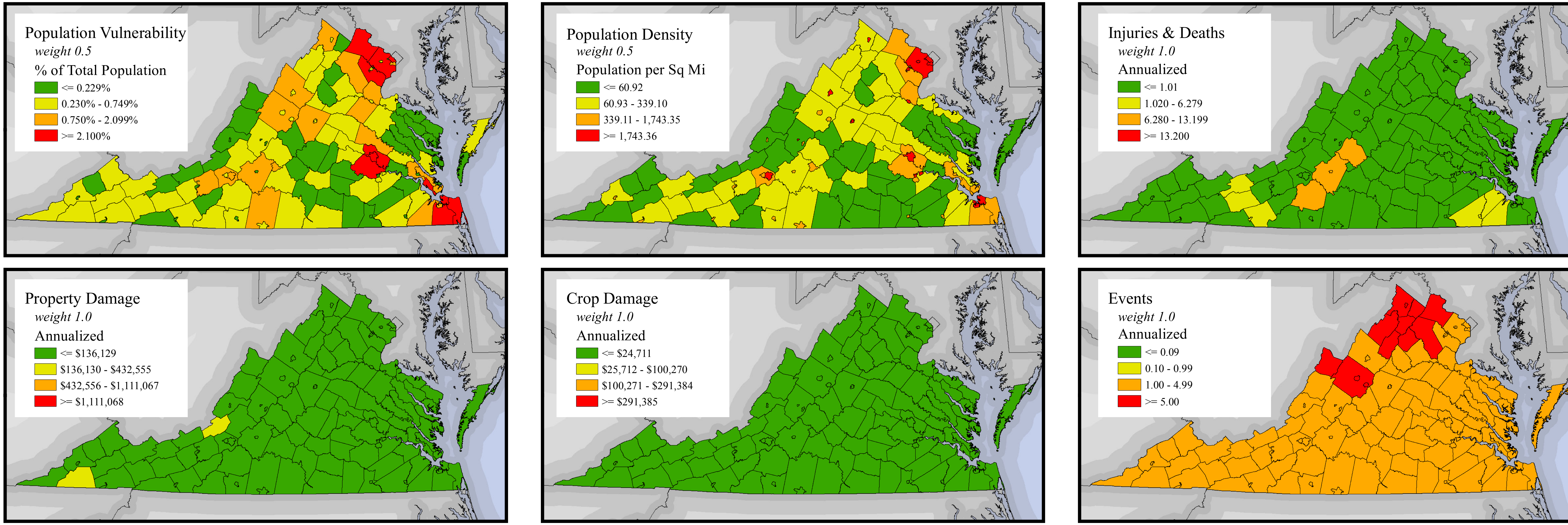
Twelve of the twenty-five regional and local plans ranked winter weather as a high hazard, two ranked as medium-high, nine ranked as medium, one as medium-low and one as low.

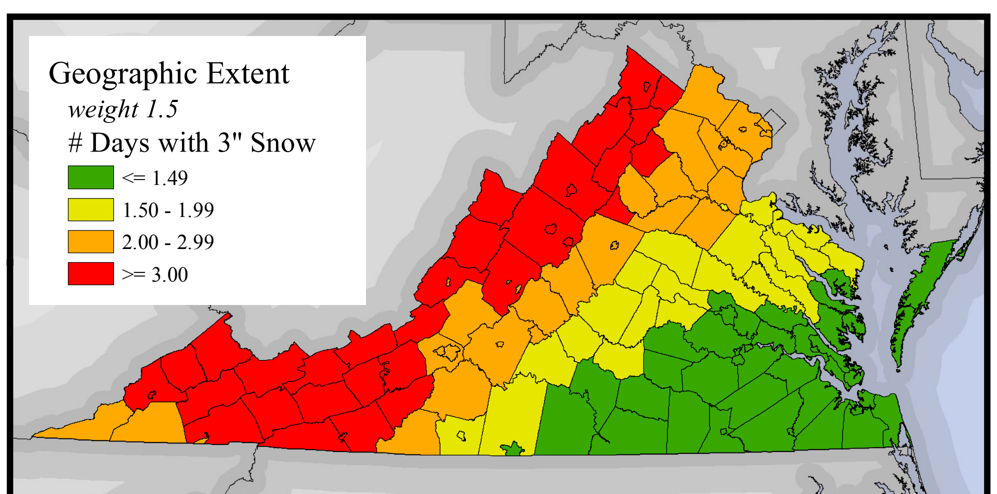
The local plan ranking average was medium-high for winter weather (section 3.6). The 2013 statewide analysis has also ranked winter storm as medium-high. Section 3.6 (Table 3.6-2) includes the complete ranking of all the local plans.

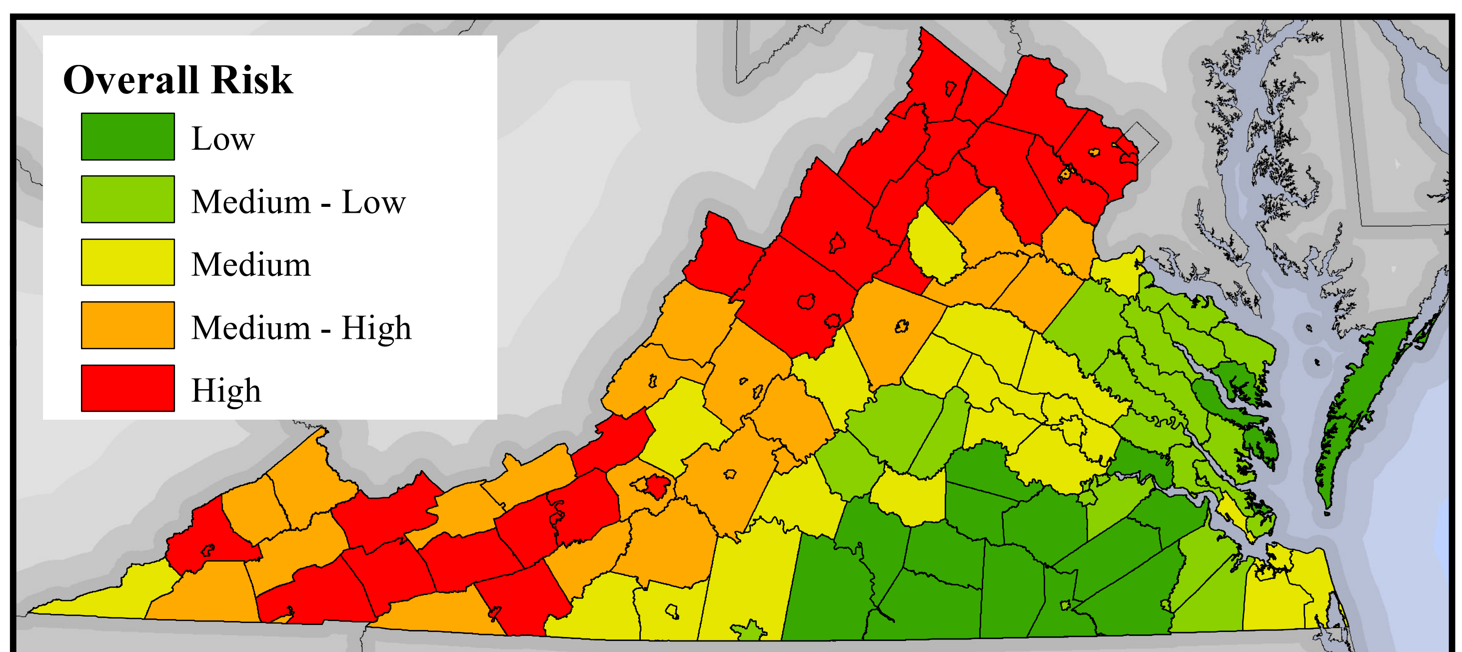
Changes in Development

The majority of local plans did not specifically address changes in development for each hazard or the effects of changes in development on loss estimates. In most cases overall development patterns were discussed in general. Sixteen of the twenty-five local plans cite their comprehensive plans for current and future land use changes (section 3.2). Although winter weather was considered high for half of the local plans no information was given to reflect changes in development in the hazard prone areas.

Figure 3.9-8: Winter Weather Hazard Ranking Parameters and Risk Map







HAZARD RANKING:

A number of factors have been considered in this risk assessment to be able to compare between jurisdictions and hazards. The factors have been added together to come up with the overall total ranking for each hazard.

Some factors were weighted based on imput from the HIRA sub-committee.

Section 3.5 explains each of the factors in detail.

Factors & Weighting Include:

- Population Vulnerability & Density 0.5 weighting
- Injuries & Deaths 1.0 weighting
- Crop & Property Damage 1.0 weighting
- Annualized Events 1.0 weighting
- Geographic Extent 1.5 weighting

DATA SOURCES:

CGIT Ranking Methodology
VGIN Jurisdictional Boundaries
ESRI State Boundaries

PROJECTION: *VA Lambert Conformal Conic*
North American Datum 1983

N W E S

DISCLAIMER: Majority of available hazard data is intended to be used at national or regional scales. The purpose of the data sets are to give general indication of areas that may be susceptible to hazards. In order to identify potential risk in the Commonwealth available data has been used beyond the original intent.

Table 3.9-6 EMAP Analysis

Subject	Detrimental Impacts
Health and Safety of Public	Localized impacts are expected to be severe for affected areas and moderate to light for less impacted areas.
Health and Safety of Response Personnel	Personnel without proper cold weather clothing and equipment could expect severe impacts, and moderate impacts for those who have proper protection.
Continuity of Operations	Unlikely to execute Continuity of Operations Plan
Property, Facilities, and Infrastructure	Downed trees and power lines cause a moderate impact, building codes significantly reduces the impact to properties and facilities.
Delivery of Services	Localized disruption of roads, facilities, communications and/or utilities caused by the event may postpone the delivery of some services.
The Environment	Damages to trees, downed trees can increase the risk for wildfires.
Economic and Financial Condition	Local economy may be impacted depending on type of event, local retailers may not be able to open for business.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery time is not sufficient

Table was modeled from the Missouri State Hazard Mitigation Plan