**4-8: Extreme Cold**

What constitutes “extreme cold” can vary across different areas of the country based on what the population is accustomed to in their respective climates. Vermont is adapted to cold conditions; however very cold temperatures remain a threat despite their commonality during Vermont winters.

Temperature fluctuations are a result of several meteorological processes[[1]](#footnote-2). Due to the tilt of Earth’s axis, regions of the globe receive varying levels of solar radiation. The delta between these levels produces circulation patterns at the global level, which drive air and storm system movement via air masses. Air masses, as defined by NOAA, are thousands of feet thick and extend across large areas of the earth. Air masses that form over tropical ocean regions will become exceptionally hot and humid, while those masses above high latitude continents will become cool and dry. When these air masses meet, a front is created; fronts can either be cold or warm. In addition to these air mass and front-related impacts humans feel at ground level, movement of narrow bands of strong wind high in the atmosphere, known as jet streams, maneuver weather systems below and transfer heat and moisture across the globe. The speed and intensity of the jet stream will affect the duration and temperature associated with a cold or warm front.

A large area of low pressure and cold air surrounding the poles, known as a polar vortex, is strengthened in the winter (Figure 44). When these polar vortex winds are distorted, due to cyclical strengthening and weakening or interaction with high-amplitude jet stream patterns, they have the potential to split into two or more patterns, allowing artic air to flow southward along a jet stream[[2]](#footnote-3). As this arctic air is able to access more southerly regions, extreme cold conditions can be observed in Vermont, which also have the potential to remain over the region for extended periods.

The NOAA Wind Chill Chart identifies those temperatures and associated wind speeds that may cause frostbite if skin is exposed to the air over a certain period of time (Figure 43).

In anticipation of extreme cold temperatures, the National Weather Service may issue the following watches, warnings or advisories[[3]](#footnote-4), which are aimed at informing the general public as well as the agricultural industry:

* **Wind Chill Warning:** Dangerously cold wind chill values are expected or occurring
* **Wind Chill Watch:** Dangerously cold wind chill values are possible
* **Wind Chill Advisory:** Seasonably cold wind chill values but not extremely cold values are expected or occurring
* **Hard Freeze Warning:** Temperatures are expected to drop below 28°F for an extended period of time, killing most types of commercial crops and residential plants
* **Freeze Warning:** Temperatures are forecasted to go below 32°F for a long period of time, killing some types of commercial crops and residential plants
* **Freeze Watch:** Potential for significant, widespread freezing temperatures within the next 24-36 hours
* **Frost Advisory:** Areas of frost are expected or occurring, posing a threat to sensitive vegetation

In the fall, both abrupt cold snaps and record warmth can be observed, where the latter tends to be associated with southerly flow. Similarly, in winter, both extreme cold and record warm conditions occur, which can affect river flow (i.e. ice jam), snow cover, ground insulation and the agricultural industry.

**Location**

Vermont is situated in the northern reaches of the continental United States, bordering Quebec, Canada. This northerly location as well as the presence of the Green Mountains can create extreme cold conditions throughout Vermont. However, extreme cold is generally located within the northern counties, namely those in the Northeast Kingdom. Conditions at the high elevations of the Green Mountains are also susceptible to extreme cold. According to the NOAA Storm Events Database, extreme cold events that impacted Vermont throughout the winter of 2022 were heavily concentrated in Northeast and Central Vermont, reinforcing the cold prone areas described[[4]](#footnote-5).

Extreme Cold History

The winter of 1933–1934 was particularly cold, and the lowest temperature ever recorded for the State (-50°F) occurred at Bloomfield on December 30, 1933. Prior to this, extreme cold temperatures were widespread on January 4 and December 18, 1835, with -40°F at Montpelier and White River, -38°F at Bradford, -30°F at Rutland and -26°F at Burlington. Following the winter of 1933–1934, more than 20% of the apple trees in Vermont were eliminated, although this figure was less than 2% for the Macintosh variety. Temperature is a very important variable in promoting apple growth. The dwarf trees introduced in the 1860s lacked the winter hardiness needed to be truly viable in Vermont. The severe winter of 1917–1918 destroyed almost all of the Baldwin and other strains. Only the Macintosh variety survived, and it remains the dominant strain grown today. In 2001, temperature fluctuations in the spring produced a different loss. Daily maximum temperatures of at least 90°F followed by minimum temperatures near 20°F accelerated the flowering of the apple blossoms, which were then killed by the low nighttime temperatures.

One of the most prolonged cold episodes lasted from January 18 to February 3, 1969. Maximum temperatures were below 0°F. Water mains and other connections froze and burst in record numbers across the State. Since then, extreme cold has been recorded in February 1993 and again on January 19, 1997. In both cases, cold dense air moving out from an Arctic high-pressure system caused temperatures to plummet. Daytime highs in 1993 were 10°F, while the minimums were -5°F. The winter of 1997 holds the record for longest streak of consecutive days below freezing, without a thaw, at 51 days.

More recently, the winter of 2015 maintained below freezing temperatures for 27 days, while the period between December 24, 2017 and January 8, 2018 (or 16 consecutive days) did not exceed 32°F.

Between the winters of 2000 and 2018, the number of recorded days per year with a daily temperature low of less than or equal to 0°F peaked during the 2015 winter at 31 days in Burlington, 44 days in Montpelier, 55 days in Island Pond and 32 days in Bennington.

NOAA storm event history for Vermont includes several extreme cold/wind chill events since 2000, none of which included any deaths, injuries, or recorded damages:

* **January 17, 2000:** A northwest wind averaging between 15-30 mph across southern Vermont, impacting Bennington and Windham Counties, with the addition of temperatures between 0°F to -10°F, produced dangerously low wind chill values of -50°F to -60°F.
* **January 25, 2007:** An arctic cold front moved across Vermont on January 24, delivering very cold temperatures of 0°F to -25°F by the following morning. A secondary cold front accounted for the combination of brisk northwest winds of 10-15 mph and temperatures -5°F to -20°F with wind chill readings of -25°F to -40°F across the State. Another arctic front pushed across the area on January 29 and brought early morning low temperatures of -10°F to -30°F.
* **March 6-9, 2007:** An arctic cold front swept across the State March 5 causing temperatures to plummet to -5°F to -20°F by dawn March 6. These frigid temperatures, accompanied by winds of 15-30 mph created dangerously cold wind chills of -20°F to -40°F. Brisk winds with temperatures around 0°F continued through the day. The winds subsided after sunset but it remained extremely cold through the morning of March 7. Arctic high pressure settled across New England March 9 with morning lows of -10°F to -34°F across Vermont.
* **January 14, 2009:** An arctic cold front moved across Vermont which delivered some of the coldest temperatures across the region in several years as temperatures dropped over 20°F within several hours, averaging 20°F to 25°F below normal values, which were already at climatological winter minimums. Nighttime minimums were -10°F to -30°F across Vermont with isolated readings colder than -40°F. These extremely cold temperatures led to numerous cold weather related problems including numerous dead vehicle batteries and broken home/business water pipes.
* **January 23, 2011:** Bitterly cold air settled into the region and temperatures plummeted to -10°F to -25°F below zero across southern Vermont in Bennington and Windham Counties. Brisk westerly winds diminished during the evening, becoming light and variable to calm after midnight, resulting in wind chill readings of -25°F to -35°F.
* **January 8, 2015:** Wind chills colder than -25°F to -40°F were observed overnight January 7, with morning lows of -15°F to -35°F across Vermont, with the coldest temperatures within the southern Green Mountains and observed wind chills in the mountains from -40°F to -70°F. These dangerously cold wind chills lead to delayed school openings of 2 hours or cancelled classes on the morning of January 8.
* **February 15, 2015:** An extremely frigid Arctic air mass pour into the region from the north, beginning during the late morning hours and a strong pressure gradient allowed for very strong winds. Northwest winds frequently gusted over 30 mph, with some gusts as high as 39 mph through the evening. Temperatures fell quickly through the day and dropped below zero for Sunday night into the morning of February 16. Some temperatures were as cold as -20°F with chill values of -20°F to -45°F, predominately in Bennington and Windham Counties. Many towns had warming shelters open and there were reports of bursts water mains and pipes due to the frigid temperatures.
* **February 13, 2016:** Behind an Arctic cold front, very cold temperatures poured into the region upon brisk northwesterly winds, reaching lows of -12°F to -28°F along with winds gusting 20 to 40 mph, wind chill values reached -25°F to -45°F in Bennington and Windham Counties.
* **December 27, 2017-January 1, 2018:** A frigid Arctic air mass poured into the region December 27 with gusty northwesterly winds. Low temperatures fell to as low as -5°F to -14°F with wind chill values as low as -37°F in Bennington and Windham Counties. Temperatures plummeted from -10°F in Windham County to -18°F Bennington County with wind chills ranging from -11°F to -31°F during the early morning hours of New Year’s day and dropping to -15°F to -35°F throughout the morning.
* **January 5-7, 2018:** A brutally cold Arctic air rushed southward into Vermont, resulting in an extended period of extremely cold conditions. The coldest wind chills occurred during the mornings of January 6 and 7, when frigid air combined with westerly winds gusting to 30 to 40 mph resulted in widespread wind chills as low as -20°F to -40°F. High temperatures on January 6 were mainly in the single digits above and below zero. Many warming shelters were opened across the Vermont as a result of the cold weather.
* **January 30-31, 2019:** An arctic cold front tracked through southern Vermont during the afternoon of the 30th, accompanied by a heavy snow squall. Frigid air poured in behind this front along with strong westerly winds. Wind chills the morning of the 31st fell to 15 to 35 degrees below zero.
* **January 28-29, 2021:** A combination of an arctic airmass and gusty winds resulted in dangerously cold wind chills across southern Vermont the night of January 28th into January 29th, 2021. Low temperatures ranged from 11 degrees below zero up to 5 degrees above zero. Wind chill values ranged from 31 degrees below zero up to 3 degrees below zero.
* **January 11-15, 2022:** An Arctic high-pressure system brought dangerously cold temperatures across Vermont, with actual air temperatures of 10 to 15 below over the course of the event. Gusts of 10 to 20 mph delivered wind chills that fell to -15 to -35 degrees over most areas.

Extreme Cold Trends

The Steering Committee considered the probability of a plausibly significant extreme cold event to be Likely, with moderate impacts to people, followed then by minor impacts to the economy, built and natural environment.

According to NOAA Climate Center[[5]](#footnote-6), annual average temperatures for the contiguous United States from 1895-2020 are increasing at a rate of 0.16°F per decade (Figure 45), an increase from 0.15°F in 2016[[6]](#footnote-7)￼. Indicating that the probability of extreme cold temperatures in Vermont is decreasing. However, while there is an overall warming trend, there may be an increase in severity of individual winter weather events in some locations. Some climate models show a weakening of the polar vortex, which can cause the artic jet stream to become “wavier” bringing cold temperatures further south than normal. While the science is still emerging, it contributes to the narrative or more weather extremes due to climate change as global climate systems are thrown out of balance[[7]](#footnote-8).

[Figure 45: Average mean temperature trends in the U.S. map, February 1895-2020 Per Decade (95% confidence interval)]

However, Vermont remains vulnerable to extreme cold temperatures and periods of prolonged cold temperatures, especially in the northeastern portion of the State. This region, colloquially referred to as the Northeast Kingdom, can see temperatures as low as -35°F. Because this area also receives the most snowfall, is the most rural region in the State, and has the oldest average resident age, it is considered to be the most vulnerable to impacts related to extreme cold temperature.

According to the Vermont Department of Health, between 2009 and 2018 there were 4 cold-related deaths (i.e. deaths caused by exposure to cold air or water temperatures), 110 inpatient hospitalizations, and 56 EMS responses[[8]](#footnote-9). The cold-related deaths figure does not take into consideration deaths by drowning following falls through ice or those deaths related to trauma experienced from slipping on ice. This number also does not consider those deaths resulting from ice-related traffic events.

Climate data confirms that since 1901, the average surface temperature across the contiguous 48 states has risen at an average rate of 0.17°F per decade. Average temperatures have risen more quickly since the late 1970s (0.32 to 0.55°F per decade since 1979). Nine of the top 10 warmest years on record for the contiguous 48 states have occurred since 1998, and 2012 and 2016 were the two warmest years on record.[[9]](#footnote-10) The most significant warming observed in New England was during the winter months.

Vulnerability

People

The effects of extreme cold weather events can have severe impacts on Vermont’s most marginalized and vulnerable communities. Those most at risk include houseless people, those living alone (especially the elderly), elderly and young populations, as well as individuals who may not be able to afford heating utilities. Each vulnerable population experience unique risks that need to be accounted for. Houseless people being exposed to the frigid conditions directly[[10]](#footnote-11). Exposure to cold temperatures can cause frostbite or hypothermia and even lead to heart attacks during physically demanding outdoor activities such as snow shoveling or winter hiking. Prolonged exposure to cold temperatures can lead to severe physical and mental damage and potentially death. Elderly and young populations can be at higher risk for cold related illnesses, both children and elderly people lose body heat faster than it can be generated, leaving them vulnerable to hypothermia. For elderly people, a body temperature of 95°F can cause many health problems, such as a heart attack, kidney problems, liver damage, or worse[[11]](#footnote-12). Since hypothermia can begin without the person knowing, due to an onset of numbness, it can pose a threat to those who live alone potentially unaware that it is too cold in their house. This goes even further for people who can’t afford to properly heat their living space, preventing the home from being properly heated due to economic reasons. Extreme cold weather is often paired with power outages in the region, as a result of stressed-out generators being overloaded or a winter storm knocking out power lines. With buildings closed up tight to prevent heat loss, the risk for carbon monoxide (CO) poisoning is increased. CO is generated by burning fuel including generators, grills, camp stoves, kerosene heaters, or other fuel-burning equipment[[12]](#footnote-13). It is highly advised that none of the above are operated indoors as well installing an operational CO detector within the house. When temperatures dip below freezing, incidents of icy conditions increase, which can lead to dangerous driving conditions and pedestrian-related slipping hazards. It is recommended that people stay indoors during extreme cold events unless absolutely necessary, and even then, to exercise caution while driving or walking on surfaces that have not been properly salted.

Built Environment

As stated before, extreme cold weather can put a lot of stress on the electrical infrastructure of a region due to increased usage and weaknesses in aging wires and facilities. The power outages that result can have a widespread impact on the health of human and economic assets that may be at risk without sufficient power or heating. While the national electric grid is often resilient enough to avoid massive outages due to plant failures, it is not impossible. For example, in February of 2021 Texas’ ERCOT electric grid failed due to extreme cold knocking gas and coal power plants offline as well as many of the few wind turbines freezing. The cut in supply could not match the increased demand due to heating, generating rolling blackouts across the state[[13]](#footnote-14). While ERCOT is separate from the National Grid, which Vermont is a part of, it demonstrates that efforts to improve the resiliency of electrical infrastructure is still important for security. Other public utilities are also exposed and at risk due to extreme cold, mainly wastewater and water infrastructure. With temperatures well below freezing, water within pipes can begin to freeze and ice expands potentially causing pipes to burst. This can occur in municipally run water systems, but it is far more common within homes with smaller pipes and stagnant water. It is advised that faucets are left dripping with cabinet and bathroom doors left open to allow warmer air to circulate[[14]](#footnote-15).

Extreme cold spells can result in the freezing of moisture within the ground and in infrastructure, which can negatively impact road infrastructure (i.e. frost heaves), water lines (i.e. burst pipes from water-ice expansion) and perennial crops that rely on the snow for protection from cold temperatures and winds. Frost heaves and potholes can result in shorter lifespans for many Vermont roadways with frost heaving having the potential to impact the foundations of buildings (typically unheated buildings such as detached garages and sheds).

Natural Environment

The impacts of extreme cold on the natural environment can be extensive, even if plants and animals in Vermont are more acclimated to cold weather. Deep freezes, especially for extended periods of time, can cause fauna and livestock to freeze to death or seek shelter in warmer areas (mainly human residencies in the instance of mice who may lack snow-cover). An increase human-wildlife interactions can pose a threat to both communities. Plant life is often dormant or cold hardy enough to weather cold temperatures, sustained extreme cold and freezes that happen before trees can prepare can cause the life-sustaining sap within a tree to freeze. Resulting in damaged or trees that have exploded from a rupture[[15]](#footnote-16). This can become an increasing problem in the future with winters that tend to fluctuate in temperature increasing the chance of a hazardous freeze-thaw cycle. Agricultural businesses can also take a toll from extreme cold, as deep freezes can injury crops with frost damage, decreasing the productivity depending on when in the growing season an event occurs.

Economy

The economic impacts of extreme cold can come from a wide variety of sources, many of which were mentioned in the previous vulnerabilities' sections. Extreme cold can prevent people from going into work for safety reasons, cause damage to the electrical grid, and impact the agricultural operations within the state. With dairy production, maple sugaring, and orcharding being main sources of Vermont food products, extreme cold can negatively impact these industries. In dairy production, cattle are generally cold tolerant and are comfortable down to 20°F. Most cows are managed outside even under extreme conditions and can benefit from extra care when effective temperature (ambient temperature and wind chill) drops below 0°F[[16]](#footnote-17). Below 0°F cattle can begin to freeze and are at risk of injury or even death. Both maple sugaring and orchards rely on trees to support their industries and as stated before in the Natural Environment section, bitterly cold temperatures can damage trees. Orchards in particular can be prone to damage due to the popular usage of Dwarfing, which have been tested to be less cold hardy than other rootstocks[[17]](#footnote-18).

|  |
| --- |
| **CLIMATE CHANGE**  Vermont is also experiencing a decline in the level of snow cover (Figure 46). During these more frequent, warmer winters, snow, which acts as a protective, insulating layer between the cold air and the ground, is less likely to accumulate and more likely to melt. A loss of snowpack can reduce the albedo, inducing a positive feedback loop of warming. As more solar radiation is absorbed by the environment rather than being reflected.  Vermont’s rivers and lakes are impacted from fluctuating periods of warmth and extreme cold. The continued freeze-melt-freeze cycle on rivers leads to increased ice accumulation, which can then be broken into large sheets of mobile ice during the next period of warming. This phenomenon is called ice jamming, which often results in flooding (see: Inundation Flooding & Fluvial Erosion).  Ice fishing is a popular winter sport in Vermont, with Lake Champlain and smaller lakes throughout the state providing ample opportunities to fish. However, warming winter temperatures have reduced the thickness of the ice as well as the time spent frozen. For example, Lake Champlain hasn’t frozen over in January since 2004 and March of 2019 was the last time the lake had completely frozen over20. These conditions threaten ice-based winter recreation such as ice fishing. In February of 2023, three fishermen fell through the on Lake Champlain and died, leading to cancelation of the ice fishing derby due to safety concerns21.  As winter conditions warm, there is a greater chance of temperatures rising and falling around the freezing point, leading to more freeze thaw events. Events like this can have major transportation impacts including more potholes and frost heaving that leads to broken and fractured roads22. Frost heaves can also impact the structural integrity of bridges and building foundations as the ground shifts, forcing parts of the foundation to move upwards while others do not23. Ice dams can also form more frequently on rooftops since daily temperature fluctuations allow snow to melt during the day and refreeze at night. After several days of this freeze-thaw cycle the melted water can work its way up through the shingles and into the attic, causing water damage and occasionally roof collapse24.  The occurrence of deep cold spells is not necessarily a negative for every species. Extreme cold is an often necessary process to prevent certain insect pest species from overwintering and developing a resistance to pesticides through increased overwintering survival, increased number of generations, increased risk of invasive insect species and insect-transmitted plant diseases, as well as changes in their interaction with host plants and natural enemies. This can have disastrous effects on agricultural operations and forest ecosystems that rely on winter as a part of their natural pest management strategy[[18]](#footnote-19). An increase in the number of insect generations afforded by overwintering can increase the potential for pesticide resistance. A decline in extreme cold spells can also increase the prevalence of insect species such as ticks that can make human interactions with nature more hazardous. Ticks with Lyme disease are typically not found in those same areas that are most prone to extreme cold, high elevation areas and northeast Vermont. As the climate warms, these areas become less exposed to extreme cold. Meaning that these areas will increasingly become suitable habitat for ticks, increasing their prevalence in the region and increasing their populations in areas that already have them[[19]](#footnote-20). Mice often act as hosts for ticks, and if conditions get warmer and the mouse population is not kept at bay. There can be an increase in the tick presence in those areas as well. However, this is also a double-edged sword as increasing temperatures decrease the available snowpack, which can put mice at risk of freezing should an extreme cold event occur. |

**Extreme Cold Current Capabilities and Mitigation**

Because extreme cold temperatures often occur in tandem with winter storms (see: Snow Storms & Ice Storms) or lead to ice jam flooding (see: Inundation & Fluvial Erosion), residents who lose power during Vermont’s coldest months need warm shelters where they can be protected from harsh conditions and reduce the potential for health-related impacts of exposure to cold temperatures, such as hypothermia or frostbite.

Several strategies in this Plan (see: Mitigation Strategy) aimed at increasing public knowledge about hazards and mitigation, supporting vulnerable populations and coordinating hazard mitigation mapping must consider extreme cold and exposure to prolonged cold weather events during implementation. In order to address the dangers of at-risk populations freezing in their homes, an action was developed to complete a review of nationwide building codes (to include residential and energy codes) to determine what codes could be best suited to Vermont, including standards for new construction and best practices for existing buildings for weatherization and retrofits and integration into existing Vermont codes. This study is to include impacts to frontline communities. Additionally, an action to evaluate methods for resilient construction standards of manufactured housing that maintain affordability for low- and moderate-income residents was prioritized in the Mitigation Strategy.

1. http://www.noaa.gov/resource-collections/weather-systems-patterns [↑](#footnote-ref-2)
2. http://climatechange.cornell.edu/what-is-a-polar-vortex/ [↑](#footnote-ref-3)
3. https://www.weather.gov/safety/cold-wind-chill-warning [↑](#footnote-ref-4)
4. https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=%28Z%29+Extreme+Cold%2FWind+Chill&beginDate\_mm=12&beginDate\_dd=01&beginDate\_yyyy=2021&endDate\_mm=12&endDate\_dd=31&endDate\_yyyy=2022&county=ALL&hailfilter=0.00&tornfilter=0&windfilter=000&sort=DT&submitbutton=Search&statefips=50%2CVERMONT [↑](#footnote-ref-5)
5. https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/national/time-series/110/tavg/ytd/12/1895-2023?base\_prd=true&begbaseyear=1901&endbaseyear=2000&trend=true&trend\_base=100&begtrendyear=1895&endtrendyear=2023 [↑](#footnote-ref-6)
6. https://www.epa.gov/climate-indicators/climate-change-indicators-high-and-low-temperatures [↑](#footnote-ref-7)
7. https://www.noaa.gov/multimedia/infographic/science-behind-polar-vortex-you-might-want-to-put-on-sweater [↑](#footnote-ref-8)
8. <https://www.healthvermont.gov/sites/default/files/documents/pdf/ENV_CH_illness-death-due-to-hot-cold-weather.pdf> [↑](#footnote-ref-9)
9. https://www.epa.gov/climate-indicators/climate-change-indicators-us-and-global-temperature [↑](#footnote-ref-10)
10. https://www.healthvermont.gov/environment/climate/winter-weather [↑](#footnote-ref-11)
11. https://www.nia.nih.gov/health/cold-weather-safety-older-adults [↑](#footnote-ref-12)
12. https://www.healthvermont.gov/environment/climate/winter-weather [↑](#footnote-ref-13)
13. https://www.dallasfed.org/research/economics/2023/0117 [↑](#footnote-ref-14)
14. https://firesafety.vermont.gov/sites/firesafety/files/documents/HOT%20TOPICS%20winter%20storm%20%20.pdf [↑](#footnote-ref-15)
15. https://www.nationalforests.org/blog/how-do-trees-survive-the-winter [↑](#footnote-ref-16)
16. https://www.extension.iastate.edu/smallfarms/caring-cows-cold#:~:text=In%20general%20cows%20are%20cold,drops%20below%200%C2%B0F. [↑](#footnote-ref-17)
17. https://waldenheightsnursery.com/soils-plants/dwarf-rootstock-mortality-in-cold-climates/ [↑](#footnote-ref-18)
18. <https://doi.org/10.3390/insects12050440> [↑](#footnote-ref-19)
19. https://www.healthvermont.gov/sites/default/files/documents/pdf/ENV\_CH\_TickborneDiseasesReport.pdf [↑](#footnote-ref-20)