4: Vermont Profile & Hazard Assessment

Vermont Profile

Vermont is located astride the Green Mountains at the center of three ranges of the Appalachians, with the Adirondacks to the west and the White Mountains to the east. Vermont encompasses 9,250 square miles of landmass.

Population Trends:

Geographically, Vermont is the sixth smallest state and the second least populated. The population of Vermont was 625,741 based on the 2010 Census and is estimated to have decreased to 623,657 in 2017, a decline of approximately 0.3%. As the maps below indicate (Figures 17 & 18), there have been relatively minor changes in population statewide since 2010. Some counties have experienced slight gains (most notably Chittenden, +3,965), and other counties have experienced decreases (most notably Rutland, -1,509).

Most Vermonters live in small, rural communities with populations of several hundred to several thousand people. The largest city is Burlington, with a population of 42,556 (2016 ACS estimate).

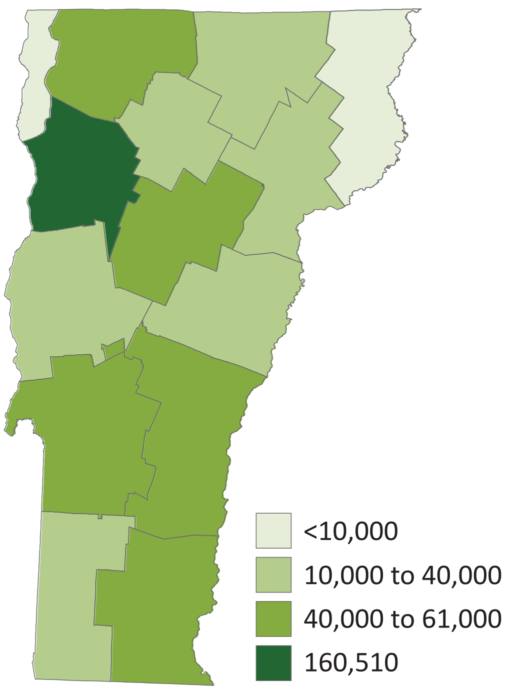

Figure 17: Vermont population by county map (2016)
Source: 2016 ACS 5-year estimates

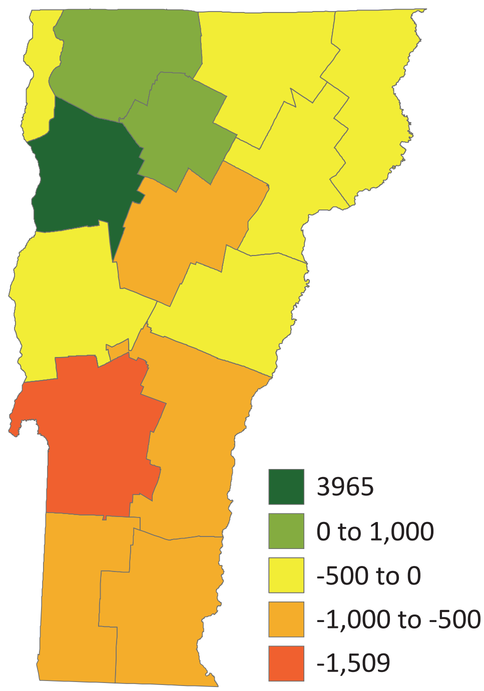

Figure 18: Vermont population change by county map (2010-2016)
Source: 2016 ACS 5-year estimates

Development Trends:

Historically, communities and infrastructure have often been sited in valleys and near water bodies, both globally and in Vermont. This development pattern was based on the assumption that rivers and coastlines would not shift or change course, which in turn relied on an assumption that climate conditions would remain relatively static. Today, with climate change models predicting increased precipitation and stronger storms in New England, many communities now find themselves and their infrastructure increasingly vulnerable to natural disasters like flooding. With the benefit of time, it is now understood that rivers and water bodies naturally adjust and change course, again threatening much of the infrastructure that lies in their path.

Between 2000 and 2010, there were no large-scale increases in either commercial or residential development in Vermont, with a total net increase of 28,157 housing units statewide. From 2010-2016, there has only been an estimated increase of 4,273 housing units (2016 ACS estimate) (Figure 20). Though this updated figure represents a shorter period of time for development, this trend, combined with population trends, suggests that the rate of new housing development in Vermont is declining.

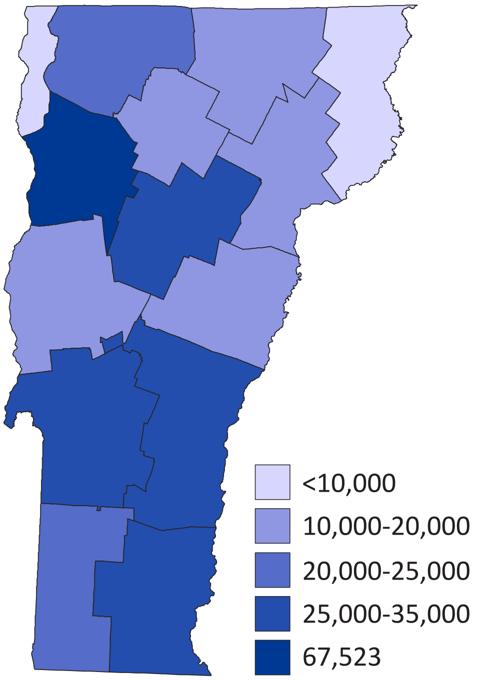

Figure 19: Housing units by county map (2016)
Source: 2016 ACS 5-year estimates

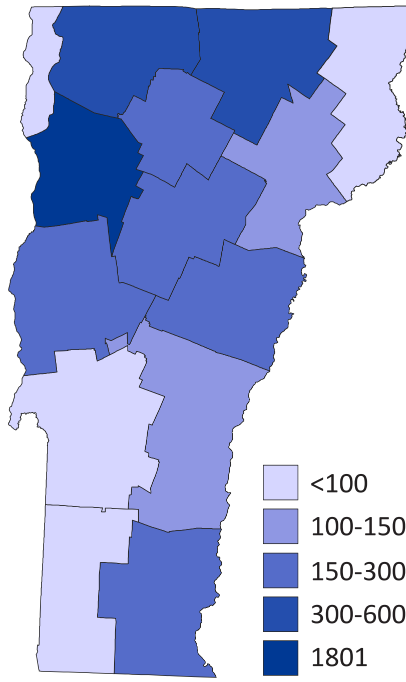

Figure 20: Housing unit change by county map (2010-2016)
Source: 2016 ACS 5-year estimates

A review of all Local Hazard Mitigation Plans that were approved by FEMA as of December 31, 2017 shows that the vast majority of communities report very little development, if any, since the 2013 State Hazard Mitigation Plan and that vulnerability has remained the same and is not projected to change. To get a better understanding of local development, VEM staff asked Regional Planning Commissions (RPCs) to note significant changes in development trends within their regions over the past five years and their impact on vulnerability, included in Table 12 below. Regions reporting no significant changes in development are not included.

In addition to the feedback from RPCs, several communities were added to Table 12 below based on the review of currently approved LHMPs (for more information on this review process, see: State & Local Capabilities). Predominately, LHMPs report that little, if any, development has taken place since their previous Plan and that vulnerability has remained the same and is not projected to change.

Table 12: Changes in Development by Region

Region	Munipality	Changes in Development & Vulnerability
ACRPC	Middlebury	Mitigation project in East Middlebury creates a false sense of security. Development of athletic fields in the floodplain increased flood depths downtown.
BCRC	Bennington	Putnam Block hotel project will increase development downtown in the floodplain, though the project will include flood-proofing of new and existing buildings and is supporting a downtown.
CCRPC	Montpelier	Several developments are planned in the City of Montpelier within the floodplain, including a hotel and a distillery. All new development will be required to follow Montpelier's NFIP standards.
CCRPC	Jeffersonville Village	Vulnerable has been reduced due to FEMA-funded projects, including the Greenway Trail Bridge replacement project and floodplain restoration, and drainage improvements downtown that are currently underway.
CCRPC	Grand Isle	There has been a decline in agricultural use of land, a small amount of additional residential development along existing roadways and the shoreline, and some commercial development along Route 2. This development has not occurred in hazard-prone areas.

Continued on pg. 41

Region	Munipality	Changes in Development & Vulnerability
CVRPC	Barre City, Northfield, Middlesex	Home buyout projects have restored the floodplain to reduce and eliminate risk from flooding.
CVRPC	Plainfield	Home buyouts at risk from landslide and fluvial erosion have eliminated risk for specific properties.
NVDA	Concord, Maidstone, Westmore, Barnet	Conversion of seasonal homes to year-round use causes more use of old septic systems close to lakes – creating potential for contamination to surface waters. Roads that used to only be used seasonally are now used year-round.
RRPC	Brandon	Box culvert was built to allow the Neshobe River to pass through downtown during heavy flows and reduce vulnerability in town.
TRORC	Woodstock	Major infrastructure was rebuilt in floodplain after Irene; the village area is highly vulnerable to inundation and fluvial erosion.
WRC	Brattleboro	While no significant development has happened in Brattleboro according to their most recent LHMP, a pending Pre-Disaster Mitigation project for property buyouts and floodplain restoration on the Whetstone Brook will lower flood levels in Brattleboro.
WRC	Dover	Changes are expected due to Mount Snow Resort development, possibly including changes to flood patterns due to snowmaking water in a different watershed.
WRC	South Newfane	Home sales are lagging, due perhaps to flooding issues; the town may begin to depopulate.

The only significant development within State-owned buildings since 2013 was the Waterbury State Office Complex, which was awarded LEED Platinum designation in December of 2017. The complex was significantly damaged during Tropical Storm Irene in 2011 and was redeveloped to accommodate future flood predictions. The buildings now lie above the 0.2% annual flood level and incorporate dry flood-proofing to provide further protection from future flooding.

Transportation:

Vermont owns approximately 3,100 miles of State highway and there are 772 miles of federal highway within the State (Figure 21). Transportation systems that run north to south within the State are I-89 (northwestward from White River Junction to the Canadian border, serving both Montpelier and Burlington), I-91 (northward from the Massachusetts border to the Canadian border, connecting Brattleboro, White River Junction, St. Johnsbury, and Newport), and I-93 (northern terminus at I-91 in St. Johnsbury, connecting the northern part of Vermont with New Hampshire).

Other significant routes include U.S. Route 5 (running south to north along the eastern border of Vermont, parallel to I-91 for its entire length in the State), U.S. Route 7 (running south to north, along the western border of the State, connecting Burlington, Middlebury, Rutland, and Bennington) and Vermont Route 100 (running south to north almost directly through the center of the State, providing a route along the full length of the Green Mountains).

East-west routes include U.S. Route 2 (crossing northern Vermont from west to east, and connecting the population centers of Burlington, Montpelier, and St. Johnsbury), U.S. Route 4 (crossing south-central Vermont from west to east, from the New York border in the Town of Fair Haven, through the City of Rutland, and across to Killington and White River Junction), U.S. Route 302 (traveling east from Montpelier and Barre, into New Hampshire and Maine), Vermont Route 9 (running across the southern part of the State from Bennington to Brattleboro), and Vermont Route 105 (crossing the northernmost parts of Vermont and connecting the cities of St. Albans and Newport).

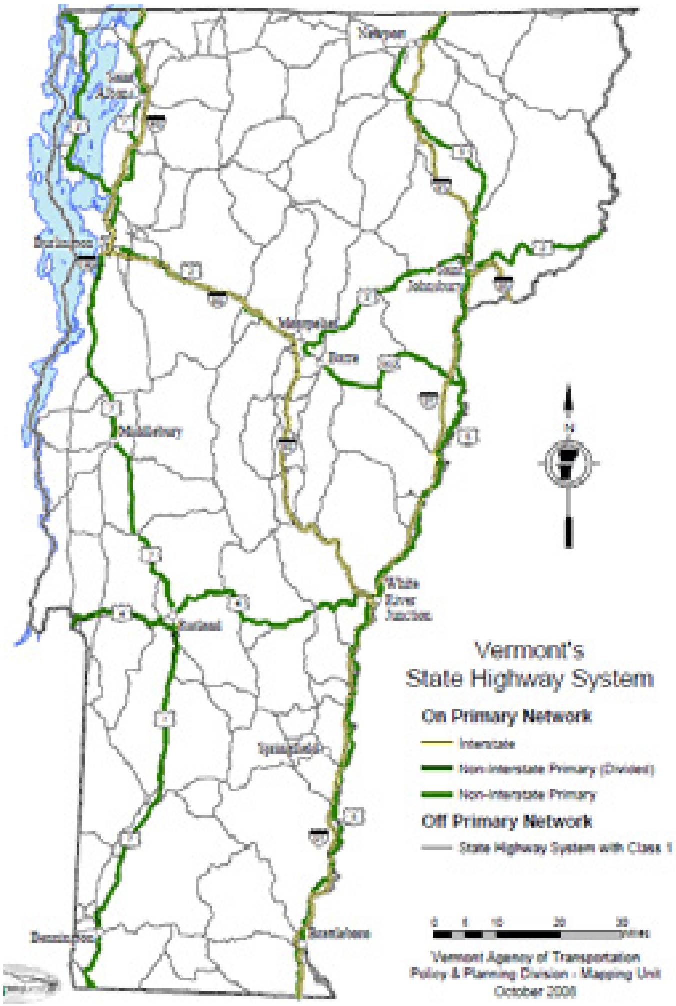

Figure 21: Vermont's state highway system map
Source: Vermont Agency of Transportation

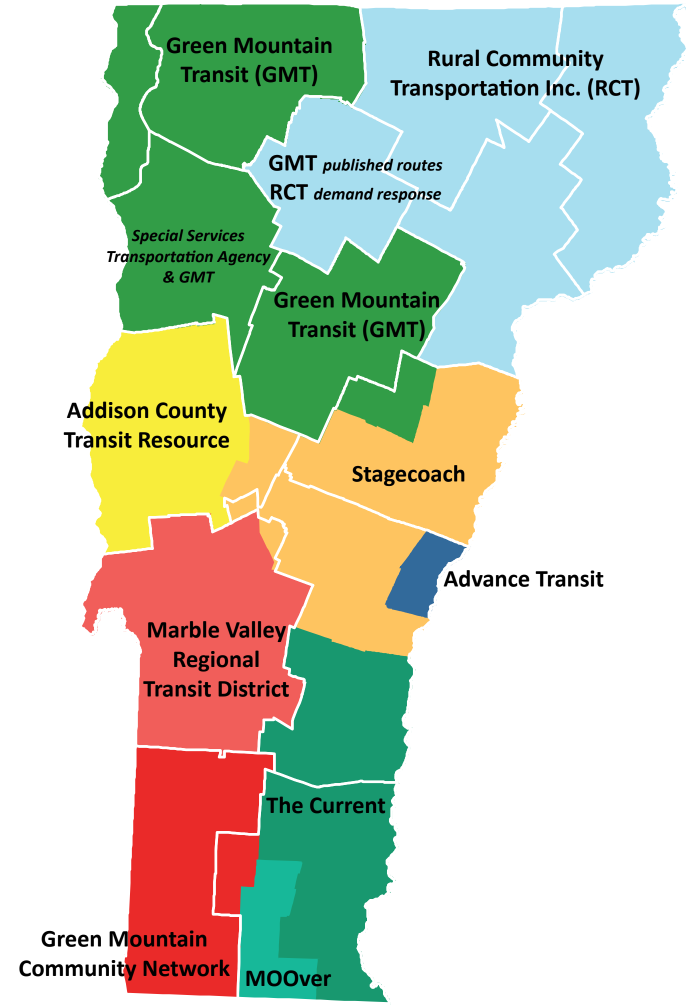

Figure 22: Vermont public transportation service areas map
Data Source: Vermont Public Transportation Association

A VTrans survey conducted in 2016 found that the vast majority of Vermonters (91%) travel in a personal vehicle frequently, with 88% commuting to work in a personal vehicle or carpool. The next largest transportation category was walking, with 45% of respondents walking as a means of transport multiple times per week or month[1]. Fourteen percent reported biking frequently, while 8% noted frequent use of public transportation.

Vermont is served by the Burlington International Airport (BTV). Vermont has eleven different bus companies (Figure 22), two ferry companies and three rail service lines throughout the State. The State of Vermont also has a program called Go Vermont[2], which is a resource for travelers who want to reduce the cost and environmental impact of driving. It provides information on bus routes, biking, or walking and features a free carpool/vanpool matching service and ridesharing tips. The State is served by Amtrak's Vermonter and Ethan Allen Express passenger lines, the New England Central Railroad, the Vermont Railway, and the Green Mountain Railroad. The Ethan Allen Express serves Rutland and Castleton, while the Vermonter serves Saint Albans, Essex Junction, Waterbury, Montpelier, Randolph, White River Junction, Windsor, Bellows Falls, and Brattleboro, with a planned extension to Canada.

1 http://vtrans.vermont.gov/sites/aot/files/planning/documents/planning/Existing%20Conditions%20%20Future%20Trends%206-7-17.pdf
2 https://www.connectingcommuters.org/

Vulnerable Populations:

Natural hazards can affect everyone in Vermont, but some populations may be more vulnerable to certain types of events or more significantly impacted during events. The Social Vulnerability Index (SVI)[3] defines overall vulnerability by summarizing four themes: socioeconomic status, household composition and disability, minority status and language, and housing and transportation. Figure 23 depicts this overall score by census block, broken into four relative categories of overall vulnerability.

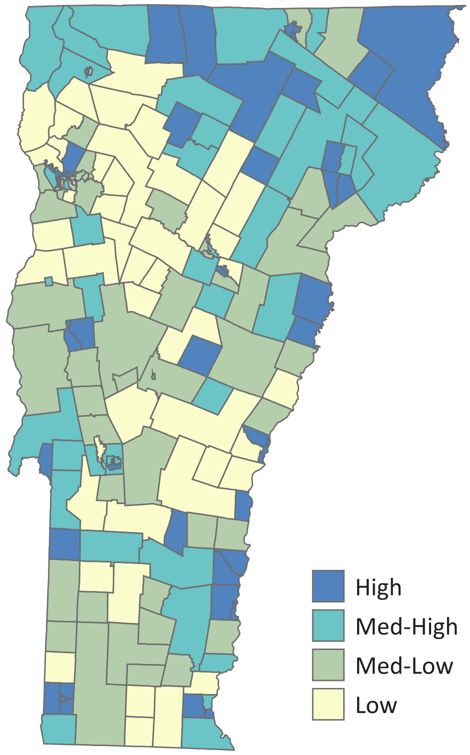

Figure 23: Social Vulnerability Index map (2016)
Source: https://svi.cdc.gov/map.aspx

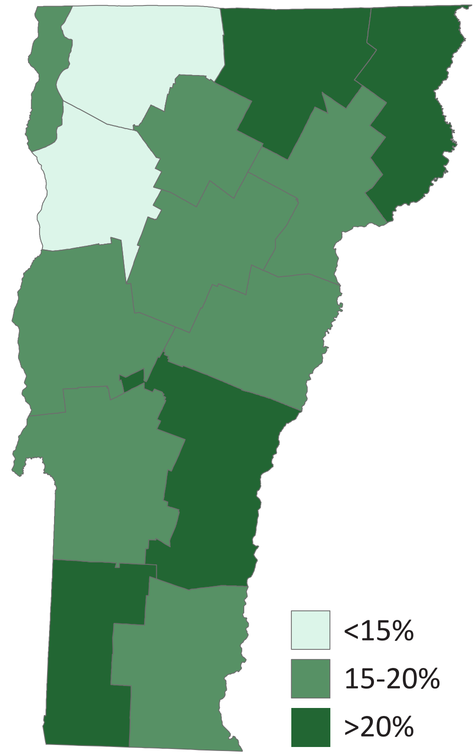

Figure 24: Vermont population over 65 map (2016)
Source: 2016 ACS 5-year estimates

Vermonters over the age of 65 is a specific demographic that is potentially more vulnerable to certain events, such as extreme heat. In 2016, 17% of Vermont was over the age of 65 based on estimates from the U.S. Census, above the national average of 14.5%. Figure 24 the percent population over 65 by county, with the most significant population in Essex County (23%, 1,408 people).

Vulnerability can also be economic. Vermont's median household income was estimated at $56,104 in 2016, slightly above the national average of $55,322. To better account for cost of living in Vermont, Vermont's Joint Fiscal Office develops a report biennially that determines a livable hourly wage for Vermonters[4]. This analysis estimates how much an individual would need to make, at a minimum, in order to live in Vermont based on a variety of family configurations and assuming employer-sponsored healthcare. The overall livable wage rate in 2016 was defined as $27,102 in individual income for a full-time worker in a two-person household without children. That equates to a household income of $54,205, which is just below the median household income for Vermont. The below table includes the various household types considered in the report and their corresponding livable wage figures.

Table 13: 2016 Basic Needs Budget Wages, Per Earner – Vermont's Basic Needs Budget

Family Type	Urban Annual Salary	Rural Annual Salary	Urban Household Salary	Rural Household Salary
Single Person	$36,691.20	$32,780.80	$36,691.20	$32,780.80
Single Person, Shared Housing	$30,076.80	$26,998.40	$60,153.60	$52,996.80
Single Parent, One Child	$61,360.00	$52,228.80	$61,360.00	$52,228.80
Single Parent, Two Children	$79,372.80	$67,641.60	$79,372.80	$67,641.60
Two Adults, No Children	$28,163.20	$26,020.80	$56,326,40	$52,041.60
Two Adults, Two Children (one wage erner)	$67,870.40	$63,793.60	$67,870.40	$63,793.60
Two Adults, Two Children (two wage erners)	$45,697.60	$42,328.00	$91,395.20	$84,656.00

Source: http://www.leg.state.vt.us/jfo/reports/2017%20BNB%20Report%20Revision_Feb_1.pdf

3 https://svi.cdc.gov/map.aspx
4 http://www.leg.state.vt.us/jfo/reports/2017%20BNB%20Report%20Revision_Feb_1.pdf

Climate Change

Over the past several decades, there has been a marked increase in the frequency and severity of weather-related disasters, both globally and nationally. Most notably, the Earth has experienced a 1°F rise in temperature, which has far-reaching impacts on weather patterns and ecosystems. This statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer), is known as climate change[5].

The Intergovernmental Panel on Climate Change (IPCC) forecasts a temperature rise of 2.5°F to 10°F over the next century, which will affect different regions in various ways over time. Impacts will also directly relate to the ability of different societal and environmental systems to mitigate or adapt to change[6]. Increasing temperatures are forecasted to have significant impacts on weather-related disasters, which will also increase risk to life, economy and quality of life, critical infrastructure and natural ecosystems. The IPCC notes that the range of published evidence indicates that the costs associated with net damages of climate change are likely to be significant and will increase over time. It is therefore imperative that recognition of a changing climate be incorporated into all planning processes when preparing for and responding to weather-related emergencies and disasters.

Most of the natural hazards identified below are likely to be exacerbated by changes in climate, either directly or indirectly. This section begins to review changes in our global and regional climate, which are further addressed in the hazard profiles, including:

- **Precipitation:** Inundation Flooding & Fluvial Erosion; Drought; Wildfire; Landslides; Snow Storm & Ice Storm
- **Temperature:** Extreme Cold; Extreme Heat; Drought; Wildfire; Invasive Species; Infectious Disease; Snow Storm & Ice Storm
- **Snow Cover:** Snow Storm & Ice Storm; Drought; Wildfire

The National Aeronautics & Space Administration (NASA) reports that global climate change has already had observable effects on the environment: glaciers are shrinking, sea ice is disappearing, sea level rise is accelerating, heat waves are occurring more frequently and intensely, river and lake ice is breaking up earlier, plant and animal ranges have shifted, and trees are flowering sooner. Though climate change is expected to have global reach, the impacts differ by region. While the southwestern United States is expected to experience increased heat, wildfire, drought and insect outbreaks, the northeastern region is predicted to experience increases in heat waves, downpours and flooding. Accordingly, consideration of climate change was identified as a key guiding principle of the 2018 SHMP, addressed in each of the pertinent hazard profiles and incorporated into all relevant mitigation actions.

Vermont's Annual Maximum and Minimum Temperatures (1960-2015)

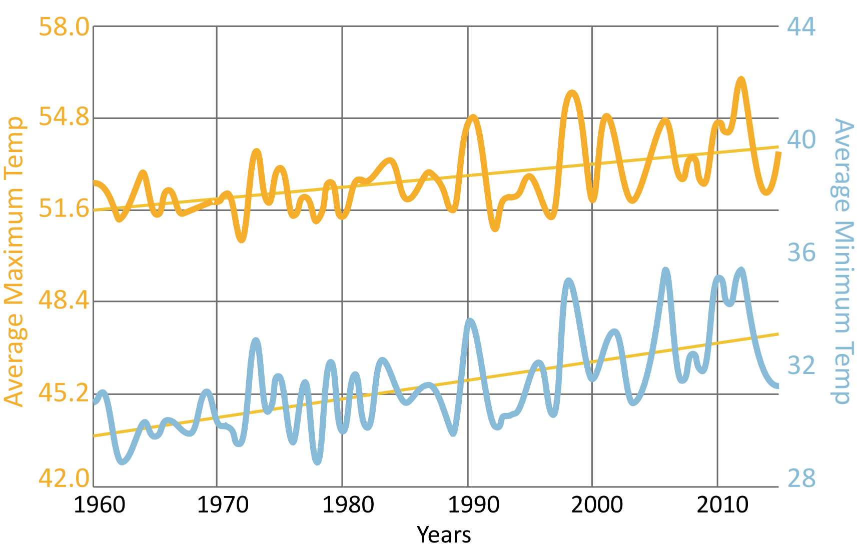

Figure 25: Vermont's annual maximum and minimum temperatures (1960-2015)
Data Source: climatechange.vermont.gov

5 http://www.ipcc.ch/
6 https://climate.nasa.gov/effects/

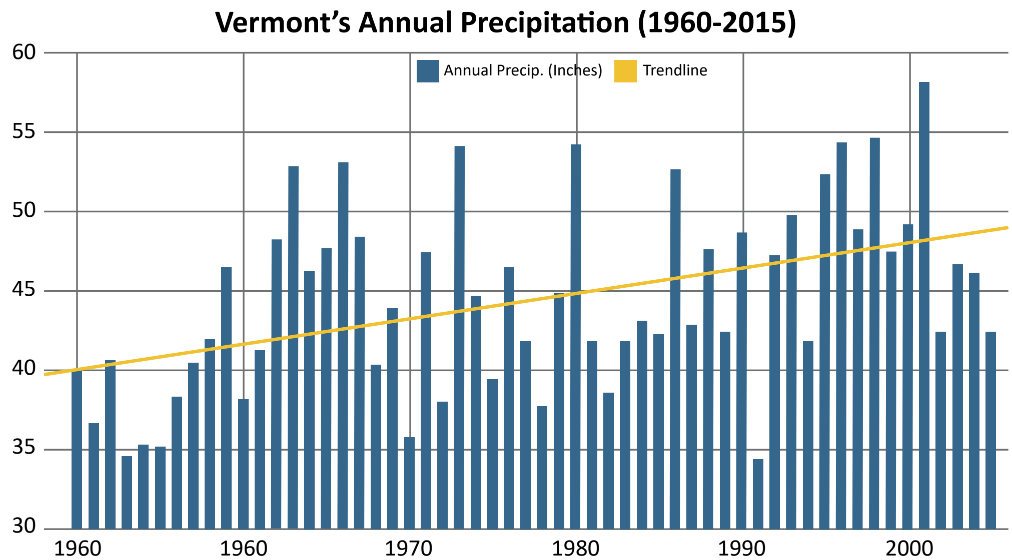

Figure 26: Vermont's annual precipitation (1960-2015)
Source: climatechange.vermont.gov

Table 14: Observed Climate Trends – Vermont's 2017 Forest Action Plan

Parameter	Trend	Projections
Temperature		
Annual Temperature	Increase	By 2050, projected increase in average annual temperature by 3.7-5.8° F; by 2100, increase by 5.0-9.5° F.
Seasonal Temperature	Increase	By 2050, projected increase in average winter temperature (December, January, February) by 4.3-6.1° F; average summer temperature (June, July, August) by 3.8-6.4° F
Hot Days > 90°F	Increase	More frequent and more intense; by the end of the century, northern cities can expect 30-60+ days with maximum daily temperatures >90° F
Cold Days < 0°F	Decrease	Reduction in days with minimum daily temperatures <0° F
Variability	Increase	Greater variability (more ups and downs)
Hydrology		
Annual Precipitation	Increase	By the end of the century, projected total increase of 10% (about 4" per year)
Season Precipitation	Variable	More winter rain, less snow; by 2050, winter precipitation could increase by 11-16% on average; little change expected in summer, but projections are highly variable
Heavy Rainfall Events	Increase	More frequent and intense
Soil Moisture	Decrease	Reduction in soil moisture and increase in evaporation rates in the summer
Snow	Decrease	Fewer days with snow cover (by the end of the century, could lose one-fourth to more than one-half of snow-covered days); increased snow density
Spring Flows	Earlier, Reduced Volume	Earlier snowmelt, earlier high spring flows with reduced volume; could occur ten days to >2 weeks earlier
Summer Low Flows	Increase	Extended summer low-flow periods; could increase by nearly a month under high emissions scenario
Ice Dynamics	Changing	Less ice cover and reduced ice thickness
Extreme Events		
Flood Events	Increase	More likely, particularly in winter and particularly under the high emissions scenario
Number of Short-Term Droughts	Increase	By the end of the century, under high emissions scenario, short-term droughts could occur as much as once per year in some places
Storms	Increase	More frequent and intense (ice, wind, etc.)
Fire	Increase	More likely
Phenology		
Growing Season	Increase	By the end of the century, projected to be 4-6 weeks longer
Onset of Spring	Earlier	By the end of the century, could be 1 to almost 3 weeks earlier
Onset of Fall	Later	By the end of the century, could arrive 2-3 weeks later

Source: fpr.vermont.gov/sites/fpr/files/Forest_and_Forestry/Vermont_Forests/Library/2017_VT_ForestActionPlan.pdf

Since 1960, the average annual maximum temperature in Vermont increased about 0.4°F per decade, while the average minimum temperature rose at 0.6°F per decade (Figure 25). Similarly, the average annual precipitation has risen 0.7” per decade since 1895 and 1.5” per decade since 1960[7] (Figure 26), suggesting increasing trends in both temperature and precipitation.

According to the 2014 National Climate Assessment, the average annual precipitation in the United States has increased by approximately 5%[8]. Of particular note, the Assessment also identifies the northern U.S. as being more likely to experience above average precipitation in the winter and spring, with even wetter conditions expected under a high greenhouse gas emissions scenario. In addition to higher annual precipitation in both the observed record and projected models, the northeastern United States is also projected to experience more frequent, heavier rainfall events. Since 1991, the incidence of these heavy precipitation events has been 30% above average[9].

Another climate change concern in Vermont is the potential for climate refugees. As portions of the U.S. become more arid and as sea levels continue to rise, Vermont may begin to see significant increases in population. One study on sea-level rise displacement projects over 4,000 migrants to Vermont from across the U.S., most predominately in Chittenden County. This study does not account for people moving from increasingly arid areas within the U.S. or from outside of the U.S., which may also increase net immigration. Based on the unpredictable nature and potential impact of an influx of climate refugees into the State, the Steering Committee decided to acknowledge climate refugees as a potential future hazard facing Vermont, to be reassessed during the next SHMP update.

HAZARD ASSESSMENT

A risk assessment is used to measure the potential loss of life, personal injury, economic impact, and property damage resulting from natural hazards by analyzing the vulnerability of people, the built environment, the economy and the natural environment. VEM staff used several methods to identify risks in Vermont, including the evaluation of historical data, consideration of changing climate trends, and feedback from stakeholders. This examination involved an extensive review of natural disasters in Vermont, both declared and undeclared. Man-made and technological hazards are covered extensively in the 2018 Vermont State Emergency Management Plan (SEMP), which follows a risk assessment methodology similar to that used in this Plan. Accordingly, the following sections of the risk assessment identify the natural hazards that Vermonters can expect to face over the next fifty years and beyond, and the mitigation strategies section reviews the actions underway or planned to address these hazards and risks. As noted in the 2013 SHMP, and confirmed again in this 2018 SHMP, the natural hazards not incorporated are coastal erosion, expansive soils, Karst topography, sinkholes, tsunamis and volcanoes. These hazards are considered non-significant, unlikely hazards in Vermont and therefore do not warrant extensive review and consideration in this Plan. Table 19 explains how each hazard addressed in the 2013 SHMP was considered in this Plan.

Hazard Events

One of the most significant changes from the 2013 Plan to the 2018 Plan is the way hazards are assessed. Instead of continuing to view hazards as events (e.g. hurricanes), the 2018 SHMP assesses the impacts of events (e.g. inundation flooding, fluvial erosion, and wind as impacts of a hurricane event), as it is the impacts, not the events, that can be mitigated. Table 15 represents the initial analysis of hazard events by the Steering Committee, which informed the creation of the hazard impact assessment.

7 http://climatechange.vermont.gov/our-changing-climate/dashboard/more-annual-precipitation
8 https://nca2014.globalchange.gov/report/our-changing-climate/precipitation-change
9 https://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing