Highlights

Climate change is no longer a thing of the future; it is affecting Vermont today. The Vermont Climate Assessment (**VCA**) presents information to aid preparation for these changes in Vermont's climate, highlighting opportunities that provide benefits by minimizing social, environmental and economic costs over time, while noting the potential outcomes of inaction.

Climate Change in Vermont: Historical Trends

Rising Temperatures: Average annual temperature in Vermont has increased by 1.3° F since 1960; 45% of this change is since 1990. Winters are warming twice as fast as summers. Warmer temperatures have caused later "first-fall freeze" and earlier "last-spring freeze". Over the past 40 years, the freezing period has shortened by 4 days each 10 years and the growing season has lengthened by 3.7 days every 10 years.

Increasing Precipitation: Precipitation has and will continue to increase, particularly in winter months. Since 1960, average annual precipitation has increased 5.9 inches; almost half (48%) of this change in rainfall has occurred since 1990. The greatest increases are in the mountainous regions. Heavy rainfall events are becoming more common, posing threats to development in floodplains and to water quality as the historical legacy of fertilizer use in agricultural areas supplies high levels of nutrient run-off into rivers and lakes.

Climate Change in Vermont: Projected Trends

Warming Temperatures: Vermont's temperatures are projected to rise by another 2-3.6° F by 2050 and 5-5.4° F of warming by 2100 according to computer simulation models by the IPCC based on low to high global emissions of greenhouse gases (IPCC-- Christensen et al. 2013).

Increasing Precipitation: Precipitation will continue to increase over the next century in Vermont, with the largest increases occurring in mountainous regions. In the near-term over the next 25 years, much of this precipitation will fall as snow in the winter. As temperatures continue to increase winter precipitation will shift to rainfall in the next 50 years and beyond.

Weather Extremes: The chances of record-breaking high temperature extremes will continue to increase. High nighttime temperatures are increasingly common. Warmer nighttime temperatures threaten snow and ice cover for winter recreation and will cause increased demand for cooling in winter and summer, respectively. An increase in high-energy lightning storms is projected to continue, threatening infrastructure and transportation systems.

The Jet Stream: Vermont's short-term weather is delivered by the jet stream that moves from season to season. Recent "blocking" or quasi-stationary patterns in the jet stream have led to prolonged periods of intense rainfall (e.g., June 2013), dryspells (e.g., August 2012), or intense cold (e.g., Polar Vortex 2014). Blocking patterns will be more common as they are due to loss of Artic Sea ice and will bring Vermont unseasonably high or low temperatures and/or precipitation.

Impacts of Climate Change in Vermont

Policy & Community Development: Vermonters value climate change action and generally support current legislation to reduce greenhouse gas emissions 50% by 2028 and source 90% of energy from renewable sources by 2050. Closer to home, every single county in the state of Vermont announced FEMA disaster declarations in response to flooding events in 2011. This vulnerability is exacerbated by the state's mountainous, rural geography and small communities with limitations existing in transportation routes and communication systems.

Energy: Net energy demand is expected to increase .7% annually through 2030. The increased use of air conditioning will likely outweigh the reduced energy demand for winter heating. An increase in major storm events threatens both Vermont's energy infrastructure (e.g., energy outages) and supply of fossil fuels from coastal regions. To strengthen Vermont's energy system, two things must be pursued simultaneously—the increase in use of renewable, local energy sources and gains in energy efficiency and conservation through behavioral change.

Water resources: Vermont's waters and snowpack are thawing earlier as spring temperatures arrive earlier. Annual average stream flows are increasing as precipitation increases. There is an 80% increase in the likelihood of high stream flows (and flooding) in coming decades, particularly in the winter months as snow shifts to rain or freezing rain. In contrast to other New England states, Vermont rivers have sustained flow over recent decades in summer months, however, climate projections show increased potential for short-term dry spells this century.

Forests: The lengthened growing season will increase the geographic range suitable for certain Vermont tree species like oak, hickory, and red maple, but decrease suitable range for cold-tolerant species like spruce and fir. The early growing season results in earlier bud burst and flowering periods that make certain trees more susceptible to pests and pathogens. Wetter winters and extended summer dry spells will place more stress on important species such as sugar maple and red spruce that have already experienced periods of decline.

Agriculture: An extended growing season will increase overall crop productivity and create new crop opportunities. Increasing CO_2 in the atmosphere may enhance crop growth to some extent. Conversely, these conditions can increase weed growth, disease outbreaks, and pest infestations. For Vermont livestock operations, enhanced growing conditions could increase pasture and forage productivity although this may be offset by small decreases in livestock productivity due to summer heat stress and increasing costs of production inputs (e.g., feed, energy).

Recreation and Tourism: Over the next 25 years, snowfall in mountainous areas may increase with increasing winter precipitation (a climate change "sweet spot"), bringing a positive impact on winter-related recreation and tourism. Within 30-40 years, most winter precipitation will fall as rain and result in shorter-lasting snowpack and snowfall. There are opportunities to compensate for winter losses—1) more tourists are expected as the summer season lengthens and states to the south experience increased temperatures combined with higher humidity; and 2) fall recreational and tourism opportunities will lengthen with extended warmer temperatures.