Versant Power Climate Change Vulnerability Study

Prepared by ICF

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Contents

Abbreviations and Definitions

- **CCRP –** Climate Change Resilience Plan
- **Climate change** – observable changes in climate variables and a shift in long-term weather patterns that are attributable to an increase in atmospheric greenhouse gas emissions driven by human activity
- **Climate projection** – simulation of a range of plausible climate futures based on assumed scenarios for greenhouse gas concentrations and earth system climate sensitivity
- **Climate risk** – the potential that a climate change-related event(s) will negatively impact Versant assets or operations
- **CMIP** – Coupled Model Intercomparison Project
- **Consequence** – the potential for impacts to assets to results in negative outcomes for the Versant system, staff, or customers
- **Exposure** – the degree to which assets, operations, or systems could face climate hazards based on their physical location and projected climate change (i.e. climate projections)
- **FEMA** – Federal Emergency Management Agency
- **FWI** – Fire Weather Index
- **GCM** – Global Climate Model
- **IPCC** – Intergovernmental Panel on Climate Change
- **LOCA** - Localized Constructed Analogues
- **NEX-GDDP** - NASA Earth Exchange Global Daily Downscaled Projections
- **NOAA** – National Oceanic and Atmospheric Administration
- **Potential impact** – the likelihood for negative outcomes to result from climate hazard exposures
- **Resilience** – the ability of a system to withstand damage and improve recovery from non-routine disruptions such as climate hazard impacts, in a reasonable amount of time
- **Sensitivity** – the degree to which assets could be negatively affect by climate hazard exposures
- **SSP** – Shared Socioeconomic Pathway
- **Vulnerability** – a combination of exposure, sensitivity, and criticality that represent the potential for assets, operations, or customers to be affected by climate hazard.

Executive Summary

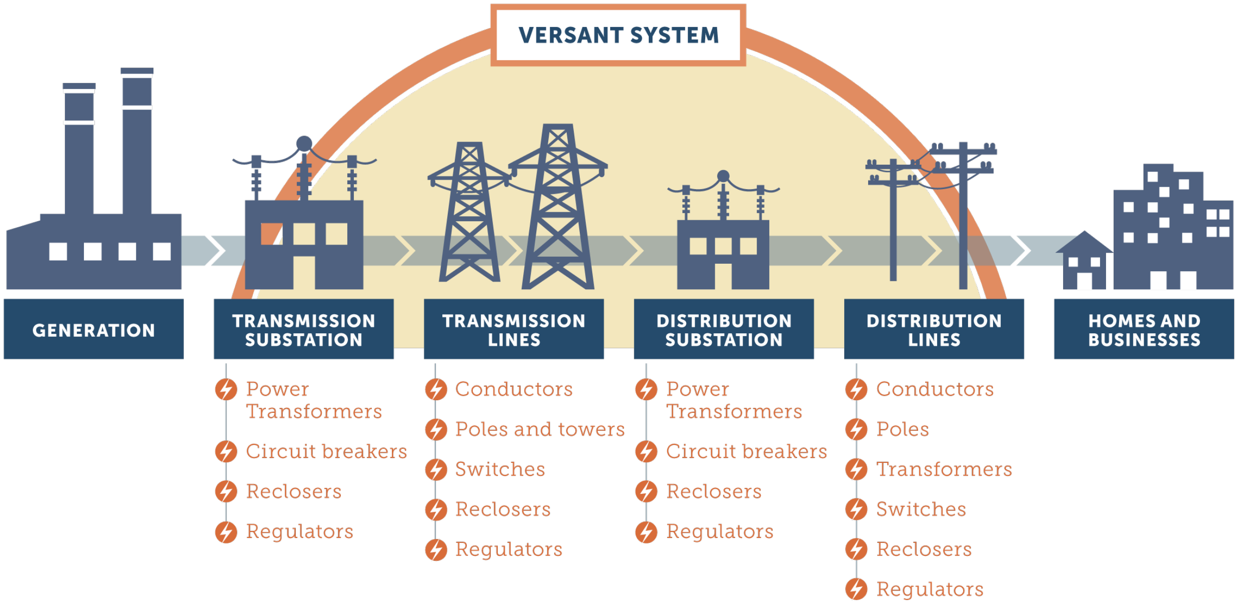
This Climate Change Vulnerability Study ("the Study") analyzes Versant Power's ("Versant") assets and operations to identify vulnerabilities to critical climate change hazards. The findings of this Study are intended to provide a granular understanding of Versant's climate vulnerabilities and serve as a foundation from which Versant can work to build climate resilience to the identified vulnerabilities in the coming decades.

Versant has already taken steps to build resilience to a changing climate. In 2018, Versant implemented a reliability improvement plan which additionally brought with it benefits to system resilience and, since then, the Company has invested more than $30 million annually in these programs that help build system resilience. Additionally, in 2023 Versant conducted and published a Climate Change Resilience Plan (CCRP) that identified several programs that can deliver significant improvements to the goal of building resilience. These programs include distribution hardening, distribution automation and enhanced vegetation management. The goal of this Climate Change Vulnerability Study is to build on Versant's ongoing resilience work by identifying specific vulnerabilities for asset-hazard combinations and proposing potential resilience measures to mitigate the impacts of identified vulnerabilities.

This Study assesses four key climate hazards: extreme heat, winter weather, wildfire, and high winds to determine Versant's observed and projected vulnerability to these hazards at the individual asset level. Additionally, the Study notes the compounding effects of multiple hazards while also recognizing the difficulty of projecting these events. These hazards were identified as the most relevant hazards to Versant's ability to deliver electricity reliably and safely and were chosen using the results of Versant's 2023 CCRP.

To identify specific climate vulnerabilities across the Versant system (Figure 1), this Study pairs exposure data with sensitivity and criticality information to quantify how specific climate hazards are projected to impact Versant as well as the severity of impact. Exposure scores were developed using locally relevant climate data projections developed for Versant and drawing on internal expertise from Versant subject matter experts. The climate hazard data was applied to the following asset types: distribution equipment, distribution transformers, distribution spans, distribution poles and structures, substation reclosers, regulators, and breakers, substation transformers, transmission poles and structures, transmission equipment, and transmission spans. Additionally, the vulnerability assessment was conducted for eight of Versant's operational processes: Vegetation Management, Environmental, Facilities, Asset Management / Transmission and Distribution System Planning, Communications Legal and Regulatory Affairs, Emergency Response, System Operations, and Workplace Safety.

Figure 1. Overview of the asset types that were assessed in this Study.



The results of this Study indicate that Versant currently has a high vulnerability to winter weather and high winds and a low vulnerability to extreme heat and wildfire. However, projections indicated increasing vulnerability to extreme heat, wildfire, and high winds across the Versant service territory. Winter weather is projected to increase in some parts of the territory and decrease in others (Table 1). Vulnerabilities across operational processes vary, but all operational processes face some vulnerability to climate change.

Table 1. Summary of observed and projected vulnerability across the Versant service territory for priority hazards.

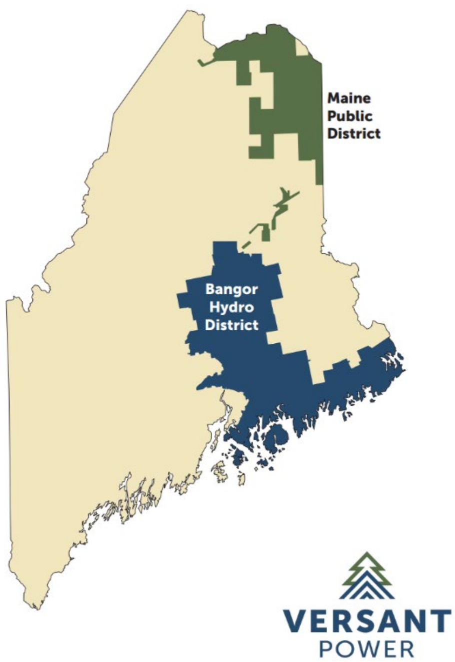
Climate Hazard	Observed Vulnerability	Future Change in Vulnerability
Extreme Heat	Low	Significant **increase** in average and maximum temperatures, causing higher energy demand and lowered capacity.
Winter Weather	High	**Increase** in frozen precipitation in northern/inland areas and **decrease** in some southern/coastal areas.
Wildfire	Low	Moderate **increase** in weather conditions conducive to wildfire, which could damage assets.
High Winds	High	Possible significant **increase** in winds associated with events such as storms. High degree of uncertainty associated with wind projections.

Building on the results of the vulnerability assessment, the Study Team identified potential resilience measures that could be used to address specific climate vulnerabilities identified in this analysis. Some of these resilience measures include implementing targeted vegetation management on highest priority lines, using different technologies to mitigate the risk of winter weather and wildfire impacting transmission equipment, installing additional cooling mechanisms to maintain substation equipment temperatures, and adopting new design standards (shorter spans, dead-ending lengths) for stronger construction of distribution equipment that may be exposed to high winds. Collectively, the list of potential resilience measures presented in this Study is intended to provide options for Versant to choose from and implement to mitigate specific climate vulnerabilities and build resilience across the Versant system.

Introduction

Climate change is not a new concept for Versant and the broader Maine community. Maine has already experienced changes in its weather and climate, and these changes are projected to continue in the coming decades. As of 2020, Maine's statewide annual temperature had increased by ~3.2° F since 1895, with greater increases in overnight low temperatures than daytime high temperatures.[1] This warming has been associated with longer summers and shorter winters, which has implications for growing season length and other seasonal cues for vegetation. Annual precipitation across the state of Maine (both snowfall and rain) has increased by 6 inches since 1895, with an unusually wet interval observed between 2005 and 2014.[2] Additionally, Maine has experienced an increase in the average number of heavy precipitation events per year, particularly in the last two decades. Storm frequency and intensity has changed across the Northern Hemisphere and in New England, there is an increasing frequency of bomb cyclones and in total storm precipitation during the fall season.[3] Furthermore, in recent years, there have been more frequent reports of climate hazard events such as heat waves, flooding, intense precipitation, warming winters, and hurricanes across the state of Maine.[4]

Figure 2. Versant Power service territory, Maine.



Climate change in Maine will continue to have far-reaching impacts on communities, ecosystems, infrastructure, and businesses. As one of Maine's energy providers, Versant is also facing the impacts of climate change. Hazards such as extreme heat, flooding, and heavy precipitation impact Versant's ability to deliver electricity to customers safely and reliably. Currently, Versant serves more than 160,000 customers across northern and eastern Maine and manages more than 1,200 miles of transmission lines and more than 6,000 miles of distribution lines.

Versant is committed to continuing to build their resilience in the face of climate change so they can provide safe and reliable service for their customers. These efforts align with broader commitments to climate resilience at the state level. For example, as of the end of 2023, the state of Maine requires transmission and distribution utilities to submit a climate change protection plan to the Maine Public Utilities Commission under Statute 3146.[5] The plan is intended to cover at least the next 10 years and include specific actions for addressing anticipated impacts of climate change to the utility. In response to this order, Versant completed a Climate Change Resilience Plan (CCRP)[i] in 2023.

[i] See the Versant Power Climate Change Resilience Plan here: https://mpuc-cms.maine.gov/CQM.Public.WebUI/Common/ViewDoc.aspx?DocRefId=%7b0040B68C-0000-C11E-BB81-2A4DDFDD0014%7d&DocExt=pdf&DocName=%7b0040B68C-0000-C11E-BB81-2A4DDFDD0014%7d.pdf

In support of building resilience, Versant engaged ICF, a climate resilience consultancy, to work closely with Versant subject matter experts (collectively, the "Study Team") on this Climate Change Vulnerability Study ("the Study"). The Study summarizes locally relevant downscaled climate projections for priority hazards across the Versant service territory. This climate information was then used to perform a vulnerability analysis to identify which of the Company's assets and operational areas are most vulnerable to specific climate hazards. The results of this vulnerability analysis were used to develop tailored resilience strategies to address specific vulnerabilities within the Versant system.

Climate Resilience in the Energy Sector

The impacts of climate change are becoming more noticeable, and adapting to and preparing for future climate change is becoming a priority across numerous sectors, including the energy sector. A global increase in energy demand as well as a societal shift away from fossil fuels is driving a greater reliance on the electric grid. Having a reliable grid system is vital to meeting growing demands and enabling the transition to cleaner forms of energy. Energy utilities are increasingly working to understand climate vulnerabilities and take steps to continue enabling safe and reliable service to customers in a changing climate. Early investments in climate resilience can offer positive return on investment over the long-term, vulnerability studies and resilience plans can lead to more efficient and cost-effective long-term planning and guide future investments in resilience.

Priority Hazards

This Study includes analysis of key climate hazards relevant to Versant's physical assets, operations, and geography. These hazards were chosen through consultation with subject matter experts, an analysis of historic climate impacts to the Versant system, and an understanding of projected climate impacts. Table 2 provides an overview of the key climate hazards explored in this Study and their relevance to the Versant system.

Table 2. Overview of key climate hazards and their relevance to Versant.

Hazard	Description and relevance to Versant
Extreme heat	Extreme heat describes changes in long-term average temperatures as well as acute extreme heat events and longer duration heat waves. Generally, the frequency and intensity of extreme heat is projected to increase due to climate change. Many utility assets are temperature-sensitive and hotter temperatures can impact asset performance and accelerate asset degradation in addition to posing risks for the health and safety of the Versant community. Additionally, heat waves can increase the use of air conditioning which, in turn, increases load and places heat-related strain on system assets.
Winter weather	Winter weather, including icing, poses a threat to a variety of assets. Ice accumulation on assets can lead to equipment malfunction or failure and lead to damage. Additionally, ice can lead to downed trees which can also damage assets and impact reliability and system function. Winter weather is projected to remain variable through mid-century, with northern portions of

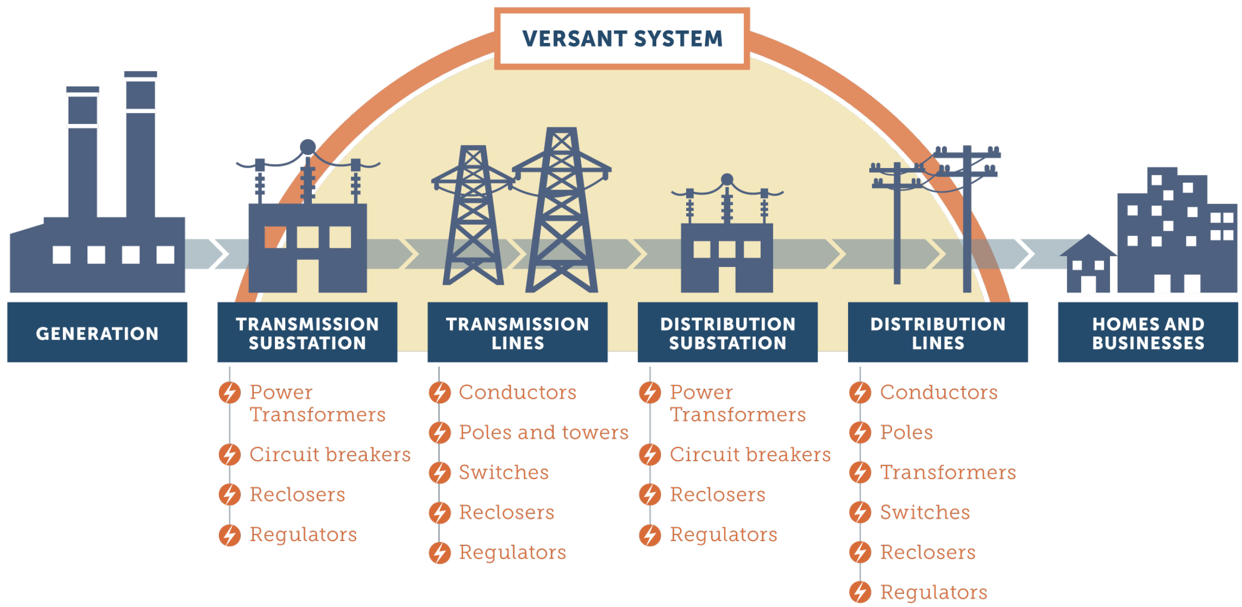
	the service territory experiencing increases while southern portions may experience decreases.
Wildfire	Wildfire risk includes both the risk wildfires pose to vulnerable assets as well as the risk of utilities triggering a wildfire. Climate change impacts both types of risk; increases in wildfire weather can increase the risk of ignition. Once a wildfire has started, it poses a risk to the health and safety of Versant employees and the broader community as well as the risk of physical damage and asset failure for assets. While Maine historically has a low risk of wildfire, the number of high fire danger days across the service territory are projected to increase by mid-century. Additionally, smoke from distant wildfires (for example, Canadian fires) can affect the Versant service territory.
Heavy precipitation and Inland Flooding	Heavy precipitation can drive inland flooding, which can lead to asset degradation and failure and cause widespread outages across the Versant system. Extreme precipitation is projected to increase in intensity across most of the Versant service territory, though its impacts can be highly geographically variable and based on local topography and other factors that impact water drainage.
Coastal Flooding	Coastal flooding can lead to physical asset damage and impact transportation networks within the Versant system. Sea level is projected to rise through mid-century, primarily impacting Versant's coastal regions. In addition to physically damaging assets, rising sea levels are also leading to saltwater intrusion, which can contaminate wells and impact drinking water.
Wind	Wind can pose a physical risk to assets, particularly to overhead distribution assets and transmission lines. Wind can also down trees which can in turn cause damage to a variety of different asset types. There is scientific consensus that the conditions that promote extreme winds and wind gusts could increase in the future, but the magnitude of this increase comes with a high degree of uncertainty.

While all these hazards have the potential to impact Versant, the Company has varying levels of vulnerability to each hazard. Versant's 2023 CCRP identified Versant as having a low vulnerability to inland flooding and coastal flooding. Given this recent analysis, the vulnerability assessment portion of this Study only assessed vulnerability to extreme heat, winter weather, wildfire, and wind.

Assets Studied

This Study included analysis of the most significant asset types that make up Versant's system, including transmission, distribution, and substation assets. Figure 3 summarizes the studied asset categories.

Figure 3. Overview of the asset types that were assessed in this Study.



Study Limitations

This Study presents a thorough analysis using the best available climate science and datasets with several underlying limitations:

- The vulnerability scores were calculated using a mix of current system data (for sensitivity and consequence) and future climate projections (for exposure scores). Thus, the future vulnerability scores represent the current system's vulnerability to future hazards and are not representative of a full future scenario.
- The vulnerability assessment focused on a subset of climate hazards that were identified as priority vulnerabilities in Versant's 2023 CCRP, so the results are not comprehensive of every climate hazard.
- The downscaled climate projections used in the Study present future possible climate realities based on assumed scenarios of different atmospheric greenhouse gas concentrations and do not represent a weather forecast for the future. As future data and best practices for analyzing climate vulnerability become available, Versant should periodically review its analysis and ensure that the results in this report are as up-to-date and informative as possible.
- This Study does not contain analysis of vulnerabilities associated with upstream power generation which could affect Versant.

Climate Hazards: Methodology, Future Projections and Exposure Results

To evaluate projected changes in exposure to different climate hazards across the Versant service territory, the Study Team used the best available climate modeling techniques and peer-reviewed literature. The

Study Team developed forward-looking climate projections and calculated exposure scores for the following climate hazards: extreme heat, winter weather, wildfire & drought, and high winds. These hazards were determined to be the most relevant to Versant through an understanding of historic impact and consultation with subject matter experts. The Study Team also evaluated projections for inland and coastal flooding.

Climate Data

Climate describes the long-term average of weather patterns, measured on the order of seasons, years, and decades. Climate change is the shift in these climate averages over extended periods of time. Currently, climate change is resulting in global trends such as rising temperatures and more frequent and severe extreme weather. However, climate change is not distributed equally and manifests differently at local scales. Forward looking climate projections are the primary tool to evaluate expected climate change in a specific region of interest. While projections are not forecasts, they do evaluate how climate change may influence a region over time, providing actionable information to prepare for a range of plausible climate futures.

Data Sources

The Study Team developed climate change projections using Global Climate Models (GCMs), which are computer-based simulations of Earth's climate and physical processes. GCMs factor in how different levels of greenhouse gases, solar radiation, Earth system sensitivity, and other factors may affect future climate. This Study relied on Coupled Model Intercomparison Phase 6 (CMIP6) projection datasets, the most recent climate datasets and models developed as part of an ongoing international collaboration for the United Nation's Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report.[6] The following datasets were evaluated to assess projections of different climate hazards using ICF's in-house ClimateSight tool:

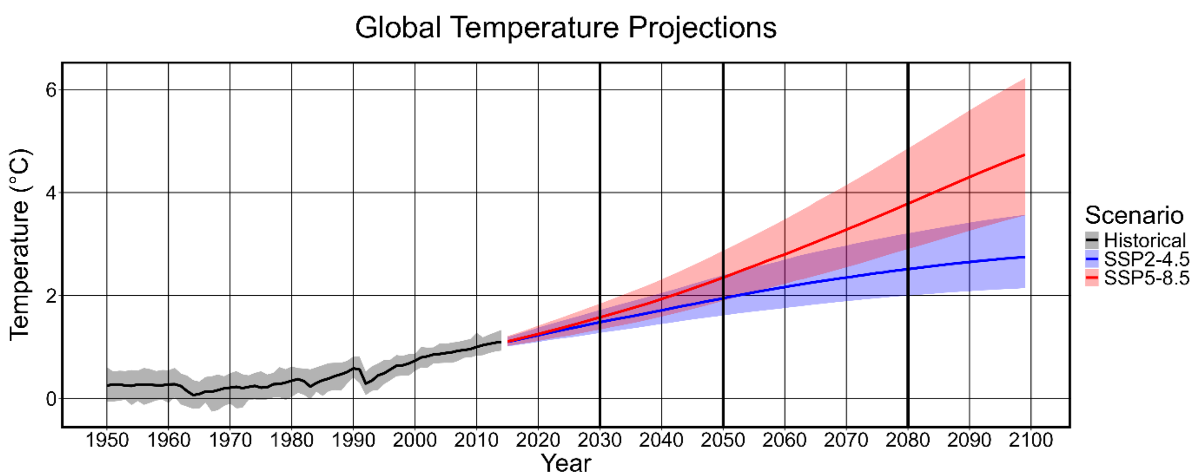
- Daily temperature and precipitation variables were evaluated using an ensemble of Localized Constructed Analogues version 2 (LOCA2) [7] statistically downscaled CMIP6 GCMs. LOCA2 projections were output at a 6 km x 6 km resolution.
- Projections for fire weather index (FWI) and daily-average windspeed were derived from an ensemble of NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP).[8] NEX-GDDP projections were output at a ~25 km x 25 km spatial resolution daily temperature, precipitation, humidity, and wind.
- Flood extent and inundation was evaluated using 1-in-100- and 1-in-500-year historical FEMA flood zones, supplemented with projections of heavy precipitation.
- Coastal flooding extent and inundation depth were evaluated using the NASA Interagency Sea Level Rise Scenario Tool[9] and the NOAA Sea Level Rise Viewer.[10] Sea level rise projections at tide gauges were available for Bar Harbor and Eastport using an ensemble of GCMs for the intermediate and intermediate-high sea level rise scenarios, which most align with the SSP2-4.5 and SSP5-8.5 emissions scenarios, respectively.

Climate Change Pathways

Climate projections are developed using climate model ensembles, or groups of climate model simulations. Model ensembles present a range of plausible climate futures reflecting the uncertainty inherent in future climate conditions due to uncertainty around greenhouse gas emissions trajectory and an incomplete understanding of Earth system sensitivity. Climate pathways represent a way of narrowing the range of uncertainty and providing more standardized projections for specific future climate scenarios.

Developed by the IPCC, Shared Socioeconomic Pathways (SSPs)[11] represent possible climate futures based on different socioeconomic policies and greenhouse gas emissions trajectories. For this Study, climate variable projections were developed under two future emissions scenarios: SSP2-4.5 ("moderate emissions") and SSP5-8.5 ("high emissions"). SSP2-4.5 assumes significant greenhouse gas emissions mitigations prior to 2050, while SSP5-8.5 assumes greenhouse gas emissions continue to rise throughout the century. The Study Team developed projections for each hazard under both emissions scenarios for the following time horizons: 2030, 2050, 2080. Modeled historical and future global temperature projections are shown in Figure 4.

Figure 4. Global temperature projections under SSP2-4.5 and SSP5-8.5 climate scenarios through 2100.



Exposure scores for each climate hazard were calculated using SSP5-8.5 projections. Notably, SSP5-8.5 represents an unlikely climate future assuming unmitigated greenhouse gas emissions throughout the 21st century. Using this scenario, however, captures the potential risks associated with a high emissions or near worst-case climate future. In this way, this scenario supports a risk-averse approach to climate planning by helping Versant prepare for the potential worst outcomes of climate change.

Probabilistic Projections

For this analysis, the Study Team developed probabilistic projections, which incorporate inherent uncertainties in climate projections and thus a more complete range of potential outcomes. Percentiles are used to communicate the range of projected values. The distribution of projections characterizes lower-probability, best-case, and worst-case outcomes. For example, the 50th percentile of projections across models might represent more likely moderate outcomes while the 90th percentile of projections across models might represent the worst-case outcome. Probabilistic projections allow for evaluation of uncertainty by providing a range of future climate change scenarios. Model-based probabilistic projections were evaluated using the LOCA2 and NEX-GDDP model ensembles. Specifically, the Study Team evaluated 10th, 25th, 50th, 75th, and 90th percentile projections to characterize a fuller range of potential climate change outcomes.

Future Climate Projections and Exposure Results

To evaluate the projected impacts of future climate change across the Versant service area, this Study leveraged downscaled GCMs to develop high resolution grids of climate projections across the service area for different climate hazards. Projections were developed for the SSP2-4.5 and SSP5-8.5 climate change pathways and results are presented below for the year 2050. Climate variables were selected based on Versant planning and operating standards, such as a 30°C assumed ambient temperature for rating transformers under normal conditions for 46kV and below transmission lines.

Table 3 provides an overview of the variables used to assess magnitude and / or frequency, where relevant, for each climate hazard.

Table 3. Climate hazard variables assessed in this study.

Hazard	Variables	Relevance to Assets and Operations
Extreme Heat	• Number of Days Per Year Over the Daily Maximum Temperature of 25°C (77°F) • Number of Days Per Year Over the Daily Maximum Temperature of 28°C (82.4°F) • Number of Days Per Year Above the Daily Maximum Temperature of 30°C (86°F) • Number of Days Per Year Above the Daily Maximum Temperature of 38°C (100.4°F) • Annual Hottest Daily Maximum Temperature	Relevant to transmission overhead conductors and distribution overhead conductor wire ratings.
	• Number of Days Per Year Above the Daily Average Temperature of 32°C (89.6°F) • Number of Days Per Year Above the Daily Average Temperature of 30°C (86°F) • Number of Days Per Year Above the Daily Average Temperature of 25°C (77°F)	Relevant to transformer ratings and design.
	• Number of 2+ Day Heatwaves Exceeding Daily Maximum Temperature of 86°F and Daily Minimum Temperature of 77°F	Potentially informative for relief from overnight radiative cooling.
	• Number of 2+-Day Heatwaves with a Daily Maximum Temperature of 86°F	Potentially informative for characterizing temperature sensitivity of reliability performance.
Cold Weather	• Number of Days Per Year with Daily Minimum Temperature Below 0°C (32°F) • Number of Days Per Year with Daily Minimum Temperature Below –17.8°C (0°F)	Potentially relevant to load forecasting and cold weather sensitive assets.
Heavy Precipitation	• Annual Maximum Frozen Precipitation (measurable precipitation with daily mean temperature < 32°F	Proxy for frozen precipitation intensity, includes snow, ice, and freezing rain.
	• Annual Maximum Precipitation Near Freezing Temperature (measurable precipitation with daily average temperature between 30-34°F)	Proxy for heavy wet snow and freezing rain.
	• Number of Days with Precipitation (> 2.5 mm/day liquid equivalent) Near Freezing Temperature (measurable precipitation with daily average temperature between 30-34°F)	Proxy for heavy wet snow and freezing rain.
	• Number of Days with Rainfall Greater than 1 inch on Frozen Ground (measurable precipitation following at least seven	Proxy for likelihood of enhanced cold-season flood events.

	consecutive days with daily maximum temperature below 32°F)	
	• 1-day Maximum Precipitation Totals • 5-day Maximum Precipitation Totals	Common variables for heavy precipitation relevant to inland flooding, and informative for several assets, including substation transformer moat design assumptions.
Wildfire	• Days with Fire Weather Index (FWI) above historical 95th percentile	Provides an understanding of environmental conditions conducive to wildfire development, relevant to physical asset risk from wildfire.
Wind	• Monthly Maximum Wind Speed (relevant to timing of peak wind speeds) • Historical maximum wind gusts at airport weather stations	Relevant to timing of peak wind speeds.

The downscaled climate projections developed for Versant were used to evaluate the exposure of the Company's assets to specific climate hazards. Exposure represents the degree to which assets, operations, and/or systems could face climate hazards based on their physical location and climate projections. Versant assets were scored for exposure across the service area and for three future time horizons. All assets assume the exposure score of the grid cell of climate data in which they are located.

Assets were scored for exposure on a scale from 0 to 5, with 0 representing no exposure and 5 representing maximum exposure. Exposure scoring thresholds were developed for each climate hazard using expert evaluation of climate change across Maine, information from past vulnerability and risk assessments across North America, and information from Versant subject matter experts on the Company's risk tolerance. For a full list of exposure scoring rubrics, see Appendix A: Exposure Scoring Rubrics. Table 4 provides a summary of exposure scores across the Versant service area for each region and climate hazard.

Table 4. Exposure score ranges across the Versant service territory for each asset type and hazard.

Overview of Exposure Scores (SSP5-8.5, 50th percentile)					
Asset	**Hazard**	**Observed**	**2030**	**2050**	**2080**
Distribution Equipment[ii]	Winter Weather	*Range: 3 - 5 Mean: 3.6*	*Range: 3 - 4 Mean: 3.4*	*Range: 3 - 4 Mean: 3.4*	*Range: 2 - 4 Mean: 3.0*
Distribution Transformers	Winter Weather	*Range: 3 - 5 Mean: 4.1*	*Range: 3 - 4 Mean: 3.8*	*Range: 3 - 4 Mean: 3.7*	*Range: 2 - 4 Mean: 2.9*
	Winter Weather	*Range: 3 - 5 Mean: 3.7*	*Range: 3 - 4 Mean: 3.5*	*Range: 3 - 4 Mean: 3.5*	*Range: 2 - 4 Mean: 3.0*

[ii] Includes reclosers, sectionalizers, and regulators.

Distribution Spans	High Winds*	*Range: 2 - 5 Mean: 3.9*	*N/A*	*N/A*	*N/A*
Distribution Poles & Structures	Winter Weather	*Range: 3-5 Mean: 3.6*	*Range: 3 - 4 Mean: 3.5*	*Range: 3 - 4 Mean: 3.5*	*Range: 2 - 4 Mean: 3.1*
	High Winds*	*Range: 2 - 5 Mean: 3.8*	*N/A*	*N/A*	*N/A*
Substation Reclosers, Regulators, & Breakers	Extreme Heat	*Range: 0 - 1.5 Mean: 1.0*	*Range: 0.5 - 3 Mean: 2.2*	*Range: 1.5 - 4.5 Mean: 3.5*	*Range: 3 - 5 Mean: 4.6*
Substation Transformers	Extreme Heat	*Range: 0 - 1.5 Mean: 0.9*	*Range: 0.5 - 3 Mean: 2.2*	*Range: 1.5 - 4.5 Mean: 3.5*	*Range: 3 - 5 Mean: 4.6*
Transmission Poles & Structures	Winter Weather	*Range: 3 - 5 Mean: 3.7*	*Range: 3 - 4 Mean: 3.5*	*Range: 3 - 4 Mean: 3.5*	*Range: 2 - 4 Mean: 3.1*
	Wildfire & Drought	*Range: 1.5 - 2 Mean: 2.0*	*Range: 1.5 - 2 Mean: 2.0*	*Range: 1.5 - 2.5 Mean: 2.5*	*Range: 2 - 3 Mean: 2.5*
	High Winds*	*Range: 2 - 5 Mean: 3.7*	*N/A*	*N/A*	*N/A*
Transmission Equipment[iii]	Winter Weather	*Range: 3-5 Mean: 4.0*	*Range: 3 - 4 Mean: 3.9*	*Range: 3 - 4 Mean: 3.6*	*Range: 2 - 4 Mean: 3.0*
	Wildfire & Drought	*Range: 1.5 - 2 Mean: 2.0*	*Range: 1.5 - 2 Mean: 2.0*	*Range: 2 - 2.5 Mean: 2.5*	*Range: 2 - 2.5 Mean: 2.5*
	Extreme Heat	*Range: 0 - 1.5 Mean: 0.9*	*Range: 0.5 - 3 Mean: 2.2*	*Range: 1.5 - 4 Mean: 3.4*	*Range: 3 - 5 Mean: 4.5*
Transmission Spans	Winter Weather	*Range: 3 - 5 Mean: 3.8*	*Range: 3 - 4 Mean: 3.5*	*Range: 3 - 4 Mean: 3.5*	*Range: 2 - 4 Mean: 3.1*
	Wildfire & Drought	*Range: 1.5 - 2 Mean: 2.0*	*Range: 1.5 - 2 Mean: 2.0*	*Range: 2 - 2.5 Mean: 2.5*	*Range: 2 - 3 Mean: 2.5*
	High Winds*	*Range: 2 - 5 Mean: 3.7*	*N/A*	*N/A*	*N/A*
	Extreme Heat	*Range: 0 -1.5 Mean: 0.9*	*Range: 0.5 - 3 Mean: 2.1*	*Range: 1.5 - 4.5 Mean: 3.4*	*Range: 3 - 5 Mean: 4.5*

** High winds hazard is scored for observed wind gusts only and, therefore, do not have future 2030, 2050, and 2080 exposure scores.*

While exposure scores were not calculated for inland flooding and coastal flooding as Versant was identified as having a low vulnerability to those hazards in its 2023 CCRP, the following section includes projections for inland flooding and coastal flooding as that climate information may be useful and relevant for future planning in response to climate change.

Extreme Heat

Climate Projections

The frequency and intensity of extreme heat and heat waves are projected to increase across the service area, particularly in the southern and inland locations and in a high emissions scenario. Multiple variables were evaluated to understand the future of extreme heat, including those summarized in Table 5.

Table 5. 2050 extreme heat projections.

Selected Extreme Heat Projections

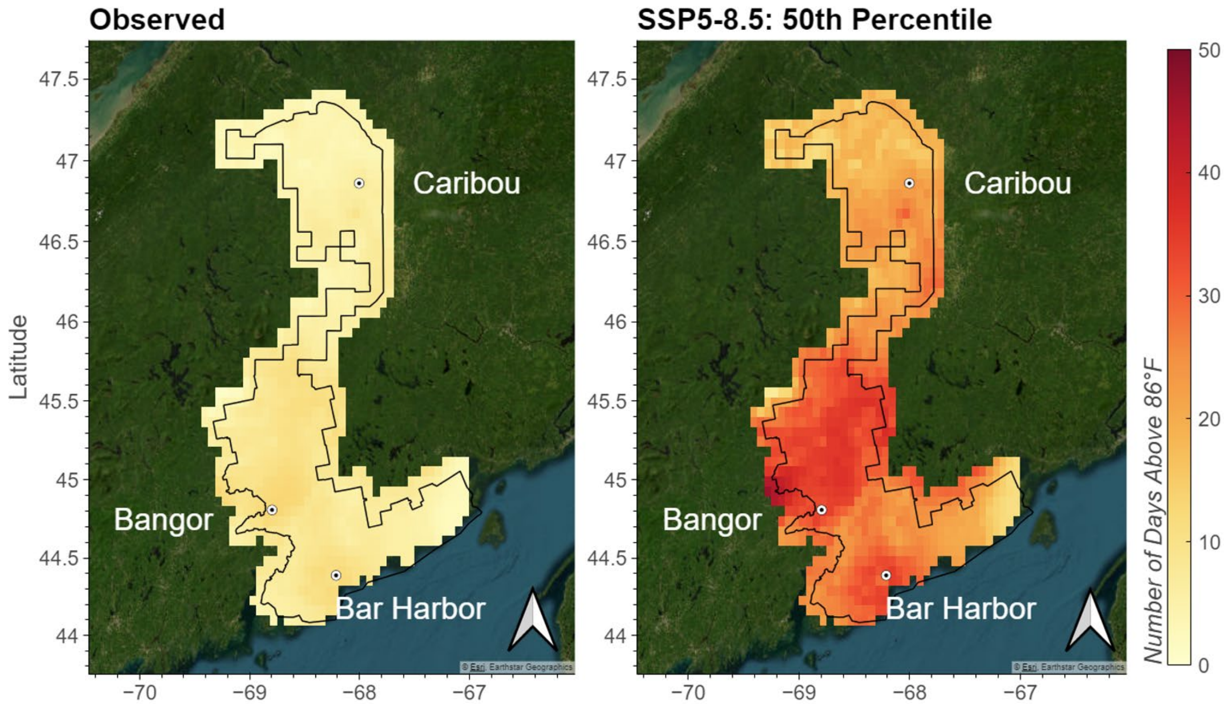
[iii] Includes reclosers, switches, and regulators.

Variable	Intermediate Emissions (SSP2-4.5: 50th Percentile)	High Emissions (SSP5-8.5: 50th Percentile)
2050 **number of days per year above daily maximum temperature of 30°C (86°F)** are projected to increase (*relative to a baseline of 0.7 - 14.0 days across the service territory*) by:	3.5 - 23.6 days	6.4 - 33.5 days
2050 **number of heat waves per year with 2 or more consecutive days above daily maximum temperature of 86°F** are projected to increase (*relative to a baseline of 0.4 - 3.5 heatwaves across the service territory*) by:	1.6 - 7.4 heatwaves	2.5 - 8.9 heatwaves

Exposure Results

Exposure to extreme heat was assessed using the number of days with daily maximum temperatures above 86°F and number of heat waves per year. Both variables are projected to increase across the service territory, indicating that exposure to extreme heat is projected to increase across the service territory. Areas along the coast surrounding Bar Harbor and southern inland regions near Bangor are projected to experience the warmest temperature extremes and thus a greater exposure to extreme heat. For example, the number of days above 86°F are expected to increase across the entire service area, with the changes most extreme over Bangor and the area surrounding Bar Harbor (Figure 5). Those two regions are projected to experience an increase of around 30 days per year with temperatures exceeding 86°F for the SSP5-8.5 2050 projection compared to the observed temperature. Increased exposure to extreme heat across the service area can result in high-load events.

Figure 5. Observed and projected number of days per year with daily maximum temperature above 30°C (86°F). Projected values represent 2050 SSP5-8.5 50th percentile data.



Winter Weather

Climate Projections

Cold weather is projected to be less frequent across the service area in the future. In the cooler inland areas, extreme precipitation and heavy snow intensity is expected to increase, while in the warmer coastal areas, the likelihood of frozen precipitation and near-freezing precipitation is projected to decrease. Table 6 highlights two of the variables used to determine the future of winter weather climate projections.

Table 6. 2050 winter weather projections.

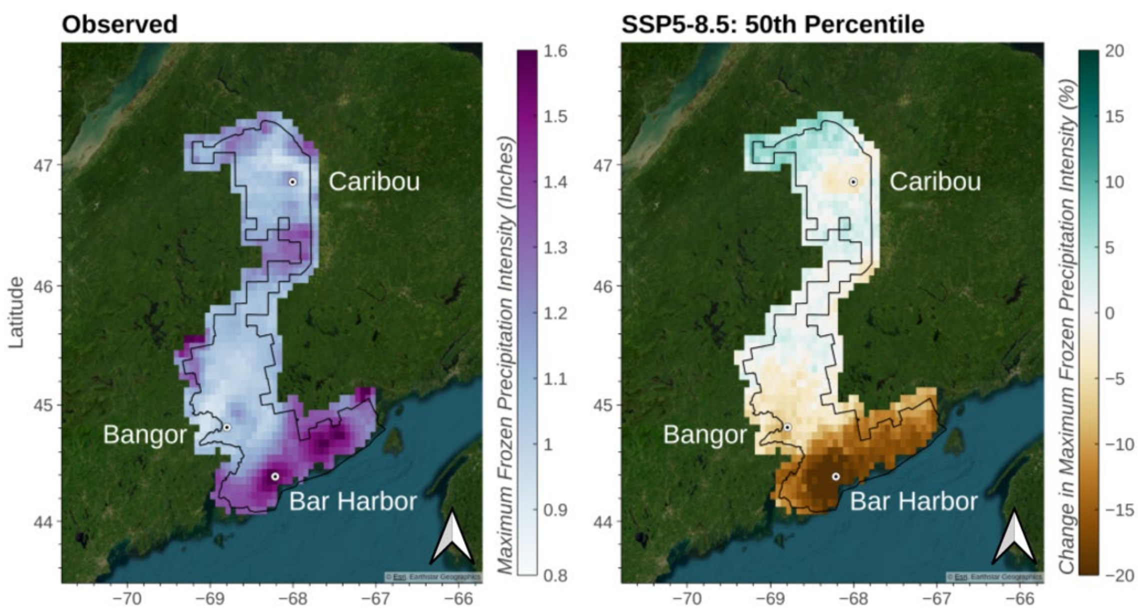
Selected Winter Weather Projections

Variable	Intermediate Emissions *(SSP2-4.5: 50th Percentile)*	High Emissions *(SSP5-8.5: 50th Percentile)*
2050 **annual maximum 1- day frozen precipitation** is projected to change (*relative to a baseline of 0.9 - 1.7 inches across the service territory*) by:	-14.4% to +11.5%	-23.6% to +9.6%
2050 **annual maximum 1-day precipitation near freezing temperature** are projected to change *(relative to a baseline of 0.5-1.4 inches across the service territory) by:*	-10.3% to +21.8%	-21.8% to +23.6%

Exposure Results

Exposure to winter weather was assessed using the change in maximum frozen precipitation intensity. Changes in this metric is projected to be geographically variable across the service territory, with decreasing intensities in southern coastal areas and increases in the most northern inland areas by midcentury, indicating that exposure to winter weather associated with frozen precipitation is projected to decrease in the south portions and increase in the most northern portions of the service territory by midcentury. For example, assets in the southernmost portion of the Versant service area near Bar Harbor are projected to experience a 10-20% decrease in frozen precipitation by midcentury (Figure 6). The change is more moderate in regions north of Bangor, which are projected to experience +/-5% change in frozen precipitation. The service territory north of Caribou is the only region projected to experience a 5-10% increase in frozen precipitation, however the town of Caribou itself is estimated to experience a slight decrease. The spatially heterogeneous nature of winter weather indicates that some areas of the Versant service territory will experience an increased exposure to this hazard while others will experience a decreased exposure to this hazard.

Figure 6. Observed and projected change in maximum frozen precipitation intensity (%) relative to observed values. Projected values represent 2050 SSP5-8.5 50th percentile data.



Wildfire

Climate Projections

Across the service territory, high fire danger days are projected to increase. This could lead to increased fire activity and intensity in historically exposed areas. Historically, the southeastern portion of the service territory has experienced the highest wildfire likelihood. Variables used to evaluate the future of wildfires are summarized in Table 7.

Table 7. 2050 wildfire projections.

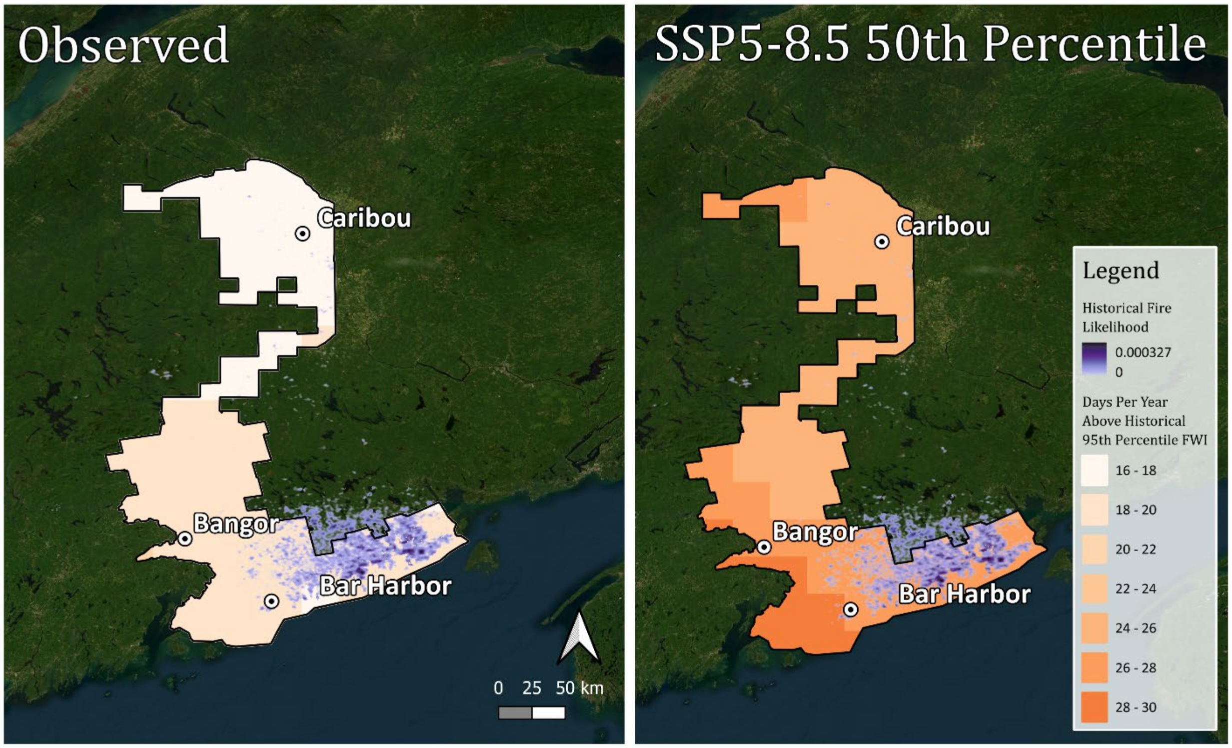
Selected Wildfire Projections

Variable	Intermediate Emissions *(SSP2-4.5)*	High Emissions *(SSP5-8.5)*
2050 **number of days per year above the historical 95th percentile FWI** is projected to *increase (relative to a baseline of 16.9 - 20.7 days across the service territory*) by:	4.4- 6.4 Days	7.0 - 10.3 Days

Exposure Results

Exposure to wildfire was assessed using both historical burn probability and the number of days above the historical 95th percentile Fire Weather Index (FWI), a representation of high fire danger days based on environmental conditions conducive to fire occurrence and spread. As temperatures warm through the 21st century, conditions favorable for wildfires could become more common, increasing wildfire exposure. However, historically, wildfire occurrence in Maine has been relatively rare compared to more fire-prone regions across the country and Maine has the lowest historical burn probability in the contiguous United States. By midcentury, assets within all operating regions of Versant are projected to experience increases in exposure wildfire weather, with the greatest increases occurring in the southeastern portion of the service territory (Figure 7). Historically, only the southeastern portion of the Versant service territory has experienced relatively high burn probabilities. Consistent with this historical data, the southeastern portion of the service territory is projected to experience the largest increase in exposure to wildfire by midcentury due to higher present-day exposure to wildfires and projected increases in wildfire weather. Increased exposure to wildfire across the service area can directly threaten the integrity of assets, lead to asset failure, and threaten the safety of Versant employees.

Figure 7. Observed and projected number of days per year above historical 95th percentile fire weather index (FWI). Projected values represent SSP5-8.5 50th percentile data. Historical fire likelihood (purple) represents areas with the highest fire likelihood in Maine.



Wind

Climate Projections and Exposure Results

Climate models have difficulty projecting changes to wind gusts due to the relatively small spatial and temporal scales at which they occur. Specifically, the strongest wind gusts are nearly instantaneous and vary considerably over scales much smaller than the grid scaling of Global Climate Models. Given the data limitations, the Study Team used projections of daily-averaged wind speed to understand how the overall distribution of wind speeds could change in the future. While daily average wind speeds are not projected to change significantly across the Versant service area by midcentury, extreme wind gusts, representing the tail-end of the distribution of wind speeds, could increase at a different rate, particularly extreme wind and wind gusts that occur during severe weather events.

High wind exposure was evaluated using the best-available data in the region, observed wind gust data derived from airport weather stations, and projections of annual maximum daily-averaged wind speeds. Despite high wind exposure during the historical period due to high observed wind gusts at airport weather stations, projections of daily-averaged wind speeds demonstrated minimal change across the service territory. Coastal and inland regions near Bangor have, historically, experienced the highest wind gusts, leading to greater exposure to high winds in these regions. This is consistent with recent research, including one study in the Northeast United States (including Maine) approximating extreme winds using daily maximum wind calculated from hourly mean wind speeds.[12] Daily maximum hourly wind speed provides a proxy to evaluate changing wind speeds across the region but may underestimate the most instantaneous measures of wind gusts. Despite the high spatial and temporal resolution of the dataset, projections for extreme wind speeds exhibited minimal change or decreases across Maine through 2041, suggesting that hourly extreme wind magnitudes in Maine may not change significantly through the next two decades. Despite minimal changes projected for exposure to daily and hourly wind speeds relative to present day, there is cause for concern that the more instantaneous wind gust intensities and frequencies may increase or change at a greater rate, which is explored below.

While the science evaluating climate change and extreme events has improved in recent years, significant uncertainty persists regarding the most severe extreme weather events. This is due to (1) the infrequency of such events compared to the historical record, (2) the limited spatial and temporal scales at which these events occur, and (3) the limited ability of current global-scale climate models to resolve events at these scales. **Despite these challenges, a growing body of research shows that climate change will likely increase the frequency and intensity of the most extreme wind events.** For example, in the North Atlantic basin, hurricane maximum sustained wind speed intensity is projected to increase under climate change, with uncertain changes to overall hurricane frequency.[13] Models also project that increases in the likelihood of favorable conditions for severe weather could lead to increased potential for thunderstorm activity and associated extreme wind events.[14] The number of days with conditions favorable for severe thunderstorms could double by late century in the Northeast United States under a high emissions scenario,[15] with environments favorable for thunderstorm development potentially increasing in frequency by 5-20% per 1˚C warming.[16] In contrast, recent studies utilizing the new CMIP6 models indicate that the number of extratropical cyclones (e.g., coastal storms, Nor'easters, and bomb cyclones) in North America is expected to decrease by approximately 5% by the end of the 21st century. However, the number of the most extreme cyclones, characterized by significant increases in wind speeds, is projected to rise by about 4%. Additionally, cyclone wind speeds are projected to intensify during the winter months, with the most substantial increases expected under the high emissions scenario.[17]

There are limited scientific studies that look at the magnitude of change in wind gusts across the Northeast United States, although limited studies suggest that more intense wind speeds will increase. For example, New York City is projected to experience higher future maximum wind gusts by midcentury under a high emissions scenario, leading to an increase to 110 mph from the recent 1973-2017 maximum wind gust of 80 mph.[18] In particular, this study showed that the historical 1-in-700-year return period event of 115 mph (associated with Hurricane Sandy) could increase to 124 mph by midcentury. **This demonstrates that one of the most intense observations of wind speed in the Northeastern United States is projected to increase significantly by midcentury.**

There is scientific consensus that the conditions that promote extreme winds and wind gusts could increase in the future,[19] but the magnitude of this increase comes with a high degree of uncertainty.

Heavy Precipitation and Inland Flooding

Climate Projections

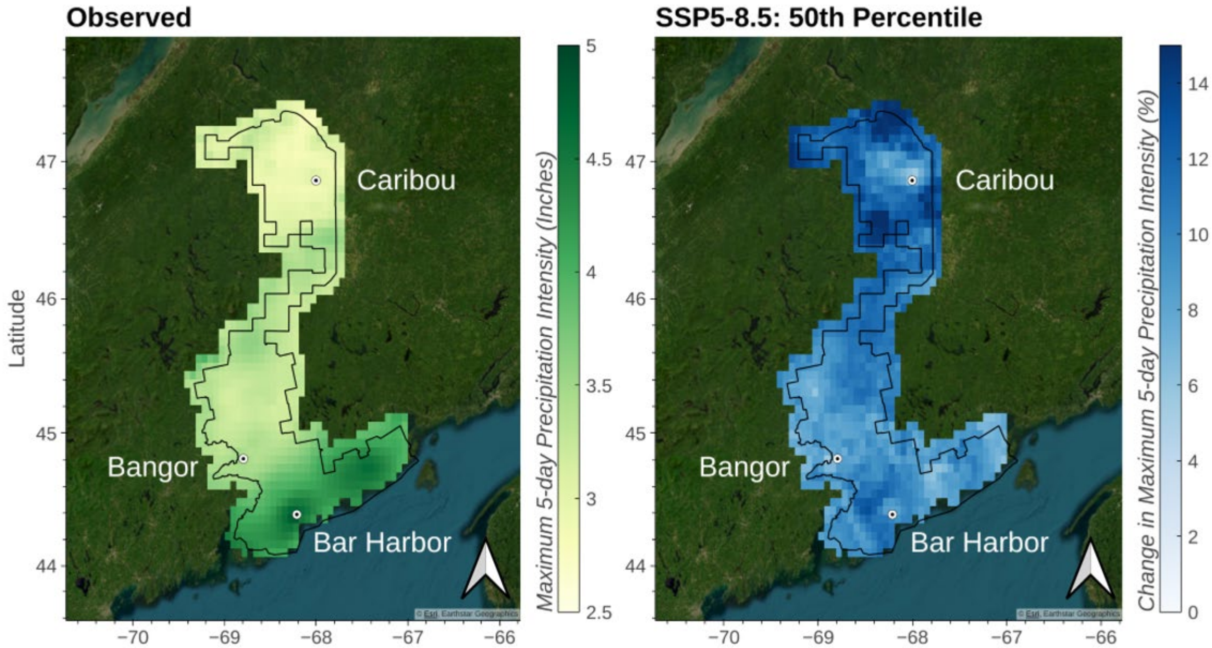
Extreme precipitation is projected to increase in intensity across most of the service territory, especially for inland locations and under a high emissions scenario. With rising precipitation rates, inland flooding is projected to increase across the service territory, particularly within and adjacent to the 100- and 500-year FEMA floodplains. Several variables were assessed to analyze the future of heavy precipitation and inland flooding. Given that inland flooding was classified as low vulnerability in Versant's CCRP, this Study did not conduct vulnerability scoring for this hazard. However, projections for heavy precipitation are included here as they may still be useful for planning in response to climate change.

Table 8. 2050 heavy precipitation projections.

Selected Heavy Precipitation & Inland Flooding Projections

Variable	Intermediate Emissions *(SSP2-4.5)*	High Emissions *(SSP5-8.5)*
2050 **annual maximum 5-day precipitation** is projected to *increase* (*relative to a baseline of 2.8 - 4.8 inches*) by:	3.1% -17.1%	5.5% - 17.9%

Figure 8. Observed and projected change in maximum 5-day precipitation intensity (%) relative to observed. Projected change represents values for SSP5-8.5 50th percentile data.

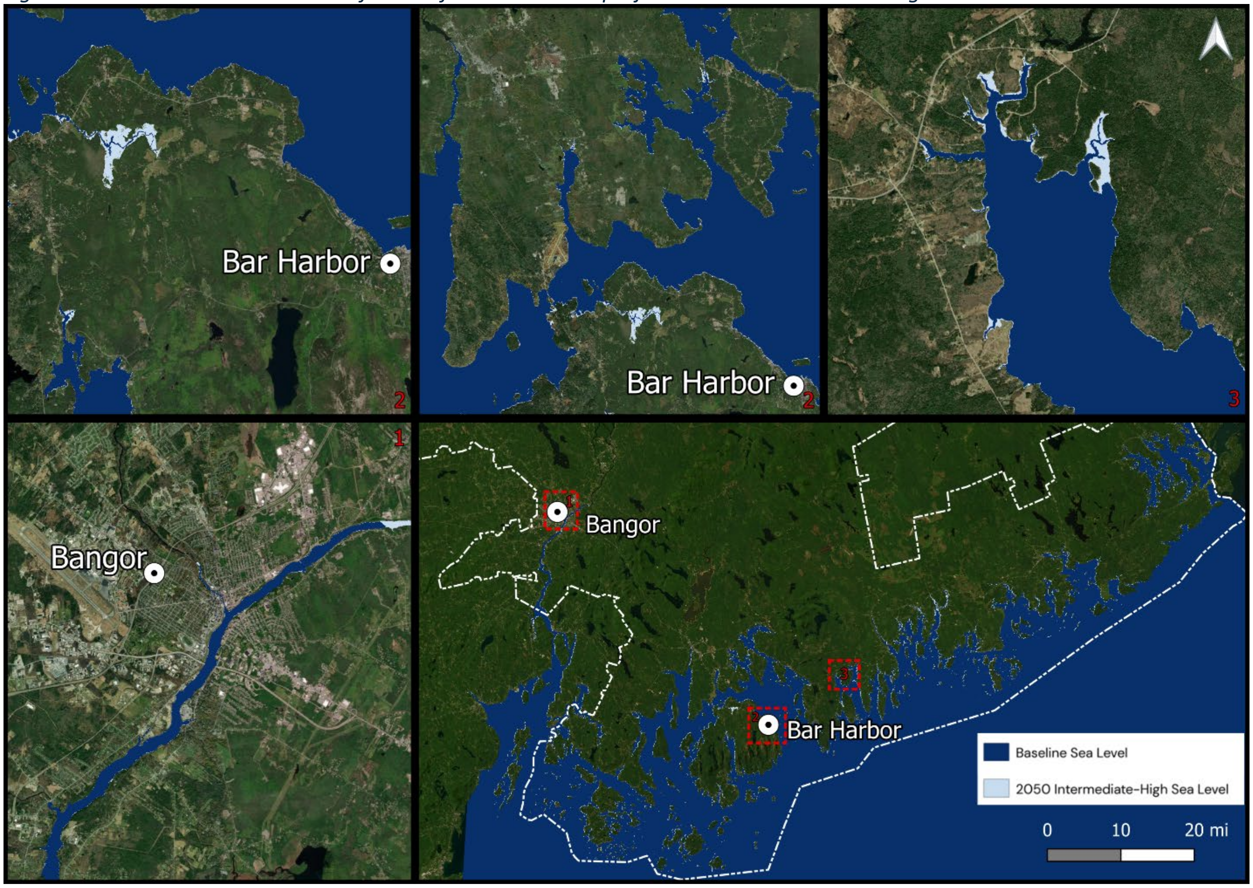


Coastal Flooding

Climate Projections

Sea level rise is projected to increase permanent inundation and coastal flood exposure in some coastal portions of the service territory if adaptation measures are not put in place. However, the extent of inundation is likely to be small. Similar to inland flooding, coastal flooding was classified as low vulnerability in Versant's CCRP. Therefore, this Study did not conduct vulnerability scoring for this hazard. However, Figure 9 below is included to show potential intermediate-high sea level rise by 2050, showing increased exposure to coastal flooding as sea levels rise in some coastal areas. The map highlights several coastal areas to demonstrate the localized nature of increased flooding along Maine's coastline. This information may still be useful and relevant for future planning in response to climate change.

Figure 9. Sea level rise on the coast of Maine for baseline and projected 2050 Intermediate-High sea level.



While coastal flooding was not explicitly scored for vulnerability in this assessment, there is potential for exposure from the hazard in some coastal areas, particularly from the effects of storm surge. Sea level rise will likely increase the potential for coastal flooding events, such as high tide flooding and storm surge. Extreme storms, such as hurricanes and coastal extratropical cyclones, are likely to increase in intensity, as well, bringing with them the possibility of higher storm surge exposing critical electric infrastructure.[20] Recent literature shows that high tide flooding (or "nuisance" flooding), storm surge, extreme sea level events, and coastal storms are projected to increase in intensity and frequency in the Gulf of Maine.[21] As sea levels rise, coastal flooding could threaten an increasing number of critical infrastructure and services in coastal Maine, particularly by late century.[22] The compounding effects of more frequent high tide flooding, more intense storms, and sea level rise could lead to greater impacts in coastal locations, although overall the bathymetry and topography of the coastline should minimize impacts relative to more vulnerable coastal locations in the United States.

Extreme and Compound Climate Events

Although some climate hazards can be modeled with a high degree of certainty, others are too complex to be evaluated quantitatively. Given their complexity, extreme and compound climate events are considered to be part of the latter group of climate hazards. A compound event is a weather or climate extreme in which two or more climate hazards occur simultaneously or in succession. When this occurs, the impacts can be enhanced beyond what would have been experienced in a single hazard event. As the likelihood of extreme events rises due to climate change, the likelihood of two or more events occurring at the same time also rises.

Maine has experienced several extreme weather events and climate trends in recent years, highlighting the growing risks of compound hazards driven by climate change. Some notable events include a winter extratropical cyclone in December 2023,[23] designated the "Grinch Storm of 2023," which brought heavy rain-on-snow, rapid snowmelt, a saturated water table, and runoff over a frozen ground. This resulted in one of the worst flooding events since the 1800s, with over 200 impacted residencies and more than $5 million in damages, exacerbated by wind gusts exceeding 60 mph.[24] Long term climate trends show sea level rise of nearly 8 inches since 1950 and warming in the Gulf of Maine; one of the fastest-warming bodies of water globally, driving further acceleration.[25] Annual average temperatures in Maine are projected to rise by the end of the century, compounding risks like coastal flooding and storm surge, as well as intensifying extreme weather events like the 2023 storm.

When extreme weather events occur close in time or space to each other, impacts can compound and intensify, potentially straining emergency response systems and resources. Coincident events are likely to continue to increase in frequency and intensity in the future, amplifying projected system stress. These events can be further exacerbated by inadequate resources to cope with climate hazards and a fatigued workforce. Examples of the way in which *compounding* weather can further affect system reliability include:

- Heavy precipitation, which can occur during thunderstorms and extratropical cyclones, saturates soil and weakens the root systems of trees. When followed by a wind event, vulnerable trees can become uprooted and damaged, potentially contacting and damaging electrical infrastructure.
- Heatwaves can exacerbate drought conditions by increasing evaporation rates. Coincident dry spells under these conditions can increase the risk for wildfire. Wildfires can result in physical damage to infrastructure which can lead to service interruptions.
- Coastal flooding impacts can be exacerbated by rising sea levels, high winds from coastal storms, and high tide, depending on the flood's timing. Flooding can damage infrastructure and assets and lead to service interruptions.
- Rain-on-snow events can exacerbate flooding during heavy precipitation events via increased runoff from snowmelt, especially over frozen ground. Enhanced flooding can damage infrastructure and lead to service interruptions.

As climate change increases the frequency and intensity of some individual hazards and extreme events, compound events will also occur more frequently. Climate hazards can also be more impactful when compounded with other climate and non-climate factors. For example, the impacts of a compound climate hazard can be exacerbated by aging infrastructure or under-resourced communities. For coastal flooding, both sea levels and storm intensity and frequency are projected to increase, which increases the likelihood of compound coastal flooding events. For inland flooding, projected increases in the intensity and frequency of heavy precipitation, rain-on-snow events, and storm intensity could increase the likelihood of compound inland flood events. While exposure to wildfire is typically low in Maine, the compounding effects of projected increases in drought and heat waves could increase the likelihood of wildfire in the future.

Examples of extreme events are projected to become more intense and frequent, include:

- ***Increased thunderstorm activity***: Thunderstorm formation is predicted to increase up to 20% per 1˚C of warming, with higher latitudes experiencing the greatest percentage increase.[26] By the late century, areas in North America could experience up to a 40% increase in thunderstorm precipitation rates under a high emissions scenario.[27] Areas in the United States could also experience up to 12% increase in lightning strikes for every 1˚C of warming.[28]
- ***Increases in extreme winds***: Extreme winds, particularly during severe weather events, could increase in some areas in the future, but daily average wind speed is not projected to be heavily impacted by climate change or decrease.[29] Models do not project significant changes in average wind direction in the near future.[30]
- ***Increased hurricane intensity in the Atlantic basin***: Hurricane wind speed intensity is projected to increase from climate change in the North Atlantic basin, while changes to overall hurricane frequency is uncertain.[31] Hurricanes are projected to intensify far more rapidly as they strengthen over warmer sea surface temperatures.[32] The frequency of the most intense hurricanes (i.e., Category 4 and 5) are projected to increase in the North Atlantic basin.[33]
- ***Variable changes in winter weather***: The likelihood of ice storms and freezing rain in New England could decrease as temperatures warm and freezing rain occurrences shift farther north, especially during spring and fall shoulder seasons.[34] Rain-on-snow events are likely to increase north of the future freezing line due to the combination of more overall rainfall and greater air temperature.[35] Heavy precipitation is predicted to increase in the Northeast with more of this precipitation expected to fall as rain instead of snow.[36] Finally, Maine is experiencing far more "winter weather whiplash," or rapid shifts in winter weather, including extreme freezing and thawing conditions, rain in the winter, and snow in spring/fall months.[37]
- ***Shifts in ice cover, snowpack, and snowmelt***: Warming temperatures are projected to shift seasonal river-ice occurrences farther north as ice cover decreases globally, which could influence the frequency and intensity of breakup ice jam events. The direction of this trend, however, is expected to vary by watershed with a high degree of uncertainty.[38] Models project declining snowpack, earlier spring snowmelt, and a shorter snow season as climate warms in the future.[39]

Vulnerability Assessment

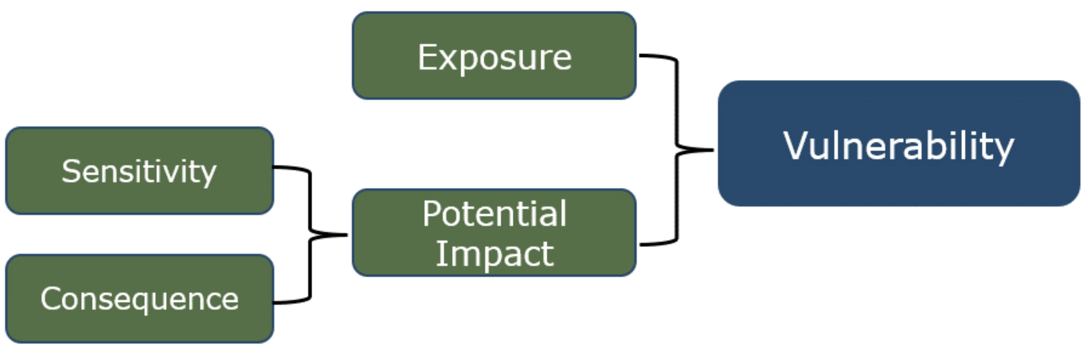
The purpose of this Study is to build on Versant's 2023 Climate Change Resilience Plan (CCRP) and perform a detailed asset-level vulnerability assessment for each of the medium and high vulnerabilities identified in the CCRP. Understanding observed and future vulnerability at the individual asset level can help Versant develop specific resilience strategies to mitigate these vulnerabilities.

Vulnerability represents the potential for Versant assets or operations to be impacted by climate hazards. The Study team calculated vulnerability scores by combining the sensitivity, consequence, and exposure scores for each asset (see additional details in Approach to Assessing Asset Vulnerability). This Study evaluated Versant's assets to determine their vulnerability to extreme heat, winter weather, wildfire, and wind, which represent the key climate hazards for the Versant service area as determined by Versant's 2023 CCRP.

Approach to Assessing Asset Vulnerability

To calculate vulnerability, the Study Team adopted an approach that is rooted in IPCC definitions of relevant concepts and leading industry practices. The Study Team calculated vulnerability by combining the potential impact score, which includes sensitivity and consequence, with the exposure score for a given climate hazard and specific asset.[iv] Figure 10 outlines the components that go into calculating vulnerability.

Figure 10. Components of vulnerability.



Sensitivity

Sensitivity represents the extent to which Versant's assets could be negatively impacted by exposure to climate hazards. It captures the potential for assets to fail, underperform, require repair or replacement, or experience degradation when exposed to various climate hazards. The Study Team used asset health as the indicator for sensitivity, and where health data were unavailable, the Team used asset age. For some asset types, such as poles, information on pole type was also incorporated.

[iv] Exposure scores are introduced and summarized in the previous section.

Sensitivity was scored on a 1-5 scale using customized rubrics designed to capture key asset attributes to each asset-hazard combination. Versant subject matter experts vetted these rubrics to ensure they accurately applied to the Versant system. Note that sensitivity scores were developed based on the current climate conditions Versant experiences.

For a complete list of sensitivity rubrics used in this assessment, see Appendix B: Sensitivity Scoring Rubrics.

Consequence

Consequence reflects the potential impacts related to an asset being physically damaged, including repair and replacement costs and the number of customer impacts by the damage.

Consequence was scored on a 1-5 scale using customized rubrics based on scores developed by Versant. The scores were determined by the number of customers served by the asset. Since transmission assets typically service more customers than distribution assets, transmission assets received higher consequence scores. Versant subject matter experts vetted these rubrics to ensure they accurately represented Versant's system characteristics. Note that consequence scores were developed based on the current climate conditions Versant experiences.

For a complete list of consequence rubrics used in this assessment, see Appendix C: Consequence Scoring Rubrics.

Potential Impact

Potential impact characterizes the negative outcomes to the system based on the sensitivity level to a given climate hazard and the consequence of the asset. Potential impact is calculated by multiplying sensitivity and consequence scores together.

To calculate vulnerability, the Study Team multiplied sensitivity (1-5), consequence (1-5), and exposure (0-5) scores together to get the final vulnerability score for each asset. The maximum possible vulnerability score is 125.

Results of Vulnerability Assessment

Based on the 2023 CCRP, the Study Team determined the most significant climate hazards, known as priority hazards, and the most vulnerable assets in the Versant system. Table 9 summarizes the observed vulnerability and projected change in vulnerability for each priority hazard. Notably, Versant already has high vulnerability to winter weather and high winds. In the future, parts of the service territory are projected to experience a significant increase in vulnerability to all four priority climate hazards with more regional variable projected for winter weather and a high degree of uncertainty associated with future changes in wind.

Table 9. Summary of observed vulnerability and the future trend of extreme heat, winter weather, wildfire, and high winds.

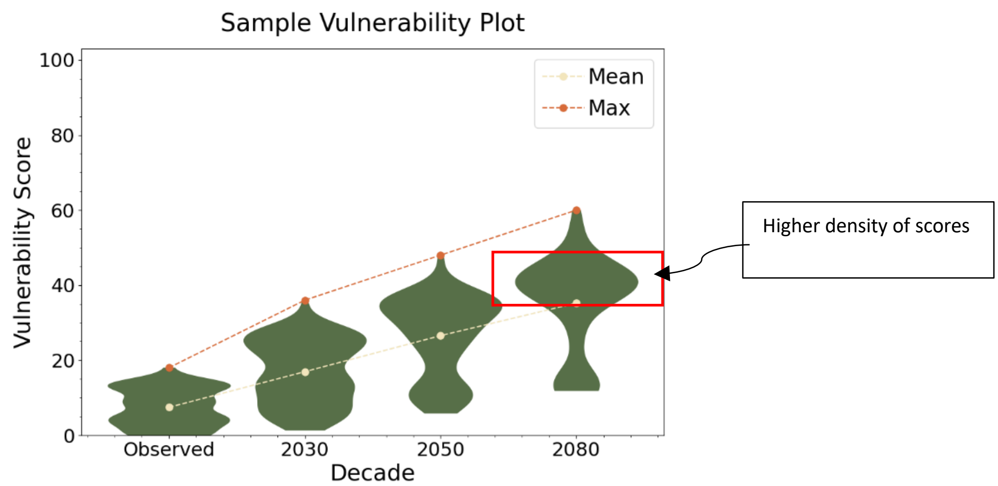
Climate Hazard	Observed Vulnerability	Future Change in Vulnerability
Extreme Heat	Low	Significant **increase** in average and maximum temperatures, causing higher energy demand and lowered capacity.
Winter Weather	High	**Increase** in frozen precipitation in northern/inland areas and **decrease** in some southern/coastal areas.
Wildfire	Low	Moderate **increase** in weather conditions conducive to wildfire, which could damage assets.
High Winds	High	Possible significant **increase** in winds associated with events such as storms. High degree of uncertainty associated with wind projections.

Detailed Vulnerability Results

The following sections provide a detailed overview of the vulnerability results. Results are organized by climate hazard and each climate hazard section includes distribution plots illustrating the results. As noted above, the vulnerability results are generated by combining sensitivity and consequence scores to generate a potential impact score which is then combined with the exposure scoring. The sensitivity and consequence scores were calculated for current conditions across the Versant service territory and thus reflect a current understanding of the Versant system while the exposure scores were calculated using future climate projections and thus represent an understanding of future conditions.

The violin plots below display the distribution of vulnerability scores for each time horizon. Each "violin" represents the spread of vulnerability scores, with the width at any point showing the density of scores within that range, as shown in the sample plot below (Figure 11). The mean vulnerability score is indicated by yellow dots, while the maximum score is indicated by red dots, connected by dashed lines to show trends over time.

Figure 11. Sample Vulnerability Plot



Extreme Heat

This Study identified extreme heat as a priority vulnerability for the following asset types: transmission spans, transmission equipment, substation equipment, and substation transformers. Currently, Versant has a low observed vulnerability to extreme heat, however, projections indicate a significant increase in vulnerability through 2080 as shown in Figure 12. The average 2050 vulnerability score across all assets is 31, with transmission spans scoring the highest with an average 2050 score of 46.

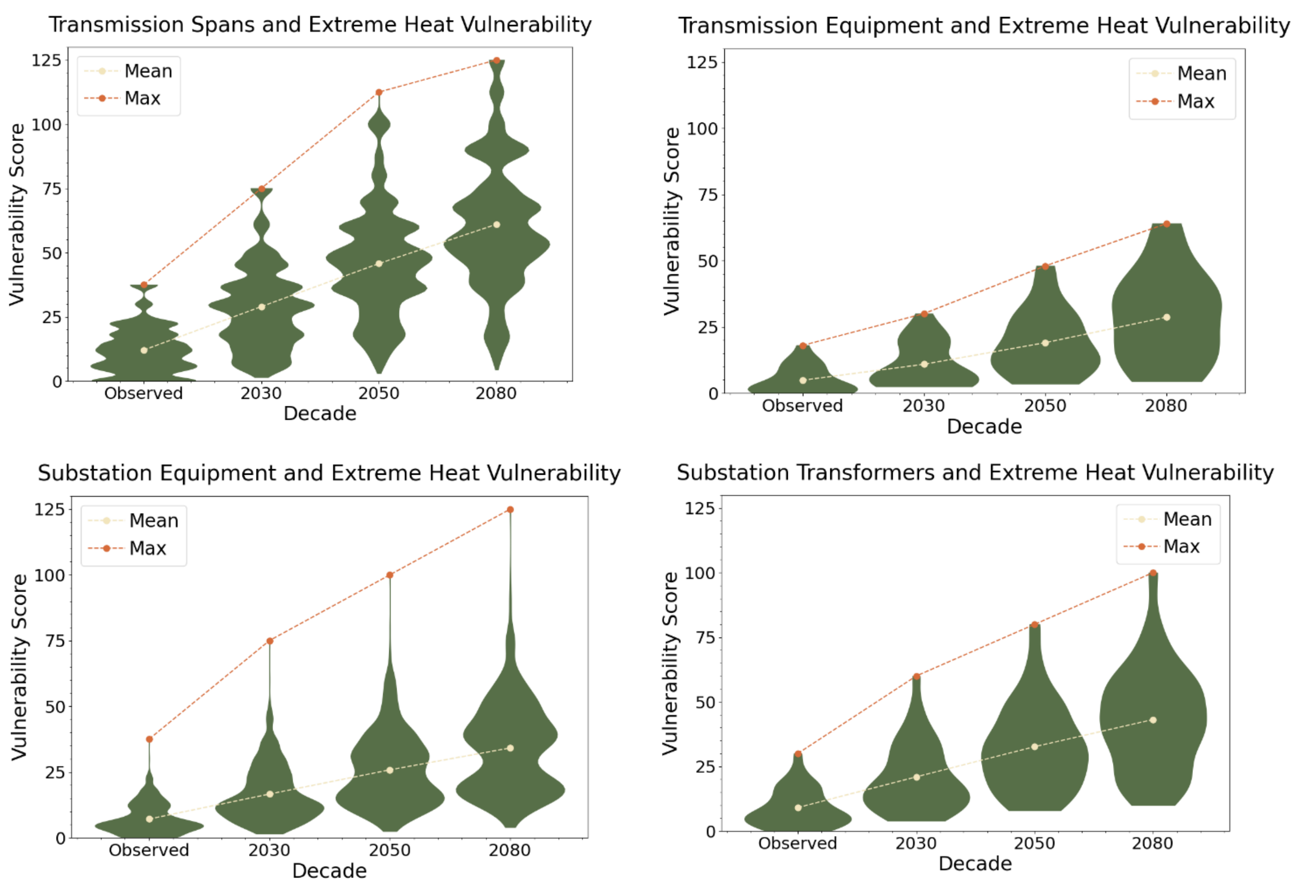
- **Transmission Spans** emerge as the most vulnerable asset type to extreme heat. Although most of Verant's transmission lines are rated at 167°F or 212°F temperatures,[v] extreme heat, which often occurs during high load periods, can lead to mechanical stress, which can increase the risk of breakage and greater sag, which can increase the risk of electrical failures (e.g., line faults with vegetation or structures), both of which can cause outages. High ambient temperatures reduce the ability of conductors to dissipate heat and often coincide with increased demand due to air conditioning. Operating lines above their thermal limits can weaken conductor materials and cause excessive sagging, reducing physical clearance and potentially leading to safety violations. Transmission spans have an average vulnerability score of 37 and have a significant increase from 12 to 46 from observed to 2050, with the highest scoring spans located in the southern inland portion of the service territory. The average maximum vulnerability increases from 38 to 113 from observed to 2050. In addition, transmission spans located in the northern region have relatively higher sensitivity scores than assets in other parts of the territory.
- **Transmission Equipment (reclosers and regulators)** can experience an increased risk of failure and accelerated aging when exposed to extreme temperatures. The mean vulnerability score increases over time with a 280% increase from observed to 2050, reaching an average score of 19 in 2050. The average maximum score also increases from 18 to 48 from observed to 2050.
- **Substation Equipment** can experience increased risk of failure and accelerated aging when exposed to extreme temperatures. The mean vulnerability score increases to 26 by 2050. The

[v] Rating depends on the voltage.

average maximum vulnerability reaches 100 by 2050, and about 30% of the substation equipment have a moderate sensitivity score.

- **Substation Transformers** can experience accelerated aging and an increased risk of failure when exposed to high ambient temperatures. The mean vulnerability score increases by 267% from observed to 2050, to a mean score of 33 by 2050. The average maximum score reaches 80 by 2050, with around 11% of substation transformers having a high sensitivity score.

Figure 12. Extreme Heat Vulnerability Score Distribution for Transmission Spans, Transmission Equipment (regulators and reclosers), Substation Equipment, and Substation Transformers. The spread of scores is represented by the width of the plot, with wider areas indicating a higher concentration of assets scoring within that range. The mean and maximum scores for each time horizon are shown in yellow and red, respectively.



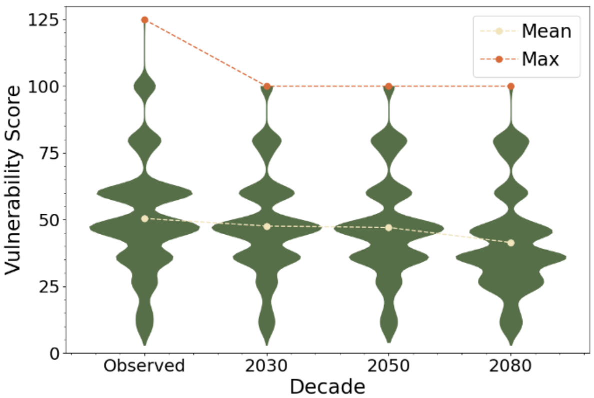
Winter Weather

This Study identified winter weather as a priority vulnerability for the following asset types: transmission spans, transmission poles, transmission equipment, distribution spans, distribution poles, distribution equipment, and distribution transformers. Winter weather poses high vulnerability under observed conditions and is projected to increase in vulnerability in northern and inland areas, while decreasing in some southern and coastal areas through 2080, as shown in Figure 13. The average 2050 vulnerability score across all asset types is 32, with transmission spans scoring the highest with a 2050 average of 47. The average vulnerability slightly decreases from observed through 2080 with an average 14% decrease across all asset types, though still remains high.

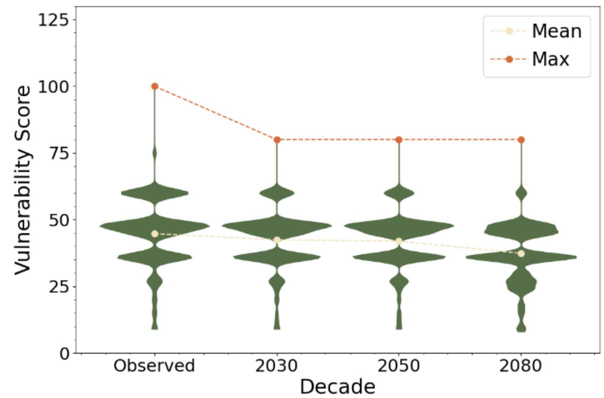
- **Transmission Spans** are built to withstand a defined design tolerance for ice loading, however, icing above this tolerance can result in conductor/attachment failure. Ice accumulation on vegetation can also result in vegetation contact with assets and contribute to failure. The average vulnerability score is 47 and average maximum score is 106.
- **Transmission Poles** are built to withstand a defined design tolerance for ice loading, however, icing above this tolerance can result in pole/tower failure, which can lead to structure collapse. The average vulnerability score is 42 and average maximum score is 85.
- **Transmission Equipment** may experience ice loading with severe ice accumulation and extreme cold may affect the movement of mechanical components. The average vulnerability score is 40 and average maximum score is 67.
- **Distribution Spans** may experience failure in instances of ice accumulation, particularly as compounded by contact with vegetation. The average vulnerability score is 29 and average maximum score is 85.
- **Distribution Poles** may experience increased loading in cases of ice accumulation on poles and cross-arms, which makes it easier for vegetation and high winds to overload poles and cause damage. The average vulnerability score is 21 and average maximum score is 85.
- **Distribution Equipment** may experience ice loading with severe ice accumulation and extreme cold may affect the movement of mechanical components. The average vulnerability score is 22 and average maximum score is 67.
- **Distribution Transformers** may experience ice loading, which can exacerbate the risk of structural overload from vegetation and cause failure. The average vulnerability score is 24 and average maximum score is 45.

Figure 13. Winter weather vulnerability score distribution for Transmission Spans, Transmission Poles, Transmission Equipment, Distribution Spans, Distribution Transformers, Distribution Equipment, and Distribution Poles. The spread of scores is represented by the width of the plot, with wider areas indicating a higher concentration of assets scoring within that range. The mean and maximum scores for each time horizon are shown in yellow and red, respectively.

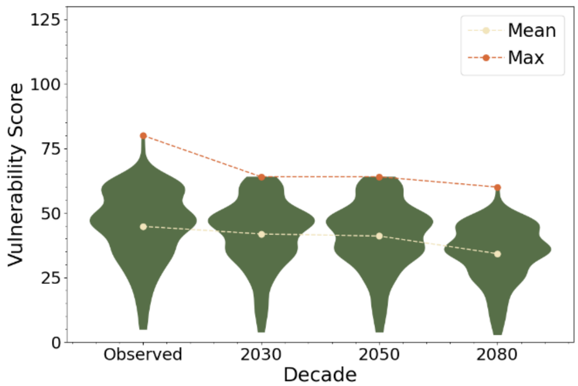
Transmission Spans and Winter Weather Vulnerability



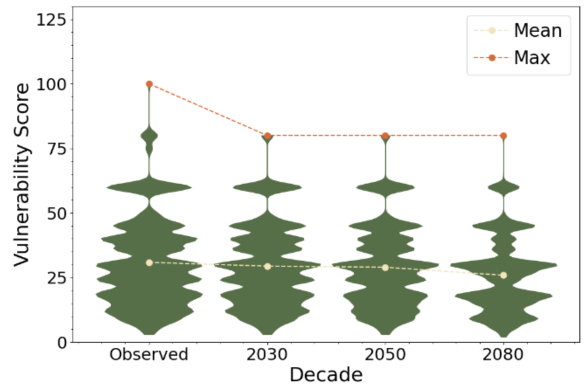
Transmission Poles and Winter Weather Vulnerability



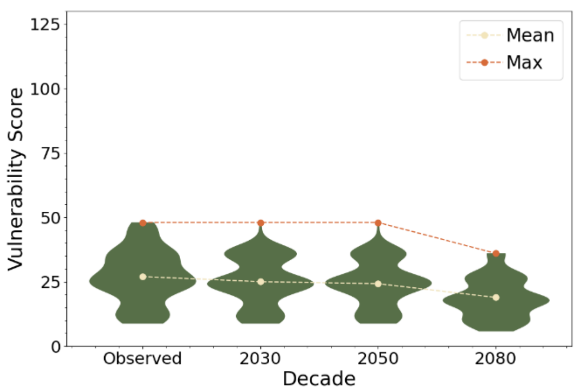
Transmission Equipment and Winter Weather Vulnerability



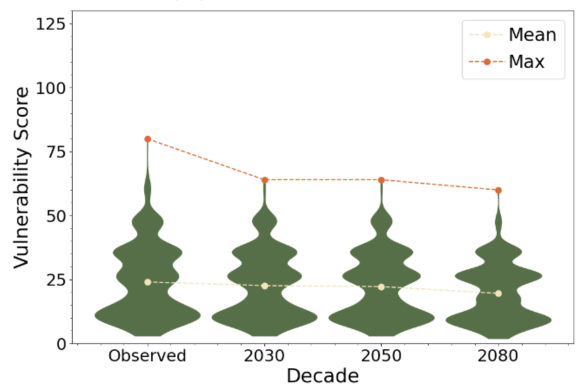
Distribution Spans and Winter Weather Vulnerability

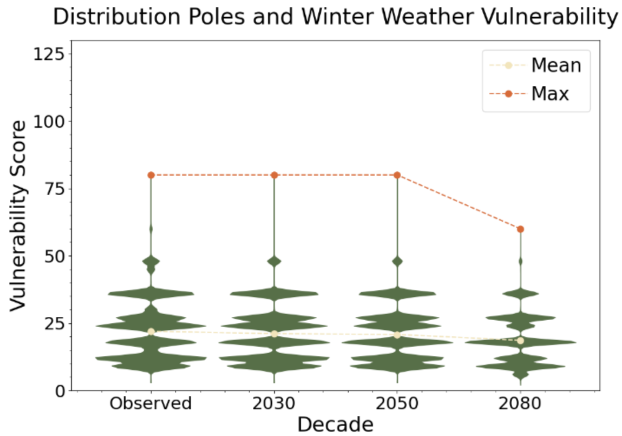


Distribution Transformers and Winter Weather Vulnerability



Distribution Equipment and Winter Weather Vulnerability



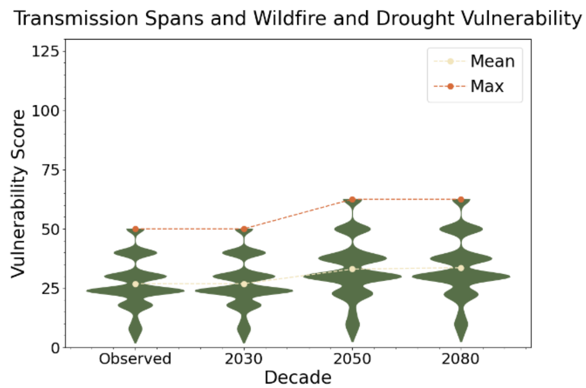


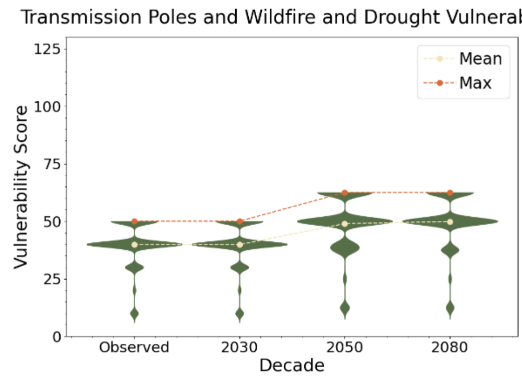
Wildfire

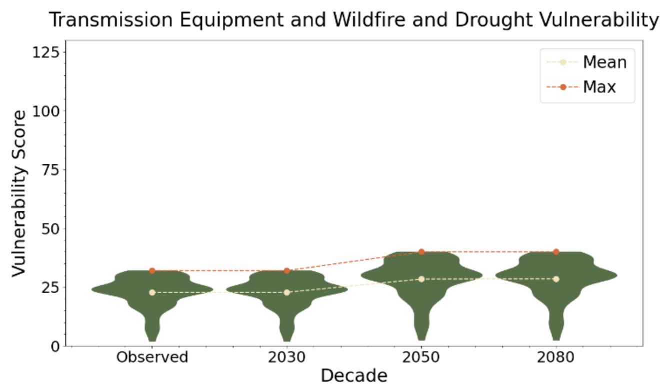
This Study identified wildfire as a priority vulnerability for the following asset types: transmission spans, transmission structures, and transmission equipment. Wildfire poses low vulnerability under observed conditions but is expected to have a 23% increase in vulnerability through 2080, as shown in Figure 14 . The average 2050 vulnerability score across all asset types is 37, with transmission poles scoring the highest with a 2050 average of 49.

- Since **Transmission Spans** tend to be above the level of the fire, they are at lower risk of damage than ground-based components. However, wildfires may cause transmission line outages due to flashovers. Transmission spans have an average vulnerability score of 30 and it stays relatively constant throughout all decades, with a slight increase in 2050 and 2080. The maximum score has an average of 56.
- **Transmission Poles** can be significantly damaged if a fire is in the direct vicinity, especially if the poles are wooden. The average vulnerability score is 45, and the maximum score has an average of 56. These scores are mainly being driven by transmission pole's high sensitivity to wildfire, with about 98% off transmission poles scoring high in sensitivity.
- **Transmission Equipment** can be damaged if a fire is in the vicinity, however, pole mounted equipment has a lower risk of damage than ground-based components. The average vulnerability score is 26 and maximum average is 34, both staying relatively constant throughout all decades, with a slight increase in 2080.

Figure 14. Wildfire vulnerability score distribution for Transmission Spans, Transmission Poles, and Transmission Equipment. The spread of scores is represented by the width of the plot, with wider areas indicating a higher concentration of assets scoring within that range. The mean and maximum scores for each time horizon are shown in yellow and red, respectively.







High Wind

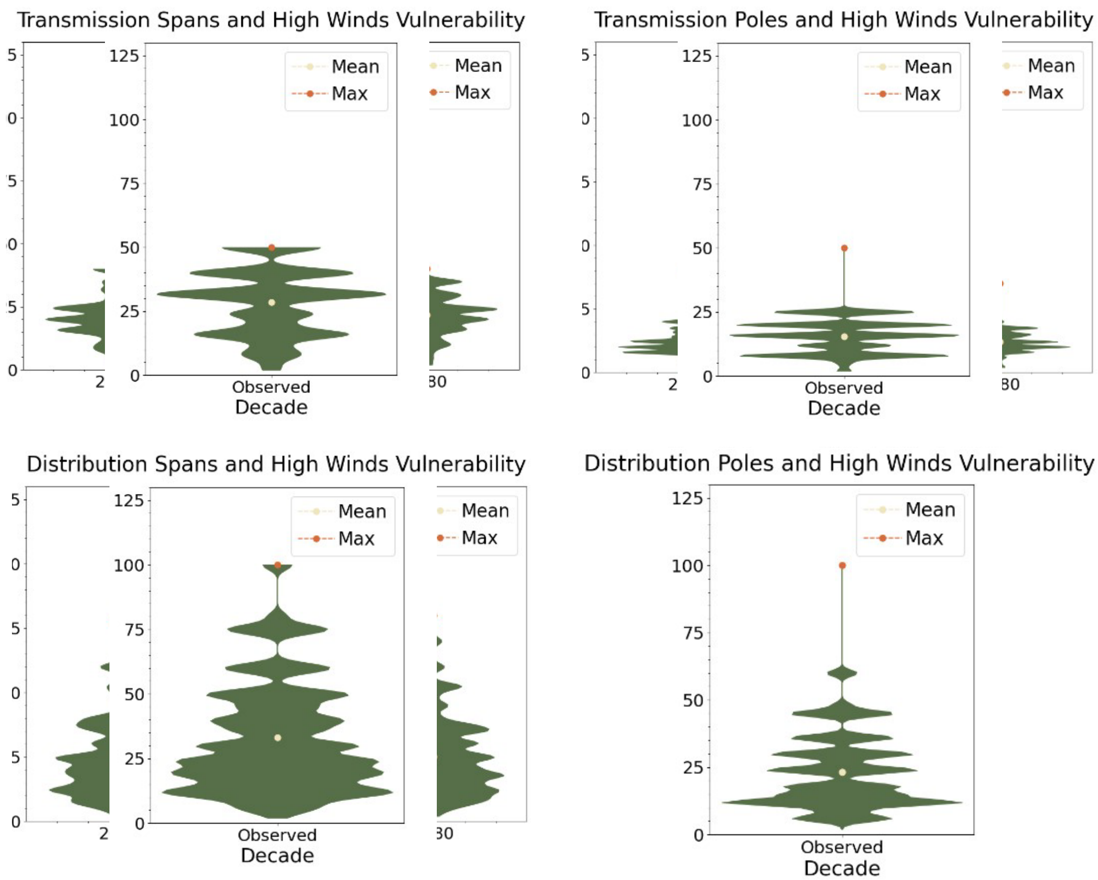
Due to the high uncertainty of future wind projections, the following reflects only observed vulnerability scores, with future conditions qualitatively assessed based on literature review in the Future Climate Projections and Exposure Results section.

This Study identified high winds as a priority vulnerability for the following asset types: transmission spans, transmission structures, distribution spans, and distribution structures. Currently, Versant has high vulnerability to winds as shown in Figure 15 and a significant increase in vulnerability in the future is possible. As highlighted in the Future Climate Projections and Exposure Results section for High Wind, there is a scientific consensus that conditions favoring extreme wind and gusts may become more prevalent. However, the extent of this increase remains highly uncertain. While daily and hourly average wind speeds are expected to show minimal change, the most intense wind speeds during tropical cyclones, extratropical cyclones, and thunderstorms are likely to rise across Maine by midcentury. This suggests that the region's already high vulnerability to extreme wind could further escalate.

- **Transmission Spans** could experience failure during high wind events, especially if the asset makes contact with surrounding vegetation, posing significant consequence, as most transmission spans have moderate to high consequence scores.
- Even though **Transmission Poles** are designed to withstand high wind events, extreme winds can result in line detachment and possible tower failure. Surrounding vegetation may also cause additional damage if contact is made.

- **Distribution Spans** may be impacted by high winds, especially if the asset makes contact with surrounding vegetation.
- **Distribution Poles** may result in line detachment and possible failure if exposed to high wind events, especially if contact is made with surrounding vegetation.

Figure 15. High wind observed vulnerability score distribution for Distribution Poles, Distribution Spans, Transmission Poles, and Transmission Spans. The spread of scores is represented by the width of the plot, with wider areas indicating a higher concentration of assets scoring within that range. The mean and maximum scores for each time horizon are shown in yellow and red, respectively.



Operational Vulnerabilities

The Study Team assessed climate vulnerabilities across eight operational areas within Versant: Vegetation Management, Environmental, Facilities, Asset Management / Transmission and Distribution Planning, Communications and Legal & Regulatory Affairs, Emergency Response, System Operations, and Workplace Safety. The analysis was conducted through interviews with operational subject matter experts, industry expertise, and analysis and application of the climate exposure results. While individual operational areas have unique climate vulnerabilities, overall, the projected changes in climate across Versant's service territory will impact all evaluated utility operational areas to some degree. Versant has already taken steps to implement climate resilience measures in some operational areas, but more measures may be needed to address the projected vulnerabilities across Versant's operations. Understanding the unique vulnerabilities each operational area faces is important when considering the most appropriate options for building resilience. The following sections provide a summary of the identified operational vulnerabilities for each operational division.

Vegetation Management

The Versant Vegetation Management program is responsible for managing vegetation along ROWs to minimize tree contact with lines which can impact safety and reliability. This program includes risk tree removal, distribution clearance, service / secondary maintenance, roadside herbicide components, and reactive service order work. Historically, aspen and balsam fir have been particularly challenging tree species for Versant's transmission and distribution lines. Versant's Vegetation Management program already prioritizes reliability and resilience measures but does not have measures specifically developed to address the risks posed by climate change. For example, the Company is pre-planning work to proactively select risk trees along the most sensitive line segments which can minimize the potential impact from events that could lead to downed trees. Given the risk trees pose to utility infrastructure, maintaining the function of the Vegetation Management program in the context of a changing climate is crucial to maintaining safety and reliability across the Versant system.

High temperatures, winter weather, and wind are expected to have the largest impact on Versant's Vegetation Management program. As temperatures increase, seasonal patterns are shifting and causing certain invasive insect species such as the emerald ash borer, to spread more widely and threaten tree health. This is projected to worsen as temperatures continue to increase. Additionally, a longer growing season and higher concentrations of atmospheric CO_2 cause trees to grow more quickly, but with lower wood density. This increased growth rate can cause trees to encroach on clearances faster than they have in the past and outgrow current trimming cycles.

The projected increase in extreme frozen precipitation and heavy snow intensity in certain parts of the service territory has the potential to threaten reliability. Significant ice accumulation can weigh down trees and lines and impact system function. Additionally, heavy, wet snow on tree limbs can cause them to break and come into contact with lines.

An increase in wind speeds across the service territory can lead to localized tree damage, resulting in contact with overhead lines or other assets.

Future increases in storm intensity could cause significant damage to the Versant system through downed trees and limbs. Increased thunderstorms and winds can lead to trees uprooting, breaking, and damaging overhead assets. Southeast winds would pose the greatest risk to the system as they are the most damaging for Versant, although current climate science projections cannot resolve specifics about wind direction with certainty.

Key actions to mitigate increased risk will include: more aggressive risk tree removal, widening of clearance zones where permission can be secured, widening of transmission rights-of-way where possible, and pre-planning of work with increased tree and limb removal on highest priority line segments.

Environmental

Versant's Environmental Department is responsible for a variety of activities, including overseeing hazardous waste disposal, spill management and cleanup from transformer leaks and other hazardous materials, and employee training on environmental matters. The Department also assists with some permitting processes, particularly those related to stormwater and hazardous waste. In recent years, notable climate events have impacted Versant's Environmental Department. For example, increased temperatures and heat waves have caused an increase in pole-mounted transformer leaks and spills, melted potential transformers[vi], and sulfur hexafluoride (SF6) breaker leaks. These incidents can impact both the reliability of the power system and compliance with environmental regulations.

Increases in precipitation could increase the risk of spills and environmental contamination, but climate change is not expected to have a significant impact on Versant's Environmental group on the whole.

Facilities

The Facilities Department manages all Company facilities, the Company fleet, the safety lab, and supplies. Some activities include testing equipment, maintaining vehicles and buildings, groundwork, and heating and cooling of buildings. The Department manages 11 buildings and several substations. In the past decades, different climate events have impacted this Department. In recent years, rain and ice have posed the biggest challenge to the Facilities Department's work. Given the large geography of the service territory, it can take a long time for the Facilities Department to travel throughout the service territory and hazardous conditions such as rain and ice can make transportation unsafe for the Facilities team and other workers. Additionally, a severe wind event caused roof damage at one of the facilities, which required repairs.

Winter weather, wind, and storms are expected to have the largest impact on Versant's Facilities. Certain areas of Versant's service territory are expected to experience an increase in extreme frozen precipitation and heavy snow intensity. Winter weather, and particularly ice, can cause poor road conditions, making it more challenging for the Facilities Department to access certain sites. Ice and heavy snow can also physically damage facility roofs and wires.

An increase in wind speeds in certain parts of the service territory can physically damage facilities and make it more challenging for the Facilities Department to access certain sites in the case of downed trees. Additionally, future increases in storm intensity could make it more challenging to restock equipment and replenish storm kits at Versant facilities due to downed trees, high winds, and other storm impacts. More intense storms could also tax the capacity of the Facilities Department, both in terms of materials and staff.

Asset Management / T&D System Planning

The Asset Management / Transmission and Distribution (T&D) System Planning Department is responsible for long-term system planning and maintenance and ensuring the reliability of transmission and

[vi] A type of instrument transformer, typically in a substation, that measures and reports voltage

distribution systems. Specifically, the group is responsible for managing a 5-year capital plan incorporating Protection and Controls (P&C) engineers, planning engineers, and substation engineers, to identify and prioritize process and system upgrades. Additionally, the Asset Management / T&D System Planning group's purview includes load studies and screenings, identification of system constraints, and load forecast modeling. Climate events that threaten the reliability of the Versant system or lead to outages have large impacts on this Department. In Versant's "Distribution Operations and Reliability" testimony for their 2022 rate case filing, the Company reported an increase in service interruption hours per storm between 2005 and 2022, indicating that, in recent decades, storm impacts have increasingly impacted system reliability.[40]

High temperature and storms are expected to have the largest impact on Versant's asset management and system planning in the future. Increases in temperature and heat events can increase failure rates and decrease the lifespans of assets. Additionally, extreme heat can impact the Department's load forecasting and capacity planning processes by increasing peak demand and requiring revised assumptions for rating equipment. 2022 data show that approximately 70% of Maine households use some form of air conditioning equipment.[41] As temperatures rise, that number could rise and lead to a significant increase in energy demand due to air conditioner use. An increase in the frequency of extreme events could lead to more frequent asset damage and failures, impacting reliability.

Communications and Legal & Regulatory Affairs

The Communications and Legal & Regulatory Affairs teams take on a variety of different roles across the Company and with external stakeholders. Responsibilities of this Department include public affairs and communications, stakeholder engagement, government relations, all of Versant's external communications, marketing and advertising, energy literacy and education, and engagement with and monitoring of the regulatory environment. Given the broad responsibilities of the Communications and Legal & Regulatory Affairs team, this Department engages with a variety of different stakeholders, partners, and governmental bodies including the Maine state legislature, Maine Public Utilities Commission, Versant customers, employees, policymakers, and other state and federal agencies.

Changes in the frequency and severity of different climate hazard events will likely require more frequent and proactive communication with customers regarding advanced warning systems, outages, restoration time estimates, and public safety announcements. Additionally, changes in climate hazards may require responding to new regulations and legislation regarding hazard response. These changes may also necessitate a revision to – or more comprehensive overhaul of – the state's traditional storm cost-recovery mechanisms to better align with current and projected circumstances. Any such changes should contemplate both effective storm-cost recovery and proactive grid hardening and resilience measures.

Emergency Response

The Emergency Response function has a variety of different responsibilities across the Company. One of the primary responsibilities is to look at near-term weather forecasts and identify any incoming weather that could impact the system. This involves weekly meetings with weather forecasting vendors and weather modeling. In the event that a storm or other emergency event is forecast, the Emergency

Response team estimates the level of impact it could cause and rates the event on a scale of 1-5. The team also determines if and when a system emergency should be declared. Depending on the event, the team also determines what type of resources are likely required during and after the storm, including staff and equipment. For storms that are likely to cause outages, this process also involves estimating the time of restoration. As the event progresses, the Emergency Response team continues to evaluate the event, assessing damage and communicating across regions as the event unfolds. After the event, the Emergency Response team may need to coordinate action items and solicit feedback. As the frequency and severity of different climate hazards shift, the functions of this Department may need to change to address new risks.

Changes in intensity of all climate hazards will likely result in more frequent activations of emergency response procedures, which can create a greater strain on staff and resources.

System Operations

Versant's System Operations Department oversees all transmission and distribution systems, including managing operations and ensuring system reliability across all voltages. The Department is responsible for real-time switching, outage management, and coordination with Central Dispatch, which oversees crew scheduling, outage reporting, and planned work during business hours. A critical component of the system is the use of Supervisory Control and Data Acquisition (SCADA), which enables remote monitoring and control during system issues. The System Operations Department also monitors the weather and prepares for any potential storm events, by adjusting staff and working with grid operators to prepare the system for incoming weather events. All of these functions may be impacted by projected climate change.

High temperature and storms are likely to have the largest impact on Versant's System Operations in the future. As temperatures are projected to increase, thermal equipment ratings and emergency limits for lines may be more frequently reached or exceeded. Additionally, rising electric demand due to heat can also add stress to the system and impact system reliability. Projected increases in storm intensity could lead to a greater risk of asset damage or failure and threaten system reliability. Additionally, increased incidence of lightning could impact line availability.

Workplace Safety

The Safety Department is responsible for creating Versant's culture of safety. This involves proactive incident reporting, development of safe work practices, corrective actions, safety training during employee onboarding, and compliance training. This Department's staff include a manager, a superintendent of safety, field specialists, a safety compliance and training specialist, technicians, and a new safety education program specialist. The Safety Department is constantly evolving to better meet the needs of Versant employees and to emphasize safety across the Company in response to shifting hazards. Recently, changes have involved updating the safety management system action plan, enhancing safety compliance training, implementing the Edison Electric Institutes Safety Classification model for categorizing incidents, and developing a 3-year plan to implement Human Organizational Performance (HOP) centered on building capacity into systems to better protect employees. This Department also coordinates public trainings with relevant external partners such as first responders and logging companies. They also engage in training for school-aged children on electrical safety.

High temperature is likely to have the largest impact on Versant's worker safety. As the frequency and severity of chronic and acute heat increases, the biggest concern is increasing the availability of Personal Protective Equipment (PPE) for line workers and modifying trainings to incorporate temperature changes. It is also important to build awareness into Safety Trainings so employees are aware of what to do when exposed to high temperatures and extreme heat. Shifts in the intensity of storms could also create riskier working conditions for field crews tasked with system repairs.

Resilience Measures

Over the years, Versant has proactively developed programs to improve electric service for its customers across the service territory. In 2018, Versant launched a reliability improvement plan which brought with it additional benefits to system resilience, and in 2023, published a Climate Change Resilience Plan, identifying key initiatives, such as distribution hardening, distribution automation and enhanced vegetation management to drive substantial improvements in resilience. Since 2018, Versant has invested over $30 million annually in these programs. In October 2024, in partnership with the Maine Governor's Office and Central Maine Power, Versant was awarded a $65 million grant for the Flexible Interconnections and Resilience for Maine (FIRM) project. This initiative aims to strengthen grid stability and improve grid management across the state.

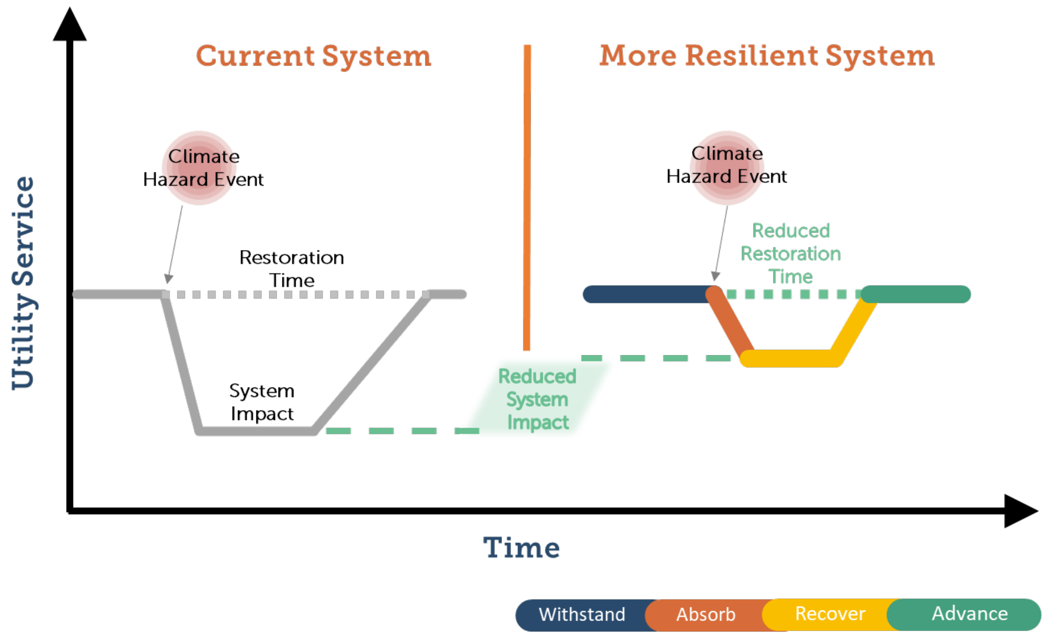
This analysis builds on Versant's past and ongoing climate resilience efforts. The following sections present resilience measures aimed at directly addressing the specific vulnerabilities identified in this Study. For each priority asset-hazard combination, strategies are proposed to mitigate associated risks. These resilience measures were developed by Versant's subject matter experts with input from industry experts, incorporating best practices and aligning with Versant's ongoing resilience initiatives.

Resilience Framework

The complexity of climate risks and their potential impacts on Versant's assets and operations requires a comprehensive, multi-pronged approach to resilience. To support Versant's resilience goals, the four-dimensional resilience framework shown in Figure 16 provides a structured approach for identifying targeted resilience measures. The framework's four key objectives—withstand, absorb, recover, and advance—guide the selection of resilience strategies that address specific vulnerabilities across Versant's assets and operations and ultimately strengthen the company's capabilities in each of these resilience dimensions:

- **Withstand** – Enhance the system's ability to resist direct impacts from climate hazards by reinforcing physical structures and implementing protective measures to minimize the system's exposure and sensitivity to such hazards.
- **Absorb –** Increase the system's ability to anticipate and absorb with minimal disruption the adverse impacts of climate hazards.
- **Recover** – Improve the system's ability to quickly respond to and recover from a climate hazard event, ensuring a quick return to normal operations.
- **Advance –** Expand the system's capabilities to continuously evolve and strengthen in response to the changing threat landscape, incorporating lessons learned and proactively addressing emerging risks.

Figure 16. System performance before and after resilience investments and the associated dimensions of the resilience framework.



Potential Resilience Measures

To build on its existing initiatives and to address the identified vulnerabilities, Versant has developed a set of resilience strategies that includes both asset-focused and operational measures. Several resilience measures were identified for each priority vulnerability, allowing flexibility in strengthening system resilience in the most cost-effective manner. The tables below outline proposed resilience measures organized by asset type and hazard. Each measure is also classified according to the specific resilience framework dimension it supports—withstand, absorb, recover, or advance.

Transmission Spans and Structures

Table 10. Proposed resilience measures for transmission spans and structures.

Hazard	Proposed Resilience Measures	Framework Dimension
Wildfire, Winter Weather, Wind	Targeted undergrounding of key sections of lines	Withstand
Wildfire, Winter Weather, Wind	Increase spare inventory and establish robust supply chain agreements for critical assets	Recover
Wildfire, Winter Weather, Wind	Install covered conductors on targeted line segments	Withstand
Winter Weather, Wind	Expand transmission corridor widths to minimize vegetation contact	Withstand
Winter Weather	Enhance situational awareness systems, such as fault indicators	Absorb, Advance
Winter Weather	Reinforce structures in areas with long spans or river crossings	Withstand
Winter Weather	Deploy ice rolling technology to prevent ice accumulation	Withstand

Wildfire	Widen right of ways (ROW) widths to contain and limit wildfires	Withstand, Absorb
Wildfire	Enhance vegetation management within ROWs, with a focus on brush maintenance	Advance
Wildfire	Assess flammable ground cover; elevate line heights in high-risk areas	Withstand, Advance
Wildfire	Apply fire retardant coatings to wooden structures	Withstand
Wildfire	Replace wooden poles with fire-resistant steel or composite poles	Withstand
Wildfire	Harden infrastructure to minimize the risk of wildfire ignition due to asset failure	Withstand
Wildfire	Establish procedures and training for Public Safety Power Shutoffs (PSPS) during high risk weather	Advance, Absorb
Wildfire	Implement advanced fault detection methods (e.g., early fault, high impedance)	Absorb
Wildfire	Deploy a combination of cameras, sensors, weather stations and maps in high wildfire risk areas	Withstand, Absorb
Wildfire	Add inspection items for wildfire risk	Advance
Wildfire	Formalize coordination efforts with state fire services	Absorb
Wildfire	Implement wildfire-specific public safety trainings for staff	Advance
Wildfire	Develop a fire mitigation plan in collaboration with state agencies	Advance
Wildfire	Replace expulsion fuses with non-expulsion fuses in targeted high-risk areas	Absorb
Wind	Reinforce structures	Withstand
Wind	Implement targeted vegetation management using satellite imagery, LiDAR and AI/ML	Withstand, Advance
Wind	Coordinate with municipalities to set up warming stations, linked to outage restoration map	Absorb
Heat	Targeted energy efficiency/targeted demand response	Absorb
Heat	Plan for reconductoring to increase capacity	Withstand
Heat	Improve voltage control with solutions like capacitor banks and dynamic voltage regulators (DVARs)	Withstand
Heat	Add additional feeders to prevent system overloading	Absorb
Heat	Use distributed energy resources (DERs) for load management	Absorb
Heat	Implement dynamic line rating (DLR) for increased capacity	Absorb, Advance
Heat	Deploy High Temperature Low Sag (HTLS) conductors	Withstand

Transmission Equipment

Table 11. Proposed resilience measures for transmission equipment.

Hazard	Proposed Resilience Measures	Framework Dimension

Winter Weather	Identify shelters or recharging stations on Versant's outage restoration maps, or provide resource links via the Versant website	Absorb
Winter Weather	Implement fault location, isolation, and service restoration (FLISR) scheme to further sectionalize the system	Absorb, Recover
Winter Weather	Ensure all substation equipment has proper heating equipment for cold conditions	Withstand
Wildfire	Implement vegetation cutbacks and establish designated travel zones	Withstand
Heat	Upgrade design standards to utilize higher capacity equipment	Withstand, Advance
Heat	Transfer load to other circuits during periods of high demand	Absorb
Heat	Upgrade existing infrastructure to higher capacity equipment	Withstand
Heat	Implement targeted energy efficiency and demand response programs	Absorb
Heat	Conduct feasibility studies on transferring load to other circuits	Advance, Absorb
Heat	Collaborate with municipalities to set up cooling stations at locations linked to Versant's outage restoration maps	Absorb

Distribution Spans and Poles

Table 12. Proposed resilience measures for distribution spans and poles.

Hazard	Proposed Resilience Measures	Framework Dimension
Wildfire, Winter Weather, Wind	Targeted undergrounding of critical line segments in areas with favorable ground conditions	Withstand
Wildfire, Winter Weather, Wind	Increase spare inventory and strengthen supply chain agreements for critical assets	Recover
Winter Weather, Wind	Deploy covered conductors on targeted line segments	Withstand
Winter Weather, Wind	Install backup battery or microgrid solutions in selected areas	Recover
Winter Weather, Wind	Implement targeted vegetation management using satellite imagery, LiDAR and AI/ML, integrated with a damage assessment process	Withstand, Advance
Winter Weather, Wind	Implement fault location, isolation, and service restoration (FLISR) scheme to further sectionalize the system	Absorb, Recover
Winter Weather, Wind	Continue integrating SCADA-controlled equipment for enhanced system automation and monitoring	Absorb, Recover, Advance
Winter Weather, Wind	Update pole design standards to use stronger material	Withstand, Advance
Winter Weather, Wind	Reinforce existing poles	Withstand

Winter Weather, Wind	Strategically replace wooden poles with steel or composite structures	Withstand
Winter Weather, Wind	Expand distribution corridor widths in high-risk areas	Withstand
Winter Weather	Deploy ice rolling technology to prevent ice accumulation	Withstand
Winter Weather	Install mechanical fuses with breakaway connectors	Absorb
Wildfire	Widen ROW to improve access to equipment	Recover
Wildfire	Establish procedures and training for Public Safety Power Shutoffs (PSPS) during high-risk weather.	Absorb
Wildfire	Establish early fault detection systems to identify and address potential issues before they escalate	Withstand, Absorb

Distribution Equipment

Table 13. Proposed resilience measures for distribution equipment.

Hazard	Proposed Resilience Measures	Framework Dimension
Winter Weather, Wind	Implement targeted vegetation management using satellite imagery, LiDAR and AI/ML	Withstand, Advance
Winter Weather, Wind	Implement a Fault location, isolation, and service restoration (FLISR) scheme to further sectionalize the system	Absorb, Recover
Winter Weather	Replace legacy equipment with modern dead-front design equipment	Withstand
Wind	Adopt new design standards (shorten spans, dead-ending lengths) to improve structural resilience	Withstand
Wind	Reinforce structures using line dampening techniques	Withstand

Substation Equipment

Table 14. Proposed resilience measures for substation equipment.

Hazard	Proposed Resilience Measures	Framework Dimension
Heat	Upgrade design standards to incorporate higher capacity equipment	Withstand
Heat	Deploy DERs and DER management software for effective load management	Absorb, Recover
Heat	Install additional cooling mechanisms (fans, pumps, fins) to regulate equipment temperatures and prevent overheating	Absorb
Heat	Implement targeted energy efficiency and demand response programs	Absorb
Heat	Increase spare inventory and strengthen supply chain agreements for critical assets	Recover
Heat	Add additional transformers to prevent overloading	Withstand
Heat	Replace existing transformers with larger, higher-capacity units	Withstand
Heat	Deploy additional mobile substation equipment (e.g., switchgear, transformers, substations, batteries, etc.)	Recover

Heat	Utilize SCADA-based load management to transfer load between substations	Absorb
Heat	Implement real-time monitoring and adaptive control using digital twins, dynamic ratings, enhanced SCADA, and data analytics	Advance
Heat	Establish microgrids	Absorb, Recover
Heat	Improve documentation of contingency plans tailored to each substation	Recover

All Assets

Table 15. Proposed resilience measures for all assets.

Hazard	Proposed Resilience Measures	Framework Dimension
All Hazards	Enhance communication and coordination with emergency management, municipalities, first responders, and customers	Advance, Recover
All Hazards	Improve resiliency and durability of communications infrastructure to support critical grid operations	Withstand
All Hazards	Enhance situational awareness through the integration of predictive weather modeling and real-time data	Absorb, Advance
Winter Weather, Heat	Enhance the mobile workforce management plan for both internal and contract resources	Recover

Criteria for Prioritization

This section outlines key considerations for evaluating and prioritizing potential resilience measures, including cost-effectiveness of the proposed strategies, their alignment with existing programs, Versant's broader strategic goals and stakeholder expectations, resource availability, implementation feasibility, and timelines. Using a multi-criteria framework for evaluating and prioritizing resilience measures not only provides a structured and clear process for decision-making, but also ensures that resources are directed toward measures that will have the most significant impact – maximize cost-effectiveness, while aligning with strategic priorities and addressing stakeholder and customer needs. Below we describe some of these considerations in more detail.

- **Efficacy of Resilience Measures:** One of the key evaluation and prioritization criteria is the degree to which a measure directly addresses the identified climate vulnerability and its overall impact in mitigating that vulnerability. Additionally, measures that address more than one vulnerability and provide greater resilience benefits may be considered more effective and, as a result, prioritized.
- **Synergies with Existing Programs:** Versant intends to prioritize resilience strategies that align with and complement ongoing initiatives, maximizing their impact and ensuring that the resources are leveraged more efficiently. Additionally, the company will prioritize strategies that offer multiple or co-benefits, such as increasing both reliability and resilience.

- **Cost and Funding Availability:** External funding, including federal grants, plays a critical role in making resilience investments feasible. Versant's recent success in obtaining resilience-focused federal funding is a great example of Versant's commitment to securing resources that support community resilience. When prioritizing resilience measures, the total cost of the proposed investments, especially for high-cost initiatives like undergrounding, will be assessed against the potential benefits for resilience.
- **Scalability and Timelines:** Prioritization should also take into account the immediacy of the risks and vulnerabilities that require mitigation. Certain vulnerabilities may require immediate or near-term attention, and some measures may provide immediate benefits. Other measures are designed to address evolving vulnerabilities and are better suited for longer-term implementation. Prioritization helps balance these timelines, providing a clear roadmap for building resilience over time.

Future Work

This Study, including its vulnerability assessment findings and potential resilience measures, will inform Versant's future resilience planning efforts. Building on these results, the company plans to develop a comprehensive climate change resilience plan, which will include a detailed prioritization framework to guide the implementation of resilience measures in a way that maximizes their impacts cost-effectively.

As Versant moves forward in its resilience journey, the company intends to continuously leverage new data, insights, and advanced technologies to refine its approach to resilience planning.

Possible future climate change initiatives Versant may undertake include:

- Adoption of a climate resilience design guideline to inform system planning.
- Incorporation of climate change risk into investment prioritization.
- Further studies on financial risks and benefits of adaptation activities.
- Integration of climate resilience concepts into grid modernization and integrated grid planning initiatives.
- Leveraging smart grid data to better understand climate and weather's impact on the system.
- Analysis of average asset useful life to identify sources of accelerated degradation.

Next Steps and Conclusion

The goal of this Study was to assess the vulnerability of different Versant assets and operations to priority climate hazards and develop resilience measures that may help mitigate the identified vulnerabilities. The vulnerability assessment evaluated distribution equipment, distribution transformers, distribution spans, distribution poles and structures, substation reclosers, regulators, and breakers, substation transformers, transmission poles and structures, transmission equipment, transmission spans, and eight Versant operational divisions. For individual assets within these families and for each operational division, the Study Team evaluated vulnerability to the following climate hazards: extreme heat, winter weather, wildfire, and high winds.

The greatest vulnerabilities identified in this Study were found to be vulnerabilities to extreme heat, wildfire, and high winds. Transmission spans and extreme heat, transmission spans and high winds, transmission poles and wildfire, and transmission pole and high winds. Vulnerabilities across operational divisions vary by division, but all operational divisions face some vulnerability to climate change.

Versant is committed to delivering electricity safely and reliably to customers. The climate vulnerabilities identified in this Study could have significant implications for the Company's ability to meet this commitment. Thus, the resilience measures proposed in this Study are intended to offer potential options for mitigation of some of the consequences associated with specific climate vulnerabilities. This Study and the potential resilience measures it includes are intended to serve as a guide from which Versant can launch future resilience planning efforts and implementation framework for specific resilience strategies. Additionally, grounding the vulnerability assessment and associated resilience strategies in climate science developed specifically for Versant is intended to help with more efficient resource allocation to prioritize the greatest, most pressing vulnerabilities and work from there.

Appendix A: Exposure Scoring Rubrics

Exposure, or the degree to which assets or regions may experience climate hazards based on their physical locations, is crucial for assessing vulnerability and risk to inform planning decisions. The following rubrics are proposed for scoring the exposure of Versant's assets to climate hazards. Exposure scores will be combined with sensitivity and consequence scores to assess asset vulnerability.

Extreme Heat

Table 1A. Exposure Scoring Rubric for Extreme Heat Variables

	Extreme Heat			
Weighting	*50%*		*50%*	
Thresholds	*Days with maximum temperature above 30°C (86°F)*	*Exposure Score*	*Number of 2+ day heat waves per year exceeding daily max temperature 86°F*	*Exposure Score*
	0-5 days	0	0-2	0
	5-10 days	1	2-4	1
	10-15 days	2	4-6	2
	15-20 days	3	6-8	3
	20-30 days	4	8-10	4
	30+ days	5	10+	5

Wildfire and Drought

Table 2A. Exposure Scoring Rubric for Wildfire and Drought Variables

	Wildfire and Drought			
Weighting	*50%*		*50%*	
Thresholds	*Annual change in the number of days above 95th percentile FWI*	*Exposure Score*	*Historical Fire Weather Probabilities*	*Exposure Score*
	<=0 day increase	0	Probability = 0	0
	0-5 day increase	1	0-0.0025	1
	5-15 day increase	2	0.0025-0.005	2
	15-25 increase	3	0.005-0.0075	3
	25-40 day increase	4	0.0075-0.01	4
	>40 day increase	5	>0.01	5

Winter Weather

Table 3A. Exposure Scoring Rubric for Winter Weather Variables

	Winter Weather	
Thresholds	*Max frozen precipitation intensity*	*Exposure Score*
	0-.25 inches	0
	0.25-0.5 inches	1
	0.5-.8 inches	2
	0.8-1.1 inches	3
	1.1-1.5 inches	4
	>1.5 inches	5

High Winds

Table 4A. Exposure Scoring Rubric for High Winds Variables

	High Winds	
Thresholds	*Observed wind gust values based on range across service territory*	*Exposure Score*
	<40 mph	0
	40-50 mph	1
	50-60 mph	2
	60-65 mph	3
	65-70 mph	4
	70+ mph	5

Appendix B: Sensitivity Scoring Rubrics

Transmission Spans

Table 1B. Sensitivity Score for Overhead Transmission Spans

	Transmission Spans (Winter/Ice, Wildfire, Heat)	
Thresholds	*Installation Year*	*Sensitivity Score*
	2016-Present	1
	2006-2015	2
	1996-2005	3
	1986-1995	4
	1985 and prior	5

	Transmission Spans (Wind)	
Thresholds	*Installation Year*	*Sensitivity Score*
	1986-Present	1
	1985 and prior	2
		3
		4
		5

Transmission Poles/Structures

Table 2B. Sensitivity Scores for Transmission Poles/Structures

	Transmission Poles/Structures (Wind)	
Thresholds	*Pole Type*	*Sensitivity Score*

	Steel, FRP, SPP, SPC, RPP, SPA, CCA, unknown, SP, other, WRC, CH, JP	1
	EC, Other	2
		3
		4
		5

	Transmission Poles/Structures (Winter/Ice)	
Thresholds	*Pole Type*	*Sensitivity Score*
	Steel, FRP	1
		2
	SPP, SPC, RPP, SPA, CCA, unknown, SP, other, WRC, CH, JP	3
		4
	EC, Other	5

	Transmission Poles/Structures (Wildfire)	
Thresholds	*Pole Type*	*Sensitivity Score*
	Steel, FRP	1
		2
		3
		4
	EC, Tree, SPP, SPC, RPP, SPA, CCA, unknown, SP, other, WRC, CH, JP	5

Transmission Equipment

Table 3B. Sensitivity Scores for Transmission Equipment (switches, regulators, and reclosers)

	Transmission Switches (Winter/ice, Wind, Wildfire)

Thresholds	All assets	*Sensitivity Score*
		3

	Transmission Regulators and Reclosers (Heat, Winter/ice, Wind, Wildfire)	
Thresholds	Health Index	Sensitivity Score
	91+	1
	71-90	2
	51-70	3
	31-50	4
	30 and below	5

Distribution Spans

Table 4B. Sensitivity Scores for Distribution Spans

	Distribution Spans	
Thresholds	*Installation Year*	*Sensitivity Score*
	2016-Present	1
	2006-2015	2
	1996-2005	3
	1986-1995	4
	1985 and prior	5

Distribution Poles/Structures

Table 5B. Sensitivity Scores for Distribution Poles/Structures

	Distribution Poles/Structures (Winter/Ice and Wind)	
Thresholds	*Pole Type*	*Sensitivity Score*
	Steel, FRP	1
		2
	SPP, SPC, RPP, SPA, CCA, unknown, SP, other, WRC, CH, JP	3
		4
	EC, Other	5

Distribution Transformers

Table 6B. Sensitivity Scores for Distribution Transformers

	Distribution Transformers	
Thresholds	All assets	*Sensitivity Score*
		3

Distribution Equipment

Table 7B. Sensitivity Scores for Distribution Equipment (switches, regulators, reclosers)

	Distribution Switches	
Thresholds	All assets	*Sensitivity Score*
		3

	Distribution Regulators and Reclosers	
Thresholds	*Health Index*	*Sensitivity Score*
	91+	1

	71-90	2
	51-70	3
	31-50	4
	30 and below	5

Substation Equipment and Transformers

Table 8B. Sensitivity Scores for Substation Equipment Transformers

	Substation Equipment and Transformers	
Thresholds	*Health Index*	*Sensitivity Score*
	91+	1
	71-90	2
	51-70	3
	31-50	4
	30 and below	5

Appendix C: Consequence Scoring Rubrics

All Assets

Table 1C. Consequence Score for all assets

	All Assets	
Thresholds	*Risk Score*	*Consequence Score*
	0-10	1
	11-100	2
	101-1,000	3
	1,001-5,000	4
	>5,000	5

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