



5.4.4 EXTREME TEMPERATURE

This section provides a profile and vulnerability assessment for the extreme temperature hazard for Putnam County.

5.4.4.1 Profile

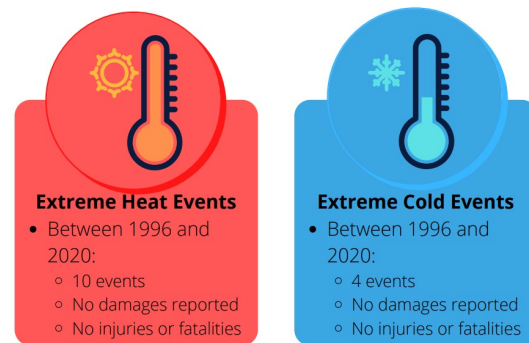
This section provides profile information including description, extent, location, previous occurrences and losses, and the probability of future occurrences for the extreme temperatures hazard.

Description

Extreme temperature includes both heat and cold events, which can have a significant impact to human health, commercial/agricultural businesses and primary and secondary effects on infrastructure (e.g., burst pipes and power failure). What constitutes *extreme cold* or *extreme heat* can vary across different areas of the country, based upon what the population is accustomed. The potential issues identified with extreme temperature events include:

- Prolonged extreme heat events can lead to drought conditions and impact the drinking water supply for residents.
- The aging population of the county may result in an increase of residents vulnerable to extreme temperature events as the senior population is less able to withstand extreme temperatures due to age and health conditions.
- Extreme temperature events can damage aging infrastructure and buildings as highways and roads are damaged by excessive heat as the asphalt softens, and roadways can be damaged from extreme cold temperatures causing frost heaving of road infrastructure.
- In 2016, the Putnam County Department of Social Services estimated that there were 38 individuals experiencing homelessness in the County. Homeless individuals experience an acute vulnerability to extreme temperatures owing to the lack of sheltering and exposure to the elements (Lohud 2017).

Figure 5.4.4-1. Extreme Temperature Events in Putnam County.



Source: NOAA-NCEI 2020

During an extreme temperature event, Putnam County and New York State provide resources for populations in need of warming or cooling centers. Information on the locations of the centers is posted on the County and municipal websites.

Extreme Cold

Extreme cold events occur when temperatures drop significantly below normal in an area for an extended period of time. No specific definition exists for Extreme Cold, temperatures at or below zero degrees for an extended time characterize a Coldwave event in New York State (NYS DHSES, 2019).

Extreme Heat

Extreme heat is defined as temperatures which hover 10 degrees or more above the average high temperature for a region and that last for several weeks (CDC 2016). An extended period of extreme heat of three or more consecutive days is typically called a heat wave and is often accompanied by high humidity (NWS 2013d). Humid or muggy conditions occur when a *dome* of high atmospheric pressure traps hazy, damp air near the



ground. Extreme hot days in New York State are defined as individual days with maximum temperatures at or above 90 °F or at or above 95 °F. Heat waves are defined as three consecutive days with maximum temperatures above 90 °F (NYS DHSES 2019).

Extent

Extreme Cold

The extent (severity or magnitude) of extreme cold temperatures generally are measured through the Wind Chill Temperature (WCT) Index. The WCT Index uses advances in science, technology, and computer modeling to provide an accurate, understandable, and useful formula for calculating the dangers from wind chill. For details regarding the WCT Index, refer to: <http://www.nws.noaa.gov/om/winter/windchill.shtml>. The WCT Index is presented in Figure 5.4.4-3.

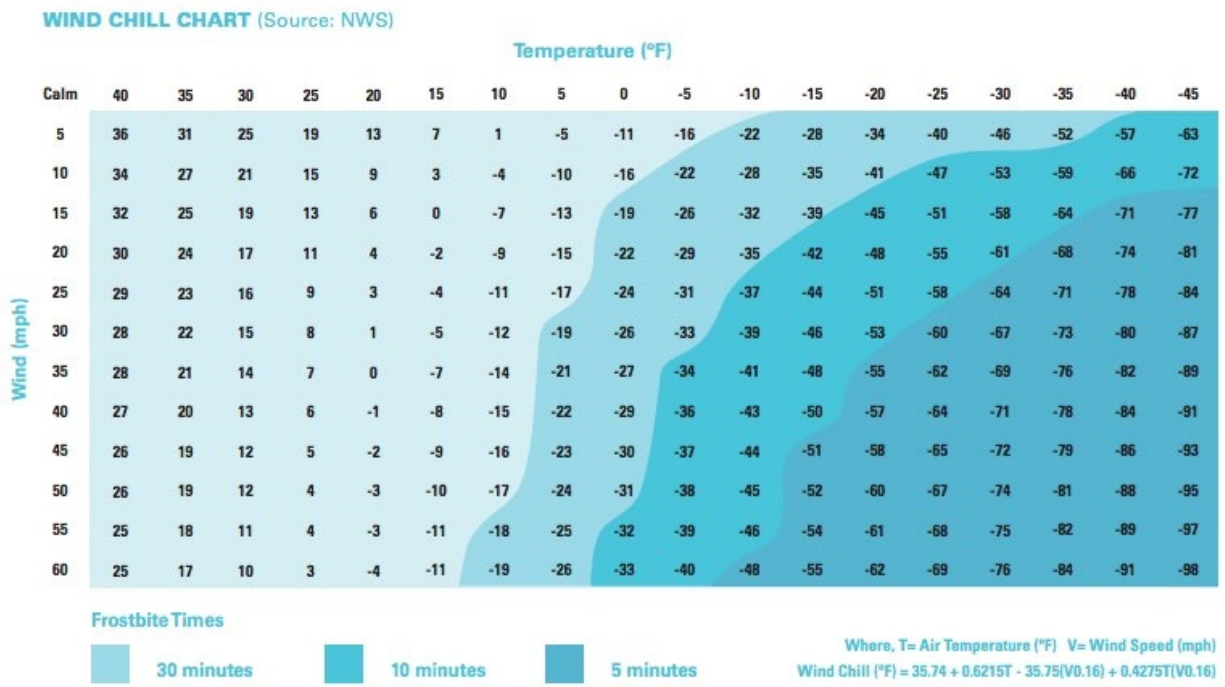
Figure 5.4.4-2. Wind Chill

*Wind Chill
At a Glance*

The wind chill is how cold it feels on your skin when the wind is factored in. It may also be referred to as the "feels-like" temperature. Bitterly cold wind chills increase your risk of developing frostbite and hypothermia.

Source: The Weather Channel (2019)

Figure 5.4.4-3. WCT Index



Source: NYS DHSES, 2019

The National Weather Service (NWS) provides alerts when Wind Chill indices approach hazardous levels. Table 5.4.4-1 explains these alerts.

Table 5.4.4-1. National Weather Service Alerts for Extreme Cold

Alert	Criteria
Wind Chill Advisory	NWS issues a wind chill advisory when seasonably cold wind chill values, but not extremely cold values are expected or occurring.
Wind Chill Watch	NWS issues a wind chill watch when dangerously cold wind chill values are possible.



Alert	Criteria
Wind Chill Warning	NWS issues a wind chill warning when dangerously cold wind chill values are expected or occurring.

Source: NWS 2018b

Extreme Heat

The extent of extreme heat temperatures is measured through the Heat Index, identified in Figure 5.4.4-5. The Heat Index was created by the NWS to accurately measure apparent temperature of the air as it increases with the relative humidity. Temperature and relative humidity are needed to determine the Heat Index. Once each value is acquired, the Heat Index is the corresponding number of both the values, as seen in Figure 5.4.4-5. This provides a measure of how temperatures feel; however, the values are devised for shady, light wind conditions. Exposure to full sun can increase the index by up to 15 degrees (NYS DHSES 2019).

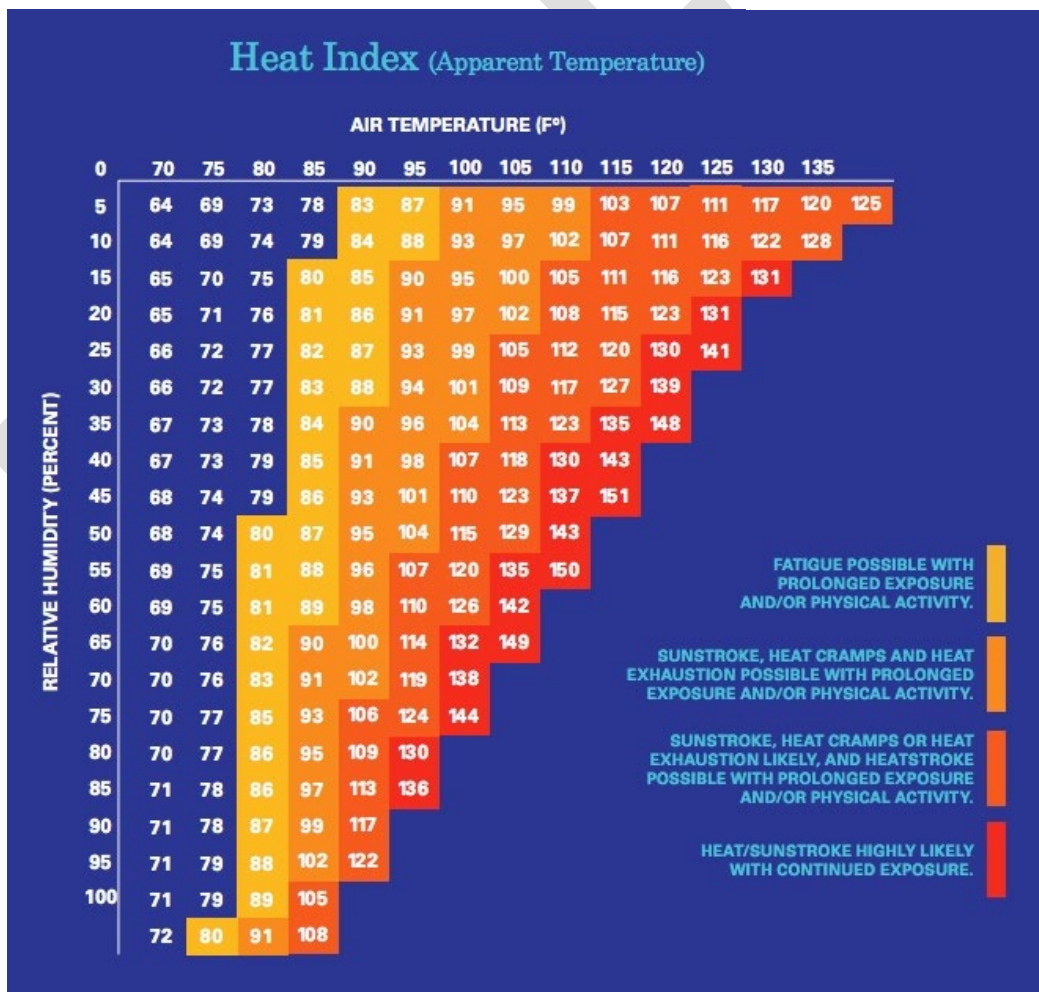
Figure 5.4.4-4. Relative Humidity at a Glance

Relative Humidity At a Glance

Relative humidity is the amount of moisture in the air at a certain temperature compared to what the air can "hold" at that temperature...it is measured as a percentage or ratio of the amount of water vapor in a volume of air RELATIVE to a given temperature and the amount it can hold at that given temperature. Warm air can hold more moisture than cold air.

Source: Molekule.com, 2018

Figure 5.4.4-5. Heat Index Chart



Source: NYS DHSES, 2019





The NWS provides alerts when Heat Indices approach hazardous levels. Table 5.4.4-2 explains these alerts.

Table 5.4.4-2. National Weather Service Alerts

Alert	Criteria
Heat Advisory	Criteria for a Heat Advisory in Pennsylvania is a heat index of 100-104 °F and in New York 95-104 °F. The heat index has to remain at or above criteria for a minimum of 2 hours. Heat advisories are issued by county when any location within that county is expected to reach criteria.
Excessive Heat Watch	Issued when Heat Warning criteria is possible (50-79%) 1 to 2 days in advance
Excessive Heat Warning	Criteria for an Excessive Heat Warning is a heat index of 105 °F or greater that will last for 2 hours or more. Excessive Heat Warnings are issued by county when any location within that county is expected to reach criteria.

Source: NWS, 2020

Location

According to the New York State Hazard Mitigation Plan (2019), excessive heat can occur anywhere within the State of New York. Excessive heat incidents are widespread, even if there are localized cooler areas. The State has varied summers. Warmer conditions are experienced in the south, whereas more mild conditions experienced elsewhere in the State.

New York State is divided into 10 climate divisions: Western Plateau, Eastern Plateau, Northern Plateau, Coastal, Hudson Valley, Mohawk Valley, Champlain Valley, St. Lawrence Valley, Great Lakes, and central Lakes. Putnam County is located in the Hudson valley climate division.

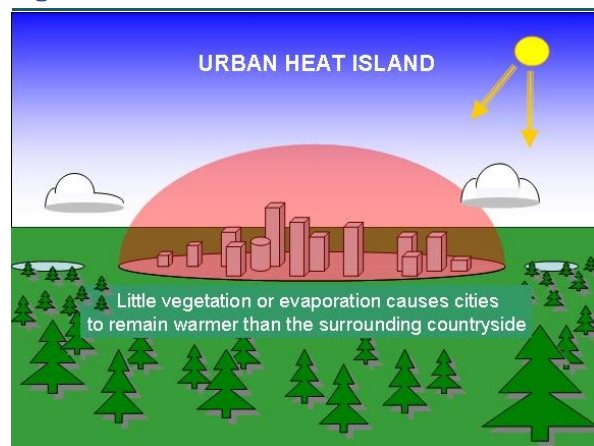
Extreme Cold

Extreme cold temperatures occur throughout most of the winter season and generally accompany most winter storm events throughout the state. When atmospheric pressures are higher than normal and Arctic air masses enter the area, extreme cold temperatures impact Putnam County, flowing southward from central Canada or the Hudson Bay (MRCC 2020, NWS 2020).

Extreme Heat Temperatures

Extreme heat temperatures degrees occur throughout the county for most of the summer season, except for areas with high altitudes. High-pressure systems can move off the Atlantic coast and become stagnant for several days. A persistent airflow from the southwest or south affects the weather in the state. This circulation brings the very warm, often humid weather of the summer season and the mild, more pleasant temperatures during the fall, winter, and spring seasons (MRCC 2020). Areas of dense urban development are prone to the urban heat island effect phenomenon that can further raise temperatures.

Figure 5.4.4-6. Urban Heat Island



Source: weatherquestions.com, 2019

Previous Occurrences and Losses

Extreme temperature events occur annually in Putnam County. To identify the events in Putnam County, the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information



(NCEI) Storm Events database were examined. The database records and defines extreme temperature events as follows:

- Cold/Wind Chill is reported in the NOAA-NCEI database when a period of low temperatures or wind chill temperatures reach or exceed locally or regionally defined advisory conditions (typical value is negative 18 °F or colder).
- Excessive Heat is reported in the NOAA-NCEI database whenever heat index values meet or exceed locally or regionally established excessive heat warning thresholds.
- Extreme Cold/Wind Chill is reported in the NOAA-NCEI database when a period of extremely low temperatures or wind chill temperatures reaches or exceeds locally or regionally defined warning criteria (typical value around negative 35 °F or colder).
- Heat is reported in the NOAA-NCEI database whenever heat index values meet or exceed locally or regionally established advisory thresholds.

FEMA Disaster Declarations

Between 1954 and April 2020, New York State was not included in any major disaster (DR) or emergency (EM) declarations due to extreme temperatures (heat or cold). However, during the same time period, the FEMA included Putnam County in five winter storm-related DR or EM declarations classified as one or a combination of the following disaster types: severe winter storm, snowstorm, snow, ice storm, winter storm, and blizzard (Table 5.4.4-3.). Extreme cold temperatures are often associated with these disaster types.

Table 5.4.4-3. Winter Storm Related Disaster (DR) and Emergency (EM) Declarations 1954-2018

Disaster Number	Declaration Date	Event Date	Incident Type	Title
EM-3299	December 18, 2008	December 11, 2008 -- December 31, 2008	Severe Storm(s)	Severe Winter storm
EM-3184	March 27, 2003	February 17, 2003 -- February 18, 2003	Snow	Snow
DR-1083	January 12, 1996	January 6, 1996 -- January 12, 1996	Snow	Blizzard of '96 (Severe Snow Storm)
EM-3107	March 17, 1993	March 13, 1993 -- March 17, 1993	Snow	Severe Blizzard
DR-801	November 10, 1987	October 4, 1987	Snow	Severe Winter Storm

Source: FEMA 2020
 DR Major Disaster Declaration (FEMA)
 EM Emergency Declaration (FEMA)
 FEMA Federal Emergency Management Agency

USDA Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2015 and 2020, Putnam County was not included in the any USDA declarations involving extreme temperatures.

Previous Events

Information regarding specific details of temperature extremes in Putnam County is limited. Previous occurrences and losses associated with extreme temperature events are limited as a result. For this 2020 HMP update, extreme temperature events were summarized from 2015 to 2020 and are identified in Table 5.4.4-5. For events prior to 2012, refer to Appendix E (Supplementary Data).





Table 5.4.4-4. Extreme Temperature Events in Putnam County, 2015 to 2020

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Event Details
August 12-13, 2016	Excessive Heat	N/A	N/A	Excessive heat affected large sections of southern New York as a high pressure system stayed over the Atlantic Ocean and brought hotter and more humid air into the region. The heat index reached 110 degrees at Montgomery Airport and 107 degrees in Poughkeepsie.

Source(s): NYS DHSES 2019; FEMA 2020; NWS 2016; NOAA-NCEI 2020

Note: Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table.

- FEMA Federal Emergency Management Agency
- NOAA-NCEI National Oceanic Atmospheric Administration – National Centers for Environmental Information
- NWS National Weather Service
- NYS DHSES New York State Department of Homeland Security and Emergency Services
- N/A Not Applicable
- USDA U.S. Department of Agriculture

Climate Change Projections

The frequency and duration of heat waves (three or more consecutive days with maximum temperatures at or above 90 °F) is expected to increase (Table 5.4.4-5) in the coming decades due to climate change. Overall warmer temperatures will cause extreme cold events (defined both as the number of days per year with minimum temperature at or below 32 °F and those at or below 0 °F) to decrease in frequency as average temperatures rise (NYSERDA 2011). With the increase in temperatures, heat waves will become more frequent and intense, increasing heat-related illness and death and posing new challenges to the energy system, air quality and agriculture. Table 5.4.4-5 displays the projected changes in these events and includes the minimum, central range and maximum days per year.

Table 5.4.4-5. Changes in Extreme Events in Region 5 – Heat Waves and Drought Conditions

Event Type (2020s)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
Days over 90 degrees Fahrenheit (°F) (10 days)	14	17 to 22	23
# of Heat Waves (1 heat waves)	2	2 to 3	4
Duration of Heat Waves (4 days)	4	5 to 5	5
Days below 32°F (155 days)	123	127 to 136	139

Source: NYSERDA 2014

Probability of Future Occurrences

Putnam County will continue to experience extreme cold and heat temperatures annually. These hazards can coincide with or cause secondary hazards, including ice or wind storms, snow, hail, thunderstorms, drought, human health impacts, and utility failures.

Table 5.4.4-6 shows the annual number of events, recurrence interval, annual probability, and annual percent chance of occurrence for the hazards associated with extreme temperatures and reported in the NOAA-NCEI Storm Events Database.



Table 5.4.4-6. Probability of Occurrences of Extreme Temperature Events

Hazard Type	Number of Occurrences Between 1954 and 2020	% chance of occurrence in any given year
Days with Maximum Temperature Over 90°F	347	100%
Days with Maximum Temperature Below 32°F	1,598	100%
TOTAL	1,945	100%

Source: Midwest Regional Climate Center 2020

Note: Probability was calculated using the available data for Putnam County.

Based on historical records and input from the Steering Committee, the probability of occurrence for extreme temperatures in Putnam County is considered *occasional* (hazard event has an annual probability of between 10 and 100 percent).

5.4.4.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable. For the extreme temperature hazard, the entire County has been identified as exposed; therefore, all assets are potentially vulnerable. The following text estimated potential impacts of extreme temperatures on Putnam County.

Impact on Life, Health and Safety

The entire population of Putnam County is exposed to extreme temperature events (i.e., 99,070 people, 2018 American Community Survey 5-year population estimates). Extreme temperature events have potential health impacts including injury and death. Exposure to excessive heat and extreme cold can pose a number of health risks to individuals (refer to Table 5.4.4-7 and Table 5.4.4-8).

Table 5.4.4-7. Health Effects of Extreme Heat

Health Hazard	Symptoms
Sunburn	Redness and pain. In severe cases: swelling of skin, blisters, fevers, and headaches
Dehydration	Excessive thirst, dry lips, and slightly dry mucous membranes
Heat Cramps	Painful spasms, usually in muscles of legs and abdomen, and possible heavy sweating
Heat Exhaustion	Heavy sweating; weakness; cold, pale and clammy skin; weak pulse; possible fainting and vomiting
Heat Stroke	High body temperature (104 °F or higher), hot and dry skin, rapid and strong pulse, and loss of consciousness

Source: CDC, 2020

Table 5.4.4-8. Health Effects of Extreme Cold

Health Hazard	Symptoms
Wind Chill	Wind chill is not the actual temperature but rather how wind and cold feel on exposed skin. As the wind increases, heat is carried away from the body at an accelerated rate, driving down the body temperature. Animals are also affected by wind chill; however, cars, plants and other objects are not.
Frostbite	Frostbite is damage to body tissue caused by extreme cold. A wind chill of -20 degrees Fahrenheit (F) will cause frostbite in just 30 minutes. Frostbite causes a loss of feeling and a white or pale appearance in extremities, such as fingers, toes, ear lobes or the tip of the nose. If symptoms are detected, get medical help immediately! If you must wait for help, slowly re-warm affected areas. However, if the person is also showing signs of hypothermia, warm the body core before the extremities.
Hypothermia	Hypothermia is a condition brought on when the body temperature drops to less than 95 degrees Fahrenheit (F). It can kill. For those who survive, there are likely to be lasting kidney, liver and pancreas problems. Warning signs include uncontrollable shivering, memory loss, disorientation,



Health Hazard	Symptoms
	incoherence, slurred speech, drowsiness and apparent exhaustion. Take the person’s temperature. If below 95 degrees F, seek medical care immediately!

Source: NYS DHSES 2014

According to the Centers for Disease Control and Prevention (CDC), populations most at risk to extreme cold and heat events include the following: 1) the elderly, who are less able to withstand temperatures extremes due to their age, health conditions, and limited mobility to access shelters; 2) infants and children up to four years of age; 3) individuals with chronic medical conditions (e.g., heart disease, high blood pressure), 4) low-income persons that cannot afford proper heating and cooling; and 5) the general public who may overexert during work or exercise during extreme heat events or experience hypothermia during extreme cold events (CDC 2020).

According to the 2018 American Community Survey 5-Year Population Estimate, persons that are most vulnerable to extreme temperature events make up 16.2-percent, 4.6-percent, 5.2-percent, and 10.1-percent of the total population in Putnam County for persons over 65-years old, persons under 5-years old, persons below the poverty level, and persons with a disability, respectively. The Town of Carmel has the greatest number of persons over the age of 65 (i.e., 5,681 persons total). The Town of Philipstown has the greatest concentration of persons over the age of 65 (i.e., 20.4-percent of its total population).

Furthermore, the homeless and residents below the poverty level might not have access to housing or their housing could be less able to withstand extreme temperatures (e.g., homes with poor insulation and heating supply). There is a total of 5,191 persons living in poverty in the County (ACS 2018). In Putnam County, areas with the highest concentration of population below the poverty level, thus most vulnerable communities due to potentially fewer resources to protect against extreme temperatures, are located in the Village of Brewster (i.e., 26-percent of its total population). The Town of Carmel has the greatest number of persons living below the poverty level (i.e., 1,144 persons total).

Overall, the CDC 2016 Social Vulnerability Index (SVI) ranks U.S. Census tracts on socioeconomic status, household composition and disability, minority status and language, and housing and transportation. Putnam County’s overall score is 0.1117, indicating that its communities have low vulnerability (CDC 2016). This score indicates that most County residents will have enough resources to respond to extreme temperature events. Refer to Section 4 (County Profile) that displays the densities of all the vulnerable populations in Putnam County.

In addition to vulnerable populations, 30-percent of all deaths caused by fire occur in the winter months. Cooking and heat sources too close to combustible materials are leading factors in winter home fires (U.S. Fire Administration 2018). Furthermore, power outages occur more frequently during extreme cold events. Individuals powering their homes with generators are subjected to carbon monoxide poisoning if proper ventilation procedures are not followed (NYC 2019). Improperly connected portable generators are capable of ‘back feeding’ power lines which may cause injury or death to utility workers attempting to restore power and may damage house wiring and/or generators.

Meteorologists can accurately forecast extreme heat and cold event development and the severity of the associated conditions with several days of lead time. These forecasts provide an opportunity for public health and other officials to notify vulnerable populations, implement short-term emergency response actions, and focus on surveillance and relief efforts on those at greatest risk. Adhering to extreme temperature warnings can significantly reduce the risk of temperature-related deaths.



Impact on General Building Stock

All buildings are exposed to the extreme temperature hazard. Refer to Section 4 (County Profile), which summarizes the building inventory in Putnam County. Extreme heat generally does not impact buildings; however, elevated summer temperatures increase the energy demand for cooling. Losses can be associated with the overheating of heating, ventilation, and air conditioning (HVAC) systems. Extreme cold temperature events can damage through freezing/bursting pipes and freeze/thaw cycles, as well as increasing vulnerability to home fires. Additionally, manufactured homes (mobile homes) and antiquated or poorly constructed facilities can have inadequate capabilities to withstand extreme temperatures.

The 2019 New York City Hazard Mitigation Plan states that older buildings following less stringent building codes are more vulnerable to drafts during extreme cold events due to cracks and leaks in the walls (NYC 2019). Roof damage can also occur due to excessive snow fall and extreme temperature change. Extreme heat may also be damaging to older structures. Further, structures with glass exposed to sunlight and structures exposed to heat on all four sides are more susceptible to damages, including interior damages from overheating (NYC 2019).

Impact on Critical Facilities

All critical facilities in the County are exposed to the extreme temperature hazard. Impacts to critical facilities that are buildings will experience similar issues as described for general building stock. Additionally, it is essential that critical facilities remain operational during natural hazard events. Extreme heat events can sometimes cause short periods of utility failures, commonly referred to as *brown-outs*, due to increased usage from air conditioners and other energy-intensive appliances. Similarly, heavy snowfall and ice storms, associated with extreme cold temperature events, can cause power interruption. Backup power is recommended for critical facilities and infrastructure.

The 2019 New York City Hazard Mitigation Plan indicates that transportation infrastructure may experience damages from extreme temperature events. This is particularly the case with ground transportation systems at risk of cracking, buckling, or sagging due to high temperatures (NYC 2019). This can cause disruptions to essential services that travel along these routes to provide services to the community.

Impact on Economy

Extreme temperature events also impact the economy, including loss of business function and damage to and/or loss of business inventory. Business-owners can be faced with increased financial burdens due to unexpected repairs caused to the building (e.g., pipes bursting), higher than normal utility bills, or business interruption due to power failure (i.e., loss of electricity or telecommunications). Disruptions in public transportation service will also impact the economy for both commuters and customers alike.

Impact on the Environment

Extreme temperature events can have a major impact on the environment. For example, freezing and warming weather patterns create changes in natural processes. An excess amount of snowfall and earlier warming periods may affect natural processes such as flow within water resources (USGS 2020). Likewise, rain-on-snow events also exacerbate runoff rates with warming winter weather. Extreme heat events can have particularly negative impacts on aquatic systems, contributing to fish kills, aquatic plant die offs, and increased likelihood of harmful algal blooms.



Cascading Impacts to Other Hazards

Extreme temperature events can exacerbate the drought hazard, increase the potential risk of wildfires, and escalate severe storm and severe winter weather events for the County. For example, extreme heat events may accelerate evaporation rates, drying out the air and soils. Extreme heat can also dry out terrestrial species, making them more susceptible to catching fire. Extreme variation in temperatures could create ideal atmospheric conditions for severe storms or worsen the outcome of severe winter weather during freezing and thawing periods. Refer to Section 5.4.2 (Drought), Section 5.4.7 (Severe Storm), Section 5.4.8 (Severe Winter Storm), and Section 5.4.10 (Wildfire) for more information about these hazards of concern.

Future Changes that May Impact Vulnerability

Understanding future changes that impact vulnerability in the county can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The county considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

The ability of new development to withstand extreme temperature impacts can be enhanced through land use practices and consistent enforcement of codes and regulations for new construction. New development will change the landscape where buildings, roads, and other infrastructure potentially replace open land and vegetation. Transformation of pervious surfaces (including vegetation) to impervious surfaces causes an island of higher temperatures (U.S. Environmental Protection Agency [EPA] 2009). Specific areas of recent and new development are indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 (Jurisdictional Annexes) of this plan.

Projected Changes in Population

According to the U.S. Census Bureau, the population in Putnam County has decreased by approximately 0.7-percent between 2010 and 2018 (US Census Bureau 2020). However, estimated population projections provided by the 2017 Cornell Program on Applied Demographics indicates that the County’s population will increase slowly into 2040, increasing the total population to approximately 100,435 persons (Cornell University Program on Applied Demographics 2017). An increase in the population throughout Putnam County will increase the County’s risk to extreme temperature events. Refer to Section 4 (County Profile), which includes a more thorough discussion about population trends for the County.

Climate Change

As discussed above, most studies project that the State of New York will see an increase in average annual temperatures and precipitation. As the climate warms, extreme cold events might decrease in frequency, while extreme heat events might increase in frequency; the shift in temperatures could also result in hotter extreme heat events. With increased temperatures, vulnerable populations could face increased vulnerability to extreme heat and its associated illnesses, such as heatstroke and cardiovascular and kidney disease. Additionally, as temperatures rise, more buildings, facilities, and infrastructure systems may exceed their ability to cope with the heat.



Change of Vulnerability Since the 2015 HMP

Overall, the entire County remains vulnerable to extreme temperatures. As existing development and infrastructure continue to age they can be at increased risk to failed utility systems (e.g., HVAC) if they are not properly maintained. Similarly, an increase in the elderly population remaining in the County increases the vulnerable population.

Identified Issues

Extreme temperature incidents are anticipated to continue impacting the County. The distributed nature of the County’s shelters and frequent power outage issues owing to severe storms and winter storms make the County and its increasingly aging population particularly vulnerable to future extreme temperature events.

DRAFT