5.4.4 DROUGHT / EXTREME HEAT

This section provides a profile and vulnerability assessment for the drought and extreme heat hazards.

HAZARD PROFILE

This section provides profile information including: description, location and extent, previous occurrences and losses, and the probability of future occurrences.

Description - Drought

The Climate Prediction Center (CPC) of the National Weather Service (NWS) defines drought as a deficiency of moisture that results in adverse impacts on people, animals, or vegetation over a sizeable area (CPC, 2004). According to the New York State Hazard Mitigation Plan (NYS HMP), drought is a normal, recurrent feature of climate. Although its features vary from region to region, this hazard occurs almost everywhere. Defining drought is therefore difficult; it depends on differences of regions, water supply needs, and disciplinary perspectives. In general, drought originates from a deficiency of precipitation over an extended period of time, resulting in a water shortage for some activity, group, or environmental sector (Draft NYS HMP, 2011). Other climatic factors, such as high temperatures, prolonged high winds and low relative humidity, can aggravate the severity of a drought. These conditions are caused by anomalous weather patterns when shifts in the jet stream block storm systems from reaching an area. As a result, large high-pressure cells may dominate a region for a prolonged period, thus reducing precipitation.

According to the Federal Emergency Management Agency (FEMA) and the NWS, there are four different ways that drought can be defined or grouped:

- Meteorological drought is a measure of departure of precipitation from normal. It is defined solely on the degree of dryness. Due to climatic differences, what might be considered a drought in one location of the country may not be a drought in another location.
- Agricultural drought links various characteristics of meteorological (or hydrological) drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evapotranspiration, soil water deficits, reduced ground water or reservoir levels, etc. It occurs when there is not enough water available for a particular crop to grow at a particular time. Agricultural drought is defined in terms of soil moisture deficiencies relative to water demands of plant life, primarily crops.
- Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply and occurs when these water supplies are below normal. It is related to the effects of precipitation shortfalls on stream flows and reservoir, lake and groundwater levels.
- Socioeconomic drought is associated with the supply and demand of some economic good with elements of meteorological, hydrological, and agricultural drought. This differs from the aforementioned types of drought because its occurrence depends on the time and space processes of supply and demand to identify or classify droughts. The supply of many economic goods depends on weather (e.g., water, forage, food grains, fish, and hydroelectric power). Socioeconomic drought occurs when the demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply.

Drought can produce a range of impacts that span many sectors of an economy and can reach beyond an area experiencing physical drought. This exists because water is integral to our ability to produce goods and provide services. Direct impacts of drought include reduced crop yield, increased fire hazard, reduced water levels, and damage to wildlife and fish habitat. The consequences of these impacts illustrate indirect impacts that include: reduction in crop, rangeland, and forest productivity may result in reduced income for farmers and agribusiness, increased prices for food and timber, unemployment, reduced tax revenues due to reduced expenditures, increased crime, foreclosures, migration, and disaster relief programs. The many impacts of drought can be listed as economic, environmental, or social (Draft NYS HMP, 2011).

Economic impacts occur in agriculture and related sectors because of the reliance of these sectors on surface and subsurface water supplies. Environmental impacts are the result of damage to plant and animal species, wildlife habitat, and air and water quality, forest and grass fires, degradation of landscape quality, loss of biodiversity and soil erosion. Social impacts involve public safety, health, conflicts between water users, reduced quality of life and inequities in the distribution of impacts and disaster relief (Draft NYS HMP, 2011). A summary of potential impacts associated with drought are identified in Table 5.4.4-1. This table includes only some of the potential impacts of drought.

Table 5.4.4-1. Economical, Environmental and Social Impacts of Drought

Economical	Environmental	Social
• Loss of national economic growth, slowing down of economic development • Damage to crop quality, less food production • Increase in food prices • Increased importation of food (higher costs) • Insect infestation • Plant disease • Loss from dairy and livestock production • Unavailability of water and feed for livestock which leads to high livestock mortality rates • Disruption of reproduction cycles (breeding delays or unfilled pregnancies) • Increased predation • Increased fire hazard - Range fires and Wildland fires • Damage to fish habitat, loss from fishery production • Income loss for farmers and others affected • Unemployment from production declines • Loss to recreational and tourism industry • Loss of hydroelectric power • Loss of navigability of rivers and canals	• Increased desertification - Damage to animal species • Reduction and degradation of fish and wildlife habitat • Lack of feed and drinking water • Disease • Increased vulnerability to predation. • Loss of wildlife in some areas and too many in others • Increased stress to endangered species • Damage to plant species, loss of biodiversity • Increased number and severity of fires • Wind and water erosion of soils • Loss of wetlands • Increased groundwater depletion • Water quality effects • Increased number and severity of fires • Air quality effects	• Food shortages • Loss of human life from food shortages, heat, suicides, violence • Mental and physical stress • Water user conflicts • Political conflicts • Social unrest • Public dissatisfaction with government regarding drought response • Inequity in the distribution of drought relief • Loss of cultural sites • Reduced quality of life which leads to changes in lifestyle • Increased poverty • Population migrations

Source: Draft NYS HMP, 2011

Description – Extreme Temperature

Extreme heat occurs when temperatures hover 10 degrees or more above the average high temperature for a region and last for several weeks. Humid or muggy conditions occur when a 'dome' of high atmospheric pressure traps hazy, damp air near the ground. Excessively hot and dry conditions can provoke dust storms and low visibility. Droughts occur when a long period passes without substantial rainfall and when combined with a heat wave, it can create a dangerous situation (NYS HMP, 2011 – need proper reference). Depending on the severity, duration and location, extreme heat events can create or provoke secondary hazards, such as: dust storms, droughts, wildfires, water shortages, and power outages (FEMA, 2006; CDC, 2006).

The Weather Channel uses the following criteria for a heat wave in the U.S.: a minimum of ten states with greater than or equal to 90°F temperatures and the temperatures must be at least five degrees above normal in parts of that area for at least two days or more (The Weather Channel, Date Unknown).

Extent

The extent (e.g., magnitude or severity) of drought can depend on the duration, intensity, geographic extent, and the regional water supply demands made by human activities and vegetation. The intensity of the impact from drought could be minor to total damage in a localized area or regional damage affecting human health and the economy. Generally, impacts of drought evolve gradually and regions of maximum intensity change with time. The severity of a drought is determined by areal extent as well as intensity and duration. The frequency of a drought is determined by analyzing the intensity for a given duration, which allows determination of the probability or percent chance of a more severe event occurring in a given mean return period. The extent of extreme temperatures (extreme heat) is generally measured through the Heat Index. The extent of drought and extreme temperatures is further discussed below.

Drought

Several indices developed by Wayne Palmer (Palmer Drought Severity Index [PDSI] and Crop Moisture Index [CMI]), as well as the Standardized Precipitation Index (SPI), are the most useful for describing the many scales of drought. Other indices include accumulated departure from normal streamflows, low-flow frequency estimates and changes in water storage, groundwater levels and rates of decline, and lake levels. Most commonly used indices that are used to measure or identify the severity and classification of past and present droughts primarily include, but not limited to, the following:

The Palmer Drought Severity Index (PDSI) was developed in 1965, and indicates the prolonged and abnormal moisture deficiency or excess. The PDSI is an important climatological tool for evaluating the scope, severity, and frequency of prolonged periods of abnormally dry or wet weather. It can be used to help delineate disaster areas and indicate the availability of irrigation water supplies, reservoir levels, range conditions, amount of stock water, and potential intensity of forest fires (NWS CPC, 2005).

The PDSI has become the semi-official drought index. It is the most effective in determining long-term droughts; however, it is not good with short-term forecasts. Table 5.4.4-2 lists the Palmer Classifications. Zero is used as normal and drought is shown in terms of negative numbers. For example, -2 is moderate drought, -3 is severe drought and -4 is extreme drought. The PDSI also reflects excess precipitation using positive numbers (NOAA, Date Unknown).

Table 5.4.4-2. PDSI Classifications

Palmer Classifications	
4.0 or more	extremely wet

Palmer Classifications	
3.0 to 3.99	very wet
2.0 to 2.99	moderately wet
1.0 to 1.99	slightly wet
0.5 to 0.99	incipient wet spell
0.49 to -0.49	near normal
-0.5 to -0.99	incipient dry spell
-1.0 to -1.99	mild drought
-2.0 to -2.99	moderate drought
-3.0 to -3.99	severe drought
-4.0 or less	extreme drought

Source: NDMC, Date Unknown

The CMI, developed by Wayne Palmer in 1968, can be used to measure the status of dryness or wetness affecting warm season crops and field activities. It gives the short-term or current status of purely agricultural drought or moisture surplus and can change rapidly from week to week (NWS CPC, 2005). The CMI responds more rapidly than the PDSI so it is more effective in calculating short-term abnormal dryness or wetness affecting agriculture. CMI is designed to indicate normal conditions at the beginning and end of the growing season; it uses the same levels as the Palmer Drought (NOAA, Date Unknown).

The Standardized Precipitation Index (SPI) is a probability index that considers only precipitation. It is based on the probability of recording a given amount of precipitation, and the probabilities are standardized so that an index of zero indicates the median precipitation amount (half of the historical precipitation amounts are below the median, and half are above the median). The index is negative for drought, and positive for wet conditions. The SPI is computed by NCDC for several time scales, ranging from one month to 24 months, to capture the various scales of both short-term and long-term drought (Heim, 2008).

The National Drought Mitigation Center (NDMC) helps develop and implement measures to reduce societal vulnerability to drought, stressing preparedness and risk management rather than crisis management. Most of the NDMC's services are directed to state, federal, regional, and tribal governments that are involved in drought and water supply planning. The NDMC produces a daily drought monitor map that identifies drought areas and ranks droughts by intensity. U.S. Drought Monitor summary maps are available from May 1999 through the present and identify general drought areas and classification droughts by intensity ranging from D1 (moderate drought) to D4 (exceptional drought). Category D0, drought watch areas, are either drying out and possibly heading for drought, or are recovering from drought but not yet back to normal, suffering long-term impacts such as low reservoir levels (Table 5.4.4-3).

Table 5.4.4-3. NDMC Drought Severity Classification Table

Category	Description	Possible Impacts	Palmer Drought Severity Index (PDSI)	CPC Soil Moisture Model (%)	USGS Weekly Streamflow (%)	Standardized Precipitation Index (SPI)	Satellite Vegetation Health Index
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures; fire risk above average. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered.	-1.0 to -1.9	21-30	21-30	-0.5 to -0.7	36-45
D1	Moderate Drought	Some damage to crops, pastures; fire risk high; streams, reservoirs, or wells low, some water shortages developing or imminent, voluntary water use restrictions requested	-2.0 to -2.9	11-20	11-20	-0.8 to -1.2	26-35
D2	Severe Drought	Crop or pasture losses likely; fire risk very high; water shortages common; water restrictions imposed	-3.0 to -3.9	6-10	6-10	-1.3 to -1.5	16-25
D3	Extreme Drought	Major crop/pasture losses; extreme fire danger; widespread water shortages or restrictions	-4.0 to -4.9	3-5	3-5	-1.6 to -1.9	6-15
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; exceptional fire risk; shortages of water in reservoirs, streams, and wells, creating water emergencies	-5.0 or less	0-2	0-2	-2.0 or less	1-5

Source: NDMC, 2002
Note: Additional indices used, mainly during the growing season, include the USDA/NASS Topsoil Moisture, Crop Moisture Index (CMI), and Keetch Byram Drought Index (KBDI). Indices used primarily during the snow season and in the West include the River Basin Snow Water Content, River Basin Average Precipitation, and the Surface Water Supply Index (SWSI).

The Drought Impact Reporter (DIR) is an interactive tool developed by the NDMC to collect, quantify, and map reported drought impacts for the U.S., which is one of the resources used to identify known drought events throughout Tioga County for this Plan (NDMC, 2012).

The North America Drought Monitor (NA-DM) is a cooperative effort between drought experts in Canada, Mexico and the U.S. to monitor drought across the continent on an ongoing basis. The Drought Monitor concept was developed as a process that synthesizes multiple indices, outlooks and local impacts, into an assessment that best represents current drought conditions. The final outcome of each Drought Monitor is a consensus of federal, state and academic scientists. Maps of U.S. droughts are available from this source from 2003 to the present (NCDC, 2012).

Extreme Heat

The extent (severity or magnitude) of extreme heat temperatures are generally measured through the heat index. The heat index provides a measure of how hot it feels (Wake, 2006). Created by the NWS, the heat index is a chart (Table 5.4.4-4) which accurately measures apparent temperature of the air as it increases with the relative humidity. The heat index can be used to determine what effects the temperature and humidity can have on the population (NCDC, 2012)

Table 5.4.4-4. Heat Index Chart

	Temperature (°F)															
Relative Humidity (%)	**80**	**82**	**84**	**86**	**88**	**90**	**92**	**94**	**96**	**98**	**100**	**102**	**104**	**106**	**108**	**110**
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Source: NCDC, 2012

Table 5.4.4-5 describes the adverse effects that prolonged exposure to heat and humidity can have on an individual.

Table 5.4.4-5. Adverse Effects of Prolonged Exposures to Heat on Individuals

Category	Heat Index	Health Hazards
Extreme Danger	130 °F – Higher	Heat Stroke / Sunstroke is likely with continued exposure.
Danger	105 °F – 129 °F	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Extreme Caution	90 °F – 105 °F	Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity.
Caution	80 °F – 90 °F	Fatigue possible with prolonged exposure and/or physical activity.

Source: NYS HMP, 2011

The temperature and relative humidity is needed to determine the heat index. Once both values are known, the heat index will be the corresponding number with both values. That number provides a temperature that the body feels. It is important to know that the heat index values are devised for shady, light wind conditions. Exposure to full sunshine can increase the heat index by up to 15 degrees (NYS HMP, 2011).

Location

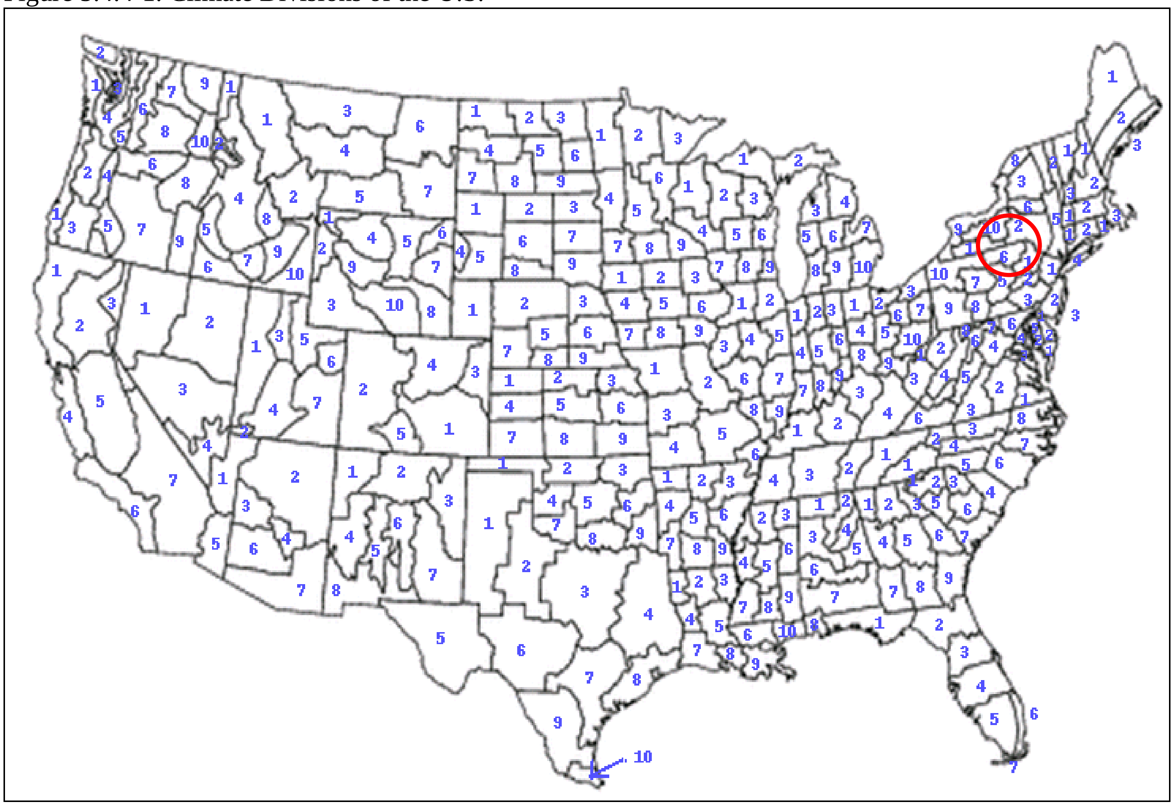
The location of drought and extreme heat temperatures throughout New York State and Tioga County are further identified below.

Drought

Climate divisions are regions within a state that are climatically homogenous. The National Oceanic and Atmospheric Administration (NOAA) has divided the U.S. into 359 climate divisions. The boundaries of these divisions typically coincide with the county boundaries, except in the western U.S., where they are based largely on drainage basins (Energy Information Administration, 2005).

According to NOAA, New York State is made up of 10 climate divisions: Western Plateau, Eastern Plateau, Northern Plateau, Coastal, Hudson Valley, Mohawk Valley, Champlain Valley, St. Lawrence Valley, Great Lakes, and Central Lakes. Tioga County is located within the Eastern Plateau Climate Division (NOAA, Date Unknown). Figure 5.4.4-1 shows the climate divisions throughout the U.S. and Figure 5.4.4-2 shows the climate divisions of New York.

Figure 5.4.4-1. Climate Divisions of the U.S.

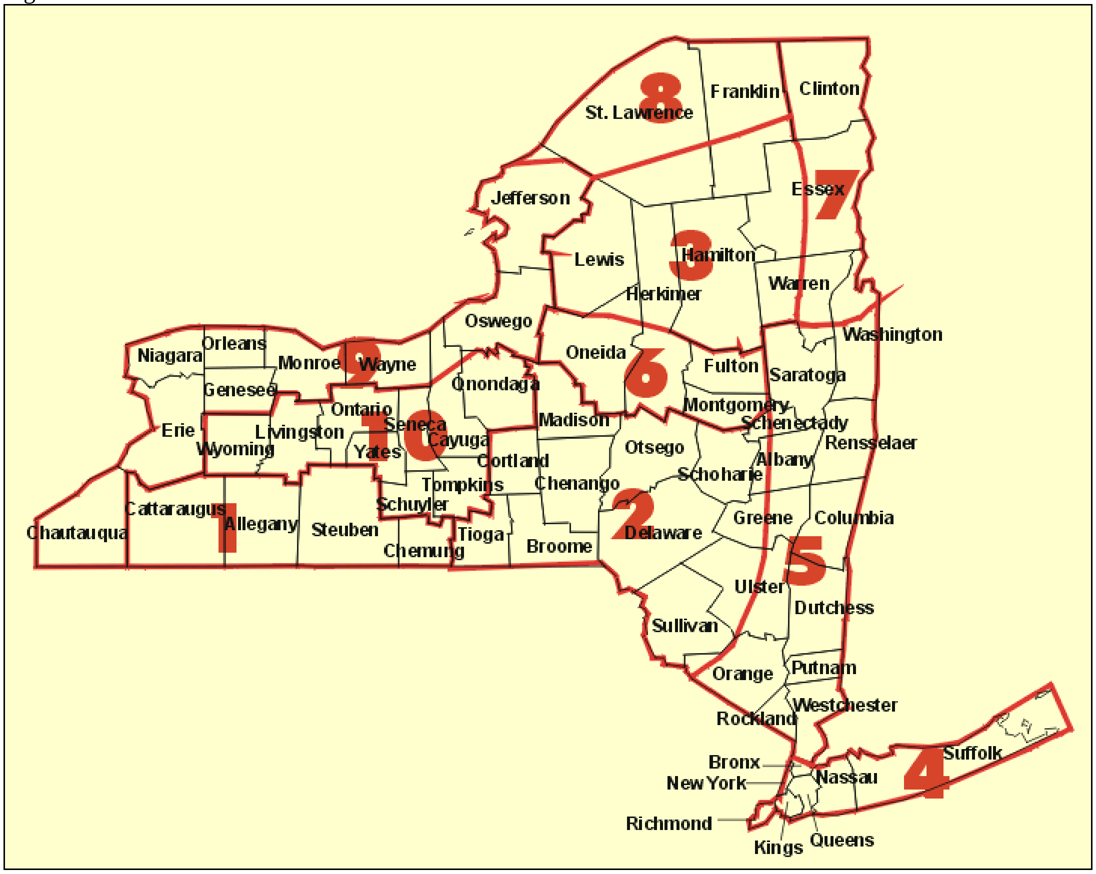


Source: NOAA, Date Unknown

Note (1): The red circle indicates the approximate location of Tioga County (Eastern Plateau).

Note (2): 1 = Western Plateau; 2 = Eastern Plateau; 3 = Northern Plateau; 4 = Coastal; 5 = Hudson Valley; 6 = Mohawk Valley; 7 = Champlain Valley; 8 = St. Lawrence Valley; 9 = Great Lakes; 10 = Central Lakes

Figure 5.4.4-2. Climate Divisions of New York

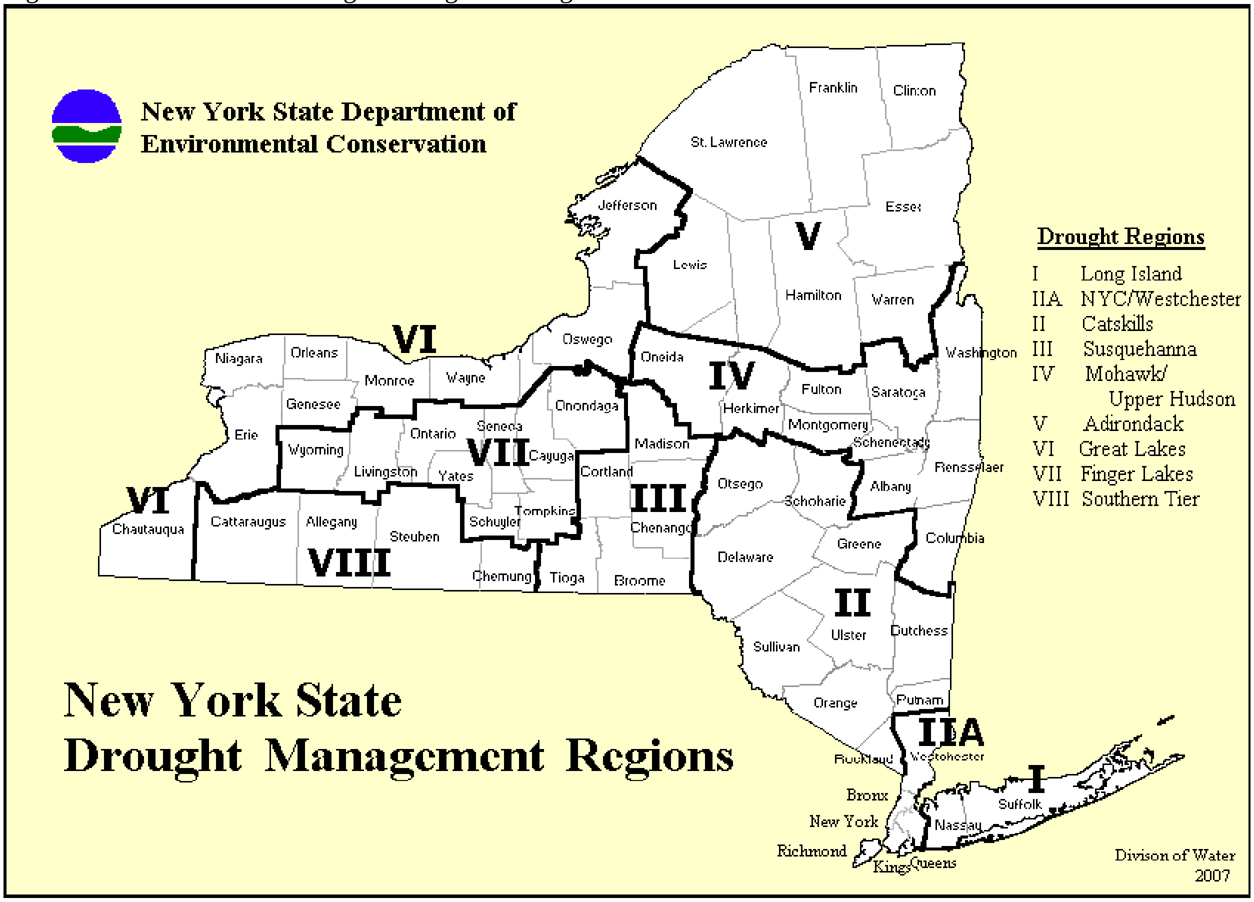


Source: CPC, 2005

Note: 1 = Western Plateau; 2 = Eastern Plateau; 3 = Northern Plateau; 4 = Coastal; 5 = Hudson Valley; 6 = Mohawk Valley; 7 = Champlain Valley; 8 = St. Lawrence Valley; 9 = Great Lakes; 10 = Central Lakes

New York State is divided into nine drought management regions based roughly on drainage basin and county lines. The New York State Department of Environmental Conservation (NYSDEC) monitors precipitation, lake and reservoir levels, stream flow, and groundwater level on a monthly basis in each region and more frequently during periods of drought. The NYSDEC uses this data to assess the condition of each region, which can range from "normal" to "drought disaster" (NYSDEC, Date Unknown). Tioga County is identified as NYSDEC Drought Management Region 3, the Susquehanna Drought Region (Figure 5.4.4-3).

Figure 5.4.4-3. NYSDEC Drought Management Regions of New York State



Source: NYS HMP, 2011 – need proper reference

Extreme Heat Temperatures

The New York State Climate (NYSC) Office of Cornell University indicates that the summer climate in the State is generally cool in the higher elevations of the Northern Plateau (Adirondack Mountains) and Eastern Plateau (Catskill Mountains) climate divisions, which are depicted on Figure 5.4.4-X. The New York City area (Coastal climate division) and lower portions of the Hudson Valley climate division have rather warm summers by comparison, with some periods of high, uncomfortable humidity. The remainder of New York State, which encompasses Tioga County, experiences warm summers with occasional, brief intervals of extreme heat. Average summer daytime temperatures usually range from the upper 70's to mid-80's over much of the State (NYSC, Date Unknown).

As provided by The Weather Channel, a range of average high and low temperatures during the summer months in Tioga County are identified in Table 5.4.4-6. The average warmest month in the County is July, with the highest recorded temperature of 102°F occurring in 1995.

Table 5.4.4-6. Average High and Low Temperature Range for Winter Months in Tioga County

Month	Average High	Record High Event(s)
May	72°F	96°F in 1996
June	81°F	98°F in 2008
July	84°F	102°F in 1995

Month	Average High	Record High Event(s)
August	83°F	99°F in 2002
September	75°F	96°F in 2002

Source: The Weather Channel – Averages and Records

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with drought and extreme heat events throughout New York State and Tioga County. With many sources reviewed for the purpose of this HMP, loss and impact information for many events could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

According to NOAA's NCDC storm events database, Tioga County experienced one drought and one extreme heat event between April 30, 1950 and December 31, 2011. There were no damages associated with this event. According to the Hazard Research Lab at the University of South Carolina's Spatial Hazard Events and Losses Database for the U.S. (SHELDUS), between 1960 and 2011, three drought events and one extreme heat event occurred within the County. The database indicated that drought events and losses specifically associated with Tioga County and its municipalities totaled over $33,000 in property damage and over $4.7 million in crop damages. The database indicated that extreme heat events and losses specifically associated with Tioga County and its municipalities totaled over $1,600 in property damages. However, these numbers may vary due to the database identifying the location of the hazard event in various forms or throughout multiple counties or regions.

Between 1954 and 2011, FEMA declared that New York State experienced one drought-related disaster (DR) or emergency (EM) classified as one or a combination of the following disaster types: water shortage. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations. Of those events, the NYS HMP and other sources indicate that Tioga County has been declared as a disaster area as a result of one drought-related event (FEMA, 2011).

Based on all sources researched, known drought and extreme events, between 1950 and 2012, that have affected Tioga County and its municipalities are identified in Table 5.4.4-7. Not all sources have been identified or researched; therefore, Table 5.4.4-7 may not include all events that have occurred throughout the County and region.

Table 5.4.4-7. Drought and Extreme Heat Events affecting Tioga County Between 1950 and 2012.

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
September – November 1895	Drought	N/A	N/A	Three month duration with the lowest PDSI of -3.54 in October.	NRCC
November – December 1899	Drought	N/A	N/A	Two month duration with the lowest PDSI of -3.35 in November.	NRCC
August 1900 – February 1901	Drought	N/A	N/A	Seven month duration with the lowest PDSI of -3.79 in October.	NRCC
August 1909 – January 1910	Drought	N/A	N/A	Six month duration with the lowest PDSI of -4.84 in December.	NRCC
July 1910 – September 1911	Drought	N/A	N/A	Fifteen month duration with the lowest PDSI of -4.31 in July 1911.	NRCC
October – December 1914	Drought	N/A	N/A	Three month duration with the lowest PDSI of -3.72 in November.	NRCC
April – June 1915	Drought	N/A	N/A	Three month duration with the lowest PDSI of -3.21 in May.	NRCC
November – December 1916	Drought	N/A	N/A	Two month duration with the lowest PDSI of -3.15 in December.	NRCC
September 1921 – February 1922	Drought	N/A	N/A	Six month duration with the lowest PDSI of -3.99 in October.	NRCC
November – December 1922	Drought	N/A	N/A	Two month duration with the lowest PDSI of -3.65 in December.	NRCC
May 1923 – January 1924	Drought	N/A	N/A	Nine month duration with the lowest PDSI of -4.23 in September.	NRCC
August 1930 – June 1931	Drought	N/A	N/A	Eleven month duration with the lowest PDSI of -5.68 in December.	NRCC
November – December 1931	Drought	N/A	N/A	Two month duration with the lowest PDSI of -3.66 in December.	NRCC

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
August 1939 – February 1940	Drought	N/A	N/A	Seven month duration with the lowest PDSI of -4.31 in January.	NRCC
May – June 1941	Drought	N/A	N/A	Two month duration with the lowest PDSI of -3.30 in June.	NRCC
September 1941 – April 1942	Drought	N/A	N/A	Eight month duration with the lowest PDSI of -3.93 in April 1942.	NRCC
August 1964 – February 1966	Drought and Water Shortage	DR-204	Yes	Nineteen month duration with the lowest PDSI of -5.99 in November 1964.	FEMA, NRCC
July – August 1966	Drought	N/A	N/A	Two month duration with the lowest PDSI of -3.52 in August.	NRCC
October – November 1966	Drought	N/A	N/A	Two month duration with the lowest PDSI of -3.06 in October.	NRCC
January – February 1967	Drought	N/A	N/A	Two month duration with the lowest PDSI of -3.17 in February.	NRCC
March 1994	Drought	N/A	N/A	The drought warning issued by the New York State Drought Management Task Force was downgraded to a drought advisory on March 21, 1994, as the usable storage in the New York City water supply system reached 73.9 percent. The drought advisory was in effect for Delaware, Dutchess, Greene, Otsego, Schoharie, Sullivan, and Ulster Counties.	NOAA-NCDC
June – September 1995	Drought	N/A	N/A	A lack of rainfall across much of eastern New York State caused officials to enforce water restrictions in some areas. Many crops were excessively damaged, include vegetable, grain and vine crops. Some private wells ran dry. The Susquehanna River level was one-third of normal. Crop yields were down 30 to 60%. Lowest PDSI of -3.63 in August.	NRCC, NYS HMP
July 4-11, 1998	Heat	N/A	N/A	Tioga County had approximately $1,667 in property damage.	SHELDUS
September 1999	Drought	N/A	N/A	A very dry spring and summer caused major crop failures and some wells to run dry. Many streams and rivers were also brought to their lowest recorded levels. The crops most affected were corn and hay. Tioga County was among the counties affected. Overall, the state had $50 M in damages.	NYS HMP

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
November 2001 – January 2002	Drought	N/A	N/A	Three month duration with the lowest PDSI of -3.28 in December.	NRCC
Summer 2005	Drought	N/A	N/A	Pastures are completely gone and have been feeding hay for the last week or more. Corn is showing severe stress at this time. The lack of rain will have a great impact on the crop. The grass hay crop was half that of a normal year. We have not mowed the lawn in 3 weeks. We had only 1 inch of rain early in July. There has only been maybe a trace of rain in Spencer since then.	Drought Impact Reporter
October – November 2007	Drought	N/A	N/A	Due to low water levels in Hinkley Reservoir, the entire state canal system was closed early to traffic, recreational users and commercial users.	Drought Impact Reporter
July 21-23, 2011	Heat Wave	N/A	N/A	Extreme heat affected the central part of the U.S., bringing high temperatures across much of central new York State. Temperatures were into the 90s and exceeded 100°F in many parts. In Tioga County, temperatures in the County reached 95°F to 100°F each day of the heat wave. It was reported in the Village of Waverly, a record high of 100°F occurred on the 21st.	NOAA-NCDC

FEMA Federal Emergency Management Agency
N/A Not Applicable
NCDC National Climatic Data Center
NOAA National Oceanic and Atmospheric Administration
NRCC Northeast Regional Climate Center
PDSI Palmer Drought Severity Index
U.S. United States

Probability of Future Events

It is estimated that Tioga County will continue to experience direct and indirect impacts of drought and extreme heat and their impacts on occasion, with the secondary effects causing potential disruption or damage to agricultural activities and creating shortages in water supply within communities.

In Section 5.3, the identified hazards of concern for Tioga County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for drought in the County is considered 'frequent' (likely to occur within 25 years, as presented in Table 5.3-6).

Climate Change Impacts

Climate change is beginning to affect both people and resources in New York State, and these impacts are projected to continue growing. Impacts related to increasing temperatures and sea level rise are already being felt in the State. ClimAID: the Integrated Assessment for Effective Climate Change in New York State (ClimAID) was undertaken to provide decision-makers with information on the State's vulnerability to climate change and to facilitate the development of adaptation strategies informed by both local experience and scientific knowledge (New York State Energy Research and Development Authority [NYSERDA], 2011).

Each region in New York State, as defined by ClimAID, has attributes that will be affected by climate change. Tioga County is part of Region 3, Southern Tier. Some of the issues in this region, affected by climate change, include: dairy dominates the agricultural economy and milk production losses are projected, Susquehanna River flooding increases, and this region is one of the first parts of the State hit by invasive insects, weeds and other pests moving north (NYSERDA, 2011).

Temperatures are expected to increase throughout the state, by 1.5 to 3ºF by the 2020s, 3.5 to 5.5ºF by the 2050s and 4.5 to 8.5ºF by the 2080s. The lower ends of these ranges are for lower greenhouse gas emissions scenarios and the higher ends for higher emissions scenarios. Annual average precipitation is projected to increase by up to five-percent by the 2020s, up to 10-percent by the 2050s and up to 15-percent by the 2080s. During the winter months is when this additional precipitation will most likely occur, in the form of rain, and with the possibility of slightly reduced precipitation projected for the late summer and early fall. Table 5.4.4-8 displays the projected seasonal precipitation change for the Southern Tier ClimAID Region (NYSERDA, 2011).

Table 5.4.4-8. Projected Seasonal Precipitation Change in Region 3, 2050s (% change)

Winter	Spring	Summer	Fall
+5 to +15	0 to +15	-10 to +10	-5 to +10

Source: NYSERDA, 2011

Even though an increase in annual precipitation is projected, other climate change factors, such as an extended growing season, higher temperatures, and the possibility of more intense, less frequent summer rainfall, may lead to additional droughts and increased short-term drought periods (Cornell University, Date Unknown).

Droughts can cause deficits in surface and groundwater used for drinking water. The New York State Water Resources Institute at Cornell University conducted a vulnerability assessment of drinking water supplies and climate change. To assess water supplies in New York State, it was assumed that long-term average supply will remain the same but the duration and/or frequency of dry periods may increase. Both types of water supplies, surface water and groundwater, were divided into three categories: sensitive to short droughts (two to three months), sensitive to moderate and longer droughts (greater than six months), and relatively sensitive to any droughts. Major reservoir systems are presumed to have moderate sensitivity to drought because there is a likelihood of decreases in summer and fall water availability (Cornell University, Date Unknown). The greatest likelihood of future water shortages is likely to occur on small water systems (Cornell University, Date Unknown).

VULNERABILITY ASSESSMENT

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For the drought hazard, all of Tioga County has been identified as the hazard area. Therefore, all assets in Tioga County (population, structures, critical facilities and lifelines), as described in the County Profile (Section 4), are vulnerable to a drought. Assets at particular risk would include any open land or structures at located along the wildland/urban interface (WUI) that could become vulnerable to the wildfire hazard due to extended periods of low rain and high heat, usually associated with a drought. In addition, water supply resources could be impacted by extended periods of low rain. Finally, vulnerable populations could be particularly susceptible to the drought hazard and cascading impacts due to age, health conditions, and limited ability to mobilize to shelter, cooling and medical resources. The following text evaluates and estimates the potential impact of the drought hazard on Tioga County including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact, including: (1) impact on life, safety and health of county residents, (2) general building stock, (3) critical facilities, (4) economy and (5) future growth and development
- Further data collections that will assist understanding of this hazard over time
- Overall vulnerability conclusion

Overview of Vulnerability

All of Tioga County is vulnerable to drought. However, areas at particular risk are: areas used for agricultural purposes (farms and cropland), open/forested land vulnerable to the wildfire hazard, areas where communities rely on private water supply, and certain areas where elderly, impoverished or otherwise vulnerable populations are located.

Data and Methodology

Data was collected from NYS, the County, and Planning Committee sources. At the time of this draft HMP, insufficient data are available to model the long-term potential impacts of a drought on the County. Over time, additional data will be collected to allow better analysis for this hazard. Available information and a preliminary assessment are provided below.

Impact on Life, Health and Safety

Droughts conditions can cause a shortage of water for human consumption and reduce local fire-fighting capabilities. The drought hazard is a concern because private water supply sources in Tioga County are from local groundwater sources.

Social impacts of a drought include mental and physical stress, public safety (increased threat from forest/grass fires), health, conflicts between water users, reduced quality of life, and inequities in the distribution of impacts and disaster relief. The infirm, young, and elderly are particularly susceptible to drought and extreme temperatures, sometimes associated with drought conditions, due to their age, health conditions and limited ability to mobilize to shelters, cooling and medical resources. Impacts on the economy and environment may have social implications as well (Draft NYS HMP, 2011). For the purposes of this HMP, the entire population in the County is vulnerable to drought events.

Impact on General Building Stock and Critical Facilities

No structures are anticipated to be directly affected by a drought and are expected to be operational during a drought event. However, droughts contribute to conditions conducive to wildfires. Risk to life and property is greatest in those areas where forested areas adjoin urbanized areas (high density residential, commercial and industrial) or WUI. Therefore, all assets in and adjacent to, the WUI zone, including population, structures, critical facilities, lifelines, and businesses are considered vulnerable to wildfire.

The Geospatial Multi-Agency Coordination Group (GeoMAC) is an internet-based mapping application developed by various government agencies, designed for fire managers to access online maps of current or recent fire locations (ranging from 2002 to 2011) and perimeters in the conterminous 48 states and Alaska (GeoMAC, 2012). This mapping application identifies not only where fires have occurred during that time period, but also identifies the WUI within the states and counties of the U.S. For the purpose of this HMP, Figure 5.4.4-4 presents the approximate WUI within Tioga County.

Impact on Economy

A prolonged drought can have serious direct and indirect economic impacts on a community. As noted in the NYS HMP, it is difficult to estimate financial damages as a result of a drought because 'the more removed the impact from the cause, the more complex the link to the cause' (Draft NYS HMP, 2011).

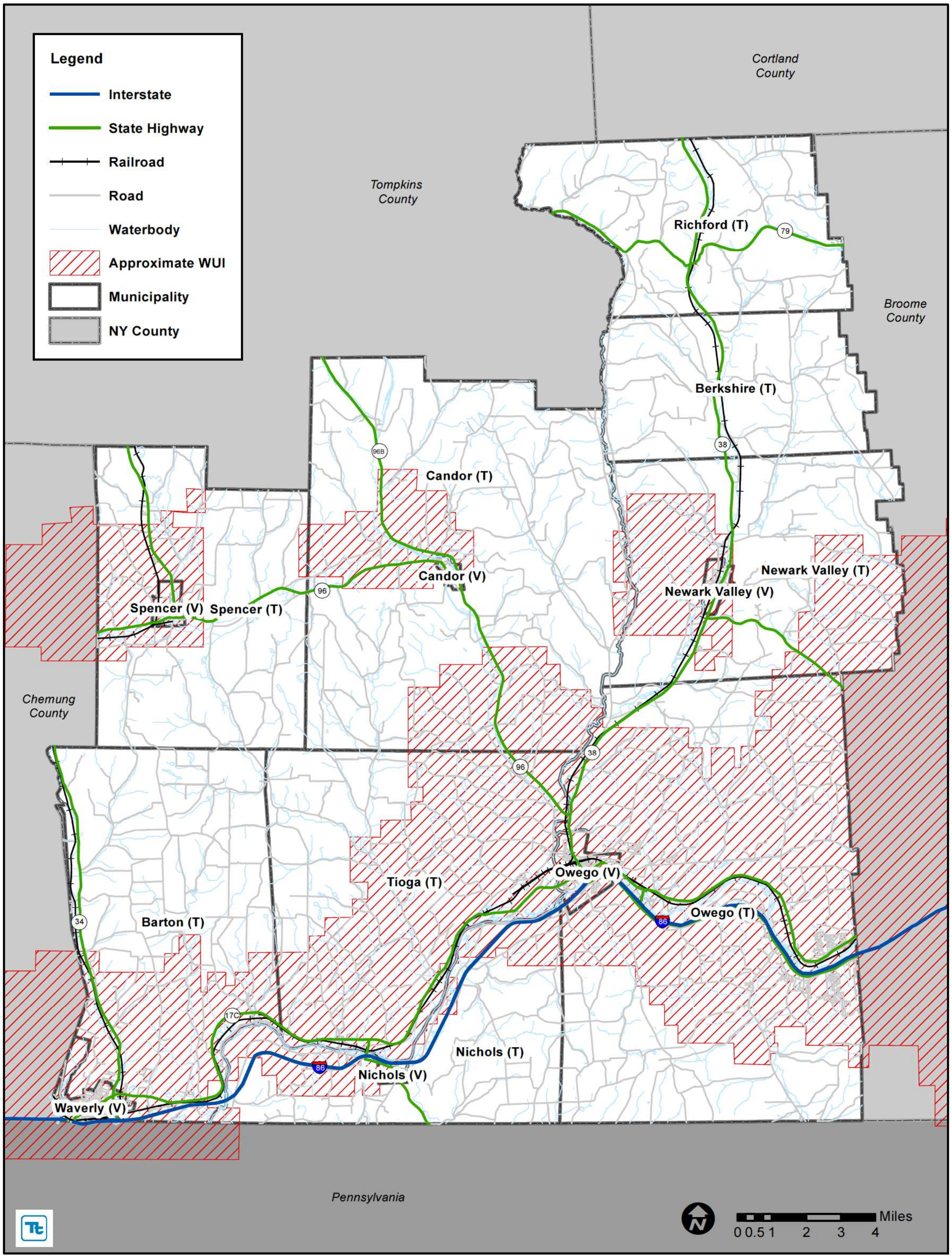
General economic effects from a drought include the following:

- Decreased land prices
- Loss to industries directly dependent on agricultural production (e.g., machinery and fertilizer manufacturers, food processors, dairies, etc.)
- Unemployment from drought-related declines in production
- Strain on financial institutions (foreclosures, more credit risk, capital shortfalls)
- Revenue losses to Federal, State, and Local governments (from reduced tax base)
- Reduction of economic development
- Fewer agricultural producers (due to bankruptcies, new occupations)
- Rural population loss (Draft NYS HMP, 2011).

A summary of the direct and indirect losses to agricultural producers, livestock producers, timber production, fishery production, and tourism is presented in Table 5.4.4-9 (Draft NYS HMP, 2011).

As noted, agricultural resources need ample water supplies for successful production, relying on natural precipitation and the supply and demand of groundwater resources, both of which become limited or compromised during times of drought. The entire agricultural industry in Tioga County is vulnerable to the drought hazard. According to the U.S. Department of Agriculture (USDA) National Agricultural Statistics Service (NASS), there are 565 farms in Tioga County, occupying 107,000 acres of land in the County. Land is used to raise livestock (dairy cows, cattle, calves and other livestock) and grow crops including corn and hay (USDA NASS, 2007).

Figure 5.4.4-4. Wildland-Urban Interface in Tioga County



Source: GeoMAC, 2012

Note: The WUI from GeoMAC was digitized to estimate the approximate WUI (or hazard area) in Tioga County. The digitized boundary created for this plan should be considered approximate.

Table 5.4.4-9. Impacts on the Economy

Losses to Agricultural Producers	Losses to Livestock Producers	Loss from Timber Production
Annual and perennial crop losses	Reduced productivity of rangeland	Wildland fires
Damage to crop quality	Reduced milk production	Tree disease
Income loss for farmers due to reduced crop yields	Forced reduction of foundation stock	Insect infestation
Reduced productivity of cropland (wind erosion, long-term loss of organic matter, etc.)	High cost/unavailability of water for livestock	Impaired productivity of forest land
Insect infestation	Cost of new or supplemental water resource development (wells, dams, pipelines)	Direct loss of trees, especially young ones
Plant disease	High cost/unavailability of feed for livestock	**Transportation Industry**
Wildlife damage to crops	Increased feed transportation costs	Loss from impaired navigability of streams, rivers, and canals
Increased irrigation costs	High livestock mortality rates	**Decline in food production/disrupted food supply**
Cost of new or supplemental water resource development (wells, dams, pipelines)	Disruption of reproduction cycles (delayed breeding, more miscarriages)	Increase in food prices
Loss from Fishery Production	Decreased stock weights	Increased importation of food (higher costs)
Damage to fish habitat	Increased predation	**Water Suppliers**
Loss of fish and other aquatic organisms due to decreased flows	Grass fires	Revenue shortfalls and/or windfall profits
Loss to Recreation and Tourism Industry	**Energy-related effects**	Cost of water transport or transfer
Loss to manufacturers and sellers of recreational equipment	Increased energy demand and reduced supply because of drought-related power curtailments	Cost of new or supplemental water resource development
Losses related to curtailed activities: hunting and fishing, bird watching, boating, etc.	Costs to energy industry and consumers associated with substituting more expensive fuels (oil) for hydroelectric power	

Source: Draft NYS HMP, 2011

Effect of Climate Change on Vulnerability

The potential effects of climate change on Tioga County's vulnerability to drought events shall need to be considered as a greater understanding of regional climate change impacts develop.

Future Growth and Development

As discussed in Sections 4 and 9, areas targeted for future growth and development have been identified across the County. Any areas of growth could be potentially impacted by the drought hazard because the entire planning area is exposed and vulnerable. Please refer to the specific areas of development indicated in tabular form (subsection B) and/or on the hazard maps (subsection I) included in the jurisdictional annexes in Volume II, Section 9 of this plan.

Additional Data and Next Steps

For the revised plan, any additional information regarding localized concerns and past impacts will be collected and analyzed. This data will be developed to support future revisions to the plan. Mitigation efforts could include building on existing New York State, Tioga County, and local efforts. The lead State Agency for drought preparedness is the NYSDEC.

Overall Vulnerability Assessment

Historic data available indicate that droughts can impact Tioga County. Drought events can cause significant impacts and losses to the County's water supply and economy. The overall hazard ranking for Tioga County determined by the Planning Committee for the drought hazard is "frequent" (Tables 5.3-5 and 5.3-6). The cascade effects of drought include increased susceptibility to the wildfire hazard, increased and thus shortages on local resources (i.e., water supply, electricity). Losses associated with the wildfire hazard are discussed earlier in this section.