Chapter 2: Climate and Air Quality of Dutchess County, NY

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INTRODUCTION TO CLIMATE

Climate is the synthesis of long-term weather patterns in a given area. Temperature, wind, humidity, precipitation, and other climatic factors continually shape our lives and the environment. Climatic factors also continually shape the land and water resources and their uses. Climate is distinguished from weather based on the measure of time; weather refers to the day-to-day state of the atmosphere in a region, while climate is how the atmosphere behaves over relatively long periods of time.

Chapter Contents
- Temperature
- Precipitation
- Barometric Pressure
- Wind
- Sun Cloud Cover
- Severe Weather
- Air Quality and Pollution
- Climate Change
- Climate Data
- Implications for Decision-Making
- Resources

1 This chapter was compiled during the summer of 2008 and revised in 2010 by Jase Bernhardt (Cornell University student and Cornell Cooperative Extension Dutchess County summer 2008 intern), Victoria Kelly (Cary Institute of Ecosystem Studies), Allison Chatrchyan (Cornell Cooperative Extension Dutchess County), and Art DeGaetano (Cornell University and Director of the Northeast Regional Climate Center), with input from the NRI Steering Committee. The document was reviewed by John DeGilio (Dutchess County EMC), Scott Chase (Dutchess County Planning and Development), Steve Dirienzo (Service Hydrologist at the Albany National Weather Service Office), and Gary Lovett (Cary Institute of Ecosystem Studies). It is an updated and expanded version of the climate chapter of the 1985 document Natural Resources, Dutchess County, NY (NRI).
Dutchess County is located in the northern portion of the temperate climate zone, as shown below in Figure 2.1.

![Figure 2.1: Climatic Regions of North America](source)

The National Climatic Data Center divides New York State into 10 climate divisions, shown below in Figure 2.2. Dutchess County is located in Region #5, the Hudson Valley (National Oceanic and Atmospheric Administration [NOAA], “New York,” 2008). These climate regions are used for various research purposes, including estimations of energy use, drought monitoring, studies of the variability of local weather, and analysis of long-term climate change.

![Figure 2.2: Climate Divisions of New York State](source)
Specifically, Dutchess County’s climate is humid continental, and is characterized by strong seasonal contrasts and highly variable weather. Major storm systems, which move through the continental United States or up the nearby Atlantic Coast, have a significant impact on the weather, especially during the fall, winter, and spring months. These systems provide ample precipitation for the region, supplemented by tropical, maritime air masses during parts of the summer. Polar air masses from Canada move southeast into the area and strongly influence winters (New York State Climatologist, 2008).

The relatively close proximity of Dutchess County to the Atlantic Ocean can have a moderating influence on the climate. The large-scale atmospheric circulation normally dominates the flow pattern near the surface. However, in the absence of strong circulation, the Atlantic can have a considerable effect on the local weather patterns, leading to relatively milder winter days and cooler days in the summer. In addition, the area generally has a slightly longer freeze-free season than places at similar latitudes farther inland, due to this moderating influence from the ocean.

Moderate temperatures and sufficient precipitation make Dutchess County an excellent location for farming, while seasonal variations help to attract tourists and recreational users. The county's relatively hot summers and cold winters result in substantial heating and cooling costs for homes and businesses.

**TEMPERATURE**

Temperature is a measure of the internal energy that a substance contains (NOAA, “NWS Glossary,” 2008). The county’s mean annual temperatures for the meteorological winter (December, January, and February) and meteorological summer (June, July, and August) are 27.3 and 69.5 degrees Fahrenheit, respectively. The highest and lowest temperatures ever reported at Poughkeepsie were 107 degrees in July 1966 and 21 degrees below zero in February 1897. The mean annual temperature of Poughkeepsie (48.8 degrees) and six major cities within 150 miles of Dutchess County are shown below (Figure 2.3), based on 30-year data from 1971-2000 (Northeast Regional Climate Center [NRCC], 2008).
Temperatures at any one place in Dutchess County normally exceed 90 degrees Fahrenheit between 5 and 15 times during the summer. It is uncommon for air temperature to reach triple digits, occurring in Poughkeepsie roughly once every five years (NRCC, “CLIMOD System,” 2008). However, hot temperatures combined with high summer humidity can lead to days that feel much hotter. The heat index is the combination of the dew point temperature (the amount of moisture in the air) and the air temperature, and measures how hot it actually feels (NOAA, “NWS Glossary,” 2008). Nearly every summer in the county features one or more hot spells with high temperatures and high humidity leading to extremely uncomfortable conditions. On average, temperatures fall below zero degrees 5 to 10 times during the winter, primarily in January and February. During milder winters, temperatures may not drop into negative territory.

Figure 2.4 below shows the mean monthly temperatures in Dutchess County. The numbers are based on the average data collected at the three principal reporting stations in the county; Glenham, Millbrook, and Poughkeepsie/ Dutchess County Airport. The monthly temperature at each individual station, as well as the coordinates and elevation of all stations in Dutchess County, can be found later in this chapter.
It is important to note that the graph above does not take into account the many, varied local microclimates across the county. Areas along and just east of the Hudson River, including Red Hook, Rhinebeck, Hyde Park, Poughkeepsie, and Beacon, are generally milder than the rest of the county. Cooler temperatures prevail in higher elevations across the eastern and especially northeastern sections of Dutchess County. Finally, sheltered valleys such as the Harlem Valley also experience cooler conditions, especially at night.

**Degree days** are a measure that gauges building energy use for heating or cooling. Days with the average temperature above 65 are known as cooling degree days, while days with the average temperature below 65 are known as heating degree days. The number of heating degree days is the most important degree day index for Dutchess County since temperatures average below 65 degrees in all months except June, July, and August and space heating is normally required at temperatures below this level. A day with an average temperature of 65 degrees or more is said to have zero heating degree days, while a day with an average temperature of 50 degrees has 15 heating degree days (65-50=15 degrees). As the number of heating degree days increases, so does the use of energy to heat homes and businesses (NOAA, “Climate Prediction Center,” 2008). Figure 2.5 below shows average monthly heating degree days in Poughkeepsie.
Poughkeepsie has an annual average of 6,438 heating degree days. The number varies with mean temperature across the county; for example, Glenham averages 5,813 heating degree days, while Millbrook averages 7,074. There is an average of 550 cooling degree days annually in Poughkeepsie. This number ranges from 312 cooling degree days in Millbrook to 790 in Glenham. With the advent of climate change, the number of degree days each year has changed due to warming temperatures. The number cooling degrees has gradually increased during the past 60 years, including a record 1,049 in Poughkeepsie during 2005. Similarly, the number of heating degree days has decreased over the same period. In 2006, there was a record low of just 5,406 heating degree days in Poughkeepsie (NRCC, “CLIMOD System,” 2008).

Another type of degree day is the growing degree day. Growing Degree Days relate plant development and insect emergence to environmental air temperature to indicate which plants may be grown in a particular area (Cornell University, 2008). For example, most varieties of peas need 1,200 to 1,800 growing degree days (based on a 40-degree threshold) to reach maturity, so they can usually be grown only in areas that accumulate that many growing degree days or more. The most common threshold temperatures for measuring growing degree days are 40 degrees and 50 degrees. These are generally accepted as temperatures required for growing economically important plants. When using a 40-degree base, annual growing degree days range from roughly 4,000 days in the eastern part of the county to 5,000 near the Hudson River. When using the 50-degree base, the
number of days varies between about 2,000 in the east to almost 3,000 near the Hudson (NRCC, “CLIMOD System,” 2008). Growing degree days in Dutchess County are shown in Figure 2.6 below.

**Figure 2.6: Growing Degree Days in Dutchess County, 1971-2000** (Source: NRCC, “CLIMOD System,” 2008).

Information about growing degree days is useful to farmers, nurseries, research and extension specialists, and home gardeners. It is especially helpful in crop selection and in determining schedules for planting, pesticide application, and harvesting.

The growing season is primarily dictated by the period between the last spring frost and first fall frost. A **frost** occurs when surface temperatures fall to 32 degrees Fahrenheit or below (NOAA, “NWS Glossary,” 2008). Knowing approximately when the first and last frost will happen and the normal length of the “frost free” season is critical for determining what types of crops are best suited for a particular area and when they can be safely planted. Generally, the frost free season in the county lasts from early May through late September or early October. Table 2.1 below shows normal frost data for Dutchess County based on the 30-year period from 1971-2000.
Table 2.1: Frost Data in Dutchess County (Source: NRCC, “CLIMOD System,” 2008).  

<table>
<thead>
<tr>
<th>Station</th>
<th>Mean Date of Last Frost</th>
<th>Absolute Date of Last Frost</th>
<th>Absolute Date of First Frost</th>
<th>Mean Date of First Frost</th>
<th>Mean Number of Frost Free Days</th>
<th>Data Record Period</th>
</tr>
</thead>
</table>

**PRECIPITATION**

Precipitation is the process where water vapor condenses in the atmosphere to form water droplets that fall to the earth as rain, snow, sleet, or hail (NOAA, “NWS Glossary,” 2008). Mean annual precipitation in Dutchess County ranges from 38 to 46 inches (Urban-Mead, 2006). During the growing season (May through September), total precipitation averages between 18 and 22 inches, a sufficient amount to support the wide variety of vegetation found in the county (NRCC, “CLIMOD System,” 2008). One or more short periods of no rainfall occur during most summers.

Table 2.2 below presents both the mean monthly temperatures and total precipitation in Dutchess County over a 30-year period at various weather stations in the county.

Table 2.2: Mean temperatures and total precipitation in Dutchess County, 1971-2000 (Source: NRCC, “CLIMOD System,” 2008).

<table>
<thead>
<tr>
<th>Station</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Temp (°F)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glenham</td>
<td>26.6</td>
<td>29.2</td>
<td>38.5</td>
<td>49.5</td>
<td>60.7</td>
<td>69.5</td>
<td>74.3</td>
<td>72.7</td>
<td>64.7</td>
<td>53.0</td>
<td>42.9</td>
<td>32.2</td>
<td>51.2</td>
</tr>
<tr>
<td>Millbrook</td>
<td>22.9</td>
<td>25.2</td>
<td>34.7</td>
<td>45.5</td>
<td>56.1</td>
<td>64.1</td>
<td>68.7</td>
<td>67.0</td>
<td>58.8</td>
<td>47.9</td>
<td>37.7</td>
<td>28.1</td>
<td>46.4</td>
</tr>
<tr>
<td>Poughkeepsie</td>
<td>24.5</td>
<td>26.8</td>
<td>36.4</td>
<td>47.4</td>
<td>58.4</td>
<td>66.9</td>
<td>71.9</td>
<td>70.5</td>
<td>62.0</td>
<td>50.1</td>
<td>40.4</td>
<td>30.0</td>
<td>48.8</td>
</tr>
<tr>
<td><strong>Total Precipitation (inches)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glenham</td>
<td>3.48</td>
<td>2.90</td>
<td>3.49</td>
<td>3.95</td>
<td>4.50</td>
<td>4.11</td>
<td>4.65</td>
<td>3.92</td>
<td>4.11</td>
<td>3.70</td>
<td>3.69</td>
<td>3.29</td>
<td>45.8</td>
</tr>
<tr>
<td>Millbrook</td>
<td>3.05</td>
<td>2.62</td>
<td>3.07</td>
<td>3.40</td>
<td>4.34</td>
<td>3.96</td>
<td>4.37</td>
<td>4.24</td>
<td>3.82</td>
<td>3.61</td>
<td>3.12</td>
<td>2.99</td>
<td>42.59</td>
</tr>
<tr>
<td>Poughkeepsie</td>
<td>3.19</td>
<td>2.53</td>
<td>3.59</td>
<td>3.79</td>
<td>4.73</td>
<td>3.73</td>
<td>4.72</td>
<td>3.83</td>
<td>3.69</td>
<td>3.56</td>
<td>3.53</td>
<td>3.23</td>
<td>44.12</td>
</tr>
</tbody>
</table>

2 Mean dates based on data from 1971-2000.

8 The Natural Resource Inventory of Dutchess County, NY
Figure 2.8 below shows mean annual precipitation for Dutchess County, as well as the locations of weather reporting stations in the county.
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The significant differences in precipitation between various parts of the county can primarily be attributed to the topographical profile of the region. The eastern half of Dutchess County receives the most rain due to its higher elevation on the uphill slopes of the Taconic Mountains. As the prevailing northerly and westerly winds reach this area, air is forced upward. As the air rises, it expands and cools. The cooler air cannot hold as much moisture, so the relative humidity increases, leading to the formation of clouds and precipitation. During large storms, total rain or snow will often be greater in these areas due to this effect. The Hudson Highlands have a similar impact on the extreme southern portions of the county. The opposite effect causes lower precipitation in northwestern Dutchess County. As air is transported over the Catskill Mountains, it sinks on the down sloping side of the mountains. Sinking air warms and loses moisture, which lowers relative humidity and leads to dry conditions. A rain or snow “shadow” can often be observed in these areas during major storms, resulting in considerably less precipitation.

Figure 2.9 below depicts the mean monthly precipitation (rain and melted snow) in Dutchess County. The numbers are based on the average of data collected at the three official reporting stations in the county; Glenham, Millbrook, and Poughkeepsie/ Dutchess County Airport (NRCC, “CLIMOD System,” 2008).

![Normal Monthly Precipitation (Inches) in Dutchess County](image)

**Figure 2.9: Normal Monthly Precipitation in Dutchess County, 1971-2000** (Source: NRCC, “CLIMOD System,” 2008).
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Much of the precipitation in the northeastern United States comes from the Gulf of Mexico and the Atlantic Ocean, and is transported by major atmospheric storm systems. These systems develop less frequently during the summer, but local convective activity in the form of thunderstorms produces significant amounts of summer rain. Local topographic variations also influence precipitation.

Figure 2.10 traces the pattern of annual precipitation in Poughkeepsie from 1931 to 2000. The graph clearly shows the extended drought that affected the area during the early and middle 1960s. In fact, the Hudson Valley experienced drought conditions every single month from June 1962 through February 1967. The worst conditions occurred between July 1964 and February 1966, as every month during that period was spent in extreme drought environments (NOAA, “Historic Palmer,” 2008). In fact, 1964 was by far the driest year of this 62-year period, with only 24.52 inches of precipitation. Furthermore, the next two years were the third and fifth driest years during this time. The drought is the only one between 1931 and 2000 that persisted through several consecutive growing seasons and reached severe levels before a return to normal precipitation (NRCC, “CLIMOD System,” 2008). The red line on the graph in Figure 2.10 is a best-fit line, which illustrates the trend in yearly precipitation data over the 62-year period. It shows there has been a gradual increase in annual precipitation to about 43.8 inches of rain per year (NRCC, “CLIMOD System,” 2008).
Figure 2.10: Annual Precipitation in Dutchess County (Source: NRCC, “CLIMOD System,” 2008).³

Snow is precipitation in the form of ice crystals, formed from water vapor as it freezes in the air (NOAA, “NWS Glossary,” 2008). Dutchess County receives a moderate amount of snowfall, with roughly 30 to 50 inches throughout the county. Higher elevations in the northeast section of the county may receive 60 inches of snow in a given year. Storms bringing at least six inches of snow to the region are frequent and normally occur at least once in most winters (NRCC, “CLIMOD System,” 2008). Mean monthly snowfall for Poughkeepsie and Millbrook is provided in Figure 2.11 below.

![Mean Monthly Snowfall in Dutchess County, 1971-2000](image)

Figure 2.11: Mean Monthly Snowfall in Dutchess County, 1971-2000 (Source: NRCC, “CLIMOD System,” 2008).

Relative humidity is the ratio of the amount of moisture present in the atmosphere to the amount of moisture that the air can hold at any given temperature (expressed as a percent) (NOAA, “NWS Glossary,” 2008). Mean annual relative humidity in Dutchess County is between 66 and 75 percent (NOAA, “Mean Relative Humidity,” 2008).

³ Note: 1931-52 data collected in Poughkeepsie, 1953-2000 at the Dutchess County Airport.
BAROMETRIC PRESSURE

Pressure is the exertion of force upon a surface by a fluid in contact with it. Atmospheric pressure refers to the pressure the atmosphere exerts on the Earth’s surface (NOAA, “NWS Glossary,” 2008). Surface barometric pressure measurements are usually converted to mean sea level pressure, which standardizes the observation so that pressure can be measured on the same scale regardless of altitude. This conversion is done to make pressure readings a useful weather and climate tool. Otherwise, barometric pressure readings at a high elevation location such as Denver, Colorado would always be lower than the readings at locations near or at sea level. The mean annual pressure in Dutchess County is about 1017 millibars, or 30.04 inches of mercury (NOAA, “Annual Mean Sea Level Pressure,” 2008). The lowest pressure in the county normally occurs during violent weather such as severe thunderstorms and coastal storms. The highest pressure is observed when large high-pressure areas move over the region, bringing fair weather and low humidity. Differences in pressure cause winds in the atmosphere and the sharper the change in pressure is over a given distance, the stronger the winds will be.

WIND

Wind is the horizontal motion of air past a given point. It is caused by differences in air pressure and can also be affected by heating differences of the air and the physical profile of the earth’s surface (NOAA, “NWS Glossary,” 2008). Northerly and westerly winds dominate Dutchess County at an average annual velocity of 5.4 miles per hour (MPH). Winds are usually strongest during the winter and early spring, averaging 6-7 MPH. During the summer months, winds are weaker, on the order of 4-4.5 MPH, and have more of a southerly component (NRCC, “Wind Summary for Dutchess County,” 2008). The wind rose diagram below (Figure 2.12) shows the average wind speed and direction at the Poughkeepsie/Dutchess County Airport during the ten-year period from 1997-2007. The numbers around the circle indicate the wind direction (0 = North, 90 = East, 180 = South, and 270 = West), while the colored bars indicate the percentage the winds occurred at a certain speed.
Under normal atmospheric conditions, winds are strongest during the day and weaken as the sun sets and daytime heating is lost. Severe winds are rare in Dutchess County. Most high wind events are caused by localized, quick-moving severe thunderstorms. Longer, more widespread wind events occur occasionally and are due to larger mid-latitude cyclones such as nor’easters.

The strongest and most frequent winds generally come from the west because Dutchess County is located in the westerly wind belt, which can be found at the middle latitudes of the earth. The westerlies are just one of the components of global circulation patterns.

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Figure 2.12: Wind Rose for Poughkeepsie, New York, 1997-2007.

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4 V. Kelly. Wind Rose created from data from the Poughkeepsie FAA Airport, latitude 41.63 degrees, longitude -73.88 degrees, elevation 155 feet.
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SUN CLOUD COVER

The ratio of actual bright sunshine to the total possible amount of sunshine in a location is known as percentage of possible sunshine (NRCC, “Percent of Possible Sunshine,” 2008). In New York State, this value ranges from 46 percent in Syracuse to 58 percent in New York City. The location of Dutchess County between New York City and Albany (53 percent) means that the area receives some of the highest amounts of sunshine in the state. Sunshine is at a maximum during July, August, and September, with clouds most prevalent in January and March (NOAA, “Percentage of Possible Sunshine,” 2008). The graph below (Figure 2.13) shows the percentage of possible sunshine as measured at Poughkeepsie/Dutchess County Airport during the ten-year period of 1997-2007.

![Percentage of Possible Sunshine Graph]

Figure 2.13: The percentage of possible sunshine by month at Poughkeepsie, New York, 1997-2007. 

SEVERE WEATHER

Thunderstorms, tornadoes, winter storms, hurricanes, floods, and droughts have all impacted Dutchess County. Many of these storms have left behind considerable damage and in a few cases proven fatal. The NOAA Storm Prediction Center in Norman, Oklahoma monitors severe weather and issues real-time watches, forecasts and discussions.

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5 Poughkeepsie FAA Airport, latitude 41.63 degrees, longitude -73.88 degrees, elevation 155 feet.
Thunderstorms are relatively common in Dutchess County, primarily during the fall, spring and summer. Thunderstorms can be accompanied by lightning, hail, torrential rains, violent winds, and tornadoes. The time of greatest occurrence for severe thunderstorms is during the late spring and summer. The National Weather Service defines a thunderstorm as severe if it produces at least one of the following: 1) winds of at least 58 miles per hour, 2) hail at least ¾ inch in diameter, or 3) a tornado. The National Weather Service issues a severe thunderstorm warning if severe thunderstorms are imminent or occurring. Additionally, a severe thunderstorm watch is issued when severe weather is possible but not yet occurring (The Weather Channel, 2008). Between 1955 and 2007 there were 71 large hail (at least ¾ inch diameter) events in Dutchess County, or about one to two per year (NOAA, “NCDC Storm Events,” 2008). Thunderstorms are also capable of producing urban and small stream flooding, uprooting trees, widespread power outages, and damage to structures.

A tornado is a rotating column of air with a circulation reaching the ground (NOAA, “NWS Glossary,” 2008). The intensity of tornadoes is measured by the Fujita Scale, with an F0 being the weakest and F5 the strongest. An update to the old Fujita Scale, the Enhanced Fujita Scale, was implemented in 2007. Tornadoes are rare but not unheard of in New York State. A total of 11 tornadoes have been reported in Dutchess County since 1950 (NOAA, “NCDC Storm Events,” 2008). All of the tornadoes have been either an F0 or F1 on the Fujita Scale, causing light to moderate damage with winds of up to 112 miles per hour (NOAA, “Storm Prediction Center,” 2008). The National Weather Service issues a tornado warning if Doppler radar indicates the presence of a tornado or if a spotter has sighted one. Additionally, a tornado watch is issued if conditions are favorable for the development of tornadoes (Florida Division of Emergency Management, 2008).

A variety of winter storms can affect Dutchess County. Heavy snowstorms bringing several inches of snow are common. True blizzard conditions in the area are extremely rare since they require strong winds of at least 35 miles per hour and extreme blowing and drifting of the snow (NOAA, “NWS Glossary,” 2008). Storms occurring with mixed precipitation often wreak havoc on Dutchess County. Rain, snow, sleet, and freezing rain may all occur as part of the same storm system. Freezing rain, rain that freezes on contact with the ground (NOAA, “NWS Glossary,” 2008), is especially problematic, as it can lead to icy roads as well as downed trees and power lines, which may
cause widespread power outages. On average, Dutchess County receives 12-18 hours of freezing precipitation (rain and drizzle) per winter (Dirienzo, 2008).

**Hurricanes** are tropical cyclones with sustained winds of at least 74 miles per hour. **Tropical storms** are also tropical systems but weaker than hurricanes, with sustained winds between 39 and 73 miles per hour (NOAA, “National Hurricane Center,” 2008). Hurricanes, tropical storms, and their remnants occasionally affect Dutchess County. Several tropical storms and four hurricanes have made landfall in New York State since 1950 (NOAA, “Continental United States Hurricane Strikes,” 2008). Since Dutchess County is well north of the Atlantic Coast, the primary impacts from tropical cyclones are heavy rain and flooding. In 1999, Tropical Storm Floyd brought torrential rain to the county as it passed through Long Island and southeast New England. There were widespread reports of over 4.5 inches of rain, with 11.02 inches recorded in Stormville (NOAA, “Floyd Deluges Eastern New York,” 2008). The National Hurricane Center in Miami, Florida monitors tropical weather in the Atlantic and eastern Pacific Oceans and issue all pertinent watches, warnings and advisories.

**Floods** occur with relative frequency in Dutchess County, with roughly three floods of varying degrees reported each year in the county (National Climatic Data Center Storm Events Database). Each major stream in Dutchess County has a significant number of flood prone areas and certain areas are prone to annual flooding. The probability of flooding is greatest from December to April. Runoff from melting snow and ice often causes minor spring floods. Ice flows and heavy rainfall sometimes aggravate spring runoff conditions, producing severe floods in low-lying areas.

Most major floods in Dutchess County are triggered by coastal storms, while some are caused by tropical storms. Widespread flooding occurred in September 1938 due to the Great Hurricane of 1938, which made landfall in Long Island and Connecticut. In August 1955, Hurricane Diane passed just to the south of the region, leading to record flooding of the Tenmile River and Wappinger Creek.

*Figure 2.14: Recent Flooding in Dover, NY, Dutchess County* (Town of Dover, 2009).
Severe nor’easters may also produce floods in the county. In April 2007, an area of low pressure intensified rapidly as it moved from the southern Appalachians to the Long Island coast. The storm brought two days of heavy precipitation, which brought about extensive flooding of small streams and creeks in the county. Record flooding occurred on the Wappinger Creek at Wappingers Falls, which crested at 15.06 feet, 7.06 feet above the flood stage of 8.0 feet. Moderate flooding was also recorded along the Ten Mile River at Webatuck, which crested at 11.23 feet. The storm produced three to eight inches of rain throughout the county, including 4.99 inches in Poughkeepsie and 6.83 inches in Rhinebeck (NOAA, “Past Storm Events,” 2008).

**Flash flooding** is a rapid water level rise in a stream or creek above a predetermined flood level (NOAA, “NWS Glossary,” 2008). Flash floods can occur any time of year in Dutchess County. On average, there are about ten days a year when at least one inch of rain falls (NRCC, “CLIMOD System,” 2008). These days are most common between May and October, and the rain usually occurs because of strong thunderstorms which can often lead to flash flooding. Rapid snowmelt in association with strong precipitation events may also lead to flash flooding during the late winter and early spring.

A **drought** is a deficiency in moisture that results in adverse effects on people, animals, or vegetation over a sizeable area (NOAA, “NWS Glossary,” 2008). The county’s major drainage basins have sufficient capacity to sustain some flow even during severe droughts, such as the aforementioned drought from 1962-1967. For a period of 29 months between May 1964 and September 1966, the lowest Palmer Drought Severity Index (PDSI) value was -6.66 in November 1964. Serious droughts are rare; brief dry spells are far more common. Dry periods temporarily place crops under stress and often force restrictions in the recreational uses of forested lands because of fire hazards. Mandatory or volunteer water restrictions may also be put in place by local municipalities. Further information about droughts can be found on the Northeast Regional Climate Center’s [Northeast Drought Page](https://www.climate.gov/drought/northeast-drought).

18 The Natural Resource Inventory of Dutchess County, NY
AIR QUALITY & POLLUTION

The major air pollutants in Dutchess County are ground-level ozone, particulate matter and acid deposition. Because some of these pollutants are transported across state and county lines, the federal Clean Air Act was enacted to control these pollutants at the state and federal geographic scale. It’s important to remember that some pollutants measured in Dutchess County are not emitted here. Likewise, some pollutants emitted in Dutchess County affect downwind areas outside of Dutchess County.

Overview of Clean Air Act

The principle statutory authority for controlling air pollution at the Federal and State level is contained in the Clean Air Act (CAA), which was enacted by Congress and signed into law in 1970. Although subsequently amended, the core provisions of the 1970 Clean Air Act are still in effect. In Section 109 of the law, the United States Environmental Protection Agency (EPA) is directed to establish National Ambient Air Quality Standards (NAAQS) for six specific criteria pollutants:

1. Carbon Monoxide
2. Lead
3. Nitrogen Oxides (NOx)
4. Ozone (or smog)
5. Particulate Matter and
6. Sulfur Dioxide (SO2)

For each of the six criteria pollutants, NAAQs are set by EPA at a level designed to protect public health with an adequate margin of safety (Brownell, 1993). One set of limits, the primary standard, protects health. Another set of limits, the secondary standard, is intended to prevent environmental and property damage (United States Environmental Protection Agency, 1993).

Under section 110 of the Clean Air Act, each state is required to submit a “State Implementation Plan,” commonly known as the “SIP” to the EPA, which details how the state will implement,

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6 Although greenhouse gases that contribute to climate change are not yet regulated under the Clean Air Act as of October 2010, they will likely be regulated in the future, due to the US Supreme Court ruling Massachusetts v. EPA, 549 U.S. 497 (2007), in which the Supreme Court found that greenhouse gases are air pollutants covered by the Clean Air Act, and subsequent Endangerment and Cause or Contribute Findings issued by the EPA under Section 202(a) of the Clean Air Act in 2009 (http://www.epa.gov/climatechange/endangerment.html#back).
maintain, and enforce the primary and secondary NAAQS in each air quality control region within the State (United States Code of Federal Regulations, 2006). As the regulatory authority for New York State, the NYS Department of Environmental Conservation (DEC), working with local authorities, drafts the SIPs for submission to the EPA to meet the requirements of the Clean Air Act in New York State.

Upon passage of the CAA Amendments of 1990, several changes were put in place, including new designation of areas of the country not meeting the NAAQS for each criteria pollutant, also known as Areas of Non-Attainment. Under the CAA, a geographic area that meets or does better than the primary standard is called an Attainment Area; areas that do not meet the primary standard are called Non-Attainment Areas (United States Environmental Protection Agency, 1993). For areas that are in Non-Attainment for any one of the six NAAQS for criteria pollutants, Title 1 of the 1990 CAA Amendments imposes deadlines for meeting the NAAQS that vary with the severity of pollution problems, and requires states to submit revised SIPs— which require that the states make “measurable progress” in meeting the NAAQS.

Ozone

One of the most critical criteria pollutants, ground level ozone, is the main harmful component of smog. It is a highly reactive gas that consists of 3 oxygen atoms. Ozone is not emitted directly, but is formed through chemical reactions between precursor emissions of Volatile Organic Compounds (VOC) and Nitrogen Oxides (NOx) in the presence of sunlight. These reactions are stimulated by sunlight and high temperature, which is why peak ozone levels occur during summer and the warmest period of the day. The VOC and NOx precursors to ozone are produced by the combination of pollutants from many sources, including smokestacks, cars, paints and solvents (Figure 2.15). According to the EPA, when a car burns gasoline, releasing exhaust fumes, or a painter paints a house, smog-forming pollutants rise into the sky (United States Environmental Protection Agency, 1993).

The initial NAAQS for ozone was a maximum 1-hour average not to exceed 0.12 parts per million (ppm) (United States Code of Federal Regulations, 2006). In 1997, the EPA established a new NAAQS for ozone. To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must
not exceed 0.08 ppm. In May 2008, that standard was lowered from 0.08 ppm to 0.075 ppm. Standards are periodically changed because the Clean Air Act requires the EPA to review and revise standards as new information develops about public health, safety and environmental and property effects of criteria pollutants.

Figure 2.15: Sources of Ozone (Source: USEPA, 2003).

Ozone in Dutchess County
The United States EPA and New York State DEC maintain a network of air quality monitoring for the United States and New York State, respectively. According to EPA, the EPA’s ambient air quality monitoring program is carried out by State and local agencies (United States Environmental Protection Agency, 2006). The New York State DEC measures air pollutants at more than 80 sites across the state, using continuous and/or manual instrumentation, as part of the federally-mandated National Air Monitoring Stations Network (NYS DEC, 2007). Continuous air quality monitoring of DEC’s Region 3 - the Hudson Valley - occurs at several sites, including White Plains in Westchester County, Mt. Ninham in Putnam County, Valley Central in Orange County, and Belleayre Mt. in Ulster County. The only monitoring station in Dutchess County is site #132801, which is maintained at the Cary Institute of Ecosystem Studies in Millbrook, NY. The DEC’s Division of Air Resources maintains accurate hourly, daily, monthly and yearly air quality data and forecasting, and information is available from the NYS DEC website. According to the DEC, in 2007,
compliance with the existing NAAQS for ozone was met at the Millbrook station in Dutchess County (see Table 2.3).

Table 2.3: Comparison between NYS Ambient Air Quality and Ambient Air Quality Standards for 2007 for Ozone for NYSDEC Region 3 (Source: NYS DEC, 2007)

<table>
<thead>
<tr>
<th>Station</th>
<th>Number of Observations &gt; 0.12 ppm</th>
<th>2007 One Hour Averages</th>
<th>4th Highest Daily Maximum 8-Hour Average – Not to exceed an avg. of 0.08 ppm during the last 3 years*</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Plains</td>
<td>3</td>
<td>0.138+ 0.127+ 0.126+ 0.121</td>
<td>0.095 0.083 0.095 0.091+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valley Central</td>
<td>2</td>
<td>0.145+ 0.131+ 0.116 0.093</td>
<td>0.087 0.077 0.084 0.082</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Millbrook</td>
<td>0</td>
<td>0.114 0.107 0.097 0.090</td>
<td>0.082 0.064 0.078 0.074</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mt. Ninham</td>
<td>1</td>
<td>0.126+ 0.111 0.108 0.108</td>
<td>0.096 0.074 0.086 0.085+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belleayre Mt.</td>
<td>0</td>
<td>0.088 0.084 0.083 0.082</td>
<td>0.080 0.077 0.073 0.076</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Particulate Matter

Particulate Matter (PM) includes dust, dirt, soot, smoke and liquid droplets. It can be formed by condensation or transformation of gases. There are two size classifications for particulates: 10 microns (PM10), which are particles that are less than 10 microns in size and 2.5 microns (PM2.5), which are particles that are less than 2.5 microns in size. The PM2.5 size class causes decreased lung function that can have serious effects on individuals with asthma, bronchitis or other airway diseases. PM2.5 is most commonly the result of combustion, including fossil fuel burning, and transformation of gases such as sulfur dioxide, nitrogen oxides, and volatile organic compounds. The National Ambient Air Quality Standards (NAAQS) for PM2.5 include a 24-hour average and annual average, which are not to exceed 35 and 15 µg/m³, respectively.

Particulate Matter in Dutchess County

PM2.5 is not currently monitored in Dutchess County. The closest monitoring sites are Newburgh and Albany. PM2.5 was monitored in Poughkeepsie between 1999 and 2002 and was compliant within NAAQS during that time. Although Dutchess County is currently within compliance for

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7 *NYS and Federal Ambient Air Quality Standard. + Denotes a contravention of Federal AAQS.
PM2.5, development and vehicular travel should be controlled to ensure that it remains in compliance.

**Air Quality Index**

The Air Quality Index (AQI) is an index that illustrates the level of each of the criteria pollutants. For Dutchess County, AQI's for ozone and PM2.5 are forecast on a daily basis by the NYS DEC. The AQI was created as an easy way to correlate levels of different pollutants to one scale; the higher the AQI value, the greater the health concern. When levels of ozone and/or PM2.5 are forecast to exceed an AQI value of 100, an Air Quality Health Advisory is issued alerting sensitive groups to take the necessary precautions. AQI alerts are reported via media outlets and weather forecasting facilities. For real-time air quality data and forecasts for the Hudson Valley visit the NYS DEC Air Quality Forecast for New York State.

**Acid Precipitation**

Acid precipitation refers to rain, snow or ice that is more acidic than what is normal for a given area. In the northeastern United States, normal precipitation pH is about 5.2. The pH scale is a measure of acidity ranging from 0 to 14, with pH 7 being neutral, pH less than 7 is acidic, and pH greater than 7 is basic. The pH scale is logarithmic, which means that each pH unit is 10 times that of its neighbor. So a solution with pH 4 is 10 times more acidity than a solution with pH 5. In Millbrook in Dutchess County, the average precipitation pH between 1984 and 2007 was 4.31 (Cary Institute of Ecosystem Studies, 2008).

Acid precipitation most commonly forms from sulfur dioxide (SO$_2$) and oxides of nitrogen (NOx). Most SO$_2$ is emitted by coal burning power plants while NOx most commonly comes from car exhaust and other industrial processes as well as coal burning. In the atmosphere, the SO$_2$ and NOx transform to sulfate (SO$_4^{2-}$) and nitrate (NO$_3^-$) which combine with hydrogen ions (H$^+$) to form sulfuric acid (H$_2$SO$_4$) and nitric acid (HNO$_3$). Acid precipitation is more correctly called acid deposition. There are 2 forms of acid deposition: wet deposition, which is deposition in the form of rain, snow or ice, and dry deposition, which is deposition in the form of gases or particles. By far, most acid deposition falls as wet deposition. H$_2$SO$_4$ is the most important component of acid deposition although HNO$_3$ is also important. Because the prevailing wind direction for Dutchess County is southwest, as it is for most of the northeastern US, we are upwind of the midsection of
the country where many coal burning power plants are. Our air and precipitation largely originates in areas with high emissions of the acid deposition precursor SO₂.

Acid deposition and other pollutants harm natural ecosystems and threaten biological diversity. Acid deposition acidifies soils, lakes and streams and enhances the process that makes toxic mercury (another pollutant emitted during the burning of coal) available to organisms. Acid deposition also enhances the mobilization of toxic aluminum from soils to tree roots, increases leaching of sulfate and nitrate to soils and surface waters and promotes the loss of important buffering nutrients from soils. In aquatic systems, aluminum can kill fish and other aquatic organisms, reducing fish species richness. The increased acidity in lakes and other surface waters can reduce ecosystem productivity. While existing acid precipitation regulations are necessary, they are insufficient to conserve natural ecosystems and their valuable services (Lovett and Tear, 2008).

Title IV of the 1990 Clean Air Act Amendments (CAAA) mandates requirements for the control of acid deposition. The CAAA set a goal of reducing annual SO₂ emissions by 10 million tons below 1980 levels. To achieve these reductions, the law required a two-phase tightening of the restrictions placed on the highest emitting fossil fuel-fired power plants. Phase I began in 1995 and Phase II began in the year 2000. The Act also called for a 2 million ton reduction in NOx emissions by the year 2000.

**Acid Precipitation in Dutchess County**

Figure 2.16 illustrates the decline in the acidity of precipitation at the Cary Institute of Ecosystem Studies in Dutchess County between 1984 and 2007. Notice, however, that the red line, which represents the acidity of normal precipitation, is still far below our rain’s acidity today.
CLIMATE CHANGE

**Climate change** is defined as any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period of time (decades or longer). The global climate can change because of natural factors (such as changes in the sun’s intensity); natural processes within the climate system; or human activities that change the atmosphere’s composition (such as through the burning of fossil fuels) (EPA, 2010). Until the advent of the industrial revolution, global climate change occurred over long periods of time and was caused by a variety of natural factors. However, the International Panel on Climate Change (IPCC), an international body of scientists working through the United Nations, has concluded that the earth’s climate is changing much more rapidly than ever before, and this change is very likely caused by the increase in atmospheric concentrations of greenhouse gases (GHGs) emitted by humans (IPCC, 2007).

The current atmospheric concentration of carbon dioxide is about 385 parts-per-million (ppm), the highest level in over 700,000 years. Most of this increase is due to the combustion of fossil fuels by humans (NOAA, “Carbon Dioxide, Methane Rise Sharply,” 2008). Natural carbon dioxide and other gases such as methane contribute to the greenhouse effect. The greenhouse effect is necessary
to maintain the earth’s atmosphere at a reasonably mild temperature by allowing solar radiation to pass through unimpeded, and simultaneously absorbing outgoing radiation. However, the greenhouse effect is being enhanced as the concentration of GHGs in the atmosphere is increasing (Pidwirny, 2006).


Average global temperatures have risen by 1.3 degrees Fahrenheit over the past century. According to the National Oceanic and Atmospheric Administration (NOAA), seven of the eight warmest years on record have occurred since 2001. As a result, the IPCC has concluded that warming of the Earth’s climate system is now unequivocal (USEPA, FAQs, 2009).

Since 1970, average temperature in the northeastern United States has increased by 2 degrees Fahrenheit, with winter temperatures rising twice this much (Global Climate Change Impacts, 2009). This warming has already brought about numerous noticeable changes to the climate of New York State and Dutchess County, which are detailed below. Estimates of continued climate change in the future are heavily dependent on the rate of human’s GHG emissions. According to the USEPA, “if
humans continue to emit GHGs at or above the current pace, we will probably see an average global temperature increase of 3 to 7 degrees Fahrenheit by 2100,” while global temperature increases would be lower with lower GHG emissions. However, even if humans were to drastically reduce their GHG emissions, the earth would still warm about 1 degrees Fahrenheit over the next 100 years, due to the long lifetime of many GHGs and the slow cycling of heat from the ocean to the atmosphere (USEPA, FAQs, 2009).

**Changing Temperatures and Seasons in the Northeast and Hudson Valley**

Dutchess County is already experiencing a rise in temperature. The mean annual temperature in Poughkeepsie has generally increased during the past 55 years, as evidenced by the Figure 2.18 below. There has been an overall increase of about 1.1 degrees Fahrenheit during this time period (NRCC, “CLIMOD System,” 2008).

![Figure 2.18: Mean Annual Temperature in Poughkeepsie, 1950-2007](Image)

Figure 2.18: Mean Annual Temperature in Poughkeepsie, 1950-2007 (Source: NRCC, “CLIMOD System,” 2008).

Mean temperatures are expected to rise an additional 1.5 to 3 degrees Fahrenheit in the Hudson Valley by 2020, and by 3.0 to 7.5 degrees Fahrenheit by 2050. By the close of the century, mean temperatures are expected to increase by 4.0 to 8.0 degrees Fahrenheit by 2080, depending on how much GHGs humans continue to emit (draft New York State ClimAid Report, 2010). Summers
are projected to warm slightly more than winters, and the combination of warmer temperatures and high humidity may cause summer days to feel substantially warmer than at the present-comparable to the current climate of South Carolina (United State Global Change Research Program, 2009).

The timing of the seasons will also continue to be affected by climate change. The growing (frost-free) season has already increased by over 20 days in Dutchess County over the past 60 years, as shown in Figure 2.19 below (NRCC, “CLIMOD System,” 2008).

![Figure 2.19: Frost Free Season in Poughkeepsie (number of days), 1950-2007](source)

This trend is expected to continue and by the close of the century in the Northeastern US, the growing season may be 4 to 5 weeks longer than it is currently (United State Global Change Research Program, 2009).

**Precipitation and climate change**

While there has been no discernable trend in annual precipitation in New York State over the past several decades, annual precipitation is expected to gradually increase through 2100 in the Northeastern US due to climate change. Precipitation in the Hudson Valley region is projected to increase by +0 to 5% by 2020; +0 to 10% by 2050; and +5 to 10% by 2080 (draft New York State ClimAid Report, 2010).

28  **The Natural Resource Inventory of Dutchess County, NY**
The most striking trend is the observed and projected increase in frequency and intensity of extreme precipitation events, especially under the high emissions scenario. In Poughkeepsie, the average number of days per year with at least 2 inches of rain has increased from one to two and a half, as shown below in Figure 2.20. In 2005, six of these extreme precipitation events occurred during the year, a record during this period (NRCC, “CLIMOD System,” 2008).

![Figure 2.20: Extreme Precipitation Events in Poughkeepsie, 1950-2007](source: NRCC, “CLIMOD System,” 2008).

By the end of the century, there will be one to two more days each year of at least two inches of rain, and on average 12 percent more rain during these events (United State Global Change Research Program, 2009). Sea level rise will affect the Hudson River in the Mid-Hudson Valley, and the level of the Hudson River is projected to be increase by +1 to 4 inches by 2020; +5 to 9 inches by 2050; and +8 to 18 inches by 2080 (draft New York State ClimAid Report, 2010).

Climate change has already had a considerable effect on the amount of snowfall and snow cover in the northeastern United States, and will continue to do so. The number of days with snow cover has already been decreasing across the Northeast. For example, in Poughkeepsie, the number of days with at least one inch of snow on the ground has decreased by about 33 percent the past 60 years (NRCC Climod System). Throughout the rest of the century, the number of days with snow cover is expected to continue diminishing, with 4-8 fewer snow-covered days per month during the winter in
Chapter 2: Climate and Air Quality of Dutchess County

the Northeast. The overall snow season will also shorten, with snowfall arriving later and leaving earlier. As temperatures rise, the snow that does fall will become “slushier” - wetter, heavier, and more dense. Furthermore, winter storms which once brought the area just snow will now be more likely to produce sleet, freezing rain, and rain with less, if any snowfall (United State Global Change Research Program, 2009).

According to the United State Global Change Research Program, climate change is already affecting the water resources, agriculture, ecosystems, energy resources, transportation and health in the northeastern United States. Over the next few decades and to the end of the century, the projected climate changes for the region include increasing adverse health effects from extreme heat and declining air quality, especially in urban areas; changes to agricultural production, including dairy, fruit, and maple syrup, as climates shift; increasing frequency of flooding due to sea-level rise and heavy downpours; and adverse impacts on winter recreation due to projected reductions in snow cover (U.S. Global Change Research Program, 2009, Global Climate Change Impacts in the United States: Northeast Region). While the exact impacts of climate change on Dutchess County are not entirely certain, recent trends and current research indicates that the climate and therefore the ecosystems and natural resources of the county will be altered substantially in the future, especially if humans continue to emit greenhouse gas emissions at the current rate.

CLIMATE DATA

The National Climatic Data Center, located in Asheville, North Carolina, is the world’s largest active archive of weather data. The NCDC archives 99 percent of all NOAA data, adding 224 gigabytes of new data daily. The center’s stated mission is “to provide access and stewardship to the Nation's resource of global climate and weather related data and information, and assess and monitor climate variation and change” (NOAA, “What is NCDC?,” 2008). The NCDC also manages six regional climate centers that disseminate climate data, research, and applications at a regional and local level. Figure 2.21 shows a map of the coverage areas of each regional climate center in the United States. The Northeast Regional Climate Center (NRCC), located in the Department of Earth and Atmospheric Sciences at Cornell University, covers Dutchess County (NOAA, “Regional Climate Centers,” 2008).
The NCDC and the regional climate centers support the American Association of State Climatologists, an organization composed of state climatologists and the directors of the six regional climate centers. The New York State Climate Office is also located with the NRCC at Cornell University.

The National Weather Service’s Cooperative Observer Program is a climate observing network of over 11,000 volunteers throughout the country. Data is used for NWS products and archived at the National Climatic Data Center (NOAA, “NWS Cooperative Observer Program,” 2008). There have been 15 cooperative reporting stations in Dutchess County at one time or another. Eight stations currently operate in the county and are listed in Table 2.4 below.
Table 2.4: Weather station locations in Dutchess County (Source: NRCC, “CLIMOD System,” 2008).\(^8\)

<table>
<thead>
<tr>
<th>Station</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Elevation (ft.)</th>
<th>Years in Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beacon</td>
<td>41° 30' N</td>
<td>73° 57' W</td>
<td>322</td>
<td>1930-1935</td>
</tr>
<tr>
<td>Clinton Corners</td>
<td>41° 49' N</td>
<td>73° 46' W</td>
<td>280</td>
<td>1971- Present</td>
</tr>
<tr>
<td>Glenham</td>
<td>41° 31' N</td>
<td>73° 56' W</td>
<td>275</td>
<td>1948-1996</td>
</tr>
<tr>
<td>Millbrook (Millbrook School)</td>
<td>41° 51' N</td>
<td>73° 37' W</td>
<td>820</td>
<td>1948- Present</td>
</tr>
<tr>
<td>Millbrook (Institute of Ecosystem Studies)</td>
<td>41° 47' N</td>
<td>73° 45' W</td>
<td>413</td>
<td>2004- Present</td>
</tr>
<tr>
<td>Millerton</td>
<td>41° 57' N</td>
<td>73° 31' W</td>
<td>732</td>
<td>1948-1985</td>
</tr>
<tr>
<td>Poughkeepsie (South Road)</td>
<td>41° 38' N</td>
<td>73° 55' W</td>
<td>170</td>
<td>1993- Present</td>
</tr>
<tr>
<td>Poughkeepsie (Rural Cemetery)</td>
<td>41° 41' N</td>
<td>73° 56' W</td>
<td>102</td>
<td>1948-1974</td>
</tr>
<tr>
<td>Poughkeepsie</td>
<td>41° 43' N</td>
<td>73° 56' W</td>
<td>50</td>
<td>1962- Present</td>
</tr>
<tr>
<td>Poughkeepsie/ Dutchess County Airport</td>
<td>41° 38' N</td>
<td>73° 53' W</td>
<td>166</td>
<td>1932- Present</td>
</tr>
<tr>
<td>Poughkeepsie (Midtown)</td>
<td>41° 42' N</td>
<td>73° 56' W</td>
<td>10</td>
<td>1960-1974</td>
</tr>
<tr>
<td>Poughkeepsie (Pendell Road)</td>
<td>41° 43' N</td>
<td>73° 55' W</td>
<td>220</td>
<td>1965-1976</td>
</tr>
<tr>
<td>Rhinebeck</td>
<td>41° 53' N</td>
<td>73° 52' W</td>
<td>301</td>
<td>1989- Present</td>
</tr>
<tr>
<td>Stormville</td>
<td>41° 32' N</td>
<td>73° 44' W</td>
<td>915</td>
<td>1990- Present</td>
</tr>
<tr>
<td>Wappingers Falls</td>
<td>41° 39' N</td>
<td>73° 52' W</td>
<td>114</td>
<td>1948- Present</td>
</tr>
</tbody>
</table>

**IMPLICATIONS FOR DECISION-MAKING**

Climate, the synthesis of long-term weather patterns, contributes to many facets of life in Dutchess County. The county has a humid continental climate, with hot, humid summers, cold winters, and generally sufficient precipitation. Severe weather such as thunderstorms, winter storms, and floods occasionally affect the county. The climate and air quality of the county have had several important ramifications for life in the county. Historically, Dutchess County’s climate has been very favorable for the production of a variety of agriculture products, including milk and dairy products, equine, nursery and floriculture, vegetables and potatoes, and fruits and nut production (USDA, 2009). The moderate climate, location near major waterways and major metropolitan areas has been a decisive factor in human settlement patterns in the region. As the county continues to grow, it will be important to plan for appropriate development in order to protect the county’s air quality and to help mitigate and adapt to climate change.

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\(^8\) Bold Stations denote NCDC principal reporting stations for 1971-2000 data period. *Italics* denote a member of the US Climate Reference Network.
Chapter 2: Climate and Air Quality of Dutchess County

Air Quality

The air we breathe is a vital resource that we should not take for granted. It is essential for the health of human life as well as the natural world around us. Without clean air, not only will our own breathing be compromised, but the health of our forests, fields and all of the animals and plants that they sustain will be threatened. For this reason, it is essential that we protect this important resource.

Some pollutants such as ground-level ozone and acid deposition have improved in Dutchess County in the last several decades. However, the current levels of these pollutants are still a long way from normal. Additionally, the latest health research indicates that our standards for pollutants such as ozone and particulate matter have been set too high to adequately protect human health. As a result, the EPA has adopted lower concentration limits for ground level ozone. The combination of the new EPA standard for ozone, together with the fact that Dutchess County is grouped regionally with Putnam and Orange Counties, has resulted in the EPA designation of nonattainment for ozone for the Dutchess/Putnam/Orange County Area. The take home message is that pollutants such as ozone and particulate matter can easily become more critical in Dutchess County, especially as the population in the county grows and development occurs.

Currently ozone, particulate matter and acid deposition are regulated at the federal level. Because those pollutants, or their precursors, are to a large extent, produced at a regional scale larger than Dutchess County, indeed larger than the state of New York, they are regulated by the federal government via the Clean Air Act and its amendments. The precursors to ozone, acid deposition and some particulate matter are produced in areas upwind from Dutchess County. As a result, we rely on our state and federal governments to regulate these pollutants in order to keep the air in Dutchess County clean. It is important to remember, however, that just as there are sources of pollutants upwind from us, there is an area downwind of us, where the pollutants that we produce will settle. Therefore, we should not only be concerned about the pollutants that come from our neighbors upwind, but we should also remember that it is our responsibility to control our own air pollutant emissions for the sake of our downwind neighbors.

What are the options or tools available at the municipal or county level for the protection of our air quality? Many pollutants or precursors to pollutants are produced by motor vehicles. Therefore,
reducing our dependence on cars will help protect our air quality, and it is critical to ensure that there are alternative means of transportation available. Providing and maintaining safe bicycle routes and adequate public transportation are two ways local governments and agencies can reduce pollution produced by vehicle exhaust. Volatile Organic Compounds (VOC) are important precursors to ozone, and one source of VOC is gasoline vapors. Our neighbors in Westchester and Putnam Counties have required gaskets on all gasoline pumps to prevent the escape of vapors. Dutchess County should consider the same or similar requirements to reduce ozone formation. Some municipalities in New York have considered ordinances to restrict emissions from outdoor wood burning furnaces, which can produce high concentrations of particulates. While manufacturers of indoor woodstoves are currently required by EPA to certify that stoves for sale in the United States comply with the EPA particulate emissions guidelines in the Clean Air Act, outdoor wood burners are not currently regulated at the federal level. Taking steps at the local level not only ensures cleaner air for Dutchess County, but also for our downwind neighbors.

Local legislation often serves as the impetus for more regional legislative action. For example, climate change legislation enacted by New York and California may serve as a template for federal climate change legislation. When local communities take steps to address regional issues, it sends the message to representatives in higher legislative offices that constituents want action, and more encompassing legislation often follows. Although local ordinances may seem limited in the short-term, they can have a more broad effect in the long-term, thus making them worthwhile for regional as well as local communities.

Climate Change
As detailed above, the climate of New York State and Dutchess County is already changing due to the affects of global climate change. These observed changes include increased temperature in the summer, milder temperatures in the winter (with less snow cover and decreased icing over of the Hudson River, more extreme precipitation events, and a longer growing season). The observed changes are already affecting facets of life in Dutchess County, whether or not they are broadly perceptible to the public and municipal officials. For example, there are fewer opportunities now than in the past for popular winter recreational activities such as skiing, ice yachting and sledding as winters are warmer and there is less snow and ice cover. Increasingly hot and humid summer
temperatures and increasing “hot spells” above 90 degrees mean that more people are using air conditioning and installing central air conditioners in their homes.

Dutchess County’s climate will continue to change in the future, and these changes will be more extreme if human GHG emissions continue unabated or increase into the future. Climate change will have far-reaching effects on many sectors. New York State and many local governments, organizations and businesses around New York have already started to reduce their emissions of GHGs (through climate mitigation, or the actions taken to permanently eliminate or reduce the long-term risk and hazards of climate change to human life and property) by improving their energy efficiency in various operations and increasing the use renewable energy.

Business and municipal leaders also need to start planning for climate adaptation, or planning for the changes to the climate that will occur and taking into account the future risks of climate change when planning and making decisions. Those involved in agriculture, insurance, transportation and many other sectors must be cognizant of the latest climate change information and future projections (Sussman and Freed, 2008). According to the US Global Change Research Program’s Climate Literacy Guide, reducing our vulnerability to climate change will require changes to our economy and infrastructure, as well as individual attitudes, societal values, and government policies to ensure the stability of both human and natural systems (2009).

Communities may want to adopt “win-win” strategies for climate change adaptation. These are actions that would be beneficial for the community and ecosystem even if the climate does not change as much as scientists are projecting. These win-win strategies may include:

- Adopting a local climate change action plan that describes the policies and measures that the municipality will enact to reduce greenhouse gas emissions and adapt to climate change. One example is a program through the New York State Department of Environmental Conservation, for communities to adopt the New York State Climate Smart Communities Pledge;
- Working on long-term infrastructure planning that takes into account changing climate models for precipitation, sea level rise and rising temperatures and their possible impacts on drinking water supplies and water treatment plants, roads and bridges and energy supplies.
• Planning to assure a continuous supply of the basic needs that may be affected by climate change, including a secure regional food system, clean water, and renewable energy.

• Establishing and enhancing riparian buffers and protecting wetlands and open space in order to prepare for possible increased high-intensity storm events;

• Working with private forest owners to protect and sustainably manage forested areas;

• Including protection of open space, biodiversity, and wetlands/watercourses in comprehensive plans, zoning and local ordinances, and incorporate smart growth and low impact development principles into planning decisions;

• For more adaptation strategies, see the NYS Open Space Conservation Plan, Climate Change Adaptation Recommendations, at: see: [http://www.dec.ny.gov/docs/lands_forests_pdf/osp09chapter3a.pdf](http://www.dec.ny.gov/docs/lands_forests_pdf/osp09chapter3a.pdf).

**RESOURCES FOR ADDITIONAL INFORMATION**

• **Albany National Weather Service Forecast Office**: The office provides weather forecasts, observations, and climate data for Dutchess County and surrounding locations in Eastern New York and Western New England. See: [http://www.erh.noaa.gov/er/aly/](http://www.erh.noaa.gov/er/aly/).

• **Cary Institute of Ecosystem Studies**: Provides real-time and summarized climate data from Millbrook, NY through the Cary IES Environmental Monitoring Program, at: [http://ecostudies.org/emp_daily.html](http://ecostudies.org/emp_daily.html).

• **ICLEI Local Governments for Sustainability**: [http://www.iclciusa.org/programs/climate](http://www.iclciusa.org/programs/climate) ICLEI is a membership association that provides tools to local governments committed to climate protection and sustainability.

• **Jet Stream**: Many of the hyperlinks in this document link to Jet Stream, an online weather course for the general public from the National Weather Service. The homepage is: [http://www.srh.noaa.gov/jetstream/index.htm](http://www.srh.noaa.gov/jetstream/index.htm).

• **National Climatic Data Center**: Provides climate data free of charge, at: [http://www.ncdc.noaa.gov/oa/mpp/freedata.html](http://www.ncdc.noaa.gov/oa/mpp/freedata.html).

• **New York State Department of Environmental Conservation, Climate Smart Communities Program**: [http://www.dec.ny.gov/energy/50845.html](http://www.dec.ny.gov/energy/50845.html).
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- Northeast Climate Data Center, Cornell Dept of Earth and Atmospheric Sciences: http://www.nrcc.cornell.edu/.
- US Environmental Protection Agency: http://www.epa.org includes comprehensive information on air quality and climate change.

REFERENCES


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