
2: CLIMATE, METEOROLOGY AND AIR QUALITY

A. Climate

Climate is a major factor in determining the kinds of plants and animals found in an ecosystem. New Jersey has a *temperate climate* because it has mild average temperatures, four seasons, and rainfall distributed throughout the year. The Office of the New Jersey State Climatologist (ONJSC) divides New Jersey into five distinct climate regions. Holland resides in the *Northern Zone*, grouped with the Valley and Ridge, Highlands and part of the Piedmont physiographic provinces (see **Section 3A** for descriptions of physiographic provinces). Since this region is surrounded by land, it can be characterized as having a continental type of climate with minimal influence from the Atlantic Ocean, except when the winds come from the east. The dominant atmospheric circulation is the *prevailing westerlies*, the broad, undulating flow of air from west to east across the middle latitudes of North America. Prevailing winds are from the southwest in summer and from the northwest in winter (ONJSC, 2004).

Climate changes naturally over long periods of time. Most climatologists believe that recent changes in climate are the result of human activities, and are attempting to predict the effects and magnitude of future trends. The NJ State Climatologist compiled data for 19 weather stations within New Jersey and created time-series graphs of many variables (e.g. min. and max. temperature, precipitation) for the NJ Climate Report Card (Robinson, Fall 2005, see **Internet Resources**). The Flemington weather station is one of these, and has been monitored from 1879 through the present for temperature and rainfall (Hartman, 2002).

B. Meteorology

Precipitation and Temperature

As the prevailing westerlies shift north and south and vary in strength, they bring wet, dry, hot, and cold airstreams. These influence the weather throughout New Jersey, resulting in highly variable daily weather.

The weather station nearest to Holland Township is located in Stewartsville, Warren County, NJ. It is currently monitored by the New Jersey Weather and Climate Network, and real-time data and weather forecasts are available on the Internet. However, historical data are not available for this site. The nearest weather station with historical data available is in Flemington, which has been monitored continuously from 1926 – 2000 by the ONJSC. The next official update from the National Climatic Data Center will be for 1981-2010 (Robinson, 2005). **Table 2.1** displays monthly average highs and lows and mean temperature, average monthly precipitation, and record highs and lows (and the year it occurred in parentheses).

Measurable precipitation falls in New Jersey on approximately 120 days per year. In Flemington, annual precipitation for the period 1926-2000 has averaged 46.42 inches, although the period 1971-2000 has been wetter, averaging 49.34 inches (see **Table 2.1**). Precipitation in Flemington averages 0.44 inches higher than the average for all sites in the northern third of New Jersey for the long-term, and 0.45 inches lower for the most recent 30 years.

During the warm season, thunderstorms (which often occur in the evening) are responsible for most of the rainfall. About twice as many thunderstorms occur here as in the

coastal zone, where the nearby ocean helps stabilize the atmosphere. On average, the fall months are usually the driest, although record rainfalls are more likely to occur then, due to tropical storms (see **Table 2.2**).

An average of 40 to 50 inches of snow falls annually (about 10" of snow equals 1" of rain) in the Northern Zone. Each winter, about 9 to 12 days receive snowfall greater than or equal to 0.5" in Holland Township. Days with snowfall greater than 4" occur only about twice per winter in this area (ONJSC, 2006). Measured in Flemington, the earliest snow on record was on October 11 (which occurred in 1979), and the latest was April 27 (in 1967), both recording an inch (ONJSC, 2004).

Hunterdon County has a growing season of about 167 days. The average date for the last killing spring frost is April 29th (in one year out of 10, the last freeze may be May 9 or earlier). The first frost in fall is around October 13th (in one year out of 10, the first frost may be October 2 or earlier) (Jablonski, 1974). The exact dates vary within the county as well as from one year to another.

During the winter, temperatures are not generally cold enough to keep the soil frozen for the whole winter. Winter rains frequently warm enough to thaw the soil. Heavy rain on partly thawed soils is very erosive.

Table 2.1: Average and Record Weather for Flemington, NJ

Month	Based on data from 1971-2000				Based on data from 1926-2000		
	Average High	Average Low	Mean	Average Precip.	Average Precip.	Record High	Record Low
January	37°F	18°F	28°F	4.25 in.	3.62 in.	74°F (1950)	-18°F (1984)
February	40°F	20°F	30°F	3.04 in.	3.00 in.	77°F (1930)	-16°F (1934)
March	50°F	28°F	39°F	4.03 in.	3.95 in.	88°F (1998)	-6°F (1984)
April	61°F	37°F	49°F	4.09 in.	3.89 in.	94°F (1976)	14°F (1969)
May	72°F	47°F	60°F	4.87 in.	4.17 in.	99°F (1939)	25°F (1966)
June	80°F	56°F	68°F	4.33 in.	3.93 in.	102°F (1934)	34°F (1978)
July	85°F	62°F	73°F	4.75 in.	4.57 in.	106°F (1936)	41°F (1957)
August	83°F	60°F	72°F	3.98 in.	4.47 in.	104°F (1955)	37°F (1965)
September	76°F	52°F	64°F	4.34 in.	3.90 in.	105°F (1953)	27°F (1963)
October	64°F	40°F	52°F	3.84 in.	3.48 in.	97°F (1941)	18°F (1952)
November	53°F	32°F	43°F	3.90 in.	3.77 in.	84°F (1950)	2°F (1938)
December	42°F	24°F	33°F	3.92 in.	3.67 in.	75°F (1984)	-14°F (1948)
Average Annual Precipitation:				49.34 in.	46.42 in.		

Source: Office of the New Jersey State Climatologist at <http://climate.rutgers.edu>

Extreme Weather

During the warm season, thunderstorms are responsible for most of the rainfall. Most areas receive 25 to 30 thunderstorms per year. In addition, each year between 1 and 10 nor'easters bring strong winds and heavy rains to the state. Approximately five tornadoes appear each year in New Jersey (usually relatively weak ones). Between 1973 and 2005, a total of 7 tornadoes were reported in Hunterdon County. Hail is not frequent, but can be destructive. On July 1, 2001, 1 3/4 inch hail was reported in Holland Township (NOAA, 2006).

Table 2.2 lists some of the highest snow and rainfall received in one day (although multiple day storms can have higher totals), for the period 1926 to 2000 (the most recent data available on the Internet).

Major droughts in recent years included 1998-1999 and 2001-2002. A drought spanning July 1998 through September 1999 included a "snow drought" – one of the least snowy seasons on record. This drought was ended by Tropical Storm Floyd. Another year-long drought

occurred between October 2001 and November 2002, when drought was ended by a series of nor'easters that resulted in a wetter than normal November (NOAA, 2006).

Table 2.2: Record Daily Precipitation Measured at Flemington, NJ

Rank	Greatest one-day snowfall		Greatest one-day rainfall	
	Amount	Date	Amount	Date
1 st	24 in.	Feb. 1961	8.49 in.	Sept. 1999
2 nd	21 in.	Feb 1983	7.2 in.	Aug. 1971
3 rd	19 in.	Jan. 1996	4.74 in.	Sept 1989
4 th	18 in.	Feb. 1979	4.46 in.	Sept. 1942
5 th	18 in.	Dec. 1960	4.19 in.	Oct. 1990

Source: Office of New Jersey State Climatologist <http://climate.rutgers.edu> (data from 1926 – 2000)

Tropical storms and hurricanes can contribute significant rainfall and can cause flooding. Hurricanes Connie and Diane, which struck in August 1955, broke four daily rainfall records, for a total of 12.27 inches in 11 days, causing severe flooding that destroyed most of the existing bridges on the Delaware River. The bridge at Riegelsville, built by the John A. Roebling Company after the flood of 1903, was one of the few which survived (Dale, 2005). Flash flooding from January 19-21, 1996 was caused by torrential rains plus melting snow, causing the Delaware River to crest at its highest stages in most places since the summer of 1955. Tropical Storm Floyd battered New Jersey on September 16, 1999 and brought with it record breaking amounts of rain and damaging winds. Storm totals of 9.52 inches of rain were recorded in Flemington (ONJSC, 2004 and NOAA, 2004).

In September 2004, the remnants of Hurricane Ivan interacted with a slowly moving cold front, causing very widespread heavy rain in the upper and middle sections of the Delaware River Valley. This combined with wet soils and full reservoirs to yield the worst flooding since 1955 (now the 7th highest discharge ever measured on the Delaware River at Riegelsville). This was followed only 7 months later, in April 2005, by a flood which became the new worst Delaware River flood since 1955. It resulted from widespread heavy rainfall up to 5" combined with wet antecedent conditions, melting snow in the mountains, and reservoirs filled to capacity. This resulted in the third highest discharge on record at Riegelsville. The most recent Delaware River flood, which crested on June 29, 2006, is the fourth highest on record (see **Table 2.3**) (USGS, 2006). River gage height and forecasts are available in real-time on the internet from USGS and NOAA (see **Internet Resources**).

Table 2.3: Record Delaware River Flows at Riegelsville, NJ

Rank	Date	Gage Height (ft)	Peak Discharge (ft ³ /sec)	Probability of Recurrence Interval (years)
1 st	August 20, 1955	38.85	340,000	>100
2 nd	October 10, 1903	35.90	275,000	>100
3 rd	April 4, 2005	34.07	262,000	>100
4 th	June 29, 2006	33.62	254,000	
5 th	January 8, 1841		250,000 (estimate)	
6 th	March 19, 1936	32.45	237,000	
7 th	September 19, 2004	30.95	216,000	70

Notes: Flood-frequency statistics at this site are based on peak-flow data from 1907 through 2005 and historical peaks from 1841 and 1903. Flood stage is 22 feet. Moderate flood stage is 26 feet. Major flood stage is 30 feet.
Source: New Jersey Geological Survey <http://nj.usgs.gov/> and National Weather Service <http://newweb.erh.noaa.gov/ahps2/hydrograph.php?wfo=phi&gage=rln4&type=0&view=1.1.1.1.1.1>



C. Air quality

The New Jersey Comparative Risk Project (March 2003), funded by the US EPA and the NJDEP, combined the efforts of 73 experts to analyze and rank 88 chemical, physical and biological factors (“stressors”) according to their relative negative impacts on human health, ecological quality, and socioeconomic conditions (monetary cost). The study ranked several air pollutants among the highest risks to human health, including ground-level ozone, particulate matter, radon, secondhand tobacco smoke, and volatile organic compounds (VOCs). Air pollution is estimated to have medium to medium-high socioeconomic impact, and lesser impacts to ecological quality (Steering Committee of the NJ Comparative Risk Project, 2003).

Exposure to air pollution is a widespread problem that occurs throughout the entire state. Airborne pollutants come from a wide variety of sources, including industry, utilities, manufacturing and commercial sources, vehicles and residential activities (such as oil burning for home heating, and painting houses). On hot summer days, when pollutant levels are worst, winds in New Jersey are usually blowing from the southwest, carrying air pollution from the Washington, Baltimore and Philadelphia metropolitan areas to New Jersey. In turn, these winds carry the pollution created here to New York, Connecticut and further to the northeast.

After the passage of the Clean Air Act in 1970, the United States Environmental Protection Agency (USEPA) set National Ambient Air Quality Standards (NAAQS) for six pollutants, known as the *Criteria Pollutants*, (ozone, sulfur dioxide, carbon monoxide, nitrogen dioxide, particulate matter, and lead). These pollutants are addressed throughout the country through a planning process and the concentrations of these pollutants in air have been monitored for compliance with the air quality standards.

Since 1970, concentrations of these six pollutants have been significantly reduced in New Jersey. The state is now in compliance with all NAAQS, except for ozone. New Jersey Department of Environmental Protection (NJDEP) developed the Air Quality Index (AQI) to provide a descriptive rating and a color code (i.e. green=good) in real-time on the internet for many sites, including Flemington, the site closest to Holland. Flemington is an automated site, which monitors for ozone (O₃), particulates and meteorological conditions.

The following summaries for ground-level ozone, particulates, air toxics and atmospheric deposition are summarized from the 2003 Air Quality Report, published by the NJDEP Bureau of Air Monitoring (NJDEP Bureau of Air Monitoring, 2004).

Ground-level Ozone

Ground-level ozone causes serious adverse health and environmental effects. It forms in the air from volatile organic compounds (VOCs) and nitrogen oxides (NO_x) under conditions of high temperature and bright sunlight. Sources include vehicles, power plants and factories. The hottest days of summer can yield unhealthy levels of ozone. The nearest site monitored for Ozone is in Flemington, NJ. **Table 2.4** presents a summary of the number of days the ozone standards were exceeded per year. The 1-hour ozone standard is an average of 0.12 parts per million (ppm), and the 8-hour ozone standard (which became effective in 1997) is an average of 0.08 parts per million (ppm). According to preliminary data for 2005, there were no exceedances of the 1-hour standard in 2005. However, the 8-hour ozone standard was exceeded 13 times in 2005. The Clean Air Act requires that all areas of the country be evaluated and then classified as attainment or non-attainment areas for each of the National Ambient Air Quality Standards. Holland is within a non-attainment area for Ozone, rated as category "Severe 2" (the highest category; with the fourth highest daily maximum 1-hour average concentration recorded over a three year period in the range of 0.191 - 0.279 ppm) (NJDEP Bureau of Air Monitoring, 2004).

Particulates

Particulate air pollution consists of both solid particles and liquid droplets suspended in the atmosphere, usually less than 70 microns in diameter. In addition to human health and environmental effects, particulate matter is a major cause of reduced visibility. Particles larger than 10 microns are usually trapped by the human respiratory system before they reach the lungs, therefore coarse particles smaller than 10 microns (PM10) are considered harmful, while fine particles less than 2.5 microns (PM2.5) are even more detrimental to human health. Coarse particle sources include windblown dust and industrial sources, while fine particles come from combustion sources or are formed in the atmosphere from gasses.

The nearest monitoring site for particulates are Trenton (for PM10), Phillipsburg (for PM2.5), and Flemington (where "smoke shade" is measured, an indirect measurement of particulates, and used for reporting in the Air Quality Index). Although the particulates sometimes reach "moderate" and "unhealthy for sensitive individuals" levels, the New Jersey standard for Total Suspended Particulates and the NAAQS standards are being met for PM10 for annual mean and maximum 24-hour average. However, three years of data are needed to determine compliance with the NAAQS standard for PM2.5. The annual average at Phillipsburg of 13.5 µg/M³ was slightly below the standard of 15 µg/M³ annual average (NJDEP Bureau of Air Monitoring, 2004).

Air Toxics

In addition to ozone and PM2.5, there is increasing concern about a group of air pollutants termed *air toxics*. These pollutants include substances known to cause serious health

Table 2.4: Summary of Ozone Exceedances at Flemington, NJ

Year	Ozone Exceedances (days)	
	1-hour averages	8-hour averages
1985	3	New ambient air quality standards for ozone became effective July 18, 1997
1986	4	
1987	4	
1988	14	
1989	3	
1990	6	
1991	1	
1992	0	
1993	0	
1994	0	
1995	1	
1996	0	
1997	0	
1998	0	
1999	2	23
2000	0	9
2001	3	12
2002	1	19
2003	0	7
2004	0	6
2005	0	13
Data for 2005 is preliminary and subject to change.		
Source: NJDEP Bureau of Air Monitoring, http://www.state.nj.us/dep/airmon/		

problems, such as damage to the immune system, neurological, reproductive, developmental and respiratory problems and cancer. Toxic pollutants may also be deposited on soil and water, taken up by plants and consumed by animals.

The list of potential air toxics is very large and includes many different types of compounds from heavy metals to volatile organic compounds (VOCs) such as benzene. In 1979, NJDEP adopted a regulation that specifically addressed air toxics emissions. This rule (Control and Prohibition of Air Pollution by Toxic Substances) listed 11 Toxic Volatile Organic Substances (TVOS) and required that sources emitting those TVOS to the air should register with the Department and demonstrate that they were using state-of-the-art controls to limit their emissions.

Under the Clean Air Act Amendments of 1990, USEPA is required to begin to address a list of 188 of these air toxics (known as *Hazardous Air Pollutants*, or HAPs). NJDEP works with USEPA to implement these various strategies to reduce air toxics throughout the state.

The USEPA prepared a comprehensive inventory of air toxics emissions for the entire country as part of the National-Scale Air Toxics Assessment (NATA) in 1996. The study determined that on-road mobile sources are responsible for 35% of the toxic emissions, off-road mobile sources (airplanes, trains, construction equipment, lawnmowers, boats, dirt bikes, etc.) account for 33%; area sources contribute 25% (residential, commercial, and small industrial sources), and major point sources account for the remaining 7%.

The NATA study also estimated levels of pollutants geographically. Although Hunterdon is estimated to have lower levels of air toxics than the more populated and industrial areas of the state, it falls within an area expected to have concentrations of benzene at 5-10 times the health benchmark. NJDEP has determined that 19 of the chemicals were predicted to exceed their health benchmarks in one or more counties in 1996. Pollutants of statewide concern include benzene, 1,3-butadiene, carbon tetrachloride, chloroform, diesel particulate matter, ethylene dibromide, ethylene dichloride and formaldehyde. Pollutants of concern in parts of the state include acrolein, polycyclic organic matter, chromium compounds, acetaldehyde, perchloroethylene, 7-PAH, arsenic compounds, cadmium compounds, nickel compounds, beryllium compounds and hydrazine.

The NJDEP has established four comprehensive air toxics monitoring sites. They are located in Camden, Elizabeth, New Brunswick and Chester. The Chester site, which is closest to Holland Township, has been measuring air toxics since 2001. Pollutant concentrations are trending downward, but many of them still exceed the NJDEP health benchmarks. At Chester, these include acetaldehyde, acrylonitrile, benzene, carbon tetrachloride, chloromethane, and formaldehyde (NJDEP Bureau of Air Monitoring, 2004).

In 2003, NJDEP adopted revisions to the Emissions Statements rule (NJAC 7:27-21) which require additional facility-wide information on 36 toxic air pollutants.

Atmospheric Deposition

Pollution that is deposited on land or water from the air is called *atmospheric deposition*. Wet deposition is washed from the air by precipitation, while dry deposition refers to particulates that settle out of the atmosphere during dry weather. Sources include motor vehicles, power plants, and incinerators. The major pollutants of concern are sulfur dioxide (SO₂), nitrogen oxides (NO_x), mercury (Hg), and volatile organic compounds (VOCs). In addition, the presence of these pollutants changes the pH of the precipitation which can harm plants and aquatic life. Of the three sites where atmospheric deposition is monitored in New Jersey, the one in Washington Crossing is closest to Holland. This site is also part of the National Atmospheric Deposition Program. Results for 2003 show a mean pH value of 4.53 (normal rainfall has a pH of about 5.6) (NJDEP Bureau of Air Monitoring, 2004).

A separate study of mercury in lake sediment cores (which may be representative of atmospheric deposition over time) throughout New Jersey demonstrated that, while mercury levels have decreased, they are still present at levels far higher than natural levels. (Kroenke et al, 2003).

Radon

Radon is a radioactive gas that is naturally occurring in New Jersey rocks, soil and ground water. Radon gas can become concentrated indoors, where it can increase risks of lung and stomach cancer. Holland Township is rated Tier 1, High Radon Potential. New Jersey requires new construction to be tested for radon, and the New Jersey Private Well Testing Act will require testing for radon (“gross alpha particle activity”) in March 2004 whenever homes are sold (NJDEP Private Well Testing Act, 2002).

References: Climate, Meteorology and Air Quality

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Air Quality

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Internet Resources: Climate, Meteorology and Air Quality

Climate and Meteorology

Office of the New Jersey State Climatologist (ONJSC) Home Page: <http://climate.rutgers.edu/stateclim/>

ONJSC NJ Climate Report Card: http://climate.rutgers.edu/stateclim_v1/climreportcard/climate_report_card.html

ONJSC NJ Drought Watch: http://climate.rutgers.edu/stateclim_v1/njdroughtwatch.html

ONJSC NJ Weather and Climate Network (the nearest site is Stewartville, NJ): <http://climate.rutgers.edu/njwxnet/>

National Oceanic & Atmospheric Administration: <http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent=storms>

National Weather Service Advanced Hydrologic Prediction Service (flood predictions and other information):
<http://newweb.erh.noaa.gov/ahps2/hydrograph.php?wfo=phi&gage=rgln4&type=0&view=1.1.1.1.1>

NOAA Frost/Freeze Occurrence for NJ: <http://www5.ncdc.noaa.gov/climatenormals/clim20suppl/states/NJ.pdf>

USGS Real-Time Water Data for New Jersey, site 01457500 Delaware River at Riegelsville NJ:
http://waterdata.usgs.gov/nj/nwis/uv/?site_no=01457500

Air Quality

Air Now: Air Quality conditions and Forecasts (Northern New Jersey):
<http://www.airnow.gov/index.cfm?action=airnow.showlocal&CityID=160>

NJDEP Bureau of Air Monitoring Home Page: <http://www.state.nj.us/dep/airmon/>

NJDEP Current Air Quality Readings – Northern Delaware Valley Region (ozone and particulates measured at Flemington, New Jersey): <http://www.state.nj.us/dep/airmon/ndelval.htm>

NJDEP Air Quality Reports: <http://www.state.nj.us/dep/airmon/reports.htm>

NJDEP Radon Information: <http://www.nj.gov/dep/rpp/radon/index.htm>

NJDEP: Air Toxics in New Jersey: <http://www.state.nj.us/dep/airmon/airtoxics/overview.htm>

NJDEP: What you can do to reduce the emissions of air toxics
<http://www.state.nj.us/dep/airmon/airtoxics/youcan.htm>

United States Environmental Protection Agency Air Topics: <http://www.epa.gov/eftpages/air.html>

United States Environmental Protection Agency Global Warming:
<http://yosemite.epa.gov/oar/globalwarming.nsf/content/index.html>