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Climate Change and Invasive Species in Hudson River Valley

Dutchess County is located in the middle region of the Hudson River Valley as well as the northern portion of the climate zone. According to the Dutchess County Environmental Management Council, climate describes “the long term weather patterns of an area, including temperature, precipitation, humidity, atmospheric pressure, and wind” while weather describes “the present condition of these elements over shorter periods.”[1] Dutchess County comprises a humid continental climate that is categorized by its strong seasonal disparities and highly inconsistent weather patterns including thunderstorms, winter storms, and floods.[2] The county experiences hot and muggy summers, chilly winters, and mostly decent amounts of precipitation; however Dutchess County residents will see in the days to come warmer winters, longer summers, and deeper droughts in summer. Such changes in climate significantly impacts the biological communities in the area, although at present many of the observations are anecdotal. As the Dutchess County climate continues to change, the county will no longer embody the essence of a rich diversity as uninvited guests invade and disrupt the natural ecosystem.[3] By analyzing primary sources from data taken from Weather Station ID: KNYPOUGH12 in Poughkeepsie, NY and the National Climatic Data Center (NCDC), this paper will examine that

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[1] Mary Ann Cunningham, Neil Curri, and Robert Wills. "Biological Resources and Biodiversity of Dutchess County, NY." *The Natural Resource Inventory of Dutchess County, NY* 6: 3.
[2] Jase Bernhardt, Victoria Kelly, Allison Chatrchyan, and Art DeGaetano. "Climate and Air Quality of Dutchess County." *The Natural Resource Inventory of Dutchess County, NY* 2: 32.
[3] Mary Ann Cunningham, Neil Curri, and Robert Wills. "Biological Resources and Biodiversity of Dutchess County, NY." *The Natural Resource Inventory of Dutchess County, NY* 6: 4.

the change over the last 20 years provides evidence to prove the existence of climate change in Dutchess County and what the results are from that change, such as invasive species.

Climate change is described as “any significant change in measures of climate such as temperature, precipitation, or wind that lasts for an extended period of time, decades or longer.”[4] 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.[5] Some of the projected climate changers for the region include increasing adverse health effects from extreme heat, and changes to agricultural production as climates shift, as well as increasing frequency of flooding due to sea-level rise and heavy downpours.[6] On a global scale, the average global temperature has risen by 1.3 degrees Fahrenheit over the past century with the average temperature in the northeastern United States having increased by 2 degrees Fahrenheit, while winter temperatures having doubled this much.[7] In addition, “seven of the eight warmest years on record have occurred since 2001.”[8]

In Dutchess County from May through September, the total precipitation averages between 18 and 22 inches.[9] However, this is usually one or more periods of short-term rainfall deficit that occur during most summers. Eastern Dutchess County receives the most rain due to its higher elevation on the uphill slopes of the Taconic Mountains, while there is lower precipitation in northwestern Dutchess County. The county receives a moderate amount of

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[4] "IPCC - Intergovernmental Panel on Climate Change." IPCC - Intergovernmental Panel on Climate Change. http://www.ipcc.ch/ (accessed April 2, 2014).
[5] "New National Climate Assessment Visualizations Available From NASA." United States Global Change Research Program. http://www.globalchange.gov/ (accessed April 1, 2014).
[6] Mary Ann Cunningham, Neil Curri, and Robert Wills. "Biological Resources and Biodiversity of Dutchess County, NY." *The Natural Resource Inventory of Dutchess County, NY* 6: 30.
[7] "Climate Choices in the Northeast." Climate Choices in the Northeast. http://www.climatechoices.org/ne/index.html (accessed April 1, 2014).
[8] "USDA | OCE | Climate Change | USDA Regional Climate Hubs." USDA | OCE | Climate Change | USDA Regional Climate Hubs. http://www.usda.gov/oce/climate_change/regional_hubs.htm (accessed April 2, 2014).
[9] Jase Bernhardt, Victoria Kelly, Allison Chatrchyan, and Art DeGaetano. "Climate and Air Quality of Dutchess County." *The Natural Resource Inventory of Dutchess County, NY* 2: 32.

snowfall, with roughly 30 to 50 inches throughout the county.[10] Floods usually occur with relative frequency in Dutchess County, with roughly three floods of varying degrees reported each year in the county.[11] Each major stream in Dutchess County has a significant number of flood prone areas and certain areas are prone to annual flooding with the probability of flooding being the greatest from December to April, "when the ground is frozen, and runoff from melting snow and ice causes soils to be saturated."[12]

In order to chart the changing climate in Dutchess County, I examined the precipitation and temperature of the four seasons using one month from each and basing my data from the Poughkeepsie station.[13] The data that I collected and juxtaposed for the monthly and annual climatological summary during January, May, August and November were provided by the National Climactic Data Center. After making conclusions based on the tables and graphs that I constructed, which I have provided at the ending of this paper, it is not necessarily clear that a slight change in climate has occurred during the last 20 years. When temperatures rose over the course of five years, it tended to decrease within the following five years. In terms of heating and cooling degree days, there was an increase during some years, which could help to validate the argument of climate changing the summer's heat and intensity. However, this increase fluctuated frequently, providing no clear sign of a consistent warming or cooling. These observations collected from the data analysis provided the following deductions.

In terms of temperature change, there was an increase of minimum and maximum temperatures (Fahrenheit) from 1985 to 1990. However, the number of heating degree days

[10] Jase Bernhardt, Victoria Kelly, Allison Chatrchyan, and Art DeGaetano. "Climate and Air Quality of Dutchess County." *The Natural Resource Inventory of Dutchess County, NY* 2: 32.
[11] Jase Bernhardt, Victoria Kelly, Allison Chatrchyan, and Art DeGaetano. "Climate and Air Quality of Dutchess County." *The Natural Resource Inventory of Dutchess County, NY* 2: 34.
[12] Jase Bernhardt, Victoria Kelly, Allison Chatrchyan, and Art DeGaetano. "Climate and Air Quality of Dutchess County." *The Natural Resource Inventory of Dutchess County, NY* 2: 32.
[13] "Climate Data Online: Dataset Discovery." Datasets. http://www.ncdc.noaa.gov/cdo-web/datasets (accessed April 4, 2014).

annually decreased while cooling days increased. On the other hand, from 1990 to 1995, there was no significant increase in temperature while there was an increase in the number of cooling as well as heating degree days. Then within the next five years, 1995-2000, the mean minimum temperature decreased as opposed to the mean maximum temperature, which increased. Once again the number of heating days increased but the number of cooling days decreased substantially. From 2000 to 2005, the temperature returned to an increase of a few degrees for both the mean minimum and maximum temperatures. However, the number of heating days decreased while the number of cooling days skyrocketed by over 500 days. From 2005 to 2010 the maximum temperature also increased slightly as well as the minimum and annual temperatures. In addition, the number of heating degree days diminished by over 1,000 as well as the number of cooling days by over 700 days. Finally, from 2010 to 2013, there was a slight decrease in the maximum, minimum and annual temperatures but the amount of heating degree days skyrocketed once again by over 900 days and cooling by over 400 days. Based on my analysis of the data collected and recorded, although there were substantial increases in temperature over the 20 year span, it was not a consistent increase in temperature. Furthermore, only within the most recent decade did Poughkeepsie have a substantial increase in the number of heating and cooling days; this deduction provides better evidence than the temperature change to validate the existence of climate change.

In terms of precipitation, I observed the same inconsistency between the 20 year span with which I recorded and analyzed. For instance, the total amount of precipitation in inches from 1985 to 1990 increased considerably while the total fall of snow, sleet and hail increased only slightly. In the following year's from1990 to 1995, the total precipitation of rain as well as the total fall of snow, hail and sleet increased marginally. I observed that again from 1995 to

2000, the total precipitation increased annually by several inches as opposed to the total of snow, sleet and hail that increased tremendously. However, from 2000 to 2005, this trend changed as the total precipitation decreased slightly and the total fall of snow, sleet and hail decreased enormously. From 2005 to 2010, again the total precipitation decreased by 30 inches but the total fall of snow, sleet and hail increased by 10 inches. Finally from 2010 to 2013, the total precipitation increased substantially by 40 inches while the total fall of snow, sleet and hail increased only somewhat. Although, I concluded that there existed more of a consistency in the change of precipitation, again I observed a lack of constant increase of decrease in total rainfall, snow, sleet and hail. My data analysis was also tainted by the inconsistency I discovered within the National Climactic Data Center's information and research. Between the annual climatological summary and the monthly climatological summary, both of which provided a monthly breakdown of the measurements as well as an annual summary, for some unknown reason the data for the same Poughkeepsie Station provided different data that was off by several decimals or sometimes whole numbers. This inconsistency within the data also hindered my evidence of the existence of a clear sign of climate change. That being said, I argue that the species which invade Dutchess County are more often introduced through human and goods transportation rather than the changing climate, although there are some cases in which climate causes their introduction to the ecosystem.

The impacts on biodiversity are likely to involve northward shifts in populations of animals and diseases or parasites that affect wildlife or plants as well as increased prevalence of invasive species. According to the Natural Resource Inventory, an ecosystem is "an interacting community of living things and the nonliving resources which they depend."[14] In order to maintain an ecosystem, there must be a high diversity of species which indicates that rare species

[14] Ibid., 7.

and common species are both protected although this is impeded by the introduction of an invasive species to the ecosystem.[15] According to the National Wildlife Federation, an invasive species involves living organisms including amphibians, plants, insects, fish, fungi, bacteria, or even organisms' seeds or eggs; although what makes it distinct is that this species is not considered native to an ecosystem.[16] Invasive species are characterized by their rapid growth and reproduction as well as aggressive expansion with the potential of causing harm to the environment, the economy, and or human health. The invasive species tends to spread predominantly through unintentional human activities, although sometimes intentional and unmindful of the species impact once it invades the new ecosystem. Ships can carry aquatic organisms in their ballast water; wood products can carry insects in palettes and crates; ornamental plants can be brought to a new ecosystem and become invasive if released into the wild; and the pet trade can be intentionally or accidentally released pets.[17] These are several of the common ways in which unasked for species wind up traveling around the world and arriving in places they don't belong in. For example, research shows that the Eurasian Watermilfoil was spread from lake to lake on boat trailers while the primary spread of the Japanese Knotweed was reported to be through mechanical movement of plant parts.[18]

The introduction of invasive species poses a threat in one instance by deliberately harming the ecosystem that they arrive in. Another distinct characteristic of an invasive species is that it typically does not have any natural predators or controls as a result of being introduced to a new and foreign ecosystem. According the National Wildlife Federation, direct threats of

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[15] Mary Ann Cunningham, Neil Curri, and Robert Wills. "Biological Resources and Biodiversity of Dutchess County, NY." *The Natural Resource Inventory of Dutchess County, NY* 6: 7.
[16] "Invasive Species - National Wildlife Federation." Invasive Species - National Wildlife Federation. http://www.nwf.org/Wildlife/Threats-to-Wildlife/Invasive-Species.aspx (accessed April 1, 2014).
[17] Ibid.
[18] "Non-native Invasive Freshwater Plants." General Information about Eurasian Watermilfoil. http://www.ecy.wa.gov/programs/wq/plants/weeds/milfoil.html (accessed April 5, 2014).

invasive species include “preying on native species, out-competing native species for food or other resources, causing or carrying disease, and or preventing native species from reproducing or killing their young.”[19] In addition, invasive species can indirectly threaten an ecosystem by changing food webs through the destruction or placement of native food sources since the invader provides little to no food value for wildlife, decreasing biodiversity through the alteration of the abundance or diversity of species, and altering ecosystem conditions through the transformation in the conditions in an ecosystem.[20] As a result of their high reproductive rates, easy dispersion, and toleration of a wide range of environmental conditions, “invasive species may out-compete native species for prey or other resource needs.”[21] According to the National Wildlife Federation, the increase in average temperature as well as the changes in rain and snow patterns caused by global warming enables some invasive plant species to move into new areas. Insect infestations are more severe as pests since they “take advantage of drought weakened plants.”[22] In many areas of New York, including Dutchess County, cold winters previously prevented the survival of many invasive species, which can cause dramatic shifts in habitat and biotic communities.[23] One example of which includes the wooly adelgid, “a minute aphid-like insect that has depleted hemlock stands in warm climates.”[24]

Furthermore, invasive species may bring about intense consequences on the Earth’s natural resources, human health, and the economy. According to the United States Fish and Wildlife Service, “when non-native species are introduced into an ecosystem in which they did

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[19] "Invasive Species - National Wildlife Federation." Invasive Species - National Wildlife Federation. http://www.nwf.org/Wildlife/Threats-to-Wildlife/Invasive-Species.aspx (accessed April 1, 2014).
[20] Ibid.
[21] "U.S. Fish & Wildlife Service." Invasives Species. http://www.fws.gov/invasives/ (accessed April 1, 2014).
[22] Ibid.
[23] Mary Ann Cunningham, Neil Curri, and Robert Wills. "Biological Resources and Biodiversity of Dutchess County, NY." *The Natural Resource Inventory of Dutchess County, NY* 6: 3.27.
[24] Ibid.

not evolve" the result may lead to their populations exploding in numbers.[25] This occurs due to the checks and balances of an ecosystem being thrown off such as predators, herbivores, diseases, parasites, and other organisms fighting for the same limited resources and environmental factors.[26] In a natural or native community, species will evolve together into an ecosystem with these checks and balances that limit the population growth of any one species. By having these checks and balances, an intricate web of natural life within an ecosystem is developed in which the native species fight for their survival. Consequently, "when an organism is introduced into an ecosystem, in which it did not evolve into naturally, it no longer has those limits" and so they unnaturally produce rapidly and expansively, which can lead to severe consequences.[27]

According to the New York State Invasive Species Council, there exist three tiers that encompass the management and regulation of invasive species. The most restrictive category is prohibited species, which "bans the commerce, use and purposeful introduction of nonnative species that pose clear risks to New York's economic, ecological and or human health."[28] The second category is regulated species, which "restricts, but does not prohibit, the commerce and other use of species that has the potential to cause significant harm and could be effectively contained through practicable and meaningful regulatory programs."[29] Finally, the last category is unregulated species, which "identifies those nonnative species that are expected to pose no significant threat and therefore can be used freely."[30] The categorizing of invasive species is

[25] Ibid.
[26] Ibid., 32.
[27] Ibid.
[28] Ibid., 19.
[29] Ibid., 21.
[30] Ibid., 32.

significant in that the New York State Invasive Species Council utilized climate change as a predominant factor during the formation of these assessments on invasive species.

According to Dutchess County Environmental Management Council, Dutchess County holds around three quarters of all non-native species although most are not high in density.[31] The Council's State of the Environment Report provides a list of the top ten invasive species with an assessment of very high invasive nature based on the tier assessment.[32] The list reads as follows in chronological order starting with: the Eurasian Watermilfoil, the Japanese Knotweed, the Autumn Olive, the Broadleaf Water-Milfoil, the Common Reed Grass, the Water Thyme, the Mile-A-Minute (MaM), the Purple Loosestrife (PL), the Japanese Barberry (JB), and finally the Black Swallow-wort (BSW).[33] Following the first table is another table listing the significant invasive species either in or within close proximity to Dutchess County that are highly destructive and should be mentioned and monitored.[34] The list reads as follows in chronological order starting with: the Brown Marmorated Stink Bug (BMSB), the Emerald Ash Borer (EAB), the Hemlock Woolly Adelgid (HWA), the Japanese Stilt Grass (JSG), and finally the Viburnum Leaf Beetle (VLB).[35] Of these species, the Emerald Ash Borer is a particular threat because it destroys native ash trees. This exotic beetle was first discovered in southeastern Michigan in 2002. It has since spread across the Mid-West, the Mid-Atlantic and eastern states as far east as New York. EAB was first discovered in western NY in 2009; in 2010 it was discovered in Ulster County and since spread to other counties in the state.[36] "The Hemlock Wooly Adelgid is a destructive introduced pest of forest and ornamental hemlock trees have been in Dutchess

[31] Ibid., 34.
[32] Ibid., 37.
[33] Ibid., 22.
[34] Ibid.
[35] Ibid., 25.
[36] Ibid., 34.

County since the mid to late 1980s" and has killed trees in as little as four years.[37] There are concerns due to climate change that its range may spread to the Adirondacks, which has dense natural stands of eastern hemlock. HWA is already well established in New York in part due to rising winter temperatures that are allowing the insect to survive the winter.[38]

In conclusion, the Earth's climate can change due to "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."[39] The IPCC has thus 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 emitted by humans.[40] New state-of-the-art research describes how this change in climate will adversely affect Northeast states under two different emissions scenarios. The lower-emissions scenario assumes a shift away from fossil fuels in favor of clean energy technologies, causing emissions to decline by mid-century. In comparison, the higher-emissions scenario assumes continued heavy reliance on fossils fuels, causing heat-trapping emissions to rise rapidly over the course of the century.[41] Therefore, the emissions choices made today in the Northeast, and worldwide will help determine the climate that future generations inherit, and shape the consequences for their economy, environment, and quality of life.

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[37] Ibid., 22.
[38] Ibid., 22.
[39] Environmental Protection Agency. "Regulatory Initiatives." EPA. http://www.epa.gov/climatechange/EPAactivities/regulatory-initiatives.html (accessed April 1, 2014).
[40] Jase Bernhardt, Victoria Kelly, Allison Chatrchyan, and Art DeGaetano. "Climate and Air Quality of Dutchess County." *The Natural Resource Inventory of Dutchess County, NY* 2: 25.
[41] "Climate Choices in the Northeast." Climate Choices in the Northeast. http://www.climatechoices.org/ne/index.html (accessed April 1, 2014).

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Date	Temperature (Fahrenheit)											Precipitation (Inches)						
Element	MMXT	MMNT	MNTM	HTDD	CLDD	EMXT	EMNT	DT90	DX32	DT32	DT00	TPCP	EMXP	TNSW	MXSD	DP01	DP05	DP10
								Number of Days						Snow, Sleet, Hail		Number of Days		
Month-Year	Mean Max.	Mean Min.	Mean	Heating Degree Days	Cooling Degree Days	Highest	Lowest	Max>=90	Max<=32	Min<=32	Min<=0	Total	Greatest Observed	Total Fall	Max Depth	>=.10	>=.50	>=1.0
Jan-85	29.8	12.4	21.1	1352	0	50	-3	0	22	30	2	1	0.31	8	5	3	0	0
May-85	72.7	47.6	60.2	181	40	88	28	0	0	3	0	4.19	1.31	0	0	6	4	1
Aug-85	79.4	56.9	68.2	12	117	91	48	3	0	0	0	4.68	2.22	0	0	5	3	1
Nov-85	50.6	34.9	42.8	660	0	72	23	0	0	14	0	6.11	1.27	2	0	9	5	1
Annual '85	**59.4**	**38**	**48.7**	**6299**	**475**	**93**	**-10**	**8**	**46**	**142**	**5**	**39.57**	**2.46**	**28.9**	**11**	**71**	**29**	**7**
Jan-90	42.6	26.9	34.8	931	0	61	16	0	2	25	0	4.1	1.15	9.7	3	8	3	1
May-90	66.6	45	55.8	273	0	80	35	0	0	0	0	6.04	1.1	0	0	9	6	2
Aug-90	80	60.2	70.1	9	176	89	50	0	0	0	0	7.91	2.52	0	0	9	4	4
Nov-90	53.1	31.1	42.1	677	0	76	19	0	0	17	0	2.7	1.64	0	0	4	1	1
Annual '90	**61.6**	**40.2**	**50.9**	**5608**	**588**	**93**	**-6**	**7**	**19**	**133**	**2**	**49.16**	**2.57**	**30.3**	**8**	**81**	**34**	**15**
Jan-95	40.6	25.4	33	985	0	64	11	0	5	21	0	4.49	1.58	2.3	1	8	3	1
May-95	68.4	45	56.7	257	9	87	36	0	0	0	0	3.43	1.22	0	0	7	2	1
Aug-95	86	58.5	72.3	1	236	95	48	9	0	0	0	1.8	1.25	0	0	3	1	1
Nov-95	47	29.2	38.1	799	0	69	9	0	0	21	0	5.4	2.7	7.8	6	8	3	1
Annual '95	**61.5**	**38.4**	**50**	**6107**	**755**	**103**	**-9**	**21**	**25**	**134**	**3**	**50.17**	**3.42**	**41.8**	**16**	**68**	**24**	**10**
Jan-00	33.5	12.5	23	1293	0	60	-9	0	16	28	9	2.95	0.8	15.9	12	6	3	0
May-00	70.3	47.1	58.7	225	51	93	33	2	0	0	0	6.51	X	0	0	8	4	1
Aug-00	75.9	57.5	66.7	39	97	85	44	0	0	0	0	5.28	0.92	0	0	5	2	0
Nov-00	47.9	30	39	771	0	64	12	0	0	17	0	2.63	0.92	0	0	5	2	0
Annual '00	**57.7**	**36.8**	**47.3**	**6735**	**360**	**93**	**-9**	**4**	**43**	**143**	**9**	**49.83**	**2.81**	**54**	**16**	**78**	**34**	**8**
Jan-05	33.4	16	24.6	1247.6	0	61	-10	0	15	28	6	3.94	1.03	0	10	10	3	1
May-05	66.4	44.6	55.6	280.6	7.2	84	32	0	0	1	0	1.51	0.3	0	0	7	0	0
Aug-05	85.8	64.6	75.2	0	319.5	96	53	10	0	0	0	1.73	0.66	0	0	3	1	0
Nov-05	56.5	34.9	45.7	578.5	0	74	20	0	0	13	0	4.7	1.66	1.3	1	7	3	2
Annual '05	**61.8**	**41.2**	**51.8**	**5850.7**	**996.3**	**96**	**-10**	**28**	**28**	**131**	**8**	**47.89**	**5.69**	**32.3**	**10**	**72**	**27**	**12**
Jan-10	37.8	20.7	29.5	177.1	0	60	4	0	2	5	0	0.02	0.02	7.8	3	0	0	0
May-10	76.6	51.1	63.9	26.5	20.2	90	41	1	0	0	0	0	0	0	0	0	0	0
Aug-10	82.2	58.8	70.7	0	28.8	89	53	0	0	0	0	0	0	0	0	0	0	0
Nov-10	54.7	34	46	38	0	60	28	0	0	1	0	0	0	X	X	0	0	0
Annual '10	**62.5**	**42**	**52.5**	**648.7**	**138.7**	**97**	**4**	**8**	**2**	**20**	**0**	**10.84**	**4.28**	**46.6**	**12**	**12**	**3**	**2**
Jan-13	36.7	20.1	28.4	1132.4	0	59	1	0	11	28	0	2.39	1.35	5	6	4	1	1
May-13	70.9	47.5	59.2	218.7	42.7	90	33	1	0	0	0	3.4	0.86	X	X	9	2	0
Aug-13	78.3	58.3	68.4	5.9	76	83	52	0	0	0	0	6.45	4.18	X	X	5	2	2
Nov-13	48.7	30	39.4	766.8	0	69	14	0	1	17	0	3.1	1.58	0	X	7	1	1
Annual '13	**59.3**	**40.3**	**49.8**	**6141.7**	**674.6**	**95**	**1**	**16**	**34**	**137**	**0**	**43.37**	**4.18**	**45.8**	**12**	**69**	**24**	**14**

Table #2 Annual Temperature Change

Date	Temperature (Fahrenheit)				
Element	MMXT	MMNT	MNTM	EMXT	EMNT
Month-Year	Mean Max.	Mean Min.	Mean	Highest	Lowest
Annual '85	59.4	38	48.7	93	-10
Annual '90	61.6	40.2	50.9	93	-6
Annual '95	61.5	38.4	50	103	-9
Annual '00	57.7	36.8	47.3	93	-9
Annual '05	61.8	41.2	51.8	96	-10
Annual '10	62.5	42	52.5	97	4
Annual '13	59.3	40.3	49.8	95	1

Graph #1 Annual Temperature Change

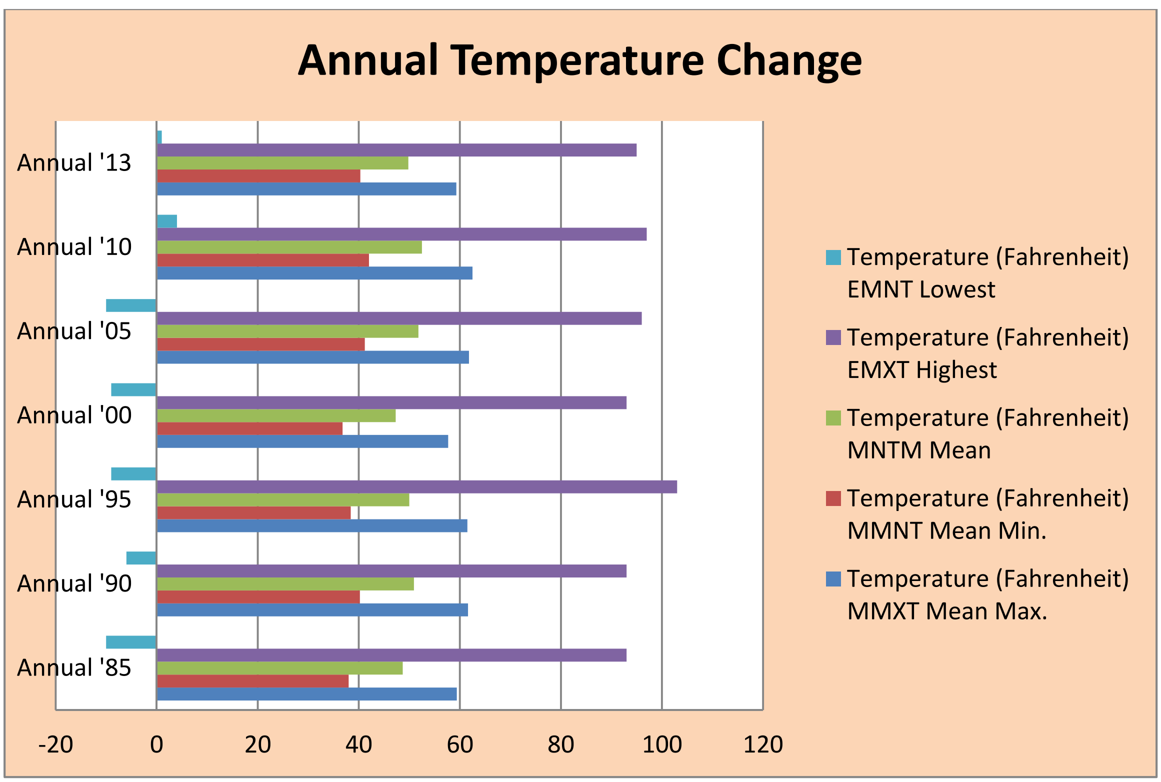


Table #3 Annual Temperatures and Number of Days

Date	Number of Days					
Element	HTDD	CLDD	DT90	DX32	DT32	DT00
Month-Year	Heating Degree Days	Cooling Degree Days	Max>= 90	Max<= 32	Min<= 32	Min<=0
Annual '85	6299	475	8	46	142	5
Annual '90	5608	588	7	19	133	2
Annual '95	6107	755	21	25	134	3
Annual '00	6735	360	4	43	143	9
Annual '05	5850.7	996.3	28	28	131	8
Annual '10	648.7	138.7	8	2	20	0
Annual '13	6141.7	674.6	16	34	137	0

Graph #2 Annual Temperatures and Number of Days

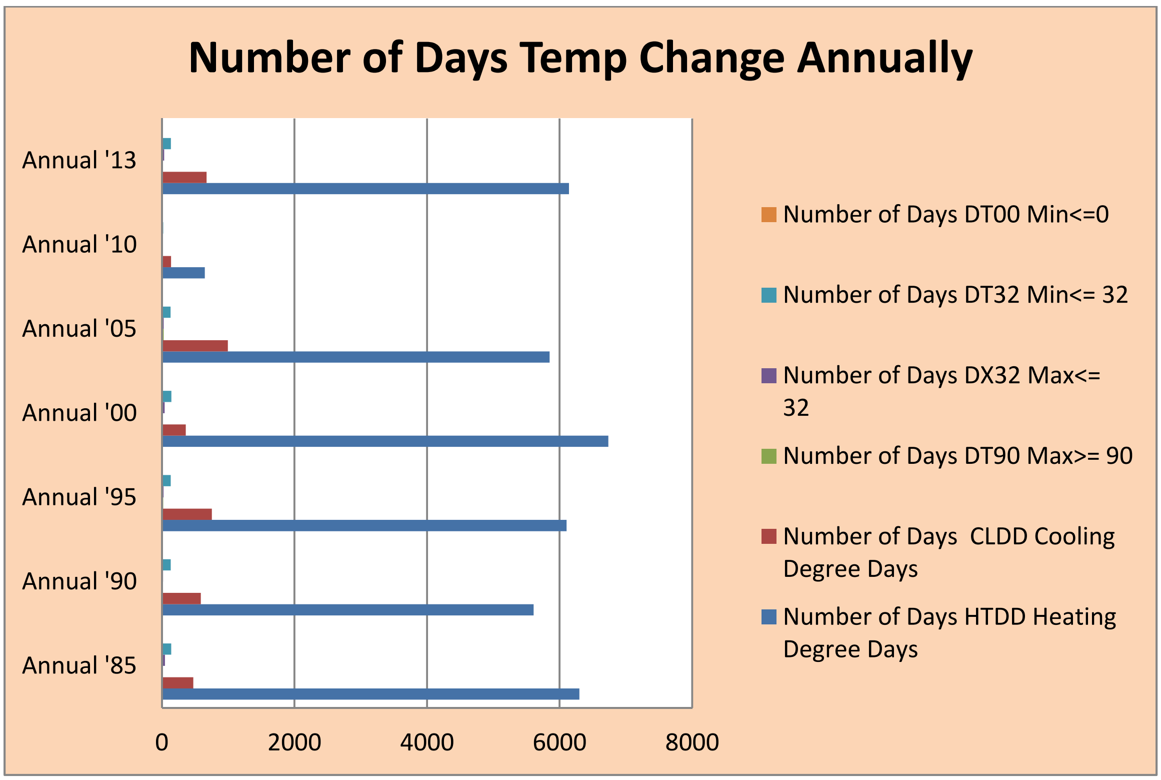


Table #4 Annual Precipitation Change

Date		Precipitation (Inches)		
Element	TPCP	EMXP	TNSW	MXSD
			Snow, Sleet, Hail	
Month-Year	Total	Greatest Observed	Total Fall	Max Depth
Annual '85	39.57	2.46	28.9	11
Annual '90	49.16	2.57	30.3	8
Annual '95	50.17	3.42	41.8	16
Annual '00	49.83	2.81	54	16
Annual '05	47.89	5.69	32.3	10
Annual '10	10.84	4.28	46.6	12
Annual '13	43.37	4.18	45.8	12

Graph #3 Annual Precipitation Change

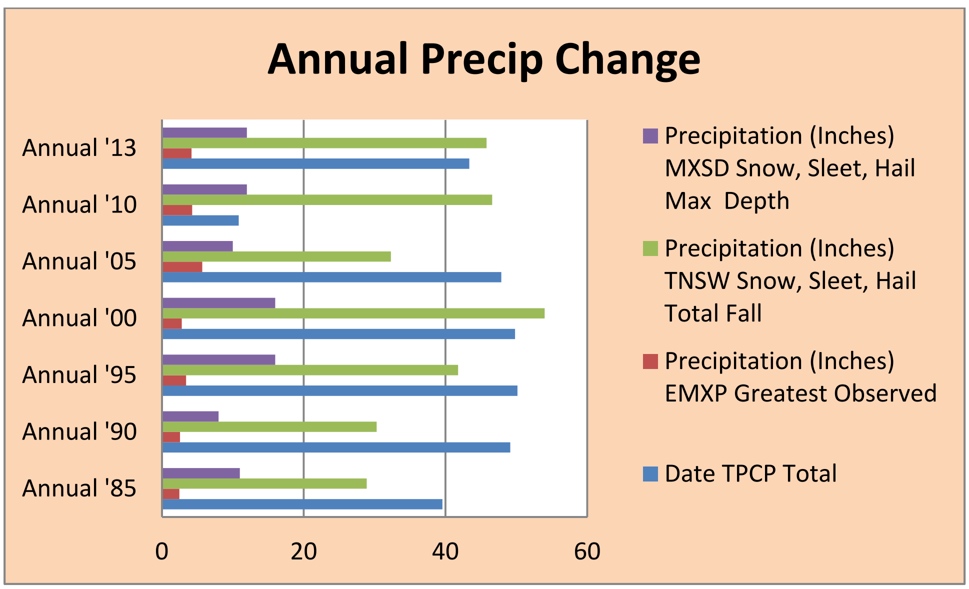
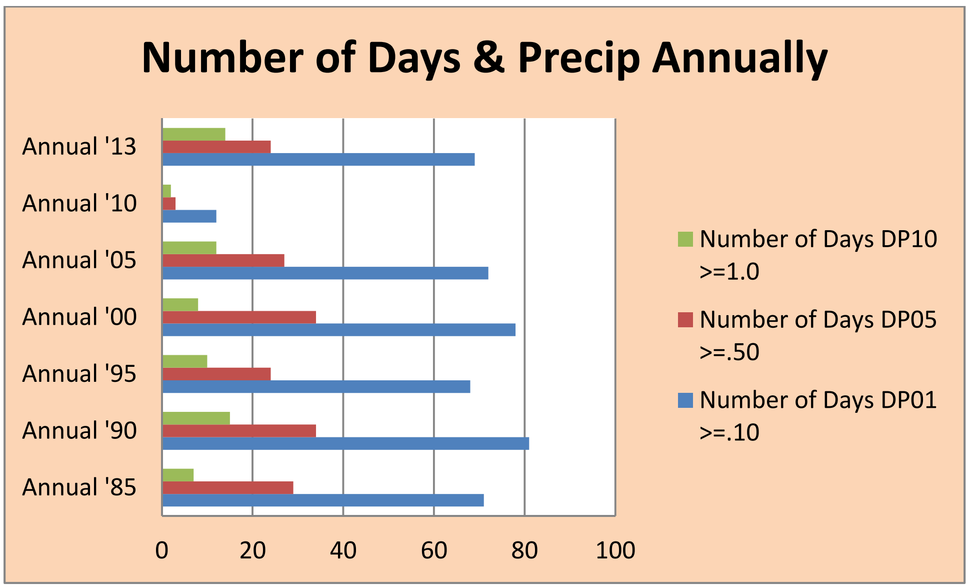


Table #5 Annual Precipitation Change & Number of Days

Date	Number of Days		
Element	DP01	DP05	DP10
Month-Year	>=.10	>=.50	>=1.0
Annual '85	71	29	7
Annual '90	81	34	15
Annual '95	68	24	10
Annual '00	78	34	8
Annual '05	72	27	12
Annual '10	12	3	2
Annual '13	69	24	14

Graph #4 Annual Precipitation Change & Number of Days



List of acronyms used in tables and graphs:

MMXT: monthly mean maximum temperature

MMNT: monthly mean minimum temperature

MNTM: monthly mean temperature

HTDD: heating degree days (base of 65 degrees F)

CLDD: cooling degree days (base of 65 degree F)

EMXT: extreme maximum temperature

EMNT: extreme minimum temperature

DT90: number of days in month with maximum temperature (X > or = 90 degrees F)

DX32: number of days in month with maximum temperature (X > or = 32 degrees F)

DT32: number of days in month with minimum temperature (X < or = 32 degrees F)

DT00: number of days in month with minimum temperature (X > or = 0 degrees F)

TPCP: total precipitation for month

EMXP: extreme maximum daily precipitation total within month

TNSW: total snowfall amount for month

MXSD: max snow depth reported during month

DP01: number of days in month with (X > or = 0.1 inches) precipitation

DP05: number of days in month with (X > or = 0.5 inches) precipitation

DP10: number of days in month with (X > or = 1.0 inches) precipitation