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Automobile Industry Growth from 1916 to 1989: The Effect on Flint, Michigan Climate

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Automobile Industry Growth from 1916 to 1989: The Effect on Flint, Michigan Climate

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By

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APPROVAL PAGE

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CHAPTER I

INTRODUCTION

Flint, Michigan, is the only city able to boast the birthplace of a world automobile company named Buick and a global automobile corporation called General Motors (GM). Flint generated great wealth and power for both Michigan and the United States because of its production of automobiles, parts, and accessories. The manufacturing plants that led to economic growth were Buick, Chevrolet, Fisher Body, Albert Champion (AC Spark Plug), and DuPont. These plants supported countless numbers of small businesses ranging from cafeterias, restaurants, metal fabrication companies, tool and die making businesses, to auto body shops. In 1965, Michigan's automobile production was 34% of the total car production in the United States (Michigan in Brief, 1998).

Each year Chevrolet and Buick gave high schools the current model of trucks and cars to assist with driver education. GM reached its highest employment numbers in 1978, employing over 77,000 workers in Flint. Buick attainted its peak employment of 28,000 workers in the 1980s (General Motors Salaried Retirees Association [GM SRA], 2014).

Based on 1920 and 1960 census data, Flint's population increased from 91,000 to 196,000 as a result of the automobile industry. The city's population became Michigan's second largest city, behind Detroit. Today, Flint has fallen to number seven with regard to city size in Michigan (Longley, 2011).

A portion of Flint's workforce was composed of individuals who migrated from the southern section of the United States in search of better wages. Men who worked on sharecrop farms making two dollars a day could earn one dollar an hour in Flint.

Statement of Problem

The problem of this study was to determine if the automobile industry affected temperature and precipitation changes in the city of Flint, Michigan, from 1916 to 1989.

Research Question

To answer this problem, the following research questions were generated:

RQ_1: Did the automobile industry expansion in Flint, Michigan (1916-1989), cause an increase in area temperature?

RQ_2: Did the automobile industry production cause an increase of precipitation in Flint, Michigan, between the years of 1919 and 1989?

RQ_3: Did the automobile industry cause an increase of heavy precipitation in Flint, Michigan, during the timeframe studied?

Background and Significance

The Industrial Revolution, which occurred between the years of 1563-1908, contributed to many global phenomena and individual achievements throughout the world (Landow, 2012). For developing countries, this led to enormous wealth among men. This work began in 1938, splitting of atoms, technology advancements, and an increase in human life. Wood was the first natural resource to fuel this revolution. Later, the fossil fuels coal, gas, and oil became crucial in powering post-revolution industries.

With the numerous advancements during and after this period, the condition of the Earth's climate was the last of the influential industries' problems.

Debate of human impact on the Earth's atmosphere began around 1820. The French physicist Joseph Fourier first suggested that the Earth's atmosphere might act as an insulator in 1824 (National Research Council, 2012). His proposal led to the term greenhouse effects. In 1850, Irish-born physicist John Tyndall, demonstrated the greenhouse effect by showing that water vapor and other atmospheric gases absorbed the Earth's radiant heat. Swedish scientist Svante Arrhenius was the first to calculate the warming power of excess carbon dioxide (CO_2) in 1896; from his calculations it was predicted that as human activity increased CO_2 levels in the atmosphere and a warming trend would occur. This is now called global warming.

The uses of fossil fuels by manufacturers introduce more aerosols into the Earth's atmosphere than its ecosystem can handle (National Research Council, 2012). These aerosols are additional tiny liquid or solid particles that are suspended into the atmosphere and come from a number of different sources. Human activities, such as fossil fuel combustion and natural processes and dust storms, all contribute to additional aerosols in the atmosphere. Aerosols retain more heat within the Earth's atmosphere than required. During a heat advisory, moisture in the air makes the temperature feel excessive. For instance, if the air temperature is 90 degrees, it can feel like 100 degrees due to an increase in moisture or high humidity.

These aerosols were highly noticeable over the years as black smoke billowed from smoke stacks, car exhausts, and smoke from refinement plants, all air pollution.

The launching of the experimental Television Infrared Observation Satellite (TIROS) on April 1, 1960, produced the first weather photos from space using television technology. These photos enabled the Department of Health, Education and Welfare and Weather Bureau meteorologists to issue the first advisories on air pollution potential over the eastern United States (National Oceanic and Atmospheric Administration Central Library, 2012). At this time, man witnessed the effects of fossil fuel use in the Earth's atmosphere.

Flint, Michigan, a city changing from carriage and wagon manufacturing to automobile production (Landow, 2012), used coal and fuel oil to power its industrial revolution. These plants, all which used fossils fuels for energy, could have affected the local climate. This is the purpose of this study. Before Earth Day in April 1970, and the birth of U.S. Environmental Protection Agency (EPA), there were no regulations or standards restricting fossil fuel plants from the amount of aerosols and pollutants to be emitted into Earth's atmosphere.

GM announced Flint, Michigan, along with four other cities, as locations of new engine assembly plants (Phelan, 2014). This study will review historical data (Landow, 2012), of the industry's effects on Flint's climate. City planners and GM can use the findings of this study to build a more environmentally friendly assembly plant. A landfill-free plant might be such a plant. They are designed to take plants' daily waste and recycle, reuse, and/or convert it to energy (media.gm.com, 2013). The study also may be used in educating employees and citizens on the importance of reducing assembly plants carbon wastes.

Limitations of the Study

This study will use research data collected from government weather stations located in Flint, Michigan, and archived by National Climate Data Center. Limiting factors include:

- Data collection only includes the years from 1916 to 1989.
- The year in which data collection ends (1989) is the decade Buick reached its highest employment and when Flint's deindustrialization began.
- Data only include automobile manufacturing plants and secondary supporting plants.
- Population, ecosystems, air quality, and atmosphere data will not be used.
- Data consisting only of precipitation, heavy precipitation, and temperature will be used.
- Hourly temperature data are excluded.
- Only daily high, low, and mean temperatures will be selected.

Basic Assumptions

This study includes assumptions related to the industry and climate within Flint, Michigan, Genesee County, where Flint is located. They include:

- As the automotive industry expanded in Flint, temperatures increased.
- Increased temperatures were caused by the increased use of fossils fuels.
- Flint will have a change of annual precipitation from 1916 to 1989 due to industry expansion.

- Flint will have an increase of heavy precipitation from 1916 to 1989 due to industry expansion.
- The greenhouse effect can occur on a local scale.
- Data collected from government archived data are considered valid.

Procedures

This study requires no weather instruments for collecting data. The local monthly mean weather data from 1916 to 1947 is taken from U.S Department of Commerce Weather Bureau archive, Michigan section, provided by National Climatic Data Center. This data will be processed manually and computed to compute a monthly and annual mean of temperature and precipitation. This data will be compiled and compared against data from government agencies to check for consistency. Archived data collected from the government agencies NOAA and National Weather Service will be the main data collection source for the years between 1948 and 1960.

Data from 1948 to 1960 consisted only of daily maximum and minimum readings used to compute a daily, mean temperature. Maximum and minimum readings noted within a 24-hour period starting at 0001 and ending at 0000 (2400). No other time record indicated a reference time. The start of hourly recordings of weather began January 1, 1960. To keep mean temperatures consistent, the same calculations methods were used for all of the data collected.

Weather data for this study will be presented in three time periods: 1916 to 1947, 1948 to 1960, and 1960 to 1989. Each period will contain the following figures: 1916 to 1947, annual data only; 1960 to 1989, daily, weekly, monthly, and annual mean

temperature and precipitation. Heavy precipitation will be noted to show an increased activity above normal. Asterisks (*) will indicate missing precipitation data and double asterisks (**) will indicate missing temperatures data.

Definition of Terms

Terms and definitions used in this study originate from the scientific research of the Earth's carbon cycle. These explanations describe weather patterns, waste management alternatives, and industry research definitions.

Aerosols: tiny liquid or solid particles suspended in the atmosphere that come from a number of human activities, such as fossil fuel combustion, as well as natural processes, such as dust storms.

Automated Surface Observing Systems (ASOS): designed to support weather forecast activities and aviation operations.

Biomass fuel: a renewable and sustainable source of energy, developed from organic materials, used to create electricity and other forms of power.

Hydrologic: the water cycle of the Earth's water cycle or the H_2O cycle describes the continuous movement of water on, above, and below the surface of the Earth.

Landfill: a low area of land that is built in layers from deposits of solid refuse and covered by soil.

Landfill gas (LFG): gas that is composed of 50 percent methane and 50 percent carbon dioxide and water vapor.

Meteorology: the scientific study of the atmosphere.

Metric ton (mt): 1,000 kilograms or 2,205 pounds.

Weather: the hourly or daily change in the atmosphere.

Climate: the long-term study of daily weather.

Precipitation: condensation of water in the atmosphere, including: rain, snow, sleet, and dew.

Heavy Snow: snowfall accumulating to 4" or more in 12 hours or less; or snowfall accumulating to 6" or more in 24 hours or less.

Heavy precipitation: the instances during which the amount of precipitation experienced in a location substantially exceeds what is normal.

Radiant energy: energy developed through electromagnetic waves that include x-rays and visible light.

NOAA: an agency under United States Department of Commerce responsible for daily weather forecasts, research, and monitoring of climate.

Summary and Overview of Chapters

In summary, Chapter I introduces a possible relation between manufacturing facilities and climate change. Flint, Michigan, changed its economic base to automobile production to compete with a change in the nation's mode of transportation. Though Flint had factories in 1916, the number of factories increased over the next 73 years. There is an assumption that with an increase of factories using fossils fuels to produce energy, there was an emission of extra aerosols into the atmosphere. Did the Flint area suffer from the greenhouse effect? Local population believes there was a change in

weather. All data collected for the study encompasses only Flint, Michigan, located in Genesee County.

This chapter explains data gathered from different sources in the Flint area. Data delineation will cover three separate periods of Flint's climate over the 73 years. Based on preliminary research, there will be additional questions asked that require more studies.

The following chapters will include Chapter II, a review of the literature. This chapter will explain what researchers have found relating to industry and climate and discuss the main source of climate change as reported by journals and government agencies. Chapter III will focus on data gathering and processing of data. Chapter IV will present findings of data gathered during research. Chapter V provides a summary and conclusion of research.

Chapter II

LITERATURE REVIEW

The industrial revolution created many issues. Evident is the day-to-day use of fossil fuels. Once fossil fuels became a main source of energy to power factories, these fuels (coal, oil, and natural gas) produced black or white smoke during processing or burning.

Fossils fuels, during processing (mining) and burning, emit gases that cause heat retention. Gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and water vapor regulate the Earth's temperature. These represent the "greenhouse" gases. Excess greenhouse gases in the Earth's atmosphere reflect more radiant heat back onto the surface causing an increase of surface heat (National Research Council, 2012). Earth emits and processes gas naturally during its carbon cycle (Figure 1). This cycle continually exchanges the Earth's water vapor, plant decay, photosynthesis, and combustion in regulation of surface temperature. The cycle, which takes millions of years, produces coal, oil, and natural gas.

Human intervention, mining, and consumption of fossil fuels introduce increased amounts of greenhouse gases into Earth's atmosphere, causing a climate change on a global scale. Human imposition on the Earth's ecosystem includes the construction of buildings and highways, cutting of rainforests, and an increase in the number of automobiles. Humans play a critical role in the production of Earth's greenhouse gas. Scientists believed the Earth's oceans would absorb extra gas, but this did not happen. Scientific papers presented by Revelle and Seuss (1957) and by Bolin and Eriksson

(1959) proved the Earth's oceans could not handle additional greenhouse gas (National Research Council, 2012).

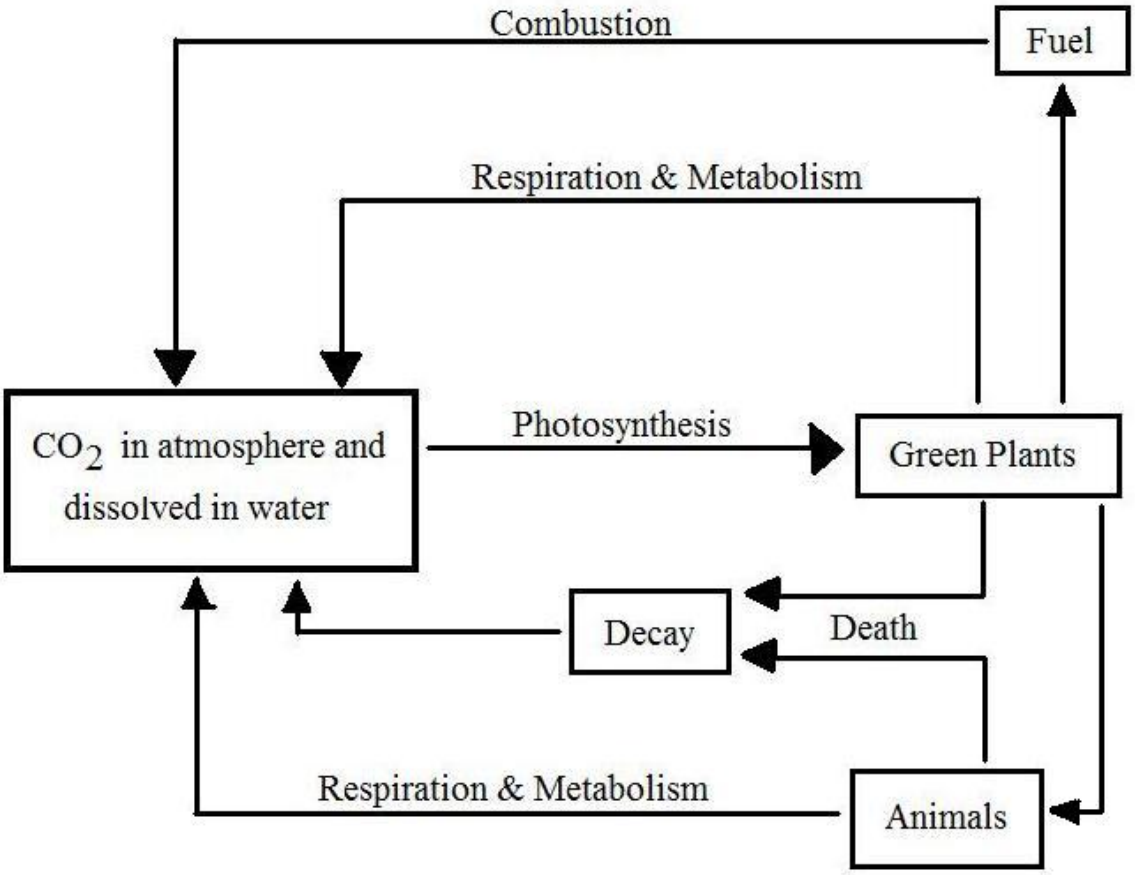

Figure 1. Basic Carbon Cycle Flow Diagram (Norris, 2011)

Carbon Dioxide (CO_2)

A main concern of scientists when studying the Earth's atmosphere greenhouse gases is the amount of CO_2. Compared to other greenhouse gases, CO_2 has an unusually long life once emitted as an aerosol. In 1953, Charles Keeling at Caltech, Pasadena, California, noticed high levels of CO_2 in the surrounding area. He became the first person

to measure CO_2 precisely on a monthly basis. By 1957, his formula for measuring CO_2 and data calculation became known as "The Keeling Curve." This curve established a baseline for how to measure CO_2 (PlanetforLife, 2010).

Opinions of CO_2's length of life will differ depending on the researcher. Some researchers approximate five years in Earth's atmosphere, others approximate 100 years. There are others who don't believe that excess carbon dioxide is a concern.

EPA, NOAA, and the National Aeronautics and Space Administration (NASA) believe CO_2 molecules last 100 years or longer, based on their research (EPA, 2014a; NOAA; 2014; and Riebeek, 2011). Nova (2011), a scientist, and the "Climate Conservative Consumer" web blog "C3" both believe that five years or fewer is the maximum life span for CO_2 in the Earth's atmosphere (Nova, 2011; Climate Conservative Consumer, N.D.). Jerry B. Anderson, Senator of Utah, introduced "H.B. 229 Air Contaminant Definition Change." The proposed bill states that CO_2 should be removed from the air contaminant list. His theory basis discusses how during the age of dinosaurs CO_2 levels were much higher than those of today. Based on samples from the Earth's polar ice caps, the atmosphere retained more CO_2 during earlier times (National Research Council, 2012).

The life cycle of a CO_2 molecule is complicated. Because it can travel in and about oceans, atmosphere, ground, and plant life, studying its longevity before destruction presents problems (EPA, 2014). Other factors complicating CO_2 studies include plants that flourish when exposed to excess CO_2 and errors of climate change research released by scientists (Sheridan, 2011). One fact on which all scientists agree is

that human intervention in the carbon cycle has increased CO_2 levels in the Earth's atmosphere, and Earth climate is changing. To assist researchers with a more comprehensive view of Earth's eco system, the EPA introduced climate indicators.

Climate Indicators

The United States Environmental Protection Agency has published 26 "climate change indicators" (EPA, 2014b). The indicators have five main headings:

1. Group 1, "'Greenhouse Gases' consists of U.S. greenhouse gas emissions, global emissions of greenhouse gases, atmospheric concentrations of greenhouse gases, and climate forcing heating effect of greenhouse gases."

2. Group 2, "'Weather and Climate' consist of U.S. and global temperature, high and low temperatures, U.S. and global precipitation, heavy precipitation (one day events), drought, and tropical cyclone activity."

3. Group 3, "'Oceans' consist of ocean heat, sea surface temperature, sea level, and ocean acidity."

4. Group 4, "'Snow and Ice' consist of Arctic ice, glaciers, snowfall, snowpack, and snow cover".

5. Group 5, "'Society and Ecosystems' consist of stream flow, ragweed pollen season, length of the growing season, leaf and bloom dates, bird wintering range, and heat related deaths."

These 26 indicators are not hardcore key markers. The EPA selected them based on quality of study by peer-reviewed data from various government agencies, academic

institutions, and other organizations. The researcher for this study selected three indicators – precipitation, heavy precipitation, and temperature – for this study.

Industry

Industry and independent researchers are aware of Earth's warming. "Steep increases in atmospheric GHG concentrations have occurred since the industrial revolution" (Center for Integrative Environmental Research, 2008, p. 3), "The U.S. industrial sector was responsible for 27% of energy-related greenhouse gas (GHG) emissions in 2008, and 29% of all U.S. GHG emissions" (Boyd, 2010, p. 4). Both identify industry as the main source of increased gases into the atmosphere. The world's middle class population has increased (Boyd, 2010). This increase has placed a demand of steel for domestic goods production (Boyd, 2010). China's raw production of steel increased to 45,000 metric ton (mt) in 2010 from 8,000 mt in 1990 (Boyd, 2010). This increase of steel production adds to a corresponding increase of Earth's surface temperature (Boyd, 2010). "According to 2005 data from the German Federal Environment Agency (UBA), the transport sector in Germany is the second largest contributor of CO_2 emissions after the energy sector, with 21% and 46% respectively" (PricewaterhouseCoopers, 2007, p. 27). This identifies the automobile industry as a major contributor of GHG emissions. EPA research released in 2012 shows a direct relation between the United States' gross domestic product and CO_2 emissions from 1990 to 2010 (EPA, Figure 3, 2012). As industry production increased or decreased, so did emissions.

Industries around the world affect Earth's atmosphere either by extraction and processing of raw materials or by consumption and recycling of plant-produced waste

material. A global population increase prompted more construction of living areas, electricity production, and food production all of which will impact Earth's CO_2 cycle. At this point, state governments, city planners, with help from industry and scientific community, amalgamate to build an environmentally friendly production plant.

Local Climate

Local municipalities have taken notice of a possible change of climate within their communities. Cities in the Midwest have noticed milder winters, followed by warmer summers. Chicago's heat wave in July 1995 caused more than 700 heat related deaths over four days (EPA, 2013). Warmer winters will allow disease-carrying insects to survive and not to die off during winter, thus causing an infestation of diseased insects in spring and summer.

Industry is a significant source of climate change on a local level (National Research Council, 2012). With industry comes a need for power plants, which use fossil fuels for production of electricity. Waste product from industries require disposal at a landfill or recycling facility. Landfills produce methane gas, causing air pollution in the local area. With this scenario, municipalities like Flint, Michigan, possibly created its own greenhouse atmosphere.

Local government taking control of climate around their cities aids the reduction of greenhouse gases. Some cities now require more energy-efficient fuel sources for energy production. One such fuel is "biomass" fuel. These fuels consist of scraps left over from lumber production or other waste that normally is moved to landfills. The organic waste burns to produce steam for turning turbines to produce electricity

(ReEnergy Holdings LLC, 2011). The city of St. Paul, Minnesota, uses 300,000 tons of biomass each year. With this system, it reduces its greenhouse gas emissions by 280,000 tons annually (EPA, 2013). Other municipalities have incorporated new technologies to reduce their dependence on fossil fuels. In 1993, Waverly, Iowa, became the first city to use wind generators to produce electricity. Yancey and Mitchell Counties in North Carolina have installed an LFG collection system. This system collects gases produced by decomposing waste and uses it as fuel for onsite businesses (EPA, 2014c).

Summary

According to all data gathered, Earth is getting warmer. This is a fact about which most scientists agree. Some believe Earth is on a natural cycle of heating and cooling, while most other scientists agree that human intervention is interfering with this cycle due to over use of fossil fuels. The life of CO_2 causes most disputes when discussing greenhouse gases and global warming. CO_2 life in the carbon cycle is from five to100 years. It remains a complicated term to define. Earth's ecosystem requires much studying of and continual data collection on a daily basis. Its CO_2 cycle is easily explained but difficult to predict or to create long-term models. This can be compared to the human stomach – it works easy, but it does much more than just digest your food. Earth's ecosystems ingest a large amount of waste, but how it processes that waste and its outcomes are not fully comprehended. Aggressive monitoring of Earth's ecosystem will continue to be a significant source of staying abreast of climate change.

Municipalities have taken control of their cities and made changes by requiring more energy-efficient standards. Changing building codes, the use of renewable sources of energy, and adding more parks and trees within neighborhoods are examples of local

governments' fight against Earth's warming. It is best to be over aggressive when it comes to the Earth's climate than to be reactive after the fact.

Next, Chapter III will discuss the procedures used to collect and analyze weather data for Flint, Michigan. This chapter will explain the methods used by the research.

CHAPTER III

METHODS AND PROCEDURES

The goal of this study was to determine if there was a relationship between the automobile industry's expansion in Flint, Michigan, and local-area climate change. Scientific evidence of Earth's climate during the Industrial Revolution and beyond supports industry as a major source of excess CO_2 in the atmosphere. Can an increase of industrial facilities in one area affect the entire precipitation and temperature of the city? This chapter consists of the location of the study, instrument designs, methods of data collection, analysis of data, and a summary.

Location of Study

The researcher selected Flint, Michigan, as the area for climate data collection. The city's geographic location is latitude: 43°00′45″ N and longitude: 83°41′14″ W and 771 feet above sea level: 0 m = 00 feet in Michigan's Genesee County (DateandTime.Info, 2014). Data collected covers 73 years or d = 26,645 days. Sample data were used to verify annual, monthly, and daily mean temperature and precipitation of three time periods. Climate data presented are from three time periods for this study: 1916 to 1947, 1948 to 1960 and 1961 to 1989.

Instruments Used

ASOS is a collaborative system maintained by Department of Defense (DoD), Federal Aviation Administration (FAA) and National Weather Service (NWS). ASOS is the nation's primary surface weather observation, every minute, 24-hours-a-day network providing support of weather forecast activities and aviation operations. The system also

provides data for meteorological, hydrological, and climatological research communities. Early weather reports used human observation. ASOS is augmented by human observation for more accurate forecasting at more than 900 locations throughout the country.

The researcher's source of pre-existing data from 1916-1989 was obtained using the following online sources: Data from 1916-1947 is taken from U.S. Department of Commerce Weather Bureau archive, Michigan section, maintained by National Climatic Data Center, weather history site "Weather Source.Com" and NOAA's "National Climate Data Center," Asheville, North Caroline. Reporting hourly data was not practiced until 1960. The researcher did not use hourly data for this research.

Weather data entered on the U.S. Department of Commerce Weather Bureau archive, Michigan section, 1916 to 1947, was taken and reported by human observation. Climate data on these records consisted of monthly and annual mean numbers. No daily or hourly recordings were taken.

Weather Source.Com utilizes data from the following government agencies: NOAA, the National Climatic Data Center (NCDC), and the NWS. This is raw daily weather data and presented on an Excel spread sheet in nine columns. The columns are: Begin and end date/time of observation, maximum, mean, minimum, temperature, and 100, 90, 32, and 0 hours.

The "Annual Climatological Summary" from NOAA is an all-inclusive monthly mean data sheet presented in portable document format (PDF). It is a climate history of an area under study. This database consists of 29 climate observations/elements.

Observations and elements range from cooling degree days, monthly mean temperature, and total snowfall, to soil temperature. The type of report requested will determine which elements will appear. For this research, the request report consisted of temperature and precipitation.

The report headings include: date of requested report, observation station number, location and description of station (longitude, latitude and elevation), and year covered.

It has 12 (1-12) numbered rows representing each calendar month, with an annual row displaying yearly totals. The requested reports consist of 20 element columns ranging from mean maximum temperature to total precipitation amount for the month. For validity of both reports, Excel auto sum was used to reduce errors.

Method of Data Collection

The method of data collection for this study was the use of existing data from two sources. The NOAA National Environmental Satellite, Data, and Information Service, located in Asheville, North Carolina, were the main sources. This data was collected using the ASOS program. The second source is collected from the U.S Department of Commerce Weather Bureau archive, Michigan section, provided by National Climatic Data Center.

Statistical Analysis

The research climate information was taken from U.S. Department of Commerce Weather Bureau archive, Michigan section, and the National Climate Data Center. All data were entered on an Excel spreadsheet to compute mean and standard deviation of climate. Information taken from data sheets dated 1916 to 1947 included annual and

monthly temperature, precipitation, and snowfall unmelted. Information collected from data sheets 1948 to 1989 consisted of annual, monthly, and daily temperature, precipitation, and snowfall.

Summary

Chapter III discussed the method and procedures used to gather data for the study. The goal of the study was to identify a relationship between climate change and automobile industry expansion. Climate data from 1916-1947 was taken from U.S. Department of Commerce Weather Bureau archive, Michigan section. The National Climate Data Center provided reliable data for the study from 1947 to 1989. From Weather Source.com and National Climate Using data were checked for validity.

CHAPTER IV

FINDINGS

Chapter IV presents the data collected for this research study. The problem addressed in this study concerned the climate of Flint, Michigan, as the automobile industry expanded from 1916 to 1989. Data for 1916 to 1947 was collected from U.S. Department of Commerce Weather Bureau archive, Michigan section, provided via the Internet by National Climatic Data Center. This consists of monthly and annual mean temperature, monthly and annual mean precipitation, and snowfall unmelted. Data was entered into an Excel spreadsheet to increase accuracy. Data from 1948 to 1989 were collected from the National Climate Data Center via the Internet. This data were collected from an Excel spreadsheet and were considered reliable for the study. This chapter contains the findings for Research Questions 1, 2, and 3 to determine if the automobile industry caused an increase of Flint's temperature and precipitation, and an increase of heavy precipitation. Single asterisk (*) indicates missing precipitation data. A double asterisk (**) indicates missing temperature data.

Research Question 1 (RQ_1)

Research Question 1 asked, did the automobile industry expansion in Flint, Michigan (1916-1989), cause an increase in area temperature?

Through statistical analysis of over the 31 years 1916 to 1947 ($n = 378^{*}$) ($\sum = 18138.8$) and standard deviation 18.10. The annual mean temperature increased to 47.98°F from 45.7°F (Table 1), an increase of 2.28°F. Table 1 also lists the annual mean temperature for the year 1916 at 45.7°F and the annual mean temperature for year 1947 at 46.9°F.

This is a difference of 1.2°F between these years. The years 1916 and 1947 annual mean temperature is supported by 28 and 59 years of temperature data, respectively, taken from the U.S. Department of Commerce Weather Bureau archive, Michigan section. During analysis of data, there was a notable increase of summer month's monthly mean temperature. This increase supports the warming of annual mean of Flint.

The years 1948 to 1989 are shown in Table 2. There were no significant changes of temperature, with no return to the 1916 annual temperature of 45.7°F.

Research Question 2 (RQ_2)

Research Question 2 asked, did the automobile industry production cause an increase of precipitation in Flint, Michigan between the years of 1916 to 1989?

Table 1

Flint Annual and Monthly Mean Temperature (Fahrenheit) 1916 to 1947

Year	N	Sum	Mean	STDEV
1916**			45.7°	
1947**			46.9°	
Annual 1916-1947**	32	1536.32	48.01°	2.27
Monthly 1916-1947**	378	18138.8	47.98°	18.10

Table 2

Flint Annual, Monthly, and Daily Mean Temperature (Fahrenheit) 1948 to 1989

Year	N	Sum	Mean	STDEV
1948-1960 Annual	13	617.3	46.78^{o}	2.85
Monthly	145	6861.6	46.99^{o}	17.50
Daily	4572	218228	47.73^{o}	19.15
1961-1989[1] Annual	29	1362.2	46.97^{o}	1.18
Monthly	348	16348.4	46.97^{o}	17.61
Daily	10592	498475	47.06^{o}	19.44

Through statistical analysis, these findings show over the 31 years, 1916 to 1947, precipitations (Table 3) a decrease of 3.73 inches to 29.09 inches from 32.82. Table 3 also shows an increase of unmelted snowfall. The total of unmelted snowfall in 1916 was 24.5 inches, based of 28 years of pervious data. The annual mean of unmelted snowfall from 1916 to 1947 is 33.68 inches. This is an increase of 9.18 inches. Through statistical analysis these findings show no significant change between 1916 -1947 and 1948 – 1960 (Table 4) of annual, monthly, and daily mean precipitation.

Table 3

Flint Annual and Monthly Mean Precipitation (inches) 1916 to 1947

Year	N	Sum	Mean	STDEV
1916-1947* Annual	32	930.88	29.09”	5.67
Monthly	381	929.59	2.43”	1.40
1916			32.82	
Annual Snowfall Uumelted	29	976.8	33.68”	11.23
Unmelted Snow 1916			24.5”	

Table 4

Flint Annual, Monthly and Daily Mean Precipitation (inches) 1948 to 1960

Year	N	Sum	Mean	STDEV
1948 – 1960* Annual	13	372.05	29.63”	8.69
Monthly	144	369.29	2.56”	1.52
Frozen* Annual	12	441.5	39.8”	17.55
Frozen* Monthly	69	492.8	7.12”	5.68
Daily Frozen	513	512.2	.99	1.26

Research Question 3 (RQ_3)

Research Question 3 asked did the automobile industry production cause an increase of heavy precipitation in Flint, Michigan, during the timeframe studied.

Analysis of data from 1916 to 1989 revealed no increase of heavy precipitation. The data did show an increase of heavy snow events. These events are identified by 4" of snow in less than 12 hours or 6" of snow in more than 24 hours.

From 1948 to 1960, Flint had 17 heavy snow events. Over the next 12 years, 1961 to 1973, the city had 25 events, and from 1974 to 1985, there were 20 events. Only one heavy snow event was recorded from 1986 to 1989.

After statistical analysis Table 5 showed no significant change between 1948 – 1960 and 1961 – 1989, annual and monthly mean precipitation with no significant increase of daily precipitation. Statistical analysis of Tables 4 and 5 show an increase of frozen precipitation between the years 1961 to 1989. Annual frozen precipitation increased to 49.14 inches from 39.8 inches with a monthly increase of 1.21 inches.

During data analysis, the researcher noticed a pattern change of frozen precipitation. The pattern changed from a five-month cycle (November to March) to a three-month cycle (January to March) from 1948 to 1989.

Table 5

Flint Annual, Monthly and Daily Mean Precipitation (inches) 1961 to 1989

Year	N	Sum	Mean	STDEV
1961 – 1989 Annual	30	856.64	28.55”	8.15
Monthly	348	871.35	2.50”	1.50
Annual Frozen*	29	1425.26	49.14”	12.62
Monthly Frozen*	169	1408.3	8.33”	6.15
Daily Frozen	1339	1427.1	1.06	1.42

Summary

Climate data were collected for Flint, Michigan, 1916 to 1989, to answer research questions developed for this study. Data were analyzed to determine if automobile factory expansion caused an increase of temperature and precipitation in Flint, Michigan. Findings revealed annual and monthly increase of temperature from 1916 to 1947, with minimal temperature change from 1948 to 1989.

There was a decrease of precipitation with an increase of unmelted snow from 1916 to 1947. There was an increase of frozen precipitation from 1948 to 1989.

Data also were collected to determine if automobile factory expansion caused an increase of extreme weather events. Data showed there was an increase of heavy snowfall between the years of 1947 to 1989. A summary, conclusions, and recommendations based on this data are presented in Chapter V.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents a summary of the research project by providing an overview of the research goals, as well as the methods and procedures used to achieve these goals. The researcher will answer the research questions and present conclusions based on the findings. The researcher also will offer recommendations based on the conclusions of this study and suggest topics for future study.

SUMMARY

The purpose of this study was to determine if the automobile industry affected temperature and precipitation changes in the city of Flint, Michigan, from 1916 to 1989. This proposal generated three questions:

RQ_1: Did the automobile industry expansion in Flint, Michigan (1916-1989), cause an increase in area temperature?

RQ_2: Did the automobile industry production cause an increase of precipitation in Flint, Michigan, between the years of 1919 and 1989?

RQ_3: Did the automobile industry cause an increase of heavy precipitation in Flint, Michigan, during the timeframe studied?

This study used research data collected from government weather stations located in Flint, Michigan, and archived by National Climate Data Center. Limiting factors included:

- Data collection only included the years from 1916 to 1989.

- The year in which data collection ended (1989) was the decade Buick reached its highest employment and when Flint's deindustrialization began.
- Data only included automobile manufacturing plants and secondary supporting plants.
- Population, ecosystems, air quality, and atmosphere data were not used.
- Data consisted only of precipitation, heavy precipitation, and temperature.
- Hourly temperature data were excluded.

This study included assumptions related to the industrial and climate within Flint, Michigan, Genesee County, where Flint is located. They included:

- As the automotive industry expanded in Flint, temperatures increased.
- Increased temperatures were caused by the increased use of fossils fuels.
- Flint will have a change of annual precipitation from 1916 to 1989 due to industrial expansion.
- Flint will have an increase of heavy precipitation from 1916 to 1989 due to industrial expansion.
- The greenhouse effect can occur on a local scale.
- Data collected from government archived date were considered valid.

The method of data collection for this study was the use of existing data from two sources: NOAA National Environmental Satellite, Data, and Information Service, located in Asheville, North Carolina was the main source. These data were collected using the ASOS program. The second source was collected from the U.S. Department of

Commerce Weather Bureau archive, Michigan section, provided by National Climatic Data Center.

Conclusions

Research Question 1 asked, did the automobile industry expansion in Flint, Michigan (1916-1989), cause an increase in area temperature? Through statistical analysis, findings showed over the 31 years 1916 to 1947 (n = 378*) ($\sum$ = 18138.8) and standard deviation 18.10. The annual mean temperature increased to 47.98^{o} F from 45.7^{o}F, an increase of 2.28^{o} F. The annual mean temperature increased 2^{o} from 1916 to 1947. The months of May, June, July, and August showed a warming trend leading to increased annual temperatures. This new annual temperature of 47^{o}F remained constant to 1989.

During the time frame 1916 to 1947, both Buick and Chevrolet expanded. Buick, by 1938 had expanded to a 12,000,000-square-foot facility that included an 184,800-square-foot foundry (Buick's first half-century, 1952). In February 1927, Chevrolet set a monthly record of 85,821 automobiles produced (Flint Journal, 1927). By 1932, the 31 Chevrolet assembly plants of Flint totaled 2,175,141 square feet of floor space (Flint Journal, 1932). The Chevrolet assembly plants of Flint received all their motors and sheet metal parts from manufacturing plants within Flint (Flint Journal, 1932). All factories used fossil fuel as a main generating power source. General Motors closed the 235-acre Buick City on June 29, 1999 (Roberts, 1999).

Research Question 2 asked, did the automobile industry production cause an increase of precipitation in Flint, Michigan, between the years of 1916 to 1989? Through

statistical analysis, findings showed over the 31 years 1916 to 1947 precipitations showed a decrease to 29.09 inches from 32.82, a change of 3.73 inches. The data showed an increase of unmelted snowfall. The total of unmelted snowfall in 1916 was 24.5 inches, based of 28 years of pervious data. The annual mean of unmelted snowfall from 1916 to 1947 was 33.68 inches. This is an increase of 9.18 inches. This increase showed a possible trend of warmer summers offset by more frozen precipitation during winter months. Through statistical analysis, findings showed no significant change between 1916 - 1947 and 1948 - 1960 of annual, monthly, and daily mean precipitation.

Research Question 3 asked, did the automobile industry production cause an increase of heavy precipitation in Flint, Michigan, during the timeframe studied. Analysis of data from 1916 to 1989 revealed no increase of heavy precipitation. The data did show an increase of heavy snow events. From 1948 to 1960, Flint had 17 heavy snow events. Over the next 12 years, 1961 to 1973, the city had 25 events, and from 1974 to 1985 there were 20 events. Only one heavy snow event was recorded from 1986 to 1989. The research showed a change in the frozen precipitation cycle. The increase of temperature and climate cycle change is part of climate indication (U.S. Environmental Protection Agency, 2014b).

Flint, Michigan, continued to produce automobiles and set production records. All major and subordinate plants had their own power houses with fossils fuels as a main power source. Without further study, it is inconclusive to determine if the automobile industry caused climate change in Flint, Michigan.

Recommendations

Based on the results of this study, the following research and actions are recommended:

- Continue to monitor Flint, Michigan, weather
- Continue the research until 2016 to cover a 100-year period. This would include the –de-industry period.
- Conduct research on similar cities.
- Conduct a population study during the same time period to include possible human impact, e.g., automobile usage, home heating and air conditioning.
- Research the state of Michigan during same time period to determine if the change was local or statewide.
- Research coal consumption of factory power plants

This study raised more question of local climate change and globe warming. Is climate change a natural cycle occurrence or induced by man? The scientific community and NOAA have established an aggressive monitoring plan that will keep humans informed of changes in and about the Earth. The last question is, have we waited too late to change?

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