Climate Change in Cincinnati

Proceedings of the 2007 Environmental Studies Seminar at Xavier University

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INTRODUCTION

This book is the result of a combined effort of the students in my environmental studies seminar class from spring semester 2007. Each year I have offered this course, the class has been focused on a different subject. We read case studies that highlighted global environmental issues, but we also focused on local aspects as a substantial component of the course. In 2004 the class discussed conservation and management of bird species. Among other readings, we discussed two of my favorite books: *The Song of the Dodo* by David Quammen and *Hope is the thing with Feathers* by Christopher Cokinos. In 2005 the focus of the class was freshwater ecosystems and we read a wonderful book about one of our local streams by Stan Hedeen, a Xavier University professor, called *The Mill Creek: an Unnatural History of an Urban Stream*. In 2006 we studied invasive species, of which Cincinnati has more than its fair share.

When I chose global climate change to be the theme for 2007, I wanted to keep the tradition of having a focus of the course on local aspects. I decided to have each member of the class write on climate change as it is manifesting here in Cincinnati. With 12 students enrolled in the course, it seemed like a good number for each to write a chapter for a book about local impacts & predictions. As a class, we decided on 12 topics and each student volunteered for one of the chapters.

I have organized the chapters into two sections. The first discusses the impacts and predictions for changes in the local climate and its biological communities. The first chapter reports the historical trends in climate data as measured by meteorological instruments. Chapter 2 investigates what is predicted to occur locally based on some of the most sophisticated computer models. The next two chapters examine how these predicted changes in climate will affect local plant (Chapter 3) and animal (Chapter 4) communities. The final chapter in this section looks at how a warming local climate may influence human health in Cincinnati.

The second section looks at social, political, and technological issues related to climate change. Chapter 6 looks at the carbon footprint of Cincinnati and compares it to that of Munich, Germany. The next two chapters examine the extremely local issue of energy usage right here on the campus of Xavier University. The first (Chapter 7) documents Xavier's current CO_2 output. The second (Chapter 8) looks toward the future. What actions and initiatives can Xavier implement to reduce its carbon footprint? Chapter 9 identifies many ways in which an average local citizen can reduce her/his greenhouse gas emissions. Transportation fuels contribute a large part of our emissions, so Chapter 10 looks at the existing technologies for supplying transportation needs to evaluate which options will result in fewer greenhouse gas emissions. We finish with a chapter discussing the role of politics in addressing the threat of global climate change.

Chapter 1

Kimberly Lears

REGIONAL CLIMATE CHANGE

During the 20th century, mean surface temperatures have been increasing all over the world. The recent warming has been consistent with the decrease in snow-cover, the retreat of mountain glaciers, spring melting of ice, and increases in ocean surface temperatures. The top ten warmest years have all occurred since 1990. Both daily maximum and minimum temperatures have been increasing, and the winter months are warming faster than summer months. There has been a great decrease in the number of days below freezing across the United States.

The increasing temperatures have caused increased evaporation, which has led to increased global precipitation. However, changes in precipitation have proven to be much more regionally variable. Whereas sub-tropical regions have had precipitation slightly decline, tropical regions have shown increases in amounts of precipitation. Though areas receiving greater amounts of precipitation have had storms of greater intensity, there is thus far no long-term evidence of specific trends of storm changes.

The city of Cincinnati, Ohio is located directly on what is considered a climatic transition zone. The city is nestled between the northern limit of the humid subtropical climate and the southern limit of the humid continental climate, which causes the local climate to result in a mix of the subtropics of the south and the mid-latitude area of the north. Both of these climates influence the city's landscape and ecology. According to the USDA Climate Zone map, Cincinnati has a 6 hardiness zone rating, in which a zone 1 indicates the coldest temperatures and zone 11 indicates the warmest temperatures. However, more mild temperatures are generally found along the Ohio River basin. In comparison to the rest of Ohio, Cincinnati typically receives less snow and has a longer growing season. Cincinnati summers tend to be hot and humid with cooler evenings. The wettest seasons are spring and summer, but rainfall tends to be rather constant throughout the entire year. Several days of snow can be expected during the winter season.

Temperature

In the past 100 years, the average temperature for the Ohio winter season, December through February, has been 29.25 degrees Fahrenheit. In 2006, the average temperature for winter was 32.5 degrees Fahrenheit. This jump in average temperature coincides with the overall trend because the average temperature for the winter season of Ohio has been increasing at a rate of 0.15 degrees Fahrenheit per decade.

December, specifically, has had an average temperature of 30.91 degrees Fahrenheit in the past 100 years for Ohio, while Cincinnati has an average temperature of 35°F. The average high is 43°F and the average low is 27°F. Cincinnati's extreme maximum temperature was 78°F in 1982, but its extreme minimum temperature was -24°F in 1989. The most number of days for the maximum temperature to be below freezing in December is 20 days, and this occurred in 1963. For Ohio, the temperature for the month of December has been increasing by 0.19°F per decade. January tends to be colder and Ohio has had an average temperature of 27.5°F in the past 100 years. Cincinnati's average January temperature is 30°F with 38°F as the average high and 22°F as the average low. The extreme maximum temperature in Cincinnati for this month was 77°F in 1950, and the extreme minimum temperature was -25°F in 1977. For January, the most number of days for the maximum temperature to be below freezing is 27 days in 1977. Unlike December, the average temperature of January has been decreasing per decade in Ohio but only by 0.04°F. The average temperature of February in the past 100 years is

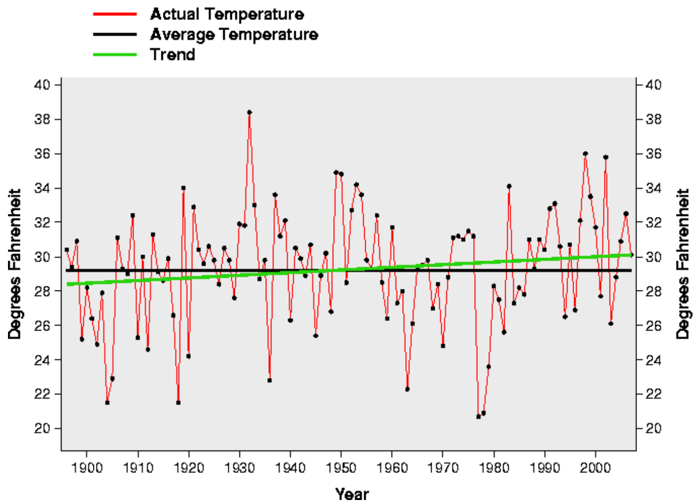
29.25°F in Ohio and 35°F in Cincinnati. Cincinnati has an average high of 44°F and an average low of 27°F. The city's extreme maximum temperature is 77°F, and this happened in 1972, 1999, and 2000. February's extreme minimum temperature is -10°F, which occurred in both 1977 and 1981. The most number of days for the maximum temperature to be below freezing in Cincinnati in February is 22 days in 1978. The trend, however, for Ohio for the month of February is an overall increase of 0.36°F per decade.

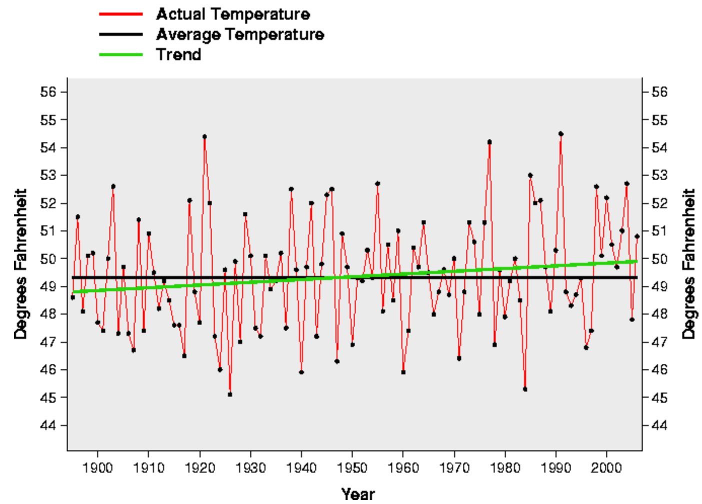
In the past 100 years, the average temperature for the Ohio season of spring, March through May, has been 49.35°F. In 2006, the average spring temperature was actually 50.8°F. This slightly higher average temperature makes sense because overall the average temperature for the season of spring has been increasing by 0.10°F per decade .

The month of March in particular has an average temperature of 38.86°F in the past 100 years in Ohio. Cincinnati has an average temperature of 44°F in March with an average high of 54°F and an average low of 34°F. Cincinnati's extreme maximum temperature was 85°F, which occurred in both 1981 and 1986, and its extreme minimum temperature was -10°F in 1980. For March, the most number of days with the maximum temperature below freezing in Cincinnati was 11 days in 1960. Overall, the average temperature for Ohio for the month of March has been increasing by 0.10°F per decade. April's average temperature in Ohio in the past 100 years is 49.24°F. Cincinnati's average temperature for April is 54°F with an average high of 65°F and an average low of 43°F. The city's extreme maximum temperature for the month of April is 90°F, which happened in 1977 and 1986. The temperature only reached 90°F for one day in both of these years. Cincinnati's extreme minimum temperature for April is 15°F in 1969. In Cincinnati, the month of April has never experienced a maximum temperature below freezing in the past 100 years. The overall trend for Ohio for this month is an increase in average temperature of 0.24°F per decade. In May, the average temperature for Ohio for the past 100 years is 59.95°F, while Cincinnati's average temperature is 64°F. Cincinnati's average high is 75°F and average low is 54°F. May's extreme maximum temperature for Cincinnati is 94°F, which took place in 1949 and 1962. The most number of days in Cincinnati with a maximum temperature of at least 90°F is 8 days in 1962. The extreme minimum temperature for May is 27°F in 1966. The trend for the month of May in Ohio, unlike both March and April, is actually a decrease in average temperature of 0.02°F per decade.

The Ohio summer months, June through August, have maintained a relatively constant temperature over the past 100 years. The average summer temperature for Ohio is 71.03°F. The average temperature for each summer month has not significantly changed over the past century. The overall average summer temperature has not changed in the past 100 years.

The average temperature specifically for the month of June in Ohio is 68.93°F. Cincinnati's average June temperature is 73°F with an average high of 83°F and an average low of 62°F. The city's extreme maximum temperature for June was 106 °F in 1988, and the most number of days with a maximum temperature above 90°F is 20 days in 1988. The extreme minimum temperature was 38°F, which occurred in 1990. Though not by much, the average temperature for the month of June in Ohio has been increasing 0.03°F per decade. July has an average temperature of 73.05°F in Ohio in the past 100 years. Cincinnati has an average temperature of 77°F in July with an average high of 87°F and an average low of 67°F. Cincinnati's extreme maximum temperature is 107°F in 1988, and the most number of days with the maximum temperature above 90°F is 24 days, which happened in 1999. The extreme minimum temperature for the month of July is 43°F in 1963. Unlike the other summer months, the average temperature of July has been decreasing in Ohio over the past 100 years. July in Ohio has been experiencing a decrease in average temperature of 0.05°F per decade. The average temperature for the month of August is 71.10°F for Ohio and 76°F for Cincinnati. Cincinnati's extreme maximum





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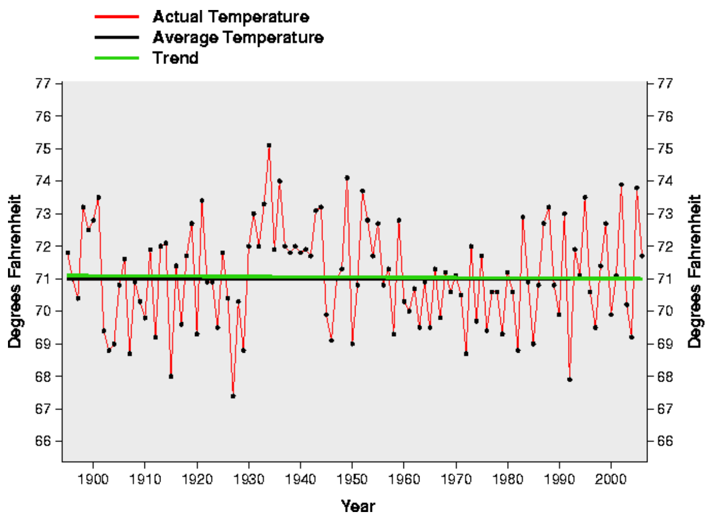

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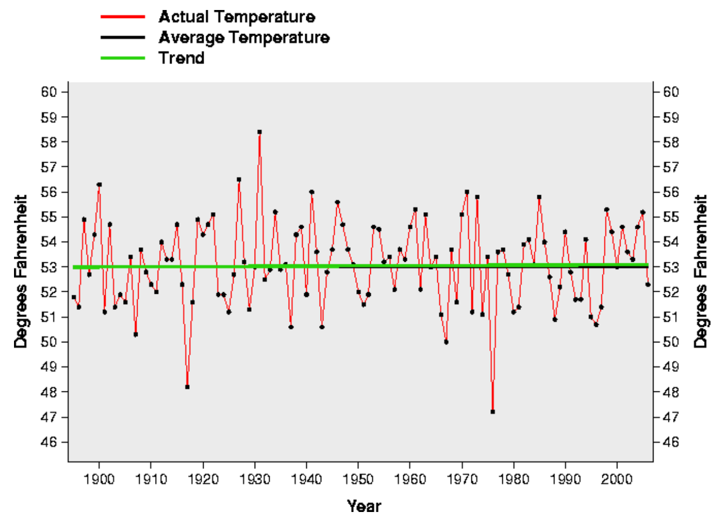

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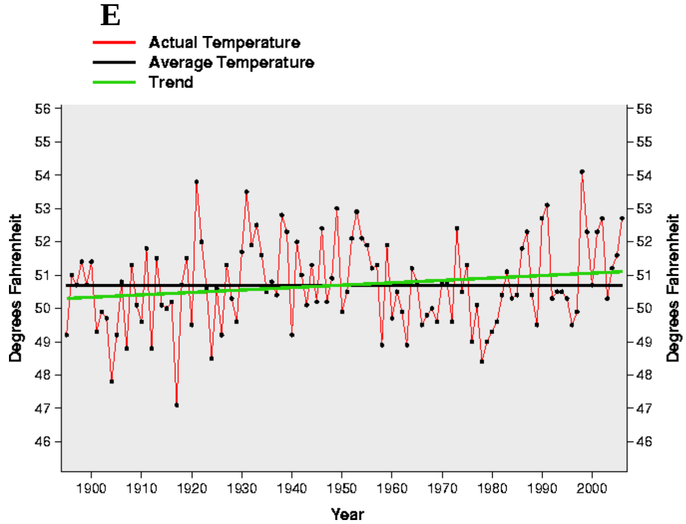

Figure 1.1. *Historical temperatures trends in Ohio for A) winter (months of Dec. – Feb.), B) spring (Mar. – May), C) summer (Jun. – Aug.), and D) autumn (Sep. – Nov.).*

temperature for this month is 105°F in 1988 while the extreme minimum temperature is 42°F in 1986. The most number of days in Cincinnati with a maximum temperature above 90°F is 23 days, which happened in 1983. The temperature in August has remained fairly constant over the past 100 years, but there has been a 0.01°F increase in average temperature in Ohio per decade.

The autumn months in Ohio, September through November, have had an average temperature of 53.03°F in the past 100 years. In 2006, the average autumn temperature was 52.4°F. Though this is slightly lower than the overall average temperature for the season, the average temperature for autumn has actually been increasing. The season of autumn has been experiencing an increase in average temperature of 0.01°F per decade.

In September, the average Ohio temperature is 64.65°F while the average Cincinnati temperature is 69°F. The average high for Cincinnati is 79°F and the average low is 58°F. The extreme maximum temperature in Cincinnati for September is 101°F, which happened in both 1953 and 1954. The most number of days September has had a maximum temperature of at least 90°F in Cincinnati is 11 days in 1959. The extreme minimum temperature for September is 30°F in 1993. The month of September has been experiencing an overall decrease in average temperature in Ohio over the past 100 years. Despite autumn's overall increase in average temperature, September's average temperature has been decreasing in Ohio by 0.13°F per decade. The month of October has had an average temperature of 53.18°F in Ohio. Cincinnati's average temperature in October is 57°F with an average high of 67°F and an average low of 46°F. Cincinnati's extreme maximum temperature was 92°F in 1951, and the most number of days October has had a maximum temperature of at least 90°F was three days in both 1951 and 1959. The extreme minimum temperature in Cincinnati for this month was 18°F in 1962 and 1976. Like September, the overall average temperature for the month of October in Ohio has been decreasing. The average temperature has been falling 0.05°F per decade. The average temperature of November has been 41.26°F in Ohio for the past 100 years. In Cincinnati, the average temperature of November is 46°F with an average high 54°F and an average low of 37°F. The extreme maximum temperature in Cincinnati was 88°F in 1987. The extreme minimum temperature was -3°F in 1958, and the most number of days November has had a maximum temperature below freezing in Cincinnati was four days in 1950. Unlike the two other autumn months, November's average temperature has been increasing in Ohio. It has been experiencing an increase of 0.21°F per decade.

Each season has faced an increase in average temperature over the past 100 years with the exception of summer that has not significantly changed at all. Trends show that seven months have experienced an increase in average temperature over the century, whereas only five months have experienced a decrease in average temperature. The annual average temperature for the state of Ohio is 50.66°F, and the annual average temperature in 2006 was 52.8°F. The average temperature has slowly been increasing over the years. The trend is an increase of 0.07°F per decade. The state of Ohio has gradually been warming over the past century (Figure 1.1).

Precipitation

In the past 100 years, the average precipitation for the winter season in Ohio is 7.83 inches. In 2006, the precipitation accumulated was 6.84 inches. This drop in precipitation is reflective of the trend for the past century. The precipitation for the winter months has been decreasing by 0.06 inches per decade.

The month of December has had an average precipitation of 2.74 inches in the past 100 years in Ohio. Cincinnati specifically has had an average precipitation of 3.0 inches in December. The most precipitation ever accumulated in Cincinnati in December was 8.45 inches in 1990, and the least was 0.38 inches in 1976. The greatest amount of precipitation in one day in December was 3.42 inches in 2004. Over the course of the century, the precipitation for

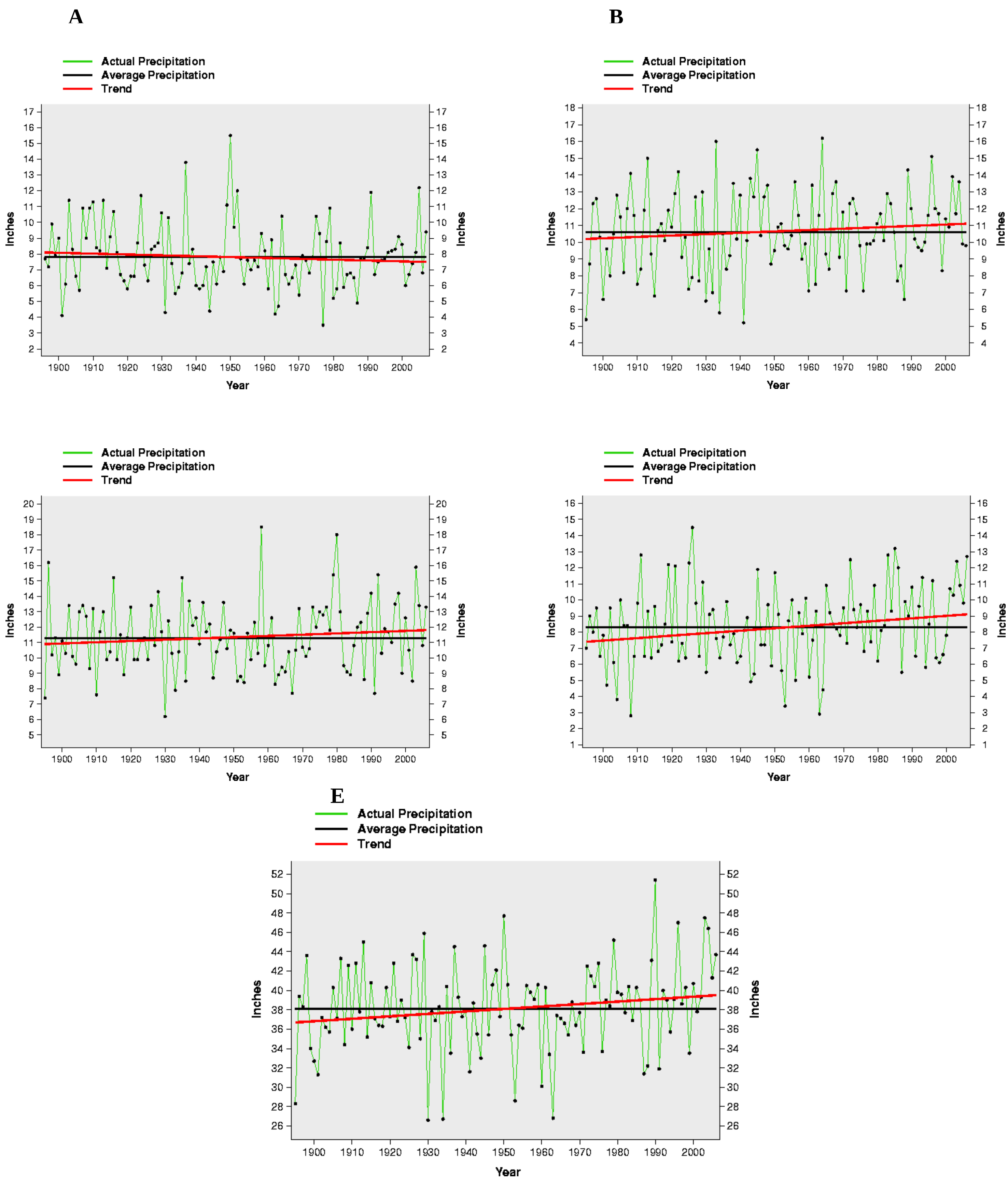

Figure 1.2. *Historical precipitation trends in Ohio for A) winter (months of Dec. – Feb.), B) spring (Mar. – May), C) summer (Jun. – Aug.), and D) autumn (Sep. – Nov.).*

December in Ohio has not significantly changed. January has had an average precipitation of 2.81 inches in Ohio and an average precipitation of 2.7 inches in Cincinnati. The most precipitation in Cincinnati in January was 14.88 inches in 1937, and the least precipitation was 0.45 inches in 1981. The most precipitation ever accumulated in one day in Cincinnati in January was 4.28 inches in 1959. Just like the winter season in general, in Ohio the month of January has been experiencing a decrease in average precipitation. In the past century, the precipitation has been falling at a rate of 0.04 inches per decade. The average precipitation for the month of February is 2.29 inches for the state of Ohio and 2.6 inches for Cincinnati. The most precipitation to fall in Cincinnati in February was 7.38 inches in 1990, and the least to fall was 0.13 inches in 1978. The greatest amount of precipitation for one day in Cincinnati in February was 2.75 inches in 2000. Like January, the month of February has been experiencing a decrease in average precipitation over the century in Ohio. The average precipitation has been decreasing by 0.02 inches per decade.

The spring season in Ohio generally brings greater amounts of precipitation. The average precipitation in Ohio for spring is 10.64 inches. In 2006, 9.82 inches of precipitation fell during the spring months. However, the average amount of precipitation has actually been increasing over the past century. Trends indicate an increase of 0.09 inches of precipitation per decade.

For March, the average precipitation in Ohio has been 3.35 inches, and the average precipitation in Cincinnati has been 3.9 inches. The most precipitation to fall in Cincinnati in March was 11.87 inches in 1964, and the least to fall was 1.05 inches in 1941. The most precipitation to ever fall in Cincinnati in one day in March was 4.73 inches in 1964. Though the amounts of precipitation in March have continued to be significantly more than other months, the trend shows a decrease of 0.08 inches of average precipitation per decade in Ohio. April has an average precipitation of 3.48 inches in Ohio and 3.7 inches in Cincinnati. The most precipitation in Cincinnati for the month of April was 10.23 inches in 1998, and the least amount of precipitation was 0.52 inches in 1962. The greatest amount of precipitation in Cincinnati for one day in April was 3.06 inches in 1998. Unlike March, the average amount of precipitation in Ohio has been increasing by 0.07 inches per decade. The average precipitation for the month of May is 3.81 inches in Ohio and 4.2 inches in Cincinnati. The greatest amount accumulated in Cincinnati was 11.8 inches in 1996, whereas the least amount accumulated was 0.61 inches in 1965. The daily extreme maximum in Cincinnati for May was 3.42 inches in 1956. The overall trend of average precipitation in the month of May in Ohio is an increase of 0.1 inches of precipitation per decade.

The summer months in Ohio have received an average of 11.34 inches of precipitation in the past century. In 2006, there was 13.31 inches of precipitation during the summer. This higher than average precipitation reflects the overall trend of increasing precipitation during the summer in Ohio. The average precipitation for the summer months has increased by 0.08 inches per decade.

The individual month of June has an average precipitation of 3.95 inches in Ohio and 3.4 inches in Cincinnati. The most precipitation to fall in Cincinnati in June was 10.92 inches in 1998, and the least was 0.44 inches in 1936. The most to ever fall in one day in June in Cincinnati was 3.84 inches in 1982. Over the past century in Ohio, the month of June has been experiencing an overall increase of 0.02 inches of precipitation per decade. July has had an average precipitation of 3.96 inches over the past century in Ohio, while Cincinnati specifically has had an average precipitation of 4.2 inches in July. The greatest amount of precipitation in Cincinnati for the month of July was 12.00 inches in 1992, and the least was 0.32 inches in 1940. The greatest amount for any single day in Cincinnati in July was 4.08 inches in 1956. Like the month of June, July has also been experiencing an increase in precipitation over the past century in Ohio. There has been an increase of 0.08 inches of precipitation per decade for the month of July. The average precipitation for the month of August is 3.42 inches in Ohio and 3.6 inches in Cincinnati. The most precipitation in Cincinnati for August was 10.24 inches in 1974, and the least was 0.45 inches in 1951. The most precipitation to fall in one day in Cincinnati was 3.94 inches in 1960. Just as in the other summer months, August has had an increase in precipitation in Ohio over the past century. Trends indicate that there has been a 0.03 inch increase in precipitation per decade.

Autumns in Ohio tend to have slightly less precipitation than the spring and summer months. The average precipitation from the past century for the autumn is 8.26 inches. In 2006, there was 13.63 inches of precipitation during the autumn months, which is significantly higher than the average. This rather high amount of precipitation reflects the trends of the past century, in which there has been an increase of 0.15 inches of precipitation per decade.

The average amount of precipitation for the month of September is 2.98 inches in Ohio and 3.0 inches in Cincinnati. The most precipitation to fall in Cincinnati in September was 9.18 inches in 1979, and the least was 0.26 inches in 1978. In a single day in Cincinnati, the most precipitation to fall in September was 5.52 inches, which happened in 1979. Over the past century, September has been experiencing an increase in total precipitation in Ohio. Trends have shown that for the month of September there has been an increase of 0.05 inches of precipitation per decade. October has had an average precipitation of 2.54 inches in Ohio in the past century and an average of 2.6 inches in Cincinnati. The greatest amount of precipitation in Cincinnati for October was 11.03 inches in 1983, and the least amount was 0.03 inches in 1963. The most precipitation for any one day in Cincinnati in October was 4.53 inches in 1985. Like September, October has had an increase in precipitation in Ohio over the century. The precipitation has increased by 0.03 inches per decade. The average precipitation for the month of November over the past century is 2.74 inches in Ohio and 3.3 inches in Cincinnati specifically. The most precipitation to fall in Cincinnati in November was 10.11 inches in 1985, and the least to fall was 0.32 inches in 1999. The most precipitation to ever fall in one day in Cincinnati in November was 2.85 inches in 1948. November has also been experiencing an increase in precipitation in Ohio over the past century just as with all of the autumn months. It has been increasing by 0.07 inches per decade.

Overall, the precipitation for the state of Ohio has been increasing over the past century. Though the winter months have apparently been experiencing a decline in amounts of precipitation, the rest of the year has shown increases in precipitation. Altogether, eight months have had gradual increases in precipitation, and only three months have been on the decline. The annual average amount of precipitation from the past century has been 38.09 inches, but in 2006, the final accumulation was 44.08 inches. This higher than average precipitation coincides with the trend of an increase of 0.26 inches of precipitation per decade (Figure 1.2).

The state of Ohio, therefore, has definitely been showing consistent climate trends over the past century. Analysis of average temperatures according to months and seasons has shown that this specific region has gradually been warming. Overall precipitation levels also appear to be on the rise in Ohio meaning much wetter years compared to the past. However, precipitation trends appear to be much more dependent on specific location. Though overall precipitation for the state of Ohio has increased, southern parts of the state, including Cincinnati, have instead had declines in precipitation. While northern parts of the state have experienced increases in precipitation up to 10%, the precipitation has declined up to 10% in southern parts of the state. The severity of storms might be affected by the increases in temperature and changes in precipitation, but there is not yet a clear trend. Still, warmer climates can bring higher rainfall, which could lead to more intense storms. The resulting wetter conditions could then increase flooding. Some of the climatic changes that are occurring within the state of Ohio have yet to result in conclusive trends for predicting the future, but other trends are arguably results of global warming. The state of Ohio and the city of Cincinnati have undergone consistent and substantial changes of temperature and precipitation that follow trends suggestive of global warming climate changes.

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Useful Websites:

http://www.ncdc.noaa.gov/oa/ncdc.html

Chapter 2

Annette Stowasser

CLIMATE MODELS

Climate models are widely used to predict our future climate. Current models allow the interactions between the different components of the global climate system as the land surface, the atmosphere, ocean dynamics, and ice coverage. Within such coupled global climate models, each component of the global climate system is represented by a separate model. The coupling of the separate models allows the exchange of energy and masses between the models, which yields in interactions between the models.

Many such climate models exist and are used for predictions. A few examples of such models are the AOGCMs HadCM2 and HadCM3 developed at the Hadley Center, the GISS ModelE developed at the Goddard Institute for Space Studies, and the CGCM1 and CGCM2 developed at the Canadian Centre for Climate Modeling and Analysis.

Since all such models are similar in their general structure, one may expect the results to be the same. However, the results of the models show differences. This is due to differences in mathematical methods such as the ocean mixing parameterization, sea-ice dynamics, differences in the depth layers of soil, ice, and ocean, the radiation calculation, or how freezing and melting soil moisture is handled. Differences are also due to how many details are incorporated into the model, the initial conditions, and spatial and temporal resolution.

For the assessment how realistic the predictions of a model seem to be, the models are validated against known reference data from the last century. The goal is to find a set up for the simulation that can successfully simulate the past, which then suggests that simulations into the future show realistic results. For this purpose, simulations are usually done for the past with keeping green house gas and aerosol concentrations concentration constant, and with different combinations of green house gas and aerosol forcing, which means changing greenhouse concentrations and aerosols over time during the simulation. The simulation results are then compared against known reference data. Adjustments are made if needed, which means correcting the model for drift over time, due to errors in the energy and mass flow calculations.

Successfully validated models are then used to predict temperature, moisture, precipitation, and many other variables over time, depending on which variable a model can handle. The different predictions can be obtained from the developer web pages, can be found in many scientific publications, and are widely used for climate change assessments.

In the following we focus on climate predictions from CGCM1 and CGCM2. The Canadian Centre for Climate Modeling and Analysis maintains a web based database which allows the extraction of data for different variables, areas, and scenarios. The source department is Environment Canada. Predictions from CGCM2 were used in the IPCC Third Assessment Report released in 2001.

CGCM1 and CGCM2

Both models have a resolution of about 3.75 longitude and latitude. The models allow the interaction between four models, an atmospheric general circulation model (GCMII), an ocean general circulation model, a thermodynamic sea ice model, and a land surface model.

The atmospheric general circulation model allows the modeling of atmospheric circulations, cloud cover, and cloud characteristics. The ocean general circulation model allows the modeling of key circulations within the oceans and their interactions with the atmosphere. The thermodynamic sea ice model allows the modeling of ice formation and melting as a result

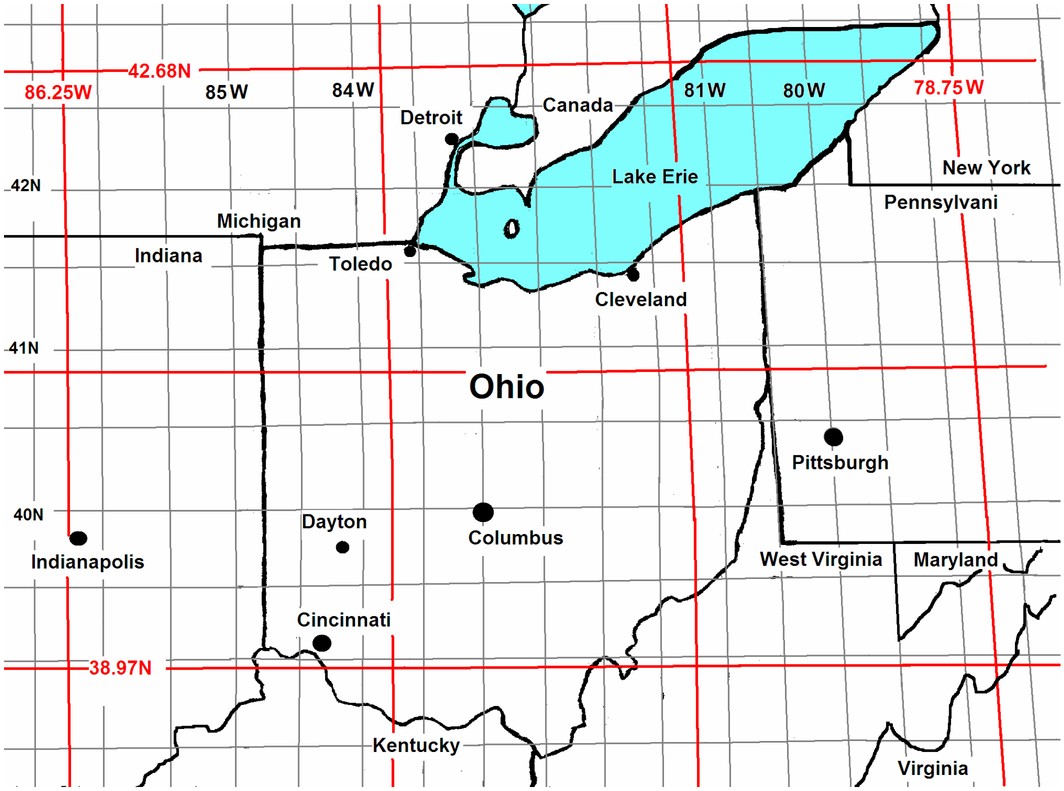

Figure 2.1. *Area covered by grids cover an area from 86.25W to 78.75W and 42.68N to 38.97N, indicated by the red lines. The gray lines show longitude and latitude in 0.5º intervals.*

of interactions between ice cover and ocean as well as the atmosphere. The land surface model allows the modeling of water run off, soil moisture, and evaporation, while taking differences in soil depth, composition, and evapotranspiration rates into account, but not vegetation. By coupling the four models, interactions between ocean, atmosphere, land surface dynamics, and ice can be simulated.

The models were validated by comparing simulation results against known climate reference data from the last century. Climate was simulated with greenhouse gasses and aerosole phosphate forcing, with only greenhouse gasses forcing, and with no forcing. The greenhouse gas forcing was based on observed CO_2 concentration changes and the assumption of a 1% increase per year for the years after 1990, called the IS92a scenario, which is the IPCC scenario. Gas concentrations were converted to CO_2 equivalences. The aerosole phosphate forcing incorporated the cooling effects of light reflection, their lifetime, and localized concentration, but not their effects on cloud properties, since they are still widely unknown.

With greenhouse gas and sulphate aerosols forcing, IS92a scenario, both models showed reasonably realistic results for climate patterns as mean global temperature, Ocean Oscillations, precipitation, and other characteristics. Forcing of only greenhouse gasses resulted in an overestimation of temperature increase, while no forcing resulted in no overall climate change.

The overall results suggest that the models can simulate climate pretty well with greenhouse gas and sulphate aerosole forcing. Even though both models with IS92a scenario widely agree on mean global climate changes, there are differences between the models. In the following we examined the predictions of both models in comparison with each other and the observed trends of the last century for the Ohio region.

We obtained data from the online database for both models, three runs each, GHG+A IS92a scenario, an area of 6 grids from 86.25W to 78.75W and 38.97N to 42.68N, a time period from 1900 to 2100, with monthly intervals, and for the variables precipitation, screen temperature (2m), and soil moisture. The GHG+A IS92a scenario stand for the IS92a scenario with greenhouse gasses and aerosol forcing.

Analyzing the Data

The selected area contains 6 grids as shown in Figure 2.1. The three runs of each model were averaged. The predictions for the 6 grids were averaged in order to calculate the overall predicted change for the Ohio region. In another setting data from only one grid was examined, which was the grid corresponding to the area around Cincinnati.

One should keep in mind that the models don't take local small scale variations into account. For this reason, uncertainties of the models increase as the area decreases. A regional climate model would be necessary for to incorporate local small scale variability. Hence, the realistic values may be different.

In addition, the predictions are based on assumptions as the future CO_2 and aerosole concentration changes. If the future realistic values are different from any of such assumptions, climate changes may well be different from the predictions. Hence, the predictions should be seen as trends and be treated with some caution. A difference between prediction and realistic value is possible in both directions, toward more and less changes than predicted.

For further assessments of the predictions, which were analyzed in a rather simplified way, we compared the predictions against a rather extensive climate change report of the Great Lakes Region from the Union of Concerned Scientists & Ecological Society of America, the UCS report. The climate predictions represented in this report are based on HadCM3 and the Parallel Climate Model (PCM) developed at the US National Center for Atmospheric Research. In addition historical observed climate data from throughout the last century were also taking into account for making the climate predictions represented in this report.

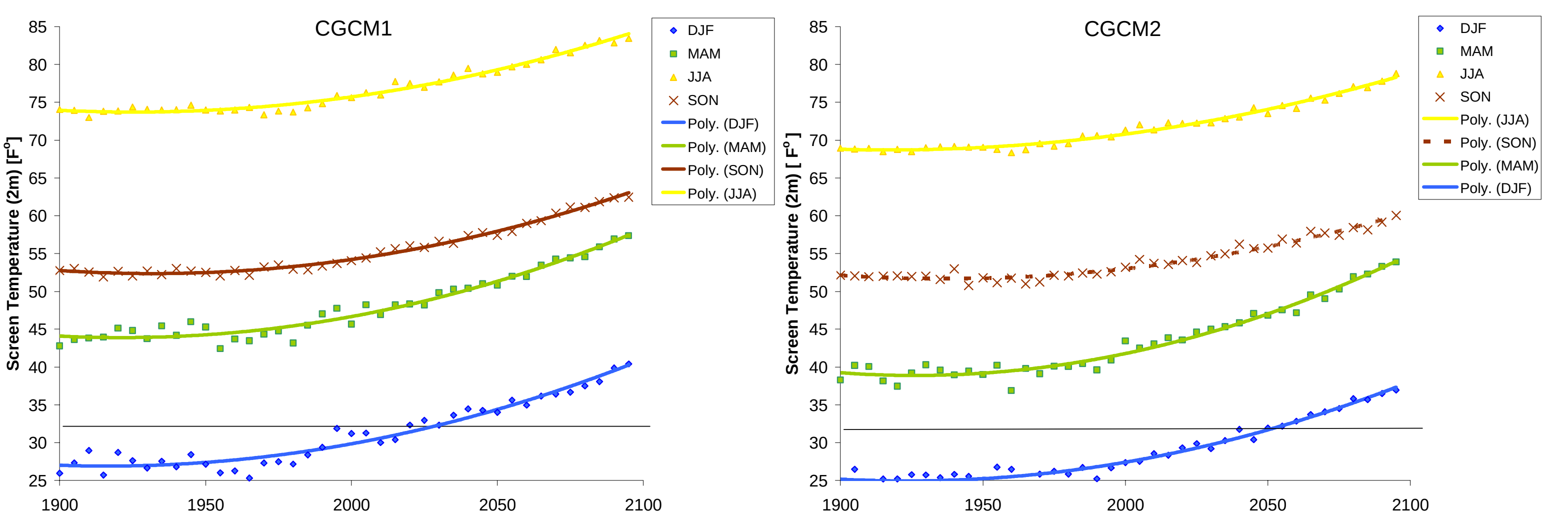

Figure 2.2. *Average temperature in °F, data points are the average over 3 runs, representing the area 86.25W to 78.75W and 38.97N to 42.68N, and a 5 years time period. DJF stands for the time period December to February, MAM is from March to April, JJA is from June to August, and SON is from September to November.*

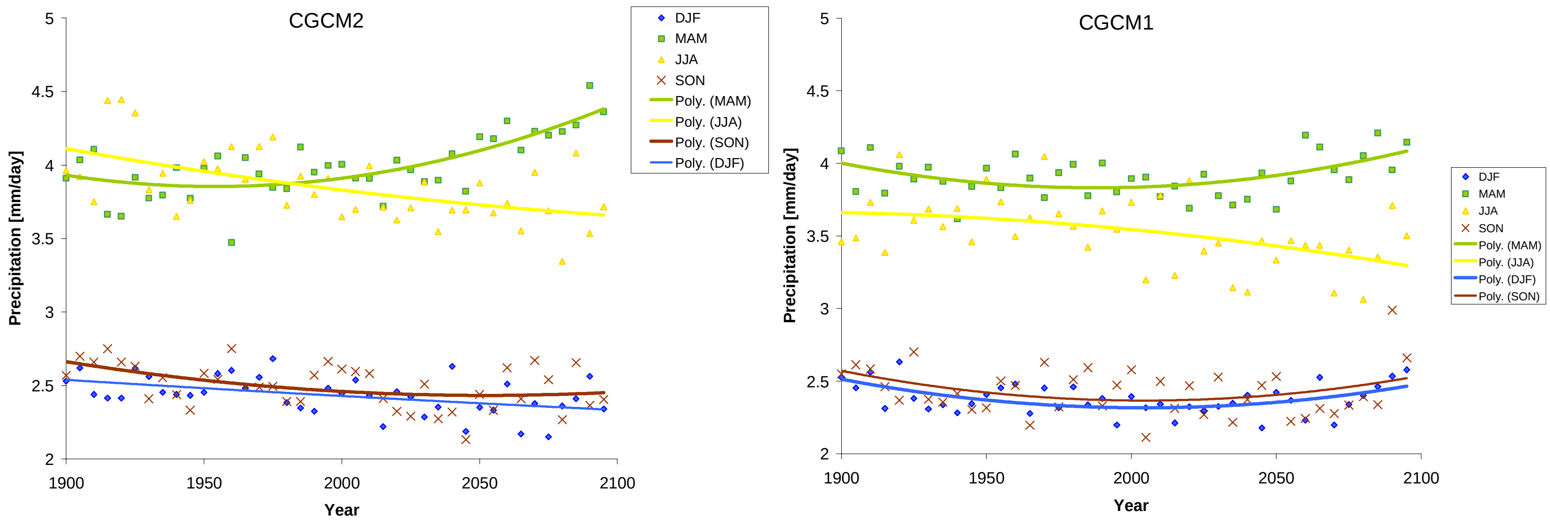

Figure 2.3. *Average precipitation in mm/day, data points are the average over 3 runs, representing the area 86.25W to 78.75W and 38.97N to 42.68N, and a 5 years time period. DJF stands for the time period December to February, MAM is from March to April, JJA is from June to August, and SON is from September to November.*

Temperature

The model CGCM2 predicts an increase in temperature within the next 30 years of 2.5 ºF for the winter, 2.6 ºF for the spring, 1.3 ºF for the summer, and 1.3 ºF for the autumn months, see Figure 2.2.

The prediction is consistent with observed temperature changes throughout the last century with highest temperature increase in the winter and spring months, as described in Chapter 1. However, while almost no temperature increase could be observed during the last century in the summer and autumn months, the climate model predicts an temperature increase also for the summer and autumn months.

The model CGCM1 shows slightly different predictions. The predicted increase in temperature is slightly less with between 1 ºF and 2.3 ºF. The predicted temperature increase is for the winter months less than for the summer months. Here, the spring and autumn months show highest temperature increase.

Within the next century model CGCM2 predicts a temperature increase between 6.7 ºF and 11.4 ºF, with highest increase for the winter and spring months. Model CGCM1 shows temperature increase between 7.4 ºF and 10.4 ºF, with a higher increase for spring and lowest increase for summer months, see Figure 2.2.

In the CGCM1 simulation, winter average temperature will be above freezing point after around 2030, while in the CGCM2 generation winter average temperature will remain below freezing point until 2050, see Figure 2.2.

The predictions of CGCM2 for the area around Cincinnati and next three decades show an increase in temperature for the winter and spring months of 3.2 ºF - 4.6 ºF, and a slight temperature increase for the summer and autumn months of about 1.3 ºF, see Figure 2.5.

The predictions represented in the UCS report are similar with a predicted increase of temperature in Ohio within the next century of 7-12 ºF in the winter and 6-14ºF in the summer.

Precipitation

For the winter, CGCM2 predicts a very slight decrease, while CGCM1 predicts an increase. For the spring both models predict an increase. For the summer both models predict a decrease, and for the autumn CGCM1 predicts a very slight increase, while CGCM2 predicts almost no change.

As discussed in Chapter 1, historical data from the last century show an increase of precipitation during the summer and decrease of precipitation during the winter, which is exactly the opposite of the trends predicted for the future. An indication for that a reversion of the historically observed trends may happen, can be found in the simulation of CGCM1. The model simulates a slight decline of precipitation during the winter and a slight increase of precipitation during the summer throughout the last century until around 2000. After around 2000 this trend then reverses. However, the historical trend can still be seen in the CGCM2 simulation for the area around Cincinnati and the next three decades, see Figure 2.5.

A similar prediction is represented in the UCS report, which predicts that the precipitation may only change slightly with the tendency of an increase in the winter and an decrease in the summer in the future.

Soil Moisture

Both models predict a consistent decrease of soil moisture throughout the next century. The soil moisture may decrease within the next three decades up to 16%, and within the next century up to 25%, see Figure 2.4. A decrease in soil moisture can also be seen throughout the year for the are around Cincinnati for the next three decades, see Figure 2.5.

This prediction is also in agreement with the UCS report, which indicates that the soil moisture may decrease due to the increase of evaporation caused by an increase of temperature. Since the precipitation change does not seem to equal out the increased moisture loss due to evaporespiration, the soil will get dryer especially during the summer.

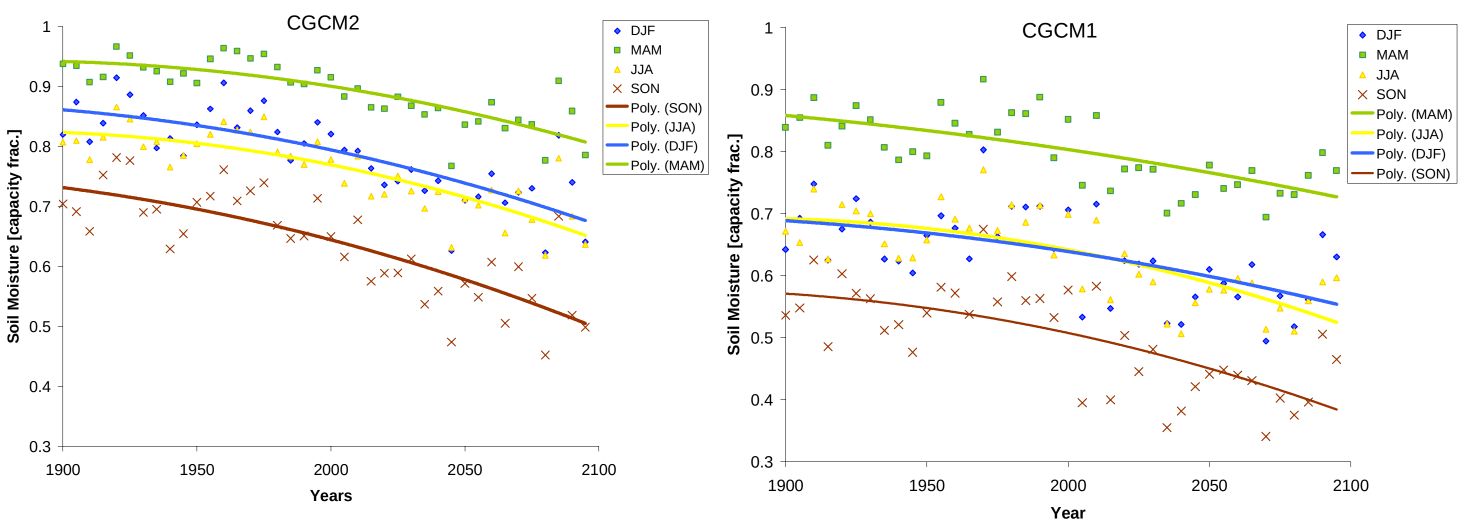

Figure 2.4. *Soil moisture in capacity fraction, data points are the average over 3 runs, representing the area 86.25W to 78.75W and 38.97N to 42.68N, and a 5 years time period. DJF stands for the time period December to February, MAM is from March to April, JJA is from June to August, and SON is from September to November.*

Summary

Climate predictions are difficult to make. The climate system is very complex. Models may not reflect the often simplified interactions sufficiently enough. Assumptions need to be made about future changes in green house gas concentrations. Those assumptions may be different from the future changes we will actually experience. In addition, the uncertainties of models increase with a decrease of the target area, which makes it difficult to predict especially local climate changes.

However, climate models are widely used for to estimate future climate changes. It seems to be that the results are even quite reasonable for relative small areas, as seen here. For Ohio, several different climate models show the same trends, and are in consistency with observed historical climate data.

As discussed in Chapter 1, historical climate data from the last century show consistent changes in temperature and precipitation in Ohio. As the climate models show, those changes will most likely continue, so that the future climate of Ohio will be quite different from what we have today.

In order to provide some idea of how the Greater Lake Region climate may look like in future, the UCP report discussed which current climate may be comparable with the future climate of the region. Such estimations are very difficult, since unique geographical features as the great lakes, ocean, and mountain ranges are impossible to take into account. However, by 2030, the summer climate of the Greater Lake Region may have shifted already over 300 miles to the south and west. The estimated summer climate of Illinois may then be that of Oklahoma or Arkansas today.

By 2100 the climate of the southern boarder of Illinois may line up with the coastline of Texas today. Following the represented pattern, by 2100, the climate of the southern-eastern boarder of the Greater Lake Region, represented by Indiana, and Ohio may have shifted to that of Louisiana, or Massachusetts today.

Changes as the increase of temperature, precipitation pattern, and the decrease in soil moisture will have effects on the environment. The impacts on plants and animals are discussed in Chapters 3 and 4; the impact on human health is discussed in Chapter 5.

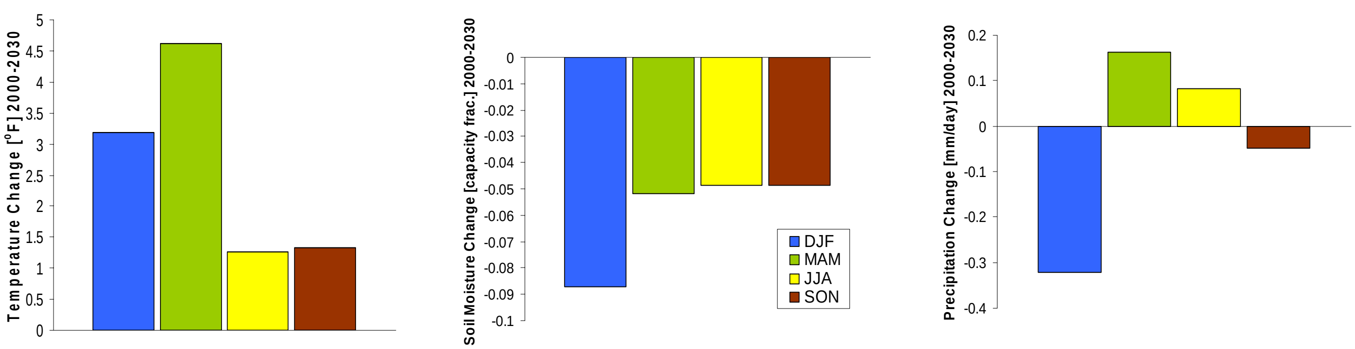

Figure 2.5. *Climate change 2000-2030 for grid representing area around Cincinnati. Average of three runs CGCM2 GHG+A IS92a scenario, December – February (DJF), March – May (MAM), June - August (JJA), and September – October (SON). Soil moisture was predicted as capacity fraction, precipitation was predicted as mm/day, and the temperature as screen temperature (2m) in ºC, which was converted to F.*

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Environment Canada: http://www.ec.gc.ca

Hadley Center: http://www.metoffice.gov.uk/research/hadleycentre/

The Union of Concerned Scientists: http://www.ucsusa.org/greatlakes

Goddard Institute for Space Studies: http://www.giss.nasa.gov

US National Center for Atmospheric Research: http://www.ncar.ucar.edu/

Chapter 3

Daniel Barket

PLANT LIFE IN CINCINNATI AND SOUTHWEST OHIO

In the media, we often hear about the effects of climate change on animal life, but rarely do we hear about their effects on plants. Plants are so abundant in our world it is often easy to overlook the fact that plant life is just as sensitive to climate change as animal life, if not more so. Plants have defined growing seasons, need CO_2 to make sugars through photosynthesis, grow at certain light intensities, require varying amounts of water, and have optimal temperatures for growth. In some ways, plants are more in danger than animals by global climate change because they cannot move as fast to a more favorable environment.

Most global circulation models, assuming a doubling of atmospheric CO_2, predict average increases in Earth's surface temperature of anywhere between 1.0 to 4.5ºC. Plants are bound to be effected by such changes. It is important to keep in mind also that climate change means more than just an average increase in the surface temperature of plant Earth, as Chapter 1 described. It means higher CO_2 concentrations. It can mean changes in the amount of precipitation certain areas receive. Even the seasons can change in length. Climate change has the potential to significantly alter many conditions and change the dynamics of the plant world everywhere.

We hear a lot about worldwide positive and negative effects from climate change, but rarely do we hear in the media specifically about how climate change affects the region we live in; Cincinnati, located in Southwestern Ohio. This chapter looks at the observed and the possible repercussions of global climate change on agricultural and wild plant life in greater Cincinnati, Hamilton County, as well as all of the surrounding area in southwest Ohio. The Canadian Climate Center predicts an average temperature increase of about 2.0º C for nearly all of Ohio in the next 100 years. Although it seems like a small change, this increase in temperature can have major effects on our crops and agriculture. The big questions that need to be addressed are the following. Have we seen any changes in our local plant life as a result of global climate change? If not, when will we? What are the implications for local agriculture? And what is happening now and what will happen in the future to plant populations in local wilderness?

Agriculture

First, I'll examine the present and future state of our agriculture. One program that has looked extensively into the crop situation and the state of America's natural forests is the U.S. Global Change Research Program (USGCRP), a body set up by the authority of President George H.W. Bush in 1989. There is much evidence to indicate that the unnatural changes like more CO_2 and higher temperatures that humans have helped to create in our environment by excessive consumption of fossil fuels may actually have some positive effects on the plant world. USGCRP reports state that a substantial temperature increase in this region will likely take place over the next 100 years. In their 2000 report, the USGCRP claimed that in the Midwest (which includes the entire state of Ohio), the temperature could increase by anywhere from 5 to 10º F (or 3 to 6º C) in the next hundred years; even in the Ohio River Valley. They claim that by the end of the 21st century, the likelihood in Cincinnati that half or more of the days in July will have temperatures in excess of 90ºF would rise. Recently, in the 20th century, the probability was about 1 in 20. Two climate model scenarios, called the Canadian scenario and the Hadley scenario, predicted that the probability could increase to 1 in 2 and 1 in 10, respectively, and that precipitation would increase by about 20 to 40%. However, it seems that the predicted temperature increase has yet to really begin to manifest itself in Cincinnati. In the Ohio River valley, the temperature has actually decreased by about 1º F (or 0.6º C) in the last 100 years. However, the reason for this decrease may have something to do with severe weather and drought events that occurred in the 1930s throwing off the prediction.

The USGCRP states that Midwestern agriculture will not only generally be able to adapt to the climate changes, but will actually likely be able to increase crop yields. The yields for crops grown in southwestern Ohio, like corn, wheat, and soybeans, have all been on the rise for the last ten years or so, and they are expected to continue rising. First of all, because increasing temperatures usually mean longer growing seasons as well as expanding the areas in which certain crops could be planted. Also, the increased CO_2 concentrations should provide more raw material for the formation of sugar via plant photosynthesis, and they claim that warmer temperatures would increase transpiration from large bodies of water such as the great lakes, resulting is more rain events.

Sources indicate that although soil quality is somewhat poorer in the more northerly parts than around the Ohio River, the warmer temperatures and increased CO_2 levels would almost certainly compensate for such soils. This would allow farmers to plant crops like corn or soybean even further north than usual. With the help of biotechnology and adequate storm drainage systems, however, this should not be a serious issue concerning crop yields. According to researchers at The Ohio State University, growing seasons are starting earlier and ending later. Since 1955, spring in Cincinnati has arrived an average of 1.2 days earlier per decade. This increased length of the growing season, combined with other factors, has led some farmers in Ohio to begin to double crop two very important crops in this area; soybean and wheat. Double cropping is the practice of planting and harvesting two crops in a single growing season. In this case, the wheat crop is planted, and thanks to a longer growing season a soybean crop can be planted immediately after the wheat crop is harvested. Under proper conditions, it is quite possible for farmers to do this easily. With better growing conditions and techniques like double cropping, crop yields are expected to continue to increase. Soybean yields, which in recent years in Ohio have averaged around 45 bushels per acre, and wheat yields, which average around 65 bushels per acre, will continue to increase.

Obviously, climate change can have many positive effects on agriculture in this region, but there are possible negatives as well. However, the consensus among the scientific community seems to be that any potential agricultural obstacles caused by global climate change are not insurmountable with the help of genetic engineering techniques, irrigation, and keeping a close eye on crop yield data and acting accordingly. Some potential pitfalls, however, that we would be harder pressed to control would include C4 grasses (which include crops such as wheat) beginning to overtake C3 grasses (including crops like corn) in some areas due to the increasing temperatures. Just like with crops, wild C3 plants will begin to be overtaken more by C4 plants. Almost all plants follow either the C3 or the C4 pathway when making organic compounds such as sugars from CO_2. C3 plants have a carbon fixation pathway that is better suited to cooler, more moderate temperatures and less intense light. The concern is that C4 plants, which have a carbon fixation method that allows them to thrive at higher temperatures than C3 plants, will gradually overtake C3 plants as temperatures increase. So, for example, a C3 crop such as wheat that is being grown here in Cincinnati could theoretically gradually begin to get overrun by a weed that follows the C4 pathway as temperatures increase. Something would need to be done to keep these weeds at bay. Since many crops like soybeans, which are grown in Cincinnati, have already been genetically modified to be “Roundup ready”, unharmed by certain herbicides, farmers will use more and more chemicals to get rid of these unwanted plants. This could result in larger amounts of toxic organic compounds seeping into our soil and water.

Natural Vegetation

Now, what does the future of our natural forests look like? What are the trends? The natural forests in southwestern Ohio are temperate deciduous forests. Much research has been done concerning herbaceous plant and tree populations in the area. The earlier arrival of spring I have mentioned before is illustrated by the documentation that some local flowers are blooming earlier. Many flowering plants, although many are not considered "forest plants", such Lilacs, forsythia, and rose of Sharon are blooming sooner in recent decades here in Cincinnati.

However, as enticing as it may be to attribute earlier blooming of many plant populations to global warming, officials with the city of Cincinnati as well as Hamilton County are reluctant to do so until more adequate studies have been carried out. I spoke to Mr. Matt Dickman, an ecologist with the Cincinnati Urban Forestry Department. According to Mr. Dickman, no recent changes have been observed regarding dates of blooming and growing seasons of flowering plants and trees in Cincinnati that can be attributed with certainty to global warming. However, there are trends. He spoke of seeing plant pests, such as the Eastern Tent Caterpillar, appearing earlier and earlier in the growing season as years have gone by. Typically the appearance of plant pests occurs along with the blooming of the plant. This statement corresponds with research I came across done by Dan Helms of the Ohio State University. Helms monitors plant pests, and came to the conclusion that the trend of earlier insect plant pest emergence in Ohio indicates that the growing season is getting longer, and the winters are getting warmer due to global warming. Mr. Dickman, however, would not go as far as to say that these changes can be traced to global climate change. It seems that there is not real consensus among the Ohio scientific community that there is enough evidence to point the finger at human-induced climate changes.

In our interview, Mr. Dickman spoke a lot about "growing degree days" when talking about trends in growing seasons, crops, and flowering plants. A "growing degree day" is not a unit that actually measures days or a growing season. Rather, a "growing degree day" is a unit that corresponds to the number of days in which the mean daily temperature is one degree above the growth optimum for a particular plant. It is a very valuable tool, for ecologists and farmers alike, to determine when plants or a crop are maturing, how long their growing seasons will last, and when insects and plant pests will emerge. A larger average "growing degree day" value for a given year or season indicates that the conditions are optimal for most plants longer, meaning a more favorable and longer growing season. The actual derivation of "growing degree day" values are quite complex.

Knowing that spring is beginning earlier every year and plants are blooming earlier than ever, I expected to see a clear increase in the "growing degree day" value over the last 20 years. However, upon examining growing degree day data for Ohio obtained from the Ohio Agricultural Research and Development Center website, it appears as though there is not much of a correlation between the total yearly average growing degree day values of plants in Ohio and increased growing seasons. There is no trend in the growing degree day data from 1985 to 2006, when one would expect to see a steady upward increase that corresponds with the emergence of global climate change at that time period. This illustrates that an increase in temperature isn't necessarily the only cause for earlier blooming amongst plants. Research still needs to be done concerning how other factors brought about by global climate change could cause this possible discrepancy.

Moving on to the future, research by the USGCRP points to a likely expansion of trees in Cincinnati's deciduous forests, which are rich in such trees as oak and maple. They are likely to expand, mostly in a northerly direction, creeping into more northern forests richer in coniferous trees. But this expansion would likely be more limited than most models claim, both by the fact that most of our forests are heavily managed by human beings. So when the trees ranges expand, the migrations will vary spatially and temporally because of channelizations of the trees habitat. According to four species of trees whose northern distribution limits are found in the southern third of Ohio will migrate northward. These trees are the American Persimmon (*Diospyros virginiana*), the Sourwood (*Oxydendron arboretum*), the Virginia Pine (*Pinus virginiana*), and the Southern Red Oak (*Quercus falcate*). It is estimated that these populations could migrate as far as about 10 km north. Work done by other researchers indicates that there are as many as 36 other tree species east of the 100th meridian (a line of longitude that cuts through North and South Dakota, Nebraska, Kansas, and other states) that have the potential to migrate 100 km north or further from their current habitats. A few species may migrate as far as 250 km north. Table 1 gives a short summary of trees species in the area, and whether the area they cover in the Midwestern and Eastern United States is expected to increase or decrease based on several climate models. The area covered by the forest type that covers much of Ohio, the Maple/Beech/Birch, is expected to decrease. Ohio's forests will likely look quite different.

However, it is important to keep in mind that it will be difficult to observe these shifts clearly. Human caused fragmentation of habitats as well as by the way humans tend to control biodiversity in forests. The Hamilton County Park system, for example, goes to great lengths to manage their forests. They regularly interrupt the natural succession of plants in the forests in order to maintain a wider variety of plants for visitors to see. In other words, the landscape and forest composition are different from what they would be naturally as a result of human management, so it is very difficult to predict the composition of trees in the next hundred years. For example, the Hamilton County Park Officials may decide that there are too many oak trees in our forests, and could simply thin the population accordingly.

In addition to that, fragmentation of forests will almost certainly slow the migration of tree species towards the north. When ecologists compose these plant models, it is quite difficult to take into account the effects of past and future human activity in the forest. Therefore, models do not usually take into account this forest fragmentation.

It is predicted that a substantial number of trees in our forest will increase their ranges northward. The density of plant populations in our forest will also change. DISTRIB, a tree regression analysis model, has been used to make such predictions. It predicts that some specific plant's populations could decrease by as much as ten percent after equilibration with the new environmental conditions. Richness of maple, beech, and birch populations over a large area that includes southwest Ohio, are again predicted to decrease in at least five different climate scenarios. Oak trees, hickory trees, and pine trees, on the other hand, are expected to increase, some species by as much as 290%.

Table 3.1. *General projected changes in the amount of land covered in the Mid and Eastern United States by various forest types, according to GISS tree model. Ohio's forests will likely have fewer trees of the Maple/Beech/Birch forest type.*

Major Forest Type	Projected Change in Amount of Land Covered
White/Red Pine	Remain about the same.
Spruce/Fir	Decrease by about 50,000km2
Oak/Pine	Increase by as much as 1,000,000 km^2
Oak/Hickory	Increase by as much as 700,000 km^2
Maple/Beech/Birch[a]	Large Decrease, between 480,000 to 600,000 km^2
Aspen/Birch	Decrease by about 100,000 km^2

[a]Ohio's main forest type

All of this being said, with climate change can come the possibility of extreme or destructive weather events. For example, the same increase in temperature that could result in increased transpiration from the Great Lakes and therefore more rain could also cause faster transpiration of water from the soil. So droughts could be more frequent or more severe, resulting in dryer forest floors and then forest fires (For more information, see Chapter 2). These types of events could become more common than they have been in recent years. On the other hand, more frequent, heavier rains that result from this increased transpiration of water from the great lakes could lead to more floods also. Environmental stresses like drought or flooding weaken plants or even completely destroy them, making them more susceptible to disease or insect defoliation. This could spell trouble for farmers all across Ohio; the trend in their crop yields could become one of extremes. Yields could alternate between excellent and terrible. Also, different environmental conditions, even slight ones, can also bring with them the possibility of new invasive species of plant or insect parasites. However, the IPCC, or Intergovernmental Panel on Climate Change, believes that such extreme weather events will be more prevalent in the more southeast portions of the United States (www.ipcc.ch). They will likely not be as severe here in the Midwest where Cincinnati is located, although this is very difficult to predict.

To conclude, scientific research suggests the climate here in Cincinnati will change in the next 100 years. The makeup of our forests and the way local farmers do their jobs are very likely to change as well. Our forests are expected to expand in to the north and our favorite flowering plants will likely continue to bloom earlier and earlier. This climate change could benefit agriculture; Farmers may be able to "double crop" and obtain higher crop yields. However, we must keep in mind that many of these predictions of the future of our plant life is based on climate modeling, and modern climate modeling is far from a perfect science. Although some of these changes are beneficial for us, we must continue to search for alternative fuels, conserve energy, and initiate new policies that are more environmentally friendly. What we can do personally to combat climate change is discussed in Chapter 9, and governmental policy is discussed in Chapter 11.

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Chapter 4

Warren Leas

POSSIBLE EFFECTS OF CLIMATE CHANGE ON SOME OF OHIO'S ENDANGERED ANIMALS

In recent years climate change, and more specifically, global warming, has received greater and greater coverage in the media. Coverage always seems to center on the effects global warming will have on the human population. There has been any number of stories predicting droughts or talking about rising sea levels or the predicted increase in the number and strength of hurricanes, typhoons, and cyclones. All this coverage of global warming's effects on the human population with little mention of other animal species in the popular media might lead people to assume that animal species take these changes in stride or that they can adapt more readily and successfully to changes in the natural environment. However, this is not the case. Climate change can have drastic effects on animal populations.

There are a myriad of environmental factors that influence animal populations. A change to just a few or even one of these can have far reaching consequences. Mammalian herbivores depend on a variety of species of food plants; changes of the ability of these plants to survive or of their growth period due to climate change will impact these species. Changes in growth period may result in the eventual change in the breeding times of some species to compensate. If less food plants are available population size my decrease. If the area in which food plants can survive shrinks or shifts the entire range of dependent species may change to compensate. If the growing period or range of food plants increases, this may lead to an increase in the range and population size of the species that eat them. This in turn will likely eventually lead to more encounters with humans and, in the case of larger species; more clashes for space of populations grow and expand. Carnivores are dependent upon their prey species, and carnivore populations will change in much the same way as their prey populations. However, a decrease in population size for carnivores is often of greater consequence than a decrease in the population size of herbivores because there are usually fewer individuals in carnivore populations than in those of their prey.

Reptiles face all the same pressures as mammals as well as the added pressure of being exothermic; they rely mainly on the conditions of their environment to regulate their body temperatures. Many reptiles in temperate regions that have extended cold periods often hibernate for much of these times. It is difficult to predict the changes that would be seen in such populations if global warming increases temperatures. Though it seems that for many a radical change in their behavior might occur.

Climate changes will not only affect terrestrial temperatures, but will increase the average temperature of bodies of water as well. This can have far reaching effects on the aquatic environment; such as the level of oxygen present or the abundance of plant and algal life, which intern effect available nutrients and light levels. All of these things affect fish and other aquatic animals.

Climate changes might not only effect the growing seasons of plants birds, or insects birds feed upon, depend on as food, it might also effect the growth of species that are the preferred roosts of some birds. Also for many species of migratory birds climate changes might alter their migration times or make breeding grounds no longer hospitable. Loss of roosts and breeding grounds in particular could potentially wipe out entire species.

In addition to all this, global warming could also allow new invasive species to move into areas they might not have previously have been able to inhabit. These new species may only increase pressure on native species that are already strained to climate change. Global warming may also allow pathogenic diseases, fungi and parasites to move into areas where they were not originally found. Any one such pathogenic organism might not only have to the potential to devastate a species but could wreak havoc on an entire ecosystem.

In the following we'll examine some local species from around the Cincinnati along with the rest of Ohio and what effects global warming may have had on these species up to this point as well as what the effects in the future might be if climate change continues unchecked.

The Eastern Hellbender

The Eastern hellbender *Cryptobranchus alleganiensis alleganiensis* is the largest salamander in North America, reaching lengths ranging from 11.5 to 20 inches, and individuals as large as 27 inches in length have been reported (Ohio DNR Division of Wildlife). Aside from being the largest North American salamander species the hellbender is also one of the longest lived. The average lifespan in nature is thought to be around twenty years. However, extrapolations on growth rate data suggest that some large individuals may live for thirty years or more (Taber et al., 1975; Peterson et al., 1983; Petranka, 1998). Hellbenders live in clear somewhat swift moving rivers and streams. They require large flat rocks or submerged logs for shelter and nest building and appear to actively avoid areas were the water temperature is above 20C. In Ohio hellbenders were originally found throughout most of the unglaciated southern and eastern regions of Ohio. However many of the waterways where hellbenders were once found now appears to be devoid of them. Hellbenders are officially listed as threatened by the IUCN and are listed as endangered in the state of Ohio (IUCN Red List; Ohio DNR Division of Wildlife). Despite the fact that hellbenders do have functioning lungs they are almost entirely aquatic. In the water the hellbender obtains approximately 90% of its required oxygen from the water through its skin. This means that without cool well oxygenated flowing water the hellbender cannot survive (Gulmond 1970). Because cool water is capable of holding more oxygen than warm water any increase in the water temperature in the rivers and streams in which they live can have a disastrous effect on hellbender populations. Thermal pollution was in fact cited as one of the causes responsible for the expatriation of the hellbender from the Ohio River drainage (Dundee 1971). It has also been observed that in summer hellbenders may move to deeper holes in the stream bed, which contain cooler waters, to avoid desiccation. This is yet another reason why hellbenders are dependent on cool water temperatures.

As early as 1916 hellbenders were reported in the Ohio River near Marietta, Ohio (Krecker, 1916), and in 1934 hellbenders were reported to be common throughout the Ohio (Green 1934). However, by 1999 no hellbender sighting in the Ohio had been recorded in a very long time. In addition to raising the water temperature of the hellbenders home streams, global warming may cause the loss of some of the animals' habitat altogether. Warmer summer temperatures could potentially cause greater evaporation which could lead to smaller streams drying up for at least part of the year further restricting the hellbenders range. Global warming may also cause an increase in precipitation which could lead to increased nutrient runoff into waterways. Increased nutrients in the water coupled with warmer water temperatures can lead to algae blooms which greatly decrease the amount of the hellbenders' much needed oxygen in the water (US Global Climate Change Research Program).

It is true that amphibian populations can be greatly effected by a number of various factors. It is also true that climate change alone is not likely to be solely responsible for the temperature increases in the rivers and streams the hellbenders call home. However, it is certain that if global warming continues unchecked it will have some effect on the temperatures of the hellbenders' habitat this combined with loss of some streams due to summer evaporation and the depletion of oxygen in others due to algae growth will put even more pressure on a species that, especially in Ohio, has greatly diminished from the range where it was once found.

Wetland-dependent Birds

Global warming has the potential to have a huge impact on populations of waterfowl and wetland dependent bird species all over the planet. What these effect may be are not easy predictable, and even changes that allow some species to expand their ranges may not have positive long term consequences.

Severe drought brought on by climate change could cause some wetland areas to dry up. Also if either drought or more severe precipitation changes stream flow or the timing or occurrence of floods major changes could occur to areas used by these birds as winter habitats or stopping points along their migration routes. Temperature increases could lead to changes in temperature sensitive behavior such as migration or egg laying. Warmer winter temperatures may make food sources more plentiful than they previously were, or if bodies of water no longer freeze over the birds might have access to habitat and food year round that they pervious did not have. This could possibly stop some populations from migrating at all. While this might be beneficial for the waterfowl, it introduces an element of competition that other resident species previously did not have to deal with (Glick 2005).

In Ohio, any of these could have far reaching consequences for three wetland dependent species endangered in the state: *Botaurus lentiginosus*, the American bittern; *Grus canadensis*, the sandhill crane; and *Cygnus buccinators*, the trumpeter swan (Ohio DNR Division of Wildlife).

The American bittern is a medium sized heron with short legs and a stout body. The bittern's entire life cycle appears to be dependent on wetlands (Tiner 1984). It is endangered in Ohio due to loss of its wetland habitats. The American bitterns in Ohio are breeding residents who migrate south once temperature begins to drop below freezing. However American bitterns that live in areas with milder climates appear not to migrate (Harris 1999). It is possible then, that if winter temperatures increase the bittern may reside in Ohio longer or even become a permanent resident. The wetlands vital to the bittern are vulnerable to eutrophication caused by nutrient runoff from lawns and agriculture. The predicted increase in precipitation brought on by global warming could increase such runoff and destroy even more wetlands. If bitterns did mange to persist in such nutrient enriched areas their numbers could still potentially be devastated by *Eustrongilides* a nematode parasite that is contracted from small fish and thrives in waters polluted with nutrients and silt. If an increase in overall precipitation also caused an increase in acid precipitation this could have a detrimental effect on wetland ecosystems sensitive to pH. Also increased chemical runoff combined with warmer water temperatures and lower oxygen content can greatly increase the uptake of contaminants by fish and amphibians (Glick 2005), which along with insects make up the American bittern's primary diet. Despite the fact that the direct effects of global warming, an increase in winter temperatures, might allow the American bittern to stay in Ohio longer; the indirect effects might just as easily drive it to extinction within the state.

Sandhill cranes are one of the oldest living bird species with origins dating back 2.5 million years. The majority of sandhills are migratory and can be seen flying in huge flocks sometimes numbering a thousand individuals or more. Sandhills were originally a native species in Ohio with a small breeding area in the northwestern corner of the state. However, by 1880 the species was likely completely expatriated. A pair of sandhills was observed in Ohio in 1985 for the first time in almost sixty years. The pair began breeding in the region two years later. The cranes can now be found in wildlife areas in Wayne and Ashland counties (Ohio DNR Division of Wildlife). The birds are still very rare in the state, and any disturbance to their small breeding areas could drive the Ohio populations to extinction. Sandhill cranes could be affected by many of the same indirect global warming effects as the American bittern, such as habitat loss due to eutrophication caused by nutrient runoff, increased acid rain or contamination of their food supply. Sandhill cranes require large tracts of wetlands for breeding. Even if wetlands are only shrunk by climate change instead of disappearing completely this could potentially limit the number of cranes able to breed in an area enough to devastate the population. Also if climate changes produce droughts these could dry up the areas of shallow standing water in which the cranes roost driving them from the area. Even though changes brought about by global warming could potentially affect sandhill cranes in the same way as the American bittern, the smaller population size of cranes in the state means that it is even more likely such changes could drive the state population to extinction.

Archaeological evidence suggests that trumpeter swans once lived in many parts of Ohio, and since 1996 Ohio has been part of reintroduction efforts to restore trumpeters to the Midwest. Despite these efforts the trumpeter swan is still listed as an endangered species in Ohio. Trumpeter swans are both the largest swan species and the largest waterfowl species native to North America. They are dependent on large high quality wetlands as well as open ponds and lakes. Although some trumpeter swans are non-migratory most form pairs in their southern wintering grounds then migrate north to breed, building nests in April or early May (Ohio DNR Division of Wildlife).

Due to the fact that trumpeter swans are migratory not only can they potentially be affected by the effect climate change has on wetlands, but also the effects it might have on their migration routes and start times. Trumpeter swans usually arrive at their breeding grounds as soon as frozen over lakes and ponds begin to melt. If increased temperatures cause lakes to thaw sooner it is possible the timing of the swans' migration might move up as well. In the same way, if increased winter temperatures cause lakes and ponds not to freeze swan populations that were previously migratory might become year round residents of an area. The consequences of such a major change in an areas seasonal ecological community are hard to predict.

Temperature not only affects the seasonal behavior of trumpeter swans but has also been shown to have an effect on the daily behavior patterns of the animals as well (LaMontagne et al., 2001).. Their team observed that on warmer days the percentage of time spent foraging increased. Foraging at these stopover sites is what provides the swans with the energy to migrate. Temperature increases might allow the swans to forage more per stopover site thus decreasing the number of stops. LaMontagne et al. also observed that when temperatures are below freezing, sleeping replaces foraging as the dominant activity. If climate changes raise winter temperatures so that there is more time in the winter that is above the freezing point trumpeter swans might forage more in the winter and have greater energy reserves at the start of their migration.

Beyond affecting wetland dependent bird species the effects of global warming on wetlands may also affect two raptor species endangered in Ohio, the bald eagle and the osprey. As mentioned before increased chemical runoff combined with warmer water temperatures and lower oxygen levels, all of which could be caused by global warming, can increase contamination uptake by small fish, aquatic invertebrates, and amphibians (Glick 2005), this contamination is further concentrated in larger fish and waterfowl that feed on these animals. Fish and waterfowl are prey for both the osprey and the bald eagle.

The Brook Trout

Like all trout species, *Salvelinus fontinalis*, the brook trout has very specific habitat requirements. They require clear fast flowing well oxygenated streams with temperatures that remain below 20C. Brook trout do not thrive in bodies of water where the temperature stays above 20C for extended periods. Brook trout in streams require resting pools, riffles near feeding sites, and escape cover under trees rocks or under undercut banks (U of Michigan Animal Diversity Web). Despite having been stocked beyond its historic range throughout the state. NatureServe (2006) listed the brook trout as critically imperiled in Ohio. Since they inhabit very similar waterways many of the threats to the eastern hellbender also apply to the brook trout. Warmer ambient temperatures will cause decreases oxygen in the water as well as depriving the trout of their refuges from summer heat. Increased aquatic plant life caused by nutrient runoff would not only decrease oxygen levels, but could also choke out the trout's needed resting pools, riffles, and paths of escape. Brook trout populations could also be affected by the potential increase in acid precipitation because there spawning is both temperature and somewhat pH dependent (NatureServe 2006). Brook trout populations are also susceptible to toxic build up in their bodies if the invertebrates and small fish they feed on have been contaminated. As mentioned before the occurrence of this too could be increased by global warming. However the must dire threat likely faced by brook trout not only in Ohio, but in all of their native habitats, is the invasion of warm water species such as bass and walleye as water conditions change. The trout which are already struggling with the changing conditions simply cannot handle the competition with the invaders and are forced out. One study in Canada, where the brook trout is common, used climate models combined with recently observed range movements to predict future distributions of freshwater fish species. The study predicted that by 2050 the brook trout will have suffered a 49% reduction in range. In every area where brook trout density went from high to low, smallmouth bass and walleye occurrence did the exact opposite (Chu et al., 2005).

Although all of these species are endangered in Ohio they all have stronger more stable populations somewhere else that may be better able to survive climatic changes. In other areas of the world more isolated species or those native to very unique and isolated environments are not so fortunate and may indeed face global extinction if climate changes continue unchecked. For the first time ever there are recorded instances of polar bears drowning in the open ocean because they can no longer swim the distance between arctic ice. Distributions of many montane rainforest birds in Australia that are found nowhere are expected to move upwards in response to temperature increases with multiple extinctions predicted to occur as a result (Shoo et al., 2005). In the New World tropics harlequin frogs are now presumed extinct in many areas; the cause behind this is thought to be a fungal infection which was able to spread to new areas after seasonal temperature changes (Thomas et al., 2006). Even some of the largest animals in the world, the whales, face extinction as some cold water species are pushed farther and farther north in shrinking areas around the poles as ocean temperatures rise (MacLeod et al., 2004). The world is a delicate place and all the species in it are interconnected. With so many factors affecting every animal species it is nearly impossible to accurately predict the effects of such drastic changes to the natural world as global warming is capable of producing. Unless steps are taken to stem the tide of climate change, the consequences of these changes may not become fully clear until it is too late.

Chapter 5

Abigail Larkin

HEALTH IMPACTS OF CLIMATE CHANGE

Climate changes can have multifaceted effects on both our planet and our lives. Future climate changes may alter the habitats of various forms of flora and fauna and also the habits of the human population. Both directly and indirectly, climate changes have an effect on the health of the human race. Most research identifies five health consequences and their corresponding climate change effects. This chapter will focus on these areas of potential health effects due to (1) temperature, (2) extreme weather events, (3) pollution of the air, (4) diseases from unsanitary water or food supplies, and (5) vector-borne disease. The relationships between changes in climate and changes in human health are demonstrated in Figure 5.1. Climate changes are occurring faster than the human race can keep up and this inability to manage is creating a conflict with our environment. To address this issue a great deal of resources and research must be committed to the study of climate changes and their effect on the health of the people of the planet.

Temperature

The globe in general, and the climate in Cincinnati is warming (see Chapter 1). It is projected that Ohio temperatures will increase by 3-4 degrees, causing Cleveland to adopt the weather patterns of Cincinnati which will more resemble the summer temperatures of Atlanta, Georgia (see Chapter 2). Increasing temperatures, which put an individual outside of their comfortable limits, place a thermal stress on the body and increase the risk to cardiopulmonary complications. Higher temperatures would particularly affect the elderly or otherwise debilitated. Evidence also suggests that people living in urban settings in developing countries are at a higher risk since they are less likely to have access to alleviating methods such as an air conditioning unit. Simply because of their urban environment, the area is more likely to retain heat at night instead of experience the relief that darkness brings.

Heat waves are often omitted as sources of fatalities, but “in the past three decades, New York City (1972, 1984), St. Louis (1980), Philadelphia (1993), Dallas (1998), and Milwaukee (1995) have experienced massive and deadly heat waves. It should be noted that these five major cities are distributed across the country. But in recent years, Chicago has become the national epicenter of heat mortality. Heat mortalities occur when temperatures are above what the population is accustomed to. According to prediction models U.S. cities in the northeastern and Midwestern state, including Cincinnati, where temperature spikes are irregular or infrequent, are the most susceptible to heat-related mortalities. Because these heat waves are inconsistent it is unlikely that the population will develop physiological adaptations to cope with the heat. Although an increase in global temperature should decrease deaths due to cold weather, it is still unlikely that a decrease in winter mortalities will equilibrate deaths due to heat.

Extreme Weather Events

Higher temperatures bring more extreme weather events. Droughts, floods, and storms may increase death and injury rates, as well as the prevalence of psychological disorders and infectious diseases. Climate changes could increase the frequencies, intensities, and durations

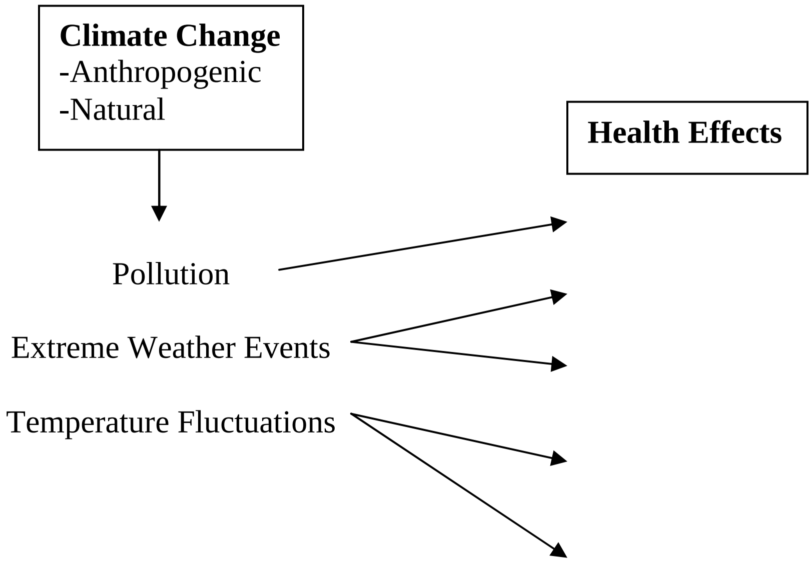

Figure 5.1 *Potential relationships between certain naturally induced and anthropogenic climate changes and the health effects they generate.*

of weather events that significantly impact the communities they affect. A total of 14,536 deaths in the United States were caused by natural disasters between 1945 and 1989, averaging 323 deaths per year. Obviously the occurrence of storms increases the likelihood of death, injury, and other destructions due to the power of Mother Nature. But extreme weather events can have an indirect effect on human health as well. According to an interview with Michael A. McGeehin, director of the U.S. Centers for Disease Control and Prevention's Division of Environmental Hazards and Health Effects, conducted by Fox 19 HealthDay Reporter Steven Reinberg, flooding can lead to the contamination of water supplies that must remain sanitary to preserve standards of hygiene while droughts deprive farmlands of the water necessary to provide communities with the foods they depend on. Such is the dichotomy of climate change.

Even those who physically survive extreme weather events may still suffer mentally. More health risks associated with natural disasters are disabling fear or aversion and posttraumatic stress disorder. Both Hurricane Agnes and Hurricane Andrew can be blamed for psychological problems in the adult population years after the events occurred.

Pollution in the Air

Another health concern that can be attributed to climate changes is the level of pollution in the air. In his interview with Reinberg, McGeehin indicated that an increase in air pollution due to the burning of fossil fuels will cause greater rates of cardiovascular and respiratory diseases. If our dependence on fossil fuels continues in the future, it will lead to an increase in emissions of pollutants and will lower our quality of air. Air pollution can negatively affect pulmonary tissues, limit optical abilities, work capacity, respiration, as well as exacerbating current respiratory and cardiovascular diseases. All of these health complications could possibly contribute to premature death and are of great concern if fossil fuel usage and emissions are not regulated in the future.

An increase in the levels and types of pollen present in the air might also be a product of climate change. Warmer weather might alter the distribution of pollen plant species; pollen production might increase or the location of the plants might change. This in turn might expose people to new allergens or to a greater level of allergens. As a result the prevalence of asthma and seasonal allergies might increase, greatly affecting public health and the daily habits of people.

Contamination of Water and Food

In addition to air, the next two necessary resources for life are also under threat. Climate changes might contaminate water and food reserves. It is estimated that 9 million cases of waterborne diseases and 76 million cases of foodborne disease occur in the United States annually, with an estimated 5,000 deaths per year due to foodborne diseases. In 1993 a *Cryptosporidium* outbreak occurred in Milwaukee, Wisconsin via a contaminated water supply. With 400,000 cases, including 54 deaths, it was the largest waterborne disease outbreak in recorded U.S. history. The contamination resulted from heavy rainfall and runoff that caused sewage to pass through the filtration system. As temperatures and weather patterns increase in intensity, flooding is more likely to lead to events like the contaminated water incident in Milwaukee. In addition, the legacy of combined storm and sewer water like that in Cincinnati may pose a greater threat to public health if storm intensities or frequencies increase and sewer water is discharged and allowed to mix into surface waters. Contaminated water and food sources can directly affect public health, but also indirectly, by providing breeding grounds for rodents and other species that act as vectors for disease.

Disease Vectors

Changes in climate would alter the distribution of vectors, bringing them into contact with novel human populations. Global warming would likely affect the vector's reproduction, maturation, and endurance, stretching the limits of the organism in a direction that is destructive to human life. With the use of models, Martens predicts an increase of risk for new human populations exposed to malaria, dengue, and schistosomiasis, the three most common vector-born diseases of the world. Excessive rainfall multiplies the amount of breeding grounds for some mosquitoes, while dry conditions are preferred for the development of mosquito larvae. Either weather extreme could increase certain populations of mosquitoes. Climate changes cause mosquitoes to migrate with the temperatures; it is likely the Atlanta heat that is predicted for the future of Cincinnati will bring with it vectors, such as mosquitoes, and their diseases.

Although diseases like malaria are less prevalent in the United States, America has experienced its own outbreaks of vector-borne diseases. In May, 1993, rodents transmitted the Hantavirus, causing the Four Corners outbreak. The outbreak was accredited to a particularly long rainy season, which in turn created a surplus of food which greatly increased the mouse population. In 1999 an encephalitis outbreak hit New York City and claimed three lives. Encephalitis can be a complication of Lyme disease, transmitted by ticks, or it can be spread by mosquitoes. Furthermore, a recent study found a 60% increase in human plague cases in New Mexico after an unusually wet period. In addition to all of these diseases emerging in the United States another has swept the country and has been found in Hamilton County.

West Nile Virus is transmitted by mosquitoes that feed on infected birds. In the year 2003, the disease was detected in 79 out of Ohio's 88 counties, including Hamilton, with more than 100 human cases within the state. Warmer weather made the United States more susceptible to mosquitoes by allowing the virus to multiply in their hosts, which carried the disease across state borders and quickly transmitted it to the human population. West Nile first struck Ohio in 2002 with 441 cases and 31 reported deaths (Figure 5.2).

Potential New Threats

An intriguing theory involving viruses and bacterium preserved in glaciers is being pursued by Dr. Scott Rogers of Bowling Green University. Dr. Rogers theorizes that migratory birds have likely deposited viruses onto frozen icecaps. These viruses, protected in the droppings of the birds, remained trapped in the ice. However, global warming is melting those icecaps. It is possible that those same birds on their return migration might pick up viruses and redeposit them into populations that lack the proper immunities to combat them. A 32,000 year-old dormant bacterium has already been discovered in a frozen pond in Alaska, as well as a 250-million-year-old bacterium from salt. The question is whether these viruses are still "alive" or viable in their frozen states. Dr. Rogers believes that if the viruses were frozen correctly then they could very well be infective once thawed. Viruses frozen in water tend to be inactivated by the low pH of the water, but the viruses frozen in droppings instead might have been protected from the low pH. In addition, if a virus thaws and refreezes many times it is more likely to become degraded and ineffective, so the thaw of deeply frozen viruses is more likely to produce viable strains. One specific virus that Roger's is investigating is the flu.

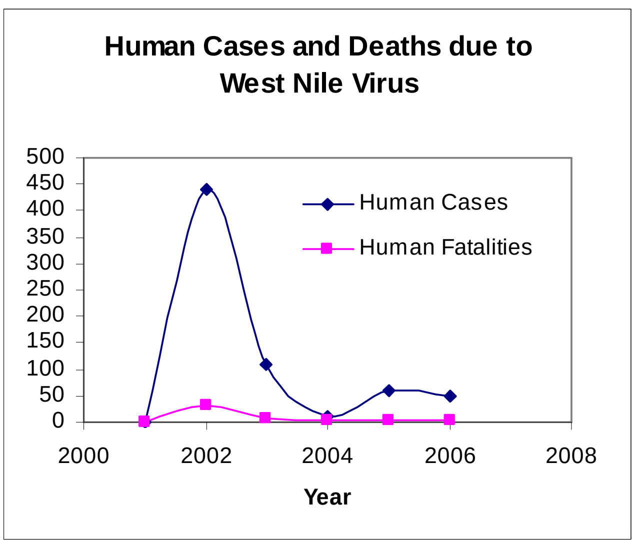

Figure 5.2 *West Nile virus in the State of Ohio. The disease was first reported in Ohio in 1999 and has been an unpredictable presence ever since.*

Flu viruses have been found in the ice of Siberian lakes. It is the natural pattern of flu strains to become dormant and then reemerge later on, preserved in the environment. Roger's points to the Spanish Flu pandemic of 1918 as an example of the devastation that flu strains can incur. As many as 20 million deaths were associated with the Spanish flu, specifically HINI, and these deaths were due specifically to influenza, not due to secondary infections. Roger's fear is that an obscure strain might reemerge, wreaking havoc on a no longer immune community. As global temperatures rise, so do the possibilities that melting glaciers will release these viruses into ill-prepared populations.

Conclusion

Another fear of melting glaciers is that they might provide a convenient mixing ground for diseases. Frozen lakes might serve the purpose of melting pots for flu viruses, allowing strains from different years to combine and create new strains that human populations have no defense against. So in addition to old strains reemerging, new strains are also evolving. Over the last few decades roughly 30 new diseases have emerged, and diseases thought to be under control have begun to surge. This is a major health concern as a response to climate changes.

Climate changes pose many possibilities for negative health consequences. A simple rise in temperature is known to increase the rate of heat-related mortalities. An increase in extreme weather events will likely cause greater fatalities and residual health problems mentally and physically. As the climate changes it redistributes pollen in the air, exacerbating our already poor air quality due to fossil fuel pollution. Flooding can mix water sources with sewage or other contaminants causing an increase in water and foodborne illnesses such as in Milwaukee in 1993. Changes in climate composition are expanding the ranges of vectors which then in turn spread diseases such as West Nile Virus across novel areas. It is even predicted that viruses once trapped in the glaciers might become reactivated as the icecaps melt, posing a great threat to the human population. Although some of these situations do not appear imminent for the time being, increasing changes in climate should be monitored for their potential to affect human health. Even though Dr. Roger's theories may seem unlikely, we cannot at this time predict for certain what our future holds or what the ramifications are for our current state of anthropogenic climate change.

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http://www.cdc.gov/ncidod/dvbid/westnile/Mapsactivity

Chapter 6

Geoffrey Putney

Cincinnati's Carbon Footprint

Global warming is a growing problem that the world has to face. Action is being taken, but everyone is asking if it is enough. Such organizations as the IPCC (the Intergovernmental Pane on Climate Change) and the GCOS (the Global Climate Observing System) meet to discern the current situation, as well as create guidelines for countries to follow to reduce their effect on the environment. Also, recently, the UN held a conference in Nairobi, Kenya called the United Nations Climate Change Conference, in conjunction with the Kyoto Protocol. This protocol set limits and regulations for countries as to how much emissions they could have as well as demands as to the reduction of these emissions. Being totally voluntary, though, created a loophole for countries not willing or ready to change their ways (e.g. the United States of America), allowing them to not sign the protocol, thus not binding them to any regulations.

Some places, though, are doing an outstanding job reducing their emissions and building up their alternative fuel supply and technology. Germany is a prime example of this. They agreed that by 2012 they would reduce their emissions by 21%. From 1990 to 2004, they had already seen a reduction of emissions summing to 17%. Compare that to the United States, who in the same time period rose 16%. As you can tell, the difference between the two is enormous, and seems to be growing.

Comparing two of the major cities in each country may give some insight as to the data that the Kyoto Protocol is seeing. Cincinnati, Ohio is the third largest city in Ohio and the 56th 2ithin the U.S., including over 330.000 people. There is also the Greater Cincinnati area, which encompasses Northern Kentucky and some of South Eastern Indiana as well as surrounding suburbs in Ohio. That population is over 2,000,000 people. On the other hand, the population of the Greater Munich Area of Bavaria is roughly 2,500,000, the capital of Bavaria and the third largest city in Germany.

With that in mind, it can be assumed that the two cities have fairly similar needs as well as mindsets, especially the local government when concerning the public. The two cities share a large amount of heritage actually. Immigrants fleeing Germany at the end of the 19th century found themselves on the shores of the United States, and then were forced to move inward on the continent due to overpopulation on the coast. Being unfamiliar with the area, the immigrants stuck together and decided to settle in the city of Cincinnati, next to the Ohio River. The two cities officially became sister cities in 1989, tightening their relationship. With that in mind, both cities are doing thing that will help them reduce their carbon footprint as well as help the environment. Duke Energy, formerly Cinergy, is also a major player in $C0_2$ emissions. With power plants spread out from Ohio to North Carolina, and the majority of the plants being coal-burning plants, there is a very large amount of carbon dioxide being put into the air. To put it into perspective, There are roughly 2.2million individuals in the Greater Cincinnati area, each emitting on average 19,000 kg of carbon per year. That is a total of $4.18x10^{10}$, or 41.8 trillion kg/yr. In 2005, the total amount of CO_2 emissions was 121,100,000 tons (Duke E). The numbers for the Greater Munich area are very similar, 2.5 million individuals, and roughly 17,000 kg/yr from each individual. That comes out to $4.25x10^{10}$, or 42.5 trillion kg/yr. If the population sizes were identical, clearly Munich residents would be emitting less CO_2 per year, and this is mainly a result of their infrastructure. Large SUVs and households of 3 or more cars are not very common. Everyone has an economy car, or simple carpools to work. Also, the public transportation system is considerably more advanced there than in Cincinnati. As a result, people take trains or buses everywhere, reducing their overall production of carbon.

E. ON Energie is the largest energy provider in Munich, as well as Western Germany. E. ON is known as being a very progressive corporation and has a list of changes that it has or will be instituting in the next decade to help control or reverse the affects of greenhouse gases. They make it a very important point to help the consumer understand that in the future, there will not be one dominant form of energy, but rather a cornucopia of sources to take advantage of, including the burning of coal. They plan on updating most, if not all of their hard coal burning plants by 2020. With this update will also bring about efficiency, as they already are getting twice as much power out of comparable amounts of coal as in the 1950s, and plan on developing technology to increase their yielded product from coal. This will directly conserve the existing resources, while reducing CO_2 emissions.

Another large scale change that they are imposing is the idea of a mass uptake and removal of CO_2 from the environment. They do make it very clear, though, that this process is still in its preliminary stages and is much too expensive and inefficient. They suggest that one possibly promising route of action is the 'post-combustion' method, which is basically the separation of the CO_2 out of the emissions which are the result of coal burning.

Another route, dealing exclusively with already emitted carbon dioxide, is to store it in deep layers of rock, similar to how carbon is stored in glaciers, but with out the potential for melting and release. They plan on implementing both of these options by no later than 2014.

E. ON has a couple of very interesting alternative fuel options that they are strongly investing in. Wind power is a fuel source that has been around for ages, on farms and in fields, and then more recently, on wind farms. Germany's limited coast line is already mostly used up at this point, as are other potential windy areas. This is where the new idea comes in. They plan on building wind farms which are out at sea. There is an almost endless supply of wind, as well as space out there, and they plan on investing in 500MW of offshore wind power by 2011. On top of that, they are planning on having wind power as the source of at least 10% of Germany's total power production.

The other fuel source, which is more popular at this moment, is biogas. Biogas is a fuel that is created by the decomposition of organic matter, including sewage and plant crops. The major short coming of biogas is that there are a significant number of *other* substances in it, not just the desired methane. E. ON is currently looking into ways of purifying the product so that it does not have any lasting negative affects on the engines it is burned in.

Obviously E. ON is working to better utilize its renewable energies. These include water, wind, sun, biomass, geothermal energy and heat pumps. Hydropower accounts for about 16% of the energy source at this time. They expect that number to remain the same, or rise slightly in the future. Wind farms are evidently being pursued as a primary source for the future. The energy from the sun, though in inconceivable quantities, is mostly useless because it can not be converted to any useful form.

The burning of biomass is definitely an option they are looking into, but they haven't quite found efficient uses for all of the different phases biomass is seen in (solid, liquid and gas). Another alternative to have great potential is the utilizing of geothermal energy, that is, steam rising from the center of the Earth. As of right now "relatively low steam temperatures in geothermal power plants [results in] these facilities only achiev[ing] efficiencies of 15%" (E. ON).

Duke Energy, located originally in North Carolina then recently extending to Ohio and Indiana with the purchase of Cinergy Electric, is making huge strides in the fight against global warming. They have many regulations already in place limiting what they emit into the air and water as well as a plan to tighten those limits in the coming future. On top of that, they also have suggested some of the policy they think the US government should implement:

We [Duke Energy] favor a U.S. policy on climate change that:

- Is economy-wide in its reach, rather than targeting a single industry for emissions reductions
- Is national in scope, yet considers varying impacts across regions and economic sectors
- Is market-based, with price signals leading to technological innovation and investment, energy efficiency and conservation
- Begins to reduce greenhouse gas emissions now, and does so gradually over time
- Is simple to administer and provides price certainty.

They believe that such means are possible "through a carbon tax, [or] through a 'cap and trade' approach." They feel that action is needed today, and not put off until later, and that it is the responsibility of every single person in the country, that the responsibility should not be put on the shoulders of one group of people or one industry.

In fact, they have an incredibly comprehensive section on their website dedicated to teaching the residential and commercial sectors of their users on how to be more energy efficient. Most of the residential fixes are very simple, which makes it even more enticing to comply. They suggest things like using energy efficient appliances while looking for the Energy Star® logo. Compact fluorescent light bulbs or CFLs are a very simple fix; they can reduce your light energy consumption by 75%. See also Chapter X.

Purchasing green energy is something they and other energy companies have been pushing much more recently. Green energy is all the renewable and alternative energy sources, such as hydro, wind and solar power. They have two programs set up at the current time, one for North Carolina (NC GreenPower) and the other in Indiana (GOGreen Power). Nothing at the moment is being employed in Ohio and the Greater Cincinnati area, but is forthcoming.

Obviously, they suggest traveling wisely, as well as taking car of your car and using the three R's, reduce, re-use and recycle. It has been said that a round trip flight from New York to Los Angeles is the equivalent consumption of a years worth of driving a Honda Insight hybrid car. So basically, airplanes use a very large amount of fuel, and emit a huge amount of pollution in a small amount of time.

Both cities have several plans for fixing the problem of greenhouse gases as well, on top of regulating company's emissions. In Ohio there is something called the Southwest Ohio Clean Energy Network, which is part of Green Energy Ohio, or GEO. GEO is a not-for-profit organization that was founded to promote alternative fuel sources for both residential and commercial sites. They tour the state informing people of what they can do to reduce their carbon impact as well as how to conserve energy and cleanse the air. They speak about all the typical fuel sources: sun, wind, hydro, biomass and green power, as well as how each one will help the environment.

Germany has a similar department, the Umwelt Bundes Amt, which appears to be equivalent to the GEO, but in a governmental setting. They handle all the publicity the matter receives as well as spreading knowledge and awareness about global warming. Their website gives projections as well as raw data about what is being observed. They speak of pollution, agriculture as well as recent and important findings.

BP, one of the largest energy companies in the world has a significant hold of the alternative fuel market, especially in Munich. Munich recently built a new terminal onto their international airport, and in the process they teamed up with Air BP and BP Solar to make the new terminal a completely solar powered entity. The solar panels are mounted on top of the building in layers, all pointing towards the sun, to optimize absorption.

BP also has big plans for the other sectors of alternative fuels and conservation. They are investing heavily in solar, wind, hydrogen, and gas-fired power. Gas fired, unlike coal burning power, is the cleanest burning fossil fuel known at this time. The main advantage, as BP states, is that everything put into burning natural gas is then recycled.

The specific process uses compressed air that is forced into a combustion chamber, where it is mixed with the gas. This mixture is then set on fire, producing a very condensed gas, which is fed through a turbine, ultimately making electricity. The hot air from this process that is left in the chamber is then recycled by mixing it with water, to make steam which is then sent through another turbine, ultimately making more electricity. On top of that, the steam is then changed back into water and used in the boiler system that is present.

As it looks now, both Duke Energy in Cincinnati and E. ON Energie in Munich are more of the progressive corporations when it comes to changing their need and usage of fossil fuels, at least when comparing the major Energy providers in each city. Both propose very similar fixes to this long ignored problem. In fact, Germany is planning on executing a change in the way they tax cars and car production. The new plan will tax based on the amount of carbon released in the form of CO_2 carbon monoxide and other fine particles by the vehicle, as opposed to how the plan works now, where they are taxed solely on engine size (LowC^{VP}).

British Petroleum also is one of a handful of companies leading the pack, trying to break the World of its oil demands, which seems ironic, since it is one of the largest oil refinery companies in the world.

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Chapter 7

Chris Hartmann

Xavier University's Carbon Footprint, Recycling, & Landscaping

Located in Cincinnati, Ohio, Xavier University is a private college with an enrollment of six thousand six hundred. It is situated on approximately one hundred thirty-three acres in this once temperate woodland climate that has become a highly urbanized area. Two-thirds of the university's acreage is landscaped and the remainder is occupied by buildings. As the university has increased in size and energy-efficient technology has decreased in cost, the Xavier University Physical Plant has remained below national averages for universities when considering energy consumption and cost.

This chapter will look at the energy, natural gas, and fuel consumption records maintained by the Xavier University Physical Plant. It will not include water consumption or energy of Cintas Center, travel by the Athletic Department or Student Government Association, and will not take into account the land acquisitions made during the 2006/2007 school year. It will discuss current technologies employed by the University to reduce operating costs, and will discuss how carbon emissions impact the environment. Current environmental concerns such as waste management, recycling efforts, and green landscaping will also be analyzed for their effectiveness in curbing carbon emissions and the University's long-term effect on the environment. Finally, Xavier University's efforts will be compared to that of the much larger and public University of Cincinnati.

Energy usage

Electricity accounts for nearly two-thirds the total utility expenditure for Xavier University over any given year; natural gas makes up one-fourth and water is one-tenth. For example, in the fiscal year of 2004 (FY2004) Xavier consumed 92,154 British thermal units per gross square foot (BTU/GSF) of electricity (Figure 7.1) and in FY2004, a total of 28,635,502 kilowatthours of electricity. According to the United States Environmental Protection Agency's 1999 calculation, the national average of output was 1.341 pounds of CO_2 for every one kilowatthour generated. Therefore, Xavier produced approximately 38,400,208 pounds of CO_2 for the FY2004.

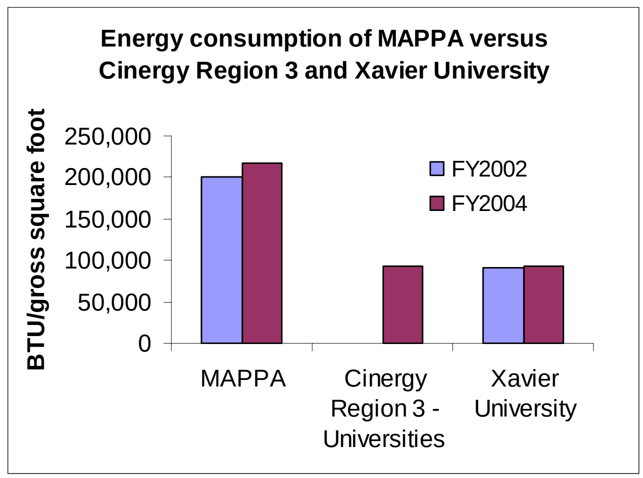

Figure 7.1. *Comparison of electricity consumption of Xavier University and the Midwest Association of Higher Education Facilities Officers (MAPPA) and Region 3 of Cinergy Corporation. Provided by Xavier University Physical Plant.*

Xavier consumed 42.4 percent of the average university of the Midwest Region for the FY2004 as reported by the Association of Physical Plant Administrators (MAPPA). The average student enrollment of universities and colleges in the MAPPA region is approximately 9,330. The average BTU/GSF per enrolled student (FY2004) of a university in the MAPPA region is approximately 23.27. The average BTU/GSF per enrolled student (FY2004) of

Xavier University is approximately 13.83, or 59.4% that of the BTU/GSF per enrolled student of a university in the MAPPA region. Whereas the Midwest Region's average BTU/GSF increased by 7.9% from FY2002 to FY2004, Xavier's increase of BTU/GSF was 1.7% over the same time period.

When the colder months arrive each year, natural gas consumption increases and electricity consumption decreases. Xavier University's natural gas consumption began to increase in September and peaked in December for FY2006. Their total natural gas consumption was 617,832 CCFs (1 CCF is equal to 100 cubic feet of natural gas). This equates to approximately 7,414,000 pounds of CO_2 (1CCF = 12 pounds CO_2). The two largest consumers of natural gas were the Logan Power Plant (35% consumption for FY2006) which serves buildings located on the Academic Mall and the Dorm Plant (26%) which serves Buenger, Husman, and Kuhlman Halls. Natural gas consumption decreased 6.4% from FY2004 to FY2006.

Also of interest is fuel consumption by Xavier University's Physical Plant. University vehicles consumed approximately 9,500 gallons of fuel (98.2% of that was gasoline and 1.8% was diesel fuel) for FY2006. According to a Sierra Club CO_2 output calculator this equates to 186,731 pounds of CO_2 emitted into the atmosphere (Sierra Club, 2007). Adding together pounds CO_2 emitted due to electricity (FY2004), natural gas (FY2006), and fuel consumption (FY2006), Xavier University emitted 46,000,939 pounds CO_2 for FY2006.

This figure, albeit large, represents the numerous day-to-day operations needed to provide students, faculty, and staff with comfortable learning, teaching, and working environments. The University has taken many steps to reduce operating costs, which is synonymous with conserving energy and thereby reducing their carbon footprint. The greatest and most effective of these steps is building management. Most noticeable to the public are the more efficient roofs and windows that Physical Plant has installed in buildings along the Academic Mall. Outdated light fixtures have been replaced by more energy efficient fixtures, some motion-sensitive light switches have been installed, high efficiency washers and driers are found throughout the residence halls, and manual flush toilets have been replaced by automatic low-flow flush toilets. Dave Lococo, Associate Director for Operations of Physical Plant, explained that the automatic toilets serve health and sanitary purposes and are not necessarily cost-effective or environmentally-friendly. Not as visible to the public eye are the upgraded and more efficient central heating and cooling units found throughout campus buildings. Also, Physical Plant has upgraded its power generating plants –namely Logan and Dorm Power Plant- and made them variable-frequency drive (VFD) systems. Whereas past energy systems were 'on' or 'off,' VFD systems control the amount of alternating current by surveying the amount of electrical energy needed to run the motor. They target a set comfort level and then increase or decrease energy based on this comfort level. Physical Plant has also installed a number of large ice-storing tanks to reduce surcharges during the summer months. These ice tanks are found above and below ground around the Logan and Dorm Plants. According to Lococo, "ice storage tanks are used to make ice during "non-peak" billing periods. This also allows us (Xavier University Physical Plant) to reduce our billing demand. Ice is "burned" during the peak periods."

Recycling

Physical Plant has also increased recycling efforts by educating students and faculty about proper recycling methods and providing student residents with recycling bins. Recycling is picked up by locally-owned and operated Rumpke. Rumpke collects glass, plastics, aluminum, scrap metals and paper products and allows for commingling of the recyclables. According to a Xavier Newswire article, Rumpke is able to re-sell 93% of the recycled material that enters the plant. Stacey Decker, Assistant Director of Campus Services, estimates that students and faculty recycle only ten to fifteen percent of the sixty-five to seventy percent of the total solid waste that could be recycled. Steve Owen of Environmental Health at

Xavier shared that recycling collection is an economic choice for Xavier because it is one-fifth the cost per month what it costs for non-recyclable waste collection. Recently it has cost Xavier $1,300/month to recycle versus $6,600/month for mixed trash. Per cubic yard, recycling is still more economic than mixed trash ($1.60/cubic yard versus $2.24/cubic yard, respectively). Owen agreed that Xavier recycles because it is cost-effective but says he is happy that thinking green pays dividends economically and environmentally. Recycling is more economical because it is less expensive to reuse materials than to create materials from raw materials. Also, according to Pennsylvania Department of Environmental Protection, recycling cuts down on methane emissions from landfills and reduces the energy needed to create recycled products versus those products made from raw materials.

Federal law mandates that Xavier University recycle toxic and environmentally hazardous materials. Such materials include light bulbs, paint, batteries, computers, refrigerators, oil, and compounds and liquids used in the science departments. Some of these items contain lead, mercury or any number of other harmful chemicals. Such chemicals can release harmful greenhouse gas emissions that increase global warming and pollute water and soil.

Though the recycling program continues to expand and students and staff become more conscious of the recycling program, Xavier still has room for improvement. The University of Cincinnati recycled 250 tons of material in 1991 and has since increased its recycling to 4,902 tons of recycled material. In comparison, if the statistics from July, August, and September 2006 are extrapolated out to a year, Xavier would recycle (and compost) an estimated 190 tons of material. University of Cincinnati Physical Plant recycles the same materials as Xavier University Physical Plant but in a much larger quantity: approximately 0.1391 tons recycled material per enrolled student versus approximately 0.02851 tons recycled material per enrolled student, respectively. Moreover, University of Cincinnati Physical Plant maintains a fleet of forty-three alternative fuel vehicles and has membership in the LEEDS Committee and the Environmental Sustainability Committee. Also, the University of Cincinnati has access to state funding assistance and, because it is assisted financially by the state government, is able to allocate more money to the upkeep and development of the recycling program compared to Xavier University, a private college that relies on endowments to pay their budget.

According to Lococo of Physical Plant, Xavier is constantly looking for ways in which to become more environmentally friendly. Physical Plant has recently completed a survey that has identified areas for improved energy-efficiency. Though the results of the survey have not yet been made available to the public, Lococo did mention that solar and geothermal energy may be economically feasible in the future. With regards to the "To See Great Wonders Campaign," Physical Plant was quick to assure me that energy efficient and environmentally friendly architecture will be heavily researched and ideally all buildings will aspire to be LEEDS Silver (merit of energy efficiency). Future green architecture and garnering the support of students and staff is the focus for the next chapter

Landscape applications

Federal laws have also strictly monitored the use of lawn fertilizers, chemicals, and insect repellents. Physical Plant complies with all EPA, state, and city-mandated laws. Tru-Green is the only routine treatment applied to campus grass and this is in limited areas. Trees, shrubs, and flowers are chosen for aesthetic value and not their impact on the environment. Carbonates and soaps are applied to control pests on the interior and exterior of buildings, and soaps are occasionally applied to areas to control weeds.

Conclusion

It was found that Xavier University emitted 46,000,939 pounds CO_2 due to energy (FY2004), natural gas (FY2006), and fuel consumption (FY2006). Xavier University reported less of an increase in energy consumption from FY2002 to FY2004 compared to the average energy consumption of universities from the Midwest region, and the University was found to have consumed approximately 59.4% the energy per student of the average Midwest university. The University reported a decrease of natural gas consumption from FY2004 to FY2006. Recycling has been shown to reduce greenhouse gas emissions and is more economic than the manufacturing of raw materials. Xavier University has campaigned to increase recycling on campus because it is more economical but realize that is a more environmentally friendly option than sending recyclables to the landfill. It was shown that the University of Cincinnati recycles nearly five times as much material per student than does Xavier University. As Xavier University works to decrease its carbon dioxide emissions and increase recycling efforts, it will be students and faculty members who will have the greatest say so in the matter.

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Chapter 8

John Kavanaugh

Xavier University's Carbon Blueprint

As discussed in chapter 7, Xavier is making an effort to reduce its carbon footprint; however, improvements could still be made in this process. Xavier has a responsibility as a Jesuit institution, as well as a community leader and role model for other universities to be an environmentally sustainable campus. This responsibility is implicit not only as a means to boost public relations, but as a Jesuit campus whose efforts revolve around being men and women for others. As a Jesuit university, stewardship and care for the environment should be integrated into everything we do as a university. In order to be ethical members of our community and the world, it is important that we consider how our actions affect the environment in which we live. These actions in turn affect every member of our community and the world. The ethical necessity of environmental responsibility is even echoed in Xavier's mission statement that says, "…woven through all our efforts on behalf of our students is an emphasis on ethics and values that stamp a Xavier education as Jesuit and Catholic."

Recently, the university has placed a big emphasis on its future building plans in its To See Great Wonders campaign. Due to the campaigns focus on buildings with the technology of tomorrow, as well as its sustainability, it might be easy to overlook what Xavier could be doing now to be a green campus. However, the university can be taking dramatic steps now in order to become more environmentally friendly.

In an interview with Fr. Ben Urmston, S.J., I discussed current steps the university could take to become an environmentally minded campus. There is a need for the university to educate students, while also being a model for other universities and the world. Fr. Urmston also emphasized the importance of making the environment part of the core curriculum. As a university whose goal in their mission statement is to instill in students, "a world view that is oriented to responsible action and recognizes the intrinsic value of the natural and human values," students need to be educated about sustainability and how current actions are affecting the environment and humanity. Increased support of the environmental studies and peace studies minor could be integrated into this goal. Also, an adequate amount of university resources could be allocated to academic, as well as extracurricular programs that emphasize environmental education.

As a campus whose goal is to serve and be a model for others, Xavier could consider various initiatives currently proposed for universities who want to be more sustainable. The Campus Climate Challenge, for example, is a coalition of campus organizations that work to engage universities in climate action on campus to promote clean energy and slow global warming. Some proactive students on campus have already signed up to start Xavier chapter of this challenge. The Campus Climate Challenge, like a few other initiatives I found, works as an advocate for universities working to be more environmentally friendly, while helping them set and meet their own environmental goals. This organization highlights the need for universities to set climate goals with specific targets and strategies, as well as the need to adopt a written proposal for a greenhouse gas reduction goal that is approved by the Board of Trustees. A greenhouse gas reduction proposal could be valuable in helping Xavier stay focused on its environmental goals, as well as prompt them to put together effective plans to meet their objectives.

Outside the infrastructure of the campus, an immense amount of resources are purchased by Xavier. The university could implement purchasing policies that favor local, energy efficient, recycled and durable products. In recent years, students and faculty have tried supporting locally grown organic produce. In many cases, our society's methods of food delivery can contribute to global warming. For example, Figure 8.1 gives an example of the amount of carbon dioxide that comes from shipping foods. In this case, the data from Rich Pirog looks at shipping food to Iowa; however, these results are typical for many states in the Midwest including Ohio. Fr. Urmston has said, "We are too heavily dependent on fossil fuel to transport our food; food in the average supermarket travels as many as 1500 miles before we ever see it." The university can take proactive steps to reduce its carbon footprint, as well as offer healthy food choices to students through the purchase of organic foods, for example, from places like Grailville Organic Farm in Loveland.

In an interview with the President of the Student Government Association at Xavier, Steve Bentley recommended looking at the Dorothy Day House as a way to get involved in helping the environment. As SGA President, Steve should be educated about the different clubs in existence on Xavier's campus, and what each club does on campus. However, in a statement possibly reflective of the student body, he recommended starting a club that dealt with the environmental issues. Sadly, this could be indicative of the fact that longstanding clubs such as Earthbread/Earthcare are not making their voices heard. However, since this club actively tries to engage the student body through various activities, including the annual Earth Week, the more likely scenario is that the rest of the student body is not interested and not listening.

Student involvement is just as important as faculty involvement. Increased student awareness and support are key components to a green campus. Clubs on Xavier's campus like Earthcare are a valuable resource for students who want to become more active in helping to protect the environment. Additionally, all students could personally challenge themselves to learn more about the environment and to reduce their carbon footprint. As a university and as people, we should make it a priority to maintain the long term value of the earth. Fr. Urmston stressed how this priority is reflected in love of our neighbor.

In regards to development, some students, especially those in Earthcare, have taken a positive step to circulate a petition that prioritizes sustainability in Xavier University's Development Project. Sustainability is defined by the United Nations World Commission on the Environment and Development as "Development that meets the needs of present generations without compromising the ability of future generations to meet their own needs." Sustainability could be key as we move into the next phase of Xavier's campus.

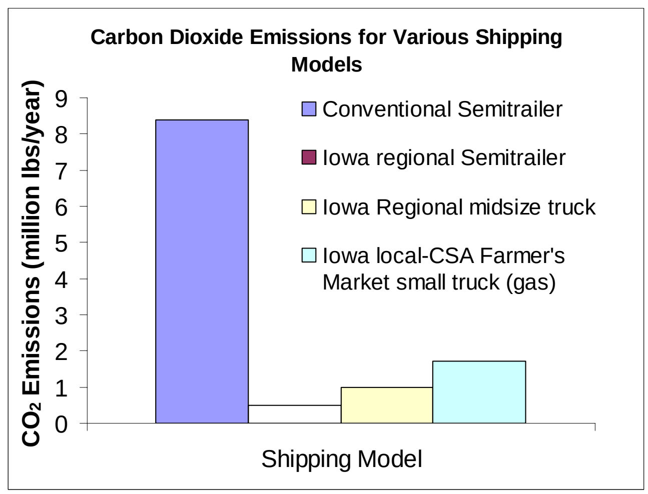

Figure 8.1. *Estimated CO_2 emissions for conventional, Iowa-based regional, and Iowa-based local food systems for produce*

In an effort to learn more about what Xavier is doing to create a sustainable campus now and with its future building plans, I talked with Dr. James Buchanan, the director of the Bruggeman Center at Xavier. Recently, the school has set up efficient monitoring in order to determine the school's energy usage in both good and bad areas. The monitoring systems help to take an "energy inventory" of the campus. This monitoring system has been developed over the past 10 years to identify and fix problem areas over campus in order to make buildings as energy efficient as possible.

The school has also initiated a recycling program in another move to close the energy loop as well as save cost. The recycling program was started with efforts from the environmental subcommittee of Justice Across Campus, a group of faculty, staff, and students that meet to discuss justice issues on Xavier's campus. The Bruggeman Center worked to set the example by using recycled materials in every piece of literature it sends out. Due to these efforts, the center has led the way for the rest of the campus to do the same. Personally, Dr. Buchanan feels the campus' recycling and "green" efforts are going well. Given the fact that four years ago the campus was not green at all; they've increased their efforts and the amount they recycle exponentially. However, he stressed the campus still has further to go, but he is optimistic they can reach their goals. See Chapter 7 for more discussion of the current state of recycling on campus.

When discussing the future, Dr. Buchanan was hopeful the campus will remain green as well as increase its efforts as an environmentally sound campus. The overall process will involve the development of five new buildings. A new learning center, a parking garage, a business school, as well as building another building as part of the learning commons and making renovations to Alter Hall. In a confident tone, Dr. Buchanan said the plans are going very well in regards to having a green campus in the Xavier's future. However, the level of sustainability depends on how far the school can practically take it given the circumstances. The campus is looking at what other universities have done in order to help them make smart decisions. For example, the University of South Carolina rebuilt the entire west side of its campus in an environmentally sustainable manner. Locally, Xavier has looked at green architect Joe Powers. Joe Powers designed the Medical Building at the University of Cincinnati. As part of the Leadership in Energy and Environmental Design (LEED) certification, developers can set their own sustainability goals. In turn, the LEED certification system helps developers meet those goals in order to be certified on various rating levels up to LEED platinum depending on what sustainability practices they achieve with each building. The university hopes to establish what it practically thinks it can do as part of this system.

There are many steps that go along with having sustainable buildings on campus. The first stage of the process involves sending proposals to various architecture firms who are green and who have done buildings similar to those in Xavier's future plans. The next steps involving getting a proposal back from the firms, as well as quote from the firms in order to see how much each firm can do, given a limited budget of about $40-45 million a building. The university will then look at its options of what level of sustainability it can practically achieve. There is little doubt that the future plans will be done in a sustainable way. However, the level of sustainability the new development will have depends on the circumstances given a limited budget.

They have much work to do in reaching the sustainable level they choose. Dr. Buchanan said a primary concern that needs to be overcome is the "Myth of First Cost." Many critics feel sustainable buildings have an initial cost that may b e too expensive to overcome. However, environmentally sustainable buildings initially cost 1 to 2 percent more, at most. This cost will come down as the market efficiencies increase, and the economies of scale continue to set in. Also, given the fact that the buildings will be pro-rated for 30 years, and energy cost will only increase in that time, after minimal initial first costs for sustainability, everything else will reduce lifetime cost.

Dr. Buchanan and other people at the Bruggeman Center are continually trying to educate the decision makers on campus that sustainability, which works on so many levels, should be the next phase of Xavier's campus. They have met with all the heads of all the departments, such as Academics and Student Life, to show them how sustainable planning affects them all. Sustainability makes sense more than just economically. Dr. Buchanan stressed that buildings also have educational value. As a campus dedicated to teaching social justice, the ecological and environmental justice incorporated into Xavier's building plans should be part of this goal. In some cases, buildings with positive carbon footprints have been created. These buildings actually expend less energy than they create from environmentally friendly practices. Dr. Buchanan pointed to David Ore who created a building just like this at Oberlin College. Also, from a public relations standpoint, green building plans make excellent sense. Xavier can be the first Jesuit school in the country, as well as the world, with this level of environmental awareness built into their campus. The building plans could also increase the quality of student life. This practice of sustainable architecture could hopefully decrease sick building syndrome through the prevention of recycled indoor air. Kenneth Freeman, an author on green architecture, says in regards to the prevention of sick building syndrome, "Green buildings by their very nature rely on natural ventilation and high autonomy over the control of the working environment." Finally, in consideration of fundraising, green sustainability may cause donors to give money they otherwise might not have given.

When asked whether the student population is making their voice heard about their concerns with the environment, Dr. Buchanan felt the students are making their voice heard, unfortunately, it's not the voice Xavier would have liked. The students don't seem to be showing particular interest in the environment or concerned with the greenness of the campus. However, he is optimistic about the student population, and hopes to get in contact with student government in order to raise the environmental conscience of the students.

Dr. Buchanan stressed the real crisis is not global warming, but the failure to convince people that it is a crisis. Due to the fact that direct impact is what spurs action in many people, it is difficult to cause action. Therefore, Xavier is trying to educate people about how energy efficiency can impact one directly. He is hopeful that sustainable development at Xavier will spur students to be more environmentally conscience when they are future leaders and homeowners. By being a role model in terms of sustainability, Dr. Buchanan hopes the university can educate students and encourage them to think in a sustainable fashion when they are the decision makers in the future.

As development continues, it appears Xavier will look to sustainability in the next phase of their school. Central to the new vision at Xavier is the mandate from Superior General Kolvenbach that justice and responsibility become integrating dimensions of Jesuit Higher Education. Justice and responsibility must be seen in terms of our role in the natural world in which we live. I am hopeful that the future development of Xavier will show some level of sustainability and this will positively affect the students. I am optimistic in the future of Xavier in regards to its locally grown food, as well as its increased focus on the environmental sustainability. I have hope for the current and future leaders of the Student Government Association. After talking with Steve Bentley, as well as other student leaders, I look forward to seeing our transition and development as a school not just in bricks and mortar, but in increased global awareness.

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Chapter 9

Tony Lioi

LIFESTYLE CHOICES

Global warming is a serious issue that is both already causing problems and is predicted to cause further problems in the near and long-term future. Carbon dioxide is a recognized greenhouse gas which helps warm the Earth's surface by trapping solar heat in the atmosphere. People are contributing to this global warming phenomenon by releasing massive amounts of carbon dioxide into the atmosphere. Each and every year the average citizen of the United States through the personal choices that he or she makes will cause about 15,000 pounds of carbon dioxide to be released into the Earth's atmosphere. This amount can be lowered. Throughout this chapter, many of the things that people do which cause carbon dioxide to be released will be examined, and changes that people can make to lower the carbon emissions that they cause will be suggested.

Carbon Emissions: At Home

The home is the first place to look to see what people are doing to cause the emission of so much carbon dioxide and therefore the first place to look to give places in their lives to change in an effort to lower personal carbon dioxide emissions.

With regard to home emissions, electricity is the big offender. According to the Energy Information Administration (part of the United States Department of Energy), in Ohio between 1998 and 2000, 1800 pounds of carbon dioxide, 26 pounds of methane, and 57.6 pounds of nitrous oxide is released into the atmosphere per megawatt hour of electricity produced. Duke Energy, which supplies the Cincinnati area and other areas in Ohio, Indiana and Kentucky, has a generating capacity in the region of 8,100 megawatts and operates power plants which utilize a variety of methods to generate this power, including nuclear, hydroelectric, oil/natural gas, and coal. And with the average cost of residential electricity increasing from $85.10 per megawatt hour to $94.20 per megawatt hour between 2005 and 2006, anything that will lower electrical consumption in the home makes economic as well as environmental sense.

Americans can do many things to lower electrical energy consumption. Compact fluorescent light bulbs utilize 60 percent less energy than the equivalent incandescent light bulbs. By switching to these compact fluorescent light bulbs, about 300 pounds of carbon dioxide a year will not be released into the atmosphere. That is about 90 billion pounds saved if everyone in the United States switched over to compact fluorescent bulbs. Using energy saving appliances is another way to lower electrical needs and reduce greenhouse gas emissions. If everyone in the United States switched to the most energy saving appliances currently on the market, 175 millions tons of carbon dioxide a year would be saved, which is a little over 1100 pounds of carbon dioxide per person per year. Also, by air drying clothing six months out of the year instead of using the dryer, another 700 pounds of carbon dioxide would not be released into the atmosphere. By turning off electric devices such as televisions and computers, and by unplugging things like cell phone chargers which can use electricity even when they are switched off, even more electricity can be conserved and the electric bill will be lowered.

Heating and cooling one's home also is a major contributor to the per capita release of carbon dioxide gas. Natural gas releases 120.593 pounds of carbon dioxide gas per one thousand cubic feet burned and propane gas (another gas used for heating) releases 12.669 pounds of carbon dioxide gas per gallon burned. Both release a lot of carbon dioxide when used. See Table 1 for the carbon dioxide coefficients released from the burning of other common fuels.

The residential price of natural gas is currently at $12.08 per thousand cubic feet so it makes both environmental and economic sense to reduce the consumption and burning of natural gas. Living in a smaller house when possible would also cut down on the heating and cooling expenses and emissions.

People can save a lot of money and carbon dioxide by reducing heating demands. According to calculations presented in *The Inconvenient Truth*, a simple adjustment of setting the thermostat lower two degrees Fahrenheit in the winter and two degrees Fahrenheit higher in the summer will save 2,000 pounds of carbon dioxide a year. Another 350 pounds of carbon dioxide can be saved by either cleaning or replacing the air filters on air conditioning units and furnaces. Having the walls and ceilings in a person's home properly insulated can reduce carbon dioxide emissions by 2000 pounds, with caulking and weather-stripping saving another 1700 pounds of carbon dioxide a year. This can also reduce the heating bill by about twenty-five percent.

It takes energy to heat water either through gas heating or electricity, so by reducing the amount of hot water used and heating water more efficiently will go a long way to lower a person's yearly carbon dioxide gas emissions. If people were to wrap the house's water heater in an insulation blanket and set the water temperature to 120 degrees Fahrenheit, 1500 pounds of carbon dioxide would be saved. Using less hot water by installing low-flow shower heads (350 pounds), washing clothes with either warm or cold water (500 pounds), and running the dishwasher when it is fully loaded and in energy-saving mode (100 pounds), even more carbon dioxide would not be released into Earth's atmosphere.

Even reducing the waste generated by a person can have a dramatic effect on carbon emissions. Merely by recycling half of the waste generated in a single household, 2,400 pounds of carbon dioxide can be saved. For a house of four, that's 600 pounds per person. Also, if a person cuts the amount of garbage produced by only ten percent, another 1200 pounds of carbon dioxide emissions per year could be curbed. Buying locally grown food would reduce the amount of emissions generated by the transport of food many miles.

All told, if people were to follow every piece of advice from above, they could reduce their emissions by about 10,600 pounds of carbon dioxide, from about 15,000 to about 4,400 (Figure 1). This is a seventy percent reduction in emissions a year! But this is only one part of the solution.

Carbon Emissions: Transportation

People do things that release carbon dioxide gas into the Earth's atmosphere even when they are not in their homes. Examining the causes of these emissions and then finding ways to curb these emissions when people are away from home is another way that global warming can be combated effectively.

Traveling is a significant source of carbon dioxide emissions in the world today. One third of the carbon dioxide gas emitted from the United States of America is emitted by cars, trucks and airplanes. For every gallon of gasoline burned to fuel the cars on the road, a little less than 20 pounds of carbon dioxide gas is produced. And for every gallon of diesel fuel burned to fuel trucks, a little more than 22.3 pounds of carbon dioxide is produced. Considering the many miles that are driven by cars in the United States, that is a rather large amount of carbon dioxide being released into the air every day.

Traveling by car less is an obvious way in which people could lower their carbon dioxide gas emissions. Walking, biking, and mass transit are all ways to lower the driving done by a person each week. For every ten miles of driving that you do not do per week, you can reduce the yearly carbon dioxide emissions you produce by 500 pounds. Car pooling is another way in which to lower emissions. A typical commuter can save 1,590 pounds of carbon dioxide gas per year by just sharing a car ride with someone two days a week. Living closer to work would also cut down on emissions.

Fuel efficiency is another way to save on emissions. If less gas is being used to get to the same place, then less carbon dioxide will be released into the atmosphere. For every three miles per gallon more a car gets, an average person in the U.S. will save 3,000 pounds of carbon dioxide a year. To increase fuel efficiency, people could buy more fuel efficient cars such as hybrids. Hybrids can save gas by shutting off the motor when the car comes to a stop and starting it again when the accelerator is pressed. Some hybrids can get up to sixty miles per gallon. To see how much carbon dioxide a particular model produces, one could visit this site: http://www.terrapass.com/road/index.html. A car needs to undergo regular maintenance as well. This helps fuel efficiency and reduces a car's emissions. By checking tire pressure on a regular basis and keeping them at the optimal pressure, a car's gas mileage can increase by about 3 percent.

Changing one's driving habits will also increase fuel efficiency. By driving aggressively (rapid acceleration, speeding, rapid breaking), a person can lose up to thirty-three percent of his or her gas mileage on the highway and about five percent in the city. Another seven to twenty-three percent would be lost by driving over sixty miles per hour. Lightening the load of a vehicle also increases gas mileage. A loss of one to two percent of a person's gas mileage occurs for every one hundred pounds of extra weight is in the vehicle. Since idling gets zero miles to the gallon, reducing the amount of time spent idling will increase the fuel efficiency of a vehicle. Also, using cruise control on the highway to keep a constant speed will save gas.

Air travel is another heavy producer of carbon dioxide emissions. The "How it was calculated" section of climatecrisis.net tells how much carbon dioxide is released by air travel. A short flight (average length of 250 miles) releases about 0.64 pounds of carbon dioxide per mile. A medium flight (average length of 800 miles) releases about 0.45 pounds of carbon dioxide per mile. A longer flight will release about 0.39 pounds of carbon dioxide per mile. The reason that the longer flights release less carbon dioxide per mile is that a large amount of fuel is burnt during takeoff, so the longer flights have a greater chance of lessening the impact on overall fuel economy than the shorter flights do. Taking fewer trips on air planes or at least limiting trips to those that are longer than 800 miles one way are both good ways to reduce carbon dioxide emissions. Alternate forms of travel should be used when traveling less than 800 miles.

By following the advice listed above, people could both reduce carbon dioxide emissions in the United States by a significant amount and save a lot of money on gasoline.

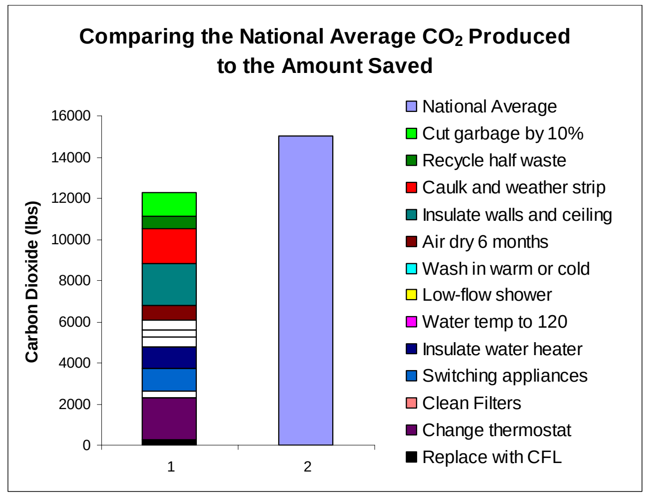

Figure 9.1: *Comparing the national average carbon dioxide produced per person to the amount a person can save. Bar number 1 represents how much total carbon dioxide a typical person in the U.S. can save and is split up into the different activities that can do it. Bar number 2 is the national average amount of carbon dioxide produced per person.*

Lifestyle Choices: Conclusion

Reducing carbon dioxide emission will go a long way toward combating the global warming phenomenon. As shown, this battle can be fought by individual people in addition to what is advocated by policy makers. If each person did his or her part and did things that would reduce his or her carbon footprint, then global warming would slow very significantly. And people do not have to do this out of the goodness of their hearts either. Reducing carbon dioxide emissions is good for their pocketbooks as well. While some things would cost more in the short term (buying a new car, insulating the house, buying state-of-the-art energy efficient appliances) they would pay for themselves in the long term. If that was not enough, a lot of things that do not cost money can be used to save money as well such as unplugging unused electrical devices or keeping a car's tire pressure at the optimum range. Many things are very easy to do and require little sacrifice.

If someone is interested in his or her personal carbon footprint, he or she could go and have it calculated at the following site: http://www.climatecrisis.net/takeaction/carboncalculator

Useful Websites

An Inconvenient Truth: http://www.climatecrisis.net

Duke Energy Power Plants: http://www.duke-energy.com/about-us/power-plants.asp

Average Retail Price of Electricity to Ultimate Customers: http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_b.html

Natural Gas Summary: http://tonto.eia.doe.gov/dnav/ng/ng_sum_lsum_dcu_nus_m.htm

State-level Greenhouse Gas Emission Coefficients for Electricity Generation 1998-2000: http://tonto.eia.doe.gov/FTPROOT/ environment/e-supdoc-u.pdf

Voluntary Reporting of Greenhouse Gases Program: http://www.eia.doe.gov/oiaf/1605/ factors.html

Driving More Efficiently: http://www.fueleconomy.gov/feg/driveHabits.shtml

How Hybrids Work: http://www.fueleconomy.gov/feg/hybridtech.shtml

Chapter 10

Jefferson M. DeLacey

ALTERNATIVE FUELS

In an urban setting like that found in Cincinnati, OH, alternative fuels for use in transportation vehicles offer an escape from the addiction on foreign oil and a break from the generation of green house gases. However, there is much to consider when adopting an alternative fuel. Some of the options presently are vehicles that run on ethanol, biodiesel, hydrogen, and electricity. Each poses unique advantages and downfalls. Some considerations when looking at alternative fuels are the availability of vehicles, infrastructure, fuel production and distribution, and emissions. When implementing a change in the fuel that is used, looking at each of these fuels in great depth and understanding all the elements, allows the consumer and politicians to make an informed and rational decision. The purpose of this chapter is to reveal the necessary information to determine which fuel best suits the needs of the Cincinnati community.

***Ethanol* (E85)**

The current infrastructure is set up for gasoline. There are approximately 175,000 fueling stations in the US. For this reason ethanol would be the most likely transition. Ethanol is an alcohol-based alternative fuel produced by fermenting and distilling starch crops that have been converted into simple sugars. Sources for this fuel include corn, barley, and wheat. Ethanol was first produced in the early 1900s as a fuel for many American vehicles. The first vehicle to utilize ethanol as a fuel source was the Ford Model T. Henry Ford saw ethanol as a fuel that could be produced locally by farmers in the United States. His vision was to create a cheap vehicle that could run on either gasoline or pure alcohol. Ford touted that ethanol was the fuel of the future. Since then ethanol has fluctuated as a fuel source. During the early 20th century ethanol was used to fuel cars alongside an effort to sustain an ethanol program in the United States. Due to the low prices of foreign oil ethanol failed to take the lead as the fuel of choice.

In the 1970s several major events occurred that renewed an interest in ethanol. The first of these major events was a disruption in the supply of foreign oil. The second was a continued increase in social awareness and environmental concerns from the use of lead as a gasoline octane booster. As the focus shifted from lead as the octane booster the next option was ethanol. Ethanol production in the United States grew from 175 million gallons in 1980 to 1.4 billion gallons in 1998, with support from Federal and State ethanol tax subsidies and the mandated use of high-oxygen gasoline. When congress passed the Clean Air Amendments in the early 1990s ethanol became an additive in all types of gasoline. Gasoline fuels at pumps today contain up to 10% ethanol. The recent trend has been production of E85. E85 is a combination of gasoline and ethanol that is made up of 15% gasoline and 85% ethanol. This combination of ethanol and gasoline lowers the amount of dependence on foreign oil and the production of green house gases. The negative aspect of ethanol is that it does not completely eliminate the dependence on foreign oil because it still contains 15% gasoline. Even though it does lower the dependence on foreign oil, agribusiness still requires significant amounts of fossil fuels like oil. Because agribusiness uses fossil fuels the dependence on foreign oil in barely reduced.

E85 is primarily made from corn and other agricultural products such as sugar, potatoes and wheat. Most of the ethanol produced in the United States comes from corn. To obtain a final product of ethanol, corn goes through a rigorous production process. The first step is milling. The corn (or other agricultural products) is ground into a fine powder. This powder is then mixed with water and another chemical compound called alpha-amylase. It is then heated to 120ºC to 150ºC ensure liquefaction. This heating process not only assists in mixing but also removes any bacteria found in the starch. After heating the mixture it is cooled and then a secondary enzyme is added known as glucoamylase is added. Glucoamylase is responsible for converting the raw starch into fermentable sugars in a process called saccharification. Yeast and CO_2 are added and allowed to ferment the mixture during fermentation. The fermented mixture is then distilled. The final product of distillation is then dehydrated to remove any water or impurities. The final result of this process is a pure ethanol alcohol that is 200 proof. Once complete a small amount of gasoline is added to the ethanol and then can be sold in fueling stations locally.

The current infrastructure that is in place would be suitable for conversion to E85. The difference would be in the fuel that they were getting at the stations. Instead of fueling up with gasoline at fueling stations they would fill up on E85. In order for these fueling stations to become E85 providers very few modifications need to be made. The major change that needs to be made is the way that the fuel is stored and distributed. Most of the current fuel storage tanks that are in use at gas stations around the U.S. that meet current EPA standards are suitable for storage of E85. To convert to this fuel the only modification that needs to be done in storage is a strict cleaning of the storage tank. The major change that must be made is in how E85 is dispensed. The E85 dispenser must use iron, unplated steel, or stainless steel in the fuel path. The E85 dispenser must use these metals to reduce the amount of impurities that is generated. Steel with a high chemical resistance will provide distributors with the least amount of impurities. Most of the fueling stations that provide E85 are located in the Midwest. This is due to the availability of the raw materials that are needed to produce the fuel. This fuel would break the addiction to foreign oil and currently there are approximately 700 fueling stations providing E85 and the number of stations is growing due to demand.

Vehicles that run on E85 are known as flexible fuel vehicles. These vehicles can run on any mixture of gasoline and E85. The engines contain special sensors that monitor the mixture of fuels and modify how the engine runs based on the mixture. Currently due to the increasing prices of gasoline automakers are manufacturing more vehicles that are flexible fuel vehicles. One of the major benefits of adopting a flexible fuel infrastructure is that of all the alternative fuels, flexible fuel vehicles are the most available for purchase on the market. The majority of automakers that manufacture flexible fuel vehicles are American. The two American automakers that have taken the lead in the production of these vehicles are General Motors, Daimler Chrysler, and Ford. General Motors is the leader with the most number of flex fuel vehicles in production with fifteen available for market. Daimler Chrysler is second with eight vehicles available for market. Finally, Ford is last with only four vehicles. Most of the vehicles that are offered with flexible fuel engines are SUVs and Light duty trucks. The most popular GM vehicles that are flexible fuel are the Chevy Tahoe, Yukon and Yukon XL. Ethanol has a lower BTU value than gasoline. Ethanol has a lower energy density due to the difference in molecular structure. Gasoline contains more hydrocarbons which when burned produce more energy. Because ethanol is a smaller molecule with fewer hydrocarbons it burns cooler and produces less energy per gallon. This is one of the downfalls of E85 as a fuel. With E85 drivers get fewer miles per gallon than if the tank was filled with regular gasoline. The plus side of ethanol is that due to burning cooler, the combustion process is gentler on the vehicle's engine which produces less wear and tear leads to longer engine life.

New research is leading to production of newer cars that have better flex fuel engines. The use of ethanol would reduce harmful green house gas emissions. As the technology improves better fuel economy and infrastructure will become available. The process of producing ethanol is becoming more efficient. All these processes working together would produce a cleaner burning, more efficient car.

***Biodiesel* (B20/B100)**
Biodiesel fuel is a fuel that is derived from renewable biological sources. As a fuel it is very similar to petroleum diesel. This mixture is known as B20. The US army uses this mixture of biodiesel in many of its vehicles. Minor modifications may be done to diesel engines so that vehicles can run on B100 which is pure biodiesel. Many of the diesel vehicles that are out on the market are able to run on a blend of biodiesel and petroleum diesel. There are some vehicles that run on B100 but these vehicles are primarily public transit buses. Current fuel infrastructure would support a change to this fuel. Biodiesel is also a renewable fuel source. Presently, Cincinnati mass transit buses are fueled on biodiesel. It reduces the level of harmful emissions by about 60%.

The compression-ignition engine was produced in the early 1900s to run on peanut oil. Rudolf Diesel created the engine to run on a form of peanut oil that could be produced cheaply. In the 1920s viscosity and engine degradation became a limiting factor for the production of biofuels. Since the cost of production of petroleum-based diesel fuel was easier and cheaper to produce it became the primary fuel for the diesel engine. Not much research was done until the price of petroleum became very high during the 1970s. Much of the research like E85 was directed towards biodiesel as an additive. Scientists used various vegetable oils, animal fats, or recycled restaurant greases to determine if they were possible sources of fuel additives. A majority of this research was aimed at offsetting the price of petroleum. Since that time many countries around the globe like France, Germany, and Italy, have become major supporters of the use and production of biodiesel. These European countries have become the leaders in the use of biodiesel. American policy makers have noticed this trend and biodiesel is continuing to make progress in the United States. The process of producing biodiesel is becoming less complicated and produces a higher quality fuel.

There are three main ways to produce biodiesel. The first is a base catalyzed transesterification reaction of any sort of oil with an alcohol such as ethanol or methanol. The second method is done using acid which directly esterifies the oil in the presence of methanol. The final process requires converting the oil to fatty acids, and then to Alkyl esters with acid catalysts. The most efficient way of producing this fuel is via the base catalyzed transesterification reaction. Biodiesel producers begin with the raw oils. These oils can come from almost any organic material. Most of the biodiesel produced comes from various vegetable oils such as corn oil or soy oil. Once these oils are filtered and purified they are heated to a specific temperature. After the oil is heated a mixture of catalyst and alcohol are added to the oil and allowed to mix and then settle. Once the reaction is complete the mixture will be separated into several layers. The top layer is the biodiesel, the middle layer is the soap layer and the bottom layer is the glycerol layer. The top layer is separated from the other two and then washed to remove any impurities that are still found in the biodiesel layer. Once this process is complete then the fuel can be mixed with petroleum diesel or used in its pure form in biodiesel engines.

The current infrastructure for diesel fuel would be ideal for changing to an all biodiesel fuel infrastructure. There are approximately 655 fueling stations that provide biodiesel fuels. The current infrastructure for diesel is similar to that of regular gasoline. Some gas stations in the United States offer a diesel fuel pump. Fueling stations for diesel are typically found along major highways due to the use of this fuel by the shipping industry. Biodiesel is stored similarly to petroleum diesel. One of the major benefits of biodiesel is that the flash point of biodiesel is higher then regular diesel. This means that biodiesel is safer to store, pump, and use than regular diesel fuel. There would be no need to convert the pump.

Most vehicles that use diesel in the US are shipping vehicles. There are few passenger vehicles that run on diesel. The automakers that provide diesel vehicles in the US are German automakers such as Volkswagen and Mercedes Benz. These automakers provide diesel engines that typically outperform most gasoline engines by getting more miles per gallon in both city and highway driving. Mercedes Benz offers the GL CDi, ML CDi, and the R320 CDi. All these vehicles are approved for B5 biodiesel fuel technology. Volkswagen also offers an SUV that runs on diesel fuel but none that run on biodiesel alone.

One of the major flaws with B100 vehicles is that they require special modifications to prevent the fuel from freezing. Many diesel vehicles may not be equipped for wintertime use of biodiesel due to the fuel freezing. This leads to various performance and maintenance problems. Much of the current research that is being done is to further the production of cars that have the necessary modifications to allow drivers to use biodiesel year-round. As technology and public awareness for these vehicles continues to improve, more options will become available.

Hydrogen

One of the more recent trends in the alternative fuel industry is hydrogen. Hydrogen is a highly combustible gas that can be compressed into liquid or maintained as a gas. This hydrogen is then stored in a unit called a fuel cell. This technology is a way to store the hydrogen, but it is also the way to generate electricity which powers the vehicle. At this point it can be used to produce the energy needed to power a vehicle. Overall, hydrogen does offer relief from dependence on foreign oil and production of green house gases. However, it does not completely eliminate the dependence on foreign oil. Currently, hydrogen is produced using fossil fuels. Major research efforts should be directed at finding a way to produce hydrogen with out the use of fossil fuels. The United States government is currently assisting this technology by providing funding for research for both production and fuel cell technology.

Like many of the other alternative fuels hydrogen fuel cell technology was started as a response to the oil crisis that occurred in the early 1970s. Due to this shortage of oil fuel cell technology began to be produced for use in commercial vehicles. Production, storage, and ‘fuel cell’ technology are 3 separate challenges. Research has been conducted to find ways to produce hydrogen efficiently and cheaply. Fuel cell technology is still relatively young. Research is being done to ensure a safe and efficient storage and use of hydrogen in commercial vehicles.

Fuel cells that are typically used in commercial vehicles are called polymer electrolyte membrane fuel cells or PEMs. These fuel cells work by using oxygen from the atmosphere and hydrogen from a storage tank to create electricity. At one end of the fuel cell hydrogen is pumped through a chamber that contains a catalyst which splits the positively charged hydrogen ions and negatively charge electrons. The membranes then allow the positive ions to pass through but not the electrons. These electrons must then pass around a circuit which creates an electrical current. At the other side of the membrane the positive ions combine with the electrons and oxygen from the atmosphere to form water vapor which then flows out of the fuel cell forming the exhaust.

Presently there is no infrastructure set up for this fuel at all. There are some hydrogen fueling stations in California that are in use for demonstration vehicles. However, no other fueling stations exist for hydrogen. At the moment there are no vehicles that are available for market. The vehicles that do run on hydrogen have a limited range of about 150 miles. Like ethanol, hydrogen has a low energy density. This makes it difficult to store for long trips. Due to the lack of infrastructure government assistance is required and being given to research providing an infrastructure and better technology. One of the main factors in setting up a hydrogen economy is the creation of safe and dependable fuel storage technology. President Bush recently proposed a multi-year research, development and demonstration program that will last until 2015. A majority of government research is dedicated to this technology, but with the lack of infrastructure and efficient equipment, the hopes for hydrogen as a fuel source are low.

Electric vehicles/Hybrid vehicles

One of the most popular technologies in the alternative fuel industry is the hybrid and electric vehicles. While hybrid vehicles still rely on gasoline for most of their energy production, some of their energy is derived from battery technology that powers a small electric motor. Gasoline is not used for electric vehicles. These vehicles are strictly driven by electricity that is stored in on board batteries. This electricity can come from a variety of different sources that are produced domestically such as coal, nuclear power, wind power, and solar power. While coal does not eliminate green house gas emissions a majority of these different sources drastically reduce dependence on foreign oil and almost eliminate green house gas emissions. Technology pertaining to hybrid vehicles is rapidly advancing toward the production of plug-in hybrid vehicles. Plug-in hybrid vehicles will still use gasoline but also get their energy from on-board electric batteries that are plugged in to charge. This new technology is leading the way as a transition to electric vehicles.

Electric vehicles became first available during the early 1900s. These electric vehicles were a majority of the vehicles on the market around the turn of the century but then as the gasoline powered vehicle became cheaper to buy and the fuel was cheaper to produce, electric vehicles went out of production. Not until the late 1990s did electric vehicles appear on the roads again. In the 1990s, California passed the Zero Emissions Vehicle Mandate which required automakers to sell a specific number of zero emissions vehicles if they wanted to continue to sell vehicles in California. In response to these standards automakers created electric vehicles. In 2001 the Toyota Prius which contained a hybrid gasoline electric engine was introduced to the global market. This vehicle could run on just its gasoline motor, its electric motor or a combination of the two. The hybrid vehicle recharged its batteries by getting power from the gasoline engine or regenerative breaking. As technology continued to improve, Toyota introduced the hybrid synergy drive in 2004 which provided better battery technology and a better computer to assist in the regulation of the vehicles engine usage. The electric vehicle programs were eventually discontinued when the Zero Emissions Vehicle Mandate was removed from law. Currently numerous innovations are becoming available for both electric vehicles and hybrid vehicles.

Electric motors are fairly simple. The energy is stored in batteries and then transferred to mechanical energy using an electric motor. There is no real infrastructure for electric vehicles. However, hybrid technology provides the solution for these vehicles. Hybrid vehicles use gasoline engines to provide energy for the vehicle. This energy not only propels the vehicle but also provides energy that is stored in batteries. When the car is moving slowly or stopped the gasoline motor shuts off and the car runs off the electric motor. If the car requires more power then the car uses the gasoline motor. This is all controlled by an onboard computer that monitors and regulates the use of the two different engines. Technologies differ from one manufacturer to another. Some vehicles have one electric motor that can be supplied with electrical power from either a battery or a gas-powered generator.

Currently there are several cars that are available for market. The major automakers that produce hybrid vehicles are the Asian automakers. The two leaders in this field are Toyota and Honda which both provide hybrid vehicles. These hybrid vehicles provide the best fuel economy of any passenger vehicle. These cars get around 45-60 mpg in city driving and 45-50 mpg in highway driving. The Honda Accord V6 is an example of a vehicle that provides the same speed and power that drivers want but with better performance than conventional gasoline engines.

Of all the alternative fuel vehicles hybrids and electric cars are being researched and produced the most. One of the main research & development goals for hybrids is the plug in hybrid. Other research is being done to create a vehicle that is both a plug in hybrid but utilizes the use of a flexible fuel engine. Research for electric vehicles is in producing better batteries. The newer Lithium-Ion batteries provide for a greater range and efficiency. Some of the concept vehicles being exhibited are the GM volt, Venturi Fetish, and Some plug-in hybrids by Toyota.

The electric vehicle offers the most promising break from our production of green house gases and foreign oil. There needs to be no change in the infrastructure. Battery technology is making leaps and bounds. Solar and wind energy production of electricity are reducing our dependence on fossil fuels. Electric vehicles are the wave of the future. This can be best seen in the production of the Tesla Roadster which runs completely on electricity and goes 0-60 mph in 4 seconds. This car is currently out on the market. However, the demand for these cars is significant. Each roadster gets approximately 250 miles per charge. To fully charge the batteries it takes approximately 3.5 hours. Because this technology is still fairly expensive, this car costs approximately $92,000. However, as technology continues to improve the price of these vehicles will continue to drop and become more affordable.

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[HYBRID] Hybrid Cars.com. Technology. http://www.hybridcars.com/technology.html

[NBD] National Biodiesel Board. Biodiesel Information. http://biodiesel.org/biodieselinformation

Useful Websites:

www.teslamotors.com

www.toyota.com

www.honda.com

www.hybridcars.com

www.afdc.doe.gov/advanced_cgi.shtml

www.fueleconomy.gov/feg/fuelcell.shtml

www.e85fuel.com/index.php

www.biodiesel.org

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www1.eere.energy.gov/hydrogenandfuelcells/

Chapter 11

Chris Helms

GOVERNMENT POLICY

In this chapter, we will take a look at the responses different governments and international institutions around the world have taken to combat this problem as well as current and proposed policies of the various levels of our local city and state governments.

International Responses

To evaluate the potential risks of global climate change to human populations, the World Meteorological Organization and the United Nations Environment Programme installed the Intergovernmental Panel on Climate Change (IPCC) in 1988. Based primarily on the collective scientific peer-reviewed literature on the subject, the IPCC has periodically issued assessment reports in which the prevalence, causality, and future implications of global warming are summarized for the purpose of policymakers around the world.

In 2007, the IPCC is releasing Assessment Report 4 (AR4) building upon findings of previous reports by including scientific advances in the last few years. Released in three parts, this report examines the scientific basis of anthropogenic climate forcing, projected changes in regional climates, and possible approaches in policy regarding greenhouse gas regulations. It largely supports conclusions made in the previous IPCC assessment reports, usually with increased confidence due to more accurate climate models, more advanced statistical methods, and the general accumulation of an ever-growing knowledge base and interest in this topic within the scientific community.

Released in February, part 1 of this report supports the consensus view of scientists that since the eighteenth century, the earth's average temperature, particularly in the polar regions, has increased at alarming rates, ocean levels have risen, and that such changes are a result of increased anthropogenic CO_2 (and other greenhouse gases) emissions since the onset of the Industrial Revolution.

In part 2, released in April, the Working Group focuses on the future implications of global warming on regional climate shifts as well as for human populations among various regions and demographics. The IPCC stated that "climate change is likely to have wide-ranging and mostly adverse impacts on human health, with significant loss of life."

Among the most at risk are those on islands and coastal regions, in large parts of Africa (particularly around the Sahara), and in the southwestern U.S., where severe droughts may become increasingly prevalent. Populations in developing nations are expected to suffer most, as climate instability is likely to exasperate pre-existing social, economic, and ecological problems. Millions of people are expected to become climatic refugees in coming years, possibly (re)igniting boundary and/or ethnic disputes.

In 1998, the United Nations produced the Kyoto Protocol, an ambitious international agreement that aims to reduce emissions of 6 primary greenhouse gases (CO_2, methane, nitrous oxide, sulfur hexafluoride, HFCs, and PFCs) by an average of 5% relative to 1990 emissions, though emissions goals varies widely among individual countries and regions. The goal for the United States was to reduce 1990 emissions levels by 7% by the year 2012, while the EU must reduce emissions by 8%, and Australia can actually increase emissions by over 10%. The average cut represents a 29% reduction from projected 2010 emission levels. Countries that do not meet the emissions regulations may instead engage in emissions trading.

To date, 169 countries have currently signed and ratified the agreement, though China and India have less stringent expectations due to population size and relative level of development. To reduce harmful repercussions on countries' economies, developed nations, called Annex I countries, are held to these standards more strictly. Underdeveloped nations, however, have much looser expectations that better fit their limited capabilities. Since the act was finally passed into law in March of 2005, 35 industrialized countries as well as the European Union have been bound by law to reduce greenhouse emissions.

Australia and the U.S. were signatories, but have since withdrawn from the agreement. Bush refused to submit Kyoto to Congress for ratification because of the exceptions given to China, possible economic restrictions such a commitment may necessitate, and because of uncertainties surrounding the issue (conflicting opinions regarding existence/magnitude of problem and how to properly address it).

In 2005, the U.S. signed the Asia Pacific Partnership on Clean Development and Climate along with Australia, China, India, Japan, and South Korea. Like Kyoto, the stated purpose of this pact is to cut greenhouse emissions, however, each country is free to establish its own standards, and there is no form of enforcement for any violations. As stated previously in 2002, the goal of the U.S. is to reduce carbon emissions by 18% by the year 2012; but, no countries involved have yet to effectively cut emissions since signing.

Federal Government

The United States is the single greatest contributor to anthropomorphic greenhouse gas emissions in the world. With just over 4% of the world's population, the U.S. is responsible for more than a quarter of emissions. The majority of this comes from energy plants that burn fossil-fuels, while about a third comes from automobile emissions. The U.S. is still heavily reliant on hydrocarbons to produce electricity, and our fuel efficiency standards for automobiles are far behind the rest of the world, including China.

Over the last fifty or so years, the Federal government has implemented various laws regarding the conservation of the environment, be it through the regulation of pollutants, the conservation of forests and threatened ecosystems, or the protection of endangered species. Although most of this legislation does not specifically cite global warming and/or greenhouse gases as potential risks worthy of regulation (at least until recently), many of these acts have been quite successful at confronting various other environmental concerns, such as the hole in the ozone layer in the 1990s, and have led to the reduction of some greenhouse gases such as nitrous oxide and carbon dioxide indirectly (due to certain emissions regulations on vehicles).

The Clean Air Act (CAA) of 1970, amended in 1990, identifies air pollutants and sets primary and secondary standards for each, with the primary standard protecting human health, and the secondary standard being based on potential environmental and property damage. An area that meets or exceeds the primary standard is called an attainment area; an area that does not meet the primary standard is called a non-attainment area. An estimated 90 million Americans live in non-attainment areas.

The primary, or "criteria," air pollutants covered by the CAA are ozone, sulfur dioxide (SO_2), particulate matter, lead, nitrogen oxides (NO_x), and carbon monoxide (CO). The CAA also includes specific goals for reducing emissions from all mobile sources. The comprehensive approach to reduce pollution from mobile sources includes requiring cleaner fuels, manufacturing cleaner automobiles, establishing inspection and maintenance programs, and developing regulations for off-road vehicles and equipment.

Despite CAA regulations on various pollutants known to be greenhouse gases, the EPA has not specifically targeted emissions as a source of global warming to date, particularly CO_2. On April 2, 2007, however, the Supreme Court ruled in the case of *Massachusetts vs. EPA* that the EPA does in fact have the power to implement regulations to counteract global warming by including CO_2 (and all greenhouse gases associated with climate change) among the list of pollutants cited in the CAA.

Interestingly, it was the EPA that lost this case citing the economic and political risks of confronting the issue as well as arguing that no clear relationship between climate change and greenhouse emissions has yet been established, and thus it was beyond their power to address CO_2 emissions. Distraught at the possibility of a diminishing coastline, it was Massachusetts and twelve other states that sued the EPA (backed by the Bush administration, nine states and numerous car manufacturers) for neglecting the issue of greenhouse emissions.

The addition of CO_2 to the pollutants under the EPA's control has potentially far reaching consequences as it sets an important (and currently lacking) precedent for the involvement of the Federal government in the current climate crisis. This decision greatly increases the chances of proposed emissions regulations for vehicles and will hopefully help to boost the development of alternative energy industries such as the electric and plug-in hybrid cars. It is important to note, however, that the Supreme Court's ruling does not force the EPA to regulate CO_2 emissions, it just grants them the power and asks them to reconsider their current emissions regulations.

Also on April 2, the Supreme Court ruled on *Duke Energy vs. EPA*, where different interpretations of coal plant modification regulations according to the 1990 amendments to the CAA were being disputed. In the CAA, there is a certain limit to the amount of modifications coal-burning energy plants can make before being replaced with cleaner technology. The Court's ruling in favor of Duke Energy allows certain modifications of coal-burning energy plants to persist that the EPA had not counted on, therefore potentially allowing many more coal-burning plants to stay in operation years longer than they would otherwise.

Among the multitude of possible implications of large-scale climate change is an increase in extinction rates due to the inability of animals and, in particular, plants to adapt at a rate comparable to the relatively fast rate of temperature increase and subsequent shifts in the local ecosystem such as increased predation or competition (see Chapters 3 and 4). According to some large-scale models on future extinction risks associated with global warming, extinction rates in certain "hotspots" may be upwards of 40% in future years. More proximate studies of climate change and extinction risks on populations of rainforest frogs, birds, cold-water marine mammals, and plant species show a similar relationship connecting global warming with a heightened possibility of extinction.

Under the Endangered Species Act (ESA) of 1973, species thought to be heading towards extinction may be listed as *threatened* or *endangered*, thus ensuring certain conservation efforts, such as hunting restrictions and habitat protection. According to the ESA, no government policy may be implemented that promotes the destruction of habitat of any species with a designation of *threatened* or *endangered* on the ESA list.

As a result of this, the diminishing habitat of polar bears as a result of global warming may soon force the federal government to take much more proactive steps to curb our contribution to climate change. Due to the warmer and longer summers, and the resulting decrease in arctic ice shelves as suitable habitat, polar bear numbers have fallen rapidly in recent years and they are currently being considered for designation as a *threatened* species by the U.S. Fish and Wildlife Service. If polar bears are indeed added to the ESA list, then the Federal government will have no choice but to take measures to reduce the destruction of the arctic habitat, and therefore the causes of global warming itself.

Recently, the issue of climate change has been largely coupled with energy policy as policymakers focus attention on fuel efficiency and renewable energy options. The Climate Stewardship Act introduced by McCain and Lieberman in 2003 aimed to reduce emissions using a market-based approach, where emissions levels could be 'traded' among businesses, therefore creating an economically friendly solution. The bill was narrowly rejected by the Senate in 2003 and the House in 2005, and has been largely forgotten since due to Congress' focus on other issues, though this year's Congress has exhibited a renewed interest in this and other such bills.

Many opponents of this bill claim that the required emissions standards will result in a decline in GDP and employment, mainly because of the lack of infrastructure and the presumed lack of a market for alternative energy industries. According to a study from 2005, however, implementation of the CSA would result in a net increase in overall employment and GDP over time.

In this study, a model projecting the CSA's effect on employment and GDP was used compare job numbers and GDP to those of 2005 (it assumed CSA implementation in 2005). In the case of employment (Figure 1), a slight initial dip (-0.01%) would be expected by 2010 (five years after the baseline) for both Ohio jobs and the national mean. In subsequent years, however, as the marketplace and big businesses adjust, employment should increase substantially. The CSA would increase total jobs by more than 0.3% by ten years after the baseline, and after twenty years, the national mean would increase by nearly 0.5% with Ohio experiencing an even larger increase (+0.53%).

A similar trend is projected for the U.S. GDP (Figure 2). After the first five years or so, the national GDP would decrease by about $5 billion (0.04% decrease in total GDP). Once the infrastructure and market have had time to sufficiently adapted, GDP is expected to rise by $18 billion (+0.11%) relative to baseline after 10 years, $30 billion (+0.16%) after 15 years, and $45 billion (+0.21%) twenty years after implementation.

In 2006, the Government Accountability Office (GAO) published a report entitled “Key Challenges Remain for Developing and Deploying Advanced Energy Technologies to Meet Future Needs.” The document points out that the Department of Energy's budget for Research and Development has decreased by more than 85% from 1978 to 2005. After peaking in the late 1970s due to the oil shortage, funding dropped sharply in the 1980s as oil prices declined again. The report concluded that Congress should consider adopting a more diversified energy portfolio by focusing R&D funding on advanced energy technologies.

Similar conclusions were reported by the Climate Change Science Program. This Program, implemented by Bush to address 'unresolved questions' about climate change, found that the earth is in fact warming, and that such warming can not be attributed solely to natural causes. The Program is reported that the change is likely man-made and a result of greenhouse emissions. Though many Republicans remained skeptical, this document finally convinced many in Washington that human-driven global warming exists.

In his 2006 State of the Union address, President Bush introduced the Advanced Energy Initiative (AEI), which provides for a 22% funding increase for clean-energy technology research at the Department of Energy. The goal of AEI is to reduce U.S. dependence on foreign sources of energy and transform the national energy economy by promoting the development of cleaner sources of electricity production. The President’s 2008 budget request includes $2.7 billion to advance the AEI, a 26% increase above his 2007 request of $2.1 billion, and 53% above the 2006 allotment.

In 2007's State of the Union, Bush announced his Twenty in Ten plan, which aims to cut gasoline consumption by twenty percent over the next ten years. In order to accomplish this objective, this plan includes the following two propositions:

1. Setting a national mandatory fuels standard requiring the use of 35 billion gallons of renewable and alternative fuels by 2017. This is nearly five times the 2012 target now in law and would reduce projected annual gasoline use by 15% in the year 2017.

2. Reforming and modernizing Corporate Average Fuel Economy (CAFE) standards for cars and extending the current light truck rule. This would reduce projected annual gasoline use by as much as 8.5 billion gallons by 2017, representing a further 5% drop in gasoline use.

The Energy Information Administration, however, projects that fossil fuels will remain the nation’s primary source of energy for decades. The Gulf of Mexico and the outer continental shelf (OCS) have received a lot of attention recently as policy-makers debate opening up more area to drilling for oil and natural gas. In August of 2006, the Senate passed the Gulf of Mexico Energy Security Act, which would open 8.3 million acres in the eastern Gulf of Mexico to new oil and gas drilling. The House of Representatives have passed a similar, yet much broader, bill called the Deep Ocean Energy Resources Act. The House bill would lift the 25-year moratorium on drilling for oil and natural gas off most of the U.S. coastline, though states do have the option to maintain an offshore drilling ban within 100 miles of their coastlines.

Despite its focus on petroleum, the House bill does address the growing demand for scientists and skilled employees in the energy industries. Within the bill, part of the federal revenue generated from offshore drilling royalties would fund the Energy and Mineral Schools Reinvestment Fund Act (EMSRA). This money would be distributed to petroleum, mining, applied geology and geophysics schools for research, education, and to encourage the growth of professionals in energy related fields. The bill provides additional funds for K-12 science education, and would also establish the National Geo Fund for geologic mapping, geophysical and other seismic studies, earthquake monitoring programs, and preservation and use of geologic and geophysical data.

On January 18th, the House passed the Creating Long-Term Energy Alternatives for the Nation Act, or the CLEAN Energy Act of 2007, in a 264 to 163 vote. Passed within Congress's first 100 hours, this legislation is designed to reduce the nation's dependency on foreign oil by investing in clean, renewable, and alternative energy resources.

The bill, which has yet to pass the Senate, would amend the Energy Policy Act of 2005 to repeal tax incentives for domestic oil and natural gas production. It would also require companies to renegotiate 1998 and 1999 leases in the Gulf of Mexico that lack price thresholds triggering royalty payments.

Some Democrats have estimated that the bill would add about $14 billion to federal assets. This money would be directed to a "strategic energy efficiency and renewable energy reserve," which would be used to pay for subsequent legislation regarding the research and development of clean renewable energy technologies.

Representative Ed Markey (D-MA) said "We will begin to move in a new, clean direction on energy and put an end to the free ride that big oil has had under the Bush Administration and this bill is a beginning. It is the beginning of a change in direction, away from subsidizing an industry that doesn't need extra financial incentives, and towards the technologies that do need a helping hand."

The bill, however, does not currently have widespread support. Although 36 Republicans voted in favor of this bill in the House, it is expected to encounter significant opposition from the rest of the Republican Party. Representative Cliff Stearns (R-FL) has voiced his opposition to the bill, saying it "will raise energy prices for American consumers, stifle domestic energy production, and increase our dependence on foreign sources of energy."

State of Ohio

In June of last year, the Ohio Environmental Council released the Ohio Climate Road Map, laying out the effects of climate change in Ohio as well as recommended policy approaches. In this report, the Council recognizes seven general areas policymakers can focus on to combat this problem. The following are seven broad areas of opportunity for policy and market action that Ohio should consider.

1. Actions industry and government could take to increase technological and industrial innovation and strengthen research and development efforts.

- *Expansion and diversification of the Third Frontier Initiative.* While much of the initial impetus for the Third Frontier Initiative has been based on fuel cells, the initiative should broaden its focus and include other climate change solution technologies.
- *Greenhouse Gas Emissions Registry.* Ohio should develop a statewide registry of Greenhouse Gases. In addition to providing

better insight to emissions from Ohio, it would also help Ohio businesses apply reductions to future federal regulations.

- *Hydrogen-methane infrastructure research and development.* In order to make hydrogen practical in the long run, Ohio should expand focus on research and development of infrastructure for the use of hythane (a mixture of natural gas and hydrogen) in Ohio's existing natural gas distribution system.
- *Improved coordination of government and industry research and development and investment activities.* Public and private research and development activities in Ohio, including Third Frontier, the Ohio Coal Development Office, the Midwestern Regional Carbon Sequestration Project, and potential private investment efforts should be more efficiently tracked and coordinated by state government.
- *Initiate and/or participate in credit trading programs.* More companies, governments, and businesses in Ohio should participate in carbon credit trading programs. Ohio should consider establishing a small-scale public greenhouse gas purchase program as an incentive for local near-term carbon reduction innovations.

2. Clean Air Initiative. Diesel particulate matter, a significant contributor to climate change, is a major source of air quality problems in Ohio. Ohio should launch a diesel cleanup initiative that reduces diesel emissions, particularly carbon emissions.

3. Modernize the Electric System. Ohio's electrical system is aging, and new investments could focus on innovative technologies, rather than conventional solutions, that avoid large future emissions.

- *Develop new low-carbon generation capacity* - avoid building new conventional coal fired power plants and encourage the deployment of IGCC (coal gasification) plants and renewable energy. Ohio should also phase out existing plants and replace them with newer technologies.
- *Greater investment in cost-effective energy efficiency.* Ohio should address regulatory and market barriers that have held back greater use of combined heat and power (CHP). Small and midsized companies should consider pooling their potential interests to leverage the development of third party services to help develop CHP projects. Ohio should also consider building on existing or creating new efforts to promote efficiency by electricity customers.

4. Transition to New Travel and Freight Systems. New fuels and engine advances will be required for travel and freight systems to meet a future low-carbon goal. While meeting the ultimate goal will be challenging, there are important near-term steps Ohio can take.

- *Use of biofuels.* The State of Ohio has incentive programs already in place for ethanol, but those incentives should be tailored to more advanced biofuels and bio-products. Ohio should also consider minimum biofuel blending requirements for ethanol and biodiesel.
- *Use of efficient vehicles.* The State of Ohio should gear government procurement toward purchasing the most fuel efficient vehicles. Ohio should also consider tax incentives and research and development investments to help the auto industry manufacture newer engine technologies, including hybrid-electric vehicles and computer-aided combustion engines.

5. Update Heating and Industrial Systems. To meet stabilization targets, the natural gas sector must also be a focus.

- *Increase end-use efficiency.* In addition to electric efficiency programs, Ohio should engage in similar efforts relating to natural gas use.
- *Use of hythane.* Ohio should encourage the short-term exploration of low percentage hydrogen hythane use by creating tax incentives and funding the development of such technology.
- *Industrial-scale IGCC.* Ohio policies should promote the development of industrial scale

IGCC in order to help address carbon reduction from industrial coal use.

6. Reduce Methane Emissions. The state could develop incentive and technology development programs to reduce emissions from landfills, coal mines, feedlots, and wastewater treatment facilities.

- *Methane trading program* - establish a statewide program for meeting methane reduction goals and trading methane credits (much like Kyoto and the CSA). Ohio could also help by encouraging the participation of methane-emitting businesses and industries in the EPA's Methane to Markets program.
- *Reduce emissions from landfills, feedlots, and coal mines* - make methane reduction a priority in any technology portfolio program. Ohio should also encourage deployment of landfill gas use technologies and bio-digesters for feedlots and development of wastewater methane capture technologies.

7. Use Agricultural and Forestry Practices

- *Incentives for no-till farming* - adopt tax incentives and crop insurance programs to encourage greater use of conservation tillage.
- *Develop accounting system standards* - work with the agricultural sector, the forestry industry, and non-governmental organizations to develop accounting and monitoring standards for carbon sequestration.

Former Governor Bob Taft had expressed interest in developing alternative energies throughout his 8-year (1999-2007) term in office. Much of his focus seemed to be on the development of hydrogen fuel cells and ethanol. Taft's commitment to develop the E85 industry included:

- Doubling E85 ethanol use in the state fleet from 30,000 gallons to 60,000 gallons per year by January 1, 2007. After 2007, Ohio will increase E85 usage by 5,000 gallons each year
- Increasing biodiesel use in the state fleet by 100,000 gallons annually starting in 2007.
- Purchasing only flex-fuel vehicles that can run on both regular gasoline and E85 ethanol blend as state vehicles are replaced. Ohio already has 1,710 flex-fuel vehicles
- Using E85 pump conversion grants to triple the amount of E85 pumps available to Ohio consumers by the end of 2006

In 2002, the Ohio Fuel Cell Coalition passed the Fuel Cell Initiative, a $103 million 3-year program (renewed in 2005 until 2008) focused on the research, development, and implementation of fuel cell technology. In this scheme, $10 million is requested from the Technology Action Board to help fund competitive technology development and commercialization.

$15 million goes towards funding research and development projects, particularly the development of clean hydrogen sources such as coal gasification and hot gas cleanup technologies. In this process, hydrocarbons are heated with steam (not burned) and are broken down into their gaseous components creating *syngas*, which is a mixture of mostly hydrogen and carbon monoxide.

Most impurities in the fuel do not become gas and are immediately left behind. Other pollutants, such as sulfur impurities and ammonia, are easily extracted, leaving a much cleaner source of fuel to be burned. This process can then release CO_2 in a concentrated gas stream, thus making it easier and cheaper to sequester.

Also, $75 million goes towards financing incentives for companies, with $15 million for investments supporting job retention, and up to $60 million (or $20 million per year) in tax incentives for companies employing energy saving practices. Finally, the initiative includes $3 million to assist in the proper training of employees at Ohio fuel cell companies as well as a loan program that offers loans (max of $250,000 per project) with interest rates ~50% lower than the market rates for energy efficiency costs.

Unfortunately, these efforts have not resulted in much progress. To date, there are only 33 E85 refueling stations in Ohio (6 within a 25-mile radius of Cincinnati), 29 open to the public and 4 restricted to government use only. Five more stations have been planned, but are not yet in service. There are currently no hydrogen refueling stations in operation in Ohio.

A wind map of Ohio recently revised by the Department of Development suggests far greater wind resources in Ohio than previously thought. In response, $25 million has been set aside for more wind power production over 5 years as well as for grants of up to 1.2 cents per kilowatt-hour of electricity produced from wind. Though this industry is still in its infancy, officials have high hopes that wind may provide a steady source of renewable energy in the future as well as create new jobs.

Other energy saving policies include the proposition of using $3.6 million from Energy Loan Fund to build 40 energy-efficient government buildings, implementing minimum educational requirements for state building operators to increase energy efficiency, and establishing an Energy Standards and Reporting Task Force to evaluate government operations and propose ways of increasing efficiency and conservation.

Cincinnati/Hamilton County

In June of 2006, Cincinnati Mayor Mark Mallory signed the U.S. Mayors Climate Protection Agreement, making Cincinnati the largest city in Ohio to sign the agreement. The primary objective of this document is to at least meet the minimum requirements of Kyoto Protocol, with more ambitious policies being adopted by many mayors across the U.S. It also addresses urban sprawl, public transportation, alternative energy, green buildings, and education among others.

This agreement stresses the need for methane recovery for energy generation, wind and solar energy, more efficient automobiles, bio-fuels, and hydrogen fuel cells. Also cited is the need for Congress to pass the Climate Stewardship Act sponsored by Senators McCain and Lieberman and Representatives Gilchrist and Olver. This Act would create a flexible, market-based system of tradable allowances among emitting industries, not unlike the Kyoto agreement.

In order to meet the expressed goal of meeting or exceeding Kyoto Protocol targets for reducing anthropogenic greenhouse gas emission by taking the following actions:

1. Inventory greenhouse emissions in City operations and in the community, set reduction targets and create an action plan.
2. Adopt and enforce land-use policies that reduce sprawl, preserve open space, and create compact, walkable urban communities;
3. Promote transportation options such as bicycle trails, commute trip reduction programs, incentives for car pooling and public transit;
4. Increase the use of clean, alternative energy by, or example, investing in “green tags”, advocating for the development of renewable energy resources, and recovering landfill methane for energy production;
5. Make energy efficiency a priority through building code improvements, retrofitting city facilities with energy efficient lighting and urging employees to conserve energy and save money;
6. Purchase only Energy Star equipment and appliances for City use;
7. Practice and promote sustainable building practices using the U.S. Green Building Council’s LEED program or a similar system;
8. Increase the average fuel efficiency of municipal fleet vehicles; reduce the number of vehicles; launch an employee education program including anti-idling messages; convert diesel vehicles to bio-diesel;
9. Evaluate opportunities to increase pump efficiency in water and wastewater systems; recover wastewater treatment methane for energy production;
10. Increase recycling rates in City operations and in the community;
11. Maintain healthy urban forests; promote tree planting to increase shading and to absorb CO_2; and
12. Help educate the public, schools, other jurisdictions, professional associations, business and industry about reducing global warming pollution.

In addition to signing this agreement, Mallory has been appointed to the U.S. Mayors Council on Climate Protection, which meets to discuss possible programs and policies regarding environmental issues. Mallory has also established the Office of Environmental Quality and has included funding for this agency in the 2007-2008 budget. The OEQ will work to enforce laws regulating odors and toxic emissions.

He has also started the Green Initiative along with the Cincinnati Parks Department. This program includes using solar and wind energy to power government facilities, a biofuel initiative to buy alternative fuels for the city's vehicles, and solar-powered garbage cans/trash compactors in city parks. The plan also involves an urban reforestation project to increase Cincinnati's tree canopies, a land management program to reduce mowing and conserve energy, and more education on environmental and conservation issues in schools.

Local policies likely to be pursued include replacing gasoline-fueled cars with hybrids, and running city buses on bio-diesel. In light of the recent Supreme Court judgment that established carbon dioxide as a CAA listed pollutant, far stricter vehicle regulations may soon be enacted in Cincinnati (and the rest of the country) making emissions goals and the development of alternative energies much more feasible than before.

Is it enough? What other steps should be taken?

Although government officials have expressed concern for the climate, have suggested numerous initiatives, and have spent billions of dollars investigating the problem, it seems as though very little has actually been done to take on climate change by the federal government. Perhaps this is due to climate change not being a high enough priority for the government, especially in light of all the attention and resources being devoted to foreign policy issues at the moment.

Of course, the first step is for policy-makers to realize the urgency of the situation. In a recent poll of Congressmen, 41 out of 42 (98%) Democrats believe in man-made pollution while only 8 out of the 35 (23%) Republicans asked agreed. The general explanation given by Republicans is that, while the earth seems to be warming, the future implications of this change are still unclear as is the role of humans. This position is clearly inconsistent with that of scientists as well as most other policy-makers around the world.

In addition to the need to further develop alternative energy industries and markets, the government should implement and enforce a cap on carbon emissions. Those opposed to an emissions cap argue that imposed regulations would only result in unnecessary bureaucracy and inhibit down the free-markets ability to adapt.

However, many CEOs of big businesses (i.e. Duke Energy) are actually in favor of such regulations. The businesses realize that they need to change, but are afraid that if they take the first step, they will lose profits to the competition. If emissions regulations are in place, however, owners know that everyone must oblige by the same standards. This should therefore stimulate the free-market to adapt more rapidly than just waiting for businesses to come around on their own.

An emissions cap could be implemented in concert with an emissions trading program (such as Kyoto or the CSA) to further stimulate the market. In addition, the laws that are already in place need to be better enforced. Much of the pollution occurring today is in fact already illegal in some manner, but many violations go without retribution.

Whether through enforcing existing laws or implementing new policies, it is crucial that our government devotes the time and resources needed to seriously take one this problem. Policy-makers need to adopt an honest proactive approach to this crisis in order to effectively uphold their duty as our nation's leaders and secure a safer future for our world.

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