Appendix A

Lesson 1 Worksheet Package: Carbon Dioxide and Global Warming (answer graph included)

Name:

Carbon Dioxide and Global Warming

Part A: Carbon Dioxide Levels Around the World

Use figures 1 and 2 to answer the following questions.

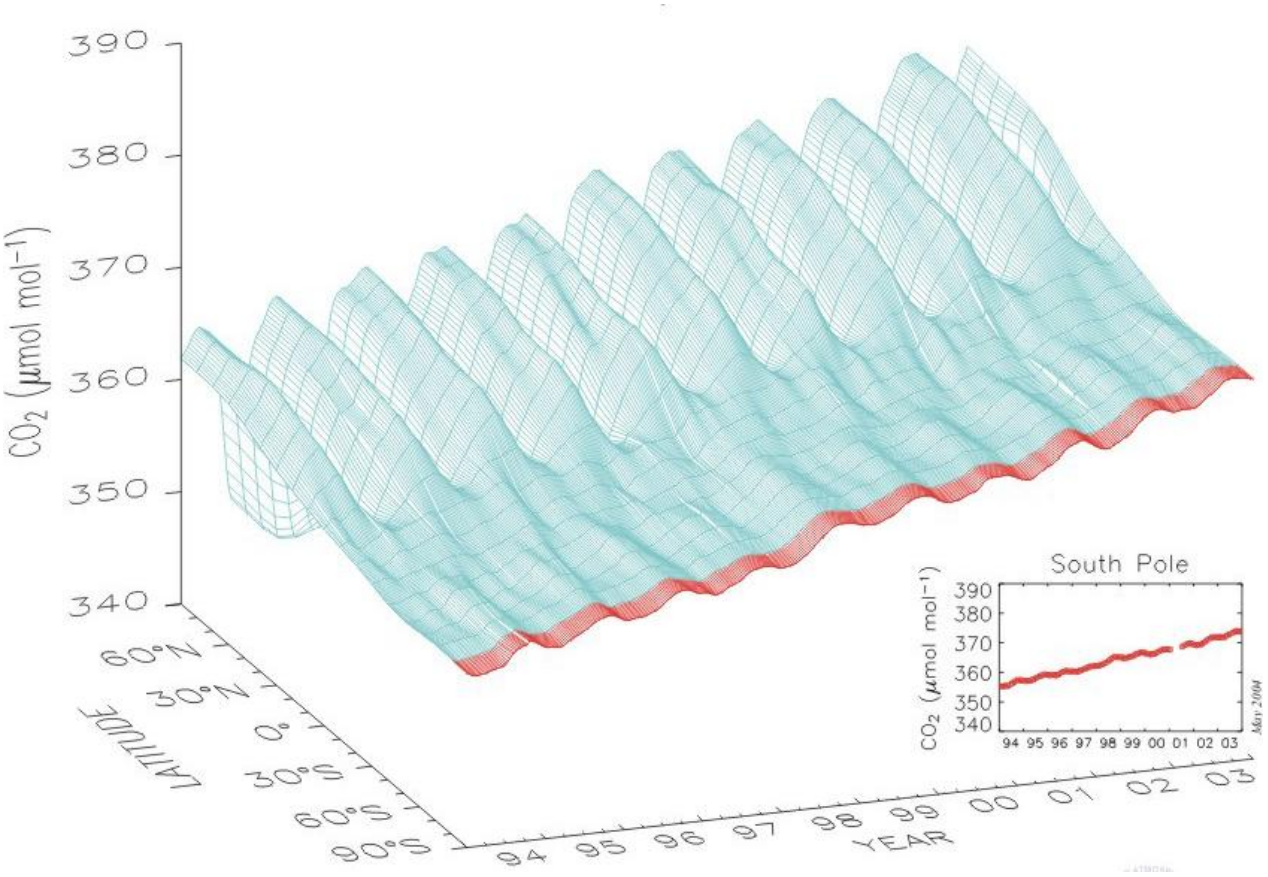


Figure 1: Global Carbon Dioxide Concentrations based on Latitude, Season and Year

Source: National Weather Service: Climate Prediction Center

1. Compare the carbon dioxide concentration between the Northern and Southern Hemispheres.

_____

_____

_____

_____

2. Explain what would account for the differences between the Northern and Southern Hemispheres. (hint: think about the amount of land in each hemisphere)

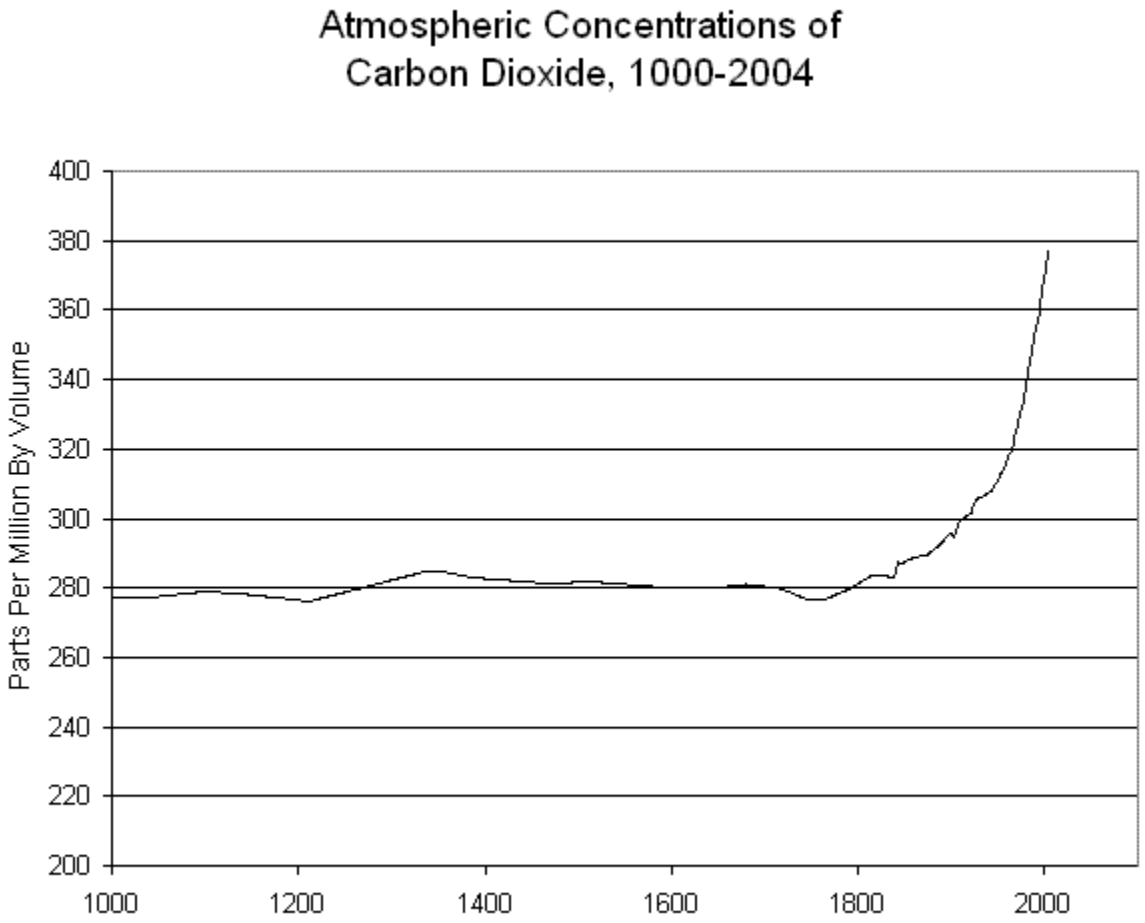


Figure 2a: Atmospheric Carbon Dioxide Concentrations over the last 1000 years.

Source: Earth Policy Institute: http://www.earth-policy.org/Indicators/Temp/2006Temp_data.htm

Insert the image for Atmospheric Carbon Dioxide Concentrations for Alert Station Canada 82.5° N here from the following link:

http://cdiac.ornl.gov/trends/co2/graphics/alt45e_thrudc04.pdf

Figure 2b: Atmospheric Carbon Dioxide Concentrations for Alert Station Canada 82.5° N.

Insert the image for Atmospheric Carbon Dioxide Concentrations for Mauna Loa Hawaii 19.5° N here from the following link:

http://cdiac.ornl.gov/trends/co2/graphics/mlo145e_thrudc04.pdf

Figure 2c: Atmospheric Carbon Dioxide Concentrations for Mauna Loa Hawaii 19.5° N.

Insert the image for Atmospheric Carbon Dioxide Concentrations for the South Pole 90° S here from the following link:

http://cdiac.ornl.gov/trends/co2/graphics/spo121e_thrudc04.pdf

Figure 2d: Atmospheric Carbon Dioxide Concentrations for the South Pole 90° S.

The Cost of Global Warming

When the levels of carbon dioxide are higher in the northern hemisphere (during winter) they are lower in the southern hemisphere (during summer) and the opposite is also true. Explain why this occurs. (hint: think about the vegetation during these months)

3. Why would the carbon dioxide concentrations get higher the closer the samples are taken to the North and South Pole?

4. What trend do Figures 1 and 2 indicate is happening to the concentration of carbon dioxide over time?

5. What might account for this trend?

6. Carbon dioxide is a greenhouse gas. What effect might this trend in carbon dioxide have on global temperatures?

Part B: Carbon Dioxide and Global Warming

Table I: Changes in Average Annual Carbon Dioxide Concentration for Mauna Loa Hawaii (19.5° N) and Global Average Annual Temperature for 1958 - 2005

Year	Average Annual CO2 Concentration	Average Annual # Temperature (°C)	Year	Average Annual CO2 Concentration	Average Annual Temperature (°C)
1958		14.10	1982		14.10
1959		14.05	1983		14.34
1960		13.98	1984		14.16
1961		14.10	1985		14.13
1962		14.05	1986		14.19
1963		14.03	1987		14.35
1964		13.65	1988		14.42
1965		13.75	1989		14.28
1966		13.93	1990		14.49
1967		13.98	1991		14.44
1968		13.91	1992		14.16
1969		14.00	1993		14.18
1970		14.04	1994		14.31
1971		13.90	1995		14.47
1972		13.95	1996		14.36
1973		14.18	1997		14.40
1974		13.94	1998		14.71
1975		13.98	1999		14.44
1976		13.79	2000		14.41
1977		14.16	2001		14.56
1978		14.07	2002		14.70
1979		14.13	2003		14.64
1980		14.27	2004		14.60
1981		14.40	2005		14.77

Source: Earth Policy Institute: http://www.earth-policy.org/Indicators/Temp/2006Temp_data.htm

Insert data for Average Annual CO2 Concentration from the Annual-Fit column of the table located at the following link: http://cdiac.ornl.gov/ftp/trends/co2/maunaloa.co2

8. Plot a double line graph (with a double y-axis) for the carbon dioxide levels and average annual temperature on the axis provided.

9. What impact are the increasing levels of carbon dioxide in our atmosphere having on global temperature?

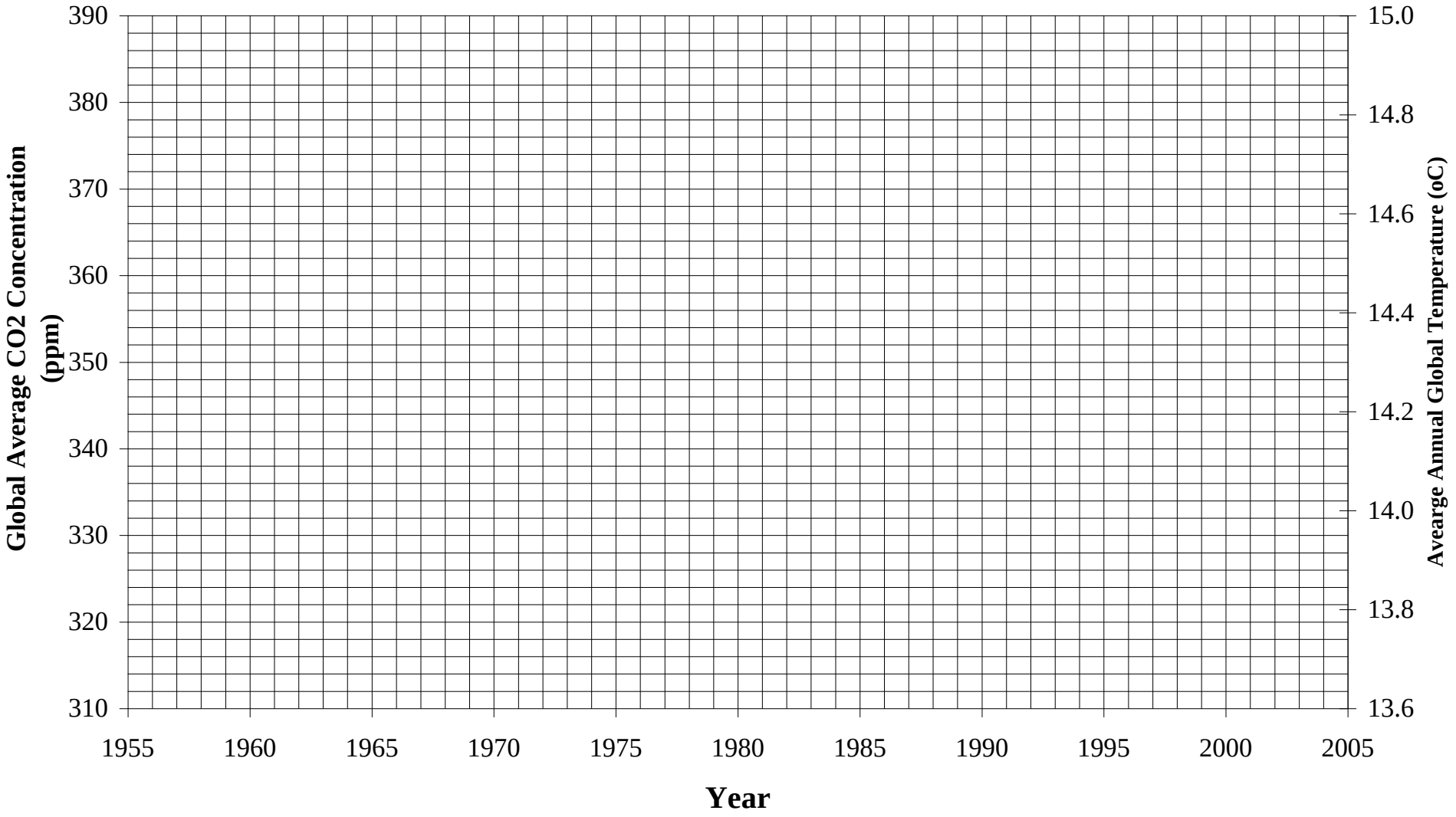
10. What types of activities are causing the increase in atmospheric carbon dioxide concentration?

11. Explain how the greenhouse effect works.

12. If this increase in global temperature continues what types of environmental problems might this cause for our ecosystems and society?

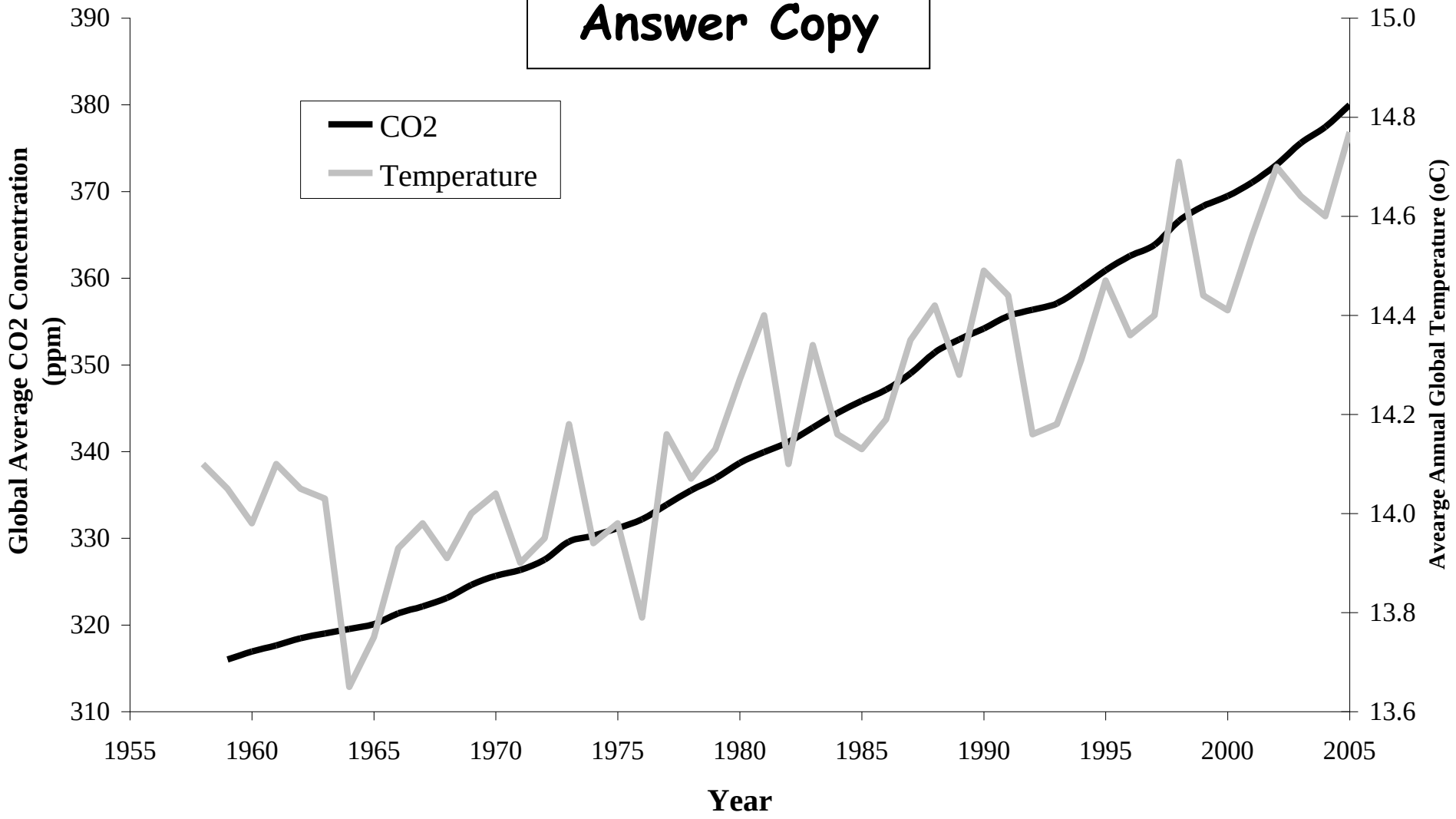
13. Average annual global temperatures are estimated (based on current trends) to rise as high as $18^{o}C$ by the year 2100. What things can people do to decrease the amount of carbon dioxide they produce and therefore reduce the amount of global warming that occurs?

Atmospheric Carbon Dioxide and Temperature Trends (1958 - 2004)



Atmospheric Carbon Dioxide and Temperature Trends (1958 - 2004)

Answer Copy



Appendix B

Lesson 2 Worksheet Package: Hurricanes and Global Warming (answer graph included)

Hurricanes and Global Warming

Name: _____

1. Draw an annotated diagram (diagram with descriptive labels) explaining how a hurricane is formed.

2. Describe the conditions that lead to hurricane formation.

_____

_____

_____

_____

_____

Table I: The Saffir-Simpson Hurricane Scale

Category	Wind Speed	Description
1	119 – 153 km/h	No real damage to buildings. Damage to unanchored mobile homes. Some damage to poorly constructed signs. Also, some coastal flooding and minor pier damage.
2	154 – 177 km/h	Some damage to building roofs, doors and windows. Considerable damage to mobile homes. Flooding damages piers and small craft in unprotected moorings may break their moorings. Some trees blown down.
3	178 – 209 km/h	Some structural damage to small residences and utility buildings. Large trees blown down. Mobile homes and poorly built signs destroyed. Flooding near the coast destroys smaller structures with larger structures damaged by floating debris. Terrain may be flooded well inland.
4	210 – 249 km/h	More extensive curtain wall failures with some complete roof structure failure on small residences. Major erosion of beach areas. Terrain may be flooded well inland.
5	>250 km/h	Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. Flooding causes major damage to lower floors of all structures near the shoreline. Massive evacuation of residential areas may be required.

The Cost of Global Warming

Table II: Number of Hurricanes and the Corresponding Average Annual Temperature by Decade 1881 - 2005

Years	Saffir-Simpson Hurricane Category*					All Hurricanes	Major Hurricanes	Average Global Temperature (°C)#
	1	2	3	4	5	1,2,3,4,5	3,4,5	
1881-1890	8	9	4	1	0	22	5	13.8
1891-1900	8	5	5	3	0			13.7
1901-1910	10	4	4	0	0			13.7
1911-1920	10	4	4	3	0			13.8
1921-1930	5	3	3	2	0			13.9
1931-1940	4	7	6	1	1			14.0
1941-1950	8	6	9	1	0			14.1
1951-1960	8	1	5	3	0			14.0
1961-1970	3	5	4	1	1			13.9
1971-1980	6	2	4	0	0			14.0
1981-1990	9	1	4	1	0			14.3
1991-2000	3	6	4	0	1			14.4
2001-2004	4	2	2	1	0			14.6
2005	7	1	2	1	4			14.8

*Source: National Weather Service: National Hurricane Center

 # Source: Earth Policy Institute: http://www.earth-policy.org/Indicators/Temp/2006Temp_data.htm

3. Calculate the number of hurricanes (category 1 -5) and major hurricanes (category 3 – 5) that have occurred since 1881 and place the answers in the appropriate box in Table II.

4. Plot a bar graph showing the number of major hurricanes per decade using the axis provided and the information in Table II. Then add the average global temperature as a line graph using a second y-axis (on the left). (Note: the last two entries are not for a full decade data, but instead for five years (2000 - 2004) and a single year (2005))

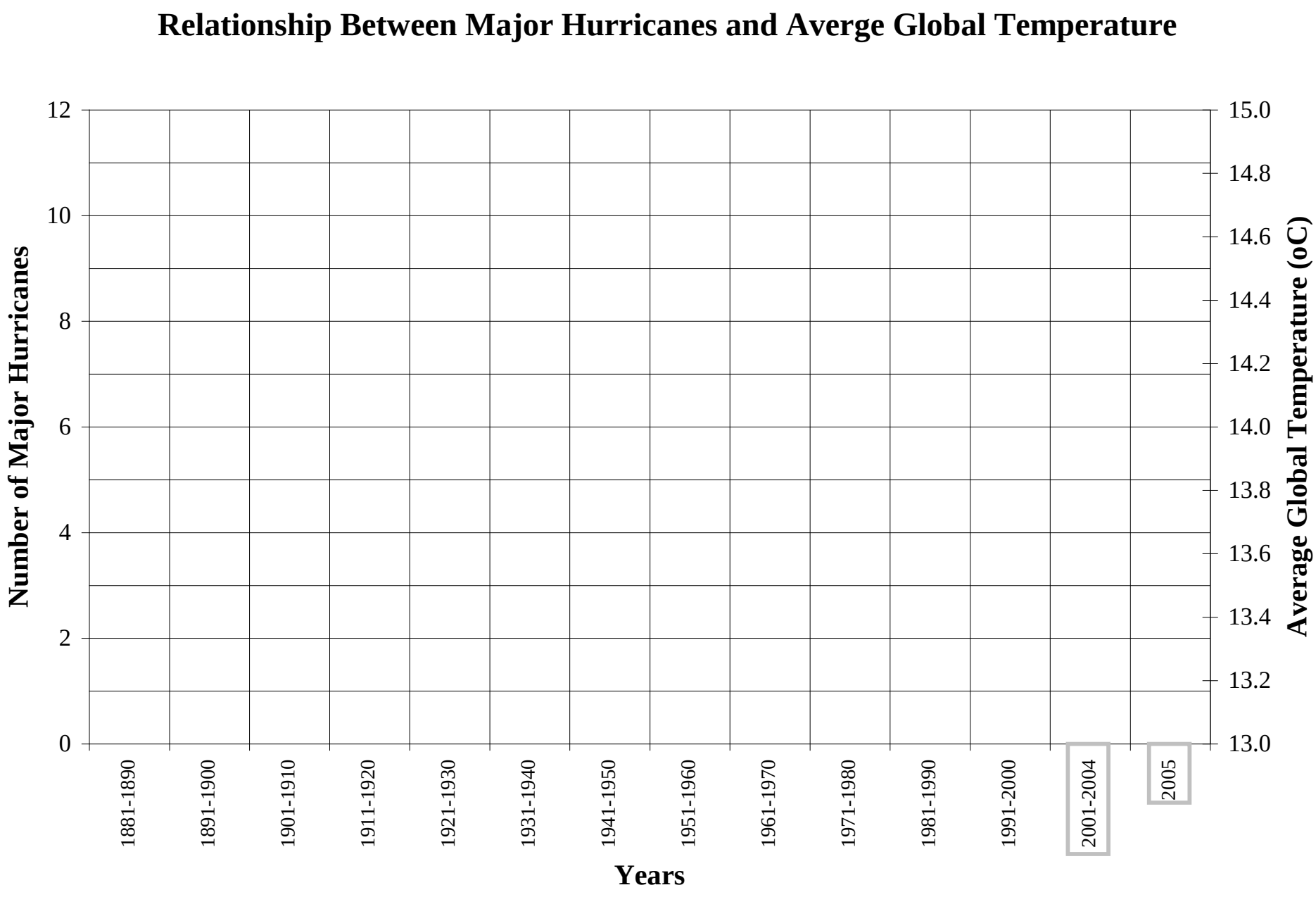
5. What relationship does there appear to be between average global temperature and the number of major hurricanes that occur?

6. What possible reason is there for this correlation?

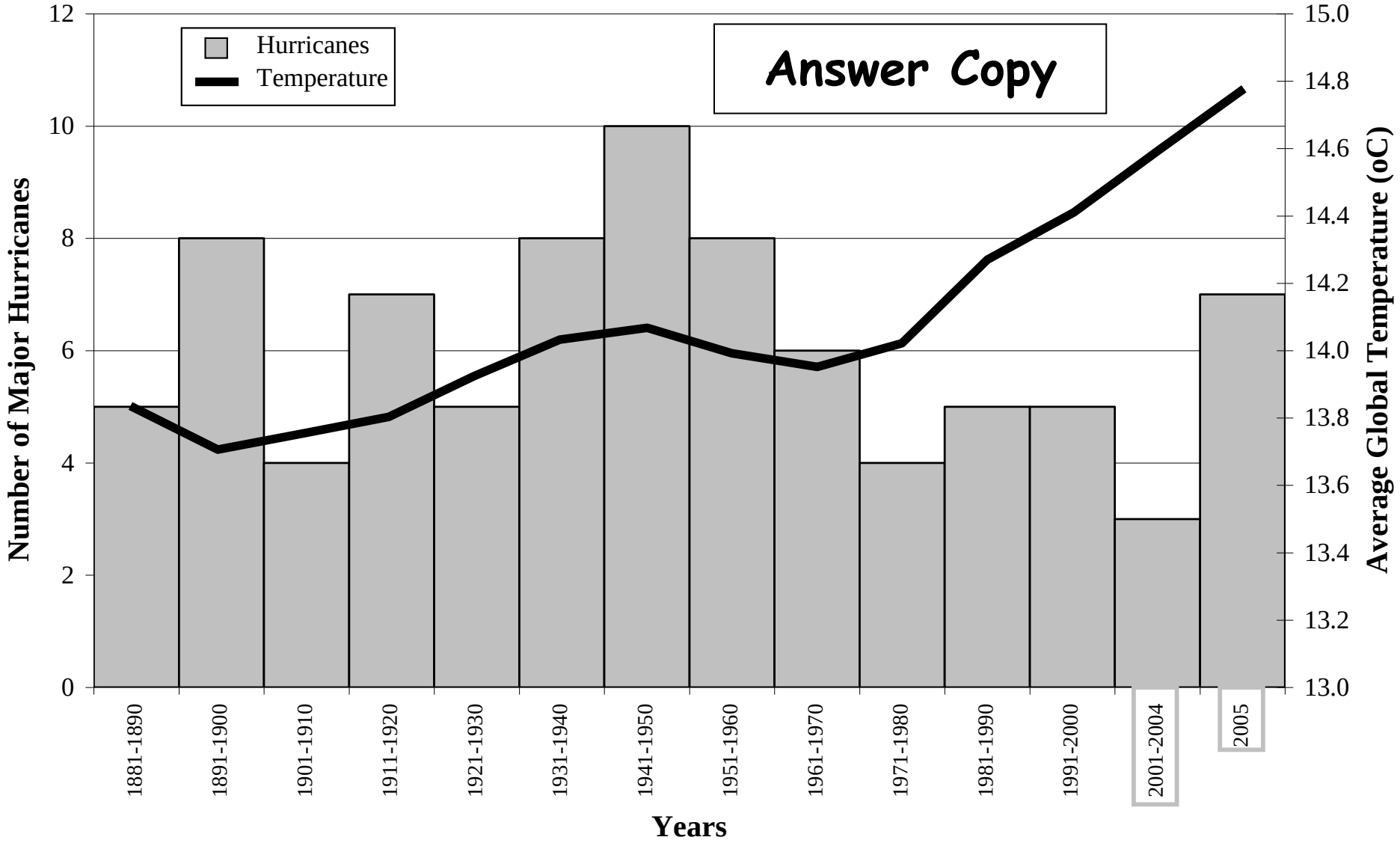
7. The last two entries for the graph are for only five years (2000 - 2004) and a single year (2005) not a complete decade. What does this indicate for future trends in major hurricane numbers?

8. Based on your knowledge of carbon dioxide levels and global warming do you feel that to some extent the increase in the number of major hurricanes could be linked to increased carbon dioxide emissions based on human activities? Explain your answer.

9. If hurricanes are causing major damage to property (and the resulting cost to fix that property) what could people do to directly and indirectly help prevent such damage in the future?


Relationship Between Major Hurricanes and Averge Global Temperature
Number of Major Hurricanes
Average Global Temperature (oC)
Years
0
2
4
6
8
10
12
13.0
13.2
13.4
13.6
13.8
14.0
14.2
14.4
14.6
14.8
15.0
1881-1890
1891-1900
1901-1910
1911-1920
1921-1930
1931-1940
1941-1950
1951-1960
1961-1970
1971-1980
1981-1990
1991-2000
2001-2004
2005

Relationship Between Major Hurricanes and Averge Global Temperature



Appendix C

Lesson 3 Worksheet Package: The Cost of Hurricanes (answer graph included)

The Cost of Hurricanes

Name:_____

Table I: The 20 Most Costly Hurricanes in US History (in $US and Adjusted to 2004 $US) *Source: National Weather Service: National Hurricane Center

Rank	Year	Hurricane Name	Hurricane Category	Cost at the time of the Hurricane $US
1	2005	Katrina	5	80.0
2	1992	Andrew	5	26.5
3	2005	Wilma	5	21.0
4	2004	Charley	4	15.0
5	2004	Ivan	3	14.2
6	2005	Rita	5	12.0
7	2004	Frances	2	8.9
8	1989	Hugo	4	7.0
9	2004	Jeanne	3	6.9
10	2001	Allison	Trop. Storm	5.0
11	1999	Floyd	2	4.5
12	2003	Isabel	2	3.4
13	1996	Fran	3	3.2
14	1995	Opal	3	3.0
15	1979	Frederic	3	2.3
16	1972	Agnes	1	2.1
17	1983	Alicia	3	2.0
18	1991	Bob	2	1.5
19	1985	Juan	1	1.5
20	1969	Camille	5	1.4

Rank	Year	Hurricane Name	Hurricane Category	Cost Adjusted to 2004 $US
1	2005	Katrina	5	80.0
2	1992	Andrew	5	43.7
3	2005	Wilma	5	21.0
4	2004	Charley	4	15.0
5	2004	Ivan	3	14.2
6	1989	Hugo	4	12.3
7	2005	Rita	5	12.0
8	1972	Agnes	1	11.3
9	1965	Betsy	3	10.8
10	2004	Frances	2	8.9
11	1969	Camille	5	8.9
12	1955	Diane	1	7.0
13	2004	Jeanne	3	6.9
14	1979	Frederic	3	6.3
15	1938	NEW ENGLAND	3	6.0
16	2001	Allison	Trop. Storm	5.8
17	1999	Floyd	2	5.8
18	1944	NE U.S.	3	5.4
19	1996	Fran	3	4.5
20	1983	Alicia	3	4.4

The Cost of Global Warming

1. Why would the 20 most damaging hurricanes (by cost) be ranked in $US at the time of the hurricane and also adjusted so that they are all equally based on the 2004 $US?

2. Based on the data for cost adjusted to 2004 $US fill in the following table.

Decade	Number of Hurricanes for the Time Period	Total cost of Damage for the Time Period (billions of $US)
Before the 1970's		
1970's		
1980's		
1990's		
2000's		

3. Using the information you have entered in the table above, what trend do you see with regards to the number of major hurricanes and the cost of those hurricanes.

4. Construct a scatter plot for the cost of a hurricane and the year it occurred on the axis provided. Use a different symbol for the $US and adjusted to 2004 $US data sets.

5. Using the graph you have created describe and account for the difference in distribution of points for the two data sets.

6. Does the information on the graph support you answer to question 3. Explain your answer.

7. Using the information form Figures 1 and 2 explain why the damage of Hurricane Katrina could have been much worse than it was.

8. Using Figures 3 and 4 explain the cost (financial and emotional) that major hurricanes can have on people.

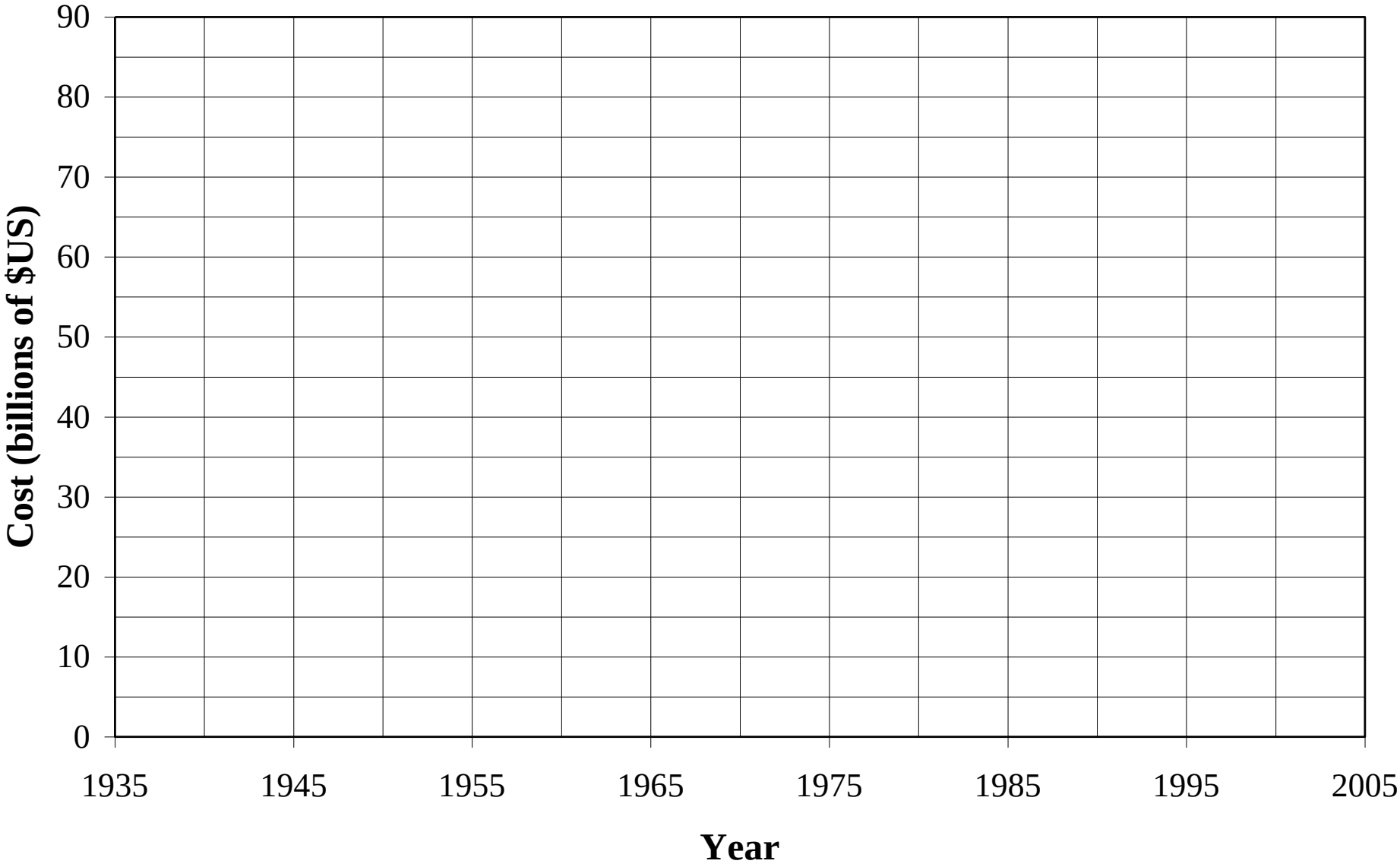
9. Using your knowledge from previous lessons how is the trend in number of major hurricanes and the cost associated with those storms linked to people's choices when it comes to carbon dioxide emissions.

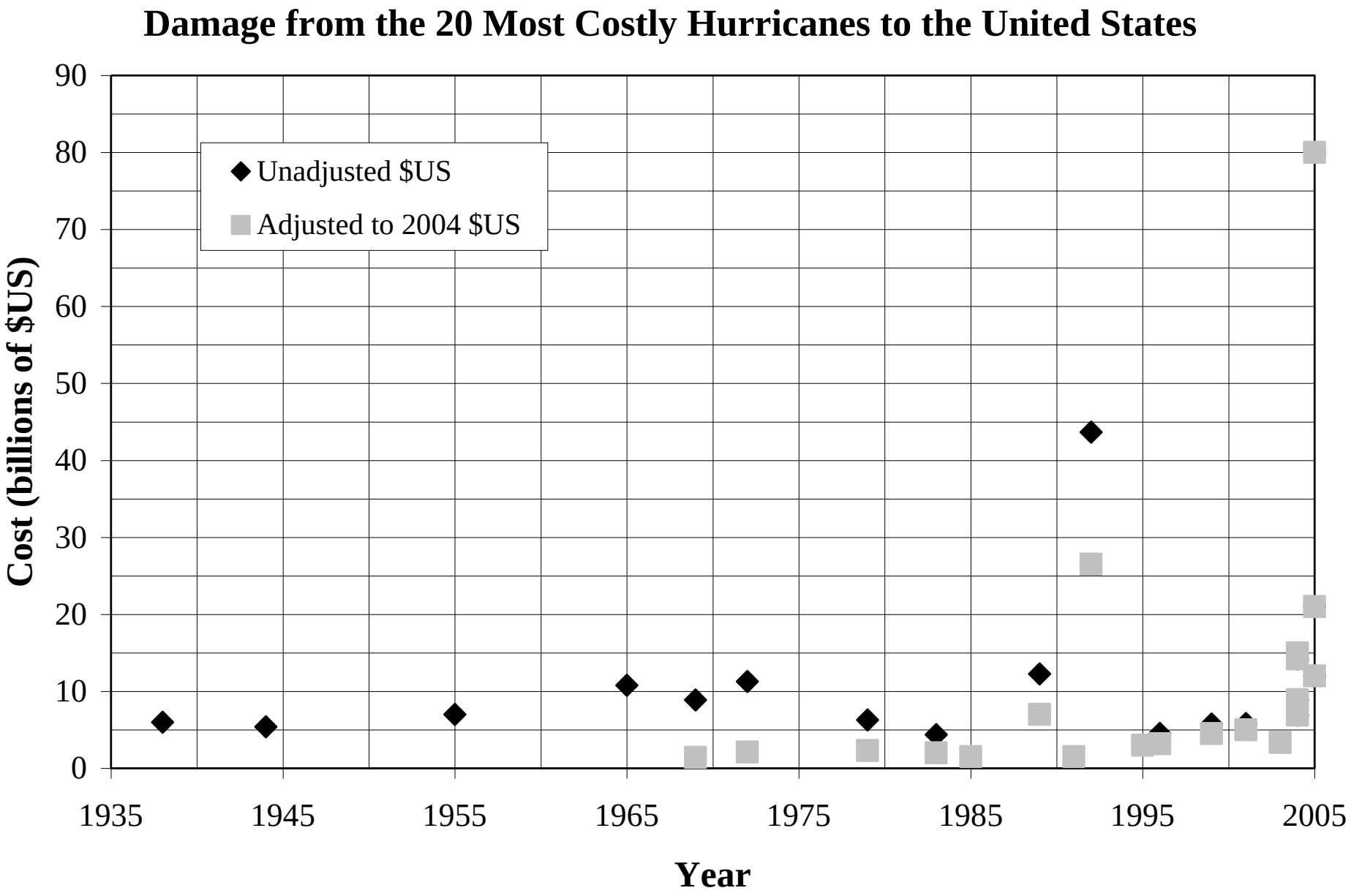
10. What changes could people make to their activities to help reduce the number of and severity of hurricanes?

11. To what extent are these changes the responsibility of the individual?

12. How would you try to convince people that their everyday actions have far reaching consequences around the world when they may not even realize they are causing problems?

Damage from the 20 Most Costly Hurricanes to the United States




Damage from the 20 Most Costly Hurricanes to the United States
Unadjusted $US
Adjusted to 2004 $US
Cost (billions of $US)
0
10
20
30
40
50
60
70
80
90
1935
1945
1955
1965
1975
1985
1995
2005
Year

Insert the image for Path and Severity of Hurricane Katrina here from the following link:

http://edbatista.typepad.com/edbatista/images/2006/08/Katrina_Map.gif

Figure 1: Path and Severity of Hurricane Katrina

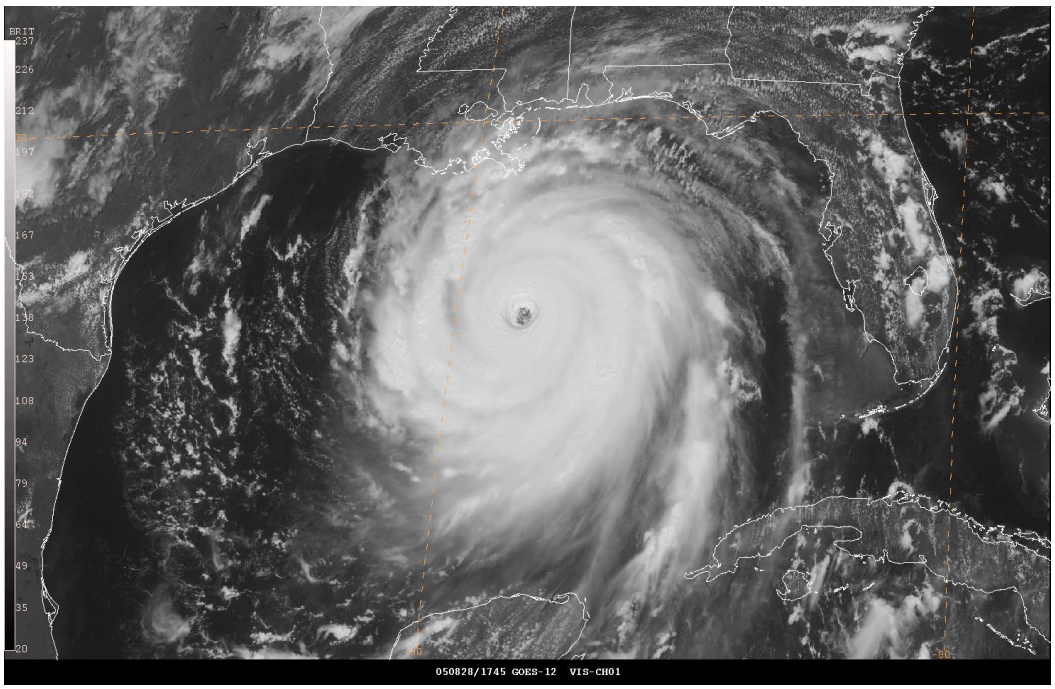


Figure 2: Satellite image of Hurricane Katrina in the Gulf of Mexico
(Source: National Weather Service: National Hurricane Center

Insert the image Ariel view of flooded New Orleans resulting from Hurricane Katrina here from the following possible links:

http://bbsnews.net/bbsn_photos/topics/hurricane_katrina/uscg_new_orleans_under_water20050829.jpg

or

http://www.lschs.org/uploaded/news-events/news-features/hurricane-katrina.jpg

Figure 3: Ariel view of flooded New Orleans resulting from Hurricane Katrina

Insert the image of the violent winds of Hurricane Katrina here from the following possible links:

http://www.katrinahelp.com/hurricane-katrina-5.jpg

or

http://cache.eb.com/eb/image?id=91879&rendTypeId=4

or

http://english.people.com.cn/200509/01/images/0901_A42.jpg

Figure 4: Economic Damage caused by Hurricane Katrina

Appendix D

Lesson 4 Worksheet Package: The Cost of Global Warming (report rubric included)

The Impact of Global Warming in North America

The vast North American continent ranges from the lush sub-tropical climate of Florida to the frozen ice and tundra of the Arctic. Within these extremes are two wealthy industrialized countries with diverse ecosystems at risk. Yet the United States and Canada are two of the largest global emitters of the greenhouse gases that contribute to a warming climate. Examples of all 10 of the "hotspot" categories can be found in this region, including changes such as polar warming in Alaska, coral reef bleaching in Florida, animal range shifts in California, glaciers melting in Montana, and marsh loss in the Chesapeake Bay.

For North America we have many more hotspots than for some other regions of the world, although impact studies have been emerging in larger numbers in recent years from previously under-studied regions. This higher density of early warning signs in the US and Canada is due in part to the fact that these regions have more readily accessible climatic data and more comprehensive programs to monitor and study environmental change, in part to the disproportionate warming that has been observed over the mid-to-high-latitude continents compared to other regions during the last century, and in part to capture the attention of North Americans who need to take action now to reduce greenhouse gas emissions.

Temperature Records -- set all around the world for hottest days, months and years

Chesapeake Bay -- Marsh and island loss. The current rate of a sea-level rise is three times the historical rate and appears to be accelerating. Since 1938, about one-third of the marsh at Blackwater National Wildlife Refuge has been submerged.

Bermuda -- Dying mangroves. Rising sea level is leading to saltwater inundation of coastal mangrove forests.

Hawaii -- Beach loss. Sea-level rise at Waimea Bay, along with coastal development, has contributed to considerable beach loss over the past 90 years.

Interior Alaska -- Permafrost thawing. Permafrost thawing is causing the ground to subside 16-33 feet (4.9-10 m) in parts of interior Alaska. The permafrost surface has warmed by about 3.5oF (1.9oC) since the 1960's.

Arctic Ocean -- Shrinking sea ice. The area covered by sea ice declined by about 6 percent from 1978 to 1995.

Canadian Rockies - Disappearing glaciers. The Athabasca Glacier has retreated one-third of a mile (0.5 km) in the last 60 years and has thinned dramatically since the 1950s-60s. In British Columbia the Wedgemont Glacier has retreated hundreds of meters since 1979, as the climate has warmed at a rate of 2oF (1.1oC) per century, twice the global average.

Mexico -- Dengue fever spreads to higher elevations. Dengue fever has spread above its former elevation limit of 3,300 feet (1,006 m) and has appeared at 5,600 feet (1,707 m).

Washington, D.C. -- Cherry trees blossoming earlier. Average peak bloom from 1970-1999 came April 3, compared to April 5 from 1921-1970.

California -- Butterfly range shift. Edith's Checkerspot Butterfly has been disappearing from the lower elevations and southern limits of its range.

Olympic Mountains, Washington -- Forest invasion of alpine meadow. Sub-alpine forest has invaded higher-elevation alpine meadows, partly in response to warmer temperatures.

Alaska -- Sea bird population decline. The black guillemot population is declining from 1990 levels because melting sea ice has increased the distance the birds must fly to forage for food and reduced the number of resting sites available.

Canadian Arctic -- Caribou die-offs. Peary caribou have declined from 24,000 in 1961 to perhaps as few as 1,100 in 1997, mostly because of major die-offs that have occurred in recent years after heavy snowfalls and freezing rain covered the animals' food supply.

Monterey Bay , California -- Shoreline sea life shifting northwards. Changes in invertebrate species such as limpets, snails, and sea stars in the 60-year period between 1931-1933 and 1993-1994 indicate that species' ranges are shifting northwards, probably in response to warmer ocean and air temperatures.

Monteverde Cloud Forest, Costa Rica -- Disappearing frogs and toads. A reduction in dry-season mists due to warmer Pacific ocean temperatures has been linked to disappearances of 20 species of frogs and toads, upward shifts in the ranges of mountain birds, and declines in lizard populations.

U.S. West Coast -- Sea bird population decline. A decline of about 90 percent in sooty shearwaters from 1987 to 1994 corresponds to a warming of the California Current of about 1.4oF (0.78oC).

Pacific and Atlantic Oceans -- Coral reef bleaching.

Increased precipitation – Record rainfall due to increased evaporation rates.

Worst fire season ever, 1998. 1.25 million acres burned during a severe drought. Smoke reaching Texas triggered a statewide health alert.

The Cost of Global Warming

Eastern USA -- Driest growing season on record, 1999. The period from April-July 1999 was the driest in 105 years of record-keeping in New Jersey, Delaware, Maryland, and Rhode Island. Agricultural disaster areas were declared in fifteen states, with losses in West Virginia alone expected to exceed $80 million.

North America - Genetic adaptation to global warming in mosquito. Ecologists have identified the first genetic adaptation to global warming in the North American mosquito Wyeomyia smithii. Modern mosquitoes wait nine days more than their ancestors did 30 years ago before they begin their winter dormancy, with warmer autumns being the most likely cause. Higher temperatures, enhancing mosquito survival rates, population growth and biting rates, can increase the risk of disease transmission.

Colorado - Earlier emergence from hibernation. Marmots are emerging from hibernation on average 23 days earlier than 23 years ago. This coincides with an increase in average May temperatures of about 1.8oF (1oC) over the same time period.

Southeast Arizona - Earlier egg-laying. Mexican jays are laying eggs 10 days earlier than in 1971. The earlier breeding coincides with a nearly 5oF (2.8oC) increase in average nighttime temperatures from 1971 to 1998.

Alaska - Changing vegetation patterns. Comparison of photographs taken in 1948-50 to those taken in 1999-2000 of the area between the Brooks Range and the Arctic coast show an increase in shrub abundance in tundra areas, and an increase in the extent and density of spruce forest along the treeline. The increased vegetation growth is attributed to increasing air temperatures in Alaska, on average 1.8oF (1oC) per decade over the last three decades.

Western Hudson Bay, Canada - Stressed Polar Bears. Decreased weight in adult polar bears and a decline in birthrate since the early 1980s has been attributed to the earlier spring breakup of sea ice. Rising spring temperatures have shortened the spring hunting season by two weeks over the last two decades.

Banks Island, Canada - Expanded Ranges. The Inuit now regularly see species common much further south that previously were never seen on the island, such as robins and barn swallows. Thunder and lightning, never before recorded in Inuit oral history, have also been reported.

Greenland -- The flow of ice from glaciers in Greenland has more than doubled over the past decade.

Extinction -- At least 279 species of plants and animals are already responding to global warming, moving closer to the poles.

Global Warming

Purpose

In this project you are going to choose and investigate a topic related to global warming. Specifically you will look at the cause and effect relationship humans have with their environment with regards to your particular topic based on the question "What is happening to our world and what can we do about it?"

Instructions

You will start by choosing a global warming topic. Then using a combination of the material covered in class, provided information, and what you research, you will gain a good understanding of what the global warming issue is all about. You will then investigate the human impact on your issue, and the impact the issue in turn has on people. Finally, you will write a report outlining your findings and offering possible suggestions for dealing with the problem.

Task

1. Choose your global warming topic and have it teacher approved
2. Research using a variety of sources (books, class notes, the internet, etc.) as much as you can about your topic
3. Write a report (using the format outlined by the teacher)

Assessment

You will be assessed using the attached Teacher Assessment Rubric. Your assessment will be based on three main areas:

- Information about the global warming issue (Knowledge)
- Relation of the issue to human activities (Making Connections)
- Proper use of scientific terminology and writing conventions (Communication)

The Cost of Global Warming

Teacher Assessment Rubric for the Global Warming Report **Student Name: _____**

Criteria	Excellent (Level 4)	Good (Level 3)	Fair (Level 2)	Needs Improvement (Level 1)	Unsatisfactory
Knowledge	The student demonstrates an excellent overall knowledge and understanding of the global warming issue.	The student demonstrates a good overall knowledge and understanding of the global warming issue.	The student demonstrates a satisfactory knowledge and understanding of the global warming issue.	The student demonstrates a nominal understanding of the global warming issue.	The student demonstrated minimal or no evidence of knowledge and understanding of the global warming issue.
Making Connections	The student demonstrates an excellent understanding of the cause and effect mechanism for the global warming issue, focusing on the link of human activities to the problem.	The student demonstrates a sound understanding of the cause and effect mechanism for the global warming issue, focusing on the link of human activities to the problem.	The student demonstrates a satisfactory understanding of the cause and effect mechanism for the global warming issue, with a weak focus on the link of human activities to the problem..	The student demonstrates a limited understanding of the cause and effect mechanism for the global warming issue, with a minimal focus on the link of human activities to the problem.	Minimal or no understanding of the cause and effect mechanism is demonstrated.
Communication	The student demonstrates the use of a wide range of scientific language appropriately and accurately. There is obvious evidence of proofreading.	The student demonstrates the use of a range of scientific language to communicate their ideas. There is evidence of proofreading.	The student demonstrates the use of a narrow range of scientific language to communicate their ideas. There is some evidence of proofreading.	Appropriate scientifically language is used minimally and at times incorrectly. There is minimal evidence of me proofreading.	There is no evidence of appropriate language or proofreading.

The Cost of Global Warming