

## **The Impact of Global Warming on North Carolina**

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### **Abstract**

This paper focused on the impact of global warming on North Carolina. There is a global consensus among scientists that humans are contributing to the increasing emission of greenhouse gases that pose a threat to land, humans and vegetation. The greenhouse gases are in the form of carbon dioxide, methane and nitrous oxides which are produced by burning of fossil fuels. The State of North Carolina has taken positive steps to address global warming by establishing the Legislative Commission on Global Climate Change (LCGCC), Climate Action Plan Advisory Group (CAPAG) and University Task Forces on Global Warming. The findings of the LCGCC include:

- Climate change is real
- Human activity is a factor in that change
- Commission should move forward to address the issues faced by the State

The following actions were recommended by the University task force on global warming as part of the University of North Carolina system's effort to examine global warming:

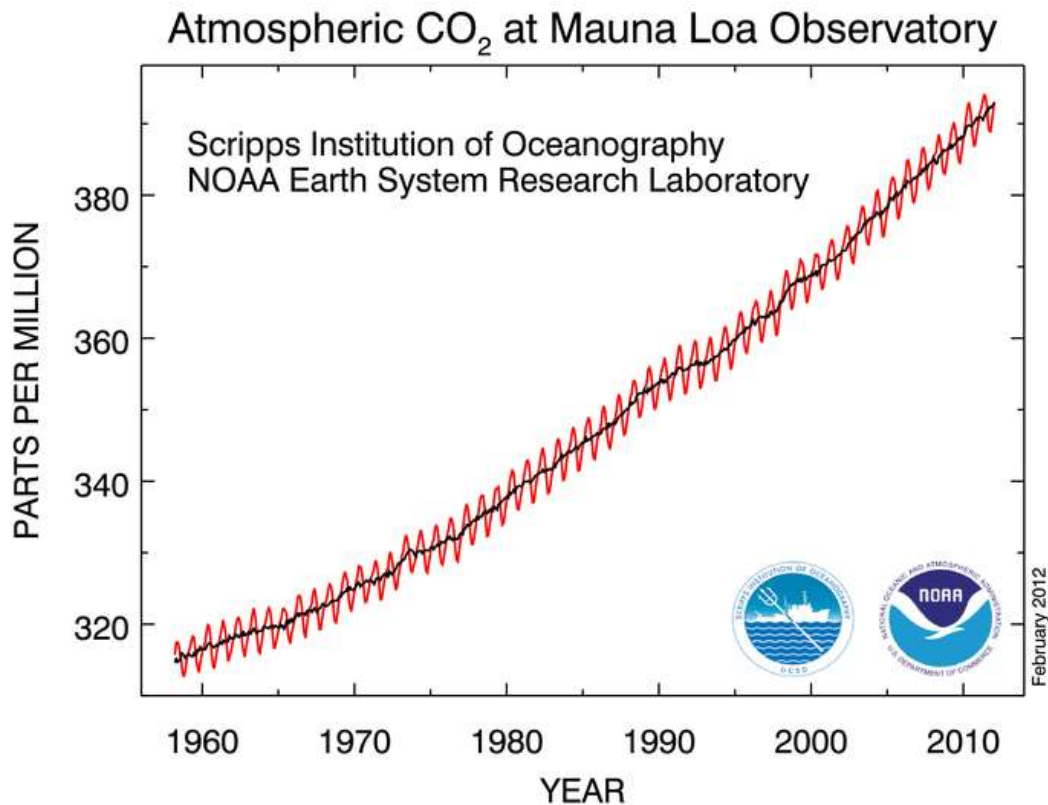
- Improve research and education on global warming
- Develop a plan to reduce carbon footprint
- Develop a comprehensive plan to protect coastal areas in North Carolina

The local effect of global warming reported in Greensboro, North Carolina, USA was an adverse effect of drought on Boxwood (*Buxus sempervirens*). Greensboro has experienced moderate to severe drought conditions in the past ten years. As a result, different kinds of plant species have been adversely impacted. Other effects of rising temperatures include but not limited to heat waves during the summer months which impact air quality. An increase in the number of asthma patients among children and adults has been reported. Increased health ailments due to global warming may lead to increased healthcare costs. Average summer temperatures in Charlotte, North Carolina could increase up to levels felt in Miami, Florida. Mosquito populations may increase because of warmer and wetter conditions. Warmer conditions in North Carolina may also increase the frequency algal blooms along the coast, damaging fish populations with adverse impacts both on human health and on local economies. It has been reported that winter-hardiness planting zones are changing in North Carolina. Gardeners have reported that rare palms, gingers and other brushes are thriving in the winter season. Sea levels are predicted to rise 0.9 meter per century, which could cause North Carolina to lose thirty to forty percent of its Coastal Plain leading to significant loss of land. Short-term trends indicate warming along the coast of North Carolina. The density of climate observations needed to be improved in order to trust observed trends.

### **Background**

#### **The Science of Climate Change In North Carolina**

It has been established that the most common greenhouse gases on earth include carbon dioxide, methane, nitrous oxide, water vapor, ozone and chlorofluorocarbons according to the United States Environmental Protection Agency (1998); Wilensky and Kane (2008). These gases have increased significantly in the 20<sup>th</sup> century partly because of human activities. The increase in global carbon dioxide concentration is the result of land use changes and various uses of fossil fuels (IPCC, 2007). Figure 1 shows atmospheric carbon dioxide concentration at Mauna Loa Observatory from 1960 to 2010.



**Figure 1: Atmospheric Carbon dioxide concentration at Mauna Loa Observatory**  
 Courtesy: Pieter Tans, NOAA/ESRL ([www.esrl.noaa.gov/gmd/ccgg/trends/](http://www.esrl.noaa.gov/gmd/ccgg/trends/)) and Ralph Keeling, Scripps Institution of Oceanography ([scrippsco2.ucsd.edu/](http://scrippsco2.ucsd.edu/))

Robinson et al. (2007) argue that the current warming trend is due to climate variation and not because of human activities. William Schlesinger noted in the Legislative Commission on Global Climate Change (LCGCC) report that a correlation between carbon dioxide levels and temperature exists and supported the theory that the rise in carbon dioxide levels is due to human activities including burning of fossil fuel and forest destruction. Schlesinger cited a statement

from the American Geophysical Union which states that the temperature of the earth is warming and that warming is caused by humans.

### **Methodology**

The research for this paper used data gathering methods. The first method was a review of North Carolina Climate Commission reports and notes taken during commission meetings. The author was a member of the commission. The second was a review of University task force reports and notes. The author was a member of the task force. The third was a review of literature on global climate change. Fourth, a review of local newspaper reports and observations of climate impacts.

### **Research Questions**

1. How important is global warming impact to North Carolina Legislators?
2. Do colleges and universities have a role in addressing global warming?
3. What are the lines of evidence to support global warming impacts on North Carolina?
4. How can this paper advance the knowledge of global warming?

### **Research Question 1**

#### **Legislative Commission on Global Climate Change (LCGCC)**

The North Carolina General Assembly Session Law 2005-442 established the Legislative Commission on Global Climate Change, LCGCC (2005). The commission was made up of thirty four (34) members. The commission was appointed by the leaders of the North Carolina General Assembly to study issues related to global warming; emerging carbon economy; need for global warming pollutant reduction goal and developing recommended goal if necessary. The Commission ended in May 2010, when the final report was adopted. The Commission's work was supported by professionals from the

Department of Environment and Natural Resources (DENR), the Department of Commerce, the Department of Transportation, the Department of Crime Control and Public Safety, and the Department of Agriculture and Consumer Services and researchers from institutions of higher education in the State (Appalachian State University, Duke University, East Carolina University, North Carolina State University, the University of North Carolina at Asheville, and the University of North Carolina at Chapel Hill. Additionally, national and international experts from several organizations were invited to commission meetings to provide expert opinions on climate change. It was noted in the commission report that actions taken by the states can have a significant effect on

global greenhouse gas levels. States have a role in addressing climate change. Stanley Riggs was cited in the LCGCC report that the impact of climate change on eastern North Carolina could be

dramatic where elevation in some places is less than 0.6 meter above sea level. Riggs noted that sea levels are predicted to rise 0.9 meter per century, which could cause North Carolina to lose thirty to forty percent of its Coastal Plain leading to significant loss of land. Beaches, marshes and wetlands will be impacted. Sethu Raman also pointed out in the LCGCC report that based on data collected, short-term trends indicate warming along the coast of North Carolina. He noted that the density of climate observations needed to be improved in order to trust observed trends.

### **Climate Action Plan Advisory Group (CAPAG)**

The purpose of CAPAG of the North Carolina Department of the Environment and Natural Resources (DENR) was to develop climate action recommendations and quantify costs and benefits of recommended actions.

### **Research Question 2**

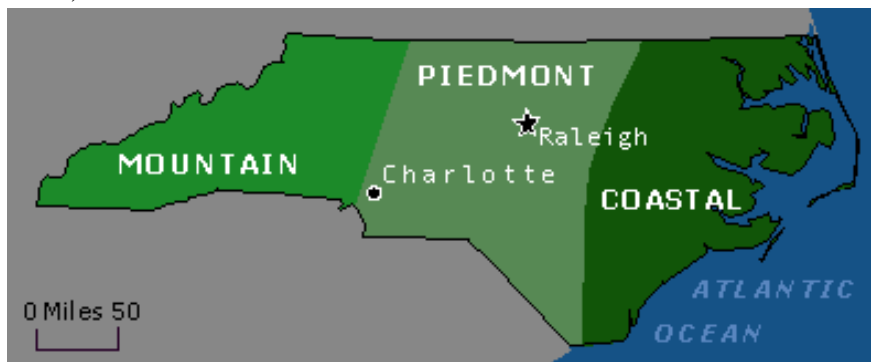
#### **Task Force on Global Warming**

A Global Warming Task Force was appointed by University administration as part the University of North Carolina system's effort to examine global warming impacts on the state of North Carolina. The University has a history of providing leadership in addressing environmental sustainability issues through interdisciplinary centers, institutes and academic programs at all degree levels. These interdisciplinary collaborations have made the university a major contributor to understanding climate change on a global scale.

### **Research Question 3**

#### **Potential Impacts of Global Warming on North Carolina**

It is crucial to evaluate the potential impacts of global warming on the citizens, natural resources, and economy of the State, including agriculture, travel and tourism, recreation, coastal real estate, insurance, and other economic sectors. Global warming are caused by environmental changes and weather processes. Global atmospheric circulation is influenced by seasonal variations of heat on earth. The Mountains and Piedmont generally experience lower temperatures while the Coast (Figure 2) experiences higher temperatures (Boyer and Raman, 2003).



**Figure 2. Geologic Regions of North Carolina**

The world’s leading scientists have agreed that human activities may be responsible for global warming. There could be an average increase in temperatures of between 2 and 10 degrees Celsius over the next century, leading to more severe drought, rising sea levels, shifting seasons, and increased disease according to consensus estimates (Environmental Entrepreneurs, 2005). This could lead to a number of problems in North Carolina. Figure 3 shows the drought monitor map of North Carolina. Temperature increases of about 3 degrees fahrenheit year round are projected. Heat-related deaths and illnesses from insect-borne diseases like malaria and West Nile virus could rise because of higher temperatures and heat waves. Average summer temperatures in Charlotte, North Carolina could increase up to levels felt in Miami, Florida. Mosquito populations may increase because of warmer and wetter conditions. Warmer conditions in North Carolina may also increase the frequency algal blooms along the coast, damaging fish populations with adverse impacts both on human health and on local economies. North Carolina’s ecosystems and human populations could be impacted by

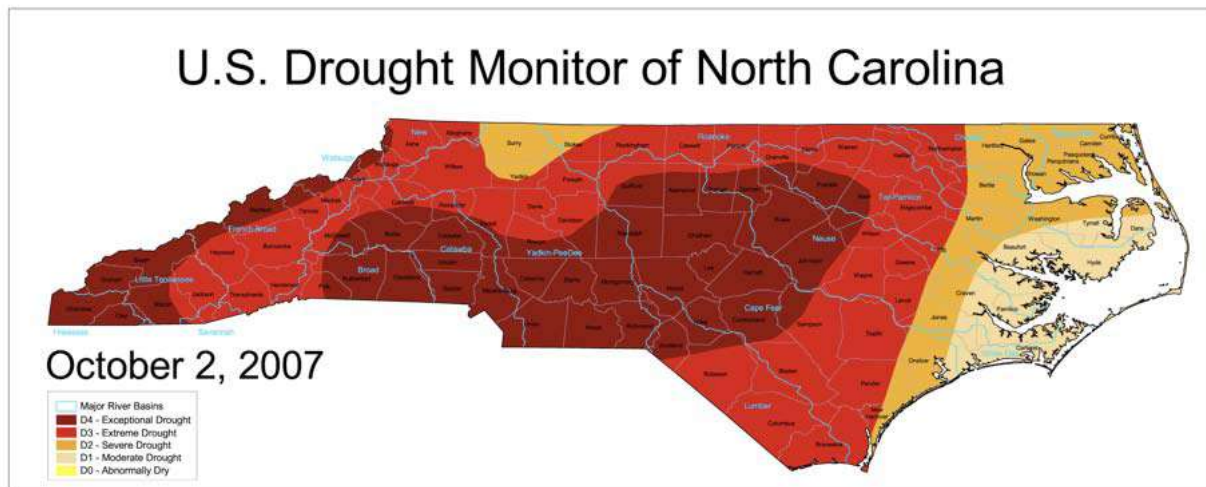


Figure 3. Drought Monitor of North Carolina

**Yellow – abnormally dry      Orange – severe drought      Red – extreme drought**  
**Dark red – exceptional drought      Peach – moderate drought**

rising sea levels and low lying populations could be forced to relocate and adapt to new conditions. Coastal activities would be threatened, and salt water marshes would move further inland. Coastal areas could suffer severe damages during hurricanes and other severe storm events as higher sea levels. In the western mountains of the state, Flash flooding could become

more common, threatening residential developments in the mountains. The state's \$4.5 billion agricultural sector will be threatened and increased temperatures could reduce corn and soybean yields by 25% (Environmental Entrepreneurs, 2005). Other potential impacts may include loss of cold water ecosystems, increase in pollen production, increase in populations of animals living at their northern range limit, increase in the area and productivity of forests, earlier onset of spring, increase in tropical fish species, earlier arrival of neo tropical migratory birds in the spring, decline in migratory birds which will winter further north, retreat of shoreline.

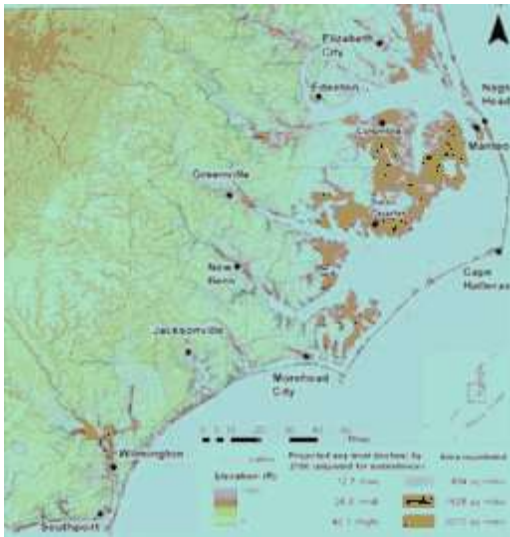
We may wonder how climate change can affect so many economic sectors. Over the 20<sup>th</sup> century, global average surface temperatures have risen by about 0.6°C (CIER, 2008). This might sound like a small value but this correlates to about 33°F. This value explains the reason why mountain glaciers have been decreasing in size and number throughout the 20<sup>th</sup> century. Snow and ice coverage have also decreased around the world and in return the sea levels are rising. Ocean temperatures have also increased which explains the increased severity of tropical storms, hurricanes, and tsunamis. Although North Carolina is fortunate enough to not have experienced any tsunamis, the coast and inland have been greatly affected by tropical storms and hurricanes. These are not the only types of storms that have increased in severity, heat storms and thunderstorms have also increased in severity around the state. More wildfires have been reported causing massive amounts of damage to the wildlife and forestry sectors. With average temperatures increasing by 1.2°F and precipitation increasing by 5% in many parts of the state, North Carolina has seen the warmest and wettest decade in 40 years (NCSL 2008). Most of the temperature increases that were noticed were along the coast of the state.

The coastal impacts of global warming have been studied extensively in North Carolina. Most of the coastal impacts presented in this paper are focused on the rise of the sea level. Only a few centimeters of rising sea level can cause millions of dollars in economic damages. Damages such as permanent land erosion and landward migration of beaches, saltwater intrusion in freshwater streams and aquifers, and infrastructure damage have been attributed to sea level rise. Sea level rise affects tourism, recreation, and real estate industries as well. Global sea level rise is expected to be 18 to 58 centimeters by 2095 (IPCC 2007b). With a projected sea level rise of 0.6 meter, massive infrastructure damage could occur. The rising sea level claims residential and non-residential properties every year. Table 1 shows projected 2080 estimates of coastal property losses for 46 centimeter sea level rise scenario for New Hanover, Dare, Cataret and Bertie coastal counties of North Carolina (Bin et al., 2007). Figure 4 shows that more than half of the state's coastal counties are categorized into high to very high risk to sea level rise.

County	Residential Property Value Loss	Nonresidential Property Value Loss
New Hanover	\$99 million	\$35 million
Dare	\$988 million	\$1.42 billion
Cataret	\$100 million	\$183 million
Bertie	\$5.45 million	\$3.8 million

**Table 1. Estimates of Lost Coastal Property Value, 2080, 46cm Sea Level Rise Scenario in Four North Carolina Counties**  
 Source: Bin et al. (2007) converted to 2007 dollars.

Tourism has also been greatly affected by sea level rise. The industry has been affected by losses of beach area combined with a decreased demand for beach trips due to more erratic weather. Losses of area business have also taken a toll due to decreased tourism. Along with the tourism industry, the fishing sector has also been greatly affected by the rise in sea level.



**Figure 4. Map of Coastal North Carolina and Sea Level**  
 Source: Poulter and Halpin (2008). “....The coastal areas shaded in dark red are at highest risk to sea level rise; the lighter shades indicate the land area at risk from higher sea levels. More than half of the state’s coast falls in the high or very high-risk categories.....”

There are also a number of other economic impacts that affect North Carolina and some of the state's largest industries. The agricultural industry is a substantial part of North Carolina's economy. Climate change has affected this industry in numerous ways including droughts, hurricanes, and increased temperatures. The farming, livestock, and forestry industries have been estimated to incur a 22.6% climate-change induced loss in agricultural profits for North Carolina (Deschenes 2006). North Carolina is second in the country in hog production which will also be affected by climate change. An increase of 9°F reduces livestock yield by 10% in the Appalachian region (CDACS, 2007). The business generated \$2 billion in cash receipts in 2006. Poultry and eggs also account for 36% of the total farm sales (NCSL 2008). This correlated to \$3.9 billion dollars in 2006. An increase in temperatures could have significant impacts on the industry and could also increase costs in heat abatement measures. Drought has also significantly affected these industries. North Carolina was among the states that experienced the driest year in the last century. Losses totaling \$398 million were incurred by the agricultural sector as a result of drought in 2002 (Hayes et al., 2004). In addition to these losses, there was also a loss of 4,337 North Carolina jobs and an additional \$233 million in multiplier effects (RESI 2008). Climate change has also increased the number of tropical storms and hurricanes that have hit the coast of North Carolina. Between 1996 and 2006, 14 tropical storms or hurricanes caused agricultural damages totaling \$2.4 billion (Bin et al 2007). North Carolina ranks fourth in the nation for number of recorded hurricane strikes. From 1851–2006, 50 hurricanes made landfall on the North Carolina coast (NCSL 2008). When Hurricane Fran devastated the North Carolina coast in 1996, the category 3 catastrophe caused damages estimated around \$1.69 billion (NCSL 2008). Furniture and related manufacturing industries that rely on the forestry sector also may be at risk due to climate change. Climate change can also affect forest compositions that might change due to the warmer climates. Pests that thrive in these warmer climates could create additional risks to the existing timber resources and decrease profits substantially in the furniture and manufacturing industries.

#### **Research Question 4**

Advancing the knowledge of Global Warming is important for public health, water resources, recreational activities and vegetation. Knowledge of global warming will lead to proactive action.

#### **Public Health**

Global warming also greatly affects the public health industry. With a possible decrease in air quality, formation of ground-level ozone and smog, and acute respiratory conditions; the public health industry will see great losses due to global. An increase in the number of asthma patients among children and adults has already been noticed. Asthma costs North Carolina \$631 million in 2003 (Jensen 2006). Increased health ailments due to climate change will lead to increased healthcare costs.



## **Water Resources**

Global warming is also expected to affect water resources in North Carolina. Coastal flooding and saltwater intrusion into aquifers will be the main cause of water shortages. Severe drought will also affect the availability of water resources available for drinking, industry, and agricultural sectors. Any affect that climate change has on water resources is substantial since half of the state's population depends on ground water for drinking purposes and 98% of all public supply systems rely on ground water (GWPC 1998). Increased severity of droughts could put an even greater strain on the already stressed water supply systems in North Carolina.

## **Recreational Activities**

The skiing industry in North Carolina generated revenue of \$23 million for the 2002- 2003 year (CIER 2008). Global warming scenarios have predicted a decrease in total number of skiing days. This means that the skiing industry will have a shorter season and for a greater part of the season they will have to rely on snowmaking to extend the season. Since there will be a decrease in the number of natural winter days, this will increase the costs of running extensive snowmaking operations. The skiing industry also comprised of over 100,000 jobs and totaled \$120 million in direct and indirect expenditures (Millsaps and Groothuis 2003). Wildlife viewing also accounted for 55,500 jobs in 2001 (NWF 2007). Changes in the habitat and population of wildlife in the state could reduce attraction for tourists and negatively impacted.

## **Vegetation**

Warming trend appears to be having an adverse effect on plants in Greensboro, North Carolina.

Figure 5 shows the adverse effect of drought on Boxwood (*Buxus sempervirens*),. Several of these plants are disappearing. Greensboro has experienced moderate to severe drought conditions in the past ten years. As a result, different kinds of plant species have been adversely impacted.



**Figure 5. Effect of drought on Boxwood (*Buxus sempervirens*)**  
Courtesy: Waste Management Institute Photo, 2012

It has been reported that winter-hardiness planting zones are changing in North Carolina. Gardeners have reported that rare palms, gingers and other brushes are thriving in the winter season (Greensboro News and Record, February, 2012).

### **Findings of the Legislative Commission on Global Climate Change (LCGCC)**

In 2008, the LCGCC adopted a resolution acknowledging the following findings:

- Climate change is real
- Human activity is a factor in that change
- The Commission should move forward to address the issues faced by the State

It should be noted that the LCGCC endorsed the findings contained in the 2009 U.S. Global Change Research Program's publication entitled *Global Climate Change Impacts in the United States*". These findings include but not limited to: Global warming is unequivocal and primarily human-induced; climate changes are underway in the United States and are projected to grow; widespread climate-related impacts are occurring now and are expected to increase; climate change will stress water resources; crop and livestock production will be increasingly challenged; coastal areas are at increasing risk from sea-level rise and storm surge; threats to human health will increase and future climate change and its impacts depend on choices made today. The following findings are specific to the southeast region of the United States according to LCGCC report (2010): projected increases in air and water temperatures will cause heat-related stresses for people, plants, and animals; decreased water availability is very likely to

affect the region's economy as well as its natural systems; sea-level rise and the likely increase in hurricane intensity and associated storm surge will be among the most serious consequences of climate change; ecological thresholds are likely to be crossed throughout the region, causing major disruptions to ecosystems and to the benefits they provide to people and quality of life will be affected by increasing heat stress, water scarcity, severe weather events, and reduced availability of insurance for at-risk properties.

### **Recommendations of the Legislative Commission on Global Climate Change (LCGCC)**

The following recommendations were made by the LCGCC in the 2010 report to the North Carolina General Assembly:

- The General Assembly should enact a permanent climate commission and separate technical advisory committee.
- The General Assembly should direct the Department of Environment and Natural Resources, with the full participation and assistance of other State agencies, to develop a State climate change adaptation plan.
- The General Assembly should direct the Utilities Commission to evaluate various mechanisms and programs that could result in further improvements in energy efficiency and conservation, as well as those that reduce carbon emissions.
- The General Assembly should direct Department of Commerce, in conjunction with DENR and the Department of Agriculture and Consumer Services to (a) study of carbon offset and carbon sequestration potential in North Carolina; and (b) investigate the feasibility and desirability of establishing a carbon sequestration market place in NC.
- The General Assembly should provide funding for improved data collection and monitoring of climate change and its impacts on North Carolina.
- The General Assembly should amend the General Statutes related to State long-term planning and environmental review programs to require consideration of environmental impacts associated with climate change.
- The General Assembly should adopt a resolution supporting federal legislation related to a national cap on greenhouse gas emissions and comprehensive legislation on climate change and energy.

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