

## PENNSYLVANIA

### ASSESSING THE COSTS OF CLIMATE CHANGE

#### CLIMATE TRENDS IN PENNSYLVANIA

Since 1955, much of the northeastern United States has experienced a 1° F temperature increase. Climate change likely will raise annual average temperatures in Pennsylvania by between 3.6° F and 12.6° F during the next century. Due to the long life of the carbon dioxide already in the atmosphere, Pennsylvania is likely to see a temperature increase of at least 3.5° F, even if extreme mitigation measures are adopted worldwide. The temperature increase will manifest itself primarily as higher minimum temperatures in winter, but also as higher maximum temperatures in summer. Predictions indicate Pennsylvania will experience a higher degree of warming relative to the global average, due to its mid-latitude location.

Pennsylvania could see an annual precipitation increase of roughly 7 percent,<sup>1</sup> much of which is predicted to occur during winter and spring. Increased precipitation extremes—such as droughts and severe storms—and temperature extremes also are predicted. Overall, climate change could produce significant economic costs for infrastructure, manufacturing, water resources, and agriculture, although forestry may see some economic benefits.

#### OVERVIEW

In the coming decades, a changing climate may increase economic impacts for Pennsylvania and the nation. The most recent climate modeling predicts warmer temperatures and increased precipitation for much of Pennsylvania. The changes could be more pronounced if global emissions of greenhouse gases are not reduced. These changes could affect Pennsylvania's manufacturing sector, infrastructure, agriculture, forestry and water resources. Since state economies are directly linked to those of neighboring states and regions, policy-makers may wish to consider both state and regional policies to address climate change.

#### ECONOMIC IMPACTS<sup>2</sup>

##### *Infrastructure*

Climate change may increase precipitation in Pennsylvania, and the frequency and severity of extreme weather also could increase.<sup>3</sup> In June 2006, more than 12 inches of rain fell in northeastern Pennsylvania over three days. Flooding due to the storm caused more than \$100 million in damage. More than 200,000 people in the city of Wilkes-Barre were evacuated, and 16 people died.<sup>4</sup>

From 1954 to 2007, Pennsylvania experienced 85 major floods<sup>5</sup> that caused more than \$16 billion in damages between 1955 and 2003,<sup>6</sup> placing the state fourth nationwide for highest overall flood losses.<sup>7</sup> The nine most populous counties in the state—Philadelphia, Allegheny, Montgomery, Bucks, Delaware, Lancaster, Chester, York and Berks—contain more than half the state's population.<sup>8</sup> A 10-year flood in Allegheny County could cause more than \$8.1 billion in damages; similar floods in the other eight counties could cause an estimated \$310 million in damages.<sup>9</sup>

Such flooding could become more frequent as climate change progresses, causing greater economic impacts. Research focused on the Mid-Atlantic region, for example, indicates that a 1 percent in-



crease in annual precipitation raises the economic losses from floods and hurricanes by nearly 3 percent.<sup>10</sup> If precipitation increases by 7 percent in the state,<sup>11</sup> the average 10-year flood could cost each of the eight most populous counties, other than Allegheny, an estimated \$375 million per event. In Allegheny County, the average cost of a 10-year flood could increase to \$9.8 billion per event.

Many experts forecast an increase in hurricanes frequency and intensity as the climate warms.<sup>12</sup> If hurricanes become more frequent in the future, rainfall, storm surges and associated flooding could cause major damage, particularly in the eastern part of the state, which is often in the path of hurricanes that made landfall in other parts of the country.

## Shipping

Pennsylvania ports are ranked fourth in the nation in domestic and foreign cargo volume. This includes a Great Lakes port in Erie, an inland port in Pittsburgh and a Philadelphia seaport. The ports collectively handled approximately 125 million tons of cargo in 2001, and waterborne commerce-related activity provided 280,000 jobs in 1999. The total financial value is estimated at nearly \$30 billion.<sup>13</sup>

Warmer temperatures from climate change are likely to increase evaporation, contributing to declining water levels in Lake Erie, inland waterways and channels. This may necessitate increased dredging in the Great Lakes-St. Lawrence shipping channels, with an estimated cost of between \$85 million and \$142 million annually.<sup>14</sup> Movement of goods along this shipping route is responsible for approximately 60,000 jobs and \$3.5 billion annually.<sup>15</sup> Lower water levels could bring increased freight costs to the area if shipping channels are less viable and it becomes necessary to use higher-priced rail transportation.<sup>16</sup> System connectivity could be impaired by 25 percent, representing an estimated annual cost of \$995 million.<sup>17</sup>

The section of the Delaware River near the Port of Philadelphia currently is being dredged to expand the depth of its main channel by 5 feet. Cost of the project is estimated at \$264 million.<sup>18</sup> Further dredging could become necessary as water levels decline with higher temperatures. While depths of inland waterways could become more shallow, rising sea levels could require alterations to the Philadelphia port to adapt to higher water levels.

## Water Resources

Climate change may challenge Pennsylvania's efforts to provide clean water. Intense precipitation can con-

taminate drinking water as heavy run-off washes more pollutants into surface waters. Higher temperatures, combined with more pollutants, also can increase the harmful bacteria and algae in surface waters. This increases water treatment needs and the risk of illness for swimmers and others who use the water for recreation.<sup>19</sup> A review of Texas water treatment facilities found that an increase in water contamination resulted in 27 percent higher treatment costs.<sup>20</sup>

The predicted rise in sea level along the Atlantic coast also could contaminate freshwater supplies as saline sea water encroaches. Since Philadelphia relies on the Delaware River for its freshwater needs, increased salinity caused by rising sea levels could considerably increase the water treatment costs.<sup>21</sup> The typical cost to treat 300,000 gallons of water from sources with average water quality is approximately \$200. It is up to five times more expensive to treat seawater, which contains salt concentrations 35 times higher than freshwater.<sup>22</sup>

## Agriculture

Pennsylvania has annual agricultural sales of nearly \$5 billion. One-third of sales are dairy products; the remainder is split among poultry, livestock, eggs and high-value nursery products.<sup>23</sup> Predicted higher temperatures due to unmitigated climate change could negatively affect the dairy industry because cows subjected to prolonged heat stress decrease milk production. One study shows that, above a critical temperature threshold of 77° F, dairy cows produce up to 22 percent less milk.<sup>24</sup> This would affect not only the state's dairy industry, but also related economic activities, such as processing and sale of dairy products that annually account for nearly \$16 billion and more than 20,000 jobs.<sup>25</sup> Decline in dairy production could create economic costs of approximately \$480 million and as many as 5,300 lost jobs.<sup>26</sup>

## Forestry

Pennsylvania is rich in forest resources; 58 percent of the state is covered by hardwood forests.<sup>27</sup> The state leads the nation in hardwood lumber harvesting, producing 10 percent of the nation's total output and \$5.5 billion worth of wood-derived products annually. The industry employs more than 134,000 people, many of whom work in wood product manufacturing, paper manufacturing and furniture production. Four of Pennsylvania's 67 counties rely on forest products for more than half their employment, and in another 13 counties, between 25 percent and 50 percent of workers are employed in the industry.<sup>28</sup>

Increases in temperature and precipitation could actually stimulate forest growth. Higher concentrations of carbon dioxide also could increase photosynthesis through a process called "carbon fertilization."<sup>29</sup> One study found that a 50



percent increase in carbon dioxide emissions resulted in a 23 percent increase in forest productivity.<sup>30</sup> If such an increase occurs, the positive economic benefit may reach more than \$850 million, as more than 5,000 indirect jobs are generated due to greater productivity yields.<sup>31</sup> Although this increase may benefit forest productivity, an increase in carbon dioxide levels of 50 percent would result in a global temperature rise of 5° F, which could cause catastrophic changes in sea levels, temperatures and precipitation and lead to major disruption of the global economy.<sup>32</sup>

An increase in the amount of ground-level ozone, which is harmful to plants, could counteract some productivity gains, however. Exhaust from motor vehicles, emission from industrial sources and gasoline vapors form ground-level ozone in the presence of hot summer sun. As temperatures increase, ozone levels also could increase. Researchers estimate that a continued increase in ozone levels could reduce plant productivity by more than 10 percent by 2100.<sup>33</sup> Additional effects of warmer temperatures, such as an increase in tree-damaging pests (already seen in Colorado and elsewhere) also could occur.<sup>34</sup> Thus, it is unclear whether yields in the forestry sector increase or decrease as the various effects of climate change emerge.

## CONCLUSION

Pennsylvania's greatest challenge is likely to be in adapting to the effects that climate change may have on water resources and infrastructure. Understanding how climate change will affect water quality and availability will be crucial to balancing development and population growth where water supplies may be compromised. Policymakers may wish to encourage improved assessments of how sea level rise could affect freshwater supplies and what practices and technologies could cost-effectively mitigate this problem. Creating a comprehensive water plan that includes the potential changes in water quality, water availability and treatment costs and determining how the plan can be adapted to meet possible scenarios could prevent future water stress for the state.

Since the likelihood of flooding is predicted to increase, policymakers can promote additional state-specific research on potential precipitation changes. Creating assessments that designate the regions most susceptible to an increase in flooding and revising flood response and mitigation plans also would be helpful. Revisiting zoning and development in susceptible areas and revising them to change development patterns, if necessary, could help avoid future disasters and their associated costs.

If water levels in Lake Erie and other freshwater shipping routes fall as predicted, the Pennsylvania shipping industry and other sectors that rely upon it could suffer losses. Poli-

cymakers may wish to create grants or other incentives to encourage research on how climate change will affect water levels and the shipping industry. More detailed forecasts on future water levels will help decision makers in government and industry allocate resources and develop plans to help shipping businesses respond to these changes.



### MISSING INFORMATION AND DATA GAPS

Much more research is needed on the degree to which climate change will affect both agricultural plants and forests. Better forecasts of Lake Erie's water level, shoreline changes and associated water quality changes are needed. Improved local modeling of the changing climate's effect on precipitation events, which could affect many sectors, also is needed.

## NOTES

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