An Agricultural Law Research Article

Climate Change and Pennsylvania Agriculture

by

David Abler, James Shortle, and Ann Fisher

Originally published in PENN STATE ENVIRONMENTAL LAW REVIEW
12 PENN ST. ENVTL. L. REV. 117 (2004)

Climate Change and Pennsylvania Agriculture

David Abler, James Shortle, and Ann Fisher

Global climate change has been in the news a lot in recent years. In a report released in 2000, the U.S. Global Change Research Program concluded that our climate is changing at a rapid rate.[1] The average annual U.S. temperature has risen by nearly 1°F in the last century, and precipitation has increased nationally by 5% to 10%, mostly due to increases in heavy downpours.[2] Worldwide, the 1990s were the hottest decade in the last 1,000 years.[3] Most scientists believe that emissions of carbon dioxide and other so called greenhouse gases are the primary cause of these changes, and that the coming century will be even warmer still.[4] Fossil fuel combustion for powering vehicles and generating electricity is the most important human activity contributing to greenhouse gas emissions. The U.S. Global Change Research Program report concludes that average temperatures in the U.S. could increase 5-9°F by the year 2100.[5] Other regions of the world are also expected to see increases in temperatures.[6] Precipitation in the U.S. is expected to rise during the coming century, although some regions could see less precipitation than today while others could see much more.[7]

Changes in climate of this magnitude would be unmatched since the end of the last Ice Age, and they could have a profound impact on world agriculture. Agriculture has always had a very close relationship with climate.

1. NAT'L ASSESSMENT SYNTHESIS TEAM, U.S. GLOBAL CHANGE RESEARCH PROGRAM, CLIMATE CHANGE IMPACTS ON THE UNITED STATES, OVERVIEW (2000).
2. NAT'L ASSESSMENT SYNTHESIS TEAM , *supra* note 1, at 7.
3. NAT'L ASSESSMENT SYNTHESIS TEAM, U.S. GLOBAL CHANGE RESEARCH PROGRAM, CLIMATE CHANGE IMPACTS ON THE UNITED STATES, FOUNDATION 23 (2001).
4. NAT'L ASSESSMENT SYNTHESIS TEAM, *supra* note 2, at 17.
5. NAT'L ASSESSMENT SYNTHESIS TEAM, *supra* note 3, at 37.
6. NAT'L ASSESSMENT SYNTHESIS TEAM, *supra* note 3, at 36-7.
7. NAT'L ASSESSMENT SYNTHESIS TEAM, *supra* note 3, at 50-1.

Climate Change

Life on earth depends on the "greenhouse effect." Certain gases in the earth's atmosphere allow sunlight through but absorb infrared radiation. These are called greenhouse gases because they retain heat somewhat like the glass panels of a greenhouse. Without heat-trapping greenhouse gases in the atmosphere, solar energy that warms the earth would radiate back into space without heating the earth enough to support life. Problems however, can arise when atmospheric concentrations of greenhouse gases increase.

Greenhouse gases make up less than 1% of the earth's atmosphere.[8] The most important greenhouse gas, carbon dioxide, is only about 0.03% of the atmosphere.[9] Other important greenhouse gases include methane and nitrous oxide. Because the amounts of these gases in the atmosphere are so small, human activities can have a significant impact on their atmospheric concentrations. The amount of carbon dioxide in the atmosphere has risen from about 270 parts per million (ppm) in 1750 to about 370 ppm today, and could rise to 650 or 700 ppm by the end of the 21st century.[10] Atmospheric concentrations of other greenhouse gases are also increasing. Most scientists believe that industrial and agricultural activities are largely responsible.[11] Carbon dioxide is a byproduct of clearing forestland to make room for agriculture and burning fossil fuels to heat homes, power autos and trucks, and generate electricity. Methane finds its way into the atmosphere from solid wastes, coalmines, oil and gas production, wet rice production, and livestock. Sources of nitrous oxide include energy production and fertilizer use.

The Mid-Atlantic Regional Assessment (MARA) began at Pennsylvania State University in 1998 with the goals of identifying how people and their surroundings in the Mid-Atlantic region will be affected by climate variability and change, how people can take advantage of opportunities and reduce vulnerabilities resulting from climate variability and change, and what additional information is needed to improve decision-making. The Mid-Atlantic, along with fifteen other regions nationwide, was part of the U.S. Global Change Research Program.[12] MARA's researchers examined how climate within the Mid-Atlantic region is likely to change during the next century. They also examined

8. C. Rosenzweig & D. Hillel, CLIMATE CHANGE AND THE GLOBAL HARVEST: POTENTIAL IMPACTS OF THE GREENHOUSE EFFECT ON ARGICULTURE 8 (1998).

9. Rosenzweig & Hillel, *supra* note 8, at 13.

10. NAT'L ASSESSMENT SYNTHESIS TEAM *supra* note 1, at 22.

11. NAT'L ASSESSMENT SYNTHESIS TEAM, *supra* note 1, at 21.

12. MID-ATLANTIC REGIONAL ASSESSMENT TEAM, PREPARING FOR A CHANGING CLIMATE: TH E POTENTIAL CONSEQUENCES OF CLIMATE VARIABILITY AND CHANGE, MID-ATLANTIC OVERVIEW (2000) at i.

how changes in climate could affect agriculture, forests, fresh water supplies, coastal zones, ecosystems, and human health in the Mid-Atlantic region. The MARA project has now concluded, but it has been succeeded by the Consortium for Atlantic Regional Assessment (CARA), which seeks to provide local and regional decision-makers in the Mid- and Upper-Atlantic with information on how land use and climate changes will affect them, and what they can do in response.[13]

In its report released in 2000, the MARA research team found that average temperatures in the Mid-Atlantic region could rise 4-10°F by the year 2100.[14] This may not seem like a lot, but a 4°F increase would make Pennsylvania as warm on average as New Jersey is today, and a 10°F increase would make Pennsylvania as warm as present-day North Carolina.[15] Precipitation is more difficult to project than temperature, but the MARA team's findings suggest that, if anything, it could increase.[16] Projections range from little long-term change in precipitation to an increase of about 10 inches per year by the end of this century.[17] Pennsylvania currently receives an average of about 42 inches of precipitation per year, so an increase of 10 inches per year would be substantial (nearly 25%).[18]

On a nearer term basis, the MARA team's findings suggest that average temperatures in the Mid-Atlantic region could rise 2-3°F by the year 2030.[19] Projections for precipitation range from essentially no change to an increase of about 3 inches per year between now and 2030.[20]

Some scientists doubt whether climate change is actually happening, while others believe that it may be happening but that human activities are not responsible. However, these scientists are in the minority, and debate over climate change is lessening as the evidence piles up.

Still, we need to bear in mind that climate change is a long-term phenomenon and not a forecast of what the weather will be like in any given year. There will continue to be cold spells, heat waves, droughts, floods, snowstorms, and other extreme weather events, just as there are now. Some years will be warm and others cool; some wet and others dry. On average, however, the projections suggest that Pennsylvania and

13. Consortium for Atlantic Regional Assessment, *at* http://www.cara.psu.edu/.
14. MID-ATLANTIC REGIONAL ASSESSMENT TEAM, *supra* note 12, at 13.
15. NATIONAL CLIMATIC DATA CENTER, COMPARATIVE CLIMATIC DATA (1997).
16. MID-ATLANTIC REGIONAL ASSESSMENT TEAM, *supra* note 12, at 13.
17. MID-ATLANTIC REGIONAL ASSESSMENT TEAM, *supra* note 12, at 13.
18. MID-ATLANTIC REGIONAL ASSESSMENT TEAM *supra* note 12, at 13.
19. MID-ATLANTIC REGIONAL ASSESSMENT TEAM, *supra* note 12, at 13.
20. MID-ATLANTIC REGIONAL ASSESSMENT TEAM, *supra* note 12, at 13.

the rest of the Mid-Atlantic region will be warmer and wetter.[21]

Climate Change and Pennsylvania Agriculture

Climate change could affect Pennsylvania agriculture in several ways. Higher levels of atmospheric carbon dioxide may lead to an increase in photosynthesis and thus crop yields, a phenomenon known as the carbon dioxide "fertilization" or "enrichment" effect.[22] Carbon dioxide is an indispensable component in the process of photosynthesis. Higher levels of carbon dioxide could also reduce transpiration (evaporation from plant foliage), which would reduce water stress facing crops during droughts. Studies by MARA's research team and others suggest that the carbon dioxide fertilization effect could be significant for important crops such as corn, soybeans, and alfalfa.[23] Corn yields in Pennsylvania could rise 5-10% by the year 2030 as a result of the carbon dioxide fertilization effect.[24]

Changes in temperature and precipitation would have additional impacts on crop yields. If summer heat waves became more common or more intense, production of a variety of crops could suffer. Increases in snowfall could worsen spring flooding in some years, delaying planting. Increases in fall precipitation could delay harvesting or lower the quality of harvested grains. On the other hand, increases in spring and summer rainfall could increase crop yields. In spite of the fact that Pennsylvania receives abundant rainfall in most years, water is still a limiting input in the production of many crops. Increases in spring and summer precipitation would ease this constraint on production. The net effect of all these changes is difficult to say, but studies by MARA's research team and others suggest that it would be small.[25] In the case of corn, the net effect of changes in temperature and precipitation might be a 2-3% increase in Pennsylvania yields by the year 2030.[26]

We know much less about how climate change might affect weeds or crop and livestock pests and diseases. The same carbon dioxide fertilization effect that benefits crops could increase growth of many

21. MID-ATLANTIC REGIONAL ASSESSMENT TEAM, *supra* note 12, at 13.

22. *See* Rosenzweig & Hillel, *supra* note 8, at 70-9.

23. *See* David Abler et al., *Climate Change, Agriculture, and Water Quality in the U.S. Chesapeake Bay Region*, 55 CLIMATE CHANGE 339-359 (2002); *see also* R. Ceasar Izaurralde, et al., U.S. REGIONAL AGRICULTURAL PRODCUTION IN 2030 AND 2095: RESPONSE TO CO2 FERTILIZATION AND HADLEY CLIMATE MODEL (HadCM2) PROJECTION OF GREENHOUSE-FORCED CLIMATE CHANGE 1-42 (1999).

24. *See* Abler et al., *supra* note 23.

25. *See* Abler & Shortle, *Climate Change and Agriculture in the Mid-Atlantic Region*, 14 CLIMATE RESEARCH 185-94 (2000) at185-194; *see also* Abler et al., *supra* note 23; *see also* Izaurralde et al., *supra* note 23.

26. *See* Abler et al., *supra* note 23.

weed species. Warming could lead to a northern expansion of warm-season weeds, plant parasitic nematodes and insects, presenting Pennsylvania farmers with a different set of pest challenges than they face today. However, Pennsylvania agriculture is more diverse in terms of growing conditions and the types of crops and livestock produced than agriculture in many other parts of the U.S. or other countries, which should make it less vulnerable to devastating disease or pest epidemics.

Livestock can also be affected by changes in climate. Heat waves can increase livestock mortality, lower livestock yields, and reduce reproductive capacity. However, increases in summer temperatures will probably not be so great as to threaten the economic viability of the Pennsylvania livestock industry. After all, much livestock production occurs today in southern states that are far warmer than Pennsylvania. North Carolina has become a major pork and poultry producer, while Florida and Texas are emerging as important dairy production states.[27] Climate change could have an indirect impact on livestock production if forage yields or the quality of forage were to change. However, studies suggest that the carbon dioxide fertilization effect and increases in spring and summer precipitation could lead to increases in forage yields.[28]

Both crop and livestock farmers have many options for dealing with problems created by climate change and taking advantage of opportunities. Agriculture is an industry already very familiar with rapid, never-ending change. Crop farmers can adapt to climate change by altering the mix of crops grown, seed varieties, planting and harvesting dates, crop rotations, tillage practices, fertilization practices, and pest management practices. Livestock farmers can change livestock breeds, feeding rations, veterinary practices, and heating and cooling systems. In particular, indoor livestock facilities can be adapted in many ways to higher temperatures, including fans, insulation and improved ventilation.

Climate change is a global phenomenon that will have impacts on agricultural production worldwide. As global agricultural commodity markets respond, prices facing Pennsylvania farmers will change. Economic studies of the effects of climate change on farm commodity prices are mixed.[29] Some find that climate change will lead to increases in global food supplies, causing farm prices to decline by 5-10%.[30] Others find that climate change will reduce global food supplies, causing

27. U.S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL STATISTICS (2003).

28. *See* Izaurralde et al., *supra* note 23.

29. NAT'L AGRICULTURE ASSESSMENT GROUP, AGRICULTURE: THE POTENTIAL CONSEQUENCES OF CLIMATE VARIABILITY AND CHANGE FOR THE U.S. 63-4 (John M. Reilly ed., 2002); *see also* Abler & Shortle, *supra* note 25, at 191-92.

30. Abler & Shortle, *supra* note 25, at 191-92.

farm prices to rise by 10% or more.[31]

Other Forces Shaping Pennsylvania Agriculture

Pennsylvania agriculture, like U.S. agriculture as a whole, has changed radically during the last century. With the exception of the Amish, tractors and other farm machinery have virtually eliminated the use of draft animals and have made it possible for a single farmer to cultivate large tracts of land. The introduction of synthetic organic pesticides in the 1940s revolutionized the control of weeds and insects.[32] Similarly, there has been tremendous growth in the use of manufactured fertilizers and hybrid seeds. Farmers have become highly specialized in the livestock products and crops they produce. Crops that were virtually unheard of 100 years ago, such as soybeans, are of major importance today. As agricultural productivity has risen, and as real (inflation-adjusted) prices of farm commodities have fallen, land has been taken out of agriculture and returned to forest or converted to urban uses.

Climate change is just one of many factors that will be shaping Pennsylvania agriculture in the 21st century. New technologies, global commodity markets, competing demands for agricultural land, and government regulation will profoundly influence Pennsylvania agriculture. Crop biotechnology has the potential to yield crops with much greater pest resistance, greater resilience during heat waves and droughts, and even cereal crops that fix atmospheric nitrogen like soybeans and other legumes.[33] Genetically engineered vaccines and drugs could significantly reduce livestock mortality and increase yields. Livestock biotechnology could lead to animals that process feed more efficiently, reducing feed requirements and leaving fewer nutrients in animal wastes.[34] Precision agriculture may substantially boost productivity by giving farmers much greater control over within-field variations in soil conditions, nutrients, and pests.

At the same time, economic conditions facing Pennsylvania agriculture will continue changing for many other reasons, including changes in global commodity markets and continuing pressures to convert agricultural land to urban uses. Globalization will tie farmers even closer to world markets than they are now. Pennsylvania's population is likely to continue to grow, leading to additional pressures to convert agricultural land to residential and associated urban uses.

31. Abler & Shortle, *supra* note 25, at 191-92.
32. Abler & Shortle, *supra* note 25, at 187.
33. NAT'L AGRICULTURE ASSESSMENT GROUP, *supra* note 29, at 11; Abler & Shortle, *supra* note 25, at 187.
34. Abler and Shortle, *supra* note 25, at 187.

Environmental regulations on agricultural producers – currently in the discussion phase – may become reality, forcing changes in where producers locate their operations and how they manage their operations.

For all these reasons, there may be far fewer commercial crop and livestock farms in Pennsylvania in the future than there are today. Due to technological improvements, however, crop and livestock yields on the remaining commercial farms should be much higher. There may be continued growth in "weekend," "hobby," and other noncommercial farms. However, these farms account for only a small fraction of Pennsylvania's total agricultural production.

It would have been all but impossible for someone in 1900 to foresee the dramatic changes in Pennsylvania agriculture that would occur during the 20th century. In the same way, it is likely that Pennsylvania agriculture in 2100 will bear only a faint resemblance to today's agriculture, but we cannot say with any confidence what it will look like.

Conclusions

Climate change is likely to benefit Pennsylvania agriculture. Higher atmospheric carbon dioxide levels should stimulate photosynthesis and raise crop yields, while crops may also benefit from additional spring and summer rainfall. At the same time, climate change is just one of many factors that will be shaping Pennsylvania agriculture in the 21st century. Technological change, globalization of agricultural markets, and government regulation will be much more important to Pennsylvania's agricultural economy in the 21st century than climate change.

Nevertheless, this is not a reason to be complacent. Pennsylvania farmers will need to obtain the education and skills necessary to operate in a warmer climate and this may also require that they make major changes in management practices. Pennsylvania State University and other agricultural research organizations in the Mid-Atlantic region will need to provide farmers with the technologies to help them adapt to climate change, such as breeding for carbon dioxide responsiveness in crops and for greater tolerance to heat stress in crops and livestock.

We should also point out that the picture is not as optimistic in some of the other areas examined in the Mid-Atlantic Regional Assessment, such as coastal zones, ecosystems, and human health.[35] Climate change is likely to cause sea levels to rise, making flooding in coastal zones more common and more damaging.[36] The effects of climate change on flooding will be compounded if residential and commercial development

35. MID-ATLANTIC REGIONAL ASSESSMENT TEAM, *supra* note 12, at iii-iv.
36. MID-ATLANTIC REGIONAL ASSESSMENT TEAM, *supra* note 12, at 26-29.

of coastal areas continues at its current pace, exposing more people to flood risk. Ecosystems in the Mid-Atlantic region – including the highly valued Chesapeake Bay – could be damaged if increases in precipitation flush additional sediments, fertilizers, and livestock wastes into rivers, streams, and lakes. Human health could be threatened if a warmer and wetter climate causes tropical infectious diseases to migrate northward. Recent outbreaks of West Nile Virus Encephalitis in Pennsylvania are an example of a migrating disease.

One critical component of the Mid-Atlantic Regional Assessment and its successor, the Consortium for Atlantic Regional Assessment, is stakeholder participation.[37] A wide variety of stakeholders throughout the Mid-Atlantic region have contributed to these assessments, helping make sure that we ask the right questions and produce useful information. We welcome your questions, comments, and suggestions.

37. MID-ATLANTIC REGIONAL ASSESSMENT TEAM, *supra* note 12, at 3-4.

For More Information

More information about climate change can be found on these websites:

Mid-Atlantic Regional Assessment

http://www.essc.psu.edu/mara/

Consortium for Atlantic Regional Assessment

http://www.cara.psu.edu/

U.S. Global Change Research Program

http://www.usgcrp.gov/

National Oceanic & Atmospheric Administration

http://www.noaa.gov/

Environmental Protection Agency – Global Warming

http://www.epa.gov/globalwarming/

Intergovernmental Panel on Climate Change

http://www.ipcc.ch/