RUTGERS
Climate Institute

Climate Change and Agriculture, Including Aquaculture and Fisheries, in New Jersey

RUTGERS
New Jersey Agricultural
Experiment Station

Climate Change and Agriculture, Including Aquaculture and Fisheries, in New Jersey

Introduction

Longer growing seasons, milder winters, more frequent flooding, heavier rains, and hotter summers are some of the expected impacts that New Jersey farmers and fishers will see more of due to climate change. In order to prepare for these changes, farmers and fishers will gradually need to adopt new or alter certain management practices in their operations, including what kinds of crops they grow, what kinds of fish they catch, and how they care for their livestock. This fact sheet is intended to provide an overview of the various impacts climate change may cause as well as how New Jersey farmers and fishers may adjust to meet these changes.

What is Climate Change?

Climate change is a change in the state of the climate that persists for an extended period, typically decades or longer. Climate change over the past half-century has primarily been driven by increasing concentrations of greenhouse gases, such as carbon dioxide and methane which have led to a gradual increase in global temperature. This warming, while global, will substantially alter local and regional weather patterns, including here in New Jersey. We already are seeing that warming here in the state. Nine of the ten warmest years in 120 years of record-keeping, have occurred since 1990, with five of those years occurring since 1998(3). Long-term seasonal records show that every season gradually is warming (15). Figures 1 and 2 show long term data for New Jersey's spring and summer season; fall and winter data can be found in Appendix A.

How is Climate Change Related to Weather?

Weather and climate are different. Weather is what you see every day and can be measured by the minute. Climate is what happens over the long-term and typically is measured by the season, year, decade, or longer. But a changing climate also means changes to the frequency of day-to-day weather events. In New Jersey, climate change will likely lead to a higher occurrence of hotter days, more heat waves, shorter and milder winters, longer growing seasons, more frequent heavy rainstorms, fewer snowstorms that replenish groundwater, more frequent periods of drought, although there still will be the occasional extreme cold snap (19).

Impacts of Warmer Temperatures

Warmer temperatures have several key impacts on agriculture productivity: growing season, the types of crops that can be grown, and heat stress on crops and livestock (12).

Climate change likely will result in a longer growing season in New Jersey, due to milder winters with later onsets of first frosts in the fall and an earlier start to the growing season. Because of the change in growing season length, as well as intensity of mid-summer heat, farmers may need to choose different varieties or even types of crops.

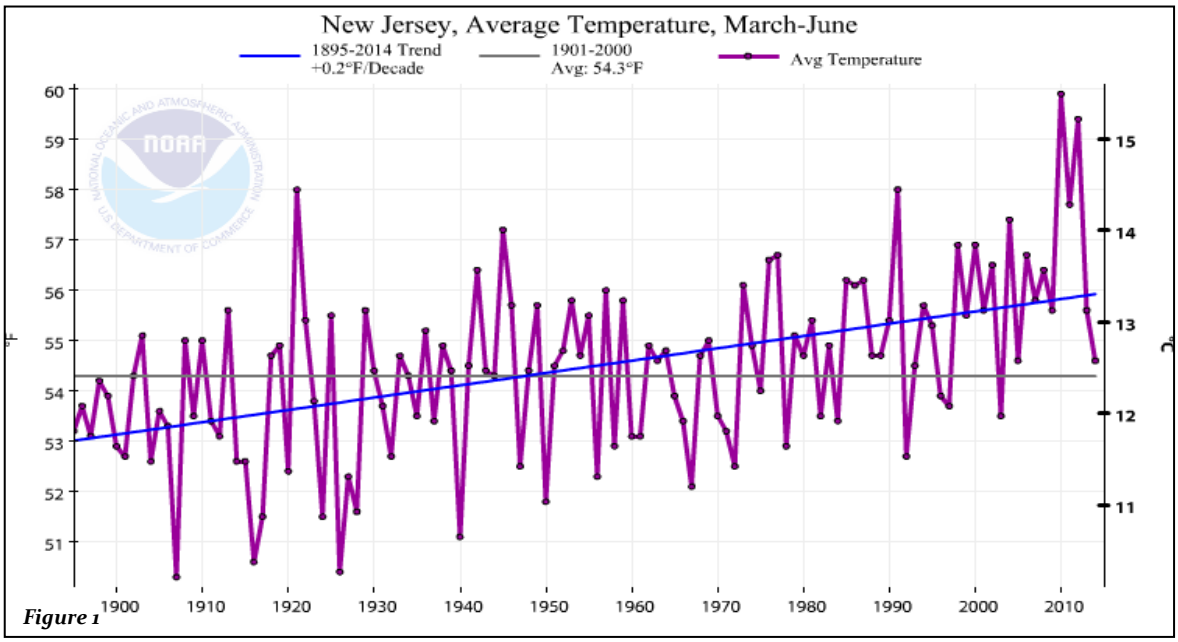

Figure 1

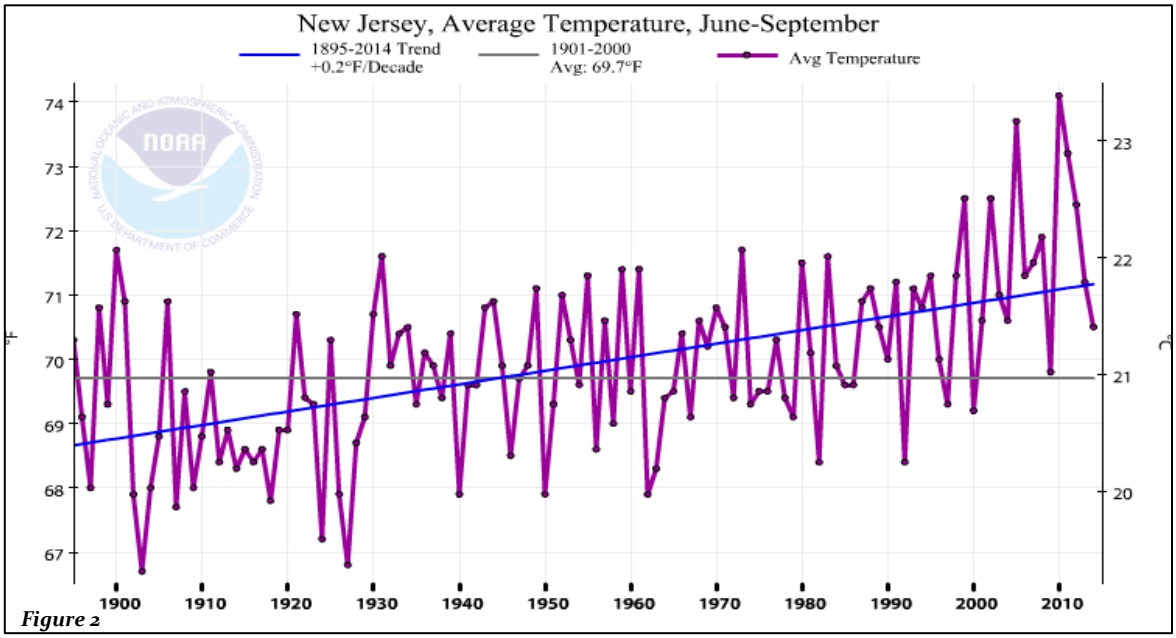

Figure 2

Figure 1 *(above): New Jersey average seasonal spring temperature from 1895-2014.*
Figure 2 *(below): New Jersey average seasonal summer temperature from 1895-2014.*
Data Source: 15. Note: Further data for other seasons can be found in Appendix A.

Crops that require long chill periods for optimum growth, such as cranberries, northern blueberries, and certain apple varieties, over time may no longer grow effectively or produce as much fruit as in the past (6). Other crops, including cranberries, may no longer thrive due to the additional exposure to high heat in the summer that could result in increased "scald", while increased temperatures combined with wetter conditions or increased irrigation to cool the crop during heat spells may promote cranberry fruit rot diseases (34). Increased summer heat also may impact the amount of moisture available to plants because of increased evapotranspiration (i.e. the combined processes of evaporation and transpiration) (2, 26). Higher temperatures will mean a longer growing season for crops that do

well in the heat, such as melons, peppers, and tomatoes, but a shorter growing season for crops more suited to cooler conditions, such as potatoes, lettuce, broccoli, and spinach (4).

An increase in heat stress also is an impact of climate change. Heat stress doesn't just come during the day during extreme hot spells. Increased nighttime temperatures also can increase livestock stress, thus reducing milk, egg and meat production (36). Warmer nighttime temperatures during hot spells also can reduce crop yields. Crops grown in areas with a warmer average nighttime temperature may be less sweet due to increased respiration where the plant taps stored sugar for energy. This may mean the quality of some crops may be lower and harder to sell. Warmer nighttime temperatures may also reduce crop yields overall and increase water demand (33, 36).Daytime heat stress could affect the health and productivity of farm workers (36).

Changes in Precipitation

Climate change may alter local and regional precipitation patterns in ways that affect agriculture. The overall trend in New Jersey has been an increase in annual precipitation, but the trend is relatively small compared to the year-to-year variability (3). As the climate warms, precipitation is projected to come increasingly from heavier storms in the form of rainfall while at the same time that dry spells may likely increase in duration (3, 5, 29). Evapotranspiration is likely to increase, especially during the summer (2, 19). For crop producers, this may mean an increase in the use of irrigation. These increases in hot and dry spells will increase the stress on plants and livestock, likely reducing production (6, 28, 30). Additionally, the increase of extreme rain storms could increase soil erosion, which results in a loss of nutrients from the soil and reduces crop yields unless producers increase the amount or change the type of fertilizers (27, 30).

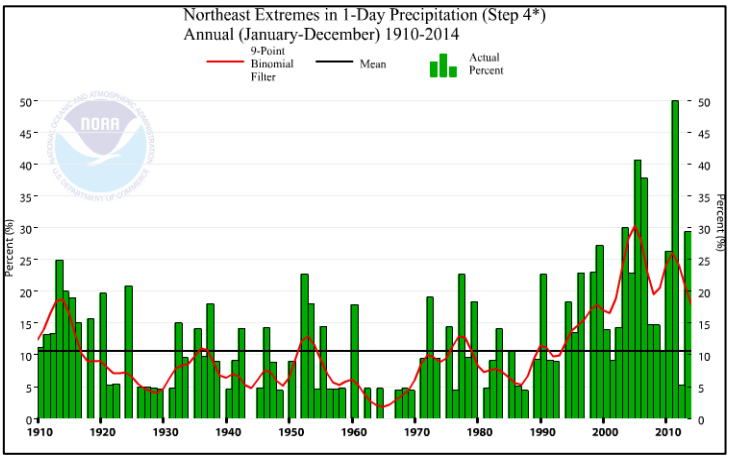

Figure 4: *The trend in the Northeastern United States Extremes in one day precipitation events from 1910-2014. Data Source: 14*

Weeds, Insects, and Crop Disease

A warmer climate may allow certain types of weeds, insect pests, as well as crop diseases, to flourish in New Jersey. Invasive weeds, such as kudzu, green kyllinga, and dallisgrass, which typically are found in southern states, will likely migrate north as their range expands (9). These increases could have economic and environmental impacts due to anticipated increases in frequency of herbicide applications (37).

A Blueberry Leafminer showing the damage pests can cause. Photo: Jack Rabin

Milder and shorter winters may not kill off certain insect pests or crop diseases, increasing the chances for greater pest and disease problems (7). Pest species, including the tomato pinworm and the beet armyworm, previously unseen in New Jersey may become common (20). Longer growing seasons may allow some pests to produce more generations in a single season. This could lead to additional crop losses and higher usage of pesticides (7, 33). Anecdotal reports from farmers to New Jersey Agricultural Experiment Station (NJAES) scientists stated that certain disease problems, such as

dollar spot in turf grass, have shown up earlier than normal and have lasted several weeks to a month longer than typical. Additionally, NJAES scientists identified species of Rhizoctonia, which causes brown patch disease also in turf grass, that previously have only been found in southeastern states (20). Traditionally southern blueberry diseases, e.g., stem canker and stem blight, have become established in New Jersey (34).

Increases in temperature and humidity may also alter the disease complex for crops, requiring growers to modify their management programs. Some plant pathogens, perhaps new to New Jersey, may be favored, while other resident pathogens may decline. Furthermore, plants stressed by drought or heat may be more susceptible to crop diseases, increasing the likelihood of crop losses (17, 33). Farmers in New Jersey reported to NJAES scientists that warmer springs already have resulted in peaches developing about three weeks ahead of normal, with record levels of two early season diseases, peach rusty spot and peach blossom blight, occurring in 2012 (10,20).

Impacts on Fisheries

Climate change also may put additional stress on fisheries that already are affected by pollution and over-fishing (9). As the water temperature increases, certain species may no longer thrive in New Jersey waters. Species that thrived in southern waters also may migrate in as their range shifts. Changes in species ranges could lead to challenges in the current ecosystems as new species compete for food and habitat. Additionally, the timing of annual migrations may shift and diseases affecting commercially important species also may increase in warmer waters (12, 18, 24).

Oysters freshly packed and ready to be sold. Photo: Jack Rabin

Cumulative stressors add to the changes affecting commercial fisheries in the state, including bycatch, habitat destruction, and loss of prey (18). Additional carbon dioxide in the atmosphere also is leading to ocean acidification, which can affect the larval stages of many shellfish species. Increasing acidity affects these species' ability to make or retain their calcium carbonate shells. The potential impacts to the larval stages as well as other zooplankton that have calcium-based shells could have substantial impacts to the entire food web (9, 16, 24).

Populations and species that currently are facing the fewest non-climate-related stressors will be able to better withstand the changes associated with a warming climate. Fisheries managers can help the industry adapt to these changes by addressing the cumulative impacts on commercial fisheries, including stock depletion, and habitat destruction. Managers can help address these stressors by accounting for climate effects in stock assessments (i.e., looking at environmental factors when looking at growth and harvest rates and health of fish), supporting habitat restoration, and encouraging fishing communities to increase catch diversity (18). For more information, visit http://oceanadapt.rutgers.edu.

Adapting to These Changes

Overall, climate change may result in higher farm management costs. However, agricultural producers may be able to reduce those costs by making short-term capital investments or adopting sustainable management practices. Farmers may need to invest in planting new varieties of vegetables, small fruit and fruit trees that are better able to tolerate a warmer growing climate. This investment also may include planting new varieties of crops that can take advantage of longer growing seasons as well as crops that can

Rye being used as a cover crop. Photo: Jack Rabin

withstand higher heat in the summer (11). Development of new plant varieties that are most suited to New Jersey's changing climate is a focus area of NJAES plant breeders. Farmers may also have to modify current management practices to improve soil health, and increase water and soil conservation, including finding ways to diversify water sources (13). Farmers can improve soil health by reducing tillage, increasing the amount of organic material used as fertilizer, and using crops in rotation that have a high residue (biomass), such as small grains or alfalfa grasses (25). Farmers also can minimize nutrient loss from soils by establishing buffers and a conservation tillage system that preserves top soils (17, 21). Additionally, farmers can reduce or eliminate periods of fallow fields by planning crop rotations, switching from annual to perennial crops, and using cover crops or hay (8).

Reducing Greenhouse Gases from Agriculture

Agriculture is responsible for about 10 percent of the greenhouse gases emitted annually in the U.S. (30). A significant source of these gases is the methane released from livestock due to digestion. Another source of greenhouse gases from agriculture comes from soils treated with nitrogen-based fertilizers. Additionally, farm vehicles and machinery release greenhouse gases by burning gasoline or diesel fuel. Improving operational efficiency and using sustainable techniques, such as no-till farming, can help reduce emissions (8).

Livestock such as cows release large amounts of methane. Photo: Jack Rabin

Methane

The amount of methane released can vary by animal species, as well as by housing, feeding and management practices. For example, cows fed greater amounts of highly digestible feeds and forages, and/or supplemented with compounds such as ionophores (an ionophore partitions digestive fermentations to increase animal production efficiency) will have improved feed efficiencies, reduced methane production, as well as increased meat or milk production. Rotational pastures, when properly managed, will result in lower fiber accumulation in forage plants and will reduce dietary methane production in livestock (35). Grazing systems can also reduce greenhouse gas emissions by reducing the amount of energy used for preserving and harvesting forages (1, 32). Another advantage of grazing is the ability of pastures to sequester organic carbon and further reduce greenhouse gas emissions. Some farmers (mostly dairy and hog) have installed anaerobic digesters to capture the methane produced during manure storage. These digesters can convert methane into energy that can be used on the farm, reducing energy costs (8). In general, any technology that increases animal efficiencies will also reduce methane release relative to animal production (35).

Nitrogen

Nitrogen-based fertilizers are digested by soil microbes into nitrous oxide, which is a greenhouse gas with nearly 300 times the heat-trapping capacity as carbon dioxide (22). Agricultural soil management accounts for 75 percent of the nitrous oxide emissions in the U.S. (31). Manure management accounts for an additional 5 percent of emissions in the U.S. (32). Farmers can reduce these emissions by reducing the frequency and amount of nitrogen-based fertilizer applications, by using slow-release fertilizers, changes in application schedules, or other best farming practices (23).

Climate Change Research, Education, and Outreach at Rutgers

Rutgers, The State University of New Jersey is facilitating collaboration across a broad range of disciplines in the natural, social, and policy sciences on helping to prepare for a changing climate. The university also is a leading source of climate change research and information.

For more information go to: http://climatechange.rutgers.edu

For additional information on New Jersey Environment and Natural Resources: http://njaes.rutgers.edu/environment/

For additional information on New Jersey Commercial Agriculture: http://njaes.rutgers.edu/ag/

For additional information on Home, Lawns, and Gardens in New Jersey: http://njaes.rutgers.edu/garden/

For additional information on New Jersey Fisheries and Aquaculture: http://njaes.rutgers.edu/fisheries/

For additional information on New Jersey's Office of the State Climatologist: http://climate.rutgers.edu/stateclim/

References

1. Boadi, D., Benchaar, C., Chiquette, J., & Massé, D. 2004. Mitigation strategies to reduce enteric methane emissions from dairy cows: update review. *Canadian Journal of Animal Science*, *84*(3), 319-335.

2. Broccoli, Anthony. 2015. Chair, Department of Environmental Sciences, Rutgers University. Personal Communication.

3. Broccoli, A.J., Kaplan, M.B., Loikith, P.C, Robinson, D.A., *State of the Climate: New Jersey 2013*. Rutgers Climate Institute.

4. Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. 2007. Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS). *http://www.climatechoices.org/assets/documents/climatechoices/confronting-climate-change-in-the-u-s-northeast.pdf*.

5. Georgakakos, A., P. Fleming, M. Dettinger, C. Peters-Lidard, Terese (T.C.) Richmond, K. Reckhow, K. White, and D. Yates. 2014: Ch. 3: Water Resources. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 69-112.

6. Hatfield, J., G. Takle, R. Grotjahn, P. Holden, R. C. Izaurralde, T. Mader, E. Marshall, and D. Liverman. 2014: Ch. 6: Agriculture. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 150-174.

7. Hobbs, P.R., Sayre, K., Gupta, R. 2008. The role of conservation agriculture in sustainable agriculture. *Philosophical Transactions of the Royal Society B: Biological Sciences.* 363(1491): 543-55.

8. Horowitz, J. and Gottlieb, J., U.S. Department of Agriculture Economic Research Service. The Role of Agriculture in Reducing Greenhouse Gas Emissions, Economic Brief Number 15, September 2010.

9. Karl, T.R., Melillo, J.M., Peterson, T.C. (eds.). U.S. Global Change Research Program. 2009. *Global Climate Change Impacts in the United States*. Cambridge University Press, New York, NY USA.

10. Lalancette, Norman. 2015. Extension Specialist in Tree Fruit Pathology. New Jersey Agricultural Experiment Station, Rutgers University. Personal communication.

11. Leichenko, R., Major, D., Johnson, K., et al, New York State Energy Research and Development Authority ClimAID Annex III, An Economic Analysis of Climate Change Impacts and Adaptations in New York State, 2014.

12. Melillo, J.M., Richmond, T.C., and Yohe, G.W., eds., 2014: *Highlights of Climate Change Impacts in the United States: The Third National Climate Assessment*. U.S. Global Change Research Program, 148 pp.

13. National Academy of Sciences, American's Climate Choices: Adapting to the Impacts of Future Climate Change, May 2010.

14. National Oceanic Atmospheric Association. U.S. Climate Extremes Index (CEI): Graph. http://www.ncdc.noaa.gov/extremes/cei/graph. Last accessed June 25, 2015.

15. National Oceanic Atmospheric Association. Climate at a Glance. http://www.ncdc.noaa.gov/cag/time-series/us. Last accessed June 23, 2015.

16. National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory Program, What is Ocean Acidification. http://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F. Last accessed February 25, 2015.

17. Oerke, E.C. 2006. Crop losses to pests. *Journal of Agricultural Science*, 144: 31-43.

18. Pinsky, M.L. and N.J. Mantua. 2014. Emerging adaptation approaches for climate-ready fisheries management. *Oceanography* 27(4):146–159, http://dx.doi.org/10.5670/oceanog.2014.93.

19. Robinson, David. 2015. Professor, Department of Geography and New Jersey State Climatologist, Rutgers University. Personal Communication.

20. Robson, Mark. 2015. Professor and Chair, Department of Plant Biology and Pathology, Rutgers University. Personal Communication.

21. Rosenzweig, C., Iglesias, A., Yang, X.B., Epstein, P.R., and Chivian, E. Climate Change and U.S. Agriculture: The Impacts of Warming and Extreme Weather Events on Productivity, Plant Diseases, and Pests, Center for Health and the Global Environment, Harvard Medical School, Boston, MA, May 2000.

22. Shcherbak, I., N. Millar, and G. P. Robertson. 2014. Global metaanalysis of the nonlinear response of soil nitrous oxide (N2O) emissions to fertilizer nitrogen. Proceedings of the National Academy of Sciences. 111 (25) 9199-9204.

23. Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H., Kumar, P., et al. 2008. Greenhouse gas mitigation in agriculture. *Philosophical Transactions of the Royal Society B-Biological Sciences, 363*(1492), 789-813.

24. State of Maine Department of Marine Resources Public Health Program Newsletters Facts: Did You Know… Ocean Acidification in Maine, November 2011. http://www.maine.gov/dmr/rm/public_health/newsletter/oceanacidity.pdf

25. U.S. Department of Agriculture. 2011. Cropland Soil Quality. Natural Resources Conservation Service – New Jersey. Soil Health Fact Sheets – Ocean County. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs141p2_018422.pdf

26. U.S. Department of Agriculture. Natural Resources Conservation Service. 1998. Field Office Guide to Climatic Data. http://www.wcc.nrcs.usda.gov/climate/foguide.html#frost. Last accessed June 8, 2015.

27. U.S. Department of Agriculture. Natural Resources Conservation Service. Climate Change, The Greenhouse Effect and Climate Change. http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/climatechange/. Last accessed February 25, 2015.

28. U.S. Department of Agriculture, Climate Solutions, Creating Modern Solutions for Environmental Challenges. http://www.usda.gov/wps/portal/usda/usdahome?navid=climate-change. Last accessed February 25, 2015.

29. U.S. Environmental Protection Agency. Future Climate Change. http://www.epa.gov/climatechange/science/future.html. Last accessed June 8, 2015.

30. U.S. Environmental Protection Agency. Sources of Greenhouse Gas Emissions, agriculture sector emissions. http://epa.gov/climatechange/ghgemissions/sources/agriculture.html. Last accessed February 25, 2015.

31. U.S. Environmental Protection Agency. Overview of Greenhouse Gas Emissions, Nitrous Oxide Emissions. http://epa.gov/climatechange/ghgemissions/gases/n2o.html. Last accessed February 25, 2015.

32. U.S. Environmental Protection Agency, Greenhouse Gas Reporting Program. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2012, Chapter 6, April 2014.

33. U.S. National Aeronautics and Space Administration Earth Observatory: Global Warming. http://earthobservatory.nasa.gov/Features/GlobalWarming/page6.php. Last accessed February 25, 2015.

34. Vorsa, Nicholi. 2015. Director, Philip E. Marucci Center for Blueberry and Cranberry Research and Extension, New Jersey Agricultural Experiment Station. Rutgers University. Personal communication.

35. Westendorf, Michael. 2015. Extension Specialist in Animal Science. New Jersey Agricultural Experiment Station, Rutgers University. Personal communication

36. Walthall, C.L., J. Hatfield, P. Backlund, L. et al., 2012. Climate Change and Agriculture in the United States: Effects and Adaptation. USDA Technical Bulletin 1935. Washington, DC. 186 pages.

37. Wolfe, D. W., Ziska, L., Petzoldt, C., Seaman, A., Chase, L., and Hayhoe, K. 2008. Projected change in climate thresholds in the Northeastern US: implications for crops, pests, livestock, and farmers. *Mitigation and Adaptation Strategies for Global Change*, *13*(5-6), 555-575.

Photo Credits

Cover photos courtesy of Jack Rabin and Olaf Jensen.

Acknowledgment

Support has been provided by the U.S. Forest Service. "This institution is an equal opportunity provider."

Published January 2016

Appendix A: Temperature Trends for Fall and Winter in New Jersey 1895-2014

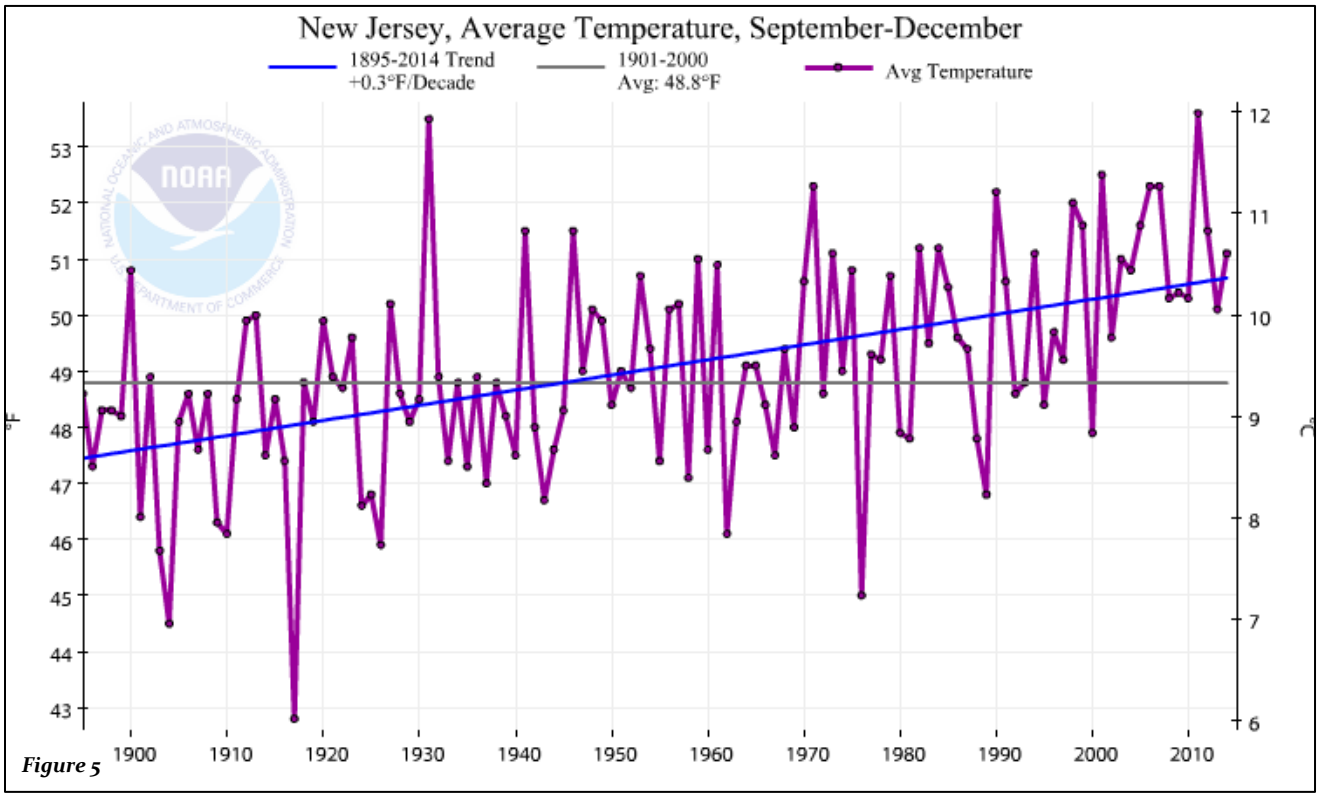

Figure 5

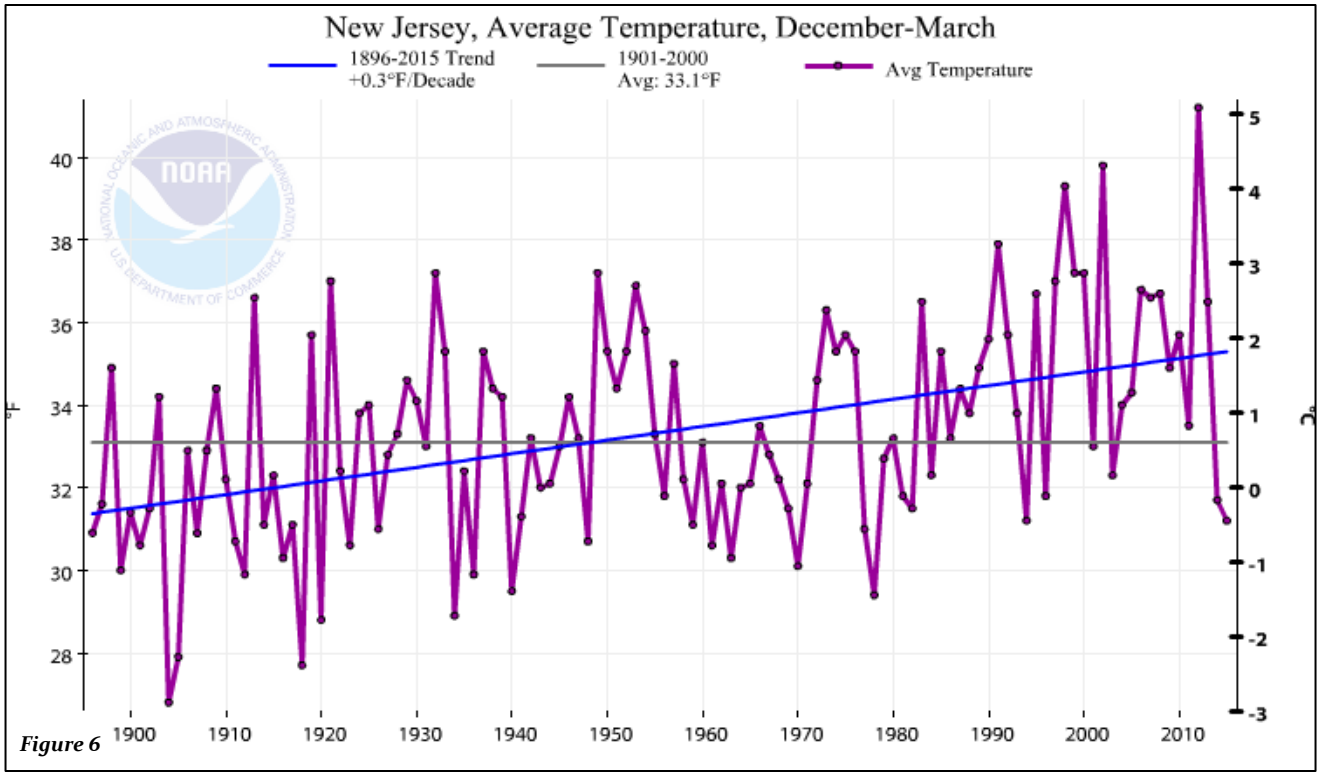

Figure 6

Figure 5 *(above): Average seasonal fall temperature from 1895-2014.*
Figure 6 *(below): Average seasonal winter temperature from 1895-2014.*
Data Source: 15