Climate Change Adaptation in New England Agriculture

Introduction

New England's climate has changed considerably during the 20th century. Average annual temperatures increased by 0.08 degrees Celsius (°C) per decade and average winter temperatures have increased by 0.12°C. The rate of average temperature increase accelerated significantly during the period of 1970 to 2000 with average annual temperatures increasing by 0.25°C per decade and average winter temperatures increasing by 0.70°C. Driven by these changes growing seasons have lengthened, the number of days with snow on the ground has decreased for many locations and the timing of peak spring stream flow has shifted to earlier in the year.[1]

A recent study of the period from 1948 to 2007 found significant increases in both the occurrence and intensity of extreme precipitation with the most significant increases occurring most recently.[2]

The pace and extent of climate change will be dependent on global efforts to limit greenhouse gas emissions. The projections in Table 1 are derived from downscaled global climate models that examine the ramifications of two different greenhouse gas scenarios.[3] The B1 scenario assumes a stabilizing of atmospheric Carbon Dioxide (CO_2) levels at or above 550 ppm by year 2100. The A2 scenario assumes atmospheric CO_2 levels of 830 ppm by 2100 and the A1FI scenario assumes CO_2 levels of 970 ppm by 2100. Results for the B1 and A1FI scenarios for two of the modeled variables, temperature and precipitation are shown in the following table.

	UNITS	2035-2064		2070-2099	
Temperature	Degrees C	B1	A1FI	B1	A1FI
Annual		+2.1	+2.9	+2.9	+5.3
Winter		+1.1	+3.1	+1.7	+5.4
Summer		+1.6	+3.1	+2.4	+5.9
Precipitation	% change				
Annual		+5%	+8%	+7%	+14%
Winter		+6%	+16%	+12%	+30%
Summer		-1%	+3%	-1%	0%

The frequency and severity of heat waves and very heavy precipitation events are projected to increase. Sites on the coast will be exposed to sea level rise in the range of 1.5 to 6 feet by 2100 depending on greenhouse gas levels and ice melt rates.[4]

Average winter precipitation in New England is projected to increase by approximately 10 to 20 percent by the end of the century and the prevalence of heavy precipitation events is also predicted to rise. Average annual temperatures are projected to climb approximately 3 to 5º C by the end of the century, and the frequency and severity of extremely hot days will also increase.[5] The associated lengthening of the growing season and projected increase in summer drought will coincide with peak groundwater use during the summer season, which will like create drier summer conditions.

Agriculture in New England

New England agriculture is an important contributor nationally to dairy products and food crops including apples, grapes, potatoes, sweet corn, onions, cabbage, and maple syrup.[6] For instance, over 50% of cropland in five of the six states is managed by dairy farms, and in 2011 cash receipts from milk sales alone in 2011 totaled $871 million in New England.[7,8] Some states have their own well known crop associations like Vermont maple syrup, Maine potatoes, and Massachusetts cranberries. Vermont alone produces 44 percent of the region's maple syrup, valued at approximately $11 million annually.[9] Agriculture is also one of the most vulnerable sectors to climate change in New England. Farmers are faced with rising temperatures shifting plant hardiness zones and causing livestock and crop heat stress, new invasive species and pests, increased water limitations, and further weather volatility. Along with challenges may come opportunities brought on by a longer growing season and evolving agriculture markets and crop options. Some specific climate change vulnerabilities, opportunities, and adaptation strategies for the agriculture industry are discussed below.

Vulnerabilities and Opportunities

CLIMATE CHANGE AND ANIMAL AGRICULTURE

- Rising Temperatures and livestock heat stress – Rising temperatures will have a largely negative impact on animal agriculture in New England, including increasing heat stress in livestock. Stress from higher temperatures, humidity, and increased exposure to sunlight can decrease animal health and productivity, and increase their water requirements.[10] Although it affects all livestock, dairy cattle are particularly sensitive because of their lower temperature thresholds. Even moderately warm temperatures combined with humidity (e.g., higher than 80ºF, greater than 50 percent relative humidity) can reduce milk productivity and calving rates.[11] While the economic impacts of heat stress are most concerning for dairy cattle, they may still be significant for other livestock as well, for instance beef cattle on pasture based systems that leave them exposed to the elements. With heat stress projected to be widespread through most of New England (excluding possibly the northernmost areas of the region) farms will need to consider adaptation measures, such as modifying or constructing livestock facilities to improve cooling and ventilation.

- Changes in water availability and water requirements – Rising temperatures are predicted to reduce water availability during summer months due to increasing transpiration from plants and evaporation from soil.[12] In combination with precipitation changes, this is projected to cause a general rise in drought frequency in the Northeast, although there is uncertainty in the variability.[13] Higher temperatures will also increase water requirements for farm livestock. Water intake is commonly two to three times greater per unit of feed intake under hot conditions compared to cold, and it is estimated under heat stress that water intake could increase between 20 to 50 percent.[14,15]

- **More frequent and intense storm events** – Increasing and higher intensity storm events may cause higher and longer flooding, resulting in erosion and a loss of topsoil, longer periods of unavailability for livestock grazing on certain acreage (e.g., floodplain acreage), and add to livestock stress. These types of rainfall events are also less effective at replenishing soil water supplies. In addition, the projected increase in annual precipitation and heavy precipitation events may increase risk for certain livestock illnesses.

CLIMATE CHANGE AND CROP AGRICULTURE

Uncertainty surrounds the overall effects of climate change on crops in New England. A warmer growing season may provide opportunities for new crops in New England. Climate change could also produce higher yields for certain crops, with the warmer temperatures creating a longer growing season, and the higher levels of carbon dioxide in the air potentially increasing plant growth.[16,17] However, increased growing season temperatures could also decrease yields in certain crops, for example cool-season grains.[18]

Warming winter temperatures will affect a range of perennial crops. For instance, warmer winter days can deacclimate these plants, making them susceptible to injury or death when followed by colder weather. Also, crops that benefit from the insulation snow provides will likely suffer from winterkill if snowcover is reduced or turns to ice. Other potentially negative effects from a changing climate include increased threat from agricultural pests (e.g., weeds, insects); as well as the decreased water availability and soil erosion concerns mentioned above.[19] Temperature increases in combination with precipitation changes are also projected to cause an increase in mild to moderate drought in the Northeast and reduce water availability for crops during summer months due to increased transpiration from plants and evaporation from soil.[20,21] Below are examples of how changing weather patterns in New England may affect some of the regions staple crops:

- **Apples** – Apple production in the Northeast could benefit from the changing environment, however this will likely come with increased risk and management requirements.[22] Models show that northern regions like New England are likely to experience

enhanced ability to produce fruit due to additional growing days,[23] which would benefit longer-season apple varieties such as Fuji or Granny Smith. However, certain fruit trees require a minimum number of cold days to achieve dormancy followed by fruit production. Current models show fruit-producing areas worldwide losing the ability to successfully grow tree fruit from loss of adequate winter chill days.[24] Cool-season species such as McIntosh and Empire will be negatively affected by the warmer climate and reduced winter chill periods, lowering their yields and fruit quality, and thus viability as a commercial crop.[25]

Fruit quality will likely also be affected by more frequent summer heat stress periods,[26] with parts of the northeast projected to have up to 10 to 15 more heat stress days. Again, this will be particularly harmful to cool-temperature adapted crops prevalent in the region's agricultural economy.[27] Farmers may likely have to invest in transitioning to new apple varieties over time to avoid lost profitability.[28,29]

- Cranberry production – Cranberry production is viable in climates significantly warmer than New England, so a warming climate will not cause the end of cranberry production. However, growers will be challenged by warming temperatures affecting their chilling requirements, increased risk of frost damage and/or heat stress (e.g., cranberry scald), changing precipitation patterns, more pest and disease pressure (e.g., fungi), and problematic extreme weather events.[30] Productivity may reduce, as higher average summer temperatures are associated with a decrease in cranberry productivity in Massachusetts, where optimal productivity occurs when temperatures remain between 60 to 86 degrees F in July and August.
- Maple Syrup – Predictions vary for maple sugaring prospects in the Northeast. The industry's future in the US will be negative overall, with maple trees failing to thrive in the Northeast under higher emissions scenarios over the long term.[31] But while sugar maples indeed do shift substantially northward and out of most of the US, sugar maples and other maple varieties remain viable in northern parts of New England such as Maine, even under

the highest emissions scenarios modeled.[32] And other scientific assessments show that through 2100, prime sap production timing will shift as the climate warms, but overall production will not be significantly affected in areas where sugar maple trees are still viable.[33] Overall, the market is predicted to be in-demand for decades, particularly as the southern supply decreases. However farms must plan to incorporate adaptation methods to prepare for a shift in tapping timing and a modified abundance of maple tree species. Decreasing sapflow rates are also a concern, as the physical relationship between temperature and internal pressure that allows for sapflow from maple trees is influenced by rising temperatures and other site specific factors (e.g., soil moisture, snow cover, tree health).[34]

Adaptation Strategies

DAIRY AND BEEF LIVESTOCK

A variety of adaptation options are recommended for dairy farms in the northeast that together can help reduce heat stress and its impacts through infrastructure changes, and alterations in diet and water supply management.[35]

- Increase the cooling capacity of existing indoor livestock areas (e.g., barns) and utilize modeled temperature projections when planning new structures – On hot days, indoor barn temperatures can be higher than ambient air temperatures in poorly ventilated structures, a more significant problem with the warming climate. Improved ventilation is a first-step adaptation strategy to address heat stress. Other potential cooling measures include the increased use of fans to improve air flow; sprinklers or misters to improve evaporative cooling; and ensuring all cows have shade in the facility.[36,37]

- Ensure adequate water availability for livestock – Check the water management system to make certain adequate water is available for livestock (especially dairy cattle) under heat stress conditions, in the barn and also while grazing. Consider the use of “nose pumps” for cattle farther away from farm facilities to essentially self-water without using additional energy or committing to new energy infrastructure. Consider increasing irrigation capacity on the farm to prepare for growing water needs of livestock as well as crops.

- Ensure adequate livestock shading in farm areas by developing a shading plan in tandem with regional agricultural support services. For example, simple structures can be built in pasture areas to provide shade.[38]

- Adjust diet and feed strategies – Changing diet and feeding management can alleviate some heat stress impacts on livestock without incurring high costs. Explore available options, which include adjusting the cattle’s diet to include more easily digestible forages, or adding minerals to reduce those lost through increased sweating and respiration. Also consider techniques such as shifting feeding times to cooler parts of the day.[39,40]

CROPS

- Explore different crop varieties – Consider varieties better suited to the changing environment, and that provide higher yield with lower maintenance if possible. Over the longer term, some farms may consider diversifying with other perennial crops better suited to the changing environment.[41]

- Consider updating water management techniques – To prepare for increasing water needs of crops, farms may consider further water conservation measures for efficient water use.[42] Make appropriate investments on an as needed basis, including maintenance of current irrigation systems and addition or expansion of irrigation capacity.

- Alter harvesting schedule – Investigate benefits of altering planting or harvesting dates to take advantage of a longer growing season or avoid adverse weather affecting crops (e.g., heat stress), keeping in mind timing of market demands to maintain profitability.[43] For example, maple syrup farmers can begin tapping trees earlier to avoid loss of sap flow days, which warming winter temperatures could reduce if traditional sap collection schedules are kept.[44]

- Monitor for pest pressures – Farms should monitor for changing pests pressure (e.g., fungi, insects) and incorporate associated management techniques as necessary. If herbicide or pesticide use is necessary, follow best management practices and select the least harmful methods to decrease associated environmental, wildlife, and human health effects.

- **Incorporate new technology and techniques to address climate change affects** – This varies greatly based on the type of farming. For instance, impacts from warming weather will require modern sap collection technology for maple syrup production that can help increase sap yield from trees and avoid backflow and plugging of spouts (i.e., high-vacuum tubing, check-valve spout adapters, and annual replacement of droplines and spouts).[45,46] Cranberry growers may want to update bog designs and management to accommodate increasingly heavy precipitation. Already the region has had a 67% increase in very heavy precipitation events in the last 50 years. And trellis based crop infrastructure (e.g, dwarf apple trees) should be maintained for maximum support under more intense storm events.
- **Seek opportunities** – The changing weather may hold some new opportunities for the region. A warmer growing season may give access to new crops that are currently not viable, and to a broader genetic base for current crops. Also, changes in national and international market structure may provide new opportunities. For instance, the predicted decreased in national supply of certain apple species may lead to an increased demand for apple production in New England. Another example is maple sugaring in northernmost New England. The price of maple syrup has increased dramatically in recent years, and although tapping season timing may shift there will likely be a net increase in sapflow days in the extreme north, provided the traditional sap collection schedules is modified accordingly. [47,48]

Endnotes

1. Katharine Hayhoe et al., “Past and Future Changes in Climate and Hydrological Indicators in the U.S. Northeast,” Climate Dynamics (2007), http://www.northeastclimateimpacts.org/pdf/tech/hayhoe_et_al_climate_dynamics_2006.pdf.
2. Susan Spierre and Camron Wake, Trends in Extreme Precipitation Events for the Northeastern United States 1948-2007 (Carbon Solutions New England, 2010), http://www.cleanair- coolplanet.org/cpc/documents/2010neprecip.pdf.
3. Sea-Level Change Considerations for Civil Works Programs (U.S Army Corps of Engineers, October 2011).
4. (Hayhoe)
5. Hayhoe, K. et al (2006) Past and future changes in climate and hydrological indicators in the U.S. Northeast, 2006 Climate Dynamics DOI 10.1007/s00382-006-0187-8.
6. Wolfe, D.W., L. Ziska, C. Petzoldt, A. Seaman, L. Chase and K. Hayhoe. 2008. “Projected change in climate thresholds in the Northeastern U.S.: Implications for crops, pests, livestock, and farmers.” Mitigation and Adaptation Strategies for Global Change 13:555–575
7. America’s Farmland Trust.nd. New England, website accessed at www.farmland.org/programs/states/ma/new-england.asp in April 2013.
8. USDA. 2011. Annual Statistical Bulliten: New England Agricultural Statistics, 2011. www.nass.usda.gov/Statistics_by_State/New_England_includes/Publications/Annual_Statistical_Bulletin/nemlk2011.pdf
9. Lauten, G., et. al. 2001. Climate impacts on regional forests, Chapter 5. In Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change. The New England Regional Overview. University of New Hampshire: U.S. Global Change Research Program.
10. Jacobson, G.L., I.J. Fernandez, P.A. Mayewski, and C.V. Schmitt (editors). 2009. Maine’s Climate Future: An Initial Assessment. Orono, ME: University of Maine. http://www.climatechange.umaine.edu/mainesclimatefuture.
11. Rosenzweig, C., W. Solecki, A. DeGaetano, M. O’Grady, S. Hassol, P. Grabhorn (Eds.). 2011. Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation. Technical Report. New York State Energy Research and Development Authority (NYSERDA), Albany, New York. www.nyserda.ny.gov.
12. (Jacobson)
13. (Hayhoe)
14. Chase, L. (2005). Climate Change Impacts on Dairy Cattle. Department of Animal Science, Cornell University. Climate Change of Agriculture: Promoting Practical and Profitable Responses. Fact Sheet. Accessed at www.climateandfarming.org/pdfs/FactSheets/III.3Cattle.pdf on 03.27.13.
15. Walthall, C.L et al. 2012. Climate Change and Agriculture in the United States: Effects and Adaptation. USDA Technical Bulletin 1935. Washington, DC. 186 pages.
16. (Rosenzweig)
17. (Jacobson)
18. (Jacobson)
19. (Jacobson)
20. (Jacobson)
21. (Hayhoe)
22. The U.S. Global Change Research Program. (n.d.). Climate Change Impacts by Sector/Agriculture. Accessed at www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/climate-change-impacts-by-sector/agriculture on December 12, 2012.
23. Luedeling E, Girvetz EH, Semenov MA, Brown PH .2011. Climate Change Affects Winter Chill for Temperate Fruit and Nut Trees. PLoS ONE 6(5): e20155. doi:10.1371/journal.pone.0020155.
24. (Luedeling)
25. (Rosenzweig)
26. (Rosenzweig)
27. Walthall, C.L et al. 2012. Climate Change and Agriculture in the United States: Effects and Adaptation. USDA Technical Bulletin 1935. Washington, DC. 186 pages.
28. Jacobson, G.L., I.J. Fernandez, P.A. Mayewski, and C.V. Schmitt (editors). 2009. Maine’s Climate Future: An Initial Assessment. Orono, ME: University of Maine. Accessed at www.climatechange.umaine.edu/mainesclimatefuture in March 2013.
29. (Rosenzweig)
30. 21st Century Challenges to Cranberry Production in Massachusetts, Horticulture in a Changing Climate., 2010, http://vimeo.com/17001202.
31. United States Global Research Program, n.d. “Changing Climate may Substantially Alter-Maple Syrup Production.” Accessed at www.globalchange.gov/whats-new/722-changing-climate-may-substantially-alter-maple-syrup-production on December 12, 2012,.
32. Prasad, A. M., L. R. Iverson., S. Matthews., M. Peters. 2007-ongoing. A Climate Change Atlas for 134 Forest Tree Species of the Eastern United States [database]. http://www.nrs.fs.fed.us/atlas/tree, Northern Research Station, USDA Forest Service, Delaware, Ohio.
33. Skinner, C.B., A.T. DeGaetano, and B.F. Chabot. 2010. Implications of twenty-first century climate change on Northeastern United States maple syrup production: Impacts and adaptations. Climatic Change, 100, 685-702.
34. (Skinner)
35. (Wolfe)
36. (Rosenzweig)
37. (Chase)
38. (Rosenzweig)
39. (Chase)
40. (Rosenzweig)
41. (Rosenzweig)
42. (Jacobson)
43. (Wolfe)
44. (Skinner)
45. Farrell, M. 2009. “Assessing the growth potential and future outlook for the US maple syrup industry.” In Agroforestry Comes of Age: Putting Science into Practice, edited by M.A. Gold and M.M. Hall, 99–106. Proceedings of the 11th North American Agroforestry Conference, Columbia, Missouri, May 31–June 3.
46. (Rosenzweig)
47. (Rosenzweig)
48. (Skinner)

Suggested citation: Grund, S., Walberg, E., 2013. *Climate Change Adaptation for Agriculture in New England.* Manomet Center for Conservation Sciences, Plymouth, MA.

Support for this project was provided by The Kresge Foundation.

This fact sheet is available for download at: http://www.manomet.org/climate_solutions/Agriculture_fact_sheet.pdf