Climate Change Adaptation White Paper Series

The Potential Impacts of Climate Change on Agriculture in Vermont

Gwen Dunnington, April 2010

Introduction

Agriculture plays a vital role in the culture and economy of Vermont. In recent years, agricultural processes have employed over 10,500 Vermonters, and local and organic food initiatives have become central to the cultural value of the state (Jeffords, 2010). As climate conditions in the northeast change as a result of global climate change, new methods for producing, processing, and distributing agricultural products may be necessary to retain Vermont's agricultural vitality.

Impacts

One of the primary long-term impacts of climate change on agriculture is seasonal shift, including changes in temperature and precipitation patterns (Frumhoff et al. 2007; Wake, 2005; USGCRP, 2010; Wolfe, 2006; Wolfe et al., 2008). A recent analysis (Wake, 2005) found that annual temperatures in the northeast increased by 1.8°F between 1900 and 2000, which is greater than the global average increase of 1.1°F observed for the same time period. The study also noted an increased rate of warming during the winter months and an average 8-day increase in the growing season. The study also reported an increase in the frequency of extreme precipitation events. Increases in temperature and extreme rainfall events could affect Vermont's agriculture in a number of ways, including:

- The spread of pests and pathogens, which may pressure farmers into heavier use of pesticides and herbicides, or, in the case of organic farms, more labor-intensive weed and pest control (Maine DEP, 2009);
- Decreased milk productivity in dairy cows (Frumhoff et al., 2007; USGCRP, 2010);
- Increased erosion due to increases in precipitation and resultant stormwater runoff, causing loss of field and crops as well as soil depletion;
- Improved conditions for warm weather-loving crops, and more difficulty in cultivating cold-weather crops;
- Increased variability in first and last frost dates, increasing the risk of crop failure (Maine DEP, 2009);
- Increases in short-term drought events, which may necessitate a greater demand for and expense of irrigation; and,

- An increase in the length of the growing season, which may improve the growing conditions and increase the productivity of warm-weather crops, and will likely decrease the productivity of cold-weather crops.

The magnitude of these challenges depends on a number of different external factors, many of which are not fully understood. In the lower emissions scenario, Vermont can expect to see moderate decreases in productivity and gradual changes toward warmer weather crops. In the higher emission scenario, research suggests the state can expect far more drastic and potentially detrimental climate changes (Frumhoff et al., 2007)

Vulnerabilities

Crop Yields
Cold-weather crops will be among the most vulnerable, as annual average temperatures increase (USGCRP, 2010). Grain crops such as field corn, wheat, and oats tend to experience lower yields when summer temperatures rise, and even warm-weather crops such as tomatoes and snap peas can suffer reduced productivity if exposed to >90°F temperatures at critical stages of development (Frumhoff et al., 2007). Many fruits, including apples, cranberries and blueberries, require approximately 1,000 hours below 45°F each winter to produce profitable yields in the summer and fall. Under the high emissions scenario, winter temperatures in southern Vermont may not be cold enough to consistently meet these requirements (Frumhoff et al., 2007; Wolfe et al., 2008; USGCRP, 2010).

Maple Sugaring
Maple syrup production in Vermont is a cultural tradition and a $200 million industry (Perkins, 2007). The impact of climate change on maple syrup production is not certain, but the earlier warming temperatures are making it increasingly difficult for syrup producers to know when to tap the trees. If they go by the traditional tapping dates, they risk missing the first and finest syrup, but if they tap too early they risk shortening their production season, since the holes eventually fill in with bacteria. Records of tapping dates show that the season is beginning about 8 days earlier than it did 40 years ago, and the end of the sugaring season is about 11 days earlier. In addition, changes to the pattern of freeze-thaw can create conditions of low sap flow rates unless sugaring pipelines are equipped with vacuum pumps. In the long-term, temperature and precipitation regimes are expected to alter the abundance of sugar maple trees in Vermont, favoring more warm-weather species.

Dairy Industry
The dairy industry faces its own set of potential setbacks. Although the optimal temperature for milk production ranges from 40-75°F, heat stress can occur at temperatures as low as 75° on especially humid days, which can reduce milk production anywhere from 5-20% (Frumhoff et al., 2007), Practices exist to help reduce heat stress, but are probably not cost-effective for small dairy producers. If temperatures continue to rise at the current observed rate, it may cause a significant decrease in the productivity of the Vermont dairy industry, which accounts for 70-80% of the state's agricultural sales annually (Parsons, 2011). Heat stress may further jeopardize the economic viability of many small farms in the state (USGCRP, 2010; Frumhoff et al., 2007).

Minimizing the Impacts

Mitigating Greenhouse Gas Emissions

Vermont's agricultural lands can reduce atmospheric carbon by absorbing carbon dioxide and storing it in plant matter and soils. Carbon storage may increase in Northeast forests as the growing season lengthens and temperatures rise, but farming practices will help determine how much CO_2 can be sequestered. Limiting tillage on the farm, which releases CO_2 stored in the soil, will increase the sequestration potential of Vermont's soils. More efficient use of nitrogen fertilizers is another ghg-saving strategy, since nitrogen fertilizers are extremely energy-intensive to produce and generate nitrous oxides, another set of greenhouse gases. Policy options include establishing public and private forest management best practices to increase and maintain carbon storage potential across the state. Standards may also be established for biomass and biofuel production and use, in order to prevent soil degradation and a subsequent increase in demand for more nitrogen fertilizers (Frumhoff et al., 2007).

Reduction of Organic Waste and Methane Recovery

Methane gas, generated by the breakdown of organic matter associated with agricultural processes, is a greenhouse gas (GHG) approximately 20 times more potent than CO_2. Reducing methane production is therefore one of the most effective ways to reduce GHG emissions. Organic matter comprises approximately 30% of Vermont's municipal solid waste stream, meaning the state could significantly increase landfill capacities by increasing education and incentives to reduce the amount of organic waste currently being disposed of in landfills (VT WPSC, 2008). Improving composting incentives and re-using organic matter as fertilizer also decrease the need for fertilizers and pesticides on producing farms. Policy options therefore include waste reduction and sustainability targets such as those suggested in the VT Waste Prevention and Diversion Strategies report put forth by the VTANR Waste Management Division, which include:

- Developing economic incentives to encourage organics waste preventionl;
- Expanding and improving the statewide infrastructure for composting;
- Enabling small and large scale composting;
- Mandating composting/diversion for all generators with specific timeframes; and,
- Increasing general public and school education about organics waste prevention and reuse/diversion (Frumhoff et al., 2007; VT ANR Waste Management Division).

Policy options could also consist of setting methane recovery targets and investing in recovery technologies and programs. A number of methane recovery projects are already at work in Vermont, including two landfills, Coventry (Orleans County) and Moretown (Washington County), which together produce approximately 11MW at peak capacity.The Cow Power program, run by the Central Vermont Public Service, is another project which promotes methane generators on six large dairy farms (VEP, 2010). Supporting and expanding these programs will reduce Vermont's dependence on fossil fuels while reducing the state's GHG emissions and supporting local farms.

What's already being done?

The Vermont Department of Agriculture is already pursuing emissions-reduction strategies with the 25 x' 25 Initiative, a project which aims to generate 25% of Vermont's energy needs from renewable energy by the year 2025. Seventy-nine percent of that renewable energy is expected to come from farms, and a number of programs are already in place to generate that transition. The 25 x' 25 steering committee has included renewable energy projects in wind, hydro, solar, biomass, and geothermal power, all of which are expected to help offset the power Vermont currently draws from fossil fuels. The 2010 Report also includes plans to improve energy efficiency technology to decrease our reliance on natural resources, reduce and improve usage of agricultural waste, and improve the production of energy crops.

Short-term Adaptation Strategies

A number of programs and initiatives already exist that will help the agricultural industry adapt to the changes posed by regional climate change, including:

- Quarantining invasive and noxious plant species and pests;
- Supporting local food initiatives through the Healthy Workplace initiative and state purchasing efforts;
- Using Farm Bill programs to re-establish buffer zones along waterways; and,
- Promoting methane recovery and reduction initiatives, such as Cow Power and the use of anaerobic digesters.

Looking ahead, Vermont may consider focusing on a few areas to strengthen agriculture's resistance to climate-related impacts:

- *Local Support* **-** Small family farms are particularly at risk. Even the comparatively "low-risk" actions farmers can take to address impacts associated with climate change may have huge implications for small farms with very low profit margins and limited capital. Altering planting and harvest dates and experimenting with different crop varieties all involve periods of high risk. The decrease in productivity may be enough to put many small or family farms out of business. Taking proactive steps to support local farming is arguably one of the most important strategies to combating climate change and preserving Vermont's agrarian heritage. The demand for local food will likely continue to increase, due to the growing interest in local agriculture and the anticipated increases in energy and transportation costs. Therefore, supporting small-scale farms that supply food to their local areas is a good climate change response strategy.

- *Crop Diversity* **-** Increasing the diversity of crops grown on Vermont farms, as well as genetic diversity within crop species, will help farmers weather changes in pests, temperatures, and precipitation. (USGCRP, 2010; Frumhoff et al., 2007).

- *River Management* **-** The economic viability of Vermont farms and the protection of prime agricultural soils, depend upon the long-term stability of river systems and the quality of river resources. Therefore, an important step is to establish vegetated river corridors in order to accommodate naturally stable "equilibrium" condition. Healthy, naturally stable streams allow for the re-establishment and maintenance of the river and floodplain connection which ameliorate the impacts of flooding and attenuate nutrient pollution loading into receiving waters. (VRMP, 2010).

- *Irrigation Efficiency* –Precipitation is expected to increase overall in Vermont, but low-flow periods are expected to arrive earlier and remain longer in the late summer and early fall, right when heat, evaporation and demand for water all peak. Water supply management strategies and efficient irrigation may become essential for late summer and fall crops. (Frumhoff et al., 2007; VRMP, 2010).

- *Research Needs* **-** The longer growing season has the potential to create opportunities for Vermont farmers, if they can identify the crops that will prosper in warmer, more variable climate conditions (Maine DEP, 2009). The first steps toward addressing these changes may include experimenting with new planting and harvest dates and new species varieties (Frumhoff et al., 2007). However, experimentation introduces significant financial risk, especially for farms with small profit margins. To assist farmers in determining the best crop portfolio for their farm, an analysis is necessary to evaluate different varieties' adaptability to higher temperatures, flooding, and drought (Frumhoff et al., 2007). This research should focus on identifying crops that can grow more successfully for the next 10 or 20 years, taking into account the expected continuing changes in climate and growing seasons.

Next Steps

Vermont's agriculture industry is vulnerable to the impacts of climate change, and should actively pursue research and policy initiatives to improve the state's adaptability to changing conditions. Some future research may include:

- Identifying and pursue collaborative research opportunities with university of Vermonties state and Federal agencies, and other interested and affected parties to:

    - Identify species varieties that will be able to adapt to changes in temperature and precipitation;
    - Determine which forest and farm management strategies would result in net carbon and/or nutrient sequestration;
    - Improve our short and long-term precipitation and temperature forecasting ability;
    - Improve climate monitoring; and,
    - Track indicators of vulnerability to evaluate and, if necessary, adjust adaptation strategies.

- Pursuing and implement policies that establish standards for long-term waste reduction andmethane recovery;
- Pursuing and implement policies that reduce greenhouse gas emissions and encourage the application of alternative energy sources at the farm; and,
- Accommodating long-term natural stream stability, where possible, through river corridor protection.

References

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).

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/*

Jeffords, J.M. 2010. *Economic Impact of Agriculture in Vermont.* University of Vermont. Online at http://www.uvm.edu/~vlrs/Agriculture/agric%20econ%20impact.pdf.

Maine Department of Environmental Protection, *People and Nature Adapting to a Changing Climate: Charting Maine's Course.* 2009. Online at *http://www.maine.gov/dep/oc/adapt/Report_final.pdf*

Parsons, Bob. 2011. Opportunities for Agriculture Working Paper Series, Vermont's Dairy Sector: Is there a Sustainable Future for the 800 lb. gorilla?. Food Systems Research Collaborative, University of Vermont. Online at: http://www.foodsystemresearch.net/opportunities-for-agriculture-white-paper-series/.

Perkins, T.D. 2007. Statement to the House Select Committee on Energy Independence and Global Warming, at the Global Warming Mountaintop 'Summit.' University of Vermont Proctor Research Center.

United States Department of Agriculture (USDA) National Agriculture Statistics Service (NASS). 2007. Vegetables seasonal 2006 annual summary. Online at *http://www.nass.usda.gov/Statistics_by_State/New_York/Publications/Statistical_Reports/01jan/veg0107.htm*.

United States Department of Agriculture (USDA) National Agriculture Statistics Service (NASS). 2002. Statistics by state. Online at http*://www.nass.usda.gov/Statistics_by_State/,* accessed June 6, 2007.

US Global Change Research Program. 2010. *Global Climate Change Impacts in the US: Agriculture.* Online at http://www.globalchange.gov/images/cir/pdf/agriculture.pdf. (USGCRP)

Vermont Energy Partnership. 2010. *Renewable Energy Sources in Vermont: A Status Report.* Online at http://www.vtep.org/documents/. (VEP)

Vermont River Management Program (VRMP), Department of Environmental Conservation. Online at http://www.anr.state.vt.us/dec/waterq/rivers.htm.

Vermont Waste Prevention Steering Committee. 2008. *Life Beyond Garbage: Vermont Waste Prevention and Diversion Strategies.* VT Agency of Natural Resources Waste Management Division. Online at http://www.anr.state.vt.us/dec/wastediv/R3/WPplanning/VT%20Waste%20Prevention%20Report%20May%202008.pdf. (VT WPSC)

Wake, C.P.. 2005. Indicators of Climate Change in the Northeast. Clean Air-Cool Planet and The Climate Change Research Center, University of New Hampshire, Durham, NH (http://neisa.unh.edu/Climate/index.html).

Wolfe, D.W., 2006. *Climate Change Impacts on Northeastern Agriculture: An Overview.* Online at http://www.climateandfarming.org/clr-cc.php.

Wolfe, D.W., L. Ziska, C. Petzoldt, 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.* In press.