Climate Change Adaptation White Paper Series

Climate Change and Vermont's Forests

Sandy Wilmot, May 2011

Impacts and Vulnerabilities

Forests are an invaluable economic and environmental resource of Vermont. Climate change will likely affect many forest functions that humans rely on, including clean water, recreational opportunities, forest products, wildlife habitat, and colorful fall foliage. There will be initial short-term impacts as forests try to adapt to environmental changes, and long-term impacts as a new forest evolves.

Climate changes are already evident in Vermont. Temperatures have increased in the Northeast by 1.8°F since 1970, with winter temperatures rising faster than summer temperatures. Precipitation has increased by 15-20% over the past 50 years with 67% of this falling in heavy precipitation events. These and other trends in climate are anticipated to affect Vermont's forests, including:

- More frequent hot (over 90), humid days;
- Longer growing seasons;
- Worsening of air quality in areas where air quality problems already exist (GCCIUS, 2009);
- Increased heavy downpours;
- More frequent winter thaws and earlier springs;
- Less winter precipitation falling as snow and more as rain;
- Earlier spring snowmelt resulting in earlier peak river flows; and,
- More frequent short-term droughts in late summer and fall.

Tree growth

Tree growth predictions vary because of the intermixing of positive and negative climate effects. Increases in carbon dioxide and temperature may have a positive effect by increasing the rate of tree growth, but only up to a point. Increased temperatures will also increase evapotranspiration, soil drying, and the frequency of short-term droughts, which would limit water availability for tree growth (Huntington et al 2009).

Changes in Species Distribution

Forests cover 75% of the Vermont landscape, and grow more than 50 different tree species. Each species has unique requirements for sunlight, soils, temperature and moisture. Some species commonly grow together, since they have similar preferred growing conditions. In Vermont, the dominant "forest-type groups" are: Northern Hardwoods (sugar maple, yellow birch, and American beech), White/Red Pine, Spruce /Fir, Oak/ Hickory, and Aspen/Birch. Under changing climatic conditions, we expect that each species will be affected differently potentially changing forest types as we know them.

Species distribution is already changing at high elevations. Northern hardwood trees are now able to survive at increasing elevations, due to moderating temperatures, outcompeting spruce and fir trees (Beckage et al 2008). Climate and pest risk model predictions identify Spruce-fir forests as being vulnerable to increased warming (Manomet 2009, Iverson et al 2008, Dukes et al 2009, Woodall et al 2009). Only slightly less vulnerable are northern hardwood forests whose dominant species are sugar maple, yellow birch and American beech. These forests are expected to be nearly eliminated in Vermont, replaced by species that prefer the warmer drier conditions, such as oak and pine species (USGCRP 2009).

Spread of Forest Pests

For many pest species, rising summer and winter temperatures, and increased carbon dioxide will improve survival and growth, and in some cases increase reproduction. Trees stressed from low water availability tend to reduce their defense mechanisms and are more susceptible to insect or disease invasion. Current introductions of 3 non-native pests illustrate potential effects. Hemlock is susceptible to the non-native hemlock woolly adelgid. Warmer temperatures may favor winter survival of this insect in Vermont, leading to increased declines and mortality of hemlock (Dukes et al 2009). Emerald ash borer has been eliminating ash trees across the US, and when it reaches Vermont, is likely to have a significant impact on white, green (a popular street tree planting) and brown (a wetland species) ash. There is likewise uncertainty about the long-term impacts of the Asian long-horned beetle (a maple invader), as well as other future pests.

Invasive plants, native (e.g. hayscented ferns) and non-native (e.g. buckthorn and barberry), are opportunistic and respond quickly to openings in the forest canopy, whether it be from natural disturbances (e.g. wind storms), forest harvesting, or declines from forest pests. Most of the non-native invasive plants have migrated from southern New England northward, and are well suited to predicted temperature increases.

Vulnerabilities

Decrease in Water and Air Quality

Forests play an essential role in protecting public and private water supplies, reducing pollution and mitigating temperature extremes for cold water streams. They also play an enormous role in protecting property and infrastructure from flooding and fluvial erosion, primarily by preventing stream bank erosion. Reduced air pollution is attributed to tree leaves as they capture particles in the air. Areas with air quality problems would see those problems worsen with rising temperatures, if no additional controls are placed on ozone-causing pollutants.

Decrease in Tourism

Fall forest colors support our tourism industry and provide a significant economic boost to the economy. As the timing of peak foliage changes due to warmer conditions, the industry must adapt to timing visits with peak foliage conditions. Also, the quality of fall foliage may change due to dry fall weather conditions, summer growing conditions, and with tree species compositional changes. Winter recreation has also supported our tourism industry, but as winter thaws increase and the length of the winter season lessens, more year-round recreational opportunities will be needed to maintain a thriving industry.

Decreased Productivity of Christmas Tree Farms

Vermont has a strong Christmas tree production industry. Production is dominated by balsam fir trees, which grow best in cool temperatures and plenty of moisture, and to a lesser extent other conifer species. Christmas trees, as well as maple products, account for over $22 million of Vermont's annual revenue, and growth reductions are likely in response to warmer and somewhat drier growing season (NEFA, 2007) (*See Maple Syrup Production under Climate Change and Agriculture).*

Increased Stress on Biomass Resources

The forests of Vermont are largely owned by private individuals. How each landowner responds to climate changes on their land will contribute towards shaping future forests, and therefore the availability and uses of wood. In 2007, forest-based manufacturing contributed $1 billion to the Vermont economy (NEFA 2007). Current increases in energy costs and uncertainty about future sources for electricity in Vermont is resulting in an expansion of interest in biomass (wood) use for heat and power, increasing the demand for low quality wood. Predicted increases in heavy precipitation, more frequent winter thaws, and earlier springs affect forest operations such as: higher risk for soil and stream erosion; shortening of winter logging season; and earlier closings of haul roads.

What's already being done?

Many of the forest health issues identified above are not new, but the approach used to address them may need to change as climate change predictions are incorporated into planning. Current forest management strategies rely on historically-based expected outcomes that may no longer be valid. Adaptation goals that safeguard forest functions and ecosystem services without trying to preserve the current composition of species are more likely to succeed. The Forestry Division's forest resource plan identifies activities that maintain forest sustainability (VT FPR 2010), including:

- *Monitoring* - Annual monitoring of forest health indicators from aerial survey and ground plots record information on: species distribution, growth, regeneration, mortality, soil conditions, spring and fall phenology, pests, and forest disturbances. In addition, as a member of the Vermont Monitoring Cooperative, the State also monitors forest conditions at high elevations where other weather and environmental monitoring is co-located, such as on Mount Mansfield and in the Lye Brook Wilderness.
- *Outreach* - The Forestry Division provides an extensive supply of educational resources to municipalities and private land owners to promote sustainable forest management. One outlet for informing landowners about sustainable forestry is the Use Value Program (UVA), whereby the State reviews and approves private landowner's forest management plans, in exchange for reduced tax rate on forested land. In addition, the Urban and Community Forestry Program provides extensive outreach on proper tree care to professionals, towns and the public.
- *Forest Management* – State Lands forest management planning and implementation are conducted on nearly 6% of the state's forests by the Forestry Division foresters using best management practices that demonstrate sustainable forest management.
- *Regulations* – Programs such as the Ecosystem Restoration Program (formerly Clean and Clear) oversee logger training and the development of Acceptable Management Practices (AMPs) to guide forest harvests in maintaining the health of Vermont's forests.

Adaptation Strategies

Vermont forests are vulnerable to the impacts of climate change, and resource managers should pursue policy initiatives to improve the state's adaptability to changing conditions. Landowners and resource managers may consider the following strategies in order to preserve Vermont's forest resources:

- Include climate change adaptation strategies in long-term and annual forest management plans;
- Emphasize creating diverse forests, diversity of species, stand structures, and age classes;
- Use monitoring as a tool for adaptive management (i.e. results of forest management that can be learned and applied to next plan); and,
- Diligently reduce other stresses on forests, and maintain forest health (e.g. invasive plant management, reduce frequency of harvests, etc).
- Preserve carbon sequestration ability of Vermont trees, which annually remove around 8.23 million metric tons of CO2.
- Preserve urban forest canopies, which filter air pollutants, absorb water to alleviate stormwater pollution, and moderate urban temperatures.

Further research opportunities also exist to improve our understanding of what strategies will be most effective in strengthening forest resiliency. Research topics may include:

- Determining accurate Vermont precipitation predictions;
- Identifying locations where climate-vulnerable species are most likely to succeed (refugia) to assist with short-term conservation efforts;
- Improving predictions about the interaction between climate and air quality variables that affect tree growth: model interactions between temperature, precipitation, carbon dioxide, and ozone, and subsequent effects on individual tree species growth;
- Determining “no-regret” silvicultural options which avoid making irrevocable decisions and yields results regardless of climate change; and,
- Identifying forest management options that maximize carbon sequestration while providing the best adaptation strategies.

References

North East State Forestry Association, 2007 (NEFA). The Economic Importance and Wood Flows from Vermont's Forests, 2007. Online at: http://www.vtfpr.org/includes/documents/ecimportfor.pdf.

Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009. Online at: http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf. (GCCIUS)

Huntington,T.G., A.D. Richardson, K.J. McGuire, and K. Hayhoe. 2009. Climate and hydrological changes in the northeastern United States: recent trends and implications for forested and aquatic ecosystems. Can. J. For. Res. 39:199-212.

Iverson, L.R., A.M. Prasad, S.N. Matthews and M. Peters. 2008. Estimating potential habitat for 134 US tree species under six climate scenarios. Forest Ecology and Management 254: 390-406.

Manomet Center for Sustainability. 2009. Forest Manager's Framework for Climate Change Adaptation. http://www.manomet.org/science-applications/docs/forestry-adaptation-and-mitigation-changing-climate-forest-resource-manage

Vermont Department of Forests, Parks & Recreation. 2010. 2010 Vermont Forest Resources Plan State Assessment & Resource Strategies. http://www.vtfpr.org/htm/for_resourcesplan.cfm

Woodall, C.W., C.M. Oswalt, J.A. Westfall, C.H. Perry, M.D. Nelson, A.O. Finley. 2009. An indicator of tree migration in forests of the eastern United States. For. Ecol. And Mngt. 257:1434-1444.