



Natural Resources
Canada

Ressources naturelles
Canada

Bulletin
76

FRONTLINE EXPRESS

Canadian Forest Service – Great Lakes Forestry Centre

The impact of climate change at the Turkey Lakes Watershed

INTRODUCTION

Evidence of climate change has been noted in many places around the world and includes observations such as increases in average air and ocean temperatures. Climate change will have a profound effect on Canada's forests so an understanding of where and how rapidly changes are occurring is required to assess the potential impacts and prepare suitable adaptation strategies.

Natural Resources Canada, Canadian Forest Service (NRCan, CFS) is involved in research studies to better understand the timing, extent and range of these changing climate conditions and their impact on forest ecosystems. Some changes have been fairly dramatic and immediate, such as the increase in frequency and severity of forest fires and insect and disease outbreaks. Other changes are more subtle and gradual such as more frequent droughts, which influence hydrologic and nutrient cycles and could affect tree growth in the long-term and the provision of other ecosystem services from the forest. In addition to providing a renewable source of fibre, forest ecosystems are a source of clean water, they sequester carbon, regulate climate and provide a myriad of cultural and recreational experiences. An understanding of the potential effects climate change will have on forests will assist resource managers in making decisions to minimize negative consequences.

GREAT LAKES FORESTRY CENTRE (GLFC) ROLE

Great Lakes Forestry Centre researchers in collaboration with partners from the National Water Research Institute of Environment Canada have measured climate variables, atmospheric deposition, soil, stream and lake water quantity and quality, and forest growth at the Turkey Lakes Watershed Study (TLWS) for three decades. This comprehensive data set has facilitated the study of climatic trends over the last 30 years and their relationship to the movement of



Little Turkey Lake – the number of days with ice cover is declining

water and elements through the biotic and abiotic compartments of a forest ecosystem, allowing for a long-term assessment of forest, soil and water resource function and health.

Background on the TLWS

The TLWS (www.tlws.ca) was established in 1980, initially as a response to Government of Canada and public concerns about the effects of acid rain. The study site lies at the northern edge of the Great Lakes-St. Lawrence Forest Region, on the Canadian Shield, approximately 60 km north of Sault Ste. Marie, Ontario.

It is the one of the longest running whole ecosystem studies in Canada and now serves as a valuable site for research across a range of disciplines. The data record and broad expertise of partners allows for the validation of scientific hypotheses regarding long-term ecosystem change and investigation of emerging environmental issues.

Climatic trends

Evidence of climate change is readily apparent at the TLWS. Mean temperatures in both the dormant and growing seasons are increasing at the rate of approximately 1°C per decade. Precipitation during the dormant season has declined, but no trend has been observed during the growing season. The date of lake ice formation has gradually become later in the year and the total number of days with ice cover has declined nearly one half a day per year over the 30-year time period of the study.

Scientists also determined the incidence of drought, using the Palmer Drought Severity Index (a measurement of soil moisture compared to normal conditions based on precipitation, temperature and soil water holding capacity). The incidence of severe and moderate to severe drought has increased over time. There were no severe droughts



Permanent growth plot measurements

during the first 15 years (1981-1995) of the study, whereas five of the years during the second 15-year period (1996-2010) had severe drought conditions. The number of months with moderate to severe drought increased from seven in the first 15-year period to 58 in the more recent 15-year period.

Forest growth response

Researchers used repeated field measurements and site specific biomass equations on 22 permanent growth plots across a range of topographic positions to calculate gross growth (survivor trees only, not including mortality) for each of the 15-year periods. Digital terrain attributes (i.e., wetness indices) were determined for each plot using a 5 metre LiDAR digital elevation model. While average gross forest growth declined across all plots between 1981-1995 and 1996-2010, impacts were not uniform across the study site. Growth declines were greater on plots located on moister, lower slope positions compared to plots on drier, upper slope positions. The five-year gross tree growth for lower and upper slopes were 16.3 and 10.6 tonnes/hectare for the first 15-year period (1981-1995) and 10.9 and 8.8 tonnes/hectare for the 1996-2010 period, respectively.

Ecosystem response

Stream discharge has been measured for headwater streams of sub-catchments within the TLWS since 1980. The long-term trend in stream runoff reflects the warming climate, with water yield from headwater basins showing a decline of 3%, or 63 mm per decade, due to increased evapotranspiration. The total number of days with zero stream flow has increased from 30 per year in the early years of the study to approximately 100 days per year more recently.

Atmospheric deposition of sulphate and nitrate, the primary ingredients of acid rain, has been measured since the study began. Deposition of sulphate has declined over the 30-year study period, reflecting the reduction in sulphur dioxide emissions due to international air quality agreements, while nitrate deposition did not show any trend.

The ecosystem response to changes in deposition has varied widely even within the small geographical area of the TLWS. Some sub-catchments within the study area have shown declines in sulphate parallel to atmospheric inputs while others have been influenced more by climate. For streams with large areas of forested wetland in their catchments, sulphate concentrations have not shown a decline, which is related to the ability of wetland soils to release sulphate to streams under drought conditions. These varied responses demonstrate that catchment characteristics can affect the degree of impact and subsequent recovery of forest ecosystems to global change.

CONCLUSION

The long term research and monitoring at the TLWS have provided scientists with evidence of climate change and how forest ecosystems respond to these changes. More frequent droughts have reduced forest growth in typically moister, lower slope positions. Analysis of the effects of these changes on forest growth as well as other ecosystem responses is important to improve our understanding of the impacts of climate change. Long-term watershed studies like the TLWS are unique and valuable scientific assets, providing insights that cannot be gained using other research approaches. Research at the

TLWS provides observational data measuring ecosystem response that can be translated into indicators and scaled up to the broader landscape level where policy and management decisions are made. This information will assist managers in predicting future changes and lead to the development of suitable adaptation strategies.

PRINCIPAL COLLABORATORS

Dean Jeffries, Ray Semkin
National Water Research Institute
867 Lakeshore Road
Burlington, Ontario L7R 4A6
Phone: (905) 336-4969
Fax: (905) 336-4972

CONTACT INFORMATION

Paul Hazlett, Fred Beall, Kara Webster
Great Lakes Forestry Centre
1219 Queen St. East
Sault Ste. Marie, Ontario, Canada
P6A 2E5
Phone: 705-949-9461
Fax: 705-541-5700
E-mail: GLFCWeb@nrcan.gc.ca
Web site: cfs.nrcan.gc.ca/centres/glfc

POLICY PERSPECTIVE

The long-term, multi-disciplinary approach of this project allows NRCan, CFS to be a leader in climate change research, to promote its scientific and technological capabilities, and to seek to enhance the responsible development and use of Canada's natural resources and the competitiveness of Canada's natural resources products. Forecasting future tree growth and understanding whole ecosystem impacts are needed to ensure the sustainable use of Canadian forests and support responsible resource development. Understanding the impacts of climate change on other forest ecosystem services is also critical to fulfilling this responsibility.