Natural Resources Canada
Ressources naturelles Canada

Canadian Forest Service

Projecting the impacts of climate change on the Acadian Forest

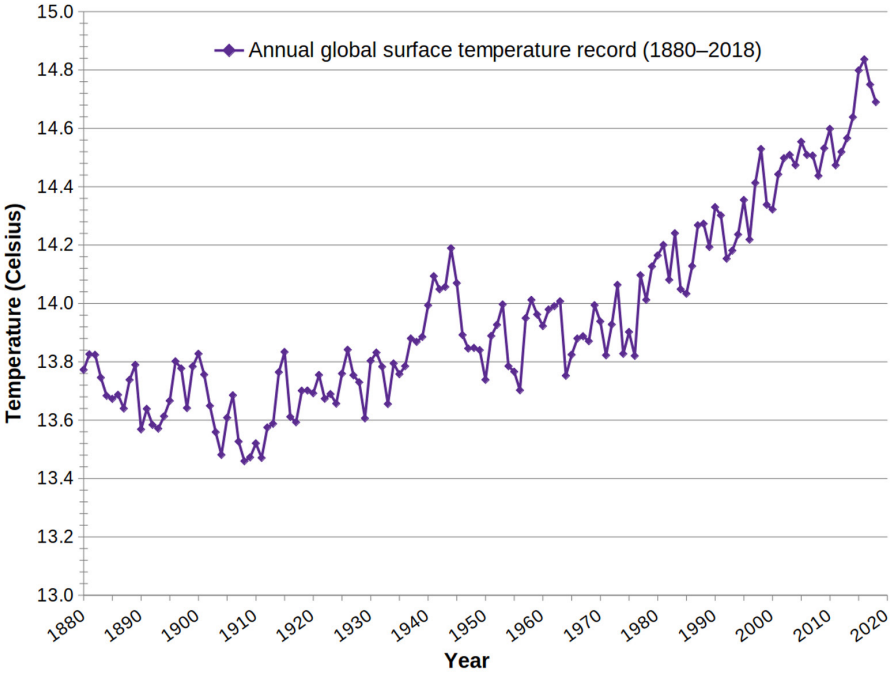
Impact Note No. 63

The Earth's climate is constantly changing and has been doing so for billions of years. Twenty thousand years ago most of Canada was covered with a sheet of ice more than a kilometre thick. As the ice withdrew, life slowly returned to the barren landscape left behind by the retreating glaciers. The fauna and flora (including trees) that are present today are mostly the result of a northward migration that occurred at end of the last ice age. Plant and animal species have different habitat requirements and are constantly seeking the "sweet spot" that will satisfy all of their needs.

Global temperatures have been steadily rising over the last 100 years. Although fluctuations in temperature are a natural phenomenon, most scientists agree that the rate of increase is greater than what would be considered "normal" and that the increase is being driven by the burning of fossil fuels, which is contributing to an increase in the amount of carbon dioxide in the atmosphere.

Dr. Anthony Taylor is a research scientist with the Canadian Forest Service at the Atlantic Forestry Centre in Fredericton, New Brunswick. He is part of a team of scientists that is using ecosystem simulation models to project the effect of climate change on the forest. More specifically, Taylor's recent work has focused on understanding and projecting the effects of climate change on the growth and species composition of the Acadian Forest.

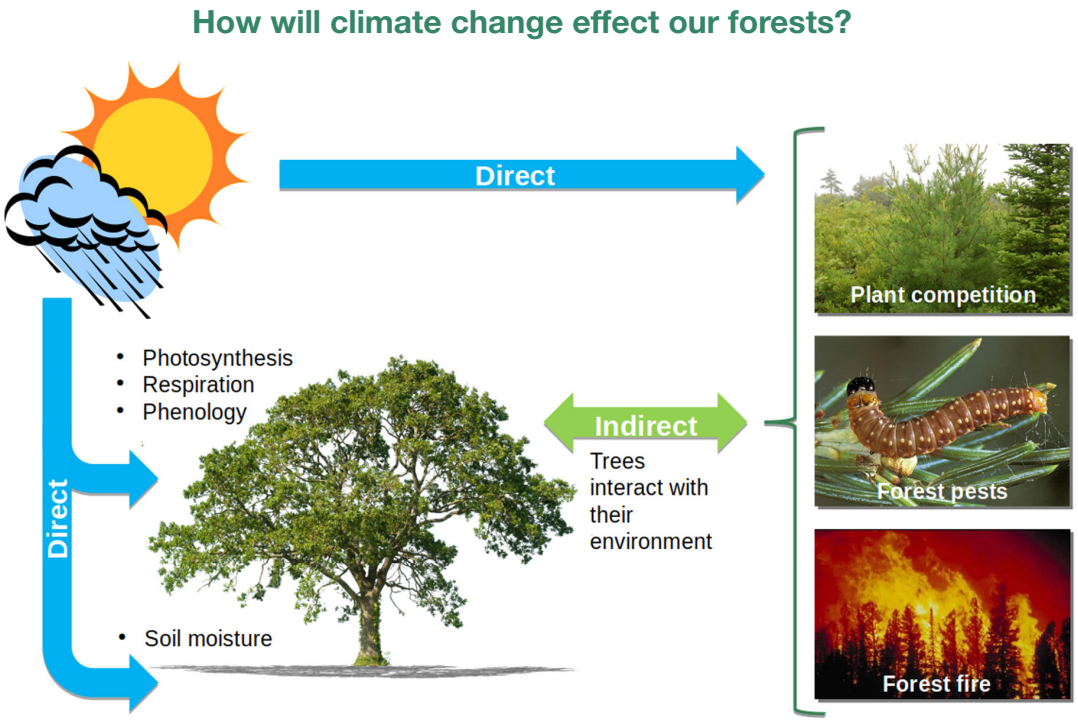
Figure 1. Annual global land and ocean temperature (1880–2018)



Source: noaa.gov

Canada

Figure 2. Direct and indirect effects of climate change on the Acadian Forest



How climate change will affect the Acadian Forest

Climate change strongly affects the distribution of tree species. Changes in temperature and precipitation directly affect tree phenology, photosynthesis and respiration. Climate also affects forests indirectly through its effects on fire, insects and diseases, severe weather events, soil moisture regimes, and competition for resources.

The best way to address the complexity of these interactions is through forest ecosystem simulation modeling. Models provide a framework that allows researchers to integrate our knowledge of many factors to project how the ecosystem will respond to environmental changes.

To project the impacts of climate change on tree species, we need to know what changes in climate are likely to occur in the future. The United Nations International Panel on Climate Change has adopted four climate change scenarios that describe possible climate futures to the year 2100. The climate scenarios are referred to as "representative concentration pathways" (RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5). They represent different radiative forcing (warming) narratives (i.e. story lines) that humanity may follow depending on our future dependence on fossil fuels and on the level of greenhouse gas emissions. Scientists use these climate scenarios to predict future impacts under different levels of greenhouse gas concentrations.

Taylor used RCP 2.6 and RCP 8.5 and compared his results to our current climate as represented by conditions that existed between 1981 and 2010.

RCP 2.6 assumes that greenhouse gas emissions will peak sometime between 2010 and 2100 and then start to decline. This situation represents a mean annual temperature increase of about 3°C from current conditions in the Acadian Forest region by mid-century, at which time it will start to decline.

RCP 8.5 represents a "business as usual" scenario in which carbon dioxide levels continue to rise unchecked, and the mean annual temperature continues to rise to about 7°C above current conditions by the year 2100.

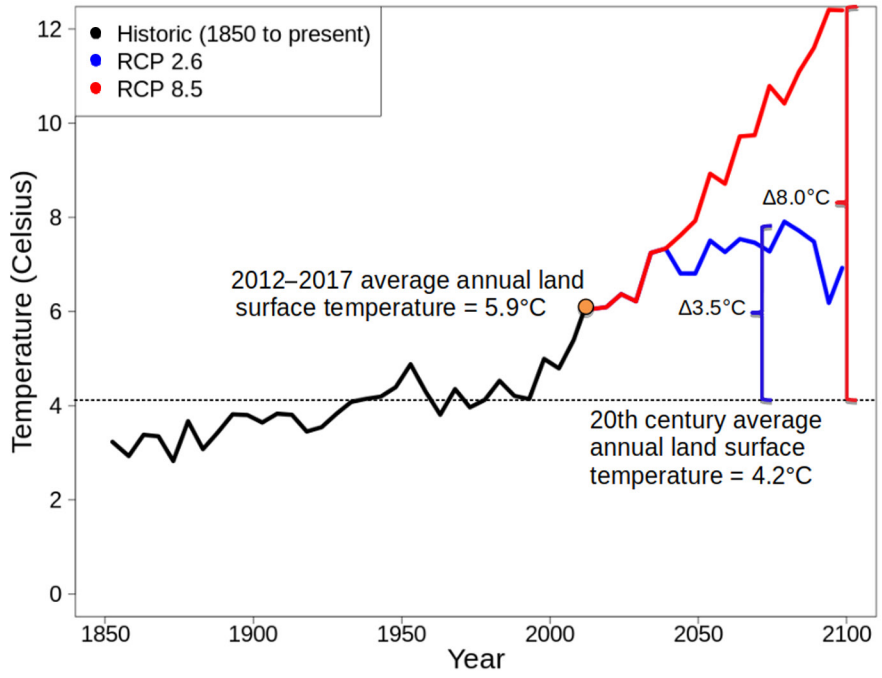
Forest ecological modeling

Various models can be used to project forest change. Some models operate at a very coarse ecological scale. This enables them to model the effects of climate change over very large spatial scales (e.g. nationwide), but at the cost of omitting important biological details about how the forest actually works.

Other models operate at finer ecological resolutions, incorporating many biological processes. This allows them to simulate forest ecosystems more realistically, but this extra detail limits their application to smaller forest areas.

Taylor used PICUS, an individual tree-based, spatially explicit, forest gap model that simulates the establishment, growth and mortality of individual trees on 1-hectare sections of forest area. The PICUS model requires information on many factors that affect the growth and composition of the forest. Those factors include soil (pH, available nitrogen, water holding capacity); climate (temperature, precipitation); tree species (18 most important species); and disturbances (fire, insects, windthrow, harvesting).

Figure 3. Climate change projections for the Maritimes under RCP 2.6 and RCP 8.5



Sources:
Historic data: berkeleyearth.org
Projection data: Natural Resources Canada

Taylor used 988 provincial forest inventory plots that are representative of stand conditions across the Acadian Forest and simulated forest dynamics in these plots under different climate change scenarios using the PICUS model.

What the Acadian Forest will look like in the future

The Acadian Forest region is a mosaic of softwood, hardwood and mixedwood forests. The Acadian Forest consists of tree species that are representative of the conifer-dominated boreal forest to the north and temperate deciduous forest to the south.

Boreal tree species such as balsam fir, black spruce, white spruce, white birch and trembling aspen are at the southern limit of their ranges. Temperate species such as red maple, red oak, American beech, eastern hemlock and eastern white pine are at their northern climatic limits.

Species that exist on the fringes of their home ranges are particularly susceptible to a changing environment. As the climate warms, tree species that characterize the temperate forest will find the conditions more favourable, while cold-adapted species of the boreal forest will find the conditions more challenging.

Species composition

In the short term (years 2011 to 2040), little or no difference in forest composition is projected between the baseline (current climate) and RCPs 2.6 and 8.5. No discernible changes in forest composition were detected under RCP 2.6 over the long-term. However, under RCP 8.5, the relative abundance of warm-adapted temperate tree species gradually begins to increase by mid-century while the cold-adapted boreal tree species (e.g. spruce and fir) decrease. By the end of the century, the abundance of spruce and fir is projected to decrease by 20 to 30% under RCP 8.5.

Forest growth

Similar to forest composition, in the short-term (2011 to 2040), little or no difference in forest growth is projected between the baseline and RCPs 2.6 and 8.5. In the long-term, growth rates under RCP 2.6 are slightly lower than baseline, showing a 6% decrease in growth by the year 2100. The greatest difference occurs under RCP 8.5, where a 42% reduction in growth is projected.

The main reason for the loss in productivity is a reduction in growth of the boreal species component of the Acadian Forest. This decrease in growth of boreal species is exacerbated by what Taylor and colleagues are calling a "blocking mechanism."

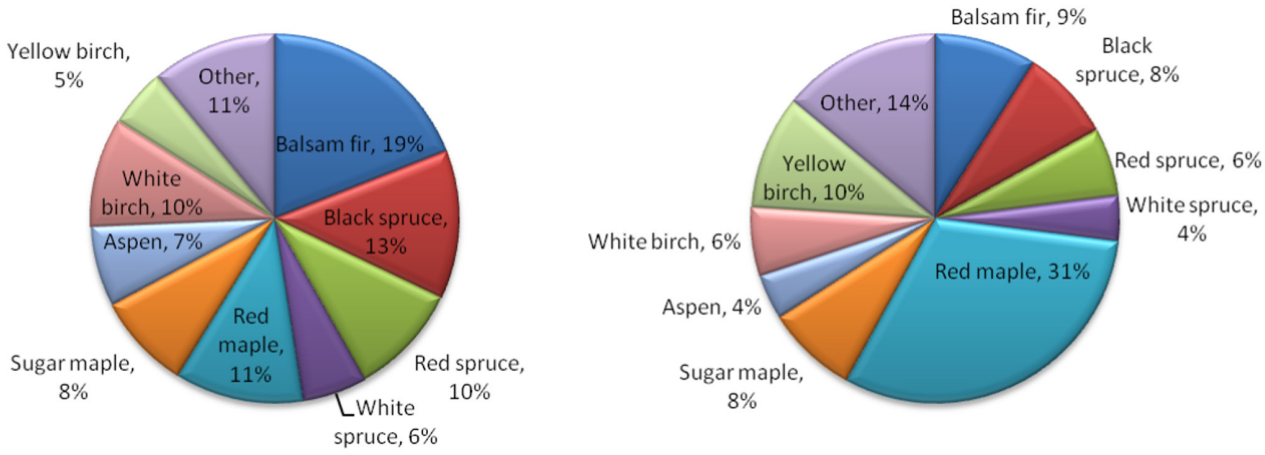
What happens is maladapted boreal species are physically blocking the establishment of better-adapted temperate trees by continuing to occupy space. Because the climate is expected to change very rapidly under RCP 8.5, the forest is unable to adapt quickly enough, causing a lag effect. The effect is that there may be a temporary adjustment period for the warm-adapted temperate trees to gradually replace the boreal component.

Figure 4. Projection of forest composition in the Acadian Forest under RCP 2.6 and RCP 8.5

Projections of forest composition

Current forest composition

Projected forest composition by 2100 under RCP 8.5



Forest managers need to be aware of the effects that a warming climate may have on our forest, especially under a "business as usual" scenario represented by RCP 8.5. In this scenario, a reduction in valuable boreal species such as balsam fir, black spruce and red spruce will occur and will likely affect forestry in the region.

The forest industry in the Maritimes needs to be aware of these potential changes and consider how best to manage the forests as our climate changes.

Taylor, A.R., Boulanger, Y., Price, D.T., Cyr, D., McGarrigle, E., Rammer, W., Kershaw, J.A. 2017. Rapid 21st century climate change projected to shift composition and growth of Canada's Acadian Forest Region. *Forest Ecology and Management* 405: 284-294.

For more information contact:

Dr. Anthony Taylor
Forest Ecologist
Natural Resources Canada
Canadian Forest Service, Atlantic Forestry Centre
Email: Anthony.Taylor@canada.ca

Impact Note No. 63

Cat. No. Fo103-3/63-2019E (Print)
ISBN 978-0-660-29420-9

Cat. No. Fo103-3/63-2019E-PDF (Online)
ISBN 978-0-660-29404-9

Aussi disponible en français sous le titre : Projection des effets des changements climatiques sur la forêt acadienne