

IMPACT

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Bison disappearance linked to expansion of aspen parkland

Up until now there was a general belief in Western Canada that the southern spread of the Aspen Parkland belt, which today stretches from northern Alberta to southern Manitoba, was produced by the settlement of early homesteaders in the late 1890's. This theory is now being challenged by a group of scientists which includes Celina Campbell of the Department of Geography, University of Alberta, Ian D. Campbell, a scientist with the Northern Forestry Centre in Edmonton, Charles B. Blyth of the Elk Island National Park and John H. McAndrews, Department of Botany, Royal Ontario Museum in Toronto.

They suggest that Plains bison, formerly abundant on the

western North American plains, inhibited growth of aspen: "The bison browsed aspen shoots, wallowed and trampled grassland, and toppled mature aspen," says Ian Campbell.

According to their findings, historical references show that aspen populations have expanded over the past century, and fossil pollen evidence suggests that the expansion occurred mainly after the near extinction of bison but before widespread European homesteading and subsequent fire suppression in the late 1800s.

Aspen often occupies recently disturbed sites. In the Prairie provinces it is the dominant tree species in the aspen parkland, which is bounded by prairie grassland to the south and boreal forest to the North.

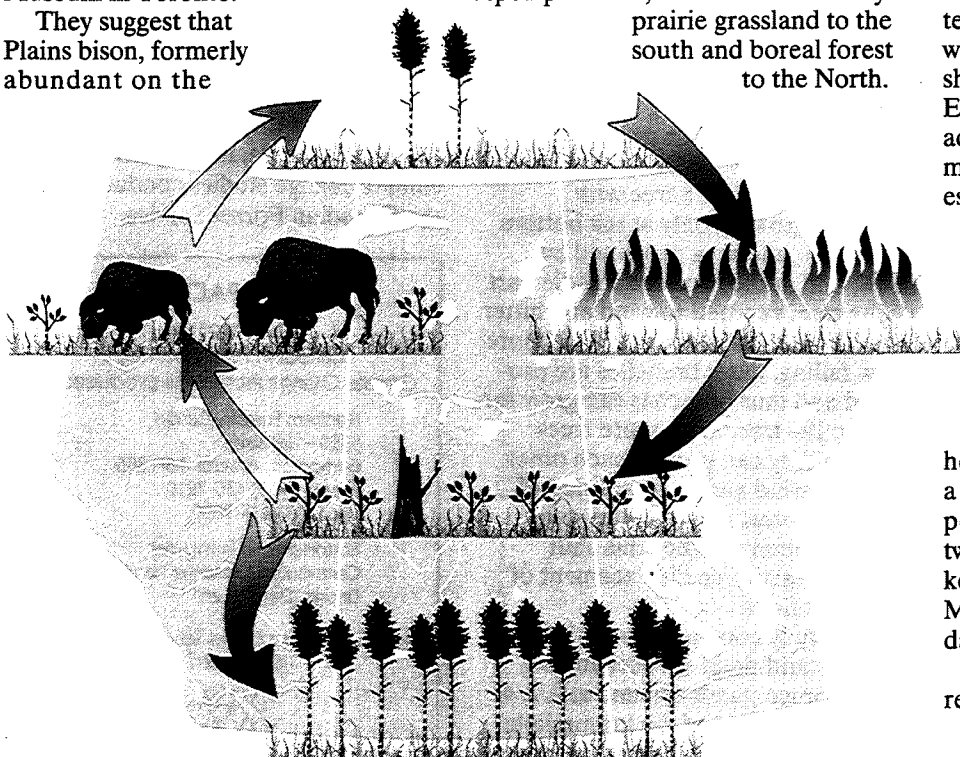
Aspen reproduces well by sprouting after surface fires or drought that kill trees and conifer seedlings, and both these mechanisms have been implicated in the development and maintenance of the aspen parkland.

Although most researchers agree that aspen populations have expanded during the last 100 years, the mechanism most often proposed is historic fire suppression by cultivation and related activities. Ecologists maintain, however, that the exclusion of conifers by drought is the primary controlling factor and that fire is secondary.

In order to support this theory this study has gathered fossil pollen from ten sites in Alberta and Saskatchewan. Data from those two locations show that the aspen spread preceded European settlement by at least a decade. This time frame means that the most common explanation of the forest growth—the suppression of fires by immigrant farmers—was not what triggered the growth spurt that we are now experiencing throughout the region.

However, the sudden increase in the pollen coincides with the period when, first in Saskatchewan, then in Alberta, the bison herds were destroyed. Until then, a new theory contends that over a period of 7,000 years, herds of between 30 million and 75 million bison kept as grassland an area in Alberta, Manitoba and Saskatchewan that today is mostly thick aspen woods.

To back up their thesis, the four researchers point out that overgrazing



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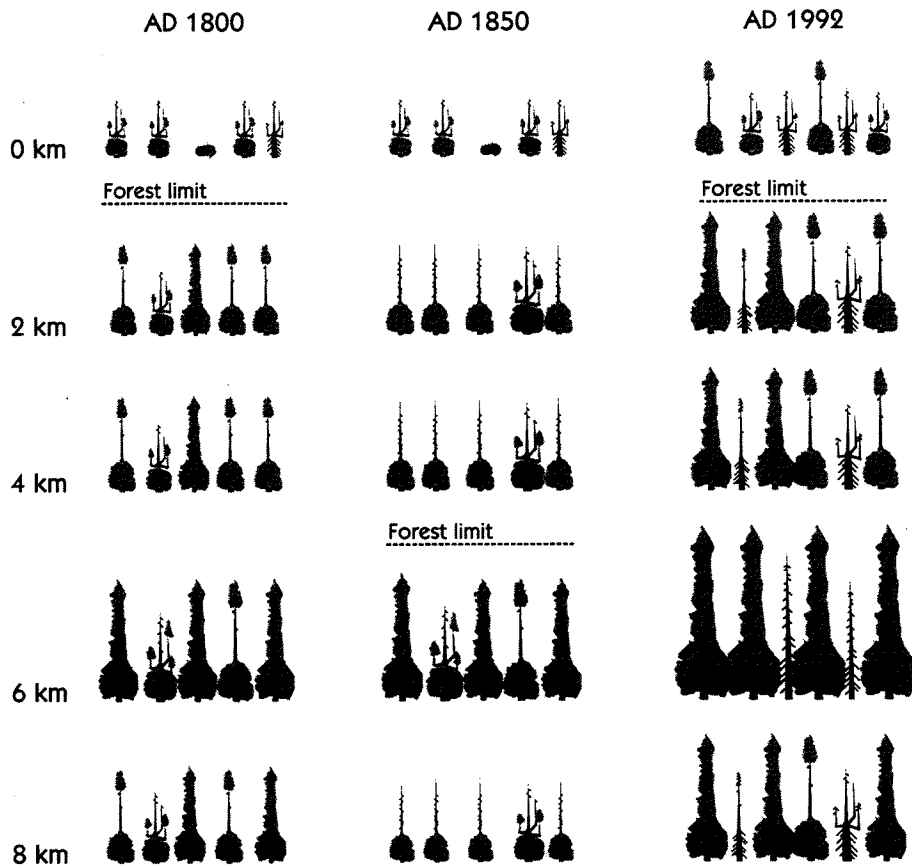
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CANADA'S
GREEN
PLAN

Canada

Is the treeline moving northward?



Structural development of lichen-spruce stands located 0, 2, 4, 6, and 8 km south of the lichen-spruce krummholz limit at three different periods (c. AD 1800, 1850 and 1992).

Treeline shifts are relatively easy to detect in tundra environments, because the evidence is based solely on the presence or absence of trees. But it is more difficult to identify changes in forest limits because it is harder to pin down the exact location of ancient forests. Claude Lavoie and Serge Payette, two scientists with the Centre d'études nordiques and Département de biologie at Laval University in Quebec City have conducted a research project to study the recent fluctuations of the lichen-spruce forest limit in subarctic Quebec to determine the nature of those changes.

"We have discovered that black spruce stems have grown wider and taller over the last 100 years at treeline in subarctic Quebec, suggesting warmer temperatures and more snow," says Dr. Payette.

They also tested if recent climate change caused a shift from forest to krummholz in the period preceding the Little Ice Age in the early 1800s,

to the predominance of krummholz during the Little Ice Age, in the mid-1800s, and the reverse process back to forest during the 1900s.

A krummholz is a tree with branches growing only at the bottom of the tree, the area protected by snow, and at the top. The middle part of the tree, exposed to wind and bitter cold, loses all its branches. With more snow falling, more branches are protected and thus branches can grow further up the tree. With more trees growing they can protect each other from the wind and over a period of time, the forest returns. The study also examined whether this shift caused measurable displacement of the forest limit.

The study compared growth forms of living and dead spruces in five lichen-spruce stands situated at 0, 2, 4, 6 and 8 kilometres of the krummholz limit. The age of the stems, standing above snow cover at each site, was also measured by analyzing tree rings.

Mr. Lavoie and Dr. Payette found that in the mid-1800s spruce-lichen forests were transformed into krummholz and that this process started to reverse in the late 1800 where the forest limit moved 4 kms northward, most likely in response to milder winter conditions. During that period, lichen-spruce trees grew wider and taller. Protected by snow and other trees, krummholz started to develop branches in their middle parts and the forest was gradually restored to its original form.

"We have found that the northward expansion of the forest limit was made by existing spruce trees and not by new ones mainly because of the lack of sexual reproduction of black spruce at the treeline," noted Dr. Payette.

In a previous study conducted in the same area in 1985, Dr. Payette demonstrated that, for the last 200 years, the only known period of seeding occurred between 1890 and 1910, indicating favourable climate conditions. But he says that more studies are needed to determine if, in subarctic Quebec, the lack of sexual reproduction depends upon the impact of low temperature on the germination cycle of spruce cones.

Even though the work is not funded under the CFS Climate Change Initiative, it complements the climate change studies conducted at the Canadian Forest Service.

IMPACT

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Aussi disponible en français

How can we predict dieback in maple trees?

The sugar maple syrup industry provides an important economic base in Quebec. In 1990, it brought a cash flow of \$61.7 million to producers, which is more than the total output of the fruit and potato industries put together. Any detrimental effects on the maple tree therefore can have economic consequences for this vital industry in the province of Quebec.

This is one of the reasons why scientists at the Laurentian Forestry Centre (LFC) have undertaken a research project to determine the causes of the maple dieback that was observed in the past few years. A team of scientists including Gilles Robitaille, Annick Bertrand (Post Doctoral Fellow), and Paul Nadeau (Agriculture Canada) carried out part of this project between 1990 and 1993.

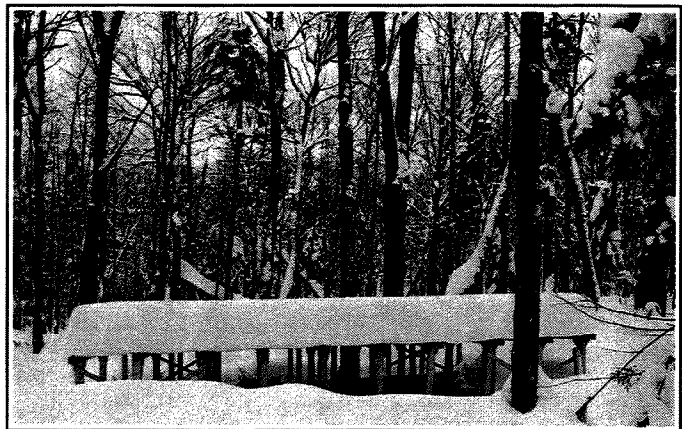
Many explanations have been proposed to explain this dieback, including the effects of cold extremes when the snow has left the ground. Previous observations have demonstrated that winters preceding dieback of sugar maple and other species were characterized by periods of unusually thin snow cover and cycles of warm and very low temperatures, conditions that could have resulted in freezing and frost damage to roots.

The LFC scientists devised an experiment to test the hypothesis that dieback in forest species may be a result of extreme cold weather, a condition that general circulation models

predict may occur with higher frequencies with a scenario of increased CO₂. To induce deep-soil freezing, snow was prevented from reaching the forest floor under mature sugar maple trees by mounting translucent plastic panels on a wooden structure 1.5 m above the ground.

Some trees were drought stressed and only 30 cm of snow was allowed to accumulate under others. The effects on growth and metabolic functions of the sugar maples were compared with those of control trees.

The results were conclusive. Gilles Robitaille and Robert Boutin observed that rapid acidification of the soil follows freezing stress at the root level of the tree. "This provides an important argument that there is a linkage between the climate and acidification of the soil and soil solution around the roots of the maple tree," noted Robitaille. They also observed that 30 cm of snow was sufficient to preserve mature trees from root freezing and subsequent dieback. As a result of soil freezing some trees died and others showed symptoms of



Snow shelter

dieback similar to those observed in the field. The quantity of spring sap decreased in freeze-stressed trees, but sucrose in the sap tended to increase. Leaf biomass decreased while, at the same time, the canopy became transparent. Root production also decreased under stressed trees.

The study also found that certain organic compounds increased in the spring sap when a tree was freeze-stressed. Some of these compounds are synthesized by the stressed plant and can be used as early indicators of physiological stress in trees and subsequently as a predictor of dieback. Absciscic acid (ABA) is one of these compounds. It was found that the ABA content in the leaves was not a good indicator of stress. However, based on their findings that sap ABA concentration was higher in freeze-stressed trees than in trees submitted to other treatments and the fact that the highest concentrations of ABA were found in the spring sap of trees in which dieback seemed irreversible, the researchers concluded that the presence of ABA in the spring sap would be useful in predicting dieback in maple trees.

Future research promises to be as relevant as that of the initial field experiment. Robitaille and Boutin, in cooperation with researchers at the University of New Brunswick, will attempt to model the effects of freezing stress on the growth of sugar maple. A first step in this direction was attempted in 1994 as soil temperature was simulated from inputs of air temperature and soil humidity.

Bison disappearance linked to expansion of aspen parkland

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by reintroduced bison and elk in national parks has been shown to limit the spread of aspen. In the Yellowstone National Park, 10,000 to 20,000 aspen stems appeared after a fire; however, constantly grazing elk destroyed all but 10 percent of these over a 12 year period, and those that remained were weak and spindly.

A similar study at Elk Island National Park, in Alberta, by C.B. Blyth and R.J. Hudson conducted in 1987, shows that, following park establishment, and after bison were reintroduced, ungulate population increased rapidly and there were major culls of

the bison and elk population in the 1930's and 1950's. Park records show that grassland expanded with the ungulate population, while aspen expanded following each cull.

If this hypothesis is correct, then the recent expansion of the aspen parkland may continue until it reaches a new balance with land use and climate. Furthermore, a southward advance of conifers and other boreal species may follow as aspen canopies shade the soil and allow moister, cooler microsites suitable for spruce to increase in numbers.

CIDET

Each year, a group of scientists eagerly collects leaf-filled litterbags from sites stretching from Port McNeill, B.C. to Gander, Newfoundland and Inuvik, N.W.T. Though the bags look like deflated square green

changes in the carbon budgets of Canadian forests. "Despite the importance of litter to the carbon cycle of the forests, our knowledge of litter decomposition is deficient," said Tony Trofymow, CFS Research Scientist



Leaf-filled litterbags

balloons, the decomposing litter they contain is helping researchers understand the possible effects of climate change on the carbon budget of Canada's forests.

The scientists are members of the Canadian Intersite Decomposition Experiment (CIDET), one of a series of research projects looking at climate change and how it affects the sustainability of Canada's forests. Because foliar litter releases carbon dioxide into the atmosphere as it decays, it is an important part of the carbon cycle, which in turn, is a catalyst to climate change such as global warming.

Currently, several projects are underway to develop computer models of present levels and potential

and CIDET Study Leader. "Some forest types have been extensively studied, while others have not. Long-term studies are rare; most are conducted only over a period of two or three years."

To remedy the lack of information, CIDET, a cooperative project involving 20 researchers from the Canadian Forest Service (CFS), universities and provincial ministries, was initiated in 1992. The group has set out to investigate the long-term rates of litter decomposition and nutrient mineralization over the broad range of ecoclimatic regions in Canada.

The 10-year study has involved the preparation of 11,000 litterbags containing samples of 12 standard litter

types such as needles, broadleaves, grasses, ferns and wood. Twenty-one forested sites across Canada, representing different ecoclimatic regions, were selected. Each site consists of four identical plots marked off with flagging tape, with 10 sets of litterbags placed in each plot. Every year for 10 years, one set of bags will be removed per plot and analyzed. Information on the mean temperature, degree days and total precipitation is gathered from nearby climate stations. Measurements on soils and microclimate are also taken.

"So far we're on track with collection and data analysis," said Trofymow. Once collected, the samples are examined to note changes in litter mass, carbon, total nitrogen and phosphorous content. Scientists then use the data to examine the role various types of litter and climate have on long-term decomposition and the relative importance of site factors and microclimate on decay rates.

This information will be used in the near future to test specific hypotheses on the patterns of litter decay. One set of models was presented by CFS chemical analysis cooperators at the International Boreal Forest Research Association meeting in Saskatoon this past September. The theoretical models can be tested when the next set of CIDET data comes in from cooperators.

In 1996, Trofymow hopes to bring CIDET cooperators together and possibly produce a joint publication. "Eventually we will have enough information to predict the rate of decomposition using the models and site data for any type of forest in Canada," said Trofymow. The carbon budget model of Canada's forests can then be adjusted accordingly; an important step toward the sustainability of the country's carbon budgets that begins with little green bags of litter on the forest floor and a group of eager scientists.

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Some of these Canadian Forest Service climate change studies are linked with other regional, national and international climate change research initiatives, including the Global Energy and Water Exchange Experiment (GEWEX), the Arctic Environmental Strategy (AES), the Boreal Forest Transect Case Study (BFTCS), the Northern Biosphere Observation and Modeling Experiment (NBIOME) and the Boreal Ecosystem Atmosphere Study (BOREAS).