IMPACT

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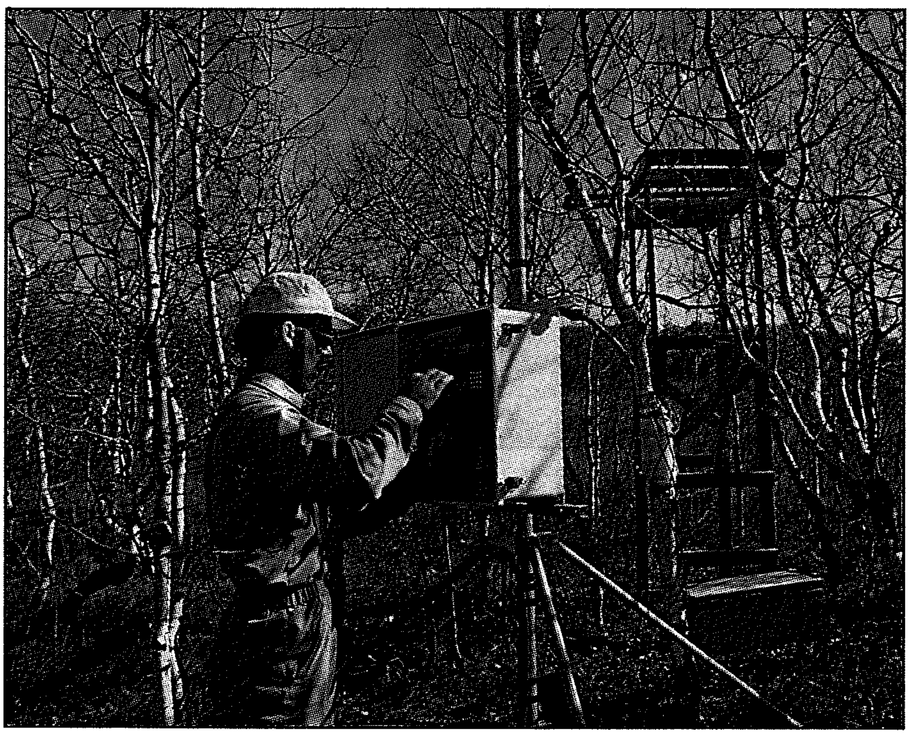
Predicting changes in the western boreal forest

Predicting how forests will grow in the future, especially if the climate changes, is no easy task. Research scientist Dr. Ian Campbell and his associates at Edmonton's Northern Forestry Centre are developing a complex computer model that will use existing data to deduce what may happen.



CFS researchers gear up for BOREAS

Several hundred researchers from around the world, including 12 from the Canadian Forest Service, are involved in BOREAS (Boreal Ecosystem Atmosphere Study). Intensive Field Campaigns will take place in Saskatchewan and Manitoba in the spring and summer of 1994. Rick Hurdle (NoFC) checks a data logger used to record sap flow in aspen at Batoche National Historic Park, south of Prince Albert, Saskatchewan (Fall 1993). The information collected will be compared to data collected at BOREAS sites north of Prince Albert.

"We want to develop an improved boreal forest simulation model that will predict the species composition and structure of the western boreal forest as it may change with future global climate change," explained Dr. Campbell.

The process is a long one. Although he hopes to have a first version of the model in two years, it may take another two years or longer to fine-tune and test the model to ensure its accuracy.

Present computer models are good first attempts but are not as comprehensive as the one being developed by the Canadian Forest Service. NoFC's research officer Harjit Grewal is studying the existing models to determine what modifications will be needed in the new model.

"One model is good at predicting direct climate change on tree physiology but doesn't account for the fact that disturbances, such as fire or insect infestations, may devastate a forest," Dr. Campbell explained. "Another model is good at predicting the effects of fire on an area but is weak in other aspects. We want to develop a more coherent and complete model."

Data collection

In order to collect some of the data needed for the model,

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Natural Resources Canada / Ressources naturelles Canada

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CANADA'S GREEN PLAN

Canada

Predicting changes in the western boreal forest

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Dr. Campbell and technician Thierry Varem-Sanders developed an x-ray densitometry system that counts and measures tree rings and wood density using x-rays. It can also be used to scan tree cookies (trunk cross-sections) or cores without x-raying, if only the ring counts and widths are needed.

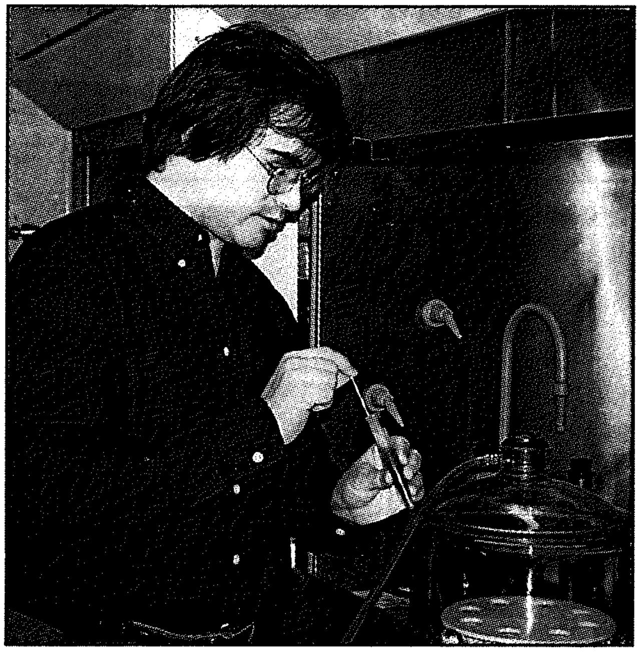
Although the technology is not new, this system is innovative in that it was assembled largely from surplus and off-the-shelf equipment and as such was much less expensive than most other densitometry facilities, which are often custom-built.

Dr. Campbell is looking at the actual density of the wood at any point in time. This will indicate how much carbon the tree stored as wood in a given year.

Every tree species in the western boreal forest will be studied, and biodiversity, plus longevity and relative abundance of a particular species, will be taken into account.

"We will also look at fire scarring and events leading to tree death and the connection between ring width and density," he said. "We can relate this to the weather during that year and see what impact different types of weather events have on the long-term health of a tree."

As well as measuring wood density, work has started on making stem maps. These maps locate each tree stem on a particular plot and indicate where it is in relation to other trees in that plot.



Dr. Ian Campbell

"These maps give us information on the interactions between trees such as how much shade a spruce can tolerate when the weather is dry as compared to how much it can tolerate when it's wet."

The plots are small, from 5 m^2 to 20 m^2, but they will present an accurate picture of the trees a particular plot holds. The plots are scattered along the Boreal Forest Transect—an imaginary line stretching 900 km from central Saskatchewan to northern Manitoba along which Canadian Forest Service scientists are conducting a variety of experiments.

Other work underway by Dr. Campbell includes the study of pollen and charcoal in peat and lake sediments. Pollen and charcoal have accumulated in sediment layers over centuries and can be dated using radio-carbon dating.

"This is exciting work. It gives us an idea of how the forest looked at different times in the past and how climate has affected forests in prehistoric times," said Dr. Campbell. "The charcoal samples will provide information on how changes in climate and vegetation can influence the incidence of forest fires. Later, this will be used to double-check the model we are developing to see if our predictions are accurate."

High calibre system for less

Where there's a will, there's a way. That's what Dr. Ian Campbell and technician Thierry Varem-Sanders have demonstrated by developing an innovative x-ray densitometry setup.

The system measures the density of wood using x-rays and reads ring widths without x-raying. Although the technology is not new, this system is much less expensive than most other densitometry facilities.

"The system was assembled largely from items already at the Northern Forestry Centre—an x-ray machine, a darkroom, a scanner connected to a 486 computer, and Thierry's software," Dr. Campbell said. "The speed, accuracy, resolution, and precision of the system is comparable to other x-ray densitometry systems in use around the world, at a fraction of the cost."

A visit to FORINTEK's $110,000 x-ray densitometry facility confirmed this fact. The ultimate resolution of the FORINTEK setup is 0.025 mm, allowing measurement of rings as narrow as 0.2 mm. The NoFC facility reaches 0.0024 mm and allows for the accurate measurement of rings as narrow as 0.02 mm. The system at NoFC was put together for under $3000 not including the value of the "on hand" equipment, which is worth another $20,000.

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RECYCLED PAPER

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Climate change and permafrost in peatlands

One of the main consequences of climate change is expected to be higher temperatures, especially at high latitudes. These warmer temperatures would result in increased thawing of permafrost in the northern regions.

In addition, the incidence and intensity of wildfires is expected to increase in the subarctic woodlands. Fires that destroy the insulating organic layer are the primary agents for initiating permafrost melting.

These possibilities prompted a 2-year research study that examines the fire-permafrost relationships in peatlands of northwestern Alberta. Extensive permafrost occurs in the peatlands in this area, but there are many depressions where the permafrost has thawed and the surface subsided.

Yet, even in such depressions small, incipient permafrost lenses can be found, indicating that a new cycle of permafrost development has begun. Such conditions are commonly encountered along the northern portion of the boreal transect.

Eight peatlands are being examined to determine the nature of the thawing-subsidence-redevelopment cycle of the permafrost. In peat cores taken from the frozen and unfrozen peat several charred layers were found.

Each of the charred layers was covered by a kind of peat moss that grows only in very wet unfrozen peatlands, followed by peat laid down in less wet conditions, and finally capped by well decomposed forest peat that contains permafrost.

The upper part of this forest peat is charred, followed by peat formed in wet conditions, repeating the cycle as before. In all cores at least one but sometimes three such cycles were found.

The interpretation is that after permafrost became established in the peat, the change from water to ice caused an upward expansion of the peat and the surface became dry enough to support open canopied black spruce forest.

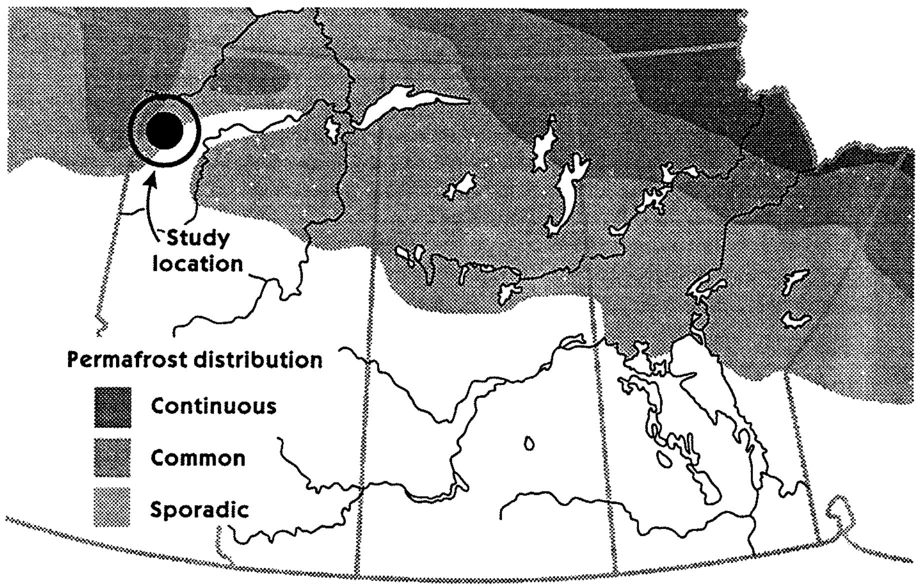
The peat began to decompose under such dry conditions. However, a fire charred the surface and caused the permafrost to melt, developing a wet, subsided depression. In time, however, the newly accumulating peat created somewhat drier conditions, allowing the redevelopment of permafrost.

Radiocarbon dates of the charred layers established that the first fire on the permafrost surface occurred about 3700 years ago and recurred at irregular intervals since then. The shortest interval between a cycle of fire-thawing-collapse-redevelopment-fire was 500 years.

This study shows that permafrost existed in the peatlands 3700 years ago, at a time when the mid-Holocene warm period ended and a cooler climate prevailed. Such permafrost peatlands were subject to forest fires that initiated the thawing of permafrost, but permafrost was readily re-established.

Under a changed climatic regime, however, the redevelopment of permafrost may be delayed or prevented by the warmer temperatures.

Steve Zoltai



Insect outbreaks may increase with warmer climate

Forest insects may become more of a problem if the climate becomes warmer, according to research being conducted at the Forest Pest Management Institute in Sault Ste. Marie, Ontario.

"There are a number of reasons why we expect insects will be able to adapt to changes in climate much more quickly than the trees with which they interact," explained research scientist Dr. Richard Fleming. "This may result in pest outbreaks in forest areas that haven't seen problems in the past."

The outcome of this could be very far reaching. Insects are considered a forest disturbance that has much more complex dynamics than even fire. Insect populations affect tree growth, longevity, and tree species ratios and have been shown in the past to influence fire occurrence.

Indicator species

There are two interdependent thrusts to this insect response research. One concerns the concept of biological indicators. Insect development rates are potentially very useful indicators of the biological impact of climate change because they integrate the effects of a variety of climatic variables such as temperature, humidity, and cloudiness.

In this research, recent historical data (which is unique world-wide in terms of the resolution and continuity of sampling) is searched for evidence of the trends in the development rates expected as a result of recent greenhouse warming. This provides quantitative measurements of the degree to which insects

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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).

Insect outbreaks may increase with warmer climate

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have actually responded to the warming experienced over the last 25 years.

Early findings suggest that these insect species are now, on average, finishing their development about one week earlier in the year than they were just 25 years ago. "To the best of our knowledge, no one has been able to report such quantitative results for any other species," said Dr. Fleming.

"These results indicate the type of response that one might expect to find under global warming. The question now is will trees change as fast as the insects? We suspect they will not. We expect that the insects will develop earlier in the year when the trees are just budding. This leaves us with large insects feeding on small buds—a situation that is often very damaging for the trees."

Computer modelling

The second focus of this research is prediction—how the occurrence of important forest pests might be affected by projected climate changes. Prediction requires the construction of models describing insect development rates as functions of climatic variables. The work on indicator species will be important in calibrating these models. By using data predicted by global circulation models these proposed climate-based models could forecast the effects of climate change on insect development rates.

Since the geographic range of many insects is limited by climate, this will provide guidelines about potential changes in insect distribution as a result of climate change. "Range expansion by insects could provide them with access to particularly susceptible forests," explained Dr. Fleming. "These forests may be particularly susceptible if the defences of their trees are unadapted to this insect, having never experienced it before, or if their defences are already weakened by the physiological stress imposed by climate change."