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Network News
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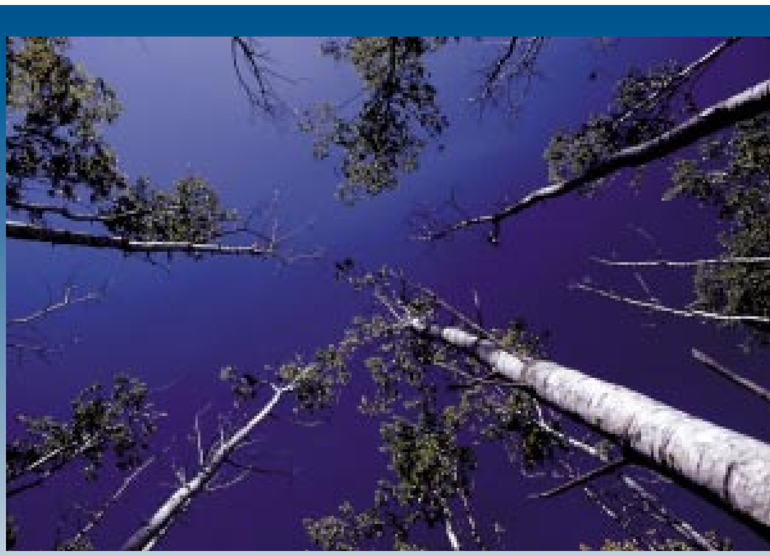
Canadian Forest Service

Climate and pest interactions affect the health of trembling aspen in west-central Canada

Trembling aspen (*Populus tremuloides* Michx.) is the most widely distributed tree species in North America, and the most abundant deciduous tree in the Canadian boreal forest. It accounts for 37 % of the gross merchantable volume in the productive forests of west-central Canada. Roundwood hardwood production, of which trembling aspen is the principal species harvested, has increased from 794 000 m³ in 1970 to 8 045 000 m³ in 1995 in the same region. Along the southern edge of the boreal forest and in the climatically drier aspen parkland of west-central Canada, dieback and reduced growth of aspen forests have been noted over the past 10 -15 years. Both the public and the forest industry have raised concerns about the future productivity and health of these forests.

Several factors have been identified as possible causes for the increased incidence of dieback, including forest fragmentation, exclusion of forest fire following settlement, increased agricultural activity, repeated defoliation by forest tent caterpillar (*Malacosoma disstria* Hübner), drought, and pollution. Recent studies by the Canadian Forest Service in collaboration with the forestry sector and Environment Canada suggest that aspen dieback in these areas was caused by a combination of drought, repeated defoliation by forest tent caterpillar, and severe early spring thaw-freeze events. Results indicate that aspen health is generally better, and dieback is less severe in the climatically moister areas of northern boreal forest than in the drier areas further south. Research to date shows that aspen health is associated with tree age, incidence of forest tent caterpillar defoliation, incidence of Armillaria root rot (*Armillaria* spp.), and drought. Drought is an important factor affecting the boundary between forest and prairie in western Canada. Based on future climate projections, the southern boreal forest may develop a drier climate, similar to that presently found in the aspen parkland, which naturally consists of stunted, unproductive groves of aspen interspersed with prairie.



Visible damage to trembling aspen.

Climate change may also lead to increases in extreme climatic events, notably thaw-freeze events in winter and early spring, which have been implicated as a major cause of large-scale forest dieback in regions elsewhere in North America and Europe. Furthermore, climate change may lead to increases in forest insects and diseases. For example, a major outbreak of forest tent caterpillar was recorded for the first time in the Northwest Territories in 1995, supporting earlier suggestions that this insect thrives in warm, dry climatic conditions. Forest insects and diseases are recognized as important regulators of forest productivity and, in some cases, the primary disturbance agent. In the case of trembling aspen and mixedwood stands, forest tent caterpillar can severely defoliate large (>5 million ha) areas of aspen-dominated forests during major outbreaks.

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Bur Oak: Its history and importance in New Brunswick's forest

Conservation of tree species is an important global issue. In New Brunswick, as in many other provinces and states, a number of tree species have significantly declined since the time of European colonization. Human intervention began to affect the forests of New Brunswick (NB) approximately 11,000 years ago with the Mi'kmaq and Maliseet entering the Maritime region from the south and southwest. It is likely that Maliseet people brought bur oak (*Quercus macrocarpa*) seed with them from farther south, to plant as a source of food near their communities given the distribution of isolated populations of this species in NB. An alternative theory is that the species was brought by blue jays after the last ice age.

European settlements were established in 1604, followed soon after by a fledgling timber industry, which had a much greater impact on the forest. The timber harvest grew steadily but slowly until 1805, when Great Britain offered massive protection to colonial timber on the British market. Explosive population growth followed this development with numbers rising from 20,000 to 150,000 people in just 40 years. As a result, much of the prime land along the St. John River valley where bur oak once grew was cleared for farming or heavily logged for timber.

Bur oak is a member of the white oak group. Its contiguous native range extends from south-central Quebec, west to central Manitoba, and south down into Texas, with isolated populations located in the New England states and in the province of NB. The bur oak in NB is separated from the fringe of the species' present contiguous range by approximately 750 km, and is approximately 220 km from the nearest population. Recently published species range maps imply that it is found along the lower St. John River valley, stretching from Perth Andover to the city of Saint John, and along Grand Lake and its flood plains. The forests of this region are influenced by the warm climate, and are peppered with species of southern affinities that are not common to the rest of NB.

New Brunswick Bur Oak Distribution
Lack of recently reported observations of the species in some areas indicated a probable reduction in the range of bur oak in NB, leading us to conduct an intensive survey that would establish its present distribution. The objective was to determine if a conservation effort is warranted by accurately assessing the current species' range and the number and location of bur oak stands remaining in NB.

Bur Oak, Jemseg, NB.

In 1996-97, the survey was conducted throughout the St. John River valley and Grand Lake Basin Ecoregion. Evidence of recent occurrences, either documented or anecdotal, was collected. Then, a thorough ground search was conducted throughout the potential species' range. All stands and isolated individuals were documented. Stands were described in terms of age, associated species, and presence and condition of bur oak regeneration.

Excluding individual trees or isolated clumps of small numbers of trees, there are eight stands of bur oak in NB. Of these, only one stand has more than 500 trees. Where stands do occur, most are small and threatened by development. Bur oak still exists around Grand Lake and in one location on Belleisle Bay. In addition, it can still be found in the Jemseg and Cambridge Narrows area. A few trees can be found in Keswick Ridge, and there are a few other isolated examples. All of the NB populations occur on flood plains or riverbanks.

The survey for bur oak throughout the St. John River valley and Grand Lake Region indicates that the current species' range has been reduced to a combined area of less than 5 km^2, of which only 0.024 km^2 is legally protected. With no historical environmental, insect or disease cause for decline, human intervention is the primary suspect. The history of the St. John River valley includes over 200 years of intensive agriculture and logging along the river, lakeshores, and flood plains. With the exception of the most poorly drained areas, much of the region has been cleared at one time or another. Dam construction for hydroelectricity at both Mactaquac (1968) and Beechwood (1957) has permanently flooded sections of the St. John River's natural flood plain. Human demands on suitable habitat for bur oak and other flood plain species continues, with several of the sites actively threatened with development.

Genetic Evaluation
Following the assessment of present distribution, the next step in developing a conservation strategy for bur oak in the province is to assess its genetic status. Conservation biology theory tells us that peripheral populations may contain atypical genetic variation in response to harsher environments at the edges of the ecological range for the species.

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Brown spruce longhorn beetle: a story unfolds

In spring 2000, Canadian Forest Service researchers in Fredericton, New Brunswick confirmed that the Brown Spruce Longhorn Beetle (BSLB) is the cause of dying red spruce in Point Pleasant Park, Halifax. Here is the background on the discovery and the facts you need to know about this beetle.

In the summer of 1998, researchers from Natural Resources Canada - Canadian Forest Service (CFS) in Fredericton observed dead and dying red spruce in Point Pleasant Park while touring the adjacent port docks with Canadian Food Inspection Agency (CFIA) staff. That observation proved to be the start of an important and challenging effort to study and eliminate the beetle. In the fall 1998, CFS field staff and researchers returned twice to the park to inspect red spruce with weeping resin. Decisions were made to investigate further through co-ordinated efforts with representatives from the Halifax Regional Municipality as the park is within a municipal jurisdiction.

In February 1999, bolts were cut from two red spruce trees with weeping resin, located 1 km apart within the park boundaries. These bolts were brought to the CFS Fredericton lab for insect rearing and fungal culturing and, throughout the spring and summer, insects emerged from them. These were tentatively identified as *Tetropium cinnamopterum*, our native species but the diagnostician noted some slight physical differences and hand-delivered some specimens to Ottawa for consultation with experts.

In September 1999, a Canadian expert with Agriculture and AgriFood Canada, Ottawa, and a visiting European expert confirmed the specimens to be the foreign species *Tetropium fuscum* (brown spruce longhorn beetle). Although the beetle was identified as foreign, researchers still could not confirm that it was the cause of the dying red spruce. Further investigation was necessary.

In February 2000, a non-governmental report revealed that *Tetropium cinnamopterum* had been trapped in the course of a study looking for various insects in Point Pleasant Park in 1990. CFS researchers located, examined, and re-identified these specimens from 1990 and found them to be *Tetropium fuscum*. It's understandable the beetle was misidentified, since it closely resembles *Tetropium cinnamopterum*, a native species. Researchers, in collaboration with Halifax Regional Municipality park staff, could now see a pattern emerging over several years to explain the many dying red spruce that had already been removed from the park.

Brown spruce longhorn beetle (male)

Finally, after identical results in 1999 and 2000 from red spruce bolts, researchers were confident in declaring that the brown spruce longhorn beetle was the cause of dying red spruce in Point Pleasant Park. With this conclusion came a recommendation to the Canadian Food Inspection Agency (CFIA) to declare this insect of plant quarantine significance and issue movement-of-wood restrictions from Point Pleasant Park. A multi-agency Task Force was formed to bring together expertise and develop a plan for action. Considerable cooperative resources, including the Nova Scotia Department of Natural Resources and CFIA, were employed for the purposes of detection and survey throughout the Halifax Regional Municipality, deploying a containment strategy and initiating various field and laboratory research studies.

Apart from the discovery that led to our conclusions concerning *Tetropium fuscum*, the CFS has continued to play a major role in research. We have received the input of colleagues from nearly every CFS research centre and CFS-Headquarters, pursued contact with many international research scientists and major entomology collections managers, and have begun compiling CFS research proposals aimed at understanding and improving our ability to respond to this non-native insect pest. As with any established exotic insect, failure to attempt eradication or control the spread of the brown spruce longhorn beetle in Maritime forests could have enormous negative implications. In addition to economic considerations, the unique Acadian forest could be threatened. To date, this beetle population appears to be restricted to the Halifax area.

Profile of the brown spruce longhorn beetle:

Name: *Tetropium fuscum* (brown spruce longhorn beetle)
Origin: Eurasia (northern and central Europe and Western Siberia)
Tree species of choice: Red spruce (in Halifax, Canada) and Norway spruce (in Eurasia and Canada) ***Identification characteristics:*** *Length:* 8 17 mm or about the size of a sunflower seed
Colour: head and neck are dark brown to black; wing covers may be tan, brown or reddish-brown
Antennae: red/brown in color and about half the length of the body in size.

The Canadian Food Inspection Agency (CFIA) toll-free hotline is 1-877-868-0662, for BSLB suspected tree reports. For more information, check out the CFS - Atlantic Forestry Centre web site: http://atl.cfs.nrcan.gc.ca

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Acknowledgements: *Many thanks to the BSLB team at CFS-AFC who provided detailed notes and advice in the preparation of this article.*

Physical damage on red spruce: an indicator of climate change in Atlantic Canada

Increased climate variability is projected for Atlantic Canada. One of the most important features of the projected changes is increased frequency and duration of mid-winter thaws. These changes could create problems for native species, such as red spruce, *Picea rubens*, which appears to be poorly adapted to such mid-winter thawing events. Red spruce may have enough inherent genetic diversity to respond successfully through natural selection to maintain and increase its fitness following these projected climatic changes. However, preliminary results from Canadian Forest Service (CFS) studies on biochemical genetic variation indicate that red spruce has less genetic diversity than other native spruces, such as black spruce, *Picea mariana*, or white spruce, *Picea glauca*. The degree to which these lower levels of genetic diversity may affect adaptive responses in red spruce is unknown.

Along with the conventional abiotic measurements used to quantify climate change such as temperature and humidity, some biological indicators are required to quantify the impact of these climatic changes on species' survival and forest health. The increased seasonal variability projected for Atlantic Canada may have significant impacts on species not well adapted to these climate changes. The Nova Forest Alliance (a Model Forest project in Nova Scotia) recently established a task force to develop operationally useful indicators for assessing climate change impacts as part of its sustainable forest management initiative.

Some of our native forest tree species may already be experiencing the effects of increased seasonal variability in Atlantic Canada. Recent observations from CFS research on the reproductive and genetic status of red spruce has shown an abnormal amount of stem cracking in populations along the northern margins of the geographic range of red spruce in the Maritimes. Some of these cracks extend from the bottom of large trees to heights of 10 m up the stem (see photo). These stem cracks result in severe wounding of trees and may increase the susceptibility of weakened trees to attack by insect pests such as bark beetles and various fungal parasites. Foliage damage from mid-winter drying has also been reported on red spruce in Atlantic Canada, and seed source differences have been

Red Spruce with frost crack

observed in our genetic studies. These symptoms indicate a species under some physiological stress.

Red spruce may be unusually susceptible to such stem and foliage damage because of a tendency to come out of winter dormancy much more quickly than other trees following the onset of favorable temperatures during the dormant season. During short periods of higher temperatures in winter, tissues become biologically active, and thus vulnerable to cellular damage during subsequent freezing events. This type of damage is apparently not related to absolute low winter temperatures alone. For instance, we have observed no damage on red spruce populations in areas such as the North Bay region in central Ontario, which regularly and often for extended periods, experience temperatures of -35 to -40°C during winter, because these central Ontario populations do not experience the same dramatic temperature fluctuations common in Atlantic Canada in mid-winter.

In response to potential climate change impacts on the health and status of native forest species in Atlantic Canada, the CFS has been investigating adaptive trait variation with the aim of characterizing the potential responses of species such as red spruce. A Canadian range-wide seed collection was carried out in 1996 from 15 trees from each of 10 populations located across Nova Scotia, New Brunswick, and Ontario. Seedlings from each of these populations have been established in several genetic tests located in central Ontario and New Brunswick to help characterize variation in growth and adaptive (physiological) traits that may influence tree responses under changing climatic regimes.

Recently, STORA/ENSO Port Hawkesbury Ltd., NS, together with support from Dalhousie University, has provided major funding for the establishment of a new University Chair in Forest Genetics and Biotechnology in the Biology Department of Dalhousie University. One of the aims of this new university Chair will be to investigate applications of molecular genetic markers to biodiversity conservation issues. In collaboration with the CFS, molecular marker techniques will be used to identify adaptive traits important to climate change impacts on forest health. The prospect of developing molecular screening techniques for tree breeding programs holds great interest and promise for the forest industry. The use of molecular marker-aided early selection is a long-term research goal, but the proposed research may provide a basis for selecting forest tree

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Springtails as indicators of soil chemical properties

Bioindicators are recognized as useful tools for forest ecosystem monitoring. They are generally organisms with low ecological tolerance that are, consequently, sensitive to various types of environmental change. Their indicator status may be reflected by their abundance, behavior and activity, or the persistence and resiliency of communities in an ecosystem.

The ecological health and balance of forest soils and associated organisms is a determining factor for the vitality and resistance of trees to such environmental stresses as insect pests, diseases, pollution, and climatic stress. Given the importance of biological activity in soils, identification of flora and fauna organisms and micro-organisms that can be used as reliable bioindicators has been attracting growing interest among agencies involved in sustainable development.

Collembolas: potential bioindicators

Springtails or Collembolas, are small micro-(<100 µm) and macrofaunal (100µm - 2mm) anthropods. They are usually very abundant in forest soils, and may reach a density of 100 000 individuals per m^2. These organisms have varied feeding strategies and functional roles within the soil processes. They influence nutrient availability through their interactions with soil micro-organisms, such as the rate of bacteria and fungi consumption and spore transportation. An exploratory study was done in 1995 to examine the possibility of using collembola as indicators of environmental change in forest soils. Collembola community structures (abundance, dominance) in eight maple stands in Quebec were studied, in relation to the types of humus (mor, moder and mull) and several soil chemical and microbiological variables. The sampling was done in May, July, and September in maple stands in three different geographical regions (the Laurentians, the St. Lawrence plain and the Appalachians). Soil-dwelling (deep layers of organic soil) species were extracted from soil core samples. Epigean (litter) species were caught in pitlight traps (Luminoc ©), and 17 % of the species caught during our research were caught solely with pitlight traps. In addition, Dicyrtoma aurata, a new species to Canada, was found abundantly, and almost exclusively, with the help of pitlight traps. Some 108 species of collembola were identified as part of this work. One constant was observed in the structure of the communities with respect to their diversity and the proportion of rare, common and frequent species: the composition of the soil-dwelling species varied according to the type of humus.

Springtail (Collembola)

The relationship between the species and soil properties was then determined by community-based statistical analyses. The results indicate a relationship between soil-dwelling species and soil properties, associated with the organic content and its quality: pH, C, N, and the C/N ratio. Among epigean species, the link between the composition of the communities and soil properties is weaker, although there is a link with the available P and exchangeable K and Mg. These results suggest that the geographic distribution of epigean species could be a determining factor in explaining the composition of surface horizon collembola communities.

A pattern of seasonal fluctuations in species has been detected among epigean communities with significant differences in species dominance when comparing spring, summer, and fall sampling results. No pattern of seasonal fluctuation was detected among soil-dwelling species, indicating the greater stability of species living at deeper depths, which are less exposed to the seasonal climatic changes affecting temperate forest soils.

The composition of collembola communities living at the soil surface appeared to be more strongly influenced by seasonal variations and region, while the composition of deeper-living communities changes little with the seasons and may be more closely linked to the chemical properties of the soil. To validate these results, a study on the effect on collembola of increasing the pH in the soil by liming was carried out in 1996 at the Duchesnay forestry station. Of the 18 experimental plots marked out, six received either 0, 2 or 20 tons / hectare of granular lime during the summer of 1994. Two years after liming, the average pH (H_2O) of the plots that had received the greater amount of lime had increased from 4.2 to 5.8. A significant increase in the microbial biomass was noted in the limed plots and a change in the collembolan community dominance occurred. A drop in the abundance and dominance of acidophilic species was observed, while the species that are characteristic of neutral/alkaline soil conditions increased. These results concur with the observations on a series of sites representing a range of soil conditions and suggest a cause-and-effect relationship between soil properties, acidity in particular, and the composition of collembolan communities.

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From a productivity perspective, it is important to recognize potential benefits of climate change on future productivity of forests in some areas, particularly at higher elevations and more northerly locations. For example, aspen growth may be enhanced if spring leafout occurs earlier or if autumn leaf fall is delayed by longer frost-free periods. In addition, rising concentrations of atmospheric CO_2 could lead to a gradual increase in the rate of photosynthesis and forest growth, if other factors such as water and nutrients are not limiting.

Research results from a large, international, field experiment (BOREAS), and a Canadian-led follow-on initiative (BERMS) are improving our understanding of the detailed processes governing effects of weather variation on primary productivity and carbon sequestration in boreal forest ecosystems, including aspen. This detailed research is mainly focused on a single aspen site so there is a serious gap in our ability to apply the results for assessments of longer-term, larger-scale effects of climate change on aspen productivity.

Another gap is our inability to detect changes in forest growth and decline on a regional scale, including changes that may already be occurring in response to climate change, and associated changes in insect and disease populations. Early detection is critical for successful adaptation to changes that may now be occurring, or which may occur in the not-too-distant future. A study is underway to establish a regional, collaborative network of long-term research plots in aspen stands across the western Canadian interior, as a means of detecting, understanding, and forecasting the impacts of global change in this climatically sensitive region. The title of this study is *Climate change impacts on productivity and health of aspen* (CIPHA). Objectives of the study include:
(i) detecting climate change impacts by monitoring growth, health, and dieback of aspen forests in climatically sensitive areas in the western boreal forest and aspen parkland; (ii) understanding how climatic variation, insects, and other factors have affected growth and dieback of aspen forests at the regional scale over the past 50 years through detailed tree-ring analysis;
(iii) predicting future changes in productivity and dieback of aspen forests in the study area employing the most likely scenarios of climate change by carbon-based modeling; and
(iv) providing a research and monitoring framework to link, promote, and expand collaborative research and regional monitoring of productivity, ecosystem functioning, and carbon sequestration of aspen forests in western Canada.

During the past field season (2000),we established research plots along a gradient that extends from the cold, moist boreal forest to the warmer, more drought-prone aspen parkland. Twelve study areas were selected in each of the boreal forest and aspen parkland ecoclimatic zones. The 24 study areas are spread across the western Canadian interior over a distance of about 2000 km, from the southwestern Northwest Territories to the US-Canada border in southern Manitoba. Three undisturbed aspen stands, about 40 to 80 years old, were selected at each study area representing the local range of dominant aspen site characteristics. Tree growth and forest health data were collected. During the fall of 2000, and again in 5 years time, tree-ring analysis will be conducted on ten randomly selected trees per stand located near, but outside, plot boundaries. White growth rings, indicative of past defoliation episodes, will be identified to obtain a complete history of past insect defoliation for each stand; these results will be compared with historic insect survey records. Climate-productivity relationships will be examined using historic climate data from several stations closest to each study area. A key component of the work is validation, improvement, and application of climate-driven simulation models of forest productivity, mortality, and carbon sequestration. Initially, results will be applied to a model specifically developed for simulating aspen responses to climate change and insect defoliation. Model predictions of aspen biomass growth and stem mortality will be tested against measurements at each site. Scenarios of climate change and associated changes in insect defoliation frequency and severity will then be applied to assess how aspen biomass, productivity, and health are likely to be affected in the future at the regional scale.

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continued from page 2… Bur Oak: Its history and importance in New Brunswick's forest

With climate change models predicting a temperature increase as high as 3°C, plant species ranges could shift northwards by as much as 500 km in this century. Northern outliers of a typical southern species such as the bur oak in NB are already adapted to the northern photoperiod.

In order to provide the background needed to develop a conservation strategy for bur oak in New Brunswick, a genetic diversity study was conducted. The technique of starch gel electrophoresis, which identifies isozyme variation at putative loci, was used. Six NB stands were compared to three isolated stands in the New England states, four stands on the fringe of the species' contiguous range, and five stands within the current species' range. The stands used in this study are separated by a minimum of 10 km and consist of at least 40 mature trees. Twelve enzyme systems with a total of 19 polymorphic loci were analyzed using bud tissue from up to 50 trees per stand. When stand size was less than 50, all mature trees were sampled.

The data collected from 19 isozyme loci indicate that, although the NB populations are small and under threat, they still maintain high levels of genetic diversity similar to other populations within the species' contiguous native range. The average number of alleles was slightly higher for the populations within the contiguous range compared with the isolated NB populations. However, the total effective numbers of alleles were similar. Estimates of gene diversity among subpopulations (DST) were small across all loci, as were the proportions of the total variation explained by differences among populations (GST).

The presence of the small, isolated, yet genetically diverse populations of bur oak at such a distance from the nearest neighboring population is surprising. The implication is that the isolation is a recent occurrence, and the genetic consequences that act on small population have not yet affected the bur oak of NB. If the seed was indeed brought to NB by the first peoples in the region, they must have brought seed over a period of time from a variety of sources to result in the level of genetic diversity observed. This scenario is likely, considering what we know of trading activities of that time.

Conclusions

Given the relatively high levels of genetic diversity remaining in the NB populations, it appears that conservation efforts for this species stand a good chance of success. Stands should be expanded and new ones be protected where they exist to prevent further loss. Where possible, stands should also be expanded and new ones established using NB seed to increase the likelihood of long-term survival.

D.A. McPhee, J. Loo,
CFS-Atlantic Forestry Centre

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populations with improved growth and adaptation to anticipated climatic changes. The benefits of this project extend far beyond tree improvement and breeding, and could also be used to enhance forest conservation and restoration efforts.

The physiological sensitivity of red spruce to precisely those climatic changes being projected for Atlantic Canada provides us with an important biological indicator for assessing and monitoring the impacts of changes on the health of our forests. Red spruce is a species of major industrial importance and ecological significance. Climatic changes that adversely affect red spruce will have a major impact of the status and character of much of Atlantic Canada's forests. For this reason, the CFS has identified red spruce as a species of special concern with respect to the impacts of climate change in Atlantic Canada. Perhaps the best forest management strategy for ensuring well-adapted red spruce populations in the future, is to ensure that high levels of genetic diversity are maintained within natural populations and that natural gene pools are better protected through use of alternative silvicultural prescriptions. CFS research on the population genetics of red spruce indicates that old-growth red spruce populations in the Maritimes may provide important natural reservoirs of such genetic diversity, and thus may have a special importance in adaptation to future environmental changes.

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This work confirms the potential of collembola as bioindicators revealing the nature, level of activity or potential modifications of a soil, especially variations in pH. Along with other organisms known for their sensitivity to soil properties, such as earthworms and enchytraeids, collembola could be included in a long-term bio-monitoring program.

Several dominant and indicator species identified as part of our work were new reports or new species.
As a result of our work, the known collembola fauna in Quebec rose from 69 to 139 species. Eleven of these species are new reports for Canada, and five others could be new species for science. The use of complementary sampling methods led to a more precise identification of the various components of collembola communities. Our results testify to the importance of a good knowledge of the ecology of species used for bio-indication, to better understand the nature of the changes.

Madeleine Chagnon, Christian Hebert and David Paré
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Canadian Forest Service announces Old-Growth Symposium

In Canada, as elsewhere, concerns have been raised about the loss of old-growth forests and the shorter rotation periods that may preclude their future development. On October 15-19, 2001, the Canadian Forest Service will host a national symposium to assess the state of science and management of old-growth forests in Canada. Research on old-growth has examined the problem from a range of perspectives and disciplines. This symposium will bring together this work in a comprehensive and cohesive way to develop a scientific assessment of what constitutes an old-growth forest, where these forests are in Canada, and how these forests may be managed and/or restored.

The symposium will generate a peer-reviewed book on old-growth forest biology and ecology. A call for papers has been issued, as described in the accompanying poster. We anticipate that as this effort will shape the national old-growth forest research agenda for coming years.

For more information, please contact Bruce Pendrel via e-mail at oldgrowth@nrcan.gc.ca or by mail: Bruce Pendrel Science Director, Forest Resources Natural Resources Canada Canadian Forest Service - Atlantic Forestry Centre P.O. Box 4000 Fredericton, N.B. E3B 5P7, or visit the symposium website at www.ulern.on.ca/oldgrowthforest.

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