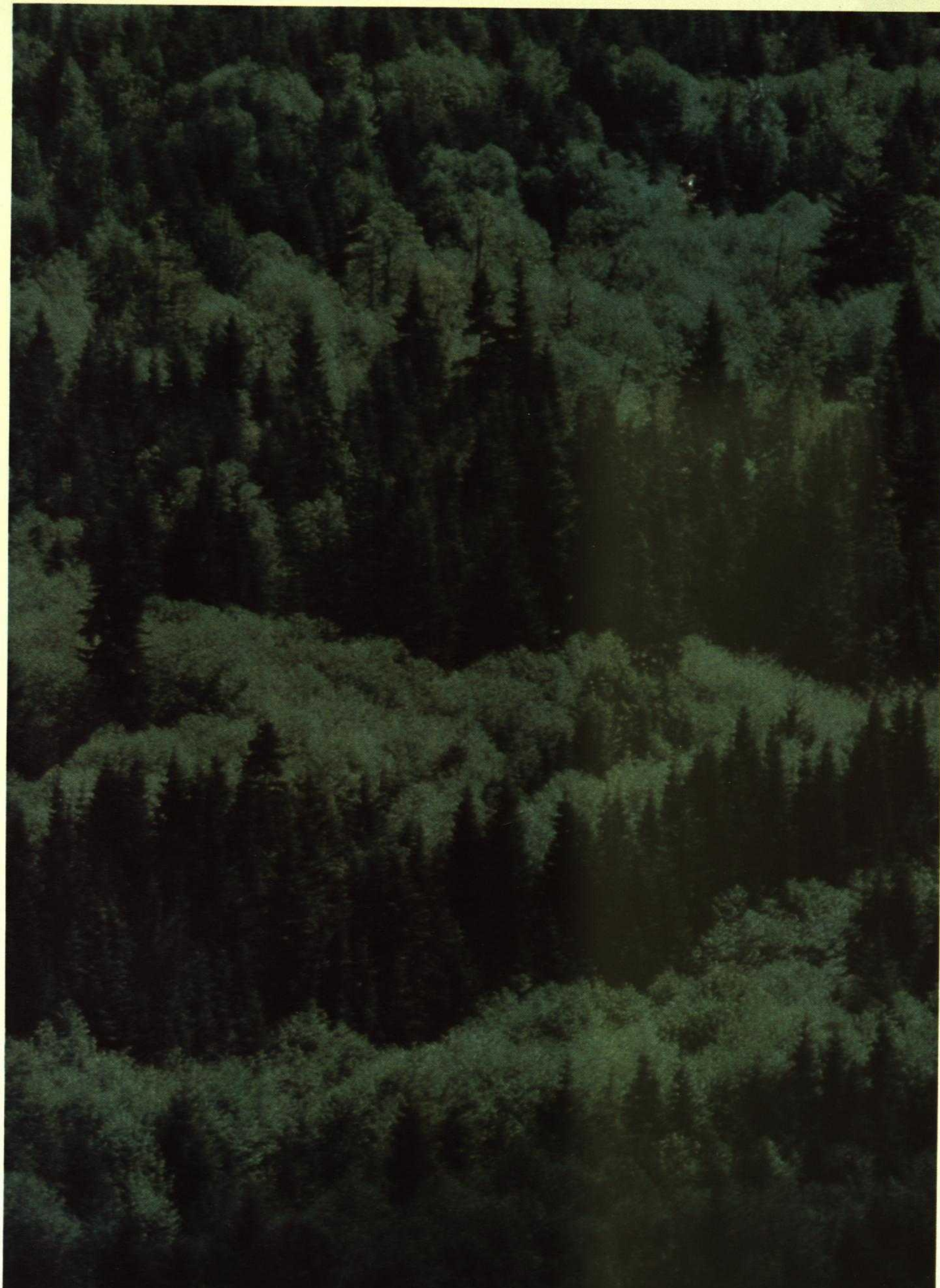
Managing the Forests: The Canadian Experience



Managing the Forests: The Canadian Experience

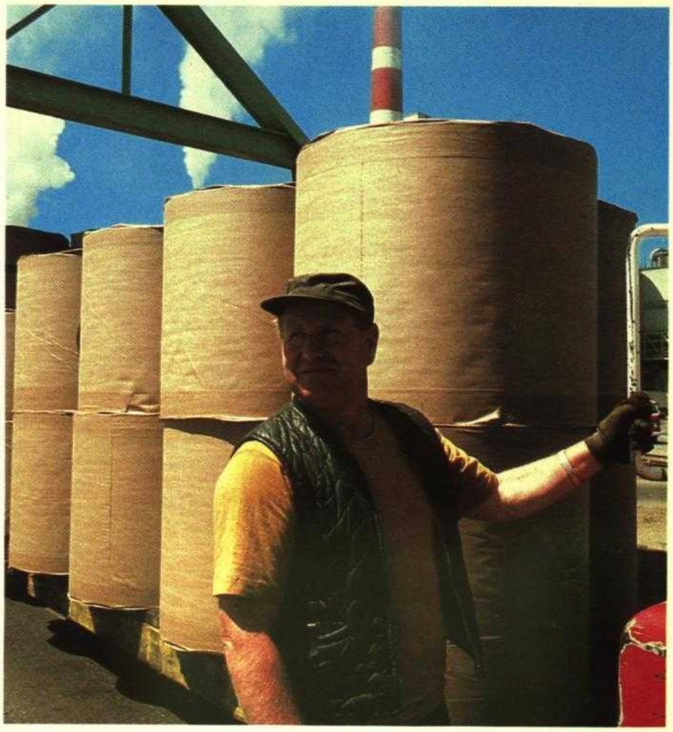
Canada's forests provide 14 per cent of the total value of shipments by Canadian manufacturing industries, 20 per cent of Canada's exports by value, and jobs for 11 per cent of the labour force. In the next two decades, these forests will be the source of energy and chemicals as well as traditional lumber, pulp and paper products. To ensure adequate timber stands for future needs, forestry research concentrates on (1) management, regeneration and cultivation; (2) protection from diseases, pests and fires; (3) product research; and (4) direct and biomass conversion to energy.

Canada's forests are about 80 per cent softwood. The federal and provincial governments own 94 per cent of the 3 400 000 km² of forested area. Of this, 1 400 000 km² are either unsuitable for industrial wood production or are in "single-purpose" reserves such as parks. The provinces own 90 per cent of productive forest lands. However, because of their loca-

Some 40,000 people in Canada are employed in logging.

tion in areas with the most favourable climates and soils, Canada's 250 000 private woodlot owners supply 16 per cent of the wood harvested each year. Although the federal government owns little forest land, its monetary, regional development, industrial efficiency, research and development, tariff and trade, and transportation programs affect forest management.

Co-ordinating research and planning among two levels of government and the private sector is a major challenge. In June 1979 the Canadian Council of Resource and Environment Ministers (from the federal and provincial governments) recommended a set of general principles for a national forest policy. The principles recognize the sole responsibility of the provinces for managing provincial lands and promote common goals and compatible policies. The interprovincial group hopes eventually to develop concrete measures that the various governments will adopt.



(top) *Canada is the largest producer of newsprint in the world.*

(bottom) *The forest industries account for roughly 20 per cent of Canadian exports.*

Management, regeneration and cultivation

In the early 1800s, when Canada began harvesting its wood to provide squared timbers and tall masts for the British navy, the forests were regarded as a self-replenishing resource. But by the end of that century, Canadians had realized that they would have to cut carefully and replant the forest. While seed trees have been left after cutting and the size of cuts has been limited throughout most of this century, the Canadian Council of Resource and Environment Ministers estimates that 12 per cent of Canada's productive forest land is inadequately stocked and that 200 000 ha are being added to this backlog each year. Whenever a new forest area is harvested, 10 to 15 per cent of its land becomes unavailable for regeneration because of roads construction.

While the productive forest area declines, the world demand for industrial wood in 1990 is expected to be 900 000 000 m^3 more than that of 1970 (540 000 000 m^3 for pulp and paper and 360 000 000 m^3 for wood products).

Canada's research to expand its forest output includes introducing more productive non-native species, such as the Norway spruce, the Japanese larch and the European larch, and genetic breeding, such as the development of a white spruce that grows 15 to 20 per cent higher than normal. One of the most promising current projects is the development of a hybrid poplar tree by the Ontario Ministry of Natural Resources.

Seedlings are used extensively in reforestation.

Poplar farms

Poplars are used for veneers and in the manufacture of fine paper.

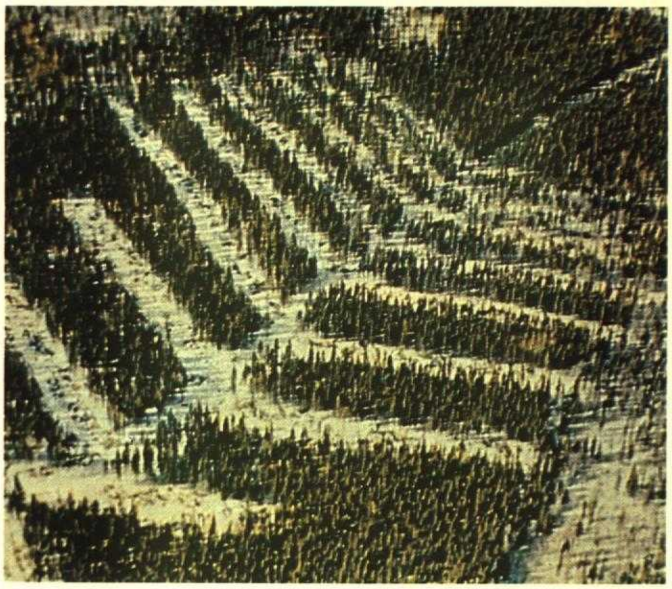
About 10 per cent of Canada's forest is poplar: aspen, balsam poplar and black cottonwood. Most grow in Ontario and Alberta. Until recently, the allowable poplar cut has been used because of a preference for readily available coniferous species, the remote locations of poplar stands, and the high incidence of decay and small tree size among poplars.

Formal research on poplars began in 1935. Since then, plantations of hybrid aspen in Ontario, spaced at intervals of 2.4 m to 3.1 m, have grown 9.6 m^3 to 21 m^3/ha at ages 9 to 15, compared with the maximum growth for native aspen of 6.3 m^3/ha at 50 to 55 years. Euramerican poplars, appropriately irrigated and fertilized, have produced acceptable pulpwood after only two years. Poplars may also provide livestock feed in the future. Poplar silage, similar to corn silage, with 25 per cent protein by dry weight has been obtained from hybrid poplars cut at the end of July. The Ontario Ministry of Natural Resources and scientists at the University of Toronto have been testing poplar leaf protein concentrate as food for roosters.

The development of poplar farms in Ontario began about ten years ago, when Domtar Inc. warned of a shortage of fibres for fine papers at its Cornwall, Ontario, pulp and paper mill. Ontario's Ministry of Natural Resources responded by developing a hybrid poplar that can be harvested eight to ten years after planting. Some 888 ha of abandoned agricultural land have been planted to date near Brockville.

In 1978, the federal government began annual funding of $1 million a year for a five-year period, and Domtar (a forest-resources company) has begun buying land near its Cornwall plant for its own tree farms. Growing trees near the plant will cut transportation costs and may provide a supplementary crop for farmers in the region.

Forests are often cut to take advantage of natural regeneration.



Students are hired during the summer to plant saplings.

Protection from diseases, pests and fires

In Canada, where the total annual forest harvest averages 128 400 000 m³, insect losses are estimated at 14 300 000 m³ and forest fires destroy about 10 500 000 m³ annually. Together they account for losses equivalent to nearly 20 per cent of the harvest.

A wide range of forestry protection research programs are conducted by the Canadian Forestry Service at six regional forestry research centres, by two national institutes, provincial forestry agencies, the forest industry and universities.

A few insect species, whose larvae eat tree foliage, stems and cones, are the major source of lost fibre and timber production in Canada. They may destroy trees or merely reduce growth.

The spruce budworm is the most widely distributed and destructive of these insect pests. Outbreaks of spruce budworm infestation occur roughly every 30 years. The larvae feed primarily on balsam fir and on several varieties of spruce (white, red, black and Engelmann) and, occasionally on hemlock and larch. Since 1909 they have killed nearly 300 million Cunits of timber in eastern Canada. The current epidemic covers about 60 000 000 ha of spruce fir forest in eastern North America.

In 1977, Canada and the United States agreed to develop a six-year joint research program aimed at accelerating technology to control this pest. Expenditures in this program will be $7 to $8 million annually.

Since 1952, spraying with chemical insecticides has been the main method used to control the spruce budworm. However, when trees are saved with insecticides, the budworm infestations are prolonged since the budworms do not starve as they ordinarily would. There are also public doubts about the long-term hidden effects of spraying. As a result, some provinces have elected not to spray and now more research is directed toward finding alternative methods of control, including biological ones.

Biological control of tree-damaging pests has already proved effective against the European spruce sawfly and the pine sawflies. Biological control agents include bacteria, viruses, parasites and predators, sex attractants and growth-regulating hormones. Unleashing biological controls against specific insect pests leaves non-target species unharmed and causes less disruption of the forest ecosystem.

Spruce budworm eggs (top), *larva* (middle) *and pupa* (bottom).

1. *Bacterial pathogens of insects*

Diseases caused by biological agents, such as bacteria, often drastically reduce insect populations naturally. Varieties of *Bacillus thuringiensis (B.t.)* are the best known of such bacteria. They carry a protein toxic to the gut cells of a broad range of Lepiodoptera larvae, including the spruce budworm, hemlock looper and tussock moth.

B.t., is used in a variety of commercially available microbial insecticides and has been used successfully in many countries for over 15 years. In Canada, for instance, *B.t.* is used against pests that attack cabbage and other vegetables.

Canadian forestry research on *B.t.* focuses on explaining the mode of action at the cellular level (the active principle in *B.t.*), devising improved serological techniques leading to better identification of more toxic strains of *B.t.*, and developing application methodology and strategy.

Several aerial applications of *B.t.* have been made against the spruce budworm in Quebec, Ontario, Nova Scotia, New Brunswick, Newfoundland and Manitoba and against the false western hemlock looper in British Columbia. These tests achieved significant larval reduction.

2. *Viral pathogens of insects*

Viruses are also an important natural pathogen of insects. For two decades, the virology unit of the Forest Pest Management Institute at Sault Ste. Marie, Ontario has conducted research on insect viruses in collaboration with other Canadian, American, British, French, German and New Zealand scientists. They are working on virus identification and mode of action and determining methods for mass production of viruses.

Canadian research has isolated and identified about 20 viruses from several major groups of forest pests, including the eastern and western spruce budworms, the two-year-cycle spruce budworm, the tussock moth, several sawflies, the tent caterpillar and some loopers.

The most significant advances by Canadian researchers, made with nuclear polyhedrosis viruses, may soon lead to using viruses for insect pest control. These viruses have been isolated from the European spruce sawfly, the European pine sawfly and the red-headed pine sawfly. Because their virus type has no morphological affinity with any known plant or animal viruses, they are more likely to be environmentally safe. Nuclear polyhedrosis virus ended a catastrophic outbreak of the European spruce sawfly

left

(top) *Chemical spraying of infested forest.*
(bottom) *Mature larva of the hemlock looper.*

right

(top) *Egg of the hemlock looper on lichen.*
(middle) *European pine sawfly larvae.*
(bottom) *Red pine damaged by the European pine sawfly.*

in eastern North America in the early 1940s. Since then, they have contributed, with some help from parasites, to natural regulation of this pest species.

In their natural state, nuclear polyhedrosis viruses are also contributing factors in terminating outbreaks of forest tent caterpillars that infest aspen trees. Preliminary testing on viruses isolated from this pest species occurred at the Northern Forest Research Centre in Edmonton, Alberta, in 1976, 1977 and 1978. Under field conditions, virus sprays caused forest tent caterpillar larvae to die. The virus infection persisted for several years, and defoliation was reduced to a negligible amount.

3. *Parasites and predators*

For many years, parasites and predators have been used as control agents against harmful insect pests, such as the winter moth and the larch sawfly. Current research on spruce budworm control includes the protozoan parasite *Nosema fumiferanae* and the predator *Formica lugubris*.

Nosema fumiferanae is the most common parasite of the spruce budworm. It diminishes vigour in the larva and pupa and reduces longevity and fecundity in the adult budworm. It may be very effective against the spruce budworm if methods can be developed to increase artificially the level of parasitism or to enhance its virulence through strain selection. Current Canadian research is concentrating on a complete biological understanding of this pathogen, methods for mass producing it for field release and means to apply it to foliage.

In Quebec *Formica lugubris*, a red wood ant from Central Europe, has proved to be a desirable predator against the spruce budworm. Scientists at the Laurentian Forest Research Centre in Ste. Foy first released the ants in 1971 in a forested area at Valcartier, about 25 km north of Quebec City. The ant colony, which started within an area of about 2 ha, increased steadily in size. By 1975 it consisted of six nests.

The first occasion for the ants to prey on a spruce budworm population came in 1973. In 1972, preliminary laboratory tests had indicated that *F. lugubris* was highly aggressive in searching for and attacking fourth-, fifth-, and sixth-instar budworm larvae, as well as papae and adults. (Because young larvae are concealed in the foliage, predation was light on the first three instars.)

Defoliation measurements taken in the area of the nests have indicated a reduction of spruce budworm damage by as much as 20 per cent during the early years of infestation. While *F. lugubris* appears to be an important control factor, further studies will be required to determine the ecological and environmental impact of introducing it into Canadian forests.

Mature larvae of the forest tent caterpillar.

4. *Pheromones*

Pheromones are chemical messengers excreted by special glands of female moths when they are ready to mate. Detected by the male's special sensory organs, the pheromones or sex attractants guide the male to the female. (Males also produce pheromones in some species.) Artificially-released synthetic pheromones can disrupt normal communication between male and female, interfere with mating and thus significantly reduce larval populations. They are also used to attract insects in order to monitor their populations.

Canadian and United States researchers at the Great Lakes Forest Research Centre in Sault Ste. Marie, Ontario, the Forest Pest Management Institute and Cornell University in Ithaca, New York, have successfully isolated and chemically identified the pheromones of a number of important pests, including the spruce budworm and associated species. They have also synthesized a number of pheromones. The pheromones of the spruce budworm are now available commercially and are used in surveying and monitoring forest pest populations.

5. *Insect growth regulators (IGRs)–hormones*

As insects grow from egg to larva to pupa to adult, the transformations are controlled by hormones. An orderly succession is essential to the survival of the insect.

In the past few decades, insect physiologists have identified a variety of hormonal compounds, known as insect growth regulators (IGRs) that are capable of altering the rate of development or modifying metabolic processes to the detriment of the insect. Applied in the smallest quantity, IGRs produe larvae that cannot pupate normally, pupae that retain larval structures or adults incapable of flying or mating. They have altered the developmental rate in some insects so that a life stage appears in a season when it cannot survive. IGR compounds are highly specific and safe. Scientists are working to identify, evaluate and develop compounds that affect a broad range of Canadian forest pest species. They are also field testing the compounds to determine under what conditions they are most effective and produce the fewest side effects.

In the Gaspé, Quebec, for example, compounds capable of preventing adult females from producing eggs and of stopping embryonic development have been tested on the balsam wooly aphid. On Anticosti Island, Quebec, in 1973, a field trial of an IGR that affects metamorphosis found the hemlock looper to be the most sensitive species tested. Non-economic levels of IGRs had to be used to achieve the desired results in the spruce budworm, the least responsive species.

In 1976 scientists at the Great lakes Forest Research Centre tested the effect of IGRs and fertilizers applied as foliar sprays during the egg stage of the sawfly. The results indicated that the ovicidal activity of IGRs might be useful in preventing defoliation, especially for ornamental and Christmas trees which receive relatively intensive care.

Forest disease

Most tree diseases develop insidiously and are not easily recognizable in routine aerial surveys. Chemical spraying techniques are rarely effective in their treatment. The control of forest tree diseases consequently relies heavily on forest management practices. These include early detection and removal of diseased, dying or recently dead trees, careful logging to minimize damage to standing trees and thus prevent or reduce disease entry; and disruption of the life cycle of contaminating organisms by eradicating intermediate hosts.

Canadian research has included the identification, description, life histories and impact of the forest diseases across the country. Intensive work is being conducted on root and butt rots of balsam fir and the spruces in Ontario and Douglas fir in British Columbia; dwarf mistletoes in western Canada; nursery problems such as corky root disease caused by the nematode *Xiphenima bakeri* and Dutch elm disease.

No cure for Dutch elm disease (DED) has yet been found despite 50 years of research in Europe and North America. DED made its first impact in Europe in 1919, in the United States in the 1930s, and in Quebec in 1944. It has killed 65 per cent of the elm population of North America. All varieties of native elm have been affected, but the American or white elm is especially vulnerable.

Canadian scientists at the Laurentian Research Centre are investigating the pathogen and its interaction with the host. Those at the Maritimes Forest Research Centre deal with chemical control of the pathogen using naturally occurring antifungal metabolites and systematic fungicides. They introduce compounds into the trees by soil trenching.

Scientists at the Great Lakes Forest Research Centre have been studying the seasonal history of the beetles that carry the fungus. They first found that the overwintering adult segment of the population that gathers on the lower 2 m of the trunks of living elms is responsible for the transmission and maintenance of *C. vulmi*. A subsequent project tested chemical barriers to control the native elm beetle. The most successful was chlorpyrifos. A single application of chlorpyrifos can exclude the overwintering beetles for two years. For six years the Great Lakes Forest Research Centre has also been using root and root-flare injections of methyl-2-benzimidazole carbamate (MBC-P) into over 1 000 mature elms to prevent or arrest DED. The method has also been used successfully on "heritage" elms.

Elm ravaged by Dutch elm disease.

So far, attempts to eradicate DED completely from a given area have not succeeded. It is possible, however, that reduction from the present epidemic level can be attained if concerted action is taken against all of the involved factors. In order to demonstrate integrated DED control in Sault Ste. Marie in 1976, the Great Lakes Forest Research Centre initiated a special project of several years' duration. In addition to controlling the incidence of the disease within the city as rapidly as possible, the program plans to establish a test setting for further research in control methods.

Fire control

Each year about 8 000 fires sweep across more than 2 000 000 ha of Canadian forest land. Losses are estimated at $65 million a year.

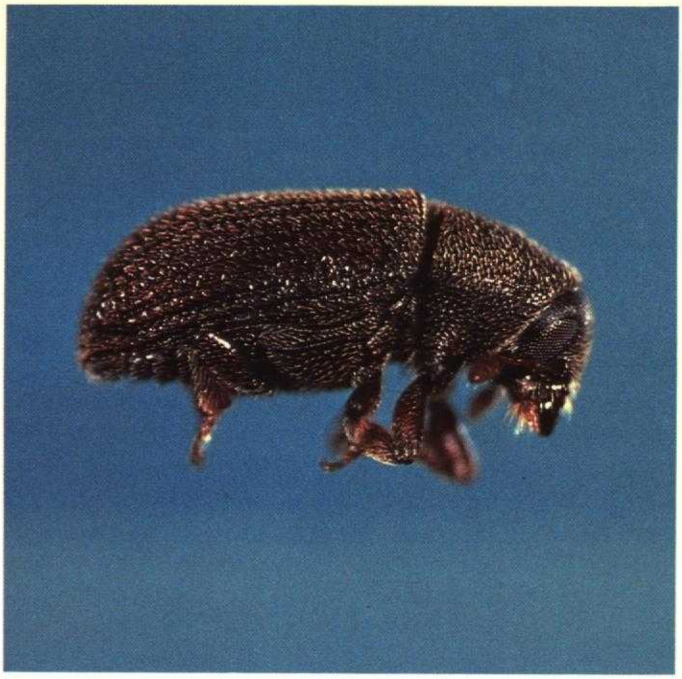
The Canadian Forest Fire Weather Index is a fire-danger rating system that predicts fire occurrence and behaviour in the Canadian forest. Based on temperature, relative humidity, wind-speed and 24-hour rainfall, it has been adopted by all fire control agencies in Canada.

A computerized system has also been developed which assists in daily detection and fire control decision-making. It draws on information related to such matters as forest fuels, thunderstorm paths and historical fire data to aid aerial detection.

Specially designed lightning detectors have been developed as an inexpensive and reliable means of thunderstorm tracking. These sensors, each with a range of about 32 km form a network extending over the major Canadian forested regions. A strong relationship exists between the sensor counts, fuel moisture and the occurrence of fires caused by lightning. With a formula that relates counts and index value to fire starts, it is possible to use the sensors to obtain a reliable estimate of possible lightning fires over an area.

Since the type of forest fuel that a fire burns is important in determining the fire's rate-of-spread and difficulty to control, fuel-type maps for fire control regions have been produced from Landsat satellite data using the Canadian Taylor-enhancement method. A digital data base is also being constructed to assist in initial-attack decision making and fire-growth modelling. This same data base will encompass detection information, such as locations of new roads and logging slash areas, that is important to long-term fire control planning.

Pacific Forest Research Centre researchers are using aerial thermal infra-red scanning technology to detect fires before visible signs such as flames or smoke occur. The British Columbia Ministry of Forests now operates six thermal scanners. They are usually flown by helicopter and are capable of pinpointing a burning cigarette from an altitude of 300 m.



(top) *Native elm bark beetle.*

(bottom) *Water bombers in use against forest fires.*

Product research

Canada's federal forest products laboratories are managed by Forintek, a new non-profit, private corporation. Their efforts cover all aspects of product development, from the forest to the production of durable, economical finished goods. Among recent projects are a steam process for producing particleboard that requires a shorter processing time and makes thicker panels economical; a weather-resistant fire retardant, Exterior-Fire-X, that inhibits flames in shingles, plywood and lumber and reduces smoke, poisonous gases and heat; a heavy-duty wood preservative that prevents decay of wood buried underground and can be used on such difficult-to-treat species as native spruce; and a ribbed tree shear blade, a single blade for cutting down trees, which causes 30 per cent less fracture damage than a conventional double blade. All four inventions are (or soon will be) produced commercially.

Energy

In recent energy-conscious years, wood has been making a comeback as a home-heating fuel. In Canada, it is also being used to create heat and steam to produce electricity in the pulp and paper industry. Canadian scientists are working on methods of using it as biomass in the synthesis of flammable gas, methanol and industrial chemicals.

Wood to burn

When fireplaces became primarily a source of aesthetic pleasure rather than heat, bark, waste wood and sawdust from Canadian mills were incinerated or used as landfill. Today they are hogged (chopped up), squeezed dry and burned to produce steam that in turn produces electricity.

The pulp and paper industry is one of 14 national sections that agreed to participate in the federal government's voluntary energy conservation program. The target was to reduce the use of purchased fossil fuels and electricity *per* unit of output by 12 per cent between the base year, 1972, and 1980. By the end of 1978 it had already achieved an 11.9 per cent reduction. In Ontario the amount of hog fuel burned increased by 129 per cent from 1976 to 1978, and oil consumption dropped 423 000 barrels (28 per cent) to 1 000 000 barrels. The five MacMillan Bloedel mills in Port Alberni, British Columbia, some of many using waste wood as fuel, supply 65 per cent of their energy needs with 325 000 tons of hog fuel each year.

To encourage mills to burn hog fuel, sawdust or waste wood, the federal Forest Industry Renewable Energy (FIRE) program provides shared-cost financial assistance in the form of taxable payments of up to 20 per cent of approved capital costs. From April 1, 1979 to March 31, 1984, it expects to make $150 000 000 available through the Department of Energy, Mines and Resources.

Biomass conversion

Hog fuel is already a viable energy source. Biomass conversion is still a resource of the future. In terms of the forest, biomass includes branches, tops, crooked boles, foliage and "unmerchantable" species left in the forest, as well as the mill wastes that go into hog fuel. It could also include cultivated short-rotation tree stands cut before they are mature enough for traditional uses.

Canadian forest biomass is being converted to gas and methanol on an experimental basis. Saskatchewan Forest Products, for example, is converting wood to flammable gas in Hudson Bay. And Lamb-Cargate Ltd. of Vancouver, with federal help, is building a pilot system to produce gas from waste wood to fuel a lumber-drying kiln.

Energy from the Forest (ENFOR) is the federal government's program to encourage research on both producing biomass and converting it to energy, prepared fuels or industrial chemicals that will significantly reduce traditional fossil fuel consumption. It is administered by Environment Canada and, like FIRE, runs from April 1, 1979, to March 31, 1984. The program normally provides 100 per cent of the cost of approved research and development work. Patents resulting from the program belong to the Crown.

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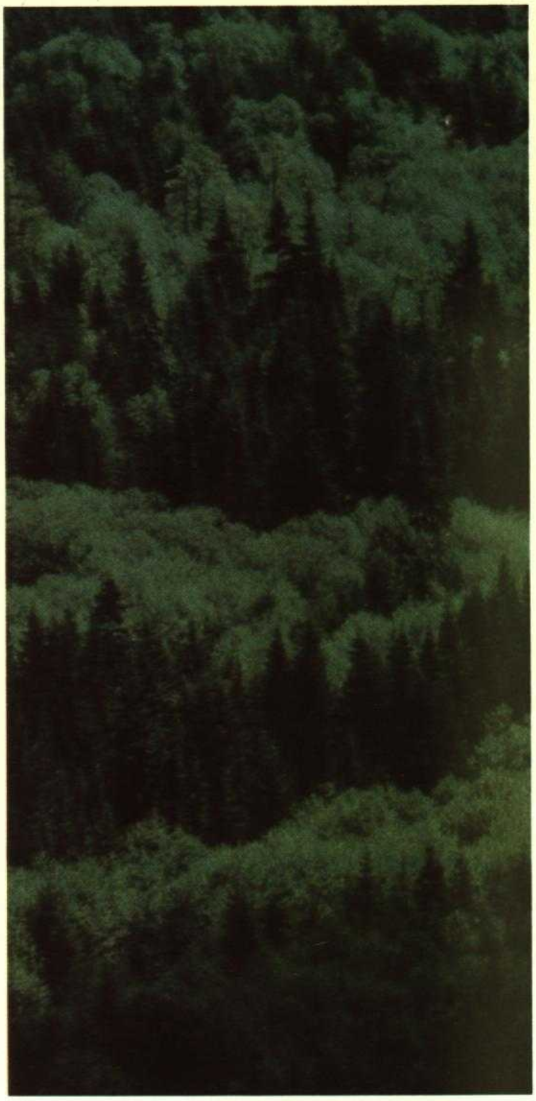

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