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ATLANTIC PROVINCES

Aerial Spraying Against the Spruce Budworm in New Brunswick, 1960 to 1963.—The 1958 operation in New Brunswick was the last to be reported in the Bi-Monthly Progress Report (15(1): 1-2). There was no spraying in 1959 but egg-mass surveys that summer showed that while eggs were scarce in the northern third of the Province, populations had increased in the central area. As a result, spraying was resumed in 1960 and was continued in 1961, 1962, and 1963. All operations were again carried out by a Crown Company, Forest Protection Ltd., representing the Province of New Brunswick and the major pulp and paper industries in the Province. The decisions to spray were made by the company Board of Directors and were approved by the Provincial and Federal governments. Costs were shared equally by industry and both governments. Timing of treatment, biological assessment of the operations, certain experimental work, and forecasts of hazard conditions in the following year were the responsibility of the Department of Forestry. This work was directed by D. G. Mott in 1960 and 1961 and by D. R. Macdonald in 1962 and 1963. The acreage sprayed and detail on the insecticides applied are shown in the accompanying table based on information provided by Forest Protection Ltd.

TABLE I

Number of Acres Sprayed Annually by Dosage Applied and Number of Applications, New Brunswick, 1960–1963

Dosage	Number of times sprayed 1	2	3	Total
	1960			
DDT 12½%/½ g.p.a.	1,220,000	—	—	1,220,000
DDT 6¼%/½ g.p.a.	1,098,000	15,000	—	1,113,000
DDT 6¼%/¾ g.p.a.	307,000	—	—	307,000
Total	2,625,000	15,000	—	2,640,000
	1961			
DDT 12½%/½ g.p.a.	14,000*	—	—	14,000
DDT 6¼%/½ g.p.a.	1,648,000	523,000	3,000	2,174,000
Total	1,662,000	523,000	3,000	2,188,000
	1962			
DDT 6¼%/½ g.p.a.	949,000	417,000	—	1,365,000
	1963			
DDT 6¼%/½ g.p.a.	493,000	154,000	—	647,000
Phosphamidon ½ lb. in ¾ g.p.a.	22,000	—	—	22,000
Total	515,000	154,000	—	669,000

*For Dept. of Forestry experiments.

1960.—Studies by the Chemical Control Section, Dept. of Forestry, in collaboration with the Fisheries Research Board and Forest Protection Ltd. in 1958 and 1959, indicated that reduction of the DDT content of the spray from 12½% to 6¼%, applied at the rate of ½ gal. per acre, would be less damaging to aquatic fauna and at the same time would effect satisfactory budworm kill if evenly distributed (Fettes, J. J. Bi-Mon. Prog. Rept. 16(1): 1-2, 1960). In 1960 the two spray concentrations were tested operationally; 1.1 million acres on the Miramichi watershed were sprayed with the 6¼% concentration (¼ lb. DDT in ½ U.S. gal. of formulation of DDT in solvent oil per acre) and 1.2 million acres on the St. John watershed were sprayed with the 12½% concentration (½ lb. DDT per ½ U.S. gal. of formulation of DDT in solvent oil per acre). A small area of 0.3 million acres on the Renous River watershed was also sprayed at an intermediate dosage of 6¼% DDT at ¾ U.S. gal. formulation per acre (⅜ lb. DDT per acre). All spraying was delayed about 5 days after the time for best foliage protection in an attempt to achieve maximum insect kill in the resurgent outbreak condition that existed.

In assessing the 1960 operation, particular attention was paid by the Dept. of Forestry to a comparison of the effectiveness of the 6¼% and 12½% spray concentrations. Where good spray distribution was obtained, the 6¼% spray appeared to be as effective in killing budworms as the 12½% spray. No advantage was demonstrated for the 6¼% DDT at ¾ U.S. gal. per acre dosage. Over-all results of the 1960 spraying were satisfactory, the egg-mass survey in August, 1960, showing that budworm populations had been reduced appreciably in the spray area. However, this survey, and an aerial defoliation survey, revealed the presence of high budworm populations inside and adjacent to the 1960 spray areas, indicating that serious defoliation might be expected in some 2.2 million acres in 1961. The surveys also indicated that budworm survival had been higher on red spruce trees than on balsam fir, and that in areas attacked for a number of years, red spruce was in poor condition.

1961—Based on egg-mass and defoliation surveys in 1960, the 1961 operation covered some 2.1 million acres in the area north and east of the St. John River in York and Carleton counties, on the lower Southwest Miramichi and Cains rivers in Northumberland County, and along the Salmon River and the coast of Kent County. An additional 0.1 million acres were treated experimentally. The 6¼% spray tested operationally in 1960, was used throughout.

To improve the uniformity of spray deposit and to make better use of the larger TBM Grumman Avenger aircraft used in the operation, Forest Protection Ltd. developed and used a new flying technique for the 1961 operation. Light 'flag' aircraft were used to position flight lines of the spray aircraft in square spray blocks of 14,000 acres each. This technique is described in the accompanying article by B. W. Flieger. Smaller Stearman aircraft were used only for smaller spray blocks of irregular size.

Examination of spray and infestation maps for several years past revealed certain areas within the 1961 spray plan in which budworm populations seemed to be persistent. In view of the finding in 1960 that survival had been greater on red spruce than on balsam fir, it was thought that this persistence of populations might be the result of a higher proportion of red spruce in the stands in central New Brunswick. Since it was known that red spruce shoots develop more slowly in the spring than those of balsam fir, areas of suspected resistance were therefore treated with two sprays about 10 days apart; the first was designed to kill larvae on balsam fir early enough to preserve foliage and the second, to reduce surviving populations on red spruce. At the same time, studies were undertaken of budworm and foliage development on balsam fir and on red, white, and black spruce, in relation to spray timing.

These studies confirmed the effectiveness of the schedule adopted for operational areas. Percentage control on balsam fir and white spruce increased progressively when spray was applied after the peak of the third-instar as the larvae grew and became more likely to contact the poison. On red and black spruce the buds remained closed until after the peak of the fourth-instar and approximately 50% control was obtained when spray was applied while the small larvae were feeding on the old foliage. When the buds opened the fourth- and fifth-instar larvae moved to the shoots where they were protected by the expanded bud-caps which remain on the tips of the growing shoots. During this period percentage control on red and black spruce declined to approximately 5%. Seven to 10 days later when the bud-caps had fallen, the larvae again became more vulnerable and percentage control increased. This sequence occurred on both red and black spruce but was not pronounced on red spruce. It was concluded from this study that an early spray timed to protect balsam fir foliage in stands with a high proportion of red spruce might leave a sufficiently high population on red spruce to re-infest the fir. A late spray, however, might give high control on all host tree species but it would not prevent serious defoliation. Thus the study confirmed that an early and a late spray would protect balsam fir foliage and give a high percentage control on all host species.

A survey of surviving larvae on both balsam fir and red spruce 5 days after the first treatment in 1961 showed that the areas designated for two applications had higher budworm counts than those designated for one. High counts were also recorded on 99,000 acres designated for one application and these were sprayed a second time. A small area of 3,000 acres was sprayed a third time. Extensive surveys of surviving pupal populations indicated that higher percentage control was obtained on balsam fir than on the spruces, on high populations than on low populations, and when spray was applied twice.

The egg-mass survey showed that budworm populations were appreciably reduced in the 1961 spray area and that they had remained low in the unsprayed northern and southern parts of the Province. In east-central New Brunswick, where moderate to high populations had been left unsprayed in 1961, egg-mass populations were also reduced, but were still high enough to indicate moderate to severe hazard in 1962.

1962—The operation this year called for approximately 0.9 million acres to be sprayed between the Southwest Miramichi and Salmon rivers and in eastern Kent County. It was known that there were scattered areas having high budworm populations outside the basic plan but their boundaries were not well defined. Surveys of larval populations were therefore conducted in May and early June before spraying commenced and resulted in the addition of 352,000 acres to the program. Another 130,000 acres were added in late June following aerial reconnaissance flights. The 6¼% spray was used throughout, and the TBM Grumman Avenger aircraft spraying by the technique developed in 1961 did 96% of the spraying. Approximately one-half of the area in the basic plan was sprayed twice to achieve better control in areas of persistent infestation.

Post-spray surveys indicated satisfactory budworm population reduction in areas treated, but there was also reduced survival in unsprayed areas. Inclement weather in early July forced the cancelling of the annual aerial defoliation survey, but ground observations at more than 2,000 points indicated that areas of moderate and severe defoliation were fragmented into relatively small pockets interspersed in large areas of light or no appreciable defoliation. A subsequent egg-mass survey confirmed that areas of moderate and severe infestation were considerably reduced from 1961. Only 12 separate areas scattered across central New Brunswick totalling approximately 360,000 acres were found to be seriously infested. It was decided that most of these should be sprayed in 1963.

1963—The basic operation scheduled 319,000 acres for treatment. The largest blocks were located along the Southwest Miramichi, Salmon, and Gasperaux rivers. The plan also called for larval surveys and aerial reconnaissance for defoliation to detect and delimit additional areas of severe infestation for treatment. The early larval survey revealed that a number of areas where 1962 egg-mass populations had been light were seriously infested in the spring of 1963, particularly along the Southwest Miramichi River watershed. Aerial reconnaissance and larval sampling with the aid of a helicopter also showed that several areas that were relatively inaccessible to ground egg-mass surveys in 1962 were also heavily infested in 1963. Consequently, some 350,000 acres were added to the plan.

The final operation thus comprised a total of 669,000 acres and was carried out largely from Dunphy airport with TBM Grumman Avenger aircraft. The 6¼% DDT insecticide was used again and 154,000 acres were sprayed twice. A systemic poison, Phosphamidon, which had been found to be less harmful to fish than DDT and effective against budworm in trials conducted by the Fisheries Research Board and the Chemical Control Section in 1962, was applied to narrow blocks or spray swaths along the Dungarvon, Nashwaak, Tay, Salmon, and Southwest Miramichi rivers in an effort to reduce the hazard to the young salmon population in these rivers. Phosphamidon was applied at the rate of ½ lb. in ¾ U.S. gal. water per acre.

Studies and surveys comparing the effects of the two poisons indicated that in most cases Phosphamidon and DDT were about equally effective in reducing budworm populations, and that with both insecticides better reduction was achieved on balsam fir than on spruce. Experimental studies and post-spray survey data indicated that the larval parasites, including *Apanteles fumiferanae* Vier., *Glypta fumiferanae* (Vier.), *Meteorus trachynotus* Vier., and several Diptera were more adversely affected by Phosphamidon than by DDT.

An aerial defoliation survey was conducted by Forest Protection Ltd. in July. The area of moderate and severe defoliation was considerably reduced from previous years but extensive areas of light defoliation were mapped throughout the central part of the Province. Collections for egg masses were made at more than 1,000 points in the Province, including 55 otherwise inaccessible locations that were sampled with the aid of a helicopter provided by Forest Protection Ltd. The survey revealed that the area of moderate and severe egg-mass infestation had increased about 4.5-fold from 1962. The Nashwaak, Cains, Taxis, Dungarvon, and Southwest Miramichi watersheds were all infested and smaller infestations occurred along the Salmon River and in the St. John River Valley. Altogether these infestations totalled approximately 2.0 million acres. The condition of the trees was also examined during the egg-mass survey. In general, the forest in central New Brunswick was found to be in good condition but there were several scattered patches where hazard was high and serious tree mortality would be expected if defoliation continued for another year.

Weather conditions undoubtedly contributed to budworm population fluctuations during the last few years. Unfavourable weather for larval growth and survival prevailed in 1961 and 1962 while extremely favourable weather with resultant high survival occurred in 1963. Also, weather systems favourable for large-scale moth transportation have occurred relatively infrequently during the adult flight period in recent years with the result that there has been little dispersion of the populations beyond the local outbreak boundaries.

Yearly post-spray surveys have shown that parasitism increased considerably between 1960 and 1962 in both sprayed and unsprayed areas. *Apanteles fumiferanae* Vier., *Meteorus trachynotus* Vier., and various species of Diptera increased 2.1-, 2.3- and 4.8-fold, respectively, between 1960 and 1962, while *Glypta fumiferanae* (Vier.) increased only 1.4-fold. These changes in parasite populations, particularly the increased frequency of *M. trachynotus,* were thought to be similar to those observed in the decline of other infestations and were regarded as symptomatic of an outbreak collapse. In 1963, however, the frequency of all species declined markedly while the host population resurged.

In view of the resurgence of budworm populations in 1963 noted above, it is anticipated that spraying operations will continue in 1964 involving some 2.0 million acres of forest in the central part of the Province.—D. R. Macdonald.

A New Method for Guiding Spray Aircraft.—Early forest spraying in northern New Brunswick and the bordering regions of Quebec (1952-1958) featured use of the Stearman aircraft. In the United States this plane had been widely used for crop dusting and spraying because of its dependability, sturdiness, work capacity, and great manœuverability. It was specified for spraying in eastern Canada for these qualities and subsequent experience showed this aircraft to be unequaled in its performance out of short fields with full load and in spraying close to tree top level in rough terrain.

In New Brunswick pairs of Stearmans sprayed forest blocks either by flying lapped straight line swaths where topography would permit or by covering blocks in a series of meandering swaths (contouring) in more difficult terrain. Block boundaries, chiefly drainage and ridge lines, delineated areas of irregular shape averaging about 7 sq. mi. ± 3 sq. mi. Pilots sprayed from familiarity with the scene and from memory.

During these years of large scale operations many changes were made in spraying techniques. However, in essence, the quality of spraying "the Stearman way" still depends on the ability of the pilot. He must be able to handle low level navigation in poor light, to determine how a particular block should be sprayed, to sense the relation between the amount of insecticide expended and the area covered, to appreciate the effect of drift, and to understand spray behaviour and weather. Inspection pilots can spot the efficient spray pilot by watching his work and when allocating responsibilities for an operation, the top pilots are assigned lead positions and the less efficient, trail positions.

By 1958 the Canadian version of the American T.B.M. (Torpedo bomber, medium) was declared surplus and was being purchased and modified for fire suppression and agricultural and forest spraying.

Experience with this aircraft in New Brunswick, first in 1958 and on a larger scale in 1960, indicated that the full potential of the T.B.M. could not be realized when using it to spray the Stearman way, even with the best of pilots. Table I lists comparative data for the Stearman and T.B.M. The disparity in size, weight, power, and speed is most significant. Flying the T.B.M. occupies much more of the pilot's time in the air. He finds that navigation is much more difficult because of greater flying speed without a concomitant gain in elevation. Mistakes are thus many times easier to make, are much larger when they happen, and are more difficult to correct. On the other hand, the aircraft possesses some real advantages as a forest sprayer, especially in the more gently rolling country into which by 1960 spraying operations had moved. For instance, more endurance combined with increased speed allows longer hauls. With its greater load carrying capacity and wider swath, one T.B.M. can do the work of several Stearman particularly when operating 15 to 20 miles from an airstrip. Therefore, more work can be done from one airfield without saturation of air traffic. These and other obvious advantages made it advisable to redesign the spraying operation.

In the winter of 1961 the technique now in use was developed. It is based on the traditional system of flagging used in field crop dusting and spraying; and is, as far as is known, the first "aerial flagging" system to be employed for the guidance of sprayer aircraft. The "aerial flags" are light aircraft of the Cessna 172 class, each carrying a pilot and a

TABLE I

Comparison of Sprayer Aircraft Used in N.B. Forest Spraying

Item	Stearman	T.B.M.
Type	Single engine two place biplane trainer.	Single engine low wing monoplane bomber.
Construction	Fabric cover on wooden wings and metal fuselage.	All metal.
Wing span	33 ft.	52 ft.
Original Engine	225 H.P. Continental.	1900 Wright.
Present Engine	450 P. & W. Wasp Jr.	1900 Wright.
Fuel Consumption	20 G.p.h.	80 G.p.h.
Speed—Cruising	100 m.p.h.	180 m.p.h.
—Spraying	90–100 m.p.h.	150–160 m.p.h.
All up weight	3,600–4,000 lbs.	18,000 lbs.
Undercarriage	Fixed.	Retractable.
Runway length to get airborne	1,500 + feet.	2,500 + feet.
Endurance	2 hrs.	4 hrs.
Crew	1 pilot seated in rear open cockpit.	1 pilot seated in closed canopy in high, forward of wing, position.
Visibility	Fair.	Good.
Tank location	Forward cockpit space.	Belly.
Useful load of insecticide	150 U.S. gal.	700 U.S. gal.
Spraying	Boom type, pressure supplied by outside wind driven pump.	Boom type, pressure from a/c hydraulic system.
Radio	None.	2 circuits.
Swath Width 2 aircraft	Up to 400 ft.	Up to 900 ft.

competent low level navigator. Two of these units, about 2 miles apart, determine the position and direction of a spray swath by flying this line in "slow motion". The spray planes line up on these and using them in every respect like terrestrial flags carry out the spraying. As finally put together into a workable flying exercise, factors such as visibility, relative flying speeds, turn time, etc. have to be considered. Flag planes fly about 80 m.p.h. and spray planes about 160 m.p.h. All are equipped with directional gyros to assist in holding a direction and radio for intercommunication. Spray blocks are square in shape, about 4⅔ miles on a side, and positioned on 1:50,000 map sheets without regard to map detail. The sides are usually oriented in a N.-S. E.-W. direction; and the blocks of 14,000 acres can be sprayed in one of two direction, whichever takes better advantage of drift. Spray planes operate in pairs (as with Stearman) in which the trail plane holds a position behind the leader and set over laterally about one-half the theoretical combined swath width.

In 1961, 1962, and 1963 the prescription was such that spray planes completed a block in five (1,400 U.S. gal.) team loads of six passes each in which the swath was about 825 ft. and the theoretical deposit was ½ U.S. gal./acre. A spray plan for 1964 retains the emission rate of 62-63 U.S. gal. per minute but will require seven loads/block which will give a theoretical deposit of slightly under ⅜ U.S. gal./acre, and the swath will be narrowed up accordingly to less than 600 ft.

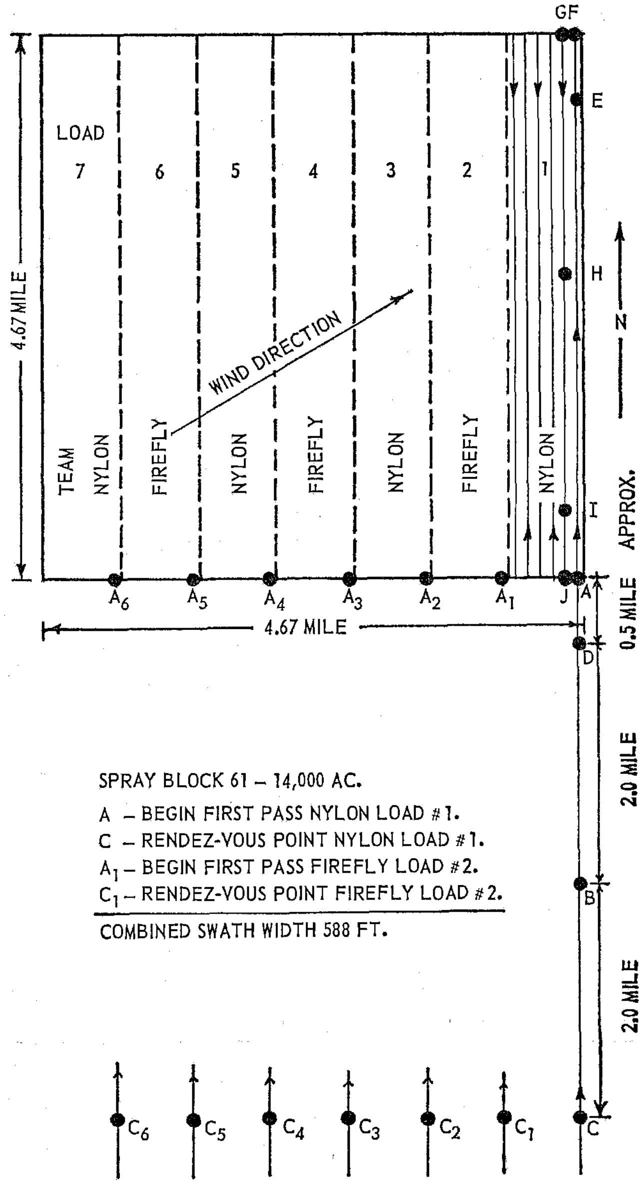
The new technique has been well received by the T.B.M. pilot since it reduces his responsibilities with improved performance and increases safety without reducing his capacity for area coverage. Furthermore, ground checks indicate a high degree of uniformity in deposit of insecticide.

Since 1961 spray programmes in New Brunswick have used this flagging system and the T.B.M. spray plane almost exclusively. In 1963 the State of Maine adopted the technique in its two spray coverages of almost 500,000 acres with gratifying results.

For those interested in the detail of the system, an example is provided. The accompanying figure shows a sample block (61) to be sprayed in a N.-S. direction by two pairs of sprayers directed by a team of flaggers. The block is so located from the flying base that one spray pair is at the airstrip loading while the other is on the block. Sprayers and flaggers have distinct names which are not likely to be confused when heard on the radio. In this instance spray teams are Nylon and Firefly. Within a spray team the lead is called 1 and the trail 2. In this case, Nylon 1 and 2 and Firefly 1 and 2. Ordinarily radio conversation involves only the lead pilot and then only when absolutely necessary. Flag teams are named for colours. In this case, Red team is made up of two aircraft, each with a pilot and navigator (pointer). One aircraft is known as Red 1 and the other as Red 2.

The lead spray pilots Nylon 1 and Firefly 1, along with Red 1 and Red 2, have been shown the boundaries of block 61. They know how to find it from the airstrip and have agreed on a rendez-vous point C. The sequence of operations is as follows:

1. Red flag team locates first pass or swath starting point A in the S.E. corner. Red 1 orbits A at approximately 700 ft. above average ground elevation. Red 2 extends the N.-S. line through A South about 2½ miles to B and orbits at 700 ft. up.
2. Nylon team flies loaded from strip directly to C, the rendezvous about 4½ miles South of A. Nylon 1 radios "Nylon lining up." Red team acknowledges. Red 1 flies North to track from A maintaining altitude of 700 ft. and speed of about 75 m.p.h. At same time Red 2 moves North from B at like speed and altitude and at this instant Red team is defining position and direction of swath 1 for Nylon 1.
3. At D, ½ mile South of A, Nylon team flying 150-200 ft. above trees and 150-160 m.p.h. passes under Red 2 who can see them as they are about to pass A. Red 2 signals "Nylon booms on." Nylon team begins to spray North lined up on Red 1. Red 2 brings up rear.



4. As Red 1 nears E, ½ mile South of swath end point F, spray team passes under him and appears in front of Red 1 so that Red 1 is positioned to signal "Nylon booms off" as spray team passes F.
5. After shut off Red 1 remains on track until he sees Nylon team bank right for a left turn. Red 1 then makes a 180° turn and in doing so sets over west about 600 ft. from swath 1. Red 2 hearing shut off signal will increase speed and maintain track until he sees Red 1 complete turn. Red 2 then turns moving west the required swath width of approximately 600 ft.
6. Nylon spray team on completing turn lines up on Red 1 and Red 2 and flying South on track will begin to spray on their own as they pass starting point G of swath 2 guided by the still visible spray pattern of swath 1. They continue South passing under Red 1 near G and following Red 2 now at H about 2 miles South of the spray team.
7. When Red 2 reaches I, ½ mile North of swath 2 end point J. Nylon spray team passes under him and he signals "booms off" as sprayers pass J.
8. Red 2 after "booms off" maintains track until he sees Nylon team bank left for a right turn. Red 2 then turns

moving over 600 ft. West. Red 1 makes turn at same time as Red 2. (Only on the first swath of a load does the trail flag aircraft wait for completion of lead flag plane turn before making his. The reason being that on the first run he needs to make up about ½ mile of distance on the lead aircraft so the two planes will be in approximately correct position, relative to each other within the ends of the block, on subsequent runs.) The flag and spray teams continue in this manner until the spray team has completed six runs, after which it continues on the prolongation of this last swath until empty. Red 1 now locates A_1 the starting point of swath 1 load 2 and orbits while Red 2 takes up a position halfway from A_1 to the rendez-vous point C_1 and orbits. They wait for the "lining up" signal from Firefly 1 who now is either waiting to work or on the way to work from the strip. The drill is repeated as for Nylon team. The two spray teams alternate and finish Block 61 after seven loads.

Spray planes are calibrated to spray lean in order not to run out of insecticide within the block limits on the last pass of the load.—B. W. Flieger, Manager, Forest Protection Ltd.

ONTARIO

Leaf-folders on Birch, Rheumaptera spp.—Almost 200 samples of geometrid larvae of the genus *Rheumaptera* have been collected from birch in northern and western Ontario by the Forest Insect Survey since 1947 but none have been collected south of Lake Nipissing. Heavy infestations have occurred only in the vicinity of Lake Nipigon, in 1953 and again from 1960 to 1962. In this area local infestations did not persist in individual birch stands for more than one season. The cause of periodicity in local larval populations is not known, but larval parasitism can be ruled out because mortality from this cause was consistently low regardless of the level of host population.

The larvae are usually blackish in colour with cream or yellow spots around the spiracles, and broken pale lines on the dorsum; the head is yellow brown with darker flecks; prolegs are pale, the anal pair with yellowish lateral plates. They feed on the inner layer of loosely folded leaves throughout July and August, usually singly, but sometimes in groups of as many as five per leaf shelter. The mature larvae drop to the ground in early fall and overwinter as pupae in the soil.

Until recently the species name *hastata* Linnaeus was applied to the birch feeding species of *Rheumaptera* based on adult determinations and substantiated by larval descriptions, host plant, and distribution (McGuffin, W. C. Larvae of the Nearctic Larentiinae. Can. Ent. Suppl. 8, 1958). In recent years, adult male specimens reared from larvae on birch have been determined *R. hastata gothicata* Gn., and *R. albodecorata stygiata* McD., by E. G. Munroe, Entomology Research Institute, Ottawa. Associated larvae have been studied and compared but no distinguishing character was found to further substantiate the separation of the two entities. More detailed studies on larger samples of larvae are required as well as information on the general biology of the species involved.—O. H. Lindquist, K. C. Hall, and V. Jansons.

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QUEBEC

Insecticide Tests Against the Pine Needle Miner, Exoteleia pinifoliella (Cham.).—Preliminary tests of dieldrin and malathion were made during the summer of 1961, and of zectran during the summer of 1963, against the pine needle miner. The tests were carried out in the vicinity of Drummondville, P.Q. in heavily infested 15-year-old jack pine plantations. The insecticides were applied with a portable "Solo" mist blower, and each tree was sprayed with approximately ½ pint of solution.

In 1961, both dieldrin and malathion were tested in five formulations. For each insecticide the five treatments were multiples of a basic (dilute) solution. The basic solution for dieldrin was a 0.06% concentration of emulsified insecticide; treatments one to five being 2, 3, 4, 5, and 6 times, respectively the strength of the basic solution. The basic solution for malathion was a 0.1% concentration of emulsified insecticide; treatments one to five being 3, 4, 5, 6, and 7 times, respectively, the strength of the basic solution. The time of application was chosen to coincide with peak egg eclosion (about mid-July). Five trees averaging about 12 ft. in height were sprayed with each formulation and 10 trees in the same plantation were used as checks. Samples of the 1961 needles were collected in October of the same year and examined under a microscope for damage. The following table gives the percentage of needles mined with the various treatments.

Treatment	Date applied	Percentage of needles mined
Dieldrin emulsion.........0.12%	17-VII-61	19.0
" " 0.18%	"	22.3
" " 0.24%	"	29.4
" " 0.30%	"	25.8
" " 0.36%	"	22.9
Malathion emulsion.........0.3%	17-VII-61	16.7
" " 0.4%	"	11.8
" " 0.5%	"	16.1
" " 0.6%	"	18.1
" " 0.7%	"	19.1
Check (10 tree av.).........	10-X-61	45.5
Zectran emulsion.........0.2%	26-VI-63	1.8
" " 0.1%	25-VII-63	2.3
" " 0.05%	"	27.0
Check (5 tree av.).........	4-X-63	39.0

It can be seen that although both malathion and dieldrin reduced the number of needles mined, they did not effectively control the insect. The reason for this poor control was probably due to the fact that newly hatched larvae do not feed until they are under the protective sheath at the base of healthy needles. Since no insecticide is deposited here, the larvae are not subject to stomach poisoning and suffer only limited contact poisoning while crawling from the oviposition site (old mined needles) to healthy needles.

In 1963 zectran was tested as a 0.2% solution, at the beginning of the oviposition period (late June), and as a 0.1% and 0.05% solution at the end of the oviposition period (late July). In choosing these extreme dates, rather than mid-oviposition dates, reliance was placed on the systemic activity of zectran to control the insect. Each spray formulation was applied to 10 trees measuring about 15 ft. in height, and five unsprayed trees in the same plantation were used as checks. Samples of the 1963 needles were collected in October of the same year and examined for damage. The above table shows that the 0.2% solution sprayed in late June and the 0.1% solution sprayed in late July gave reasonably good control, but that the 0.05% solution sprayed in late July did not give satisfactory results.—R. J. Finnegan.

Parasites of Pulicalvaria piceaella (Kft.) in Quebec.—*Pulicalvaria (Recurvaria) piceaella* (Kft.) is a needle-miner of spruce indigenous to North America. Its first occurrence on the continent of Europe near Pfungstadt (Hesse) has recently been reported (Führer, E. 1963. Anzeiger für schädlingskunde 36: 93-4), and its further spread in Germany is considered highly probable.

The following is a list of 30 species of parasites recovered from *P. piceaella* during studies carried out between 1956 and 1959 at various localities in the Province of Quebec. It has been prepared in anticipation of the interest that may be expressed by workers in Germany. The list is subdivided according to host stage attacked and the habits of the parasite.

Group 1. Attacks and emerges from host eggs in June or July. Alternate hosts probable. HYMENOPTERA: Trichogrammitidae; *Trichogramma minutum* Riley.

Group 2. Attack young larvae in September, may emerge as adults in fall or overwinter as larvae or pupae, emerging the following spring. Ectoparasites; host killed at onset of attack. Alternate hosts probable. HYMENOPTERA: Eulophidae; *Dicladocerus westwoodii* West., *Sympiesis* sp.

Group 3. Hyperparasitic on species in Group 2. HYMENOPTERA: Eulophidae; *Tetrastichus* sp.

Group 4. Attack young larvae in later summer, overwinter and emerge following spring or summer from mature larvae. Endoparasites. Life history apparently synchronized with that of host. HYMENOPTERA: Encyrtidae; *Copidosoma deceptor* Miller. Braconidae; *Eubadizon gracile* Prov., *Agathis bicolor* (Prov.), *Apanteles paralechiae* Mues., *Apanteles* sp. near *tischeriae* Vier., *Chelonus* sp. Ichneumonidae: *Pimplopterus parvus* (Cress.).

Group 5. Attacks and emerges from mature larvae in spring. Endoparasite. Alternate host probable. HYMENOPTERA: Ichneumonidae; *Campoplex rufipes* (Prov.).

Group 6. Emerge from mature larvae in spring or early summer. Endoparasites. Complete life history of parasite unknown. HYMENOPTERA: Braconidae; *Meteorus pinifolii* Mason, *Orgilus* sp., *Agathis* n. sp. near *pumilus* Ratz. Ichneumonidae; *Neliopisthus piceae* Cush., *Horogenes stenosomus* (Vier.), *Trathala (Zaleptopygus)* sp. DIPTERA: Tachinidae; *Shizactia vitinervis* (Thom.).

Group 7. Known or suspected to be hyperparasitic on one or more species in Groups 4, 5, or 6. HYMENOPTERA: Eulophidae; *Elachertus pini* Gahan. Elasmidae; *Elasmus atratus* How. Perilampidae; *Perilampus fulvicornis protoracicus* Smul. Pteromalidae; *Amblymerus verditer* (Nort.). Ichneumonidae; *Mesochorus* sp.

Group 8. Pupal parasites. Little is known of the life histories of these parasites on *P. piceaella*. HYMENOPTERA: Pteromalidae; *Amblymerus verditer* (Nort.). Chalcidae; *Spilochalcis* sp., probably *albifrons* (Walsh). Ichneumonidae; *Itoplectis* n. sp., *Alegina apantelis* (Cush.), *Alegina* n. sp., *Phaeogenes epinotiae* (Cush.), *Campoplex* sp.

During the 4-year study period, apparent parasitism of *P. piceaella* eggs varied between 6 and 7%; of young larvae by parasites in Groups 2 and 3 (ectoparasites), from 3 to 6%; of larvae by endoparasites (Groups 4 to 7 inclusive), 8 to 79%; and of pupae, 11 to 17%. Of the endoparasites attacking larvae, those in Group 4 were by far the most abundant.

A more complete report on parasites and other mortality factors encountered during studies on *P. piceaella* is in preparation.—J. M. McLeod.

ONTARIO

A Northward Extension of the Recorded Range of Fomes annosus in Ontario.—Since *Fomes annosus* (Fr.) Cke. was first recorded from the area of St. Williams Forest Station in 1955 (Jorgensen, E. For. Chron. 32: 87-88. 1956) its presence has been reported from two other localities, in York County Forest and in Midland Provincial Forest Nursery. These two more recent records were from single pockets of dead trees and resulting damage has been slight.

In September 1963 the author's attention was drawn to the presence of disease pockets in a 31-year-old red pine (*Pinus resinosa* Ait.) plantation at Orr Lake Forest in Simcoe County. A. A. Harnden had investigated a number of dead trees and suspected the presence of *F. annosus* root rot. Discovery of sporophores on a number of trees and stumps allowed positive identification of the pathogen.

Trees in this stand were planted at a spacing of approximately 5 x 5 ft. on derelict cultivated land. The site has been described as a well drained, base-poor, Oro sand and is both stony and hilly. That part of the plantation in which disease pockets were found has been the subject of experimental thinnings by the Ontario Department of Lands and Forests. Five ¼-acre plots were marked out in 1948. At that time 20% of the trees had died but the remainder showed no sign of disease. Four plots underwent thinning in August 1948 by various combinations of the line and selection methods, resulting in removal of between 20 and 35% of the stand; the fifth plot was not thinned. A 40-ft. strip surrounding each plot received the same treatment as the plot itself. Subsequent thinning operations were carried out in January-February 1954 and midsummer 1958. On each occasion plots and their surrounds were thinned selectively so that 10 to 25% of the remaining basal area was removed.

A more detailed survey has revealed the presence of 14 separate disease pockets, some of which have given rise to pockets up to 60 ft. in diameter (see Fig. 1.) and including as many as 15 dead trees. Sporophores were found on the majority of dead trees and stumps in these pockets. No trace of the pathogen could be found in the control plot, its surround, or the unthinned remainder of the compartment—strong evidence that stump infection was the original means of entry at this location. The wide range in size and the spatial separation of disease pockets indicate that these have arisen at different times and hence from a number of discrete stump infections. Since Rishbeth (Ann. Bot., N.S., 15: 1-21, 1951) has found that stumps remain susceptible for only a few weeks after felling, these infections presumably occurred during August-September 1948, January-March 1954, or June-August 1958.

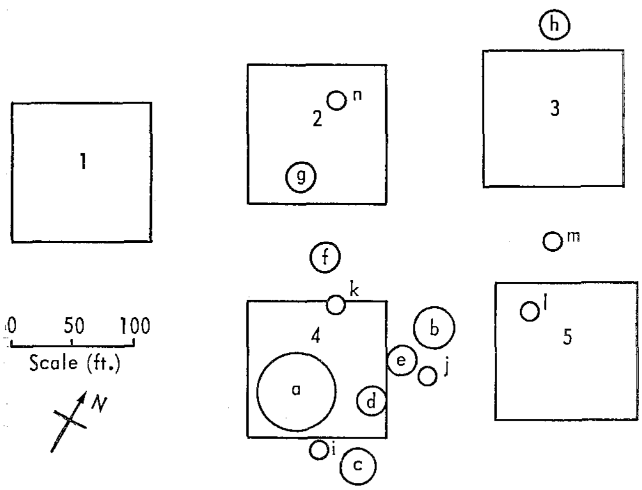

FIGURE 1. Distribution of pockets (a-n) of *Fomes annosus* root rot in and around experimental thinning plots (1-5) at Orr Lake Forest (Cpt. 44), Simcoe County.

Observations in plantations of Scots and Corsican pines (*Pinus sylvestris L.* and *P. nigra* var. *calabrica* Schneid.) on Breckland sands of E. Anglia (Rishbeth, J. Forestry 30: 69-89. 1957) indicate that annual advance of this pathogen is usually between 0.5 and 1.0 m. If, in the absence of local data for Ontario, a similar annual radial increment for disease pockets of *ca.* 2 ft. is assumed, it follows that *F. annosus* first became established in Plot 4 (Fig. 1., *a*) as a result of a stump infection after the first experimental thinning in 1948. Although this hypothesis may appear somewhat tenuous at first sight, support for it may be derived from three other pieces of evidence. (1) The only stumps whose ages may now be determined with certainty are those of the line thinning carried out in 1948. One such row runs through pocket *a* close to its centre and sporophores are still to be found on some of these stumps. (2) Records of the Ontario Department of Lands and Forests indicate that eight trees died in Plot 4 between 1948 and 1953 compared with 2, 0, and 1, respectively, in Plots 2, 3, and 5. (Although 28 trees died during the same period in the control plot, this high mortality rate has been sustained to the present time, despite the total absence of *F. annosus*, and is almost certainly the result of acute competition in this unthinned stand). (3) Under prevailing climatic conditions, it seems more likely that basidiospores discharged from a distant source would have been sufficiently plentiful to cause infection of a stump during the susceptible period in the fall of 1948 than in the winter of 1954. This situation will become clearer as a result of spore trapping studies presently in progress.

The size of pocket *b* suggests that it was initiated by secondary stump infections, after the 1954 thinning, from basidiospores produced in pocket *a*. A much larger number of infections is presumed to have occurred as a consequence of the 1958 thinning for there are 12 distinct disease pockets of appropriate dimensions in or around plots 2 to 5. This is to be expected since sporophores should have been plentiful in pocket *a* by that time, resulting in an abundant supply of spores during the susceptible period after this midsummer thinning. The overall picture is therefore of an initial long-range infection by air-borne basidiospores, these possibly originating from St. Williams, 135 miles distant. No other source of spores is known to have been available in the area in 1948 and viable spores of *F. annosus* have been trapped on muslin squares as far as 180 miles from source (Rishbeth, J. Trans. Brit. Mycol. Soc. 42: 243-260. 1959). Infections after subsequent thinnings were more probably caused by spores of local origin and increased in number as inoculum became more plentiful.

Several features make this new record especially noteworthy. It is the most northerly record of *F. annosus* in Ontario, being 10 miles north of Midhurst Nursery. This, the severest attack known in the Province outside the St. Williams area, has apparently been established for some time but overlooked. It is situated in a region where a considerable acreage of pine is about to be thinned for the first time. In view of the severe threat to this area, stump treatment with aqueous sodium nitrate* (10%) was immediately recommended and is now being used by the Ontario Department of Lands and Forests on thinning stumps in adjacent plantations. The disease area will be kept under observation and the success of this control measure will be evaluated in the future.—D. Punter.

PRAIRIE PROVINCES

Liberation of Bavarian Mesoleius tenthredinis Morley Against the Larch Sawfly.—This ichneumonid, which is considered native to Europe, was collected in England for releases against the larch sawfly in eastern Ontario, Quebec, and Manitoba from 1910 to 1913. It rapidly become established in Manitoba and was found at widely separated locations in eastern Canada by the late 1920's. The spread of the parasite was expedited by transfers from areas of early establishment to other parts of Canada in the years 1927-29 and 1934-35. Parasitism as high as 70% was recorded in Manitoba in 1927, in New Brunswick in 1939, and in British Columbia following releases that began in 1934. The association of parasitism at this level with declining sawfly outbreaks has been interpreted as indicating that *M. tenthredinis* played an important role in reducing host numbers in these areas.

Larch sawfly populations began to increase in southern Manitoba in 1938 and outbreak conditions have since been recorded from a progressively enlarging area now extending to New Brunswick in the east and almost to the limit of occurrence of tamarack in the west. Studies during the early stages of the outbreak in Manitoba showed a very low incidence of *M. tenthredinis*. Dissections revealed that many of the parasite eggs were encapsulated by host blood cells and further studies showed that these inhibited embryonic development and eventually killed the parasite. The liberations in central Canada during the period 1947-52 of *M. tenthredinis* collected in British Columbia failed to increase parasitism significantly.

Dissections of larch sawfly larvae collected from the outbreak areas as these developed east and west of Manitoba showed a high degree of resistance to *M. tenthredinis* with effective parasitism usually less than 5% and only rarely greater than 20%. In areas under intensive study in Manitoba the parasite has declined to the point of near extinction.

In 1959 a few *M. tenthredinis* of Austrian origin were received at Winnipeg and were used in cage experiments to parasitize resistant larch sawfly from Manitoba. Dissections showed that over 90% of 84 parasitized hosts were successfully parasitized. Larger numbers of Austrian and Bavarian *M. tenthredinis* were received in 1961 and 38 groups of resistant

*This substance achieved considerable success as a stump protectant against *F. annosus* in trials carried out by the author in Britain and has recently been adopted for use there by the Forestry Commission. Full results of trials including this treatment will be published elsewhere.

host larvae originating from eight locations in Manitoba and Saskatchewan were experimentally parasitized. No evidence of encapsulation was found in 60% of these groups and parasitism of 594 larvae in which eggs were deposited was again approximately 90% successful. In controls parasitized by Canadian *M. tenthredinis* the successful parasitism was 25%.

Studies on Bavarian-Canadian and Austrian-Canadian crosses of *M. tenthredinis* showed a high degree of successful parasitism when the female parent was European (61 of 76 parasitized hosts in 1961 and 29 of 31 parasitized hosts in 1962) and a lower degree of successful parasitism when the female parent was Canadian (13 of 34 parasitized hosts in 1961 and 7 of 13 parasitized hosts in 1962). However, some evidence was obtained that the characteristic conferring greater success in hatching was transmitted to female progeny from the male parent in Bavarian male-Canadian female crosses.

Because of these promising results, a total of 1,151 male and 1,870 female Bavarian *M. tenthredinis* were released near Riverton, Manitoba, in 1963. Austrian *M. tenthredinis* received in 1963 were not released because European workers had found encapsulated eggs in certain Austrian larch sawfly populations but not in Bavarian populations.

Simmonds (Can. Ent. 95: 561-567. 1963) considers that "the most important factor . . . in the material liberated for biological control (is) the maximum possible genetic variability, from which by natural selection in the given environment, the most suitable strain for that environment would be developed." The release of the Bavarian genotype of *M. tenthredinis* is an attempt to increase the genetic variability of this parasite in Canada and will be closely studied to determine if benefit occurs.—J. A. Muldrew.

Liberations of Additional Species of Parasites Against the Larch Sawfly.—In 1958 a program was initiated to discover additional parasites of the larch sawfly, *Pristiphora erichsonii* (Htg.), for release in Canada. This program involves the co-operation of several agencies: the Forest Entomology and Pathology Branch, Department of Forestry, initiated the program and is responsible for the release of parasites and assessment of results; the Entomology Research Institute for Biological Control, Department of Agriculture, is responsible for the importation of exotic species; and the Commonwealth Institute of Biological Control is responsible for overseas exploration, research, and collections.

Parasite releases have been restricted to Manitoba, beginning in 1961 near Pine Falls (sec. 12, twp. 20, rge. 10 EPM) and continuing in 1962 and 1963 near Riverton (sec. 21, twp. 26, rge. 4 EPM) as shown in Table I. The species liberated to date have all been of central European origin except *Vibrissina turrita,* which was obtained from Japan.

TABLE I. EXOTIC PARASITES RELEASED AGAINST THE LARCH SAWFLY IN MANITOBA, 1961-63

Species	Locality and Numbers					
	Pine Falls		Riverton			
	1961		1962		1963	
	♂	♀	♂	♀	♂	♀
Ichneumonidae						
Holocremnus sp. nr. *nemoratum* Tschek.	56	158	65	152	910	1,245
Hypamblys spp.	—	—	—	—	80	134
Tachinidae						
Hyalurgus lucidus Mg.	99	154	48	61	692*	
Myxexoristops stolida Stein	—	—	281*		77*	
Vibrissina turrita (Mg.)	—	—	—		149*	

*Not sexed.

Evaluation of the results of the 1961 and 1962 releases showed that *Holocremnus* sp. passed through a full generation on the larch sawfly at both release points and offers promise of becoming permanently established. Evidence of establishment came from cocoons collected in the fall of 1962 in larch sawfly study plots at the release points: 337 from Pine Falls and 1,121 from Riverton. These cocoons were kept under near-natural conditions until adult emergence was completed the following summer. Four *Holocremnus* sp. adults emerged: two females from the Pine Falls cocoons and one male and one female from the Riverton cocoons. These specimens have been deposited in the Canadian National Collection, Ottawa. No evidence was obtained of the establishment of the tachinids *H. lucidus* or *M. stolida.*

Efforts to obtain evidence of the establishment of species released in 1963 are continuing and further releases of these species and studies on the spread and impact of *Holocremnus* sp. are planned.—W. J. Turnock and J. A. Muldrew.

BRITISH COLUMBIA

Mealy Bug Damage in Conifers.—A localized but heavy infestation of *Puto cupressi* (Coleman) discovered 12 miles northwest of Princeton by F. Baker of the B.C. Forest Service apparently constitutes the first record of mealy bug damage in the forests of Interior British Columbia. The infestation covers about 15 acres of open-growing, immature lodgepole pine, alpine fir, Engelmann spruce, and a few Douglas-fir seedlings at an elevation of 4900 ft.

Damage symptoms were (*a*) blackened foliage and branches caused by a fungus growing on deposits of "honey dew", (*b*) atrophy of the main leaders, frequently accompanied by degeneration of the upper crown into a rounded, broom-like mass, and (*c*) gross malformation of main stems and branches caused by numerous tumour-like swellings. Alpine fir exhibited all three types of damage, and a few trees ranging up to 5 in. d.b.h. had been killed. Lodgepole pine, having sparser foliage than the other conifers, was not as heavily smothered in fungus growth, but many of the understory trees were disfigured by growth abnormalities. Tumours were scarce on Engelmann spruce, although the infestation had resulted in dense brooming of the upper crowns. The scattered Douglas-fir seedlings in the stand appeared to have been less severely affected than the other tree species, but a few had nodules on the branches.

Stages present on September 12, 1963, were motile nymphs (or females) feeding on the smaller twigs, and pre-adults enclosed in white cottony "cocoons" which occurred singly or in clusters amongst the needles, in lichens and accumulated debris amongst the brooms, and in bark crevices.

Although examination of growth rings of four trees indicated that mealy bug feeding had begun to retard growth about 10 years ago, the infestation appears to be confined to an open stand on the southwestern exposure of a low knoll. Reasons for its failure to spread into the adjacent forest are not known.—J. Grant.

Host Ranges and Taxonomy of the Poplar Rusts of the World.—The discovery of Melampsora rust on seedlings of ponderosa pine (*Pinus ponderosa* Laws.) in a forest tree nursery at Telkwa, British Columbia, in 1960, led to intensive surveys and experimentations, because it was feared that the rust might be a foreign disease recently introduced to the North American continent. In the course of these investigations, Molnar and Sivak (Can. J. Bot. 42: 145-158. 1964) showed that the disease on ponderosa pine was not caused by European pine twist rust (*Melampsora pinitorqua* Rostr.) as suspected, but by the well-known indigenous poplar rust *M. albertensis* Arth. Previously, Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) was considered to be the only aecial host of *Melampsora albertensis.* Molnar and Sivak showed, furthermore, that seedlings of ponderosa pine are susceptible to another well-known indigenous poplar rust, *M. occidentalis* Jacks., which was also, like *M. albertensis,* considered to be restricted to Douglas-fir in its aecial state.

In view of these findings it seemed reasonable to expect that other Melampsora rusts throughout the world might likewise have a wider host range than presently assumed. For that reason, and because poplar rusts can cause damage to valuable timber (species of *Populus, Pinus, Larix, Pseudotsuga* and *Tsuga* are known suspects), it was decided that investigations into their host ranges and taxonomy were warranted on an international scale. Consequently, the collaboration of three eminent forest pathologists was obtained: Dr. A. Biraghi, University of Florence, Italy; Dr. N. Hiratsuka, University of Tokyo, Japan; and Mrs. E. v.d. Pahlen, Instituto de Fitotecnia, Argentine. A joint program was designed with the following principal objectives:

(*a*) to carry out inoculation experiments designed to test economically important conifers for their susceptibility to poplar rusts occurring in each of the following regions of the world: Italy, Japan, eastern Argentine, and western Canada;

(*b*) to review the taxonomy, host ranges, and geographical distribution of poplar rusts on a worldwide basis in the light of experimental results, regional observations, and specimens obtained in (*a*), above.

The conifers selected for testing represent species of six genera: *Abies, Larix, Picea, Pinus, Pseudotsuga,* and *Tsuga.* The conifers are grown from seed distributed to each of the collaborators. In each of the four regions of the world, Melampsora rusts occurring locally on poplar leaves are used to inoculate the conifer seedlings to test their susceptibility to each of the rusts. The inocula used and the specimens of infected conifers obtained by inoculation are preserved for comparative study of the rusts on a worldwide basis.

It is hoped that the results of the program will aid in controlling these rust parasites and lead to fundamental taxonomic revisions in the genus *Melampsora.*—W. G. Ziller.

Five Systemic Insecticides Used Against Douglas-fir Cone Insects.—In previous tests it was shown that the systemic insecticides phosphamidon and systox are capable of killing larvae of the midge, *Contarinia oregonensis* Foote, in Douglas-fir cones (Hedlin, A. F. Bi-Mon. Prog. Rept. 18(1): 3-4. 1962).

In 1963 experiments were continued using the systemic insecticides bidrin, dimethoate, and C-43064 in addition to phosphamidon and demeton (systox). The materials were applied as sprays with a 1-gal. pressure type garden sprayer at concentrations ranging from 0.5 to 4.25% active ingredient by weight. Treatments were made during the period from flower bud burst (about April 20) until cones became pendant (about May 20). Trees ranged in height from 20 to 40 ft. with most about 25 to 30 ft. Applications were made by climbing the tree with a ladder and thoroughly spraying the cone-bearing area. The portions of trees too high to spray were used as additional checks. In early September when cones had reached maturity a 20-cone sample was taken from each treated tree and examined for insects and seed loss. Similar samples from 15 untreated trees in the same area were examined. Seed loss was recorded for the following insects: cone moths (*Barbara colfaxiana* Kft. and *Dioryctria abietivorella* Grt.), gall midge (*Contarinia oregonensis*), seed chalcid (*Megastigmus spermotrophus* Wachtl.), and scale midge (*C. washingtonensis* Johnson).

The experiments showed that:

1. Bidrin gave better control of all insects than any of the other materials used. Applications on all trees treated over the period from April 22 to May 22 reduced seed loss considerably. Two trees sprayed on May 22 with 1.6% active ingredient suffered no seed loss to insects. The other materials gave no control when applied at earlier dates but concentrations of 4.25% of dimethoate on May 16 and phosphamidon and demeton on May 22 gave fair control. The seed losses caused by all insects were 1.6, 7.2 and 10.0%, respectively. C-43064 which was used in fewer tests at fairly low concentrations gave very little control. Fifteen check trees suffered an average seed loss of 65% (range 20 to 100%) to all insects.
2. Materials applied at concentrations which gave effective insect kill caused phytotoxicity in the following descending order (*a*) demeton, (*b*) bidrin, (*c*) phosphamidon, and (*d*) dimethoate. Phytotoxicity was indicated by (*a*) yellowing of current needles (light), (*b*) yellowing plus burned needle tips (medium), and (*c*) burned cone bracts and scales in addition to damage to current needles (severe).
3. Best results for all materials were obtained from applications made in late May when cones were at or near the pendant stage.
4. The untreated upper crowns served as good checks against the lower sprayed portions of the same trees. They experienced much greater seed loss than the treated portions.

The results indicate that bidrin may be the most effective of materials used from the standpoint of insect control. In considering both insect control and phytotoxicity, dimethoate is possibly superior. When applying the insecticides it is apparently necessary to treat the entire cone-bearing portion of the crown, and best results can probably be expected when cones are at or near the pendant stage. However before recommendations can be made regarding use of these materials, further information is required on the relative effectiveness of different concentrations of the better materials, on methods and time of application, and the possible deleterious effect on seed viability.—A. F. Hedlin.

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O. H. M. S.

DOUGLAS C. EIDT,
FOREST ENT. & PATH LAB.,
CANADA DEPT. OF FORESTRY, (3-6)
COLLEGE HILL,
FREDERICTON, N.B. L-205

DEPARTMENT OF FORESTRY
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ATLANTIC PROVINCES

Relative Pathogenicity of a Non-specific Cytoplasmic Polyhedrosis Virus for the Winter Moth, Operophtera brumata L., and the Fall Cankerworm, Alsophila pometaria (Harr.).—In 1956 a non-specific cytoplasmic virus was imported from England for testing against forest insect pests in Canada. Although this virus has been shown to be pathogenic for a large number of species in England and Canada (M. M. Neilson, J. Insect Path. 6:41-52, 1964) no attempt has ever been made to measure its pathogenicity for any of the susceptible hosts. Because of the importance of this point in the evaluation of any insect pathogen for possible use in biological control, comparative pathogenicity tests against the winter moth and the fall cankerworm were conducted.

Polyhedra used in the tests were the product of four passages through each host. The various concentrations to be fed were prepared from purified suspensions with the aid of a Petroff-Hausser bacterial counting chamber. To ensure that the larvae would each ingest approximately the same quantity of each concentration of polyhedra, they were reared individually and each was fed a 1 $cm.^2$ piece of apple leaf smeared with 0.009 ml. of the suspension to be tested. Larvae that did not consume three-quarters of this initial feeding were not included in the results. Control larvae were handled the same as treated larvae except that they were not fed polyhedra. At least 10 larvae of each species were treated at each of six dosages ranging from 7.8 to 7.8×10^5 polyhedra per insect. The tests were repeated using early- and late-instar larvae of both species to find if there was a difference in susceptibility associated with age.

To facilitate comparisons between species and between larvae of different ages, the data were subjected to probit analysis. The calculated LD_{50}'s for these two species were 5,000 polyhedra per insect for the winter moth and 19,000 polyhedra per insect for the cankerworm. The winter moth is therefore considerably more susceptible to this virus than the cankerworm. No significant difference in susceptibility could be demonstrated between early- and late-instar larvae of either species, but the apparent complete recovery of some heavily infected late-instar fall cankerworm larvae suggests that older larvae of this species may be less susceptible than young larvae. None of the control insects died from a polyhedrosis.

Although the LD_{50} estimates obtained by other workers with different pathogens and hosts are not strictly comparable to the results obtained here because of differences in techniques and host-pathogen relationships, they do serve as a guide in assessing the relative pathogenicity of this virus. Thus, the LD_{50} estimates of 5,000 and 19,000 polyhedra per insect for the winter moth and the fall cankerworm indicate that this virus may have considerable potential as a biological control agent. In addition, some of the adult winter moths and fall cankerworms that survived the tests were found to contain polyhedra. If vertical transmission occurs in these or other susceptible species, the value of this virus in the field would be enhanced. The non-specificity of this virus is also an advantage in cases of mixed infestations of several susceptible species.—M. M. Neilson.

QUEBEC

Notes on Avian Predators of Neodiprion swainei Midd.—The following observations were made during studies on the population dynamics of the Swaine jack-pine sawfly, *Neodiprion swainei* Midd., in a stand of jack pine on the Rivière à Mars watershed near Bagotville, Chicoutimi County, Quebec, and definitely established the following bird species as predators on larvae or prespinning eonymphs of *N. swainei*: the evening grosbeak, *Hesperiphona v. vespertina*; the black-capped chickadee, *Parus atricapillus*; the Acadian brown-capped chickadee, *Parus hudsonicus littoralis*; the myrtle warbler, *Dendroica c. coronata*; and the American robin, *Turdus m. migratorius*. The determinations were based on stomach analyses of birds shot on September 25 and 26, 1963 (Table 1), and upon direct observations of birds feeding on *N. swainei* larvae or prespinning eonymphs between September 24 and 27. Of the six species of birds shot, only the white-throated sparrow, *Zonotricha albicollis*, did not contain sawfly remains. All the others contained varying numbers of sawflies. The evening grosbeak appeared to have been feeding almost exclusively on sawfly larvae: its stomach contained 12 intact sawfly larvae plus massive quantities of sawfly remains. The black-capped chickadees, Acadian brown-capped chickadee, and myrtle warblers each contained one or two identifiable sawfly larvae or prespinning eonymphs as well as what appeared to be partial remains of sawfly larvae. In addition their stomachs contained an abundance of insect material including moths, chironomids, small beetles, and various lepidopterous larvae. The American robins were feeding on sawfly eonymphs which they apparently picked from the ground, in contrast to the other species which are arboreal. The stomach of one robin contained six identifiable *N. swainei* prespinning eonymphs in addition to large quantities of miscellaneous insects and seeds; the other individual contained partial remains of eonymphs.

TABLE 1

Results of Stomach Analyses of Birds Shot on September 25 and 26, 1963, in a Jack Pine Stand on the Rivière à Mars Watershed, near Bagotville, Chicoutimi County, Quebec.

Species	Number shot	No. of specimens with *N. swainei* present	No. of specimens with *N. swainei* question-able*	No. of specimens without *N. swainei*
Evening Grosbeak............ (*Hesperiphona v. vespertina*)	1	1 (larvae)		
Black-Capped Chickadee....... (*Parus atricapillus*)	4	3 (larvae and pre-spinning eonymphs)	1	
Acadian Brown-Capped Chickadee.......................... (*Parus Hudsonicus littoralis*)	1	1 (larva)		
Myrtle Warbler................ (*Dendroica c. coronata*)	4	3 (larvae)	1	
American Robin.............. (*Turdus m. migratorius*)	2	1 (pre-spinning eonymph)	1	
White-Throated Sparrow....... (*Zonotrichia albicollis*)	2			2

*Partial remains of what appeared to be *Neodiprion swainei* larvae or prespinning eonymphs.

In addition to the evidence provided by the stomach analyses, the evening grosbeak, black-capped chickadee, and myrtle warbler were actually observed feeding on sawfly larvae. The grosbeaks were observed on September 24 when a flock of five (1♂ and 4♀) alighted on the upper crowns of jack pine trees near a road. They stayed in the trees for nearly half an hour, feeding almost exclusively on *N. swainei* colonies. One female in particular had alighted on a branch approximately 6 in. from a colony which it methodically consumed to the last individual, the whole operation taking about 20 min. Along with the larvae, she was taking in bits of partially defoliated needles which she would spit out while consuming the larvae.

Black-capped chickadees and myrtle warblers were observed on numerous occasions between September 24 and 27 taking individual sawfly larvae. Unlike the grosbeaks, however, these birds were constantly on the move, usually never staying more than 1 min. in any tree. On one occasion, a black-capped chickadee was observed to take a sawfly larva in the upper crown of a tree after which it rapidly flew to one of the lower branches of the tree where it appeared to decapitate the larva, following which it consumed the body, then wiped its bill vigorously on the branch.

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It must be emphasized that these notes were made during the course of the fall bird migration; at this time of the year the bird population in jack pine stands is apt to be considerably higher than during the breeding season; resident birds in jack pine stands are encountered only rarely. In terms of abundance during the course of the observations, the chickadees and myrtle warblers appeared to be most numerous; considerable numbers could be seen moving through the stands at almost any time of the day. Flocks of grosbeaks varying in number from five to over 20 could be observed daily and their calls were heard on numerous occasions. The sparrows and robins were considerably less abundant and appeared to restrict their feeding almost exclusively to the roadsides.

These results point to the potential importance of birds as mortality agents during the migratory period in late summer or early fall, when larvae of *N. swainei* are mature. Furthermore the above should not be interpreted as a complete list of avian predators of sawfly larvae, since there are many other species not encountered during the course of these observations which might be equally important. Studies will be continued more extensively during the coming field season.—J. M. McLeod.

ONTARIO

Susceptibility of Natural Stands of White Pine to the White Pine Weevil, Pissodes strobi Peck.—The viewpoint that eastern white pine trees more than 25 to 30 ft. tall are seldom attacked by the white pine weevil, *Pissodes strobi* Peck, has been accepted by some forest managers. A project to test the validity of this viewpoint was carried out in the Pembroke Forest District in 1962 and 1963. Three pine stands with trees ranging in height from 20 to 36 ft., 60 to 80 ft., and 70 to 110 ft. were examined to determine the history of weevilling.

The first stand was in the Shirley Lake area in Preston and Clancy townships, where good quality white pine was harvested early in the present century. In 1924, a large fire burned approximately 10,000 acres of pine forests in this area. In 1931, a second fire destroyed 400 acres of white pine regeneration, and gave rise to a mixed stand of pine and deciduous species. When the white pine reached a height of about 20 ft., serious leader whipping by aspen and white birch occurred, and in 1957, the white pine was released by removal of the deciduous growth as part of a stand improvement program by the Department of Lands and Forests. This program was soon followed by a heavy infestation of the white pine weevil. Measurements of weevil attack by 5-foot height intervals were made on 30 trees in the stand. This was done by standing an aluminum pole, marked off in one-foot intervals, against the stem of each tree, and recording the height of defects resulting from weevil attack with the aid of binoculars. The weakness of the method is readily apparent. It had to be assumed that all the recorded defects were actually caused by weevil attack, and examinations of felled trees indicated that errors from this assumption were relatively few. Table 1 shows the history of weevil attack at various height intervals. It is interesting to note that the increase in the incidence of weevilling on the 15- to 20-foot height intervals coincided with the height of the trees when release cuttings were carried out.

TABLE 1

Summary of Weevil Attack on 30 White Pine Trees in the Shirley Lake Area

Height interval by 5-foot sections	No. of 5-foot sections examined	No. of 5-foot sections attacked	Percentage of 5-foot sections attacked
10–15	30	2	7
15–20	30	13	43
20–25	30	23	77
25–30	19	7	37
30–35	5	5	100

The second study area was located in Head Township, about 60 miles northeast of Shirley Lake. This stand consisted of a mixture of white pine, largetooth aspen, and balsam poplar and was not known to be disturbed until cutting began in 1962. The location of apparent weevil damage was recorded on 15 white pine trees that were being felled for commercial use. These trees ranged in age from 65 to 80 years (Table 2).

The third study area was in Clara Township, in the Upper Ottawa River valley about 40 miles north of Shirley Lake. This area, well-known for its excellent white pine, was last logged from 1922 to 1924. The stand contained white pine, largetooth aspen, and yellow birch. Here 15 white pine trees, from 113 years to 139 years of age, were felled, and the location of all weevil damage was recorded (Table 3). Although few trees exceeded 90 ft. in height, weevil attacks were found as high as 107 ft.

TABLE 2

Summary of Weevil Attack on 15 White Pine Trees in Head Township

Height interval by 10-foot sections	No. of 10-foot sections examined	No. of 10-foot sections attacked	Percentage of 10-foot sections attacked
20–30	15	2	13
30–40	15	4	27
40–50	15	8	53
50–60	15	8	53
60–70	13	9	69
70–80	9	8	89

The survey showed that heavy weevilling occurred well above the 25- to 30-foot level in pine stands, and that under some circumstances the incidence of weevilling may increase directly with tree height. In Head and Clara townships this increase probably occurred when the white pine broke through the poplar-birch canopy. Assuming that the increase in weevilling in all three stands resulted from the release of white pine, it would appear that the effect of shading rather than the height of the leading shoots limits attack by the white pine weevil.—H. J. Weir.

TABLE 3

Summary of Weevil Attack on 15 White Pine Trees in Clara Township

Height interval by 10-foot sections	No. of 10-foot sections examined	No. of 10-foot sections attacked	Percentage of 10-foot sections attacked
40–50	15	7	47
50–60	15	10	67
60–70	15	10	67
70–80	12	11	92
80–90	9	7	78
90–100	3	2	67
100–110	1	1	100

Observations on the Effects of Stem Cankers Associated with Pezicula ocellata (Pers.) Seaver in Young Trembling Aspen.—In early summer, 1962, a high incidence of unusual stem cankers was observed in young trembling aspen trees in the Long Lac area of northwestern Ontario. The disease was characterized by single or, more often, multiple cankers on the stems. They were oval, and ranged from one-quarter to 2 in. in width depending upon the size of stems, and from one-quarter to 3 in. in length. Frequently, repeated and vertically adjacent cankers merged to form elongated necrotic areas up to 4 ft. in length. The periphery of the diseased tissues was clearly defined by a continuous narrow ridge of yellowish-brown bark. Most affected stems exhibited several single and multiple cankers. No relationship was noted between the positions of cankers on stems and the aspect. Discoloured tissue in the central parts of cankers was characteristically dark brown or black, whereas in the outer extremities it was yellow. The resultant colour contrast between cankers and adjacent pale-green healthy bark was a conspicuous character that simplified detection of infected trees, especially when they were wet with rain.

In June and July, acervuli of the imperfect stage of *Pezicula ocellata* (Pers.) Seaver occurred commonly in concentric circles on the surface of the blackened areas. Within these same areas apothecia were detected in late August.

In June 1962, a 1/20-acre permanent sample plot was established to determine the current and future incidence and severity of the disease, and mortality attributable to it. The sample consisted of 82 trembling aspen trees ranging from 1 to 6 in. d.b.h. with the average height of dominants being 40 ft. The aspen occurred intermixed with balsam fir and black spruce. The stand, which originated from a clear-cut pulpwood operation in 1938, had a southern aspect, approximately a 15° slope, and a 3-to-5-in. organic layer over-till. For trembling aspen the site was rated fair.

The incidence and severity of the disease in 1962 was determined for each diameter class as shown in Table 1. Both increased more or less according to diameter, and appeared to be governed by the area of bark exposed to infection.

Table 1

Variations in Disease Incidence and Severity, 1962-63, in 82 Trembling Aspen Trees, Long Lac Area, Geraldton District, Ontario

Diameter class (inches)	No. of trees	No. of diseased trees		Incidence (%)		No. of cankers		Severity*	
		1962	1963	1962	1963	1962	1963	1962	1963
1	10	4	0	40	0	18	0	1.8	0
2	16	10	2	60	12.5	43	7	2.5	0.3
3	27	19	1	70	5	79	1	3.0	0.04
4	20	12	0	60	0	50	0	2.5	0
5	7	5	0	71	0	18	0	2.5	0
6	2	2	0	100	0	10	0	5.0	0

*Average number of cankers per stem.

The sample trees were re-examined 1 year later, in June 1963. It was observed that most cankers had disappeared, that this was accompanied by a sharp decline in both the incidence and the severity of the disease (Table 1), that no mortality attributable to these cankers had occurred, and that profound changes had taken place in the character of tissues previously diseased. Despite the destructive appearance of the cankers in 1962 their sites in 1963 were traceable only through irregular black scars and callus tissue.

The rapid and spectacular recovery of the diseased trees from cankers in the space of 1 year was not unexpected. Examination of stem cross-sections through cankers in 1962 showed that lesions usually were shallow-seated in the outer bark with underlying tissue healthy above the cambium. However, in occasional instances infections extended to, and killed, the cambium locally. By 1963, these lesions had healed over. Similar lesions had occurred in 1960 and 1956, and although they had healed successfully and growth continued beyond the wound, relatively large areas of the adjacent heartwood were discoloured with brown stain.

While young aspen trees can quickly recover from the external symptoms of this disease, permanent internal injury in the form of brown heartwood stain results from the condition.—Dance, B. W., Lynn, D. F. and V. Jansons.

Correction.—In the article by D. Punter entitled *"A Northward Extension of the Recorded Range of Fomes annosus in Ontario"*, Vol. 20 No. 2, "sodium nitrate" should read "sodium nitrite".

ROCKY MOUNTAIN REGION

Unhatched Forest Tent Caterpillar Egg Bands in Northern Alberta Associated with Late Spring Frost.—The current outbreak of the forest tent caterpillar began in 1957 in the Elk Point district east of Edmonton. Since that time it has gradually increased and now covers a large area of north central Alberta.

Egg populations in the Naylor, Hawk, and Buffalo Head hills located in the Peace River Region were sufficiently high in the fall of 1962 to predict a continued severe attack in 1963. This attack failed to materialize and an examination of egg bands in the Naylor Hills in mid-June 1963 revealed that no hatch had occurred. Dissection of egg bands showed a high mortality of well-developed embryos. The mortality observed in this area was similar to that reported by Prentice (Bi-Mon. Prog. Rept. 10(5): 2. 1954) from northern Saskatchewan in 1954.

Weather records at the Naylor Hills Forestry Tower (Alt. 2,600) showed that a severe frost occurred during the first week of May 1963. This unfavourable weather had been preceded by unusually warm temperatures. The mean maximum temperature from April 22 to May 1 was 56.9°F with a mean minimum temperature of 35.1°F. The mean maximum temperature from May 2 to 7 was 46.1°F with a mean minimum temperature of 25.5°F. The lowest temperature recorded (10°F) was on May 3. A snowfall totalling 6.1 in. occurred on May 6 to 7. The effects of these unfavourable temperatures on aspen and birch were very noticeable causing extensive killing of buds. It is interesting to note that on descending the Naylor Hills to approximately the 1,500 ft. level, climatic damage ceased to be evident. An examination of forest tent caterpillar egg bands at this elevation revealed that a good hatch had occurred and larvae were causing light to moderate defoliation.

Forest tent caterpillars overwinter as fully developed embryos. According to Hodson (Minn. Agr. Exp. Sta. Bull. 170. 1945), these can withstand very low temperatures. However, it is only during the dormant period that the cold resistance is so marked. The threshold for hatch is reported to lie between 5° and 10°C (41 and 50°F).

While evidence here is not adequate for a final conclusion, it is believed that the warm temperatures occurring in late April initiated embryo activity making them susceptible to the freezing temperatures which occurred in early May in the Peace River Region of Alberta.—E. J. Gautreau.

BRITISH COLUMBIA

Ambrosia Beetle Brood Production in Relation to Tree Growth and Sapwood Depth.—During studies of ambrosia beetle brood development in relation to tree felling date, it was noted that the ambrosia beetle, *Trypodendron lineatum* (Oliv.), usually had largest broods in logs cut from the fastest growing Douglas-fir trees in an even-aged stand. To obtain more information about this relationship, 15 logs, five from each group of 20 trees felled October, November, and December 1961, were chosen for fastest growth in terms of annual rings in the outer inch. Another 15 logs of these felling dates were selected from trees with the slowest recent growth. Measurements of annual rings and sapwood depth were made at the base of the first logs. Sapwood is easily recognized in Douglas-fir logs because it is pale compared with the darker heartwood. No trees less than 8 in. diameter were felled. The average and range of the measurements are shown in Table 1.

Table 1

Average and Range of Growth Measurements from 15 Fast-growing and 15 Slow-growing Trees

Measurement	Fast-growing	Slow-growing
D.B.H. (inches)	15.1 (11.0—23.5)	9.3 (8.0—11.8)
Age 1961[1]	58 (54—61)	56 (53—59)
Sapwood depth (millimetres)	40.3 (31—51)	24.4 (17—32)
Rings per outer inch	10.2 (8—14)	22.8 (18-29)

[1]Based on 10 trees of each growth type.

In 1963, five galleries, selected at random along the top of each log, were excavated and measured for length, maximum depth, numbers of egg niches and pupal cradles. The latter indicate fully developed larvae or pupae. These data are given in Table 2.

Table 2

Measurements of 75 Galleries Each in Logs from Fast-growing and from Slow-growing Trees

Gallery measurements	Logs from fast-growing trees		Logs from slow-growing trees	
	Mean	S.E.	Mean	S.E.
Total length (millimetres)	107	4.0	76	3.7
Max. depth (millimetres)	23	1.0	14	0.7
Number egg niches	34	1.9	16	1.3
Number pupal cradles	23	1.7	9	0.8

The means of all gallery measurements differ significantly (t.01) between the types of logs. Gallery development and brood numbers were clearly greater in logs from fast-growing trees. These also had larger diameters, wider annual rings, and deeper sapwood than trees of slow growth, although tree ages did not differ significantly. Although there was a significant difference in the density of attack between fast- and slow-growing trees, this is not considered to be of an order that would influence gallery length and productivity. Something about the physiological or physical condition of logs from fast-growing trees resulted in the beetles boring longer galleries and laying more eggs. It is also of interest that although galleries were deeper in the logs with thicker sapwood, in both fast- and slow-growing trees they still penetrated only slightly more than half the sapwood depth.—E. D. A. Dyer and J. A. Chapman.

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O. H. M. S.

DOUGLAS C. EIDT,
FOREST ENT. & PATH LAB.,
CANADA DEPT. OF FORESTRY, (3-6)
COLLEGE HILL, L-205
FREDERICTON, N.B.

DEPARTMENT OF FORESTRY
OTTAWA

CANADA

DEPARTMENT OF FORESTRY

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A REVIEW OF THE DUTCH ELM DISEASE

FOREWORD

The present issue of the Bi-monthly Progress Report consists of a series of articles on the Dutch elm disease prepared by officers of the Federal Departments of Forestry and Agriculture. It has been prepared primarily to meet demands for an up-to-date review of the disease and, in addition, to indicate the direction in which current research is proceeding.

The Dutch elm disease, so-named because of the early and excellent studies by pathologists in the Netherlands, is caused by a fungus, *Ceratocystis ulmi* (Buism.) C. Moreau, that is transmitted by bark beetles. It was accidentally introduced into Canada and is currently causing extensive mortality of white elms in Quebec, Ontario, and New Brunswick.

At present, it is practically impossible to save an infected tree by pruning the diseased branches, spraying, or by any method known. Control of the disease is based, therefore, on prevention rather than cure. The role of bark beetles in the transmission of the causal fungus provides two ways by which infections can be prevented or reduced. Because of the costs involved, these measures can be applied only in urban areas for the protection of high value trees. The first prevents or greatly lessens feeding by bark beetles through the use of insecticides; the second reduces the bark beetle population by destroying elm material used as breeding sites by the beetles, that is, by sanitation. There has been some difference of opinion as to the relative effectiveness of the two methods but for best control, both should be used as one complements the other. Although the most carefully devised and executed program will not eradicate the disease, losses can be kept within reasonable limits.

Recent studies on insecticides, chemotherapeutants, and resistant varieties have made some progress in the search for better control measures. There is hope, therefore, that, in the foreseeable future, methods will be available for general use that will greatly reduce the rate of infection of healthy elms or "cure" diseased ones.—A. G. Davidson.

HISTORY AND DISTRIBUTION

The Dutch elm disease was first observed in the Netherlands and northern France in 1919 (66). The origin, date, and mode of introduction of the causal fungus were not determined but circumstantial evidence indicated Asiatic origin. The disease rapidly invaded most European countries and spread into central Asia (64).

The first cases of the disease in North America were discovered and identified in Ohio during 1930 and in northern New Jersey in 1932 (15), the causal fungus having been introduced in elm burl logs imported for the manufacture of veneer (6). By 1961, the disease occurred over some 600,000 square miles in the United States, a large part of the elm range north of Maryland and east of Montana, Wyoming, and Oklahoma (39).

In Canada, the first infected trees were found in St. Ours, Richelieu County, Quebec, during August 1944 (59). When the distribution of the disease in Quebec became known in 1945, it was apparent that the port of Sorel was the centre of the infection and subsequent analysis of early distribution records indicated that infectious material probably was introduced in that area before 1940 (58). Since the Quebec outbreak was separated from the known northern limits of the disease in the United States by more than 200 miles, it is reasonable to think that the pathogen was introduced by ship, probably from Europe, on crates made of diseased elm wood. These would have evaded quarantine regulations designed to prohibit the entry into Canada of elm and elm products from Europe and the United States that were placed in effect in 1928 and 1934, respectively. By 1959, the disease was prevalent in 55 Quebec counties and covered an area of about 24,800 square miles. Between 1954 and 1959 the disease spread at the rate of 1,200 square miles per year and caused the death of 600,000 to 700,000 elms (58). In 1962, infected trees were found in Temiscouata and Bonaventure counties along the New Brunswick border and removed from the main Quebec outbreak (51). This apparently represented a spread of the disease from New Brunswick. By 1963, the disease occurred over 46,000 square miles or 80% of the range of elm in Quebec (Fig. 1), the non-infected area including districts where elms are scarce and scattered.

The first infected tree in Ontario was found at St. Isidore, Prescott County, in 1946. This was a predictable extension of the Quebec outbreak. In 1950, the disease reached the Niagara Peninsula and Windsor from the United States. The disease now occurs in 46 counties south of a line between the northern part of Georgian Bay and Mattawa on the Ottawa River (18), an area of approximately 64,000 square miles (Fig. 1). During its 17-year history in Ontario, the disease has spread at the rate of 3,700 square miles per year—three times faster than in Quebec. This rapid rate of spread is attributed to the fact that the disease entered Ontario at three points in areas of high elm populations.

The first diseased tree in New Brunswick was found in November 1957 at Woodstock on the St. John River (4), the causal fungus apparently having been introduced from Maine. By 1963, diseased trees had been found in 9 of the 15 counties in New Brunswick (45) and the outbreak occurred in river valleys of the western half of the Province (Fig. 1). This represents a spread of about 2,200 square miles per year, probably from a number of points along the Maine border.

The most important single factor affecting the progress of the disease appears to be the concentration of elm trees (58), and future spread is expected to occur mainly in areas of high elm concentrations. If the disease reaches other areas, it is unlikely to cause important damage because elm trees are scattered and the vectors are absent or occur in low numbers. Consequently, further spread in Quebec will be slow and restricted and according to Dance and Lynn (19), extensions of the disease in Ontario are likely to be confined to river valleys and to a narrow band bordering the northern shores of Lake Huron and Lake Superior. However, it is expected that the disease will spread to river valleys throughout much of New Brunswick and reach the other Maritime Provinces within the next few years.

Although naturally-occurring elm has a restricted distribution along lakes and in river valleys in Manitoba and Saskatchewan, elm is an important shade tree and has been planted in concentration in urban areas. Because of the sporadic distribution of elm throughout northern Ontario, Dance and Lynn (19) consider it unlikely that the disease will reach the western provinces by natural spread through Ontario. In the United States the disease occurs in the Minneapolis-St. Paul area of Minnesota approximately 250 miles from the Manitoba border (48). Elms occur in several river valleys between St. Paul and Winnipeg but the relative sparseness of these elms will undoubtedly hinder natural spread to Manitoba. As suggested by Hafstad (37), long distance spread of the fungus is possible by infected beetles transported on motor vehicles. Surveys to determine the presence or absence of the disease are being maintained in Manitoba and Saskatchewan by the Canada Department of Forestry and the Plant Protection Division, Canada Department of Agriculture.—R. Pomerleau.

SYMPTOMS AND DIAGNOSIS

External symptoms usually are evident by late June, but may appear later if the season has been retarded (Fig. 2). They become most pronounced in July and August, and usually are more acute in young, succulent, vigorously growing trees than in slow-growing or senile specimens (69). Initially there is sudden wilting of the leaves on one or more limbs in the upper crown. These leaves turn dull green, dry out, and fall, or they turn brown, curl, shrivel, become brittle and remain attached to twigs for many weeks. When the tree is dormant, tufts of such leaves are symptomatic of the disease (69). From midsummer onward symptoms consist mainly of the development of yellowish leaves in one part of the crown or on occasional twigs. This has been termed "flagging" (75). Following the development of foliar symptoms affected branches die and the condition extends to all other branches until the tree dies.

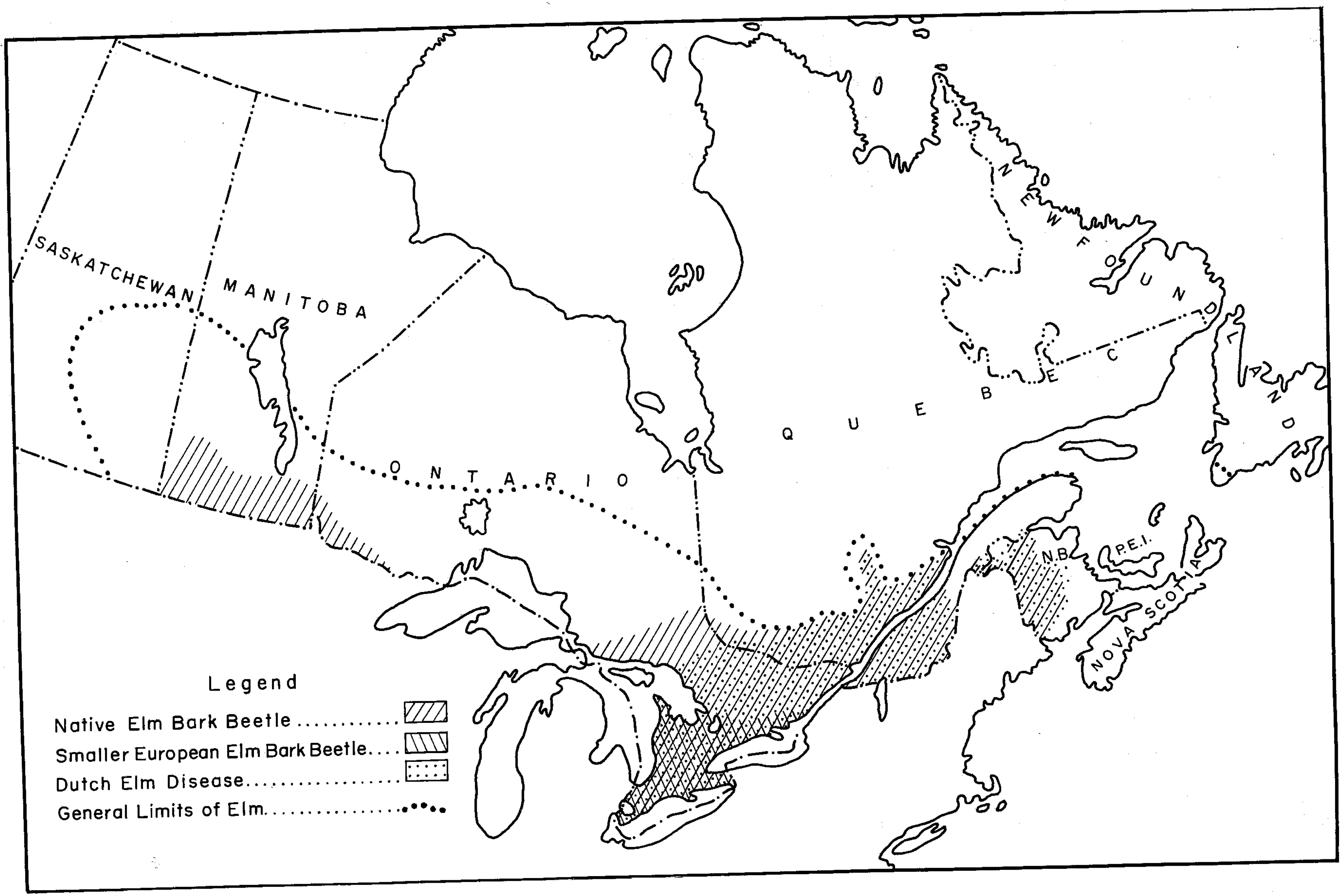

Fig. 1. The known distribution of the Dutch elm disease and vectors in Canada, 1963.

Fig. 2. Diseased elm tree.

Wide variation occurs in the time required for the disease to kill individual trees. Small trees may die in a single season but in large trees the disease usually progresses more slowly and such trees may survive for a number of years (12). In the latter, the foliage is likely to be thin with undersized and yellowish leaves. At times, however, even large trees may be killed rapidly.

The internal symptoms of the disease occur in the outer sapwood (Fig. 3) as long, discontinuous, brown streaks visible in longitudinal sections of infected branches and stems. In transverse sections the discoloration appears as dark spots, or a partial to complete ring. This staining results from the development of a dark, gummy substance (69), including spores (52), deposited in the large vessels formed in the spring.

A few instances have been recorded where recovery was indicated by the disappearance of external symptoms. These cases have been attributed to the ability of certain trees to seal-off infections under layers of more resistant summer wood (69). However, these trees remain susceptible to reinfection.

Because there are two less virulent fungous diseases with similar symptoms, Verticillium wilt caused by *Verticillium albo-atrum* Reinke and Berth. and Dothiorella or "Cephalosporium" wilt, (sometimes called dieback) caused by *Dothiorella ulmi* Verrall & May, Dutch elm disease cannot be safely diagnosed from symptoms alone. Therefore, accurate diagnosis of the disease requires laboratory examination to identify the causal fungus.

If an owner suspects that one or more of his elm trees have Dutch elm disease, samples should be collected and submitted for diagnosis. Take samples from elm branches that have wilted leaves and the discoloration in the outer sapwood described previously. Several samples from ½ to 1 inch in diameter and from 6 to 7 inches long should be taken, preferably from more than one branch. Wrap the samples in waxed paper to prevent drying and send them to the laboratory with as little delay as possible. In the Maritime Provinces send samples to the Forest Entomology and Pathology Laboratory, College Hill, Fredericton, N.B.; in Quebec to the Forest Research Laboratory, Box 35, Sillery (Quebec); in Ontario to the Laboratory of Forest Pathology, Southern Research Station, Maple; in Manitoba to the Forest Entomology Laboratory, Box 6300, Winnipeg 1; and in Saskatchewan to the Forest Pathology Laboratory, University Sub-Post Office, Saskatoon.—B. W. Dance.

VECTORS OF THE DISEASE

Two bark beetles, the native elm bark beetle, *Hylurgopinus rufipes* (Eichh.), and the smaller European elm bark beetle, *Scolytus multistriatus* (Marsh.), are the primary vectors of the Dutch elm disease. Two weevils, *Magdalis armicollis* (Say) and *M. barbita* (Say) are capable of transmitting the disease (62), but neither species is considered an important vector (34). The Forest Insect and Disease Survey has conducted intensive surveys to determine the distribution of the bark beetle vectors in Canada and the results of these operations are shown in Fig. 1.

Until recently it was assumed that the native elm bark beetle occurred throughout the range of white elm. However, it is now known that, although the beetle occurs from western Manitoba to central New Brunswick, there are extensive areas along the eastern, northern, and western limits of the host tree where this insect has never been recorded. This may be due largely to the rather low incidence of elm in these regions.

The European elm bark beetle was first reported in the United States at Boston in 1909 (14), and in Canada near Windsor in 1948 (71). The spread of this beetle in Ontario has been recorded annually by the Survey (72), and a study of these records has provided information on the direction and rate of dispersion. The beetle has never been recorded outside of Ontario and at present its distribution is limited to approximately 22,000 square miles in the southern part of that Province. Over the past 15 years, the European beetle has spread about 20 miles per year to the north and east across southern Ontario. This is equivalent to its westward spread in the United States from Massachusetts to Minnesota (approximately 1200 miles) in 54 years. In contrast, the beetle has failed to move any appreciable distance northward in some areas. Along the north shore of Lake Ontario, the northern limit of distribution has remained virtually static since 1959. The same may apply in the New England States, for it is 27 years since the beetle was reported in southeastern New Hampshire, only 160 miles from the Quebec border (16). Dispersal northward is probably regulated to some extent by low winter temperatures, as demonstrated for another introduced pest in Ontario, the European pine shoot moth, *Rhyacionia buoliana* (Schiff.) (35). Nevertheless, the distribution of the European elm bark beetle will be kept under close surveil-

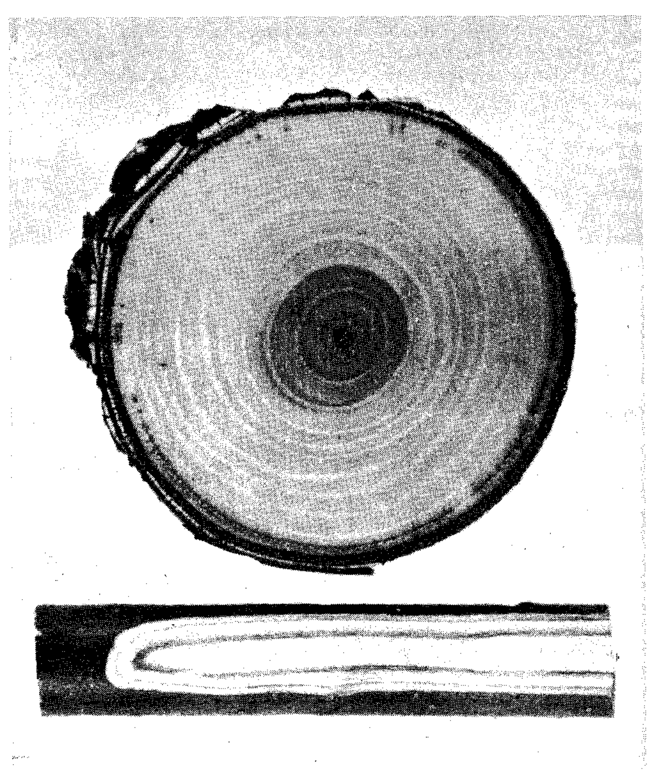

Fig. 3. Diseased elm branch in cross and longitudinal sections, showing the brown ring and streaks.

lance particularly in the west where both the disease and the vector are known to occur in Minnesota about 250 miles to the south of the Manitoba boundary (48).

The bark beetle vectors may be distinguished by the general appearance of the adults and by the pattern of feeding damage on the inner bark and outer surface of wood. The adults of both the native and European species are about ⅛ inch long and range in color from brown to black (Figs. 4 and 5). The European species can be identified by its shiny surface, the concavity on the posterior ventral side of the abdomen, and the blunt spur extending back from the centre of the second ventral segment. Egg galleries of the European species are cut along a single line parallel to the grain of the wood (Fig. 6), whereas the native species cuts two diverging egg galleries forming a broad "V" across the grain of the wood (Fig. 7). The larvae of each species feed in galleries constructed at right angles to the egg gallery: the European species feeding across the grain and the native species feeding parallel to the grain of the wood. Larvae of both species are similar in appearance being white, wrinkled, legless grubs with brown heads.

Both of the vectors pass through one and a partial second generation a year in Canada but there are significant differences in the seasonal activity and occurrence of the various stages (31). The main population of *H. rufipes* overwinters in the adult stage and emerges in early May to feed and construct brood galleries. They breed and oviposit in May, June, and July. This gives rise to a new generation of adults which emerge in late summer and fall and feed in the bark of branches and stems of healthy trees until late fall. They overwinter in special hibernation tunnels. A very small proportion of the population of fall adults constructs brood galleries and oviposit to give rise to overwintering larvae which do not emerge as adults until the following June. *S. multistriatus* overwinters in the larval stage and the adult beetles emerge in June or July feeding in the bark of small branches and twigs. Most of the progeny of these adults emerge in August and September although some do not complete development and remain as larvae which form the bulk of the overwintering population. Only a few of the adults which emerge in late summer are able to breed, oviposit, and give rise to overwintering larvae. The remainder simply feed and die with the approach of cold weather without establishing a brood.

In Canada, the disease has spread and caused extensive losses in Quebec, New Brunswick, and parts of Ontario in the presence of only *H. rufipes*. Adults of this beetle are active nearly one month earlier than those of *S. multistriatus*. As will be shown in the following section, this is important from a pathological point of view since inoculations causing extensive infections of healthy trees occur almost completely in the spring and early summer. When both species are present, *S. multistriatus* is considerably more aggressive than *H. rufipes*, invades available breeding material more readily, and limits the *H. rufipes* population to relatively small numbers. For this reason, as well as the fact that it feeds in parts of the tree with thinner bark, *S. multistriatus* is generally accepted in the United States as the most important vector of *C. ulmi*. —R. J. Finnegan and W. L. Sippell.

MECHANISM OF PATHOGENESIS

The most frequent means of inoculation of *Ceratocystis ulmi* into healthy trees is by the feeding of adult elm bark beetles. Feeding wounds must reach the xylem for inoculation to be successful but other factors are involved. Studies by Al-Azawi and Norris (2) indicate that feeding wounds of *Scolytus multistriatus* 3 mm. or longer are required for transmission of the fungus and infection of the tree through terminal twigs. Ouellette (53) observed that feeding wounds of this insect in twig crotches were less efficient infection courts than those extending to the sides of crotches and those made on the sides of branches. High relative humidity at wounds made by *S. multistriatus* was found by Kais, Smalley, and Riker (42) to be a prerequisite to pentration by the fungus.

The pathogen may also pass from diseased to healthy trees by means of root grafts (70). Himelick and Neely (38) have pointed out the importance of this mechanism of transmission in city-planted elm trees.

The fungus invades all types of xylem cells. It grows from cell to cell through pits and directly through cell walls. In the vessels it spreads by means of spores which are distributed by the sap stream to other parts of the tree (5). Microspores formed by the pathogen in culture (55) and observed in infected elms (52) may explain the rapidity with which the fungus is distributed. The rate and extent of spore distribution within the tree and of subsequent disease development are dependent on a number of factors, some of which are related, including: the amount of inoculum, season of inoculation, length of vessels into which the fungus is introduced, moisture conditions in the soil, and soil and air temperatures (5, 42). Extensive infection of living elms, however, depends upon the spores entering the long, functioning conductive vessels of the spring and early-summer wood. During the spring and early summer these vessels are close to the surface of the wood and the spores may be introduced by adult beetles feeding at this time. The vascular system produced after midsummer consists of much shorter and relatively compressed conducting vessels at the wood surface that restrict spore movement. Inoculation at this time usually results in a very localized and temporary infection (12, 56).

Kerling (43) observed that the first alteration in infected tissue is the coloration of vessel walls, followed by changes in the appearance of the contents of living cells which become darker, exudation of gum droplets through pits from parenchyma and ray cells, and the formation of tyloses in non-discolored parts of vessels. These tyloses later disintegrate (66). Histochemical tests performed by the author show that the changes in the appearance of living cells are due to the formation and oxidation of polyphenols. As the disease progresses, these phenolic compounds are extruded through pits into vessels and other xylem elements and are even deposited in tyloses when these have not disintegrated.

Most workers before the mid-forties attributed the rapid wilting and dying of infected elm trees to the plugging of the water-conducting vessels by gums, tyloses, fungus growth, or degradation products of parenchyma cells (10, 15, 60, 74).

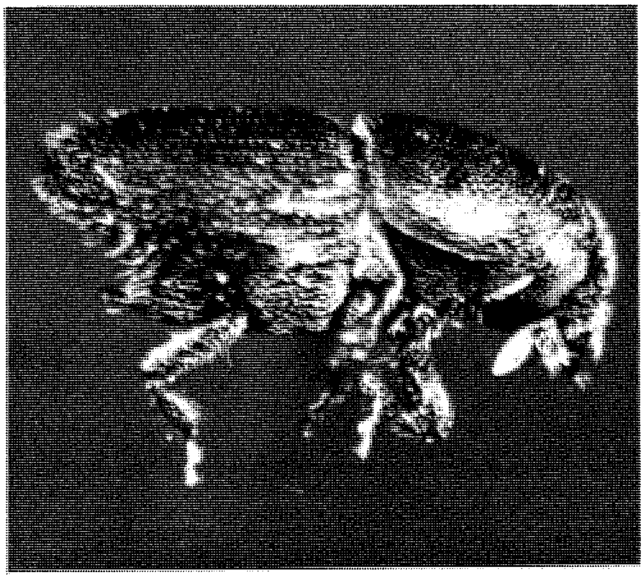

Fig. 4. Adult of the smaller European elm bark beetle. (X24)

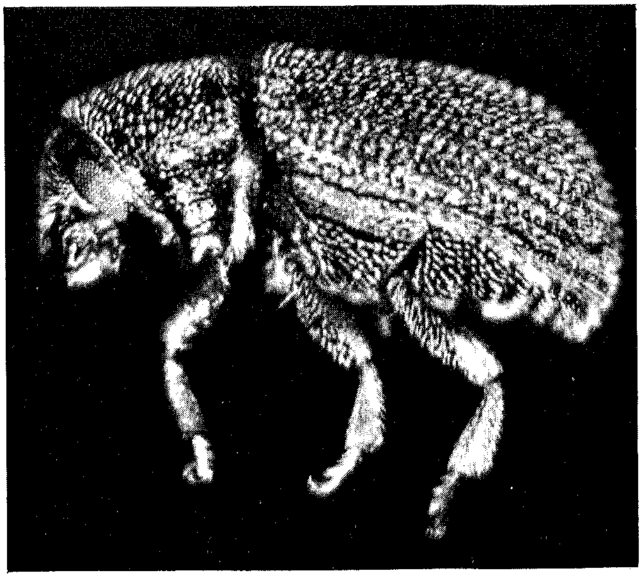

Fig. 5. Adult of the native elm bark beetle. (X24)

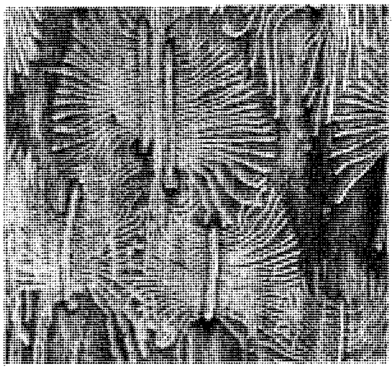

Fig. 6. Galleries of the smaller European elm bark beetle on the outer wood surface of elm. About natural size.

In the late forties, a trend developed towards a toxin theory of disease causation. Much evidence in support of this theory is derived from the injection into healthy plants of cell-free filtrates of pathogen cultures. Brookhuizen (10) produced tyloses and Zentmeyer (76) a wilting of test plants, discoloration of cell walls, and formation of gum in vessels following injection with culture filtrates. Dimond (22) separated two fractions in the toxic filtrate; one caused the upcurling and marginal withering of the leaves, and the other caused severe interveinal necrosis when injected into elms. The work of Feldman *et al* (29) showed that the first of these fractions is of minor importance in the toxin complex, that the heat stability of the toxin is only partial (suggesting the presence of active enzymes in the toxin complex), and that the filtrate is almost completely inactive at pH 6.0 and above. Tests conducted by the author have shown that xylem discoloration may be obtained by injection of water adjusted to pH 5.4 and below. Consequently, the toxicity of culture filtrates, being active below pH 6.0, could be an effect of the low pH.

All evidence for the toxin theory of pathogenesis of the Dutch elm disease is based on the toxicity of culture filtrates, but no one has demonstrated that the toxic substances produced by the fungus in culture are also produced and active in diseased elm trees. However, if translocated, polyphenols liberated in diseased elms under the action of the fungus could conceivably produce toxic effects in distant cells, for example, in leaves.

In the early fifties, attention was drawn to the role of enzymes in the wilt diseases. The theory proposed by Ludwig (44) is a modification of the plugging theory in that it explains the origin of the gums from alteration of cell wall constituents, expecially of pectins, through the action of hydrolytic enzymes. Although enzymes of this type have been demonstrated in culture filtrates of *C. ulmi* (9, 23, 40), Dimond and Husain (23) concluded that their main function was the digestion of cell wall constituents to provide food for the fungus. However, alteration of cell walls may affect the flow of materials into the vessels from parenchyma and ray cells and contribute to their plugging.

Dimond (20) discussed the role of other enzymes in the formation of brown substances in wilt diseases. He postulated that these liberate and oxidize polyphenols which are condensed to produce pigmented, melanin-like compounds. There is a possibility that some of the polyphenols are liberated from lignin in the cell walls, as indicated by histochemical tests conducted by the author.

Recently, Ouellette (53, 54) suggested that acute symptoms of the disease are due to the complete plugging of the vessels of small branches by spores and mycelium of the pathogen, alone or in combination with cytoplasm and residues from adjoining cells. He stated also that gradual and partial plugging of vessels in stems and larger branches and disintegration of cell walls contribute to chronic symptoms of the disease.

In summary, the causal fungus of Dutch elm disease is well adapted for rapid spread in elm. Large numbers of microspores can attack many living cells of the xylem at many points along the vessels. This multisite infection of living cells, which results in the production of polyphenols and death of the cells, is of prime importance when considering the fact that living cells are probably necessary for the active transport of sap, as shown by recent workers (36, 61). In a more advanced stage of disease, enzymatic action of the fungus on cell walls would allow the contents of recently dead parenchyma and ray cells to leak into the vessels. These materials, which have become "gummy" may contribute to vessel plugging along with fungous spores and hyphae, or may be translocated and act as toxins in distant parts such as leaves. Further studies are in progress to determine the exact role of these substances in pathogenesis.—C. Gagnon.

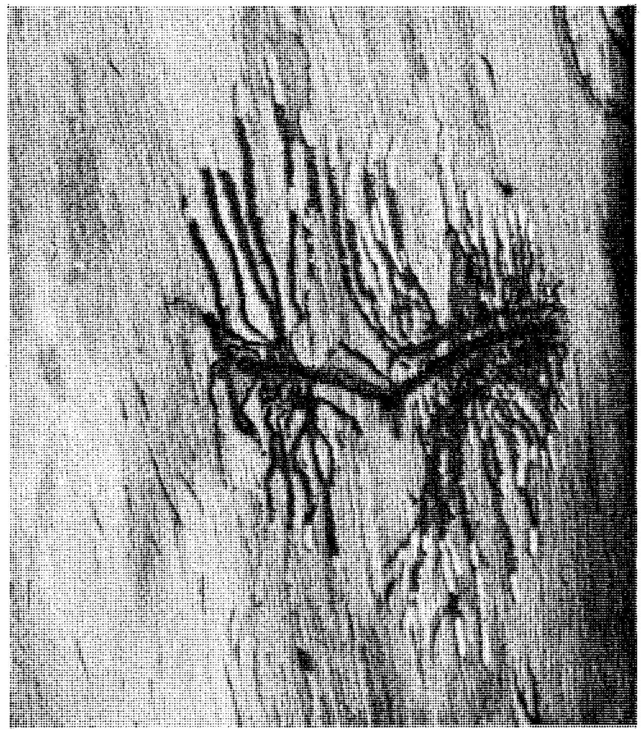

Fig. 7. Galleries of the native elm bark beetle on the outer wood surface of elm. About natural size.

METHODS OF CONTROL

Quarantine Regulations.—When it became known that the Dutch elm disease occurred in several European countries, a regulation (No. 17 Foreign) under the Destructive Insect and Pest Act was passed, effective April 12, 1928, prohibiting the importation of elm and elm products from Europe. This regulation was amended May 9, 1934, extending the prohibition to all countries, and is still in effect.

A regulation (No. 12 Domestic), in accordance with the provisions of the Destructive Insect and Pest Act, effective April 24, 1945, was drawn up restricting the movement of elm and elm products to disease-free areas from certain counties in the Province of Quebec where the disease had been found. This regulation was designed to prevent long-distance spread of infected elm material as well as the insect vectors.

Amendments were made to Regulation No. 12 (Domestic) in 1947, 1949, and 1955 as elms in additional territory in Quebec and Ontario were found to be infected. The present quarantine embraces the entire Province of Quebec and all of the Province of Ontario except the districts of Thunder Bay, Rainy River, Kenora, Patricia, Cochrane, and Algoma. This regulation is now being revised because of recent changes in the distribution of the disease.—L. L. Reed, Plant Protection Division, Canada Dept. of Agriculture, Ottawa.

Sanitation.—Sanitation for the control of Dutch elm disease was recommended as early as 1936 in the United States when it was observed that the incidence of the disease was reduced by the rapid removal of infected trees around New York City (16). By 1940, research and experience had shown that other dead and dying elm material used as breeding sites by the bark beetles is also of importance in the spread of the disease (17). Since then, the prompt destruction (at least before the beetles emerge early in May) of diseased trees, all recently dead elm wood with the bark present, and dying trees and branches in the vicinity of healthy trees has been recommended in the United States and Canada. Several methods of destroying this material are currently in use: burning; debarking and burning or burying the bark in soil to a depth of 1 ft. or more; burying; or spraying the material with a 1% DDT solution (12, 73). To prevent the spread of the disease through root grafts, Himelick and Neely (38) suggest that a trench $3\frac{1}{2}$ ft. deep be cut in the soil between noninfected and diseased trees within 40 ft. of one another immediately after discovery of the diseased tree and before its removal. In addition to the above procedures, the use of measures that help to maintain tree vigour, such as fertilizing, watering, and the control of other insects and diseases, are also recommended because elms in good condition are less attractive to bark beetles (73).—R. Pomerleau.

Protection of Healthy Trees by Chemical Insecticides.—There are two approaches to the protection of healthy trees from bark beetles and consequent infection by the fungus. The first, the conventional method, is to apply a stomach-contact insecticide to the trees to kill attacking beetles, and the second, which has attracted attention in recent years because of the undesirable toxicity of conventional insecticides to other forms of animal life, is to place a systemic insecticide into the tree to be carried in the sap stream to all parts and kill the insects before their feeding niches have reached a sufficient size to constitute infection courts.

DDT is the most commonly used conventional insecticide. If applied when the tree is dormant, it will remain effective throughout the spring and early summer when trees are most susceptible to infection. DDT may be applied either as a 2% emulsion by hydraulic sprayer or as a 12% emulsion with a mist blower (12). A high volume of spray is necessary with a hydraulic sprayer and this leads to excessive run-off and contamination of public and private properties. The effect of run-off is minimized by the use of the mist blower since a smaller volume of spray is used.

However, even if applied by mist blower, DDT is toxic to many forms of animal life, especially birds. This has been particularly true in the case of robins in areas where DDT has been used for several years (41). DDT contaminates the food of earthworms which are a staple diet of robins. Because of the additive residual toxicity of DDT, a great many chemicals including dieldrin, heptachlor, chlordane, toxaphene, lindane, methoxychlor, thiodan, zectran, malathion, and parathion (11, 26, 27, 46) have been tested in a search for a safer insecticide. Of these only two show promise. Methoxychlor, which has only 1/25 the toxicity of DDT to birds and is less persistent than DDT, provides almost as good protection as DDT and is now recommended for use in areas of high bird hazard. Lindane shows considerable effectiveness and warrants further investigation.

A number of systemic insecticides including demeton, phorate, dimefox, di-syston, phosphamidon, dimethoate, tetram, and bidrin (1, 2, 3, 49) have been tried but only two, tetram and bidrin, were effective in restricting beetle feeding. Tetram is unfortunately so toxic to mammals that it cannot be used safely, which leaves bidrin as the most promising systemic to date. It, however, has not been adequately tested. Many new systemics are in the experimental stage of development and may prove to be satisfactory. Because this class of chemicals is toxic to both plants and animals, their effects must be thoroughly investigated and safe dosages defined before any can be recommended for use.—J. J. Fettes.

Chemotherapy.—Chemotherapy has been defined as the control of a plant disease by compounds that, through their effect on the host or the pathogen, reduce or nullify the effect of the pathogen after it has entered the plant (21). Many promising compounds have appeared in recent years but the striking feature of the work on chemotherapy is that, to date, no successful therapeutant is available for general use in the control of Dutch elm disease. A number of chemicals have been tested experimentally, but for one reason or another, they have failed to fulfill their early promise. However, in spite of these failures, the potential value of such treatments is so great that new groups of chemicals are continually being studied, and new techniques employed in the hope that the basic problems will eventually be overcome.

The chemicals currently under intensive investigation for the Dutch elm disease employ the principle of indirect action. Here a chemical is applied to, or injected into, a healthy tree to change its physiological and anatomical state in such a way that it is immune or resistant to penetration of the causal organism, or failing this, to prevent the development of extensive damage after the causal organism has become established.

One group of chemicals being studied is the growth regulators and a number of investigators have studied the effect of some of these on the control of the disease. Beckman (8) obtained a reduction in symptom incidence in nursery elms implanted with dry sodium-4, 5-dimethyl-2-thiazolylmercaptoacetate prior to inoculation with the causal fungus. Disease inhibition was correlated with the prevention of normal sapwood development, for when trees treated with the chemical were re-inoculated after normal sapwood development had resumed (that is, when the effect of the chemical had worn off), the trees became infected.

Subsequently, Beckman (7) working with 2, 3, 5, 6-tetrachlorobenzoic acid, a chemical which penetrates the bark and is mobile in the host, obtained a significant decrease in the incidence of disease in trees treated prior to inoculation. However, the therapeutic level of the chemical was about the level at which it caused damage to the host trees.

Smalley (68) tested salts of 2, 3, 6-trichlorophenylacetic acid (TCPA) applied to large nursery elms in several concentrations and by several methods before inoculation. The results indicated a degree of control with bark applications and a high level of protection following injection. With the appropriate chemical concentration and application time, it was possible to obtain complete protection without phytotoxicity. Smalley's study offered some support to Beckman's (7, 8) suggestion that control results from inhibition of formation of large spring vessels, but also suggested that a second mechanism was involved. Smalley observed that TCPA treatments induced heavy tyloses development in large xylem vessels and felt that such vessel occlusion limited spread of infection and was at least partially responsible for the observed control of the disease. This is implied morphological resistance, but the morphological change believed to be imparting resistance to the host is strikingly similar to one of the morphological changes which occur when an untreated host is affected by the disease.

Edgington (28) obtained fewer systemic infections in young trees injected with various concentrations of aminotrichlorophenylacetic acid (HRS-399). Phytotoxicity occurred at the higher concentrations. Histological studies revealed that HRS-399 induced the elms to form dense, starch-filled summer wood immediately after treatment. This induced summer wood appeared to delimit the fungus, allowing the trees to lay down functional non-infected xylem during the growing season.

At the Maple laboratory, since the spring of 1962, TCPA and HRS-399 have been employed in a program designed to test their efficacy to control Dutch elm disease. The techniques employed have been: (a) injection of the chemical directly into test trees by means of a bottle-siphon system (47), (b) bark sprays, (c) bark paints, and (d) soil injection. The test trees were inoculated before and/or after the various treatments. Trees employed were up to 45 ft. in height under natural conditions, and 2- to 4-ft. high in greenhouse experiments.

While it would be premature to present the results of these experiments at this time, indications are that direct injections of the chemical into host trees, at appropriate concentrations, will prevent establishment of Dutch elm disease. Furthermore, there are indications that if trees in a very early stage of disease development, and at the same time in a very early growth stage (about ½ full leaf), are treated with appropriate concentrations, disease development is arrested.

—J. Reid.

Resistant Varieties.—While the white elm is one of the most susceptible species, several elms are relatively resistant to Dutch elm disease, notably: European strains including the Christine Buisman and the Bea Schwarz elms, and the Asiatic Chinese and Siberian elms. However, these are susceptible to other diseases or storm damage, are not cold hardy, or are of poor form, and cannot be generally recommended as suitable replacements for the white elm in Canada. The most promising approach in this method of control at present appears to be the search for resistant strains of the native elm.

For this purpose, artificial inoculations have been carried out extensively at L'Assomption Experimental Station, P.Q., since 1950 on cuttings from 290 healthy trees occurring in heavily infected areas and on 178,000 seedlings from irradiated and non-irradiated seeds. None of the adult elms and the 32,000 seedlings from untreated seeds collected from 309 elms in 35 countries of Quebec were found to be resistant. This has confirmed the very high susceptibility of the white elm and the absence of resistant strains in nature.

The remaining 146,000 seedlings tested were from seeds treated with X-rays or thermal-neutrons in an attempt to induce artificial mutations promoting disease resistance. Only four of these seedlings were considered promising—two from seed treated with X-rays and two from seed treated with thermal-neutrons. Of the former, one appears to be immune and has not shown disease symptoms after 7 consecutive years of inoculation; the other showed light symptoms in 2 of the 7 years of inoculation. The latter were inoculated during 6 years and showed light symptoms in 1 and 2 years, respectively.

Testing is being continued on cuttings from the "immune" specimen and these have resisted inoculations for 2 years.—C. E. Ouellet, Plant Research Institute, Canada Dept. of Agriculture, Ottawa.

Biological Control.—Although parasites, predators, and diseases of the bark beetle vectors occur in North America (13, 24, 25, 30, 57, 65), information collected to date indicates that they do not occur in sufficient numbers for effective control.

Three species of Hymenoptera have been observed to parasitize from 50 to 89% of bark beetle populations in parts of Europe (32, 33, 63, 67) and at least two of these have been recorded in North America (13, 57). However, the possible transmission of the causal fungus of Dutch elm disease by these parasites lessens their potential in controlling the insect-disease complex and has discouraged extensive study in North America.

In 1930, an endoparasitic nematode was reported as sterilizing 39% of a population of *S. multistriatus* in England (50). This and other nematodes are associated with *S. multistriatus* in the United States (65). Since nematodes are known to reduce populations of similar scolytids significantly, research was initiated by the Institute for Biological Control, Belleville, Ont., to determine the efficacy of parasitic nematodes to reduce bark beetle numbers in Canada. In 1963, hundreds of beetles collected throughout Ontario were dissected and found to be free of pathogenic nematodes. Attempts will be made within the next year to manipulate indigenous nematodes in an effort to have them attack the elm bark beetles. Contacts have also been made with scientists in other countries for the importation of nematodes for use against the beetles. The successful establishment of these natural enemies would reduce bark beetle numbers and provide a self-perpetuating method of control.—W. R. Nickle, Entomology Research Institute for Biological Control, Canada Dept. of Agriculture, Belleville, Ont.

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CANADA
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O. H. M. S.

DOUGLAS C. EIDT,
FOREST ENT. & PATH LAB.,
CANADA DEPT. OF FORESTRY,
COLLEGE HILL, (3-6)
FREDERICTON, N.B. L-205

DEPARTMENT OF FORESTRY
OTTAWA

CANADA

DEPARTMENT OF FORESTRY

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ATLANTIC PROVINCES

The Larch Sawfly in Newfoundland.—Although tamarack, *Larix laricina* (DuRoi) K. Koch, comprises less than 5% of forest composition in Newfoundland, it is the most common softwood next to balsam fir and black spruce. It is concentrated largely in the central and northeastern section of the Province, and elsewhere, stands are usually small and widely scattered. On the Avalon Peninsula, thin soil and windswept conditions have produced stunted, inferior trees. The species has little economic value, being used only occasionally for pulpwood. Although mature stands are rare today Cormack, 1822, (*Cormack's Journey*), referred to the large size of tamarack and about 25 years ago, dead trees up to 10 inches d.b.h. were common in parts of the Northern Peninsula. Such evidence suggests that, as in other parts of eastern Canada, mature stands were destroyed early in the century, probably by the larch sawfly, *Pristiphora erichsonii* (Htg.). Since then, repeated outbreaks of the sawfly and the larch casebearer, *Coleophora laricella* Hbn., have prevented trees from reaching merchantable size in any quantity. Control of the sawfly has been attempted by biological methods. Several colonies of a parasite, *Mesoleius tenthredinis* Morley, were introduced between 1940 and 1947 and in 1958 the shrew, *Sorex cinereus cinereus* (Kerr.), was liberated in western Newfoundland and in 1961 in central Newfoundland.

Recorded observations on sawfly attacks were few until about 1945 when annual reporting of forest insect conditions was initiated by the Newfoundland Forest Protection Association. The first reference to occurrence of the larch sawfly in the Island was by C. G. Hewitt, 1910, (Can. Dept. Agr., Ent. Bull. 5), although J. Fletcher, 1906, (Can. Dept. Agr., Rept. of Entomologist and Botanist), recorded a severe outbreak in Labrador from 1882 to 1885. J. M. Swaine, 1925, (unpublished report), reported severe outbreaks on the Avalon Peninsula. Two major outbreak periods have occurred in the past 30 years—one reported by R. E. Balch, 1942, (unpublished report), started in 1935 and terminated in 1947; the second began in 1953 and still persists, especially in central Newfoundland. Data on the development of the recent outbreak were obtained from ground and aerial surveys of defoliation and cocoon sampling.

The outbreak started in the northeastern section of the Island and in 1953 severe defoliation was recorded in localized areas, mainly in mixed stands. By 1955, it had expanded to include tamarack stands from St. John's to Grand Falls and parts of the Northern Peninsula. In 1956 and 1957, sawfly numbers declined in eastern and central Newfoundland, but severe attacks developed in the southwestern region near St. George's and Corner Brook. All of these infestations terminated in 1960 and 1961. From 1959 to 1961, new outbreaks developed in central Newfoundland in the Notre Dame Bay region from Springdale to the Baie Verte Peninsula, and in the Red Indian Lake Basin. Some of these terminated in 1961, particularly those between Hall's Bay and Badger, but others continued and in 1963 caused the most severe and extensive damage recorded in any year. In 1963, severe defoliation was also reported in tamarack stands north and east of Gander and at one location on the Avalon Peninsula. Based on the history of past outbreaks, the present outbreaks will likely persist in the Province for at least another 3 years.

A striking feature of infestations has been the extreme irregularity in their development, spread, and severity. Not all stands in a region were attacked at the same time and in some cases in almost adjacent stands defoliation varied from nil to nearly 100%. Defoliation was highly variable between trees in the same stand. Outbreaks in a region were often preceded by moderate to severe injury to scattered trees often in mixed stands. After the collapse of the main outbreak, small localized pockets of defoliation often persisted for a year or two. Infestations in an area generally lasted from 2 to 5 years. In slow-growing stands, such as those that occur on the Avalon and Northern peninsulas, severe injury rarely continued more than 3 years, but lasted up to 5 years in the more vigorous central and western stands. Despite the severity of attacks tree mortality has been surprisingly light, occurring mainly in some of the more exposed stands of the Avalon Peninsula where from 10 to 25% of the trees have been killed and up to 75% of the remainder have dead tops and branch tips. Elsewhere mortality has been recorded only occasionally in mixed stands and twig mortality has rarely exceeded 25% even in severely defoliated stands.

Large numbers of sawfly larvae and cocoons have been collected annually and reared by the Forest Insect Survey. Because collections are processed on a regional basis, representing a wide range in outbreak intensity, and because of the heavy losses of material in rearing due to unknown causes, the data are not adequate to effectively interpret the role of parasites in sawfly control. However, they do provide some understanding of the parasite complex and relative abundance of the various species. Only three parasites have been reared—two native species, *Bessa harveyi* Tnsd., and *Eclytus ornatus* Holmgren., and the now widely distributed introduced species, *M. tenthredinis*. Parasitism has ranged from less than 10% to over 50% during the last 10 years, averaging about 20%. *B. harveyi* is the most common species, accounting for almost two thirds of the parasites reared, and *M. tenthredinis*, about one third. *E. ornatus* occurs each year but in very small numbers. Limited investigations of the immunity of sawfly larvae from Newfoundland to *M. tenthredinis* have been conducted by J. A. Muldrew of the Winnipeg laboratory and results indicate that the incidence of encapsulated eggs in the host is relatively low.

Although rearing mortality has been high, there is no record of diseased larvae occurring in significant numbers. Most rearing problems are evidently related to environmental requirements of larvae and cocoons. Large numbers of dead larvae, presumably from starvation, were recorded in the Hall's Bay infestation in 1960 following complete defoliation of the trees early in the season. The introduced shrew is still too localized to be an effective factor in sawfly control. However, it is established in large numbers in three areas and promises to be the most valuable predator in the sawfly control complex. Cocoon mortality by other predators is a minor factor in control.—W. J. Carroll.

QUEBEC

History of Spruce Budworm Outbreaks in Southeastern Quebec and Northern Maine.—Recently, methods of verifying the occurrence of past spruce budworm outbreaks through radial-growth studies of host and non-host trees have been perfected and it was decided to apply these methods to confirm the history of spruce budworm outbreaks recorded by earlier workers for southeastern Quebec and northern Maine. These investigations were not meant to be exhaustive but rather to definitely establish the number and time of occurrence of past outbreaks.

Evidence for the past outbreaks was based on the characteristic growth-suppression pattern induced during years of severe defoliation by the spruce budworm. Radial-growth data were obtained from discs cut at the butt end of logs of red spruce, *Picea rubens* Sarg.; white spruce, *Picea glauca* (Moench) Voss; white pine, *Pinus strobus* L.; and red pine, *Pinus resinosa* Ait. Data from the spruces served to date the occurrence of old outbreaks, while the pines being non-budworm hosts served as controls. Radial-growth measurements were made and analysed according to the techniques described by Blais (Forestry Chron. 38: 474-484. 1962).

Log piles were examined in 15 different mill yards in the Eastern Townships of Quebec to locate specimens cut from very old trees. When desirable specimens were found, the source of the logs was determined through the mill operators. The logs from which samples were obtained came from six localities in northern Maine and from one locality in Quebec (Table 1).

Most of the trees sampled were over 200 years old, making it possible to determine the history of spruce budworm outbreaks for the past two centuries. The spruce from the localities sampled showed four periods of typical radial-growth suppression caused by spruce budworm outbreaks. Since radial-

TABLE 1

Number of logs sampled by locality and by tree species

Locality	Red spruce	White spruce	White pine	Red pine
Moosehead Lake, Maine			12	
Ross Lake, Maine	9		5	
Millinocket Lake, Maine			3	5
St. Martin, Maine		5	3	
Jackman, Maine	7			
Megantic Lake, Quebec	7	4		
Azicoss Lake, Maine	4			
TOTAL	27	9	23	5

growth suppression caused by spruce budworm defoliation starts 2 to 4 years after initial attack (Blais, J. R., Forestry Chron. 34: 39-47, 1958), these outbreaks began about 1760, 1802, 1877, and 1911 (Fig. 1). The four periods of suppression were quite evident in the logs from Megantic, while suppression was somewhat less pronounced for some of the periods in the other localities. Although the trees in all the localities were not affected equally during the four outbreaks, it is apparent that all four occurred throughout the region. Growth in the pines was not suppressed during these four periods.

The present findings confirm the occurrence of all previously recorded outbreaks in eastern North America. This is especially important in the case of the 1760 outbreak for which former evidence was questionable. The only record of this outbreak was based on evidence of a radial-growth suppression pattern starting about 1770 and upon the discovery of overgrown terminal shoots of that date in both stems of an old forked red spruce tree from the Renous River watershed in New Brunswick (B. W. Fleiger, Canadian International Paper Co., Sun Life Bldg., Montreal, Canada. Personal Communication, February 28, 1963). The 1911 outbreak being fairly recent is well known and has been described by Swaine and Craighead (Can. Dept. Agr. Tech. Bull. 37 (N.S.), 1924). These authors also reported the occurrence of the 1802 and 1877 infestations but were unable to furnish much information on them. The pronounced and prolonged radial-growth suppression caused at the time of the 1802 outbreak indicates that this was the most severe. However, the degree and duration of the radial-growth suppression in the various localities indicates that some tree mortality occurred during each of the four outbreaks.—J. R. Blais.

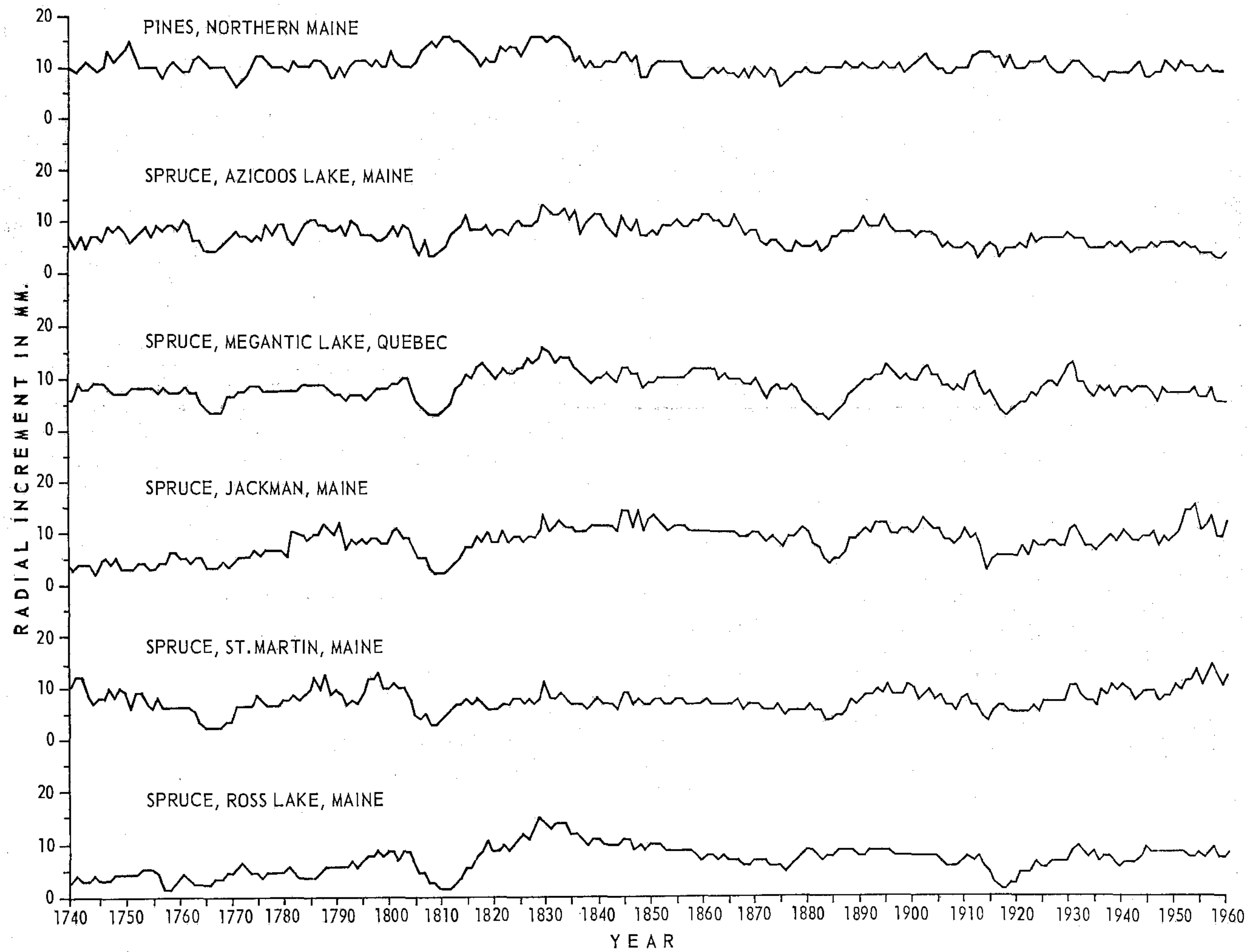

FIGURE 1. Average yearly radial growth at stump height from 1740 to 1960 for pine and spruce trees at various locations in northern Maine and southeastern Quebec.

ONTARIO

Small Scale Trial With a Systemic Insecticide Against Pissodes strobi Peck and Eucosma gloriola Heinr.—All species of pines commonly grown in Ontario are subject to attack by the white pine weevil, *Pissodes strobi* Peck, and the white pine shoot borer, *Eucosma gloriola* Heinr. These pests are of particular importance on Christmas trees where weevil attack in the leaders can effectively girdle the stem, destroying at least two years' terminal growth and causing stem deformity. Shoot borer attack kills six or more inches of the branch tips, spoiling the symmetry of the tree that can be restored only by intensified pruning.

Weevil injury may be prevented by chemical insecticide sprays applied in the spring prior to oviposition by the overwintered adults, but no satisfactory control of the borer has been devised other than the removal and destruction of infested shoots as soon as damage occurs and before the larvae drop to the ground. Because the commonly used contact and stomach insecticides give little control of both species once the larvae have hatched and become protected under the bark, it has been speculated that a systemic insecticide might be utilized to kill developing larvae within infested trees before irreparable damage has occurred. To be economically feasible on a plantation basis, however, the material would have to be absorbed and translocated to the cambial region of the growing tips from a foliar application rather than from an injection into the trunk or soil.

In 1963, six plots each containing 15 white pine trees were selected in a plantation in York County. The trees had been planted in 1949, with some restocking in 1956. They averaged 8½ ft. in height and supported fairly heavy populations of *P. strobi* and *E. gloriola* in 1962. Hibernating weevils began to emerge from the duff in late April 1963 and oviposition commenced before the end of the month. A few adults were observed feeding and mating on May 13. Moths of *E. gloriola* were also observed in flight on this date.

Phosphamidon, a contact and systemic insecticide that has been used effectively against various sucking, mining, and defoliating insects of both broad-leaved trees and evergreens was applied as a fine spray to all foliage on May 24. The concentrate[1] was diluted 1:400 by volume with water and applied by hand sprayer at the rate of 1.25 gal. per test plot. With a 6 x 6 ft. spacing of trees, this was equivalent to 2 pt. of concentrate (1.2 lb. active ingredient) per acre, the highest concentrate recommended on the manufacturer's label for use on forest areas and shade trees.

The trees were examined on July 17. Leaders successfully attacked by the weevil were obvious but shoots infested with the borer could not be identified with certainty on that date. A second survey was made on August 14 at which time the tunnelled tips had turned brown. Wilted terminals with apparently normal foliage were removed and dissected for evidence of unsuccessful attack.

The level of both insects throughout the plantation decreased in 1963, a trend which appeared also in adjacent areas. Within the test area, however, the infestation in the sprayed rows was not sufficiently reduced from that in the check rows to indicate that the insecticide provided any effective measure of control. Indeed, even the proportion of weevil attacks that were unsuccessful in killing the leaders was equal in the treated and untreated plots, as shown in the following synopsis:

Plot number	Average height (ft.)	Number of trees infested by *P. strobi*			Number of shoots infested by *E. gloriola*	
		1962	1963		1962	1963
			Successful	Unsuccessful		
1	9	9	5	1	45	40
2	9	11	4	1	65	43
3	8½	16	5	5	43	18
4	9	11	4	1	34	24
Control	8½	8	4	3	29	15
Control	8½	7	4	1	43	18

Although the objective of preventing death or deformation of terminals infested by *P. strobi* and the killing of branch tips by *E. gloriola* was not attained by the use of phosphamidon at the concentration, dosage, time, and method of application employed in the present test, it is planned to conduct further tests in 1964 on Scots pine, the species most commonly grown for Christmas trees.—C. S. Kirby and A. A. Harnden.

Cabbaging of White Pine Seedlings.—During July and August 1962 large numbers of 1-0 pine seedlings in nurseries in Ontario were affected by an unknown disease. Because the main symptoms were inhibited elongation and dense arrangement of distorted leaves, the disease was called "cabbaging".

Isolations were made from the tops and roots of seedlings showing typical symptoms in two Ontario nurseries. Various agar media were used including one employed for the isolation of *Cylindrocladium scoparium* Morg., the cause of root rot of conifers in Minnesota (Anderson, N., D. W. French, and D. P. Taylor. Forest Sci. 8: 378-382. 1962). Fungi belonging to 16 genera were isolated, including *Alternaria, Fusarium, Hormodendron, Phoma, Epicoccum,* and *Rhizoctonia*. The only possibly virulent organism, *Rhizoctonia* sp., was not common and inoculations with *Alternaria* sp., the only fungus consistently present in diseased material, failed to produce disease symptoms.

The following facts tend to refute the hypothesis that the cabbaging condition is of fungal origin: (1) many species and genera of fungi were present in the tissues of diseased seedlings; (2) they were mainly epiphytes, saprophytes, or weak parasites which are also found commonly in or on healthy conifers; (3) the only possibly virulent organism was not common: and (4) negative results were obtained from inoculations with the only fungus consistently present in diseased material. Many of the fungi isolated could be of importance after initial injury by an unknown agent.—O. Vaartaja, B. W. Dance, and D. F. Lynn.

PRAIRIE PROVINCES

Inoculation of Eight Saskatchewan Trees with Polyporus tomentosus.—The susceptibility of eight native Saskatchewan trees (Table 1) to infection by the root-rotting fungi *Polyporus tomentosus* Fr. and *P. tomentosus* var. *circinatus* Fr. was tested by inoculation near Candle Lake, Sask. Nine roots about ¾ in. in diameter of each tree species were inoculated with *P. tomentosus* and 13 similar roots of each species with *P. tomentosus* var. *circinatus*. The black spruce, jack pine, and balsam poplar were 40 to 60 years old at breast height; the other five species were 80 to 120 years old. All trees were within a ¼ mile radius on generally good sites. Roots were surface sterilized with $HgCl_2$ (1:1000) and washed with sterile distilled water prior to making the incision. A deep slanting incision was made in the root and the sharpened end of a wedge-shaped piece of branch wood (2 in. long by ½ in. in diameter) infected with the test fungus was inserted into the incision. Four roots of each tree species were inoculated with sterile wood to serve as controls.

Two years after inoculation the roots were dug and sectioned. Wood and bark were resinous in the area around the incision in black spruce, white spruce, and jack pine. Resin impregnation of the wood was especially abundant in jack pine, often extending 1 to 2 in. beyond the incision.

Platings were made to determine the presence and extent of *P. tomentosus* decay. Significantly (1% level) more black spruce roots were infected than all other species. White spruce and tamarack were significantly (5% level) more susceptible than all the remaining species. Jack pine and balsam fir had lower percentages of infection than white birch; one infection was recorded on trembling aspen and none on balsam poplar. Natural infections of *Polyporus tomentosus* or *P. tomentosus* var. *circinatus* have not to the author's knowledge been recorded on hardwoods. *Polyporus tomentosus* caused significantly more infections than the variety *circinatus*.

The average extent of *P. tomentosus* discoloration from the inoculum was greatest in tamarack, followed by those in balsam fir, black spruce, white birch, and white spruce. Sapwood was infected in all host species, but bark was most extensively killed in black spruce and tamarack. Decay columns usually tapered from the sapwood near the inoculum, proximally and distally toward the centre of the root. *Polyporus tomentosus* caused reddish-brown stained wood in white spruce, similar to natural infections. The variety *circinatus* caused somewhat paler stains compared with *P. tomentosus* in white spruce roots. In black spruce *P. tomentosus* stains were dull and greyish brown. In tamarack they were also greyish brown with a yellowish margin. The other tree species had too few infections for *P. tomentosus* stains to be characterized.—R. D. Whitney.

TABLE 1

Percentage infection and average length of resultant decay column in roots of eight tree species two years after inoculation with *Polyporus tomentosus* and *P. tomentosus* variety *circinatus*[1].

—	Per cent infected	Average length of decay column (ins.)
Black spruce	41	3.0
White spruce	23	2.5
Tamarack	18	4.0
White birch	9	2.6
Balsam fir	5	3.3
Jack pine	5	1.8
Trembling aspen	5	1.2
Balsam poplar	0	0

[1]Interactions between *P. tomentosus* and the variety *circinatus* and host species were not significant. Therefore the two are grouped in the table.

ROCKY MOUNTAIN REGION

A Poplar Scale, Aspidiotus (Hemiberlesia) popularum Marlatt.—Marlatt ("New species of Diaspine Scale Insects". U.S.D.A. Tech. Series, No. 16 (2): 23-24, 1908) in the original description of this species reported it from *Populus* sp. near Deming, New Mexico, and from the same host near Phoenix, Arizona. Ferris ("Atlas of the Scale Insects of North America" Series II and Series III, Stanford Univ. Press, 1938) lists two other locations, one near Tucson, Arizona, from *Populus* sp., and one near Glenn Springs, Texas, from *Salix* sp. There appear to be no further published reports of its distribution but collections made in Alberta indicate that this insect may not be as rare as the literature indicates. In 1959 the known range of the insect was greatly extended by its discovery on trembling aspen at Warspite, Alberta. Although the infestation appeared vigorous in 1959 it subsided during the summer of 1960 and no new infestations were found until 1963 when it was discovered 35 miles northwest of the original infestation. This insect was also collected by survey personnel from aspen in 1953 near Starbuck, Manitoba, and recorded under the genus *Hemiberlesia*.

A. popularum is a bark feeder. The scales mass together in colonies and form a grey lichen-like encrustation on the bark of the main stem of aspen trees. At Warspite they were found on the south and southeast sides of tree stems in a patchy pattern from a few feet above ground level to the

[1] A test sample of Ortho Phosphamidon 4.8 Spray (2-chloro-2-diethylcarbamoyl-1-methylvinyl dimethyl phosphate......4.8 lb./1 Imp. gal.) was made available by Ortho Agricultural Chemicals Limited.

mid-crown. Colonies of these scales were very difficult to see and were only detected by the presence of *Chilocorus stigma* (Say) adults, a predator of scale insects, on the trunks and large branches of the infested trees.

Confirmation of a local identification was made by W. R. Richards of the Entomology Research Institute, Ottawa, from collections made by J. K. Robins at Warspite in 1959.—N. W. Wilkinson.

Correction.—In the article by E. J. Gautreau entitled *"Unhatched Caterpillar Egg Bands in Northern Alberta Associated with Late Spring Frost"*, Vol. 20, No. 3, page 3, the lowest temperature recorded should read 19°F.

BRITISH COLUMBIA

Rusty Tussock Moth in Interior British Columbia, 1963.—The first known infestation of the rusty tussock moth, *Orgyia antiqua badia* (Hy. Edw.), in interior British Columbia was recorded during 1963. Approximately 400 acres of timber were affected 1 mile north of Kingsgate, in the Moyie River Valley of southeastern British Columbia. The stand is primarily lodgepole pine with some Douglas-fir and western larch regeneration.

Tussock moth eggs were present on lodgepole pine, Douglas-fir, western larch, soopolallie, and serviceberry, with the majority on the branches of lodgepole pine and soopolallie. By June 13, 1963, many had hatched and defoliation was evident by July 12. Light to heavy defoliation of understory lodgepole pine trees was noted throughout the infestation. Preferred hosts were logepole pine and soopolallie, but some feeding occurred on the foliage of other tree species in the stand. Two 6-foot lodgepole pine trees, one western larch of the same size, and about 90% of the soopolallie bushes were completely denuded by July 22.

Mass collections taken on July 22 contained larvae infected with a polyhedral virus. By July 30, disease larvae outnumbered apparently healthy ones throughout the infestation. On August 24 an attempt was made to collect pupae, but the virus had virtually exterminated the population.

Late in September four partially defoliated lodgepole pine trees were felled as samples. The foliage, branches, and stems of each tree were examined, but no eggs were found. Fifteen cocoons were located; moths had emerged from only three, the remainder were either empty or contained dead prepupal larvae.

Although some of the regeneration lodgepole pine trees that were severely defoliated may die, no mortality of the larger trees is expected to result from tussock moth defoliation.—N. Geistlinger.

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ATLANTIC PROVINCES

Predation of Larch Sawfly Cocoons by the Introduced Shrew, Sorex cinereus cinereus (Kerr.), in Newfoundland.—Outbreaks of the larch sawfly, *Pristiphora erichsonii* (Htg.), have occurred annually at some locations in Newfoundland for the last 30 years (Carroll, W. J. Bi-Mon. Prog. Rept. 20(5): 1. 1964). After an inspection of Newfoundland forests in 1942, Dr. R. E. Balch (unpublished report) recognized the absence of shrews and the scarcity of mice as a weakness in the control complex of the sawfly. Attempts to trap shrews by W. A. Reeks in 1949 (Ann. Rept. Nfld. Forest Prot. Assoc.) and later efforts by the writer confirmed Balch's observation that shrews were not present on the Island. Only one species of woodland mouse, *Microtus pennsylvanicus terraenovae* (Bangs), was recorded. Severe outbreaks of the larch sawfly in central Newfoundland in 1954 and 1955 focused attention on the possibility of improving biological control by introducing shrews that were known to play an important role in sawfly control on the mainland with no damaging effect on man or the forest. The masked shrew, *Sorex cinereus cinereus* (Kerr.), was selected because it has a wide habitat range, is almost entirely insectivorous, and appears to thrive under similar forest and climatic conditions of the Maritime Provinces.

In September 1958, 22 animals were trapped in New Brunswick and released near St. George's in western Newfoundland (MacLeod, C. F. Bi-Mon. Prog. Rept. 16(2):1. 1960). Dispersal has since occurred up to 75 miles from the release points. In 1961, two colonies from the St. George's plot were released in central Newfoundland—20 animals at Hall's Bay and 23 at Exploits Dam. Dispersal up to 20 miles was recorded at Hall's Bay and 30 miles at Exploits Dam in 1963 and it can be concluded that the shrew is now established in three fairly extensive areas on the Island. Investigations to assess predation on sawfly cocoons were initiated at the release sites—the one at St. George's in 1959 and the two in central Newfoundland in 1961—using the cocoon-planting technique (Buckner, C. H. Can. Entomol. 91:275-282. 1959). Cocoons wired to stakes were buried about 2 in. beneath the forest duff. From 1959 to 1961, cocoons were planted in mid-August and retrieved about mid-October; in the latter 2 years, missing and opened cocoons were renewed and left overwinter for spring examination. The overwinter plants were discontinued in 1962 and 1963 because of pressure of other duties and the autumn inspection was made about mid-November. Chewed cocoons were classified using Buckner's method (Proc. Xth Int. Congr. Entomol. Vol. 4: 353-361. 1956(1958)) and special samples supplied by Dr. Buckner. The accompanying table summarizes data on the fate of planted cocoons.

SUMMARY OF PREDATION ON LARCH SAWFLY COCOONS

Year and location	Cocoons	Fate of cocoons by percentages				
		Sorex	Microtus	Insect predators	Missing	Present
St. George's						
(Fall)						
1959	400	14	5	9	18	54
1960	396	22	3	8	22	45
1961	344	23	2	7	15	53
1962	345	16	4	6	40	34
1963	395	17	2	4	34	43
(Overwinter)						
1960	394	17	3	7	42	31
1961	333	12	2	8	27	51
Hall's Bay						
1961	52	2	2	12	4	80
1962	92	5	1	10	5	79
1963	194	8	2	11	6	73
Exploits Dam						
1961	83	7	1	11	3	78
1962	86	12	2	12	13	61
1963	200	15	5	12	12	56

At St. George's, fall predation by shrews increased from 14% in 1959 to 23% in 1961 and declined to 17% in 1963. The average for the 5-year period was 18%. Missing cocoons ranged from 18 to 40%, averaging about 26%. Such cocoon loss has been attributed mainly to shrews because of the light mouse predation. Combined values for cocoons attacked by shrews and missing cocoons ranged from 32 to over 50%, averaging 44%. This appears to be a more realistic figure in view of the high shrew population recorded by C. F. MacLeod (personal communication, 1961). The percentage of cocoons chewed by shrews during the winter was considerably less than those exposed during the fall only, being 22 and 17% in 1960, and 23 and 12% in 1961. However, the percentage of missing cocoons over the winter period was nearly double that in the fall. In the last 2 years of the study when cocoons remained in the soil until November, the proportion of cocoons missing in the fall increased considerably. Missing cocoons are apparently an indication of caching activity by the shrew late in the season.

In central Newfoundland, shrew predation was relatively light, ranging from 2 to 8% at Hall's Bay and 7 to 15% at Exploits Dam. The combined data for shrew-attacked and missing cocoons ranged from 6 to 14% and 10 to 27% respectively for the two locations.

Comparative data on shrew numbers and dispersal rates at the three release areas are unavailable and it is difficult to explain the light predation values in central Newfoundland. The three areas were similar in most respects, having a bog-type vegetation in low-lying sections and mixed softwoods and hardwoods, often with a dense understory, at higher elevations. The principal differences were in sawfly numbers and dispersal barriers. During the period of study, sawfly numbers in square foot soil samples showed a progressive annual decline from 9 to less than 1 at St. George's, from 14 to 4 at Hall's Bay, and from 50 to 9 at Exploits Dam. The average sawfly numbers for the three areas were 3, 8, and 30 respectively. Low sawfly numbers at St. George's may account for higher predation of planted cocoons in comparison with Exploits Dam, but does not explain the light predation at Hall's Bay. Topographic barriers at the St. George's plot and to a lesser extent at the Exploits Dam plot may have restricted shrew dispersal, resulting in localized concentrations of animals. The absence of barriers at Hall's Bay, no doubt, resulted in a more rapid and extensive dispersal, comparatively low numbers of animals in the plot, and subsequently reduced predation on planted cocoons.

The introduction of the shrew has apparently not seriously affected predation by mice. At St. George's, mouse predation has varied at low percentages from 5 in 1959 to 2 in 1963, averaging about 3. A somewhat similar pattern has occurred in the other areas. Reports suggest that mouse populations have reached noticeably high levels during the period of study. For example, in 1960 several reports were received of mice swimming in lakes in western Newfoundland. In one instance, more than 25 were counted in one hour and numerous others were dead along the shoreline. Reports in 1963 also indicated comparatively high numbers of mice in central Newfoundland.

The percentage of cocoons attacked by insects has been reduced by about one-half at St. George's but remains relatively unchanged in the other locations. Reduced insect predation at St. George's, no doubt, results from the combined factors of shrew competition and declining sawfly numbers.

It is evident that the shrew is established in Newfoundland and, although natural dispersal appears to be fairly rapid, it will take several years to spread over the Island. Colonies may have to be started in new localities. Investigations have been limited but they indicate that the shrew is a valuable predator of sawfly cocoons and, despite some evidence of reduced predation by other factors, presumably from competition, there has been an important net gain. No appreciable damaging effects have resulted from the introduction. Local residents have reported some minor incidents of shrew tunnelling in dead rabbits (snared commercially). In one instance, campers expressed concern over the almost constant presence of shrews in their tents. Two cases have occurred of individuals catching shrews in their hands—one in summer was brought to the laboratory alive about 5 hours after capture, the other in mid-winter died about 2 hours after capture.—W. J. Carroll.

Populations of Larch Shoot Moth in New Brunswick.— In a paper on the life history of the larch shoot moth, *Argyresthia laricella* Kft., Eidt and Sippell (Can. Entomol 93: 7-24, 1961) suggested that this insect may have value as a subject for the study of population dynamics. They pointed out that it is apparently a species with narrow population fluctuations at low levels. Such animals have not been studied because they are, as a rule, extremely difficult and costly to collect. *A. laricella,* at least as ultimate instar larvae and pupae, is easy to collect and the following records are based on sampling in New Brunswick from 1959 to 1963.

Samples of approximately 1,000 shoots were collected from each of 12 or 13 locations annually and larval densities per 1,000 shoots were: 1959—4.11, 1960—1.16, 1961—3.92, 1962—2.97, 1963—5.79, and for all years 3.60. Omitting one location (Holmesville) with a consistently higher population averaging 19 larvae/1,000 shoots, the coefficients of variation of sample counts per plot ranged from 73 to 136% for the various years. Analysis of variance showed no significant differences between years.

To check intra-plot variation nine samples were taken from a 5-acre stand of young tamarack at Stewarton, N.B., late in 1963. The mean density was 3.64 larvae/1,000 shoots and coefficient of variation was 82%, about the same order as the samples collected all over the Province. From these data it was calculated that approximately 17 samples of 1,000 shoots would be necessary from each locality to establish a mean with a standard error of 20%. (It takes less than one man-hour to examine 1,000 shoots for larvae, and they can be collected for very little more than travel time to the sample site.) If the sample unit is considered in terms of larvae rather than shoots, and counts are expressed as shoots per larva, this tends to stabilize variance. This is not a reciprocal expression because the last shoot counted is the last shoot containing a larva, whereas in the other method all shoots from each locality are counted. A sample size of 40 larvae is suggested, which at these population levels would involve about 12,000 shoots.

Table I shows that the braconid *Apanteles laricellae* Mason accounted for the greatest mortality of fifth-instar larvae and that the ichneumonid *Pimplopterus argyresthiae* Walley accounted for consistently less. "Other parasites" includes varying numbers of the above species that were unidentified, but too few to affect the results. Predation was low, except in 1963, when a very high incidence of bird predation at one locality was enough to affect the results for the year. The main components of "other causes" were desiccated and moldy larvae although the actual cause of death was unknown.

Table I

Percentage of Fifth-Instar Larvae Killed by Various Factors

Mortality factor	1959	1960	1961	1962	1963
Apanteles laricellae	32.0	23.8	18.2	23.6	26.8
Pimplopterus argyresthiae	8.9	6.1	3.6	2.3	2.7
All other parasites	4.0	2.4	0.5	2.0	2.7
Total parasitism	44.9	32.3	22.3	27.9	32.2
Predation	0.6	0.3	3.0	0.2	10.3
All other causes	12.0	15.6	5.9	7.2	7.5
Total	57.5	48.2	31.2	35.3	50.0

Table II shows that the ichneumonid parasites *Phaeogenes laricellae* Mason and *Alegina laricellae* Mason together accounted for the largest amount of pupal mortality, one or the other being more abundant in any year. Many unsuccessful specimens of *Phaeogenes* and *Alegina* are included under "other parasites", especially in 1959 and 1962 when many dead larvae were not identified. Predation of pupae was consistently low and difficult to measure. Emergence failures, which included adults trapped in the galleries, varied in number for no known reason. Other causes of mortality included a high proportion of desiccated pupae dead of unknown cause. No diseases were found in many specimens checked.

Data on hyperparasitism through two larval parasites are given in Table III. Parasitism of *Apanteles* and *Pimplopterus* involved the same species, mainly the chalcid *Euderus argyresthiae* Cwfd. In both cases it was low; the more erratic figures for *Pimplopterus* are probably a result of too few observations. The data bear a vague relationship with *Apanteles* parasitism of the shoot moth, but lag by 1 year.

Table II

Percentage of Pupae Killed by Various Factors

Mortality factor	1959	1960	1961	1962	1963
Phaeogenes laricellae	9.3	3.7	2.7	13.1	10.1
Alegina laricellae	23.5	11.8	8.1	5.1	10.8
All other parasites	15.6	4.3	0.8	11.1	3.0
Total parasitism	48.4	19.8	11.6	29.3	23.9
Predation	3.5	3.2	1.6	7.9	5.4
Failed to emerge	2.6	13.4	2.4	7.5	10.5
All other causes	13.3	17.1	9.9	11.3	12.8
Total	67.8	53.5	25.5	56.0	52.6

Table III

Percentage of Hyperparasitism of Two Larval Parasites

Parasite	1959	1960	1961	1962	1963
Apanteles laricellae	6.8	6.6	5.9	1.4	3.1
Pimplopterus argyresthiae	10.2	0.0	25.0	14.3	25.0

Total mortality of larvae and pupae was low in 1961, but then mortality due to most factors making up this total was also low. The incidence of all the parasites declined to 1961, *Apanteles* and *Phaeogenes* recovered partially in 1962, *Alegina* in 1963, but *Pimplopterus* remained low. Although the parasitism data are convincing, it is not possible to analyse the mortality data statistically since they are derived from many variable-sized samples, usually from different localities each year.

Survival ratios for the developmental period of fifth instar to adult emergence were .07, .15, .23, .16, and .12 for the 5 years. These data could not be incorporated into a key-factor analysis (Morris, R. F., Ecology 40: 580-588. 1959) because of the lack of a significant change in population density during the census period.

When Holmesville with its consistently high population was examined alone, survival ratios for the years 1961 to 1963 were .44, .49, and .66. Pupal mortality was much the same as for all locations averaged except that the proportions of *Alegina* and *Phaeogenes* were reversed. Parasitism by *Apanteles,* which was about half the level at all other locations, may account for the higher survival at Holmesville. It is noteworthy that during the course of earlier studies at St. Williams, Ontario, *Apanteles* was never collected although populations of *A. laricella* were unusually high.

A better understanding of the population dynamics of this insect might be provided by comparisons from place to place, selecting locations with different population levels. The usefulness of this insect for studying population dynamics *per se* is dependent upon the detection and definition of real population fluctuations in time. The data collected over the past 5 years have shown how to design a program adequate to do this.—D. C. Eidt.

QUEBEC

Xyloterinus politus (Say), Another Possible Vector of the Dutch Elm Disease.— There are only two important insect vectors of the Dutch elm disease fungus, *Ceratocystis ulmi* (Buism.) C. Moreau, known in North America. These are the native elm bark beetle, *Hylurgopinus rufipes* (Eichhoff), and the smaller European elm bark beetle, *Scolytus multistriatus* (Marsham). However, several other species of insects are known to be occasional carriers of the pathogen and it has been shown experimentally that some are capable of transmitting the pathogen from diseased to healthy plants. Chief among these are: *Scolytus sulcatus* Lec. and *Xyleborus germanus* Blandf. (Scolytidae), *Magdalis armicollis* (Say) and *M. barbita* (Say) (Curculionidae), and *Saperda tridentata* Olivier (Cerambycidae).

In May 1964, a diseased elm tree was found on the outskirts of Quebec City with several dozen recently constructed galleries of an ambrosia beetle, *Xyloterinus politus* (Say). Over 50 adults emerged from sections of the tree which had been placed in cages. Twenty of the insects were permitted to crawl on agar media in petri plates, and positive *C. ulmi* cultures were obtained from 11 of these. This does not necessarily mean that the insect can transmit the disease from one plant to another, for not only must it carry the spores of the fungus on its body, but it must also be able to introduce them into the xylem of living trees—a fact which has not yet been demonstrated experimentally. However, since adults must penetrate through the bark and cambium of trees to reach the wood, where they construct their galleries, it is highly probable that the insect is capable of transmitting the disease to trees weakened by other agents, thus creating an inoculum potential for transmission by known vectors.

—R. J. Finnegan and C. Gagnon.

ONTARIO

Survival of Fusarium, Pythium, and Rhizoctonia in Very Dry Soil.—There are scattered records in the literature of the amazing survival ability of sclerotia of *Rhizoctonia* spp. and of oospores of *Pythium* spp. in soil. Understanding the epidemiology of many important soil-borne diseases would be easier if more knowledge was available of the saprophytic action and survival of these pathogens in soil. The following observations on survival of fungi in soil may therefore be of some use until more systematic studies are available.

Sandy soil was taken from the nursery at Midhurst, Ontario, in the spring of 1962 and stored in wooden bins in the headerhouse of the Laboratory. Because of the dryness of the atmosphere and darkness in the bins, there could not be any growth of weeds to provide for pathogenic activity of fungi in the soil. In March 1964, after almost 2 years' storage, the soil contained only 0.2% of water by weight. Microbiological analysis of this soil was made using conventional dilution and soil plate techniques, the former with malt agar and the latter with cornmeal agar with and without selective antibiotics. Bacteria were suppressed with 50 p.p.m. of streptomycin and certain fungi with 200 p.p.m. of mycostatin.

The most interesting result was the finding of species of *Pythium and Rhizoctonia*. Both were found only a few times when using large amounts of soil (over ½ gm.) per plate. Under these conditions other organisms could not be fully excluded and they probably prevented some *Pythium* and *Rhizoctonia* from being observed. The numbers of bacteria and actinomycetes were very low, 12,000 and 400 per cc. of soil. There were 1,180 fungi per cc. of soil (dilution plates), mostly species of *Aspergillus* (540) and *Penicillium* (580). Soil platings revealed the presence of *Fusarium solani* (Mart.) App. et Wr., *Mortierella* spp., *Mucor* spp., and *Trichoderma viride* Pers. ex Fr. The colonies of the later four and of *Pythium* and *Rhizoctonia* usually originated from large soil aggregates probably always containing humus or plant residues. Other fungi were very rare.

The survival of *Pythium* and *Rhizoctonia* in very dry soil suggests that these important damping-off pathogens can spread with dust particles blown by wind from unsterilized soil to adjacent sterilized seedbeds.—O. Vaartaja.

BRITISH COLUMBIA

Nematode Infestation, and Sex Difference in Response to Log Odors, in the Cerambycid Beetle, Leptura obliterata (Haldeman).—For field studies of scolytid attraction, at Lake Cowichan, B.C., in 1963, plastic-coverd frame cages were filled with May-felled Douglas-fir logs or bark. These cages served as sources of odors, which were released through a top opening in each cage, above which small glass-barrier traps were mounted. The cages were placed in a second-growth stand of Douglas-fir, and insects collected from the traps at intervals during the season.

The cerambycid, *Leptura obliterata* (Haldeman), started appearing in the traps in late July and was the most common insect in late August and early September catches. Individuals were attracted by whole logs, bare logs, and by bark alone.

Specimens from some of the early catches were dissected, to determine sex with certainty. There were two interesting results: 1) no males were found, and 2) several females were heavily infested with internal nematodes. The sex, and the incidence of nematode infestation, were then determined in all other specimens collected from 18 cage-trap units that season, the results being given below.

Sex and nematode infestation of *L. obliterata* taken at log odor sources.

	July 21	July 29	Aug. 2	Aug. 12	Aug. 21 (part)	Aug. 21 (part)	Sept. 4	Sept. 18	Total
male	0	0	0	1	0	0	0	0	1
female	10	10	16	161	42	78	237	42	596
per cent females infested	—	—	—(1)	31	18(1)	29	30	59	27

(1) Individuals of the first three dates were combined with the first part of the August 21 collection for this determination.

In all infested individuals the abdominal cavity was packed with nematodes. Uninfested beetles had large ovaries, with well developed eggs, but ovaries of infested beetles were poorly developed, the ovarioles being small and often obscured by nematodes. Judging by appearance, it seems unlikely that infested individuals could have produced offspring. I thank Dr. K. C. Sanwal, Entomology Research Institute, Ottawa, for a provisional identification of the nematodes (from water-soaked material) as rhabditid dauerlarvae, possibly of the genus *Parasitorhabditis* (Fuchs, 1937) Chitwood, 1950. These parasites may be a significant factor in the biology of *L. obliterata* and their presence raises questions concerning their life history and mode of transmission.

L. obliterata is reported as breeding in a variety of dead conifers (Craighead, F. C., 1923. Dept. Agr. [Dom. of Canada] Bull. No. 27, New Series, Tech.). I cannot find any reference to normal sex ratio in *Leptura* species, in the literature. The above data clearly suggest, however, that only females of *L. obliterata* are attracted by log odors (the single male is considered an accidental catch). *Leptura* species are well known to frequent flowers, where mating occurs, and are considered pollen feeders. (Linsley, E. G., 1961. Univ. Calif. Pub. Ent. Vol. 18). Although males visit flowers, they apparently are not attracted to logs. This demonstration of sex difference in response to log odors raises various questions. For example, in how many other flower-frequenting cerambycid species does attraction to brood material involve females only? Is it feeding or mating that causes females to change their behavior when they leave flowers and begin to search for logs on which to oviposit?—J. A. Chapman.

Uptake of Water by the Ambrosia Beetle Trypodendron Following Desiccation.—Physiological studies of insects often utilize tracer materials, including radioisotopes, which are fed or otherwise introduced into the body. Ambrosia beetles cannot be fed these materials readily because their food consists only of the symbiotic fungus with which they are associated. A simple method has been found to make *Trypodendron* take up water; desiccate the beetles and then allow them to drink. This makes it possible to introduce dyes and other tracers via the alimentary tract. A short description of our experience with this method is given here.

Adult *Trypodendron lineatum* (Oliv.) collected from overwintering sites in bark in January and March were used for tests. After removing them from the bark they were stored in moist bark flakes in a refrigerator until used. During desiccation beetles were kept separately in small gelatin capsules perforated at both ends. Beetles were individually weighed and kept over anhydrous calcium sulphate in a darkened container at room temperature.

Five series consisting of five male and five female beetles each were used. They were re-weighed at intervals to determine rate of moisture loss. At several different levels of moisture loss, beetles were transferred to stoppered shell vials, each containing a roll of wet glass paper. They were removed and weighed again within a day. Desiccated beetles could be seen to push their heads into wet paper and appeared to drink as they did this.

The rate of weight loss with time was fairly constant, so that it was possible to estimate with reasonable accuracy the time required to reach a certain level of desiccation. Results from the experiment are summarized in the accompanying table.

Percentage weight loss in adult *Trypodendron* subjected to desiccation[1] for various periods

Hours of desiccation	MALE Av. loss	MALE Loss per hour[2]	MALE Range	FEMALE Av. loss	FEMALE Loss per hour[2]	FEMALE Range
7	3.3	.477	.313—.569	4.8	.688	.421—.863
17	7.8	.457	.387—.532	—	—	—
24	12.6	.525	.378—.720	14.4	.600	.569—.923
48	25.3	.528	.481—.666	32.0	.666	.579—.721

Average weight of beetles before test: male—3.23 mg. (2.42—3.78); female—3.62 mg. (3.05—4.29).

[1] All percentages of weight loss are based on original weights of beetles.

[2] Value during interval since previous weighing.

There was considerable individual variability in rate of weight loss and gain during desiccation and subsequent exposure to water, but it can be stated that, under the conditions of our tests, adults survived a weight loss of 10—25%, while drying over a period of 17—30 hrs. If given access to water, desiccated individuals regained their original weight and often exceeded it for 1 or 2 days. In these instances subsequent weighings showed that most of them soon returned to their original weights. Tests with a dye solution (Neutral Red) demonstrated that the anterior part of the alimentary canal may be filled with water after drinking. This could account for the excess weight after beetles are given water, as the ventriculus and other parts of the intestine of resting beetles are usually empty.

Individuals desiccated appreciably beyond 25% weight loss do not usually survive, nor will they regain weight when given water. After drying to a 10—25% weight loss, however, beetles usually recover if given water, and appear to be normal, as judged by ability to walk and fly. Some individuals tested, however, did not regain much weight when allowed to drink. These lost weight during desiccation faster than the majority, appeared weak, and showed no tendency to fly after the tests were completed.

Using this method, 1% aqueous solutions of a number of dyes were readily introduced into partially desiccated *Trypodendron*. Most beetles, when given Basic Fuchsin, Rose Bengal, Thionin, or Trypan Blue to drink and examined internally within a day or two showed the alimentary tract to be stained and some diffusion of stain into the body cavity was often noted.

The above method could be used to introduce radioisotopes into these beetles, for physiological or ecological studies. The same approach could undoubtedly be used with many other scolytid beetles and other insects, including those that are so small that introduction of tracers by injection would be difficult.—W. W. Nijholt and J. A. Chapman.

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O. H. M. S.

DOUGLAS C. EIDT,
FOREST ENT. & PATH LAB.,
CANADA DEPT. OF FORESTRY, (3-6)
COLLEGE HILL, L-205
FREDERICTON, N.B.

DEPARTMENT OF FORESTRY
OTTAWA