THE KNAPSACK MIST BLOWER AND ITS USE FOR CONTROL OF INSECT PESTS AND WEEDS IN CHRISTMAS TREE STANDS

by

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INTRODUCTION

The knapsack mist blower (Figure 1) was developed about 20 years ago and several million units are in use all over the world. Mist blowers have not, however, been widely used for forestry applications in North America and instructions for such use are not readily available even from the manufacturers. This manual brings together information on the knapsack mist blower from users outside the Maritimes, provides some data on four models now available in the Region, outlines methods of treating sizeable areas, and suggests kinds and formulations of insecticides and herbicides. Sections two and three describe the mist blower and application techniques; and the fourth and fifth cover safety precautions and the preparation of pesticide mixtures.

One authority on spraying systems said: "for applying herbicides and silvicides the mist blower is the most fantastic plant killer known". Tractor-drawn mist blowers are also commonly used in orchards in applying insecticides. What makes the mist blower so effective?

Most insecticides and herbicides are extremely active and very minute quantities will kill an insect or a plant. It is difficult, however, to distribute these minute quantities evenly so that all members of the population are affected. Traditional spraying systems, referred to as hydraulic systems, have achieved the objective by diluting the pesticide with large volumes of a carrier such as water and by applying large volumes of the spray mixture, often 100 to 150 gallons per acre. The mist blower, by using air instead of liquid as the carrier, and by breaking the spray mixture into very small droplets, will distribute a much smaller volume more evenly over a large area. Good coverage can be obtained with as little as 1 gallon of spray mixture per acre, and usually no more than 10 gallons per acre. The strong air blast penetrates dense foliage and deposits the droplets on all leaf surfaces.

The mist blower involves much less time and effort than the hydraulic sprayer, particularly in forestry situations where the equipment and the spray mixture are carried on the operator's back. There is good evidence that some pesticides, when applied in

fine droplets, work more effectively than when they are applied as a coarse spray. Less chemical is therefore needed to control the pest. As the cost of chemicals is often a major part of the total cost of treatment, this may be important when large areas are to be treated.

The mist blower is also useful for other jobs such as white-washing farm buildings, or applying foliar fertilizers and artificial colorants to Christmas trees. Most mist blowers can be adapted to distribute dusts and granular materials, and can be converted to flame-throwers with special attachments. Those that can be equipped as flame-throwers are useful for thawing frozen pipes, burning out fire lines, or starting fires in brush piles. Park attendants have found that leaves can be removed from lawns and golf courses much more rapidly with a mist blower than with a rake. Indeed, there seems to be no limit to the mist blower's versatility.

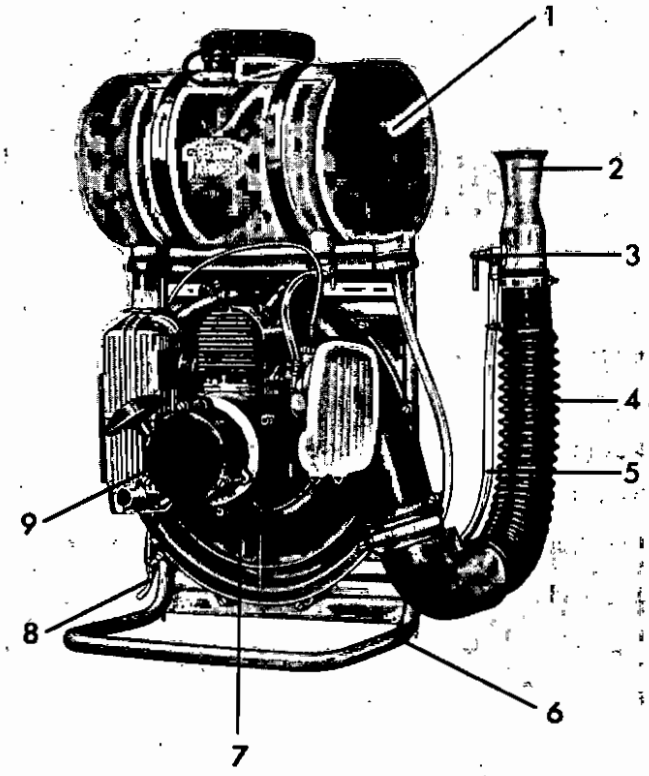


Figure 1. Parts of a typical knapsack mist blower.

1. Chemical storage tank
2. Nozzle
3. Flow-control valve
4. Flexible air hose
5. Chemical delivery tube
6. Carrying frame
7. Centrifugal fan housing
8. Throttle
9. Recoil starter

THE MACHINE

The knapsack mist blower (Figure 1) has a centrifugal fan driven by a two-cycle gasoline engine (1 to 4 horsepower). The fan drives a large volume of air at high speed through a flexible tube to a nozzle by which the air flow is directed to the target. Various models deliver from 350 to 780 cubic feet of air per minute at about 200 miles per hour. The mist blower has a chemical storage tank, usually holding $2\frac{1}{2}$ Imperial gallons, from which the spray mixture is delivered through a tube and a flow-control valve to the nozzle. Flow to the nozzle is by gravity, and by some air pressure feed-back from the fan into the tank. At the nozzle, the spray mixture drips into the air flow which breaks the liquid into fine droplets. These are carried by the air blast to the target. In still air, the machine will deliver the spray droplets horizontally about 35 feet, or vertically about 25 feet; some models may exceed these distances.

The machines tested weigh between 43 and 53 pounds with fuel and chemical tanks filled. All are mounted on well-designed frames and are quite comfortable to carry. Neither noise nor vibration cause discomfort to the operator.

There are only three controls (see Figure 1). The *flow-control valve*, located at the nozzle, controls the flow of spray mixture from the storage tank and allows the operator to vary the amount of chemical applied during a given period; a *shut-off valve*, located near the handle on the flexible air hose, enables the operator to stop the flow of chemical entirely (the *shut-off valve* may be combined with the *flow-control valve* on some models); and a *throttle control*, usually mounted on the carrying frame, with which the operator can regulate engine speed. The operation of these controls will be discussed later.

Choosing a Mist Blower

Several makes and models of mist blowers are available from Maritime distributors (Appendix A). All are of the same basic design but differ in details such as engine power, tank capacity, location of controls, design of the carrying frame, and the materials used in construction. Some of the differences may be important to an individual operator. Prices vary but the quality of the machines, and the availability of spare

parts and servicing should be carefully evaluated before the price is allowed to influence the choice.

Before buying a machine, one should insist upon a demonstration, preferably under conditions similar to those under which the machine will be used. The buyer should test the machine for comfort and balance with the tanks empty and full, and while walking through brush and over rough ground, make sure that the engine starts easily and runs smoothly, that all controls function properly, and that no leaks exist at any connections, particularly at the flow-control and shut-off valves. Have the dealer fill the tank with a dye solution so that the fine droplets will show up on a smooth, light-colored surface, then check the size of droplets produced and the horizontal and vertical distance the spray is carried at the various settings and engine speeds. Examples of spray patterns are given in Figure 2.

Care of the Mist Blower

With proper care, a mist blower should last through many spraying seasons. The handbook provided with the machine should be studied and the instructions followed carefully, especially those for mixing the fuel -- most mist blower engines use less oil in the fuel mixture than other two-cycle engines.

After use each day, flush the chemical tank and feed lines with clean water. See that the screens are not clogged and that no chemical residues remain on any interior surfaces. This is particularly important if wettable powders have been used. *Excess spray materials and rinse water should be disposed of at a spot where there is no danger of the material contaminating water.* As some pesticides will corrode metal parts, tanks should never be used to store mixture for prolonged periods. After each use, wash the tank with detergent or soap solution, rinse with clean water, and leave it uncapped during storage to allow drying.

It is best to have one tank for insecticides and fungicides, and another for herbicides. If this is not possible and only one tank is used, all traces of a herbicide should be removed by careful cleaning of hose and tank. After washing and rinsing, add one teaspoon of household ammonia or baking soda per gallon of detergent solution and leave overnight in the tank and hose; empty tank by draining solution through the nozzle, then rinse with clean water.

Checking the Flow-control Valve

The flow-control valve of the mist blower will probably have four or more numbered settings, but this does not mean that there are a limited number of pre-set delivery rates because the valves on most machines may be set to give delivery rates between the numbered settings. The handbook accompanying the mist blower will probably state the lowest and the highest rates that the machine is designed to deliver, but the rates will probably be expressed in "liters per minute" (equivalent to 0.88 quart per minute) and in some cases may not be exact.

To use the calibration technique described in this manual, it is not necessary to know how many quarts per minute the machine will deliver. All that is required is the time taken for 1 quart of spray mixture to pass through the flow-control valve at each setting. A simple way to get this information is as follows.

Fill the chemical tank with water, set the mist blower on a bench or raised platform so that the flexible air hose can hang more or less vertically with the nozzle over the opening of a 1-quart measure. Set the indicator on the flow-control valve at the lowest number, open the shut-off valve and find out how many seconds it takes to fill the quart measure. Repeat at least once to make sure that the timing is correct. Record the average time on a calibration record similar to the one below. Then repeat for each numbered setting.

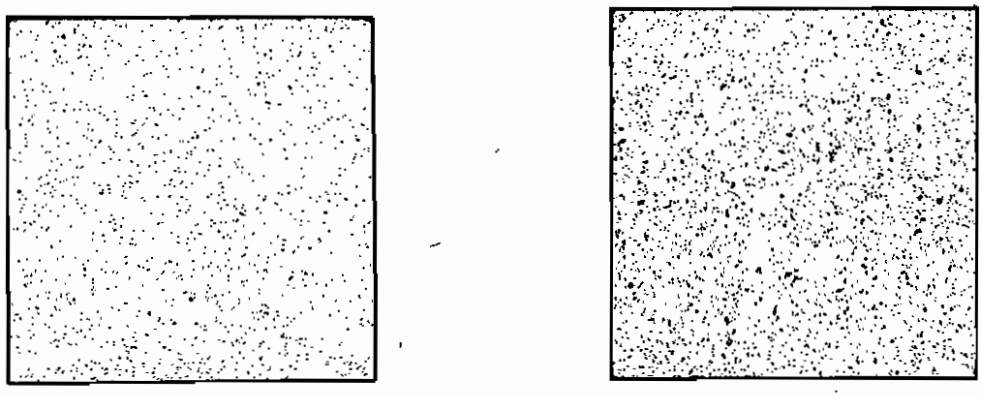
Calibration Record

Machine No.....						
Setting	....	....	....	....	....	....
Time	....	....	....	....	....	....
Machine No.....						
Setting	....	....	....	....	....	....
Time	....	....	....	....	....	....

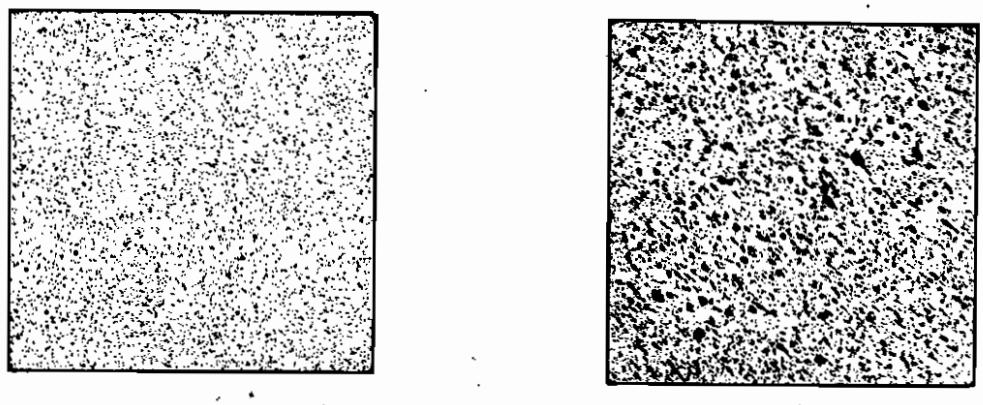
As deposits may build up in the flow-control valve, thus reducing the size of the orifice through which the liquid must flow and changing the delivery rate, repeat the check described above at regular intervals.

Delivery rate

Lowest Highest



Target height - 15 feet



Target height - 5 feet

Figure 2. Droplet size and distribution obtained with knapsack mist blower. Horizontal distance to target was 20 feet and engine speed high in each case. Nozzle was swept slowly past targets.

Calibrating the Mist Blower for Use

If treatment with a particular pesticide mixture is recommended at the rate of 5 gallons per acre, it is important to apply the spray at that rate. The amount of spray mixture applied to an acre will vary according to the setting of the flow-control valve, the width of the spray strip, and the travel speed. These can be related in a simple equation. However, the step-by-step procedure outlined below will eliminate most of the mathematics.

(1) Lay out a sample plot that is typical of the area to be treated. The plot should be at least $\frac{1}{10}$ acre (66 feet by 66 feet) and preferably $\frac{1}{4}$ acre (110 feet by 100 feet).

(2) Fill the mist blower tank with water.

(3) Find out how long it takes to spray the sample area thoroughly, following the travel pattern which has been chosen (see page 13); and using the appropriate nozzle technique for the planned treatment. Walk at a steady speed that can be maintained.

(4) When the time in minutes to spray the sample area has been determined, multiply this by 10 ($\frac{1}{10}$ acre) or 4 ($\frac{1}{4}$ acre) to obtain the time required to spray 1 acre.

(5) Enter the graph (Figure 3) at the left side with the time obtained in Step 4, follow the horizontal line to the sloping line labelled with the required application rate, then follow the vertical line to read the time required to fill a 1-quart measure at the bottom of the graph. For example, 6 minutes were required to spray a $\frac{1}{4}$-acre test area, therefore the time to spray 1 acre would be 24 minutes. If treatment requires is 5 gallons per acre, then the setting that requires 72 seconds to fill a 1-quart measure should be set on the flow-control valve.

(6) From the calibration record (page 6), select the setting for which the time is closest to the value obtained in Step 5. As mentioned earlier, most flow-control valves are continuously variable, so an intermediate setting can, if necessary, be selected to give a closer approximation to the required application rate.

(7) Verify the setting by refilling the tank to the very top with water, setting the flow-control valve as determined in Step 6, and then spraying the sample area. Find out how much water is needed to replace the amount used. Multiply by 10 (or 4, depending on the size of the test area), the result should equal the number of gallons to be applied per acre.

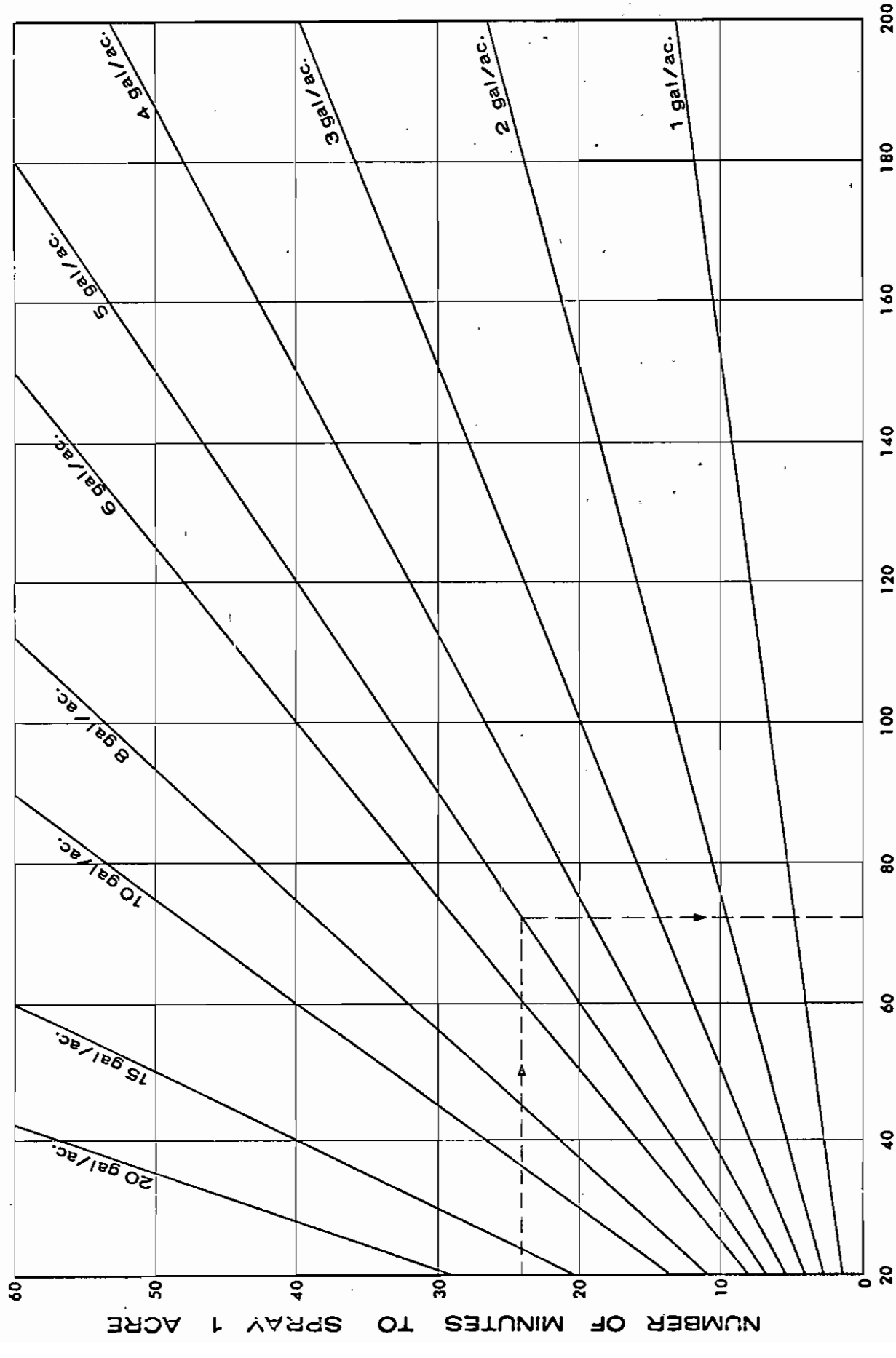


Figure 3. Calibration chart.

Record of Spraying Operations

Keep a record of all spraying operations. Carefully maintained spraying records can often help identify reasons for success or failure of a particular treatment, and may be useful if the spraying operation results in some legal action later. At least the following information should be recorded:

Date of operation

Time spraying began and ended

Area sprayed - Location

Area in acres

Objective of spraying

Pesticide used - Kind

Total amount

Weather - Temperature

Wind speed and direction

Amount and duration of rainfall within 24 hours

Results obtained

APPLICATION TECHNIQUES

Insecticides

Insect populations are usually distributed fairly uniformly on the trees throughout an infested area and, for good control, the treatment should be applied to trees all over the area. Most insect damage progresses very rapidly and if some trees are missed, follow-up treatment may be too late to be effective.

To get complete coverage without wasted effort, the area should be treated systematically by blocks or strips. Conventional spray systems use enough spray to wet the foliage and it is not difficult to determine which parts of a stand have been sprayed. Because mist blowers use much lower volumes of spray, it is often impossible to detect any spray deposit on the foliage (do not wet the foliage because of the high concentration of pesticide). Thus it is essential to mark out clearly defined units before starting to spray.

If the area is already divided into blocks by roads, trails, streams, or other boundaries, it may be convenient to treat one block at a time. If the blocks are small enough, no further division will be required. Larger blocks should be divided into parallel strips, generally no more than 20 to 30 feet wide. In a plantation, one may walk along every third or fourth row, but in a natural stand it will generally be necessary to mark the strips with paint, blazes, or flagging tape. Cleared trails make walking easier and, in an intensively managed area such as a Christmas-tree stand, it would be worth preparing such trails in advance of spraying. Mist spraying should always be done when air is calm or when only a light breeze is blowing, and under these conditions the direction of the strips will not matter much. However, it is easier and safer to walk along contours than up and down hill, and there are some advantages to spraying in the downhill direction.

For best coverage, the nozzle should be elevated at an angle of about 45 degrees and directed to one side as the operator walks along the edge of the strip, allowing the droplets to drift over and through the tree crowns and settle upon the foliage. Stop spraying when moving from one strip to another. Either of the two travel patterns shown in Figure 4 may be used. Pattern 1 gives a complete and uniform coverage, especially if a breeze is blowing across the strips. In that event,

spraying should begin on the down-wind side and the nozzle should be directed down-wind. Pattern 2 requires less flagging or trail cutting but is likely to give less uniform coverage and a cross-wind might carry insecticide onto the operator. If the strips are not too wide, a light breeze blowing *along the strips* will not seriously affect the coverage obtained with either pattern.

The mist blower should normally be operated with the engine running at full throttle to produce a uniform pattern of fine droplets. At reduced engine speeds, coverage is likely to be less complete, but when drift is a problem, it may be necessary to use a lower speed (see Control of Drift, page 14).

Herbicides

In most brush control work, the same travel patterns are used as in insecticide application. However, if there are only patches or scattered clumps of brush to be treated, strips may not be necessary. An area of brush measuring 60 feet across, for example, could be treated by walking around it with the nozzle directed at the center. If a larger area of brush is to be treated, the higher volumes of spray normally used for brush control may wet the foliage well enough for the operator to see where the spray has been applied and thus strip marking would not be necessary. Any missed areas can be dealt with in a follow-up treatment.

When resistant species, such as red maple, form part of a stand of more susceptible species, another variation can be introduced. The spray mixture can be made up for the susceptible species and applied in the manner described, but when a clump of the resistant species is encountered, the operator can direct the air blast at the clump, using a "painting" motion to ensure that the stems and foliage are thoroughly covered.

Mist blower techniques for applying herbicides to control grass and herbaceous weeds in young plantations and before planting have not yet been developed. Therefore, do not use your mist blower for this purpose until more information is available.

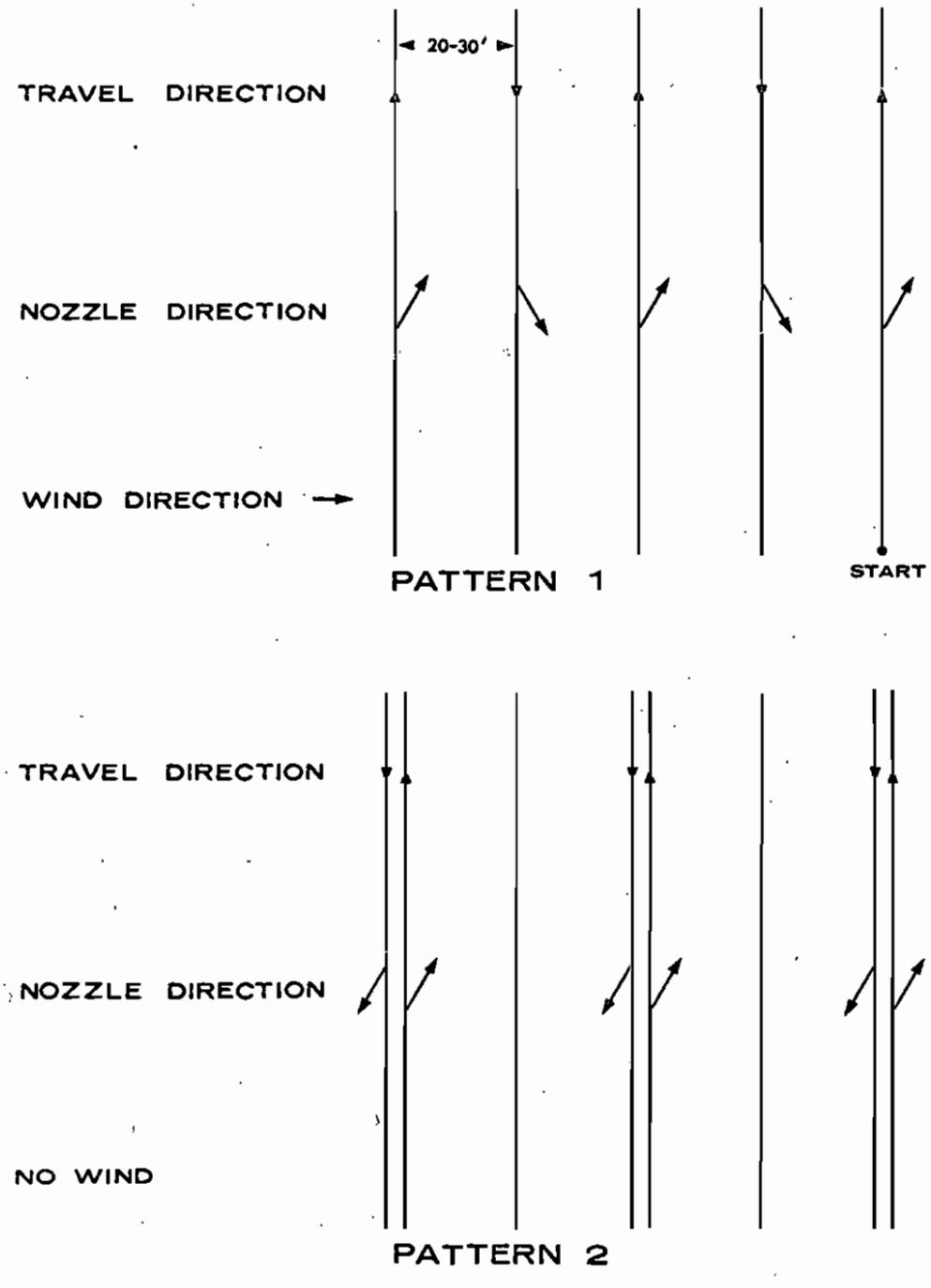


Figure 4. Travel patterns which may be used when spraying.

SAFETY PRECAUTIONS

Pesticides are chemicals which kill many organisms injurious to man, his crops, and domestic animals. They include insecticides to kill harmful insects, and herbicides to kill unwanted vegetation. They will also kill beneficial insects and fungi, wildlife, domestic animals, food and other crops, and ornamental plants. Therefore, care must be taken to ensure that only the pests are exposed to lethal dosages.

Because the mist blower breaks the spray material into very fine droplets, it is potentially dangerous to the operator and to various life forms both within and without the treatment area. For example, droplets may be inhaled by the operator or deposited on his skin; they may move considerable distances through the air and cause lasting damage to animal and plant life. The following precautions *must* be taken to avoid or minimize such undesirable effects.

Control of Drift

Spraying should, when possible, be confined to the early morning and evening hours when the air is still and when there are no ascending air currents. On cool, cloudy days, the period of use can be extended. Spraying should never be attempted when winds exceed 2 or 3 miles per hour (barely detectable) nor when the air temperature is more than 80°F.

Even under favorable weather conditions, some drifting may occur. It can be reduced by running the engine at half throttle to produce larger droplets. At lower engine speeds, the spray will not travel so far and spray strips may be narrower than usual. Another method of producing large droplets is by using a higher delivery rate. To do this without wasting chemical, a more dilute mixture is necessary meaning that more spray material will have to be carried. *Both* precautionary measures may be necessary, thus further reducing operational efficiency.

Operator Safety

Some pesticides are extremely toxic to man, and even those which are not regarded as dangerous can cause harm if swallowed, inhaled, or allowed to remain on the skin for more than a few minutes. The mist blower uses highly concentrated mixtures and it is not always possible to avoid inhaling the fine droplets released into the air. Therefore, all

possible precautions should be taken. While handling, mixing, and applying pesticides, protective clothing should be worn, including neoprene rubber gloves, waterproof boots, coveralls, and goggles or a close-fitting eye shield. Coveralls should be washed frequently. If the spray job takes more than a few hours, a waterproof suit should be worn instead of coveralls. While running the machine, the operator should wear a respirator; one with twin cartridges will permit easier breathing than one with a single cartridge. Filters should trap and absorb acid and organic vapors.

Some protective devices recommended by two safety equipment dealers are listed in Appendix B. Equally effective items may be stocked by other dealers and their help should be sought in selecting your requirements.

Pesticides and Their Hazards.

Pesticides vary greatly in their toxicity to different animals, as well as to humans. For example, DDT is not very toxic to dogs, but it is lethal to cats. A few pesticides are non-toxic, most are moderately toxic, and some are extremely toxic. *Every pesticide should be considered as potentially dangerous and treated accordingly.* Users of pesticides should study the precautions and directions on the labels of containers *before opening the package.*

Toxicity of pesticides is expressed in two ways: *oral toxicity*, which refers to the effects of the chemical when it enters the body through the mouth, and *dermal toxicity*, which refers to its effects when it is absorbed through the skin. Relative toxicities are expressed as the amount of poison (in milligrams per kilogram of body weight) required to kill 50 per cent of rat or mouse populations (called LD_{50}). The relationship between LD_{50} values and probable lethal dosages for a 150-pound man are shown in the following tabulation.

Acute oral toxicity (LD_{50})	Hazard rating	Probable lethal dosage for a 150-pound man
10 or less	Extreme	A taste (less than 15 drops)
11 - 20	High	15 drops to ½ teaspoons
21 - 100	Moderate	½ to 2½ teaspoons
101 - 500	Low	2½ teaspoons to 1 fluid ounce
500 or more	Very low	More than 1 fluid ounce

The LD_{50} values (oral) for the most common chemicals used against pests of Christmas trees in the Maritimes, including those mentioned in this manual, are:

Pesticide	LD_{50} Value	Hazard rating
Insecticides and Miticides		
Dimethoate (Cygon, Rogor)	215 (30[a])	low and moderate
Diazinon	135	low
Fenitrothion (Sumithion)	250	low
Chlordane	335	low
Dylox	595	very low
Carbaryl (Sevin)	850	very low
Kelthane	1100	very low
Malathion (Cythion)	1375	very low
Genite	1400	very low
Methoxychlor	6000	very low
Herbicides		
2,4,5-T	100	moderate
Paraquat (Gramoxone)	207	low
2,4-D	450	low
Trichloroacetic acid (TCA)	3320	very low
Simazine	5000	very low

[a] LD_{50} for humans.

The dermal toxicity LD_{50} values for most of the pesticides listed are higher than their oral toxicity values. In other words, it is less dangerous to spill them on the skin than to swallow them. Nevertheless, contamination of skin or clothing should be avoided. Relatively small quantities of some chemicals can cause discomfort, skin rash, and possible internal disorders. The eyes and mucus membranes of the nose, mouth, and lips are especially vulnerable, and lung tissues are easily damaged by inhalation of particles of some of the more toxic pesticides.

Recommendations for safe-guarding the health of those handling and applying pesticides are given below.

Precautions in Handling and Using Pesticides

(1) Follow instructions on labels of containers, especially those for precautions and antidotes.

(2) Use water-proof jacket and trousers, rubber boots, neoprene rubber gloves, and goggles while mixing pesticides and a respirator fitted with the proper cartridge to filter out fine droplets and spray vapors while spraying.

(3) Mix pesticides in an open area where ventilation is adequate, *never indoors*.

(4) Avoid swallowing pesticides or inhaling the mist or fumes; never use the mouth to siphon pesticides from one container to another.

(5) Avoid spilling pesticides on skin or clothing; if it happens remove contaminated clothing immediately and wash exposed skin thoroughly with soapy water; keep soap and clean clothing on hand in field in case of accidental spills.

(6) Do not smoke while mixing or applying pesticides.

(7) Wash hands frequently, especially before eating, drinking, or smoking.

(8) Remove clothing after using pesticides and bath with plenty of warm soapy water. Before wearing again, wash work clothes using a detergent.

(9) Clean respirators between operations; wash or replace filters or filter cartridges at intervals recommended by the manufacturer.

(10) Store application equipment beyond reach of children and livestock.

(11) Keep pesticides in their original, labelled containers (never in containers used for food or drink) and store in room or cabinet that can be locked.

(12) Crush or break empty metal or glass containers and bury at least 18 inches deep and well away from water supplies; *never* place them in garbage cans or dumps accessible to children or animals. Bury empty paper containers, unwanted spray mixtures, or deteriorated pesticides.

(13) If symptoms of poisoning become evident during or shortly after spraying, contact the local Poison Control Center listed inside the cover of the telephone directory.

PESTICIDE FORMULATIONS

How to Mix Them

The pesticides most commonly used for control of Christmas-tree pests are sold either as emulsificable concentrates (labelled E or EC), wettable powders (WP), or soluble powder (SP).

An emulsifiable concentrate consists of a technical grade poison dissolved in oil or some other suitable solvent with an emulsifier added. These are used as water emulsions, in which the oil is evenly dispersed in minute droplets in the water. The best method of mixing an emulsion is to stir the desired amount of concentrate in an equal amount of water in a container, such as a pail, and then add this mixture to about a half-tank of water while stirring it. When a uniform milky emulsion has formed, fill the tank. Water emulsions require frequent agitation. Occasionally an emulsion may become "broken" or separated if the water is hard or if the spray mixture is allowed to stand for a long period. Therefore, do not prepare more spray than is required for 1 day.

Some oils used as solvents are toxic to plants and, if not completely emulsified, the floating oil may damage the plants being protected. The highly concentrated insecticide mixtures used in mist blowers can damage the foliage if applied at rates higher than those recommended; therefore, do not point the nozzle directly at the tree at close range nor allow it to remain stationary for more than a few seconds.

A wettable powder is produced by mixing finely milled particles of the technical grade poison with an inert material that is readily wettable. A wetting agent is often added to improve dispersion of the powder in the water. Weigh amount of wettable powder desired for a treatment, mix in a little water to make a thin paste, then add to the required amount of water. Wettable powders require almost constant agitation to keep the particles in suspension. Movements of the mist blower while in operation usually provide sufficient agitation, but if the machine is stationary, even for a few minutes, with the spray mixture in the tank, the mixture should be stirred thoroughly before resuming spraying. Similarly, the mixture in the mixing tank must be stirred before refilling the mist blower tank.

Soluble powder is, as the name suggests, a finely ground powder that will dissolve in water. Add the required amount of powder to slightly less than the required amount of water, mix until the powder is dissolved,

and then add water to make up the specified amount of spray.

Spray Mixtures for Mist Blowers

For effective results, the correct amount of active ingredient must be incorporated in the spray mixture for the particular treatment desired. If the quantity of pesticide is insufficient, the treatment will be ineffective; if an overdose is applied, it may waste money or injure the crop being protected.

Appendix C includes notes on the more common pests, and suggests dosages for the various pesticides used to control them. These should be followed carefully. For problems not covered in the Appendix, refer to the manual "Christmas Tree Management in the Maritime Provinces -- Part 2: Common Insects and Diseases and Their Control", or contact the Tree Pest Extension Officer, Canadian Forestry Service, P. O. Box 4000, Fredericton, N. B.

The directions on product labels are usually for mixtures used in hydraulic (high volume) spraying systems and are much less concentrated than mixtures used in mist blowers. They will not be effective if applied at the spray volumes recommended for mist blowers.

Measuring Equipment

Wettable powders are measured in pounds and ounces (avoirdupois). An accurate scale or balance should be used (balance the container on the scale before placing the material in it). For measuring liquids, four measures are required -- gallon, quart, pint, and cup graduated in fluid ounces. Measures should be kept exclusively for pesticides and should be carefully cleaned before being placed in storage.

Table of Imperial Liquid Measure

1 tablespoon	3 teaspoons
1 fluid ounce	2 tablespoons
1 cup	8 fluid ounces
1 pint	$2\frac{1}{2}$ cups or 20 fluid ounces
1 quart	2 pints or 40 fluid ounces
1 gallon	4 quarts or 160 fluid ounces

APPENDIX A. Some Mist Blowers Available in the Maritimes

(Listed in alphabetical order)

Make	Model	Approximate price	Distributor[a]
Arimitsu	MD-35DX	$190	Charles H. Dearborn & Co. 171 Rothesay Avenue Saint John, N. B.
Kinkelder	1.7 hp 3 hp	$170 $190	Klear Bright Farms Co-operative Mouth of Keswick, York Co., N. B.
KWH	26M	$270	Charles H. Dearborn & Co. 171 Rothesay Avenue Saint John, N. B.
Solo	Junior 410 Port 423	$180 $255	Lansdowne Nursery 56 Lansdowne Street Fredericton, N. B.
Stihl	SG17	$260	Stihl Chain Saw Dealers

a. All distributors supply parts and service, except Charles H. Dearborn & Co. who supply only parts.

APPENDIX B. Protective Clothing and Equipment

Note: The items listed below have been recommended by two safety equipment dealers in the Fredericton area for use with mist blowers. They have not been tested by the Canadian Forestry Service. Prices shown are wholesale and as quoted by the dealer.

Waterproof Clothing		Price	Dealer
"Duralite" nylon and neoprene suit --	Jacket	$11.25	A
	Overall	11.25	
	Hood	2.35	
"Vinylon" rubberized nylon suit --	Jacket	8.95	A
	Pants	8.95	
"Canuck" rubberized nylon suit --	Jacket	9.15	B
	Overall	8.75	
	Hood	2.70	
Respirators			
M-S-A Gasfoe Respirator with single GMC cartridge		10.95	A
M-S-A Custom Comfo Respirator with twin GMC cartridges		10.95	A
GMC cartridges (each)		1.75	A
Welsh single cartridge respirator		5.85	B
Welsh double cartridge respirator		8.70	B
Cartridges for Welsh respirators (4 per box)		4.00	B
Goggles			
"Fog Ban" non-perforated softside goggles		3.95	A
Non-perforated softside goggle		2.15	A
"Allsafe Monogoggle" with chemical vent		1.95	B

APPENDIX C. Notes on control of some of the more common pests

BALSAM-FIR SAWFLY

The balsam-fir sawfly is a native species with a wide distribution in Canada and the United States. Its preferred food plant is balsam fir but it also feeds on spruce. Injury is caused by the larvae feeding on mature foliage. Severe infestations, when prolonged, can kill trees. However, the trees usually are not killed, but they suffer loss of radial growth and may be weakened, rendering them more subject to attack by other insects.

The insect spends the winter as an egg which hatches in June. The larvae, which feed in colonies on the old needles, complete their development in late August. The head is black and the body dull green, marked with darker longitudinal stripes. After the last molt, when the larvae are about ¾ inch long, the color fades considerably. At this time, they spin reddish-brown cocoons among the needles on the twigs and in the litter on the ground. The adults emerge in early September and, soon after, the female deposits her eggs in slits cut in the needles with a saw-like ovipositor.

Control

The balsam-fir sawfly can be killed by spraying the trees with an insecticide as soon as the insects are noticed. One of the following mixtures at about 5 gallons per acre is suggested.

Insecticide	Per acre		Quantity of pesticide required for following amounts of spray --		
	Active ingredient	Approx. cost	1 gallon	2½ gallons	5 gallons
Malathion 50 EC	1¼ lb.	$3.70	6 fl. oz.	16 fl. oz.	32 fl. oz.
Sevin 80 W	1 lb.	$1.50	4 oz.	10 oz.	1¼ lb.
Sevin 50 W	1 lb.	$1.70	6½ oz.	1 lb.	2 lb.

BALSAM GALL MIDGE

The balsam gall midge is a native insect that periodically occurs in large numbers over wide areas of Canada and the northeastern United States. It causes galls on the new needles of balsam fir. Infested needles turn yellow and drop in October and November, resulting in devaluation of trees selected for the Christmas market. However, if the larvae die when the galls are still small, development of the galls will cease and the needles will remain green and not drop prematurely.

In light infestations, there is usually only one gall per needle but when population levels are high there may be as many as six per needle. The insect seldom causes serious injury to trees, and if infested trees are not cut until after the outbreak subsides, they usually recover and become suitable for the Christmas trade within 3 years.

The insect overwinters in the soil as a mature larva. It pupates in the spring and, in central New Brunswick, the adult emerges from about 20 May to 20 June. The female lays eggs between the needles of partly opened buds. The young larva settles down near the base of a needle, and a gall forms within which the larva develops during the summer. Between mid-September and mid-November, the larva leaves the gall and drops to the soil where it hibernates.

Control

Control of the midge is not simple because the larvae, entombed in the galls, are protected from most contact insecticides. To be effective, the chemical must penetrate the needle tissue or have systemic action (be absorbed into the plant, making it poisonous to insects when eaten). Tests, however, indicate that serious damage to balsam fir can be prevented by spraying the trees with either Malathion or dimethoate immediately after the galls begin to form (usually between 10 and 20 June in central New Brunswick). Malathion, however, is not effective at temperatures below 65°F, therefore it should not be applied when the air temperature is not likely to rise above 65°F on the day of treatment. One of the following spray mixtures, applied at about 5 gallons per acre, is suggested.

Pesticide	Per acre: Active ingredient	Per acre: Approx. cost	Quantity of pesticide required for following amounts of spray -- 1 gallon	$2\frac{1}{2}$ gallons	5 gallons
Malathion 50 EC	2 lb.	$7.40	13 fl. oz.	32 fl. oz.	64 fl. oz.
Dimethoate[a]	1 lb.	$6.25	6 fl. oz.	16 fl. oz.	32 fl. oz.

[a] Trade names are Rogor 40 and Cygon 2E and 4E; if Cygon 2E is used, the amounts shown should be doubled. Cost is given for Cygon 4E.

BALSAM TWIG APHID

The balsam twig aphid feeds on the new shoots and needles of balsam fir, causing the ends of the shoots to twist and the needles to curl. Severe infestations give the foliage a ruffled appearance. Trees growing in the open are more susceptible to attack. Infestations become obvious in late June when many fir shoots are covered with a sticky "woolly" substance. Damage by the insect sometimes lowers the quality of Christmas trees.

The insect has three and sometimes four generations between early May and mid-July; throughout the rest of the year, it is in the egg stage. The nymphs of the first generation develop from the overwintering eggs and are small (2 mm long) and wingless. They feed around the bud, mostly on the old needles, and do little or no damage. They occur in small numbers and are not often noticed. However, each adult produces 40 to 60 offspring (nymphs) mostly in early June.

The second (and third) generation aphids suck the juice from the new needles and cause permanent deformation. This is the peak generation. The young aphids secrete masses of waxy wool and large quantities of "honeydew" which makes the shoot "woolly" and sticky. The aphids mature in the second half of June as winged but wool-free adults about 3 mm long. After flying to other balsam fir trees, each adult produces about 10 living young.

The fourth generation consists of males and females, minute (1 mm or smaller), wingless, and lightly "woolly". They conceal themselves in the shoots, feed lightly, and become adults about 1 week after birth. Each female lays one or two black eggs around the buds and covers them with white wax scales. These eggs hatch the next May.

Control

The insect can be killed by spraying the trees with a contact or systemic pesticide as soon as the buds begin to swell and show green (20 to 31 May in central New Brunswick). A second application may be necessary about 10 days later if aphids are still numerous. Timing of the spray application and thorough coverage are both important. The pesticides suggested are Diazinon or dimethoate. The mixtures given below are based on a rate of about 5 gallons of spray per acre.

	Per acre		Quantity of pesticide required for following amounts of spray --		
Pesticide	Active ingredient	Approx. cost	1 gallon	2½ gallons	5 gallons
Diazinon 50 EC	¾ lb.	$4.00	5 fl. oz.	12 fl. oz.	24 fl. oz.
Dimethoate[a]	1 lb.	$6.25	6½ fl. oz.	16 fl. oz.	32 fl. oz.

a - Trade names are Rogor 40 and Cygon 2E and 4E; if Cygon 2E is used, the amounts shown should be doubled. Cost is given for Cygon 4E.

SPRUCE BUDWORM

The spruce budworm is one of the most destructive insects of softwoods in eastern Canada. During outbreaks, the larvae may destroy most or all the new foliage. Christmas trees are seldom killed unless growing near large trees, but they may be sufficiently damaged to be down-graded or rejected.

The insect overwinters as a small larva in a silk web on the twigs or branches. About the time the buds begin to swell, the larvae emerge from their webs and begin to feed, mining in the old needles first then in the developing buds. When fully grown, about 15-30 June, the larva spins a thin web among the needles; it is about 1 inch long and pale brown with light spots. It transforms into a brown pupa within the web and the adult emerges about 10 days later. The moth is usually dull grayish-brown and about $\frac{5}{8}$ inch long. The eggs are laid during late July, and are light green and deposited in groups of 15 to 50, overlapped in rows on the needles. The eggs hatch after about 10 days and the young larvae moult once and then hibernate until the next spring.

Control

To protect Christmas trees, it is necessary to kill the larvae before they cause noticeable defoliation. When an outbreak of budworm is expected, growers should examine the buds every 2 or 3 days, as soon as they begin to open in late May or early June. If small larvae are numerous, spray as soon as the needles are flaring (usually between 1 and 10 June, in central New Brunswick). If all the larvae are not killed, a second application may be necessary about 5 days later when larvae are about $\frac{1}{2}$ inch long and more exposed. A delay in spraying may well result in considerable loss of new foliage. For control of budworm one of the mixtures listed below, at about 5 gallons per acre, is suggested.

Dimethoate lasts longer than Malathion and therefore may be more effective; Dylox is intermediate between them. Malathion is not effective at temperatures below 65°F and should not be used when the air temperature is not likely to rise above 65°F on the day of treatment.

Insecticide	Per acre		Quantity of pesticide required for following amounts of spray --		
	Active ingredient	Approx. cost	1 gallon	2½ gallons	5 gallons
Dylox 80 SP	¾ lb.	$1.75	3¼ oz.	½ lb.	1 lb.
Dimethoate[a]	1 lb.	$6.25	6 fl. oz.	16 fl. oz.	32 fl. oz.
Malathion 50 EC	1¼ lb.	$3.70	6 fl. oz.	16 fl. ox.	32 fl. oz.

a - Trade names are Rogor 40 and Cygon 2E and 4E; if Cygon 2E is used, the amounts shown should be doubled. Cost is given for Cygon 4E.

WHITE-MARKED TUSSOCK MOTH

This native insect occurs periodically in large numbers. It is primarily a pest of hardwood trees, but when populations are high, it also feeds on softwood species, including balsam fir and spruce species. It may cause extensive damage to Christmas trees and sometimes kills them.

The insect overwinters as an egg on branches, crevices of buildings, or wherever the fully grown caterpillar crawled to spin its cocoon. The eggs hatch in late June or early July. The caterpillar has a red head, two long black tufts of hair on each side of the head and one near its hind end, and four greyish brush-like tufts and two bright red spots on its back. The caterpillars feed for about 6 weeks, growing to about 1½ inches long. They spin loose grey cocoons within which they transform to pupae. Grayish moths emerge about 2 weeks later. The males are winged and the females are wingless. The female lays its eggs on or near the cocoon.

Control

If the insect is abundant, control measures should be undertaken before the caterpillars become too large. The best control is obtained when the larvae are about ½ inch long, usually early in July. Later applications of pesticide are not as effective because larger caterpillars are more difficult to kill. One of the following mixtures at about 5 gallons per acre is suggested.

Pesticide	Per acre		Quantity of pesticide required for following amounts of spray --		
	Active ingredient	Approx. cost	1 gallon	2½ gallons	5 gallons
Dylox 80 SP	1 lb.	$2.00	4 oz.	10 oz.	1¼ lb.
Sevin 4 Fl.	1 lb.	-[a]	6 fl. oz.	16 fl. oz.	32 fl. oz.
Sevin 80 W	1 lb.	$1.50	4 oz.	10 oz.	1¼ lb.
Sevin 50 W	1 lb.	$1.70	6½ oz.	1 lb.	2 lb.

a - No price available, estimated at $2.00 per acre.

ALDER, BIRCH, PIN CHERRY, AND ELDERBERRY

Control of the above species can be obtained with 3 pounds (acid equivalent) of 2,4-D herbicide per acre. Use of this herbicide is suggested because of its low cost and because it is not, at present, subject to public criticism which has restricted the use of 2,4,5-T.

Purchase only low-volatile esters of 2,4-D, since these are less likely to vaporize and cause damage outside the sprayed area. *Do not* buy amine formulations. Some trade names are: Weedone LV-4; Esterone 6E; Chipman 2,4-D Ester 80 (LV).

Mix the herbicide with water according to the following table, having determined from the product label the acid equivalent value, in pounds or ounces, of the product purchased. Each mixture provides 3 pounds of active chemical in 5 gallons of spray mixture.

Acid equivalent per Imperial gallon of commercial product		Amount of commercial product required for following amounts of spray --		
lb.	oz.	2½ gallons	10 gallons	25 gallons
4	64	3 pts	1 gal + 2 qts	3 gals + 3 qts
	76.8	1 qt + 1 cup	1 gal + 1 qt	3 gals + 1 pt
5	80	1 qt + 1 cup	1 gal + 1 qt	3 gals
6	96	1 qt	1 gal	2 gals + 2 qts
7	112	1 pt + 2 cups	3 qts + 2 cups	2 gals + 2 cups

Apply to the foliage at the rate of 5 gallons per acre.

Timing. For best results apply after full leaf development when brush is growing vigorously. *Do not* apply during or immediately after extended periods of dry weather. In Christmas tree stands, apply after the beginning of August when new growth of conifers has hardened off.

Approximate cost of chemicals - $3.00 per acre

RESISTANT HARDWOOD SPECIES

Mixtures containing 2,4-D and 2,4,5-T (often referred to as brushkillers) are more effective than 2,4-D alone in controlling many hardwood species, including the aspens and maples. The application rate suggested should give good control of these relatively hard-to-kill species.

Purchase only the low-volatile ester formulations, since these are less likely to vaporize and cause damage outside the spray area. Some trade names are: Weedone Brushkiller 2:1; Esteron 3-3E; Chipman Brushkiller 96.

Mix the herbicide with water according to the following table, having determined from the product label the *total* acid equivalent value, in pounds or ounces, of the product purchased. Each of the spray mixtures provides 5 pounds of active material in 5 gallons of the spray mixture.

Total acid equivalent per Imperial gallon of commercial produce		Amount of commercial product required for following amounts of spray --		
lb.	oz.	2½ gallons	10 gallons	25 gallons
4	64	2 qts + 1 pt	2 gals + 2 qts	6 gals + 1 qt
	76.8	2 qts	2 gals + 1 pt	5 gals + 1 qt
5	80	2 qts	2 gals	5 gals
6	97	3 pts + 1 cup	1 gal + 3 qts	4 gals + 1 cup
7	112	3 pts	1 gal + 2 qts	3 gals + 2 qts

Apply to the foliage at the rate of 5 gallons per acre.

Timing. For best results apply after full leaf development when brush is growing vigorously. Do not apply during or immediately after extended periods of dry weather. In Christmas tree stands, apply only after the beginning of August when new growth of conifers has hardened off.

Approximate cost of chemicals - $8.00 per acre