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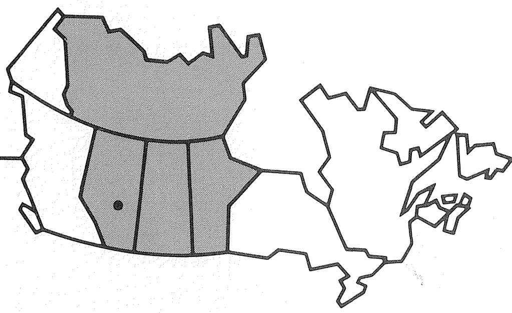
R.G. Newstead and R.J. Lieskovsky



Information Report NOR-X-273
Northern Forestry Centre

AIR TANKER AND FIRE RETARDANT DROP PATTERNS

R.G. Newstead and R.J. Lieskovsky[1]

INFORMATION REPORT NOR-X-273

NORTHERN FORESTRY CENTRE
CANADIAN FORESTRY SERVICE
1985

[1] Present Address: Alberta Forest Service, Box 7040, Postal Station M, Edmonton, Alberta T5E 5S9.

Catalogue No. Fo46-12/273E
ISBN 0-662-14323-X
ISSN 0704-7673

This publication is available at no charge from:

Northern Forestry Centre
Canadian Forestry Service
5320 - 122 Street
Edmonton, Alberta
T6H 3S5

Newstead, R.G.; Lieskovsky, R.J. 1985. *Air tanker and fire retardant drop patterns*. Can. For. Serv., North. For. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-273.

ABSTRACT

Air tanker and fire retardant products were evaluated during 1967–80 to determine ground distribution patterns under a variety of drop conditions. This report provides background information on air tankers and drop pattern testing and describes the data collection, compilation, and analysis procedures of the evaluation program. The major factors influencing ground distribution patterns are the tank and gating systems, wind speed and direction, drop height and speed, retardant properties, and forest canopy interception.

RESUME

De 1967 à 1980, on a évalué des avions-citernes et les retardateurs chimiques pour déterminer la répartition au sol de ces produits dans une foule de conditions de largage. Le rapport donne des renseignements généraux sur les avions et les essais de largage puis décrit la collecte, la compilation et l'analyse des données d'évaluation. Les trois principaux facteurs qui influent sur la répartition au sol sont le réservoir et les conduites de largage, la vitesse et la direction du vent, la hauteur et la vitesse de largage, les propiétés du retardateur et l'interception par le couvert forestier.

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NOTE

The exclusion of certain manufactured products does not necessarily imply disapproval, nor does the mention of other products necessarily imply endorsement by the Canadian Forestry Service.

INTRODUCTION

Aircraft have played an increasingly important role in forest protection since the end of World War I. Following World War II, the use of aircraft in activities related to forest fires increased to the point where, today, fire detection and suppression objectives could not be readily attained without them.

Among the various functions served by aircraft since their introduction to forest protection, aerial tankers have probably received the most attention during the 30 or so years that they have been in active service. Numerous reports and publications document and discuss everything from tank modifications to operational strategies. Simard and Young (1977) prepared a comprehensive bibliography on air tanker related publications with over 700 references.

This publication deals with the general subject of aerial drop tests and provides a brief perspective on the evaluation of air tankers and the development of the drop pattern evaluation program at the Northern Forestry Centre (NoFC). During 1967–80 more than 180 drop pattern tests were conducted under a variety of drop conditions with several types of air tankers and fire retardants, including both long-term chemicals and short-term water thickeners. The results of these tests, the details of which are appended to this report, are referred to in the discussion of ground distribution patterns and the factors that influence their outcome. Where possible, examples are presented and displayed. This report consolidates several years of research and evaluation, although data limitations confine the presentation of specific conclusions and recommendations.

BACKGROUND

Initial attempts to use air tankers date back to the 1930s; however, these trials were largely experimental and the results did not support operational acceptance. During the 1940s and 1950s, the Ontario Department of Lands and Forests experimented with float tanks and water-filled bags for dropping water on forest fires. In the United States during this period, tests with water-filled surplus fuel tanks were abandoned because of the hazards they posed to ground crews (Simard and Forster 1972).

During the 1950s, World War II bombers and fighter-bombers were converted, and evaluation of water and retardant drop patterns was initiated (Simard and Forster 1972). Air tankers quickly became an accepted fire fighting tool in both Canada and the U.S., and the development and modification of water and retardant delivery systems were well under way. This trend has continued to the present and includes the more recent development of role-specific air tankers such as the Canadair CL-215 and the conversion of postwar military and civilian aircraft such as the C-S2F Tracker and the Douglas DC-6B.

Although the aeronautics of air tankers have received much attention, it is really the onboard delivery (tank and gating) system that accounts for the performance of a given aircraft as a retardant delivery platform. In addition, factors such as retardant physical properties, operational conditions (drop height and speed, topography, flight safety, maneuverability), and environmental circumstances (wind, humidity, fire regime, smoke, forest canopy) critically influence the performance of aerial tankers. From the instant a load is released until the moment it comes to rest on a given fuel complex, the combined influence of the preceding parameters and the delivery system determines the size, shape, recovery, and eventual effectiveness of a retardant ground distribution pattern (Fig. 1).

Aerial drop tests are a means of assessing the nature and extent of the influence of these individual or combined factors that dictate how a retardant mass will be distributed on the ground. Retardant or water drop testing for pattern evaluation has been an ongoing research activity in North America for the past 25 years. The results of these tests have led to real improvements in the physical properties of retardants, tank and gating systems, and load release strategies. In addition, a better understanding has evolved of the many and varied factors influencing the drop environment (i.e., load breakup, descent, canopy penetration, and fuels coating). Research results and ground pattern responses indicate that while some factors are controllable, others such as environmental and fuels characteristics are beyond human or mechanical control.

Some early drop testing programs were reported by Storey et al. (1959), Davis (1960), Williams (1962), Hodgson (1967), MacPherson (1967), and Grigel (1970, 1971a). Drop tests were conducted to quantify air tanker delivery-system-specific patterns in some cases (Grigel 1971b; Newstead 1973) and retardant-specific patterns in other cases (Grigel 1972a, b). In other

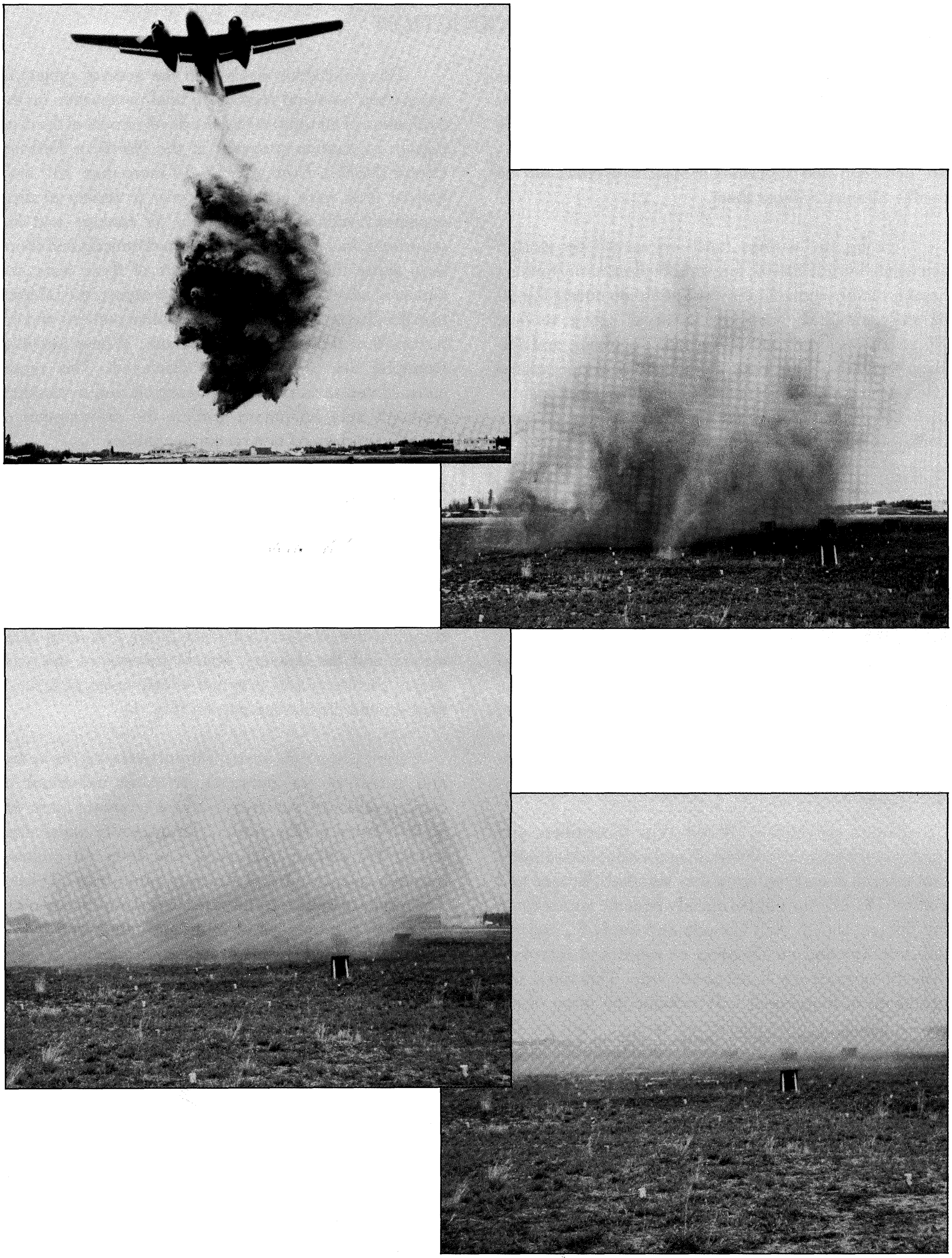

Figure 1. Delivery system and environmental factors affect the ground distribution pattern.

instances, drop tests were the only available means of assessing environmental factors, such as wind, that influence drop pattern responses (George and Blakely 1973). More recently the significance of tank and gating geometry, flow characteristics, and retardant rheological (physical) properties have been evaluated (George 1975; Swanson et al. 1978).

Static testing, a process developed to predict ground distribution patterns for water or retardant, measures the flow rate of retardant or water from an air tanker while parked (Blakely et al. 1982). This testing electronically monitors and records the almost instantaneous and simultaneous occurrence of events that comprise the release and exit of a load of water or retardant from an aircraft tank and gating system. Although MacPherson (1968) initially discussed the pioneer work in drop pattern prediction, it was the work of Swanson and Helvig (1973, 1974) 5 years later that showed that pattern simulations could be readily derived from static-tested air tankers. User guidelines for various air tankers soon evolved from these simulation studies (Swanson et al. 1975). Another significant outcome from the work of Swanson and Helvig (1973) was their recommendation that the development of cascade delivery systems continue in conjunction with work on improved retardant rheological properties. This led to the development and testing of an Experimental Tank and Gating System (ETAGS) to facilitate a better understanding of the effects of aircraft tank and gating characteristics on retardant dispersion and ground pattern formation (Swanson et al. 1978). A concomitant research effort in the U.S. was directed toward investigation of the rheological properties of aerial-delivered fire retardants (Anderson et al. 1974, 1976). This research was later extended to include the interaction of fire retardant droplets with fuel surfaces (Andersen and Wong 1978).

Over the years the air tanker industry developed a variety of tanker delivery systems to improve the release and distribution of retardants. This publication considers only the drop tests conducted by the Northern Forestry Centre for air tankers with rigid-door, cascade delivery systems. These systems consist of a tank, usually compartmented and shaped to conform with the structural design of the air frame, one or more drop gates or doors that make up the bottom of the tank, and ram or static air vents in the tank top to permit air replacement in the tank as the load is released (Grigel et al. 1975). Originally the rigid-door system was designed to be compatible with the existing bomb-bay doors on converted military aircraft. Subsequently belly-pod systems, also incorporating rigid-door systems, were mounted partially or entirely outside the aircraft fuselage.

The U.S. has several continuous-flow delivery systems on the market, some of which are constructed in association with rigid-door systems as trail doors on drop gates (e.g., C-119, B-17). The C-130 Hercules, however, carries an onboard pressurized modular tanking system known as a Modular Airborne Fire Fighting System (MAFFS), which discharges retardant continuously from two nozzles extending from the rear cargo door of the aircraft. In addition to these proven delivery systems, others have been conceived and, in some cases, developed to the prototype stage but have failed to gain acceptance (e.g., FIRETRAC—Fireline Extension by Transposition Refinement and Control, a flow regulation device located at the base of the tank; and the Membrane Tank System—a progressive release drop system with a membranous tank bottom and variable speed cutting mechanism).

PROCEDURES

Drop grid layout

The Northern Forestry Centre first conducted retardant drop tests in 1967 using slightly modified procedures from Hodgson (1967) and MacPherson (1967). These initial tests were designed to quantify drop patterns for the Snow Commander air tanker and Gelgard "F" short-term fire retardant. Drop grids were established in an open field and beneath a well-stocked lodgepole pine stand near Edson, Alberta. The open field grid system had an inner grid of 7.5-ft.^{2} (2.3-m^2) spacing and an outer grid of 10-ft.^{2} (3-m^2) spacing (Grigel 1970). In the pine stand the grid was a uniform 10-ft.^{2} (3-m^2) spacing as a labor- and cost-saving measure.

A similar series of tests in 1968 involved the Thrush Commander air tanker to determine ground patterns for Fire-Trol 100 and Phos-Chek® 205 long-term fire retardants (Grigel 1971a). These 10-ft.^{2} (3-m^2) drop grids were located (a) in an open field, (b) beneath a well-stocked lodgepole pine stand, and (c) beneath a mature, medium-stocked white spruce-aspen stand. Another series of tests was also conducted that year with a PBY-5A Canso and Gelgard "M" short-term fire retardant using 10 × 20 ft. (3 × 6 m) rectangularly

Figure 2. Typical layout of the NoFC sampling grid.

spaced grids established in (a) an open field, (b) a white spruce-aspen stand, and (c) a white spruce stand (Grigel 1972b).

A B-26 air tanker, introduced to Alberta in 1970, was used in another test series with both Fire-Trol 100 and Fire-Trol 931 long-term fire retardants (Grigel 1971b, 1972a). The grid layout format was slightly modified in 1973 for a series of drop tests with the DC-6B, A-26, and TBM air tankers using Phos-Chek® 202 XA long-term fire retardant (Newstead 1973). The new format involved staggered row and column spacing with 10 ft. (3 m) between containers along the rows and 20 ft. (6 m) between rows along the columns. Columns were offset half the distance (5 ft.; 1.5 m) of the row spacing, alternately for each column. This basic grid layout has remained unchanged, although the spacing was converted to exactly 3 and 6 m following the introduction of metric measurements. The NoFC sampling grid consists of 1000 open-ended cans 7.5 cm in diameter by 11 cm in length, each of which is mounted on a metal stake to hold it firmly in place near ground level (Fig. 2). Each container is identified in numerical sequence to accommodate the layout format of the test series. This allows overall grid dimensions to be changed within the 3 × 6 m spacing requirements to respond to drop test conditions that may vary according to factors such as tank and gating configurations, retardant rheological parameters, drop site constraints, and environmental conditions (e.g., prevailing winds).

Data collection

The grid is established at the selected site to best suit the performance of the aircraft involved, taking into consideration safety factors, approach and departure flight paths, prevailing winds, pilot orientation, and visibility. Before each drop, disposable cold drink containers compatible with the dimensions of the cans are numbered in a sequence corresponding to the grid layout and placed inside each grid container. Following each drop, team members immediately cap each cup containing a trace or more of contents, which minimizes evaporation from the cups while they are stored in cardboard boxes at the drop site prior to weighing. The cans are then refilled with numbered replacement cups in preparation for another drop.

Following several such drop collection procedures, the cup, lid, and contents of each cup are weighed, and the net weight of the contents is tallied for each drop. The net weight is determined by subtracting the predetermined average tare weight of the cup and lid from the gross weight of each cup, lid, and contents. The retardant volume recovered at each grid point can then be determined based on the weight and specific gravity of

Table 1. Volume conversions for retardant levels

Depth of retardant cm	Depth of retardant in.	Converts to	Litres per m²	Imperial gallons per 100 ft.²	U.S. gallons per 100 ft.²
0.005	0.002		0.05	0.10	0.12
0.01	0.004		0.1	0.20	0.24
0.05	.019		0.5	1.02	1.23
0.10	.039		1.0	2.04	2.45
0.20	.078		2.0	4.09	4.90
0.25	.098		2.5	5.11	6.13
0.30	.118		3.0	6.13	7.36
0.40	.157		4.0	8.17	9.81
0.50	.197		5.0	10.22	12.26
>0.50	>0.197		>5.0	>10.22	>12.26

the retardant product recovered. The used cups and the contents are discarded.

Observations and particulars recorded in conjunction with each drop are as follows:

1. Air tanker drop height is determined with a conventional height measuring instrument (hypsometer) from a position located at a right angle to the flight path near the point of load release.

2. Weather parameters such as wind speed and direction, relative humidity, and temperature are recorded.

3. Distance of the air tanker to the right or left of the center of the grid is determined for drop height calculation (corrected).

4. Photographic and videotape records are made for each drop.

The test series coordinator usually acts as communications officer to maintain radio contact with the air tanker pilot and ground personnel.

Data compilation and analysis

Data are compiled, analyzed, and interpreted following completion of the field portion of a drop test program. Before computerized techniques were introduced in 1973, this was done by hand. Cup recovery volumes were transferred to drop grid blueprints for all collection points recorded for each drop. Recorded values were interpolated to define isolines of predetermined uniform recovery levels, which were then drawn on the grid blueprint. The commonly used isoline values are presented in Table 1. The area within each contour class was determined by planimeter, and the length, width, and area of each contour level were measured. The percentage of the drop volume recovered on the grid was determined on the basis of the known sampling intensity of the grid. Load losses resulting from drift and evaporation between the point of release and ground contact were calculated.

Computer graphics make this entire process more efficient, and the uniformity of interpretation and presentation adds a new dimension to drop test programs. Raw data from field tally sheets are currently keypunched, and volume determinations, interpolation of results, pattern length, width, and area calculations, and percentage recovery are compiled by computer. Digital information is then transposed into a graphical presentation using a graphics software routine (e.g., CAL COMP). Drop pattern results can be presented in several perspectives and in three dimensions; however, operationally only a slightly elevated side view and a vertical (plan) view of each pattern are prepared. All drop patterns compiled to date have been reworked using this computer plotting technique to attain uniformity of presentation.

Appendix 1 contains a summary of drop pattern lengths and widths by depth of recovery for all fixed-wing air tanker ground response patterns compiled to date by NoFC. Additional information pertinent to each pattern, such as air tanker type, retardant type, volume dropped, and height and speed measurements, is also presented. Because of the bulk of information involved, the actual patterns are not included in this publication, but copies of specific patterns may be obtained from the Northern Forestry Centre upon written request. Requests must indicate the drop number; drop test day, month, and year; and air tanker type.

Drop test results are compiled and presented in both graphical and tabular formats to permit analysts to visualize the ground response pattern in either the plan or perspective view of the contour lines that represent the different depths of coverage or levels of recovery. Summary statistics may also be derived, for example, to show pattern size and shape irregularities or concentration levels.

The results of all drop tests conducted by NoFC have been tabulated for drop-specific factors (i.e., air tanker type, volume, drop mode, and drop height speed and direction) and retardant-specific parameters (product name, viscosity, specific gravity, and density). Environmental conditions prevailing at the time of each drop (wind direction and velocity, air temperature, and relative humidity) are noted for each drop.

Computer interpolation and interpretation of the raw data for each drop test produces numerical output for volume recovered and area coverage for each designated contour class; percentages of recovery and area coverage; cumulative volume; and areal determinations, total volume recovered, overall percentage recovery, and the total area of each drop (Fig. 3). Air tanker, drop mode and volume, retardant type, and environmental parameters are specified for each drop summary. Computer-drawn top and side perspectives are subsequently prepared within scaled grid dimensions with the contours presented in centimetres (cm). Between-drop comparisons for chemical (long-term) fire retardants are made at the 0.10-cm contour line, the suggested minimum level of effective coverage (after George and Blakely 1972).

DISCUSSION

Drop patterns are informative documents despite the number of variables that can influence the outcome depicted in any given "footprint". There can be great variation between patterns produced by two totally different tank and gating systems (Figs. 4 and 5). The PBY-5A Canso has a drop gate that is smaller than the basal area of the tank compartment; consequently, the flow rate is variable. This results in a wide teardrop-shaped pattern that exhibits a relatively large peripheral zone of low concentration around the main body of the pattern (Fig. 4). The S2F Firecat, on the other hand, has an efficient tank and gating system that exhibits a rapid flow rate from each of its four compartments to produce an elongated pattern with minimal trace zone coverage (Fig. 5). The influence of load increments (door options) and varying load release intervals (drop sequence timing) can also be assessed from ground response patterns. For example, there can be gaps in the 0.1-cm recovery level contiguity from delayed door opening intervals (Fig. 6).

The influence of wind can be seen in the close proximity of contour intervals on the windward (front) edge of the pattern (Fig. 7). The downwind side of the pattern suffers reduced recovery (coverage) because of retardant cloud breakup and drift. Similarly, the differences between aircraft flight variables (e.g., drop height, speed, and altitude) are evident in pattern responses on the ground. George and Blakely (1973) offer an excellent interpretation of the general effects of wind speed and drop height on retardant cloud settling time, recovery, and ground coverage.

Retardant rheological (physical) properties play a major role in the behavior of a retardant cloud during the breakup and descent phases following release from an air tanker. The manner and extent of breakup, deformation, and drift of the retardant mass coupled with the effects of drop speed, height, and tank geometry are largely governed by the rheological makeup of the retardant. Water or water-like retardants, which include clay-thickened products (Swanson et al. 1976), tend to break up and produce smaller cloud droplets than gum-thickened retardants and hence are more liable to drift and settle to the ground to form a broader pattern with a larger trace zone around the higher concentration regions of the footprint (Figs. 8 and 9). Similarly, the increased settling time of the smaller droplets, particularly when drop height is increased, subjects them to greater drift and evaporation losses, resulting in reduced recovery (Figs. 10 and 11). Phos-Chek® retardant products tend to exhibit gum-thickened characteristics, and Fire-Trol retardants are referred to as water-like. These different rheological characteristics influence the percent recovery with increasing drop height (Fig. 12).

Retardant drops conducted within standing timber produce results quite different from those conducted under open field conditions. The extent of canopy interception and through-fall can be deduced by relating

Volume dropped

DROP NUMBER = 05 DATE:06-05-80 RETARD = FIRE-TROL 931 ; DENSITY = 1.090; LITERS = 1655.0

Air tanker | Date | Retardant | Drop mode | Drop speed | Wind direction & velocity | Viscosity | Relative humidity

FIRECAT 0605FIRE-TROL931 STRING46M 222KM/H S-N S02KM/H1.062 1535MPAS 16C 63%

Drop height | Flight direction | Specific gravity | Air temperature

CM.CLASS:	TRACE-0.005	0.006-0.01	0.02-0.05	0.06-0.10	0.11-0.20	0.21-0.25	0.26-0.30	0.31-0.40	0.41-0.50	0.51 & UP
GM.CLASS:	0.010-0.233	0.234-0.467	0.468-2.33	2.34-4.67	4.68-9.33	9.34-11.66	11.67-14.00	14.01-18.66	18.67-23.33	23.34 & UP
LITERS:	14.1225	28.9692	456.2646	435.6240	319.7473	0.0000	0.0000	0.0000	0.0000	0.0000
ACC LT:	14.1225	43.0917	499.3563	934.9803	1254.7275	1254.7275	1254.7275	1254.7275	1254.7275	1254.7275
PER LT:	1.1255	2.3088	36.3636	34.7186	25.4834	0.0000	0.0000	0.0000	0.0000	0.0000
ACC% LT:	1.1255	3.4343	39.7980	74.5166	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
AREA:	432.	414.	1854.	684.	288.	0.	0.	0.	0.	0.
ACC AREA:	432.	846.	2700.	3384.	3672.	3672.	3672.	3672.	3672.	3672.
PER AREA:	11.7647	11.2745	50.4902	18.6275	7.8431	0.0000	0.0000	0.0000	0.0000	0.0000
AC% AREA:	11.7647	23.0392	73.5294	92.1569	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000

TOTAL RETARD ON GRID = 1254.73 LITERS PERC OF TOTAL GRID = 75.814 TOTAL AREA COVERED = 3672. SQUARE METERS

Figure 3. Computer summary of drop test results.

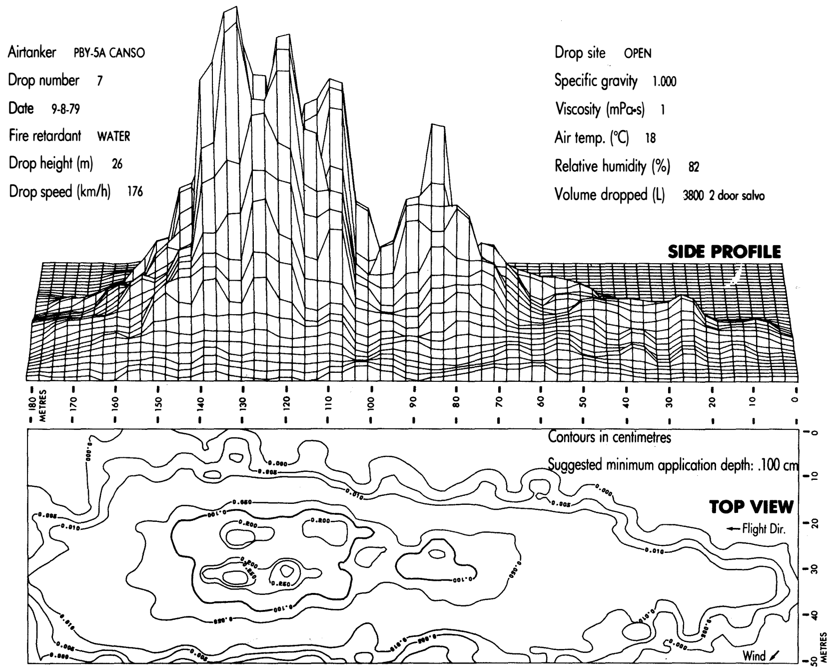

Figure 4. Influence of the PBY-5A Canso tank and gating system on drop pattern. Note the teardrop shape and large area of reduced coverage.

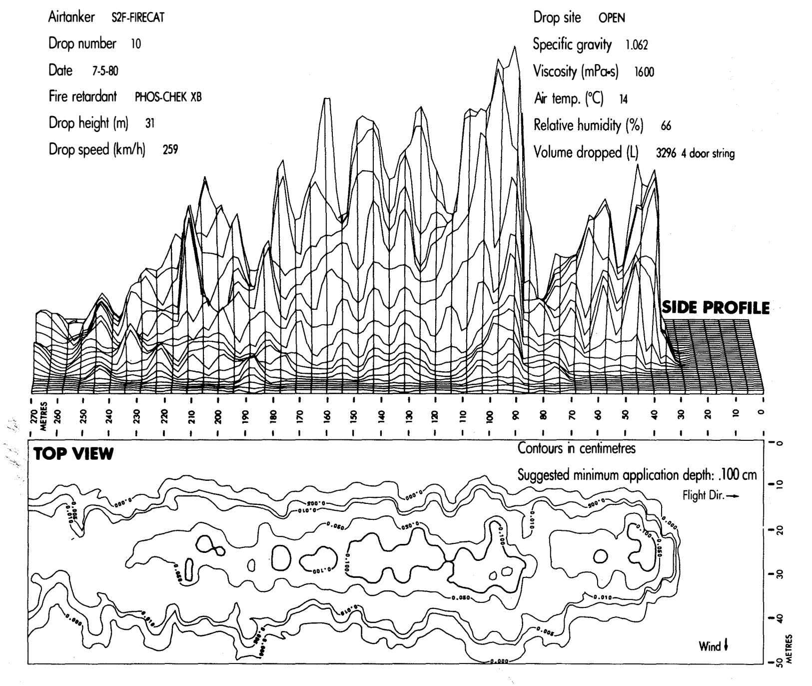

Figure 5. Influence of the S2F Firecat tank and gating system on drop pattern. Note the elongated pattern and narrow overall width of reduced coverage.

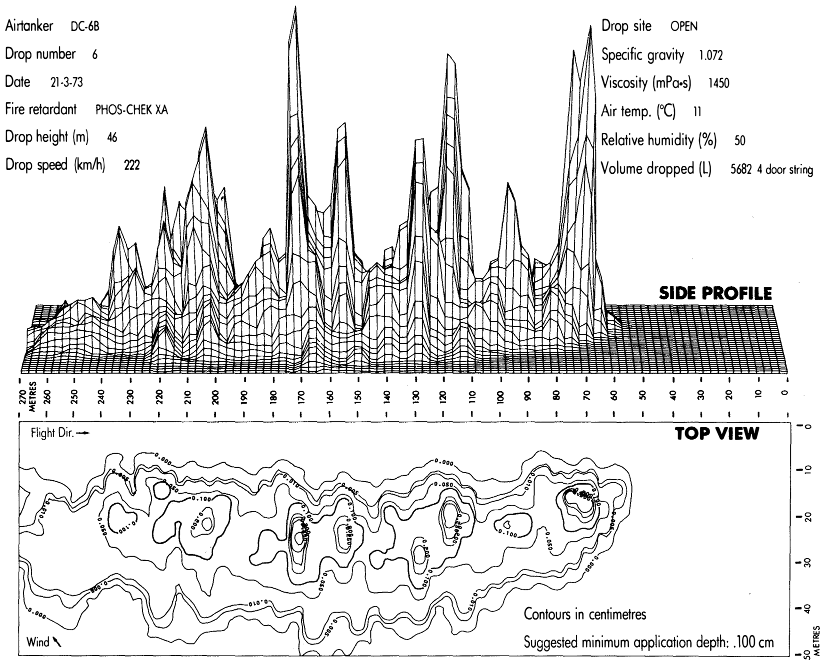

Figure 6. Gaps in the 0.10-cm contour level resulting from delays in drop gate sequencing.

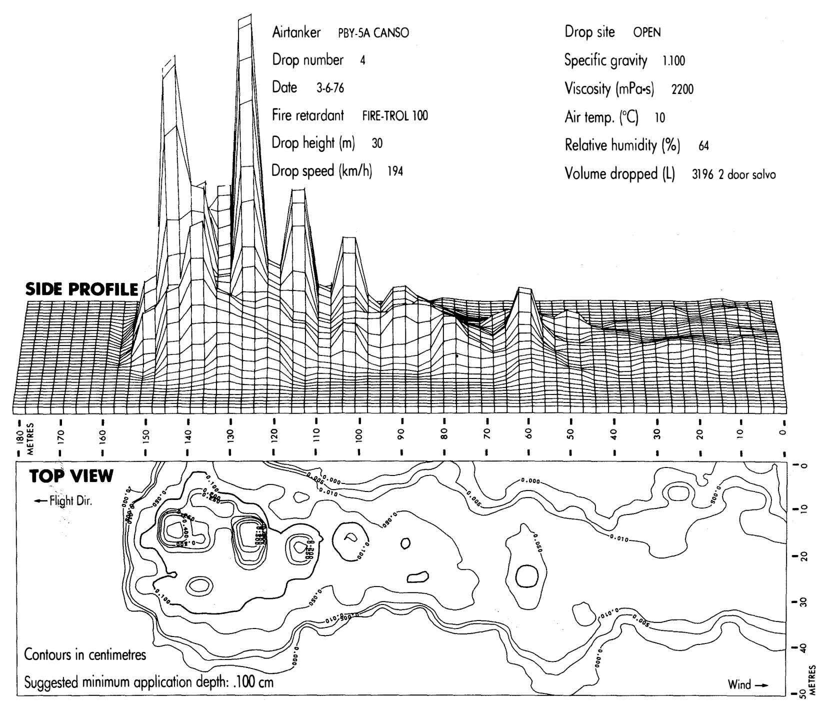

Figure 7. Frontal pileup of load resulting from a 10 km/h head-wind drop. Note the close contour lines at the front of the drop and the down-wind dispersion.

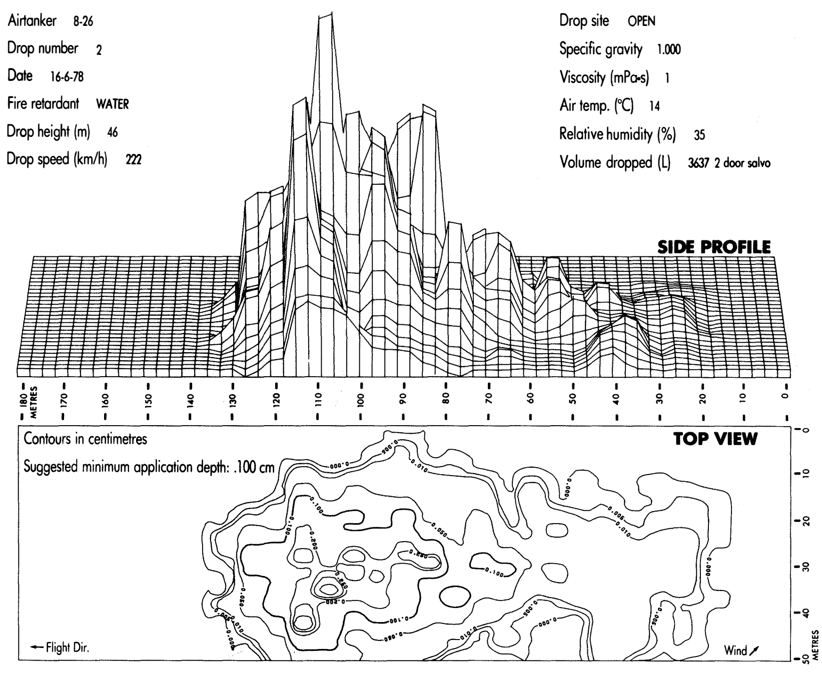

Figure 8. Ground response pattern resulting from a B-26 salvo water drop. Note the short, dispersed coverage at the 0.10-cm level.

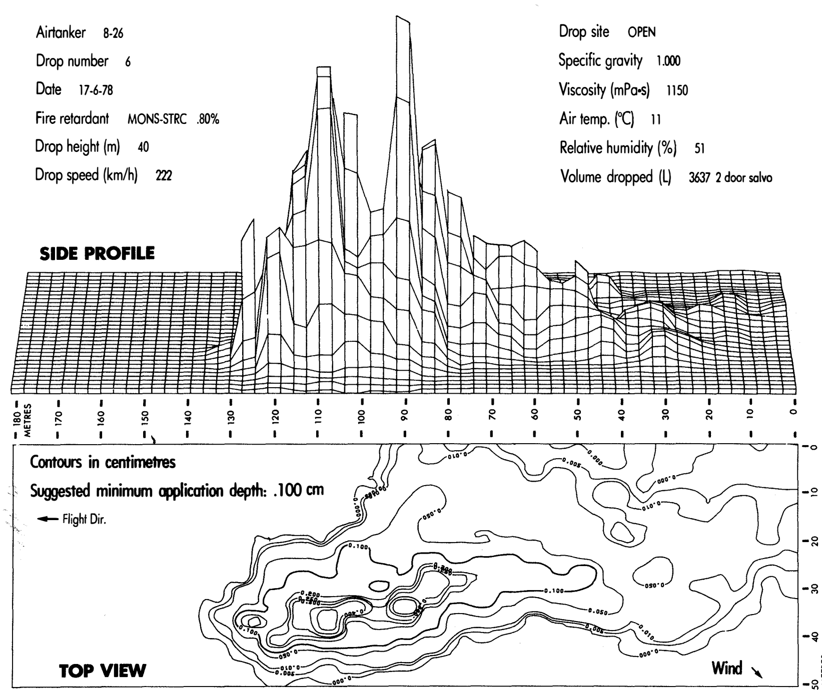

Figure 9. Ground response pattern resulting from a B-26 salvo drop of a gum-thickened, short-term retardant. Note the elongated pattern at the 0.10-cm recovery level and the higher concentration zones within.

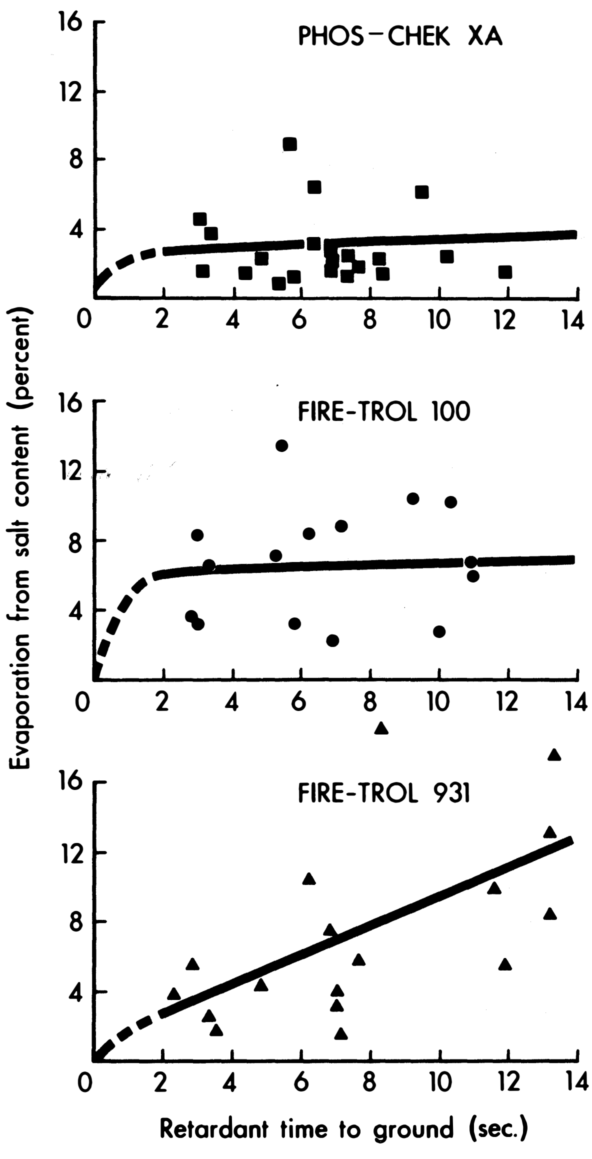

Figure 10. Evaporation losses as a function of drop time to 14 seconds (George and Blakely 1973).

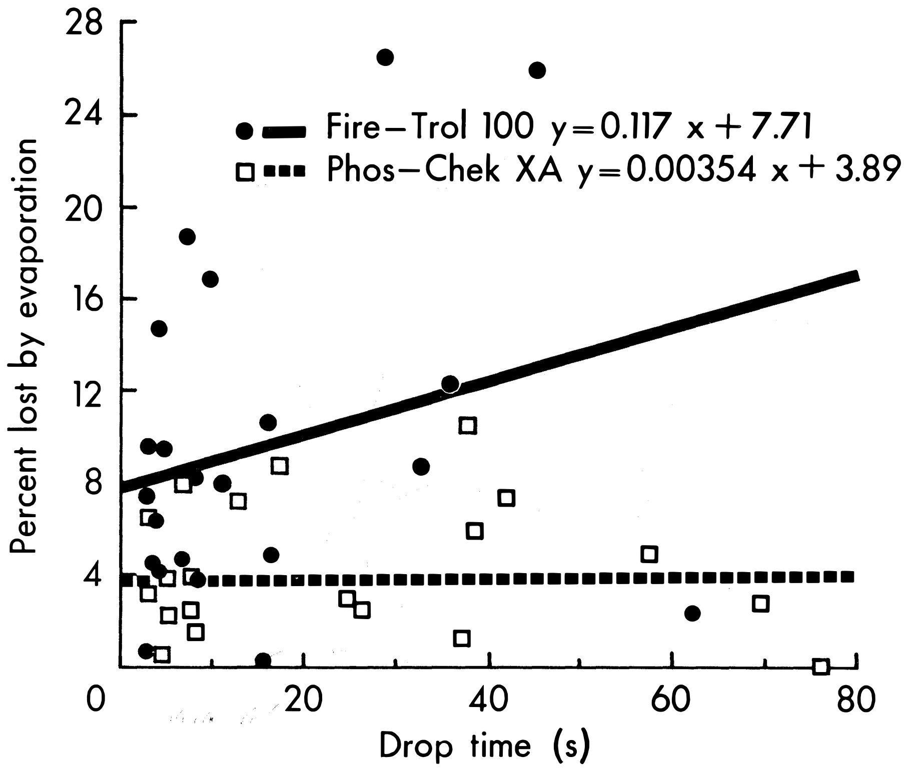

Figure 11. Evaporation losses as a function of drop time to 80 seconds (George 1975).

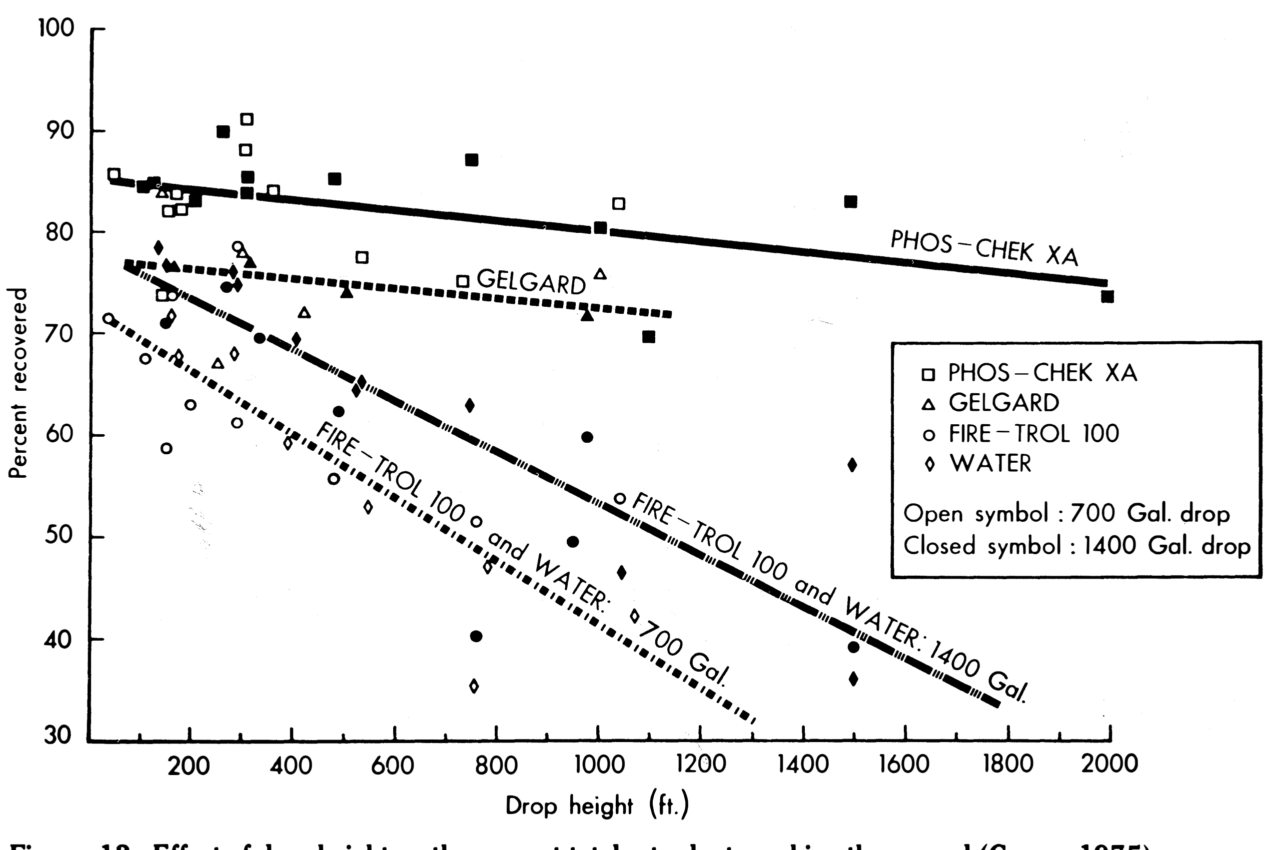

Figure 12. Effect of drop height on the percent total retardant reaching the ground (George 1975).

the results of open field drop tests conducted under comparable conditions for the same retardant and delivery system with those from in-stand drop patterns. Ground response patterns are affected by the nature and extent of crown closure in the overstory and the intermediate or shrub vegetation. The rheological properties of the retardants influence the extent of canopy coating and penetration such that retardants exhibiting high adhesive characteristics tend to coat the canopy and intermediate vegetation, while the more elastic, cohesive retardants tend to drip and run through several layers of forest vegetation before reaching surface and near-surface fuels.

Storey et al. (1959) reported that 50% of the volume of kaolin slurries dropped from a TBM air tanker into pine canopies with 63–69% crown closures reached the ground. Drop tests by Johansen (1964) in a mature well-stocked, fully leafed, hardwood stand showed that only 10–15% of the retardant reached the ground. Grigel (1970) reported that for most Gelgard drops from the Snow Commander air tanker (Figs. 13 and 14), approximately two-thirds of the retardant load was intercepted and retained by the tree crowns and stems of a mature, well-stocked lodgepole pine stand (estimated crown closure 40%). Further tests by Grigel (1971a) showed that, on the average, two-thirds of the volume of Thrush Commander retardant loads was retained by a mature, well-stocked lodgepole pine canopy (estimated crown closure 50%), and 55–62% of the load volume was retained by a mature, medium-stocked white spruce-aspen stand (estimated crown closure 35%). Naturally, individual drop conditions, drop heights and speeds, and the rheological properties of the retardant influence the outcome of each stand drop. The terminal, or impact, velocity and the angle of penetration of a retardant load upon contact with the forest canopy influence penetration and retention factors. The above studies and numerous personal observations of retardant drops under a wide variety of forest stand conditions indicate that at best only one-half to one-third of any given retardant load is likely to penetrate a mature, well-stocked coniferous forest canopy. As crown closure, stocking density, and stand height decline, improved penetration should result.

CONCLUSIONS

Ground distribution patterns have played an important role in the evaluation of the physical and environmental parameters that affect a retardant load during and after its release from an air tanker. Although there is much general knowledge, a great deal remains to be learned about the specific factors that contribute to the size and shape of ground response patterns.

This report has discussed and, where possible, demonstrated how a retardant's physical characteristics; the environmental circumstances such as drop height, wind shear, and canopy interception; and the tank and gating design and mechanics contribute to the outcome of drop patterns. Some are controllable, other are not, but nonetheless each can dictate the effectiveness of a retardant load by the time it reaches the fuel complex to which it is intended to be applied. Naturally, the fire environment can also significantly affect the eventual effectiveness of a given retardant drop.

In the end it is the human skills involved in the development, preparation, and delivery of retardants and their associated air tanker systems that are responsible for the effective placement of a retardant load and the pattern it produces.

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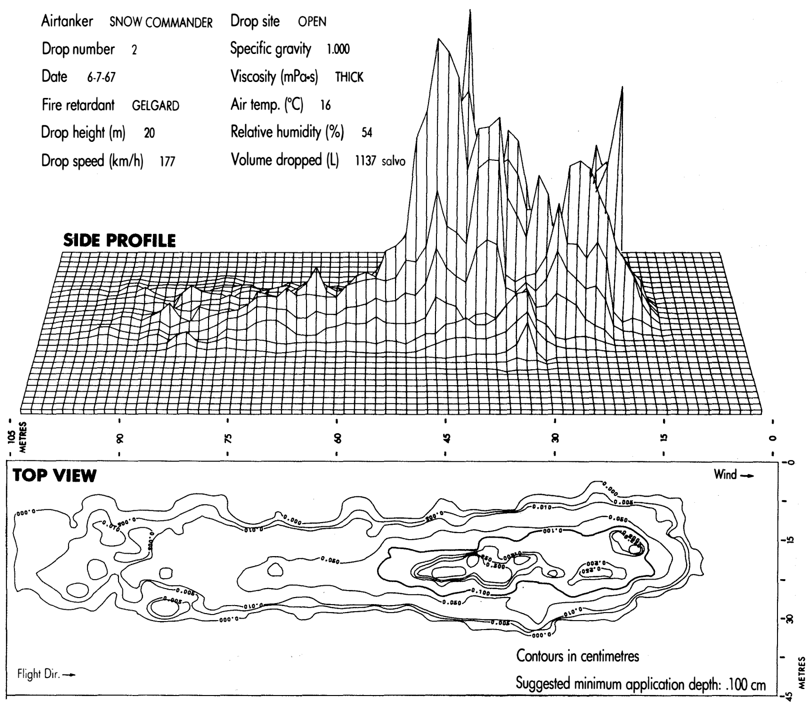

Figure 13. Ground response pattern for a Gelgard drop from a Snow Commander in an open field. Note the extent of the 0.10-cm coverage level.

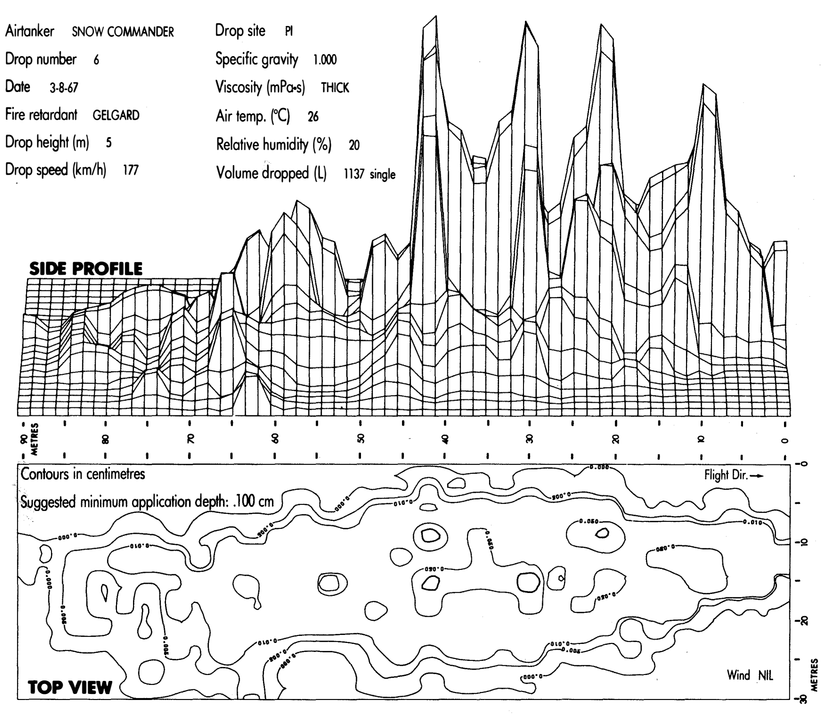

Figure 14. Ground response pattern for a Gelgard drop from a Snow Commander in a lodgepole pine stand. Note the extent of the 0.10-cm coverage level.

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APPENDIX I

SUMMARY OF RETARDANT DROP DETAILS AND PATTERN DIMENSIONS

APPENDIX I. SUMMARY OF RETARDANT DROP DETAILS AND PATTERN DIMENSIONS

Day/Month/ Year	Air tanker & drop no.	Volume dropped (L)	Drop site	Retardant	Drop height (m)	Drop speed (km/h)	Viscosity (description or mPa·s)	Recovery (%)	Length (L) & width (W)	0.00 cm (trace)	0.005 cm
5/7/67	Snow commander 1	1137 Salvo	Open	Gelgard	22	161	Medium	81	L*	105	91
									W*	15	17
6/7/67	Snow commander 2	1137 Salvo	"	"	20	177	Thick	88	L	97	90
									W	19	16
7/7/67	Snow commander 3	1137 Salvo	"	"	23	177	"	81	L	99	90
									W*	20.5	18
7/7/67	Snow commander 4	1137 Salvo	"	"	25	177	Medium	81	L*	74	73
									W*	21.5	20
7/7/67	Snow commander 5	1137 Salvo	"	"	33	177	Thick	62	L	83	76
									W	19	18.5
11/7/67	Snow commander 6	1137 Salvo	"	"	25	177	Medium	76	L	103	100
									W	20.5	18
10/7/67	Snow commander 7	1137 Salvo	"	"	27	177	Thick	70	L*	97	88
									W	22.5	15.5
7/7/67	Snow commander 8	1137 Salvo	"	"	32	177	"	70	L*	90	88
									W	25	18
6/7/67	Snow commander 9	1137 Salvo	"	"	32	177	"	74	L	98	96
									W*	19.5	17
11/7/67	Snow commander 10	1137 Salvo	"	"	38	177	"	68	L*	96	91
									W*	23	19
6/7/67	Snow commander 11	1137 Salvo	"	"	30	177	"	85	L*	95	93
									W	21	19
7/7/67	Snow commander 12	1137 Salvo	"	"	38	177	"	70	L*	92	89
									W	23.5	23
21/6/67	Snow commander 13	1137 Salvo	"	"	20	161	Thin	76	L*	95	90
									W	20.5	13
21/6/67	Snow commander 14	1137 Salvo	"	"	21	161	"	69	L*	95	85
									W*	19.5	17
21/6/67	Snow commander 15	1137 Salvo	"	"	22	161	"	74	L*	93	89
									W	16	15.5
20/6/67	Snow commander 16	1137 Salvo	"	"	23	161	"	72	L	96	86
									W*	18	16
21/6/67	Snow commander 17	1137 Salvo	"	"	21	161	"	76	L*	72	70
									W	17.5	16
20/6/67	Snow commander 18	1137 Salvo	"	"	32	161	"	58	L*	81	80
									W	24	21
10/7/67	Snow commander 19	1137 Salvo	"	"	29	177	"	62	L*	90	89
									W	21	16.5
23/6/67	Snow commander 20	1137 Salvo	"	"	30	161	"	71	L*	92	87
									W	19.5	17
23/6/67	Snow commander 21	1137 Salvo	"	"	37	161	"	68	L*	79	77
									W*	20	20
13/6/67	Snow commander 22	1068 Salvo	"	"	20	161	"	62	L	90	83
									W	18	15
11/7/67	Snow commander 23	1068 Salvo	"	"	23	177	"	61	L	93	88
									W	22.5	17.5
6/7/67	Snow commander 24	1137 Salvo	"	"	17	177	Thick	80	L*	83	82
									W	18	15.5
2/8/67	Snow commander 1	1137 Salvo	Lodgepole pine	"	5	177	Medium	30	L*	72	70
									W*	21	18
2/8/67	Snow commander 2	1137 Salvo	"	"	5	177	Thick	25	L*	76	74
									W*	18	15

Pattern dimensions (m) by depth of recovery

0.01 cm	0.05 cm	0.10 cm	0.20 cm	0.25 cm	0.30 cm	0.40 cm	0.50 cm
83 16	62 9.5	39 5.5	7, 10 3, 4.5	5, 8 3.5, 4	4, 5 2.5, 2.5		
79 15	59 10	38 9	32 6	4 5, 16 2.5, 2, 4	13 3	5 2	
85 16	51 12	43 10.5	5 4	4 3.5			
72 19	62 13	43 7.5	8 7	5 3	4 2		
6, 4, 64 3.5, 4.5, 14.5	53 10.5	39 8	4, 6 2, 3.5	5 2.5	4 2		
82, 6 20, 3.5	65 11	43 7	5, 11, 16 2, 4.5, 2	6 4	4 2		
75 14.5	55 12	42 8	10, 6 4, 2.5	5 2			
8, 5, 74 5.5, 3, 19	53 12	4, 35 2, 9	9 2				
94 17	54 10	34 7	5 4				
79 19	58 12	31 11	5 1.5				
85 17	60 11	41 8	23 5	13 5.5	6 4.5	3 3	
77 18.5	62 11	8, 25 4, 9					
80 13	56 9	49 7	29 6.5	12 4	10 3.5	8, 4 2.5, 2	
83 13.5	16, 49 4, 11.5	46 7	5, 4, 4 2.5, 1, 3.5	4 1			
85 14	52 11	47 8	8, 5, 11 3.5, 2.5, 3.5	7 3.5	5 2.5		
80 14.5	57 10.5	4, 40 2, 8	10 4.5				
69 15.5	50 14	3, 9, 30 3.5, 3, 9	6, 7, 8 2.5, 4, 4.5	6 4	4 3.5		
78 16	51 13	30 7					
88 14.5	50, 7 8, 6	30 9.5	6 3.5	4 3.5	3 2.5		
79 15.5	65 8.5	34 7	26 3.5	9 3	7 2.5	6 1	
74 18	66 8.5	26, 43 5.5, 5.5					
72 14	4, 48 3.5, 10	40 7	4, 5, 9 3, 2.5, 2.5	4 2.5			
80 17	4, 52 3.5, 10	20, 8 5, 2.5	6 4.5				
82 12.5	10, 49 5, 12	41 8	19 4.5	14 4	12 3.5	7 2.5	4 2.5
69 16	16, 18, 7, 2 3, 5, 8, 1.5	3 2					
51, 3, 3 13, 2, 2	27, 2, 3, 3 6, 2, 2, 2	12 4					

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APPENDIX I continued

Day/Month/ Year	Air tanker & drop no.	Volume dropped (L)	Drop site	Retardant	Drop height (m)	Drop speed (km/h)	Viscosity (description or mPa·s)	Recovery (%)	Length (L) & width (W)	0.00 cm (trace)	0.005 cm
2/8/67	Snow commander 3	1137 Salvo	Lodgepole pine	Gelgard	5	177	Thick	38	L W	79 18	76 14
3/8/67	Snow commander 4	1114 Salvo	"	"	9	177	Thick	29	L* W	79 24	77 20
3/8/67	Snow commander 5	1068 Salvo	"	"	5	177	Thick	36	L* W*	70 20	68 17
3/8/67	Snow commander 6	1137 Salvo	"	"	5	177	Thick	30	L* W*	92 23	89 18
3/8/67	Snow commander 7	2251 Double salvos	"	"	5	177	Thick	34	L* W*	82 25	81 22
12/9/68	Thrush commander 1	1409 Salvo	Open	Fire-Trol 100	26	161	2000	67	L* W	80 24	76 21.5
12/9/68	Thrush commander 2	1409 Salvo	"	"	28	161	1700	79	L* W*	94 28	86 23
10/9/68	Thrush commander 3	1409 Salvo	"	"	15	161	2075	67	L* W	83 28	81 23
10/9/68	Thrush commander 4	1409 Salvo	"	"	26	161	2550	74	L* W	67 27	61 22
10/9/68	Thrush commander 5	1409 Salvo	Wh. spruce-aspen	"	6	161	1850	53	L* W	100 28	98 23
10/9/68	Thrush commander 6	1409 Salvo	"	"	6	161	2000	32	L W	87 25	83 21
11/9/68	Thrush commander 7	1409 Salvo	"	"	18	161	1850	49	L* W*	58 29.5	53 22
11/9/68	Thrush commander 8	1409 Salvo	"	"	30	161	1950	27	L W*	87 22.5	76 19
11/9/68	Thrush commander 9	1409 Salvo	Lodgepole pine	"	6	161	1950	22	L* W	82 28	73 20.5
11/9/68	Thrush commander 10	1409 Salvo	"	"	6	161	1900	27	L* W	95 23	88 16
12/9/68	Thrush commander 11	1409 Salvo	"	"	9	161	2050	24	L* W	88 26	63 23
12/9/68	Thrush commander 12	1409 Salvo	"	"	18	161	2250	31	L* W*	76 24	74 22
14/9/68	Thrush commander 13	1409 Salvo	Open	Phos-Chek 205	24	161	1000	76	L* W	97 25	86 22
14/9/68	Thrush commander 14	1409 Salvo	"	"	23	161	1225	75	L* W	87 24	3, 80 5.5, 22
14/9/68	Thrush commander 15	1409 Salvo	"	"	26	161	1250	78	L* W	80 25	66, 4 20, 3
18/9/68	Snow commander 16	1137 Salvo	"	"	23	161	1775	66	L* W	95 19	94 17
18/9/68	Snow commander 17	1137 Salvo	"	"	21	161	1380	83	L* W*	102 24	100 22
18/9/68	Snow commander 18	1137 Salvo	"	"	24	161	1550	80	L* W*	103 26	96 21
14/9/68	Thrush commander 19	1409 Salvo	Lodgepole pine	"	6	161	1040	30	L* W	96 23	83 14
14/9/68	Thrush commander 20	1409 Salvo	"	"	18	161	1000	34	L* W	64 20	62 19
15/9/68	Thrush commander 21	1409 Salvo	"	"	6	161	1140	23	L* W	88 21	75 17

Pattern dimensions (m) by depth of recovery

0.01 cm	0.05 cm	0.10 cm	0.20 cm	0.25 cm	0.30 cm	0.40 cm	0.50 cm
76 13	25, 2, 2, 2, 4, 6 7, 3, 5, 2, 8, 5	6, 5 3, 5					
2, 67 2, 17	14, 21 2, 6	6 3	2 2				
65 12	43 6	22, 4 4, 3	3, 7 2, 2.5	6 2	5 1		
81 16	10, 31, 4, 12 4, 6, 2, 3	3, 3 2, 2					
80 20	53, 2 12, 1.5	27 6.5	3, 12 2, 3	9 2	7 2		
74 19	9, 33 6, 15	3, 25 3, 12	20 7	18 4.5	17 3	5 3	
83 20	40 16	2, 27 2, 15	22 7	17 4	13 3	6 2	5 2
80 19	5, 52 5, 12	35 9	26 3	3, 3, 3 2, 3, 2			
50 20	44 17	35 12	17 9	13 6	12 4	10 3	3 2
78 18	37 15	21 10	7 10	6 6	5 3	3 3	2 2
75 18	32 9.5	16 3	5, 3 2, 2				
52 19.5	48 11	31 7	3, 3 2.5, 3				
56 16.5	18, 10, 3 8, 2.5, 4	14 6	6 3	5 2			
65 17	25, 5 5, 4.5	6 3.5					
65, 4 15, 3	34 7	9, 13 5.5, 4	2 4				
58 18	22, 2 6, 2	15 5	10 3	7 2	5 2	2 1	
73 19.5	35 8	9 4					
72 20	46 14	36 12	20, 3 6, 2	12 5	10 3	3 2	
78 20	8, 42 6, 14	32 13	20 8	12, 3 5, 2	11, 2 3, 2		
64 19	58 13	32 12.5	21 6	12 3	8 2.5	6 1.5	3 1
83 15	58 11	5, 36 2, 9	23 4	3, 9 5, 3	8 3	4 2.5	3 2
89, 5 18, 1	48, 5 13, 3	44 7	6, 15 2, 3	7 2.5	6 1.5		
86 19	52, 3 12.5, 2	46 8	8, 3 3, 2.5	4 2	3 2		
64 13	35 9	3, 13, 3 2.5, 6, 2	7 3				
61 17	30, 7, 4 11, 4.5, 3	28 5	3 2				
73 15	27, 3 7, 2	3, 6 4.5, 5					

Continued on next page

APPENDIX I continued

Day/Month/ Year	Air tanker & drop no.	Volume dropped (L)	Drop site	Retardant	Drop height (m)	Drop speed (km/h)	Viscosity (description or mPa·s)	Recovery (%)	Length (L) & width (W)	0.00 cm (trace)	0.005 cm
15/9/68	Thrush commander 22	1409 Salvo	Lodgepole pine	Phos-Chek 205	6	161	1075	19	L* W	97 24	75 16
18/9/68	Thrush commander 23	1409 Salvo	"	"	6	161	1550	16	L* W*	85 27	67 19
18/9/68	Snow commander 24	1137 Salvo	"	"	18	161	1760	25	L* W	97 20	89 15
18/9/68	Snow commander 25	1137 Salvo	"	"	6	161	1550	34	L* W	85 17	72 12
13/9/68	Thrush commander 26	1409 Salvo	Wh. spruce-aspen	"	18	161	950	42	L W	75 25	68 21
14/9/68	Thrush commander 27	1409 Salvo	"	"	8	161	1270	24	L* W	94 24	77 17
15/9/68	Thrush commander 28	1409 Salvo	"	"	8	161	1550	28	L* W	83 22	78 19
15/9/68	Thrush commander 29	1409 Salvo	"	"	8	161	1410	32	L W	93 24	75, 4 18, 3
17/7/68	PBY-5A Canso 1	3637 Salvo	Open	Water	23	204	1	57	L W	136 39	131 35
17/7/68	PBY-5A Canso 2	3637 Salvo	"	"	23	204	1	60	L W*	140 39	127 32
9/8/68	PBY-5A Canso 4	3637 Salvo	"	"	23	185	1	71	L W	106 35	85 21
31/7/68	PBY-5A Canso 5	3182 Salvo	"	"	30	185	1	75	L* W*	149 38	116, 6 34, 3
9/8/68	PBY-5A Canso 6	3637 Salvo	"	"	32	185	1	68	L* W*	143 42	109 35
9/8/68	PBY-5A Canso 8	3637 Salvo	"	Gelgard	27	185	Thick	60	L W	166 35	141 30
10/8/68	PBY-5A Canso 9	3637 Salvo	"	"	29	185	"	73	L* W	159 39	149 33
11/8/68	PBY-5A Canso 10	3637 Salvo	"	"	19	185	"	65	L W	152 35	123 27
10/8/68	PBY-5A Canso 11	1818 Single	"	"	33	185	Thin	78	L W	166 29	162 24
10/8/68	PBY-5A Canso 12	1818 Single	"	"	33	185	Thick	75	L* W	148 35	128 27
11/8/78	PBY-5A Canso 13	1818 Single	"	Water	17	185	1	76	L W	151 30	128 25
11/8/68	PBY-5A Canso 14	3637 Salvo	"	Gelgard	16	185	Medium	68	L* W	148 37	132 29
20/7/68	PBY-5A Canso 16	3637 Salvo	Wh. spruce	Water	15	204	1	30	L* W	124 35	109 30
24/7/68	PBY-5A Canso 17	3637 Salvo	"	"	15	185	1	29	L* W	148 34	145 29
19/7/68	PBY-5A Canso 18	3637 Salvo	"	"	15	204	1	36	L* W	162 46	117 37
3/8/68	PBY-5A Canso 19	3637 Salvo	"	"	15	185	1	37	L* W*	159 43	145 39
24/7/68	PBY-5A Canso 20	3637 Salvo	"	"	27	185	1	36	L W*	141 61	127 49
23/7/68	PBY-5A Canso 21	3637 Salvo	"	"	12	185	1	29	L* W	126 36	107 29.5

Pattern dimensions (m) by depth of recovery

0.01 cm	0.05 cm	0.10 cm	0.20 cm	0.25 cm	0.30 cm	0.40 cm	0.50 cm
72 13	11, 4 4, 2.5						
55 13.5	13 4	6 3					
67, 6 13, 4	27, 8 4, 3						
69 10	32, 7 8, 3	23 6	8 2.5				
63 19	38, 7 11, 2	33 8					
70 13	29 7	11, 3 4, 3					
66 17	32 11	21 9	16 3.5	6 2			
70, 3 14, 2	33, 3 10, 2	26 5	7 2	3 2			
127 31	83 22	60 15	24, 6, 8 4, 2, 4	23, 8 2, 4	6, 7 2.5, 2	4 2	
119 28	79, 6 18.5, 5	56 17	25, 10 9, 2.5	8, 6 8.5, 2.5	4, 3 2, 2		
79 29	71 21	59 18	42 14	41 9	37 6	12, 12 9, 3	7, 5 4, 2
106 31	58, 6 27.5, 3	56 20	29 11	18, 5 10, 3	13, 4 6, 2		
105 31	70 26	60 19	29, 4 9.5, 4	28 5	11 4	5 2	3 2
127 26	76 21.5	59 17	34, 5 6, 4	29 4	7, 4 3, 3		
136 27	89 22	81 17.5	37, 8 5, 5	24, 7 3, 5	6, 5 2, 3		
117 25	83 21	71 15	36 7.5	30 7	29 5	22 3.5	4 3
131 22	84 12	59 8.5	20 5	8, 5 5, 2	7 4	5 2	3 2
112 22	74 15	47 11	8, 10 5, 3	7 4	5 2	3 2	
120 21	71 13	54 9	19, 6 6, 2	13 6	8 5	5 5	
124 26	83 20	69 17	58 7	30, 18 7, 4	8, 18, 5 5, 4, 3	3 2	
105 26	55, 19, 8 10, 4, 6	19, 8, 8 9, 4, 4	6, 4 2, 2	5 2	3 2		
123 24	68 14	22 4.5					
102 28	44 19	24 17	7, 6 10, 4	5, 4 7, 2	4, 3 5, 2		
127 33	71 16	29, 3, 4 8, 2, 5					
78 41.5	67 14	20, 6, 5 8, 5, 3	7, 3 5, 2	5 2	4 2	3 2	
82, 15 25, 5	56 17	40 7	5 2				

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APPENDIX I continued

Day/Month Year	Air tanker & drop no.	Volume dropped (L)	Drop site	Retardant	Drop height (m)	Drop speed (km/h)	Viscosity (description or mPa·s)	Recovery (%)	Length (L) & width (W)	0.00 cm (trace)	0.005 cm
26/7/68	PBY-5A Canso 22	7274 Double salvos	Wh. spruce	Water	12	185	1	29	L W	127 33	121 27
31/7/68	PBY-5A Canso 23	3637 Salvo	"	Gelgard	15	185	Thick	28	L* W	148 36	131 28
9/8/68	PBY-5A Canso 24	3637 Salvo	"	"	15	185	Medium	30	L* W	158 32	127 26
3/8/68	PBY-5A Canso 25	3637 Salvo	"	"	15	185	Thick	35	L* W	158, 13 31, 16.5	124, 7, 3 31, 1.5, 1.5
31/7/68	PBY-5A Canso 26	3637 Salvo	"	"	27	185	"	36	L* W	164 33	142, 4 32, 5
26/7/68	PBY-5A Canso 27	4091 Salvo	"	"	27	185	Thin	25	L* W	152 37	147 29
19/7/68	PBY-5A Canso 28	3637 Salvo	"	Water	23	204	1	21	L* W	152 43	131, 9 29, 5
20/7/68	PBY-5A Canso 29	3637 Salvo	"	"	15	204	1	15	L W	144 30	127 19
31/7/68	PBY-5A Canso 30	3637 Salvo	Wh. spruce-aspen	Gelgard	27	185	Thick	32	L W	155 35	131, 4, 3 28.5, 2.5, 3
26/7/68	PBY-5A Canso 31	3637 Salvo	"	"	27	185	"	28	L* W*	97 34	90 31
31/7/68	PBY-5A Canso 32	3637 Salvo	"	"	27	185	"	36	L* W*	122 38	120 31
26/7/68	PBY-5A Canso 33	7274 Double salvos	"	Water	15	204	1	32	L* W	142 41	140 34
20/7/68	PBY-5A Canso 34	3637 Salvo	"	"	15	204	1	21	L* W	140 41	136 30.5
26/7/68	PBY-5A Canso 35	3637 Salvo	"	"	15	204	1	39	L W	150 38	118, 12 35, 5.5
19/7/68	PBY-5A Canso 36	3637 Salvo	"	"	15	231	1	32	L* W	140 46.5	136 41.5
24/7/68	PBY-5A Canso 37	3637 Salvo	"	Gelgard	15	185	Thick	32	L* W	132 39	128 39
3/8/68	PBY-5A Canso 38	3637 Salvo	"	"	15	185	"	35	L* W	158 31	120 27
23/7/68	PBY-5A Canso 39	3182 Salvo	"	"	15	185	"	28	L W	162 28	132 22
9/8/68	PBY-5A Canso 40	3637 Salvo	"	"	20	185	"	35	L W	143 32	115 30
10/8/68	PBY-5A Canso 15	3637 Salvo	Open	"	17	185	Thin	66	L W	141 40	135 35
28/5/70	B-26 1	1282 Single	Open	Fire-Trol 100	26	225	2700	62	L* W	107 35.5	103 27.5
28/5/70	B-26 2	1023 Single	"	"	26	225	2700	68	L W	139 25	127 18
28/5/70	B-26 3	2273 2-door string	"	"	25	225	2700	61	L* W	161 35	148 23.5
28/5/70	B-26 4	4546 4-door salvo	"	"	30	225	2700	73	L* W	155 48	152 36
16/9/71	B-26 1	3182 4-door salvo	"	Fire-Trol 931	27	225	50	76	L* W*	183 39.5	175 28
16/9/71	B-26 2	2273 2-door salvo	"	"	27	225	50	69	L* W	180 35	168 27
17/9/71	B-26 3	1023 Single	"	"	27	225	50	52	L W*	110 26	102 19.5

Pattern dimensions (m) by depth of recovery

0.01 cm	0.05 cm	0.10 cm	0.20 cm	0.25 cm	0.30 cm	0.40 cm	0.50 cm
112 25	78 18	66 13	10, 30 2, 8	13, 12 5.5, 4	11, 11 3, 3	6, 4 2, 2	
109 25	79 13	18, 17 5, 1	4 1				
101, 5 24, 5	70 17	50 5	6 2.5	4 1			
109 25	73, 12 9, 2	38, 5 6, 2	5, 4 4, 1				
109 26	61 20	36 14	5, 4 3, 1	3 2			
120 27	73, 10 10, 2.5	25, 5 7, 5	3 2.5				
108 22	54 13	7, 7, 12 5, 5, 5	3, 4 3, 1				
93, 8 17, 4	18, 10, 30 4, 3, 4						
80, 22, 7 25.5, 7, 3.5	70 13	19, 18, 6 12.5, 6, 5	4 2				
89 25	60, 4 15, 2.5	25, 3 13, 3	11 6	5 2			
113 26	49, 5 18, 4.5	40 14	18, 5 5, 3	9 3			
139 26.5	76, 8, 5, 3 23, 5, 2, 2.5	62, 6 16, 3	40 6	17, 11 3, 2	4, 2 1, 1.5		
102 25.5	45, 19, 5 10, 5, 2	5 2.5					
116, 6 32.5, 2	68 21	41, 5 10, 2	20, 6 5, 2	18, 5 3, 1	17 2	5 1	
99, 18, 10, 4 34.5, 7, 10, 2.5	63, 9, 8 14, 4.5, 6	12, 6, 7, 7 7.5, 4.5, 8, 4	4 2	3 1			
122 29	44, 28, 3 14, 6.5, 1.5	31, 5, 5 7, 3, 2					
117 25	80 16	43, 4 13.5, 2					
92 19.5	60 11	25, 5 7, 6	14 3.5	10 2.5	3 2		
110 25	61, 6, 4 20, 3, 3	54 9	12 6	6 5	5 4	3 1	
118 30	92 21	76 16	49, 12 7, 2	17, 12, 4 5, 4, 3	10, 11 3, 2	6 2	4 2
101 18	46 13.5	24 4	3 2				
95 15	39 8	29 5.5	4 2				
144 17.5	81, 7, 3 11, 5, 5	20, 27, 18 7, 4, 8	6 5	5 3	3 2.5		
149 34	84, 11 25, 5	79 16	53 7	25, 18 5, 1	16, 3 4, 3		
151, 5 28, 5	87 17	59 15	29 4				
142 23	98 11	51, 11 8, 2					
66, 26 13, 7	36 8						

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APPENDIX I continued

Day/Month Year	Air tanker & drop no.	Volume dropped (L)	Drop site	Retardant	Drop height (m)	Drop speed (km/h)	Viscosity (description or mPa·s)	Recovery (%)	Length (L) & width (W)	0.00 cm (trace)	0.005 cm
17/9/71	B-26 4	1282 Single	Open	Fire-Trol 931	25	225	50	49	L W*	97, 12 34, 11.5	90, 8 26, 5.5
17/9/71	B-26 5	2273 2-door string	"	"	30	225	50	49	L* W	168 39	161 30
17/9/71	B-26 6	2273 2-door salvo	"	Fire-Trol 100	30	225	850	55	L* W	100 30	97 24
17/9/71	B-26 8	2273 2-door salvo	Lodgepole pine	Fire-Trol 100	26	225	850	27	L* W*	99 29	93 19
16/9/71	B-26 7	2273 2-door salvo	"	Fire-Trol 931	30	225	50	19	L* W*	94 30	92 19
20/3/73	DC-6B 1	2841 2-door salvo	Open	Phos-Chek XA	47	222	1600	85	L* W*	122 25	114 24
20/3/73	DC-6B 2	1421 Single	"	"	44	222	1600	79	L W*	128 29	124 19
20/3/73	DC-6B 3	5682 4-door string	"	"	44	222	1150	78	L* W*	221 26.5	220 25
20/3/73	DC-6B 4	5682 4-door string	"	"	43	222	1250	89	L W*	260 32	250 27
20/3/73	DC-6B 5	5682 4-door salvo	"	"	43	222	1600	80	L W*	167 36	153 31
21/3/73	DC-6B 6	5682 4-door string	"	"	46	222	1450	70	L* W*	214 27	212 21
21/3/73	DC-6B 7	5682 4-dr. dbl. strg.	"	"	46	222	1450	70	L* W	178 30	176 22
21/3/73	A-26 8	1818 Single	"	"	44	225	1450	63	L* W	110 27	108 18
21/3/73	A-26 9	3637 Salvo	"	"	46	225	1450	72	L W*	120 30.5	117 24
21/3/73	A-26 10	3637 2-door string	"	"	42	225	2300	83	L* W*	156 25	153 25
22/3/73	TBM 11	1296 Single	"	"	44	222	1250	84	L W	117 25	112 18
22/3/73	TBM 12	2591 Salvo	"	"	44	222	1250	98	L W*	106 31	102 28
22/3/73	TBM 13	2591 2-door string	"	"	23	222	1250	80	L W	164 24	149 20
3/6/76	PBY-5A Canso 4	3196 Salvo	Open	Fire-Trol 100	30	194	2200	90	L* W*	155 33	153 30
3/6/76	PBY-5A Canso 5	3637 2-door string	"	Water	30	176	1	81	L* W*	132 26.5	128 25.5
3/6/76	PBY-5A Canso 6	3637 Salvo	"	Tenogum	27	176	310	62	L W*	158 29	144 21
3/6/76	PBY-5A Canso 7	3637 2-door string	"	"	24	176	310	66	L* W*	142 26	140 23
3/6/76	PBY-5A Canso 8	1818 Single	"	"	30	176	310	62	L* W*	125 26	122 20
21/6/76	PBY-5A Canso 9	3637 Salvo	"	"	29	176	354	75	L* W*	176 23	158, 6 21, 7
21/6/76	PBY-5A Canso 10	3637 Salvo	"	"	26	176	310	78	L* W*	154, 10 24, 6	140 23
21/6/76	PBY-5A Canso 11	3637 2-door string	"	"	21	176	310	67	L* W*	143 30	140 25

Pattern dimensions (m) by depth of recovery

0.10 cm	0.05 cm	0.10 cm	0.20 cm	0.25 cm	0.30 cm	0.40 cm	0.50 cm
86, 7 20, 5	35 10	3, 3 5, 6					
157 22	44, 38, 6 8, 8, 4	7 5.5					
93 22	80 15.5	51 8	20 3	5, 5 1.5, 1.5			
89 15	29, 12 7, 6.5	19, 2 5, 2	8 4	7 3	4 3	3 2	
91 13	40, 15, 3 5.5, 3, 3	9, 7, 3 2, 2.5, 3					
113 19	99 12	66, 7 10, 3.5	33 8	32 7	16, 6 5, 4	15 3	11 3
122 17	75, 4 25, 3.5	16, 5, 4 8, 3, 5.5					
219 24	212 11	59, 44, 60, 12 9, 10, 9, 6	17 7	12 6	11 5	10 3	
248 23	203, 5 15, 3	38, 26, 6 8, 9, 4	15, 12, 11, 5 6, 5, 5, 6	10, 5, 4 4, 3, 4	4 3		
141 26.5	103 21	86 20	27, 23 8, 9	21, 20 8, 4	16, 10 7, 4	15 5	9 4
211 17	179, 8 14, 3	78, 27, 15, 13, 10 11, 9, 9, 4.5, 4.5	11, 12, 6, 6, 7, 8 7, 6, 7.5, 8, 9.5, 4.5	10, 7, 6, 5, 4 4, 8, 8.5, 4.5, 3.5	10, 5, 5 3, 6, 4.5		
153, 13 19, 5	129, 6 14, 5.5	101, 8 12, 5	23, 20, 8, 5 9, 7, 4, 3	21, 16 7, 6	20, 6 6, 7	16, 3 5, 3	15 3
107 17	57 14	28 10	12 4	4 3.5			
114 22	70, 9, 5 19, 7.5, 4	63 12	41, 5 7, 3	35 6	21, 3 6.5, 3	5, 5 7, 3	
152 19	110, 10 14, 4.5	101 11	17, 16, 7, 4, 5 11, 5, 4.5, 4, 3	16, 14 7, 4	15, 10 6, 2	6, 3 8, 3	4 6
110 14	68 9	47 5	9 3				
100 25	70 21	68 17	12 5	10 4			
132, 5 19, 4	95 11	74, 6 8, 8	17, 13 7, 7	12, 10 6, 6	10, 5 4, 3	6 3	5 4
152 26	80, 10 21, 13	55, 5 17, 5	25, 7 10, 6	24, 3 6.5, 2	10, 7 6, 7.5	5, 5 6, 6	4, 3 5, 2.5
123 25	94 20	77 13	30, 18, 4 5, 8, 2	18, 10, 5 3, 4, 2	10 3		
135 17.5	76, 5 15, 3	61, 4 11, 4.5	20 10	15 9	10 8.5	4 5	
124 22	97 15	42, 30, 8 11, 10, 8	18, 10, 7 6, 7.5, 5	17, 5, 4 4, 7, 3	10, 4 3.5, 7	3 3	
120 16	78 10	25, 9, 6 8, 2.5, 8					
152 19	76, 14 16, 9	55, 8 15, 4	41 5	14, 11, 4 6, 3, 2	12 4	11 3	6 2.5
137 20	90 20	79 17	18, 9, 8 10, 3.5, 3	17 5.5	12 5	6 5	5 3
139 23	102, 7, 7, 4 17.5, 4, 3, 3	58, 12, 12 11, 6, 3	18, 10, 5 3.5, 2, 2	11 3.5			

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APPENDIX I continued

Day/Month Year	Air tanker & drop no.	Volume dropped (L)	Drop site	Retardant	Drop height (m)	Drop speed (kn/h)	Viscosity (description or mPa·s)	Recovery (%)	Length (L) & width (W)	0.00 cm (trace)	0.005 cm
3/8/77	PBY-5A	3228	Open	Fire-Trol	29	185	4250	88	L	160	148
	Canso 1	Salvo		931					W*	30	26
4/8/77	PBY-5A	1600	"	"	37	176	1800	84	L*	190	142
	Canso 2	Single							W	25	17
4/8/77	PBY-5A	3228	"	"	27	176	1660	87	L*	185	160
	Canso 3	2-door string							W*	25	20
4/8/77	PBY-5A	3864	"	"	29	185	810	76	L*	197	161
	Canso 4	Salvo							W*	23	20
4/8/77	PBY-5A	3228	"	"	26	176	1270	81	L*	130	127
	Canso 5	Salvo							W	28	26
4/8/77	PBY-5A	3637	"	Water	29	176	1	79	L*	140	130
	Canso 6	Salvo							W*	50	44
4/8/77	PBY-5A	3228	"	Fire-Trol	27	176	1720	74	L*	175	137
	Canso 7	Salvo		931					W	22	18
9/8/78	PBY-5A	1818	Open	Chemonics Poly-	32	176	43	73	L*	155	132
	Canso 1	Single		Trol 200					W	23	19
9/8/78	PBY-5A	1818	"	"	32	176	160	89	L*	184	174
	Canso 2	Single							W	22	17
9/8/78	PBY-5A	1818	"	"	27	176	95	75	L*	185	163
	Canso 3	Single							W*	22	18
9/8/78	PBY-5A	1818	"	"	29	176	188	80	L*	180	163
	Canso 4	Single							W*	25	23
10/8/78	PBY-5A	1637	"	Fire-Trol	29	176	850	71	L	119	83
	Canso 5	Single		931					W	24	22
10/8/78	PBY-5A	1637	"	"	36	176	20	72	L*	137	120
	Canso 6	Single							W	25	22
10/8/78	PBY-5A	3273	"	"	52	176	2230	90	L*	140	130
	Canso 7	Salvo							W*	34	30
10/8/78	PBY-5A	1637	"	"	29	176	1870	93	L*	140	130
	Canso 8	Single							W*	22	19
11/8/78	B-26 9	1818	"	Chemonics Poly-	44	222	178	63	L*	90	86
		Single		Trol 200					W*	25	23
11/8/78	B-26 11	1818	"	"	43	222	+500	73	L*	110	108
		Single							W*	25	22
11/8/78	B-26 12	3637	"	"	41	222	360	79	L*	110	104
		Salvo							W*	40	32
16/6/78	B-26 1	1818	"	Water	44	222	1	68	L*	110	102
		Single							W*	22	20
16/6/78	B-26 2	3637	"	"	46	222	1	72	L	124	114
		Salvo							W*	39	34
16/6/78	B-26 3	1818	"	Monsanto	44	222	1100	70	L*	160	111
		Single		S.T.R.					W	23	21
17/6/78	B-26 4	1818	"	"	38	222	1300	78	L	135	130
		Single							W*	30	28
17/6/78	B-26 5	1818	"	"	46	222	1000	78	L*	145	134
		Single							W*	28	24
17/6/78	B-26 6	3637	"	"	40	222	1150	79	L*	170	160
		Salvo							W*	36	32
17/6/78	B-26 7	1818	"	Tenogum	46	222	950	82	L*	150	144
		Single							W*	36	34
18/6/78	B-26 8	1818	"	General	46	222	5850	54	L	100	93
		Single		Mills S.G.P.					W*	35	32

Pattern dimensions (m) by depth of recovery

0.01 cm	0.05 cm	0.10 cm	0.20 cm	0.25 cm	0.30 cm	0.40 cm	0.50 cm
144 21	89 16	78 13	55 8	25 7	22 7	8 7	7 6
135 15	76 12	61 8	15 5	10 4	4 3		
155 18	110 14	92 10	42 8	40 6	19, 11 4, 4	6 3	
148 19	91 18	66 14	57 9	42 7	30 6	15 4	5 3
125 25	88 16	78 12	28, 20 12, 6	25 9	22 5		
120 30	90 21	51, 30 16, 9	17, 23 12, 5	12, 13 8, 4	10, 10 6, 3		
133 17	104 15	71 12	43 9	25 7	22 5		
127 17	85 15	50 12					
150 13	96 10	81 7	13, 10 4, 5	12, 7 3, 3	11 3		
140 16	97 9	62 7	7 5	4 4			
152 19	78 13	62 8	10 4	3 3			
80 19	67 13	55 9	17 5	6 4	6 3		
114 17	85 12	50 8	4 4				
120 26	110 21	76 18	37 11	28 6	12 6	6 3	3 3
125 17	77 13	69 10	19 9	18 8	13 7	10 4	5 3
79 20	68 12	31 9	16 7	12 8	10 4		
105 19	103 12	48 9	12 6	11 5	8 5	6 4	5 3
100 30	86 27	58 19	35 7	6 5	5 3		
90 19	63 13	25 14	12 8	7 6	5 5		
111 29	68 21	49 16	34 11	11 5	5 4		
109 18	66 11	43 9	19 7	18 5	13 4	5 3	
125 22	67 11	43 9	18 5	11 5	8 4	5 3	
127 17	72 14	48 10	6 6	5 5	4 4	3 3	
148 30	90 16	84 13	49 7	47 6	35 5	12 4	3 3
140 30	78 13	61 8	6 4	5 3			
88 28	55 16	25 12	10 3				

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APPENDIX I concluded

Day/Month Year	Air tanker & drop no.	Volume dropped (L)	Drop site	Retardant	Drop height (m)	Drop speed (km/h)	Viscosity (description or mPa·s)	Recovery (%)	Length (L) & width (W)	0.00 cm (trace)	0.005 cm
18/6/78	B-26 9	1818 Single	Open	General Mills S.G.P.	31	222	800	62	L W	110 30	100 26
18/6/78	B-26 10	1818 Single	"	Tenogum	40	222	200	76	L W*	118 27	106 24
18/6/78	B-26 11	3637 Salvo	"	"	40	222	1225	81	L* W*	185 29	162 27
8/8/79	B-26 1	1818 Single	Open	Chemonics Poly- Trol 200	47	222	152	87	L* W*	120 50	115 40
8/8/79	B-26 2	1818 Single	"	"	46	222	262	98	L* W*	150 50	128 35
8/8/79	B-26 3	1818 Single	"	"	38	222	429	80	L* W*	140 40	128 32
8/8/79	B-26 4	1818 Single	"	"	55	222	211	77	L W*	86 31	80 26
8/8/79	B-26 5	1818 Single	"	"	46	222	213	69	L* W*	125 50	110 40
9/8/79	PBY-5A Canso 7	3800 Salvo	Open	Water	26	176	1	72	L* W*	210 39	190 30
5/5/80	Firecat 1	3296 4-door salvo	Open	Fire-Trol 931	45	207	70	73	L W*	130 36	115 32
5/5/80	Firecat 2	1655 2-door salvo	"	"	46	222	700	53	L W*	118 29	113 25
5/5/80	Firecat 3	1655 2-door string	"	"	43	222	700	63	L W*	147 27	138 21
6/5/80	Firecat 4	1655 2-door salvo	"	"	48	222	1535	82	L W	123 38	103 31
6/5/80	Firecat 5	1655 2-door string	"	"	46	222	1535	76	L* W*	161 29	152 24
6/5/80	Firecat 6	3296 4-door salvo	"	Water	46	222	1	69	L* W*	108 32.5	100 31
7/5/80	Firecat 7	1655 2-door salvo	"	Phos-Chek XB	46	222	2087	88	L W*	130, 15 35, 10.5	127, 9 28, 7
7/5/80	Firecat 8	1655 2-door string	"	"	44	222	2087	73	L W	197 30.5	177, 10 23, 7
7/5/80	Firecat 9	3296 4-door string	"	Phos-Chek XB	46	222	1600	83	L* W	270 31	270 24
7/5/80	Firecat 10	3296 4-door string	"	"	31	259	1600	88	L* W	240 32	239 27
7/5/80	Firecat 11	827 Single	"	"	46	222	2200	95	L W*	118 35	108 27
7/5/80	Firecat 12	3296 4-door salvo	"	"	46	222	2200	78	L W*	153 34	141 31.5
8/5/80	Firecat 13	1655 2-door salvo	"	Fire-Trol 100	35	232	2255	93	L W*	138 33	132 31
8/5/80	Firecat 14	1655 2-door string	"	"	30	232	2255	87	L* W*	188 29	160, 15 26, 13.5
8/5/80	A-26 15	1818 Single	"	Chemonics Poly- Trol 200	44	232	58	94	L W*	141 34	113, 17 29.5, 6
8/5/80	A-26 16	1818 Single	"	"	46	232	279	87	L W	161 33	150 27
8/5/80	A-26 17	3637 Salvo	"	"	35	232	279	77	L W*	162 35	141 29

Pattern dimensions (m) by depth of recovery

0.10 cm	0.05 cm	0.10 cm	0.20 cm	0.25 cm	0.30 cm	0.40 cm	0.50 cm
97 23	65 16	30 12	10 8	8 7	6 5	4 3	
104 20	54 14	33 12	17 8	7 6	3 3		
136 23	107 17	81 14	21 9	19 6	18 5	4 3	
110 30	76 14	46 9	17 6	13 5			
115 30	74 16	38 7	18 6	5 3			
125 30	57 14	34 10	12 8	11 6	5 3		
77 22	63 14	49 10	19 6	9 5	8 4	6 3	
100 35	43 19	25 11	3 3				
175 26	90 18	43, 20 18, 6	24 6	21 4	6 3		
113 30	75 22	42, 5 20, 3	22 15	17 7	6, 5 5.5, 3		
67, 28, 4 21, 12, 4	40, 15 12, 6	28 8	10 4.5	6 4.5	5 3		
130 19	40, 38 13, 10.5	17, 7 8, 7.5					
8 6.5	101, 5 27, 3	49 16	30 15	8 10	6 8	5 3	
148 21	100 11	9, 11, 10, 3 7.5, 7, 4, 3					
99 29	73 22	43, 5 17, 3	22 8	15 5.5	7 4.5		
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