AIR DROP TESTS WITH FIRE-TROL 100 AND PHOS-CHEK 205 FIRE RETARDANTS

by

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ABSTRACT

Fire-Trol 100 and Phos-Chek 205 long-term fire retardants were dropped by a Thrush Commander airtanker onto three sites: 1) an open field; 2) a lodgepole pine stand; and 3) a white spruce-aspen stand. The twenty 310-gallon loads were calibrated and ground distribution patterns drawn. On each site, there were no important differences between the drop patterns of Fire-Trol and Phos-Chek, although the drop patterns of both retardants differed between drop sites. In the open area, 82% of the Fire-Trol and 83% of the Phos-Chek loads was recovered on the ground; in the lodgepole pine stand 29% and 28%, and in the white spruce-aspen stand 40% and 33% was recovered respectively. Sixty-six per cent (66%) of the Fire-Trol was retained by the lodgepole pine tree canopy compared to 67% for Phos-Chek. However, Phos-Chek coated more aerial and ground fuel surface area than did Fire-Trol, a result of the gum-thickener versus clay-thickener. At the .04" retardant application rate (2.1 imperial gal/100 sq. ft.), the Thrush Commander airtanker builds 95 feet of ground fire-line in the open, 35 feet in the lodgepole pine stand and 55 feet in the white spruce-aspen stand to a minimum width of 10 ft. The tests indicate the Thrush Commander has limited capability as an 'airtanker'.

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INTRODUCTION

The use of long-term retardants is an established practice in aerial fire suppression in the United States and western Canada. In the United States Forest Service Northern Region, 2,435,000 gal of long-term retardant were applied by aerial tankers in 1967 (Hardy, 1967). This amount evenly consisted of Fire-Trol 100 and Phos-Chek 202[2], at present the most commonly used fire retardants. Liquid concentrate (LC) retardant is gaining popularity, but its volume of use is still small compared to that for Fire-Trol 100 and Phos-Chek 202.

The effectiveness of long-term retardants in retarding and/or suppressing wildfires was established through both laboratory and field tests (Hardy _et al._, 1962; Davis _et al._, 1962; Davis _et al._, 1963). At the same time, the superiority of both Fire-Trol 100 and Phos-Chek 202 over bentonite, a short-term retardant, was recognized during operational trials at selected air-tanker bases. Since only one of the long-term

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[1] Research Officer, Canadian Forestry Service, Department of the Environment, Edmonton, Alberta.

[2] In Canada, Phos-Chek 202 was marketed as Phos-Chek 205, prior to 1969. Phos-Chek 205 was a two-bag (unblended) product; one bag contained the diammonium phosphate salt and the other the thickening agent and other additives.

retardants was usually tested and subsequently operationally applied from a base, the two could not be readily compared. Thus, although both have been operationally utilized since the early 1960's, a quantitative comparison of their air drop characteristics, e.g., ground distribution pattern, drift, and tree canopy penetration and retention, has not been made.

A series of air drop tests with the two retardants was conducted in co-operation with the Alberta Forest Service near Edson, Alberta, during September, 1968. The Thrush Commander[3], a low-winged agricultural aircraft with a normal load capacity of 310 Imperial gallons, was used to drop the retardants. Objectives of tests were: 1) to compare the air drop characteristics of Fire-Trol 100 and Phos-Chek 205; and 2) to determine the effectiveness of the Thrush Commander as an airtanker. Results of the study are presented in this report.

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[3] Henceforth referred to as the Thrush.

DESCRIPTION OF RETARDANTS

Fire-Trol 100

Fire-Trol 100, a slurry, is manufactured by Chemonics Industries Limited, Kamloops, B.C. It consists of a 15% ammonium sulphate solution by weight, is thickened by attapulgite clay to 1400-2000 centipoise units (cps), and has a corrosion inhibitor and pigment added (Anon., 1967). Attapulgite clay is similar to bentonite, but the former is less affected by variation in water temperature, hardness, or impurities.

For a 15% solution, 333 lb of Fire-Trol 100 are added to 100 gal of water (3.3 lb/gal). With mixing, there is a 20% swellage in the slurry. Mixers with high shear impellers are mandatory to obtain proper viscosity; but once attained, the viscosity level holds almost indefinitely (Anon., 1967). One gallon of slurry weighs 11.2 lb.

There is no bacterial deterioration and only slight contamination in a retardant chemical thickened by attapulgite clay. An inhibitor reduces the rate of corrosion to "an acceptable level" (Anon., 1967). Cost of a ton of Fire-Trol 100 is $133.50 f.o.b. Kamloops, B.C. (18.5¢/gal excluding mixing). One ton of dry material makes 720 gal of retardant slurry.

Phos-Chek 205

Phos-Chek 205, a viscous retardant solution, is manufactured by Monsanto Canada Limited, Vancouver, B.C. The retardant mixture contains 10% diammonium phosphate (DAP) solution by weight, is thickened by sodium carboxymethylcellulose (CMC) to 800-1200 cps, and has corrosion and spoilage inhibitors and pigment added (Anon., 1967).

For a 10% solution at proper viscosity, 137 lb of Phos-Chek 205 are added to 100 gal of water (1.37 lb/gal). Upon mixing, there is a 7% swellage in the solution. It can be mixed in a Lely-type side-entry propeller batch mixer; a high shear impeller may not develop maximum viscosity (Anon., 1967). An efficient continuous flow mixer has also been developed for mixing the retardant. One gallon of solution weighs 10.7 lb.

An inhibitor prevents bacterial deterioration, however, contamination by residue of other materials may cause irreparable loss of viscosity. An inhibitor reduces the rate of corrosion to "an acceptable level" (Anon., 1967). Cost of Phos-Chek 205 per ton is $350.00 f.o.b. Kamloops, B.C. (22¢/gal excluding mixing). One ton of dry material makes 1570 gal of retardant solution.

PROCEDURES

Description of Field Sites

Three level sites were selected for the air drops: 1) an open field; 2) a mature, well-stocked stand of lodgepole pine (Pinus contorta var. latifolia); and 3) a mature, medium-stocked stand of white spruce-aspen (Picea glauca, Populus tremuloides). Grid systems, one in the open field and two in each of the forest stands, were established to calibrate the retardant drops[4]. Each grid system was 400 ft long and 170 ft wide, and consisted of 738 containers arranged in a 10-foot-square spacing. Paper cups were placed into the containers to collect the retardant. After each air drop, the cups containing retardant were capped to prevent evaporation, collected, and weighed. Figure 1 shows the drop areas and grid system. A detailed description of the field sites, grid system, and drop procedures is presented in the Appendix.

Preparation of Retardant Mixtures

Fire-Trol 100 and Phos-Chek 205 were mixed according to manufacturers' specifications with a side-entry propeller-equipped batch mixer. Creek water at a temperature of 50 to 55°F was used. The viscosity of each airtanker load was measured with a Brookfield Viscometer Model LVF, No. 4 spindle, 60 rpm.

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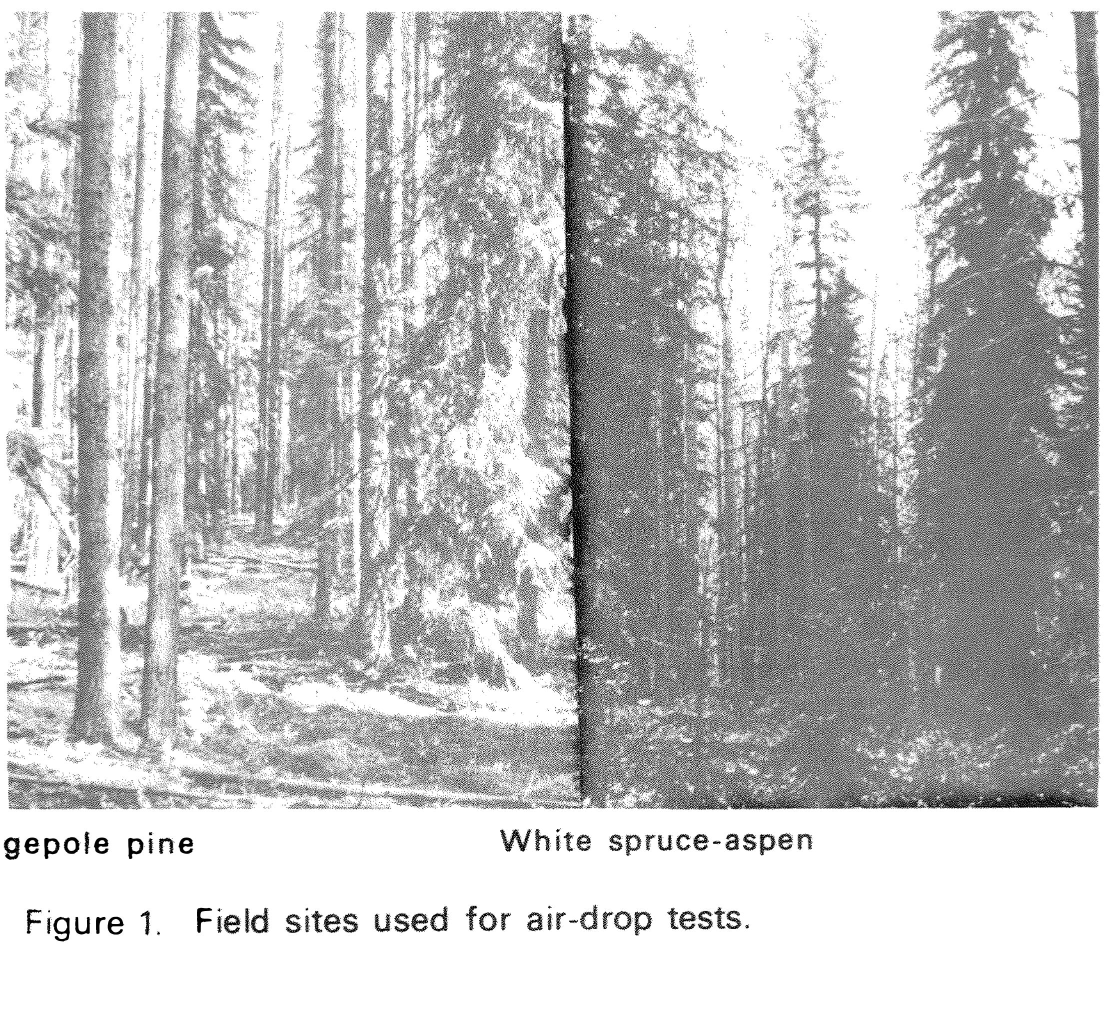
[4] The procedure described by both Hodgson (1967) and MacPherson (1967) was modified and used to establish the grid systems in the open field and forest stands.

Open field with closeup of container and retardant collected in cup.



Lodgepole pine White spruce-aspen

Figure 1. Field sites used for air-drop tests.

Drop Specifications

Air drop tests were made with the Thrush CF-XLE. Loads of 310 gal of retardant were released on the open field from 85 ± 10 ft and on the forest stand sites from 20 ± 10 ft (low drop) and 60 ± 10 ft (high drop) above the tree canopy. Air speed for all the test drops was approximately 100 mph. The loads were dropped when ground wind speed on the site was less than 7 mph. To permit the release of retardant onto a dry tree canopy, the schedule was arranged so that only one load was dropped on a forested grid on any one day.

A total of 22 air drop tests was made (Table 1). Operational data for the drops are presented in Table 2. Figures 2-4 show air drops onto the different field sites.

Table 1. Air drop tests with Fire-Trol 100 and Phos-Chek 205 by a Thrush Commander airtanker, Edson, Alberta, September, 1968

	Drop height (ft)	Number of drops	
		Fire-Trol 100	Phos-Chek 205
Open	85 ± 10	3	3
Lodgepole pine	20 ± 10	3	3
	60 ± 10	1	1
White spruce-aspen	20 ± 10	3	3
	60 ± 10	1	1

Table 2. Operational data for air drop tests of Fire-Trol 100 and Phos-Chek 205 by Thrush Commander airtanker. Edson, Alberta, September, 1968

Drop no.	Date and drop no.	Site[a]	Vis-cosity (cps)	Drop height[b] (ft)	Air temper-ature (°F)	Relative humidity (%)	Wind speed (mph)	Wind direction
				Fire-Trol 100				
1	Sept. 10 (1)	S 1	1850	L	62.5	98	0	--
2	Sept. 10 (2)	S 2	2000	L	66.5	98	0	--
3	Sept. 10 (4)	0	2550	85'	62.0	98	0	--
4	Sept. 11 (1)	S 1	1850	H	54.5	65	3	NW
5	Sept. 11 (2)	S 2	1950	L	55.0	65	2	NW
6	Sept. 11 (3)	P 1	1950	L	55.5	71	2	NW
7	Sept. 11 (4)	P 2	1900	L	54.5	77	2	NW
8	Sept. 12 (1)	0	2000	84'	51.5	86	1	NW
9	Sept. 12 (2)	0	1700	91'	58.0	75	3	NW
10	Sept. 12 (3)	P 1	2050	L	58.5	60	4	NW
11	Sept. 12 (4)	P 2	2250	H	58.5	61	5±	NW
				Phos-Chek 205				
1	Sept. 13 (1)	S 1	950	H	59.5	61	2	NE
2	Sept. 14 (1)	0	1000	80'	54.0	73	0	--
3	Sept. 14 (2)	0	1225	75'	56.5	72	0	--
4	Sept. 14 (3)	0	1250	85'	56.0	71	1	SE
5	Sept. 14 (4)	S 2	1270	L	57.0	75	0	--
6	Sept. 14 (5)	P 1	1040	L	61.5	64	0	--
7	Sept. 14 (6)	P 2	1000	H	61.5	80	0	--
8	Sept. 15 (1)	S 1	1550	L	51.0	69	2	NW
9	Sept. 15 (2)	S 2	1410	L	51.0	63	4	NW
10	Sept. 15 (3)	P 1	1140	L	54.0	56	3	NW
11	Sept. 15 (4)	P 2	1075	L	55.5	44	7	NW

[a] 0 = open area; P = lodgepole pine; S = white spruce-aspen; 1 and 2 indicate grid system plot.
[b] L = 20 ± 10 ft. above canopy; H = 60 ± 10 ft above canopy.

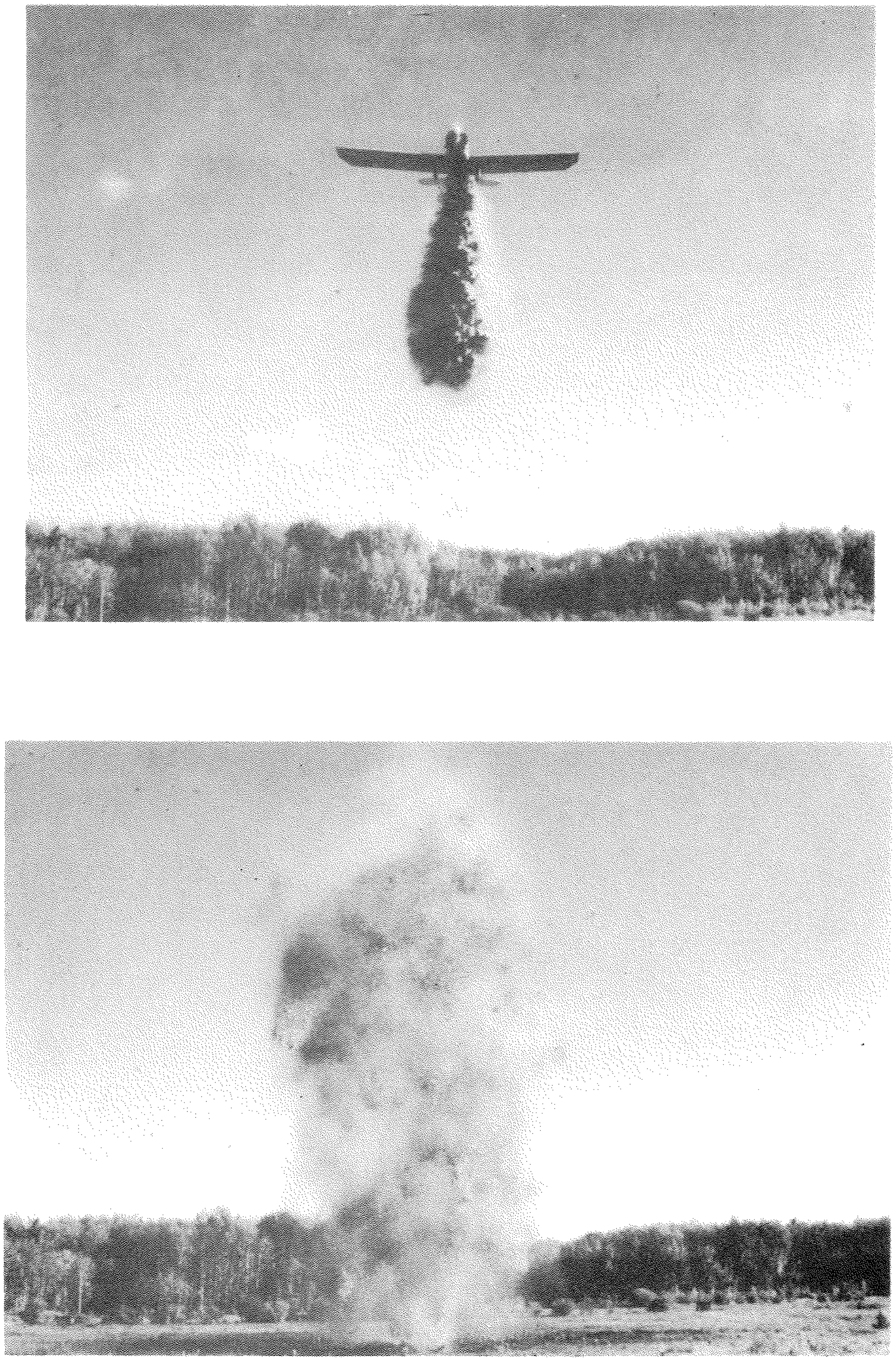


Figure 2. A Phos-Chek 205 drop on the open field grid system.

Figure 3. A low drop on the white spruce-aspen stand with Phos-Chek 205.

Figure 4 A high drop on the lodgepole pine stand with Fire-Trol 100.

ANALYSIS OF DATA

The retardant weights measured for each drop were plotted on a scaled grid, and isolines representing >0, .005", .01", .02", .04", .07", .10", .15" and .20" retardant depth were drawn[5]. A planimeter was used to measure the area of each of the retardant contour levels. Three readings of each level were taken, averaged, then multiplied by a conversion factor to obtain the area in square feet.

The length of individual contour levels was measured along the direction of flight to a minimum width of 10 ft according to criteria described by MacPherson (1967). The 10-ft width was considered the minimum required for an effective fire-line.

The amount of retardant reaching the ground was calculated for each drop, with the assumption that each cup in the 10 x 10-ft grid system represented one-half the distance to the adjacent containers, or an area of 100 sq ft. From this, the total weight of the retardant collected in grams was converted to gallons and the amount recovered

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[5] A retardant weight of 1.24 gm represented the .01" contour level for Fire-Trol 100, while 1.19 gm represented the .01" contour level for Phos-Chek 205. Similarly, 2.48 gm and 2.38 gm represented the .02" contour level for Fire-Trol 100 and Phos-Chek 205 respectively. The retardant depths correspond to the following gal/100 sq ft values:

Retardant Depth (inches)	Gal/100 sq ft Imperial	U.S.
.005	0.2	0.3
.01	0.5	0.6
.02	1.0	1.2
.04	2.1	2.5
.07	3.6	4.4
.10	5.2	6.2
.15	7.8	9.3
.20	10.4	12.5

on the ground calculated in per cent.

In addition, the percentage of retardant recovered in the contour intervals of the ground distribution patterns was calculated for the open field drops using a different procedure. The average retardant depth of two adjoining contour intervals was multiplied by the corresponding area and converted to gallons.

RESULTS

Open Field

The overall sizes of the Fire-Trol 100 and Phos-Chek 205[6] ground distribution patterns, as represented by the .005" contour, were similar. However, the concentration of the retardants within the patterns differed. The area covered by Phos-Chek was greater at .01", .02", and .04", the same at .07", and less than Fire-Trol at $\geq$.10" (Fig.5, Table 3). In the length of individual contour levels, a trend similar to that of area was established. The contour lengths were similar at .005" and .01", longer for Phos-Chek at .02", .04", and .07", but longer for Fire-Trol $\geq$.10" (Fig.5, Table 4).

The proportion of retardants reaching the ground was the same; Fire-Trol averaged 82% and Phos-Chek 83% of the amount dropped (Table 3). The proportion of retardant in each contour level and the accumulated percentage are shown in Table 5. (The total amounts recovered vary because of the two procedures used to calculate the proportion reaching the ground.)

The results indicate that Phos-Chek solution with an average viscosity of about 1200 cps exhibited more lateral and forward dispersion during the fall to the ground than did Fire-Trol with an average viscosity of about 2100 cps. However, at the .04" level of application,which is considered the minimum effective application rate,

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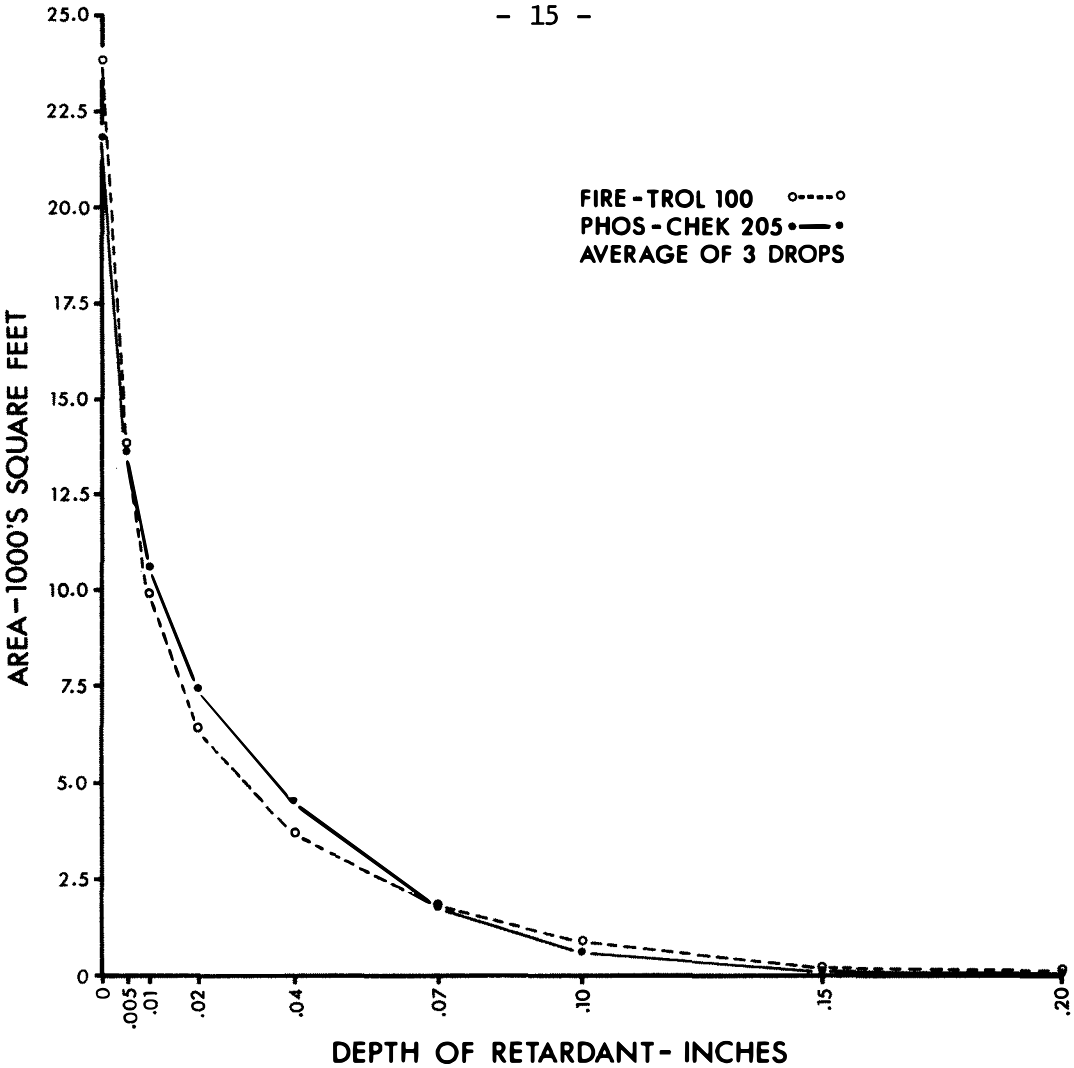
[6] Henceforth referred to as Fire-Trol & Phos-Chek.

Phos-Chek covered more area and length than did Fire-Trol. Examples of the open field ground distribution patterns are shown in Figures 6 and 7.



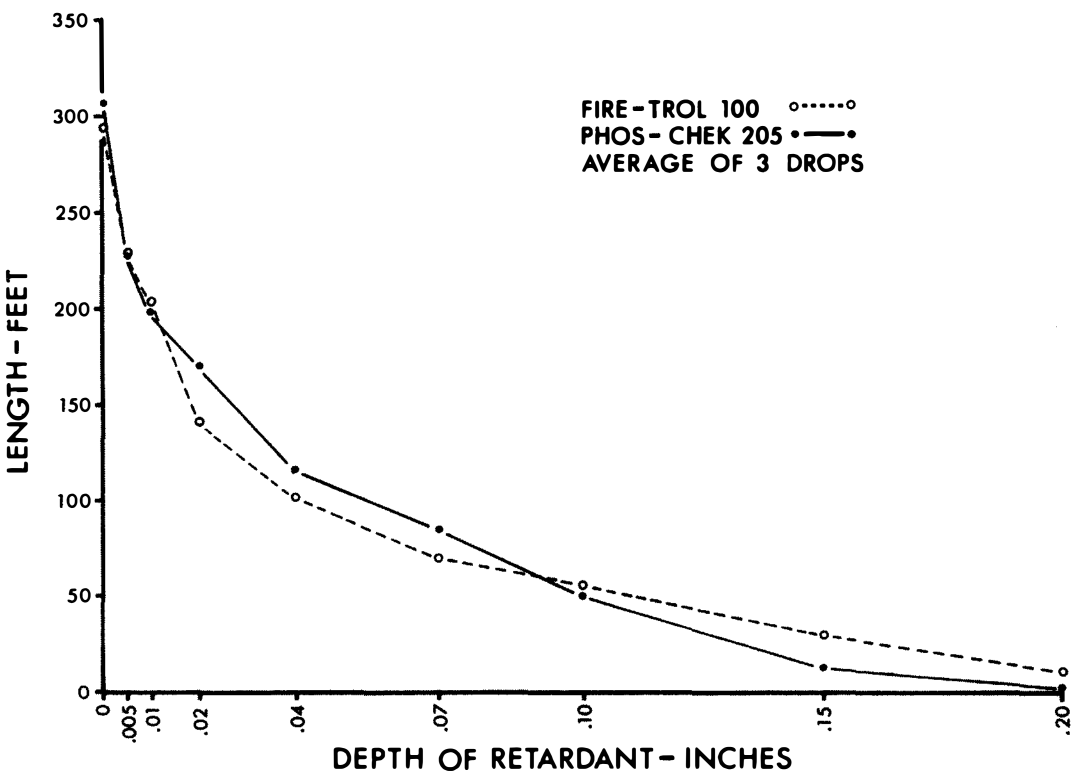


Figure 5. Area and length of contour levels for ground distribution patterns in open field.

Table 3. Contour areas and percentage ground recovery for Fire-Trol 100 and Phos-Chek 205 ground distribution patterns in open field

Retardant and drop no.[1]	Viscosity (cps)	Contour (depth in inches)									Ground recovery (%)
		>0	.005	.01	.02	.04	.07	.10	.15	.20	
Fire-Trol 100		Area in square feet									
3	2,550	24,240*	12,583*	10,026*	6,916	3,968	1,736	924	324	64	85
8	2,000	19,804*	12,012	8,620	5,692	3,460	1,892	1,036	176	4	75
9	1,700	27,467	16,856	11,012	6,652	3,736	1,812	828	180	56	86
Average	2,083	23,837	13,819	9,886	6,420	3,721	1,813	929	227	41	82
Phos-Chek 205		Area in square feet									
2	1,000	24,788	13,268*	10,372*	7,376	4,556	1,624	660	40	--	85
3	1,225	21,544*	12,824	9,944	7,217	4,592	2,120	740	68	--	80
4	1,250	18,988*	14,860*	11,412	7,640	4,284	1,684	492	124	28	83
Average	1,158	21,773	13,651	10,576	7,411	4,477	1,809	631	77	9	83

[1]Indicates drop number as listed in Table 2.
*Part of contour fell outside of grid.

Table 4. Contour lengths for Fire-Trol 100 and Phos-Chek 205 ground distribution patterns in open field

Retardant and drop no.[1]	Viscosity (cps)	Contour (depth in inches)								
		>0	.005	.01	.02	.04	.07	.10	.15	.20
Fire-Trol 100		Length in feet								
3	2,550	283*	178*	170*	137	105	60	48	39	13
8	2,000	282*	240	205	149	107	72	63	24	2
9	1,700	316*	273	233	137	90	78	56	23	14
Average	2,083	294	230	203	141	101	70	56	29	10
Phos-Chek 205		Length in feet								
2	1,000	347*	237*	193*	158*	124	102	57	7	--
3	1,225	305*	228	191	168	112	73	49	8	--
4	1,250	270*	223*	214*	183	108	81	41	22	7
Average	1,158	307	229	199	170	115	85	49	12	2

[1]Indicates drop number as listed in Table 2.
*Part of contour fell outside of grid.

Table 5. Recovery rates for Fire-Trol 100 and Phos-Chek 205 by contour intervals. Open field drop tests.

Fire-Trol 100

Drop no.	Viscosity (cps)	Contour interval (inches) >0≤.005	>.005≤.01	>.01≤.02	>.02≤.04	>.04≤.07	>.07≤.10	>.10≤.15	>.15≤.20	Total Recovery (%)
		-Retardant recovered in per cent-								
3	2550	4.8	3.2	7.8	14.8	20.5	10.2	12.5	7.6	81.4
8	2000	3.2	4.2	7.3	11.2	14.4	10.7	18.0	5.0	74.0
9	1700	4.4	7.3	10.9	14.6	17.7	14.0	13.5	3.6	86.0
Average	2099	4.1	4.9	8.7	13.5	17.5	11.6	14.7	5.4	80.4
Accumulated %		-	9.0	17.7	31.2	48.7	60.3	75.0	80.4	-

Phos-Chek 205

Drop no.	Viscosity (cps)	>0≤.005	>.005≤.01	>.01≤.02	>.02≤.04	>.04≤.07	>.07≤.10	>.10≤.15	>.15≤.20	Total Recovery (%)
		-Retardant recovered in per cent-								
2	1000	4.8	3.6	7.5	14.2	27.0	12.1	13.0	1.1	83.3
3	1225	3.6	3.6	6.8	13.2	22.8	17.3	14.1	1.9	83.3
4	1250	1.7	4.3	9.4	16.9	24.0	15.0	7.7	2.8	81.8
Average	1158	3.4	3.8	7.9	14.8	24.6	14.8	11.6	1.9	82.8
Accumulated %		-	7.2	15.1	29.9	54.5	69.3	80.9	82.8	-

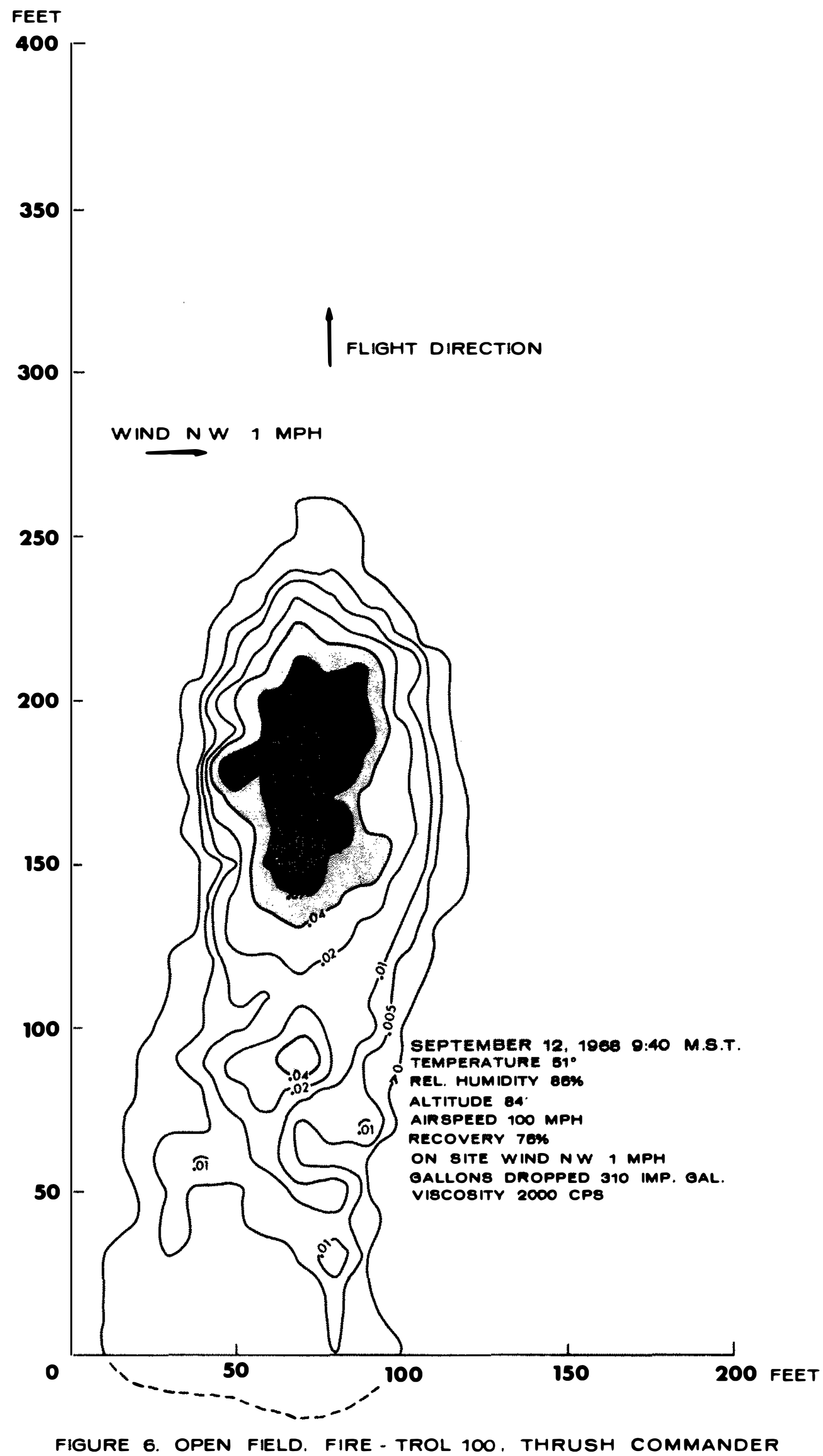


FIGURE 6. OPEN FIELD. FIRE - TROL 100. THRUSH COMMANDER

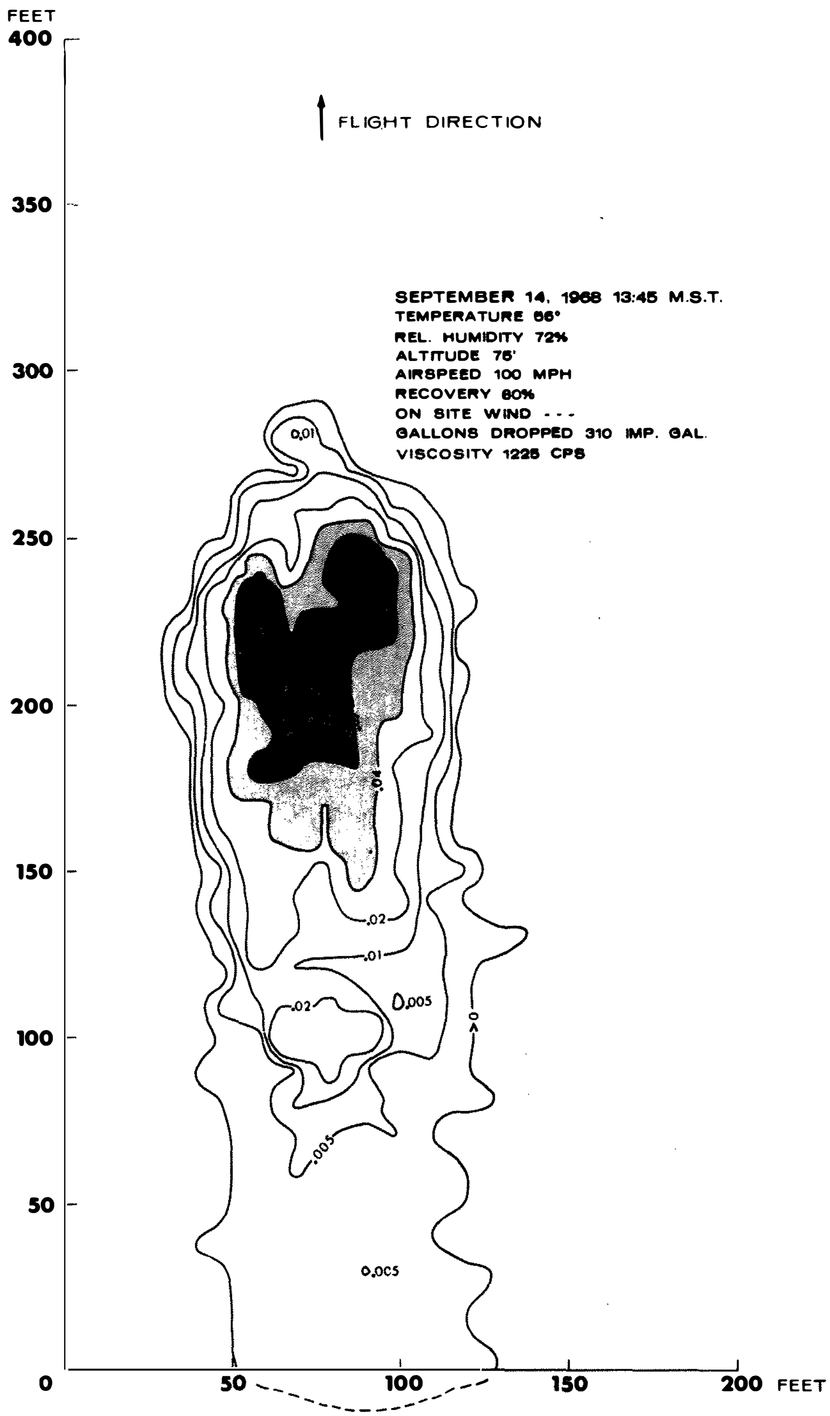
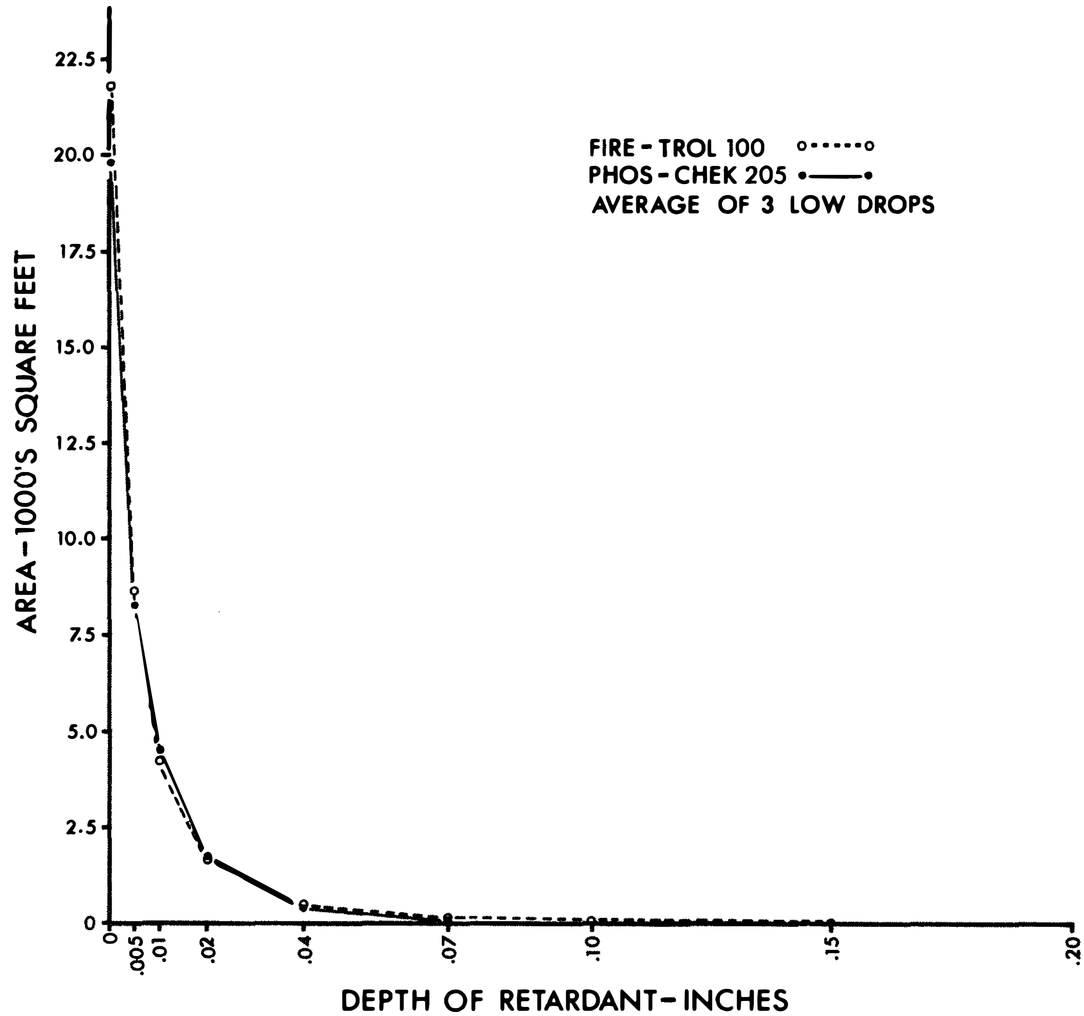


FIGURE 7. OPEN FIELD, PHOS - CHEK 205 , THRUSH COMMANDER

Lodgepole Pine Stand

Total areas of the contour levels in each ground distribution pattern in the lodgepole pine stand were similar for the two retardants in the low drops (Fig.8, Table 6); the lengths were longer for Phos-Chek at $\leq$.02" but longer for Fire-Trol at $\geq$.04" (Fig.8, Table 7). The sizes of the contours in the lodgepole pine stand were smaller than those in the open field. The effect of the tree canopy on the ground distribution pattern is shown in Figs 9 and 10. The amount of retardant reaching the forest floor in the low drops averaged 29% for Fire-Trol and 28% for Phos-Chek (Table 6).

When compared to the average of the low drops, the area and length of the levels less than .04" for the high drop were noticeably greater for both Fire-Trol and Phos-Chek. The amount of material reaching the forest floor in the high drops was 37% for both retardants--greater than for the low drops (Tables 6 and 7).



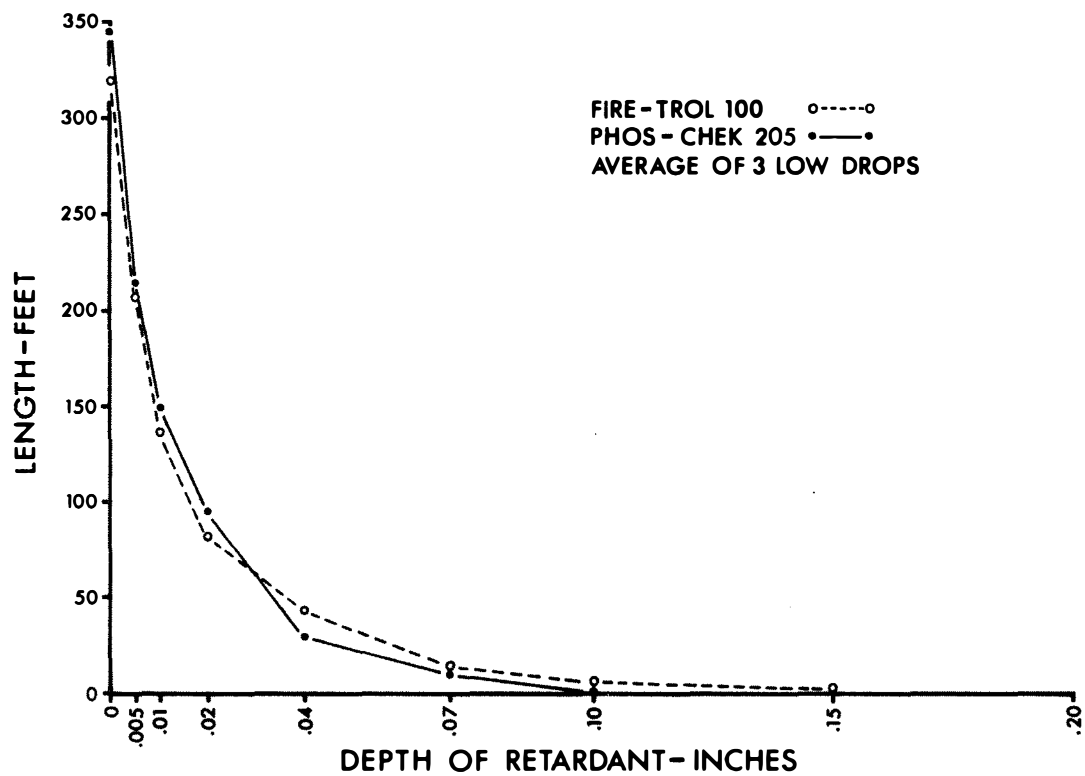


Figure 8. Area and length of contour levels for ground distribution patterns in lodgepole pine.

Table 6. Contour areas and percentage ground recovery for Fire-Trol 100 and Phos-Chek 205 ground distribution patterns in lodgepole pine stand

Retardant and drop no.[1]	Drop type[2]	Viscosity (cps)	Contour (depth in inches)									Ground recovery (%)
			>0	.005	.01	.02	.04	.07	.10	.15	.20	
Fire-Trol 100			Area in square feet									
6	L 1	1,950	22,588*	10,184	4,536*	1,220*	188*	--	--	--	--	29
7	L 2	1,900	21,644*	8,548	4,876	2,304	564	24	--	--	--	28
10	L 1	2,050	20,504	7,168	3,308	1,372	728	340	123	36	--	29
Average		1,967	21,579	8,633	4,240	1,632	493	121	43	12	--	29
11	H 2	2,250	23,548*	12,972*	7,868	2,188	588	36	--	--	--	37
Phos-Chek 205			Area in square feet									
6	L 1	1,040	19,128*	7,642	5,276	2,916	1,012	300	20	--	--	31
10	L 1	1,140	18,780*	8,240*	4,292*	1,680	356	12	--	--	--	28
11	L 2	1,075	21,424*	9,256*	4,192	592	4	--	--	--	--	26
Average		1,085	19,777	8,379	4,587	1,729	457	104	7	--	--	28
7	H 2	1,000	15,448*	10,148	8,000	3,500	1,184	136	32	--	--	37

[1]Indicates drop number as listed in Table 2.
[2]Low = low drop (20± 10'); H = high drop (60± 10'); 1 and 2 indicate grid system plot number.
*Part of contour fell outside of grid.

Table 7. Contour lengths for Fire-Trol 100 and Phos-Chek 205 ground distribution patterns in lodgepole pine stand

Retardant and drop no.[1]	Drop type[2]	Viscosity (cps)	Contour (depth in inches) >0	.005	.01	.02	.04	.07	.10	.15	.20
Fire-Trol 100			Length in feet								
6	L 1	1,950	328*	219*	163*	69*	30*	--	--	--	--
7	L 2	1,900	315*	223	154	109	52	6	--	--	--
10	L 1	2,050	316*	178*	94*	67	50	40	22	10	--
Average		1,967	320	207	137	82	44	15	7	3	--
11	H 2	2,250	305*	245	196	99	35	11	--	--	--
Phos-Chek 205			Length in feet								
6	L 1	1,040	344*	201	154	126	58	27	6	--	--
10	L 1	1,140	337*	239*	159*	110	31	5	--	--	--
11	L 2	1,075	355*	203*	134*	48	1	--	--	--	--
Average		1,085	345	214	149	95	30	11	2	--	--
7	H 2	1,000	220*	206	195	134	85	36	8	--	--

[1]Indicates drop number as listed in Table 2.
[2]L=low drop (20± 10'); H=high drop (60± 10"); 1 and 2 indicate grid system plot number.
*Part of contour fell outside of grid.

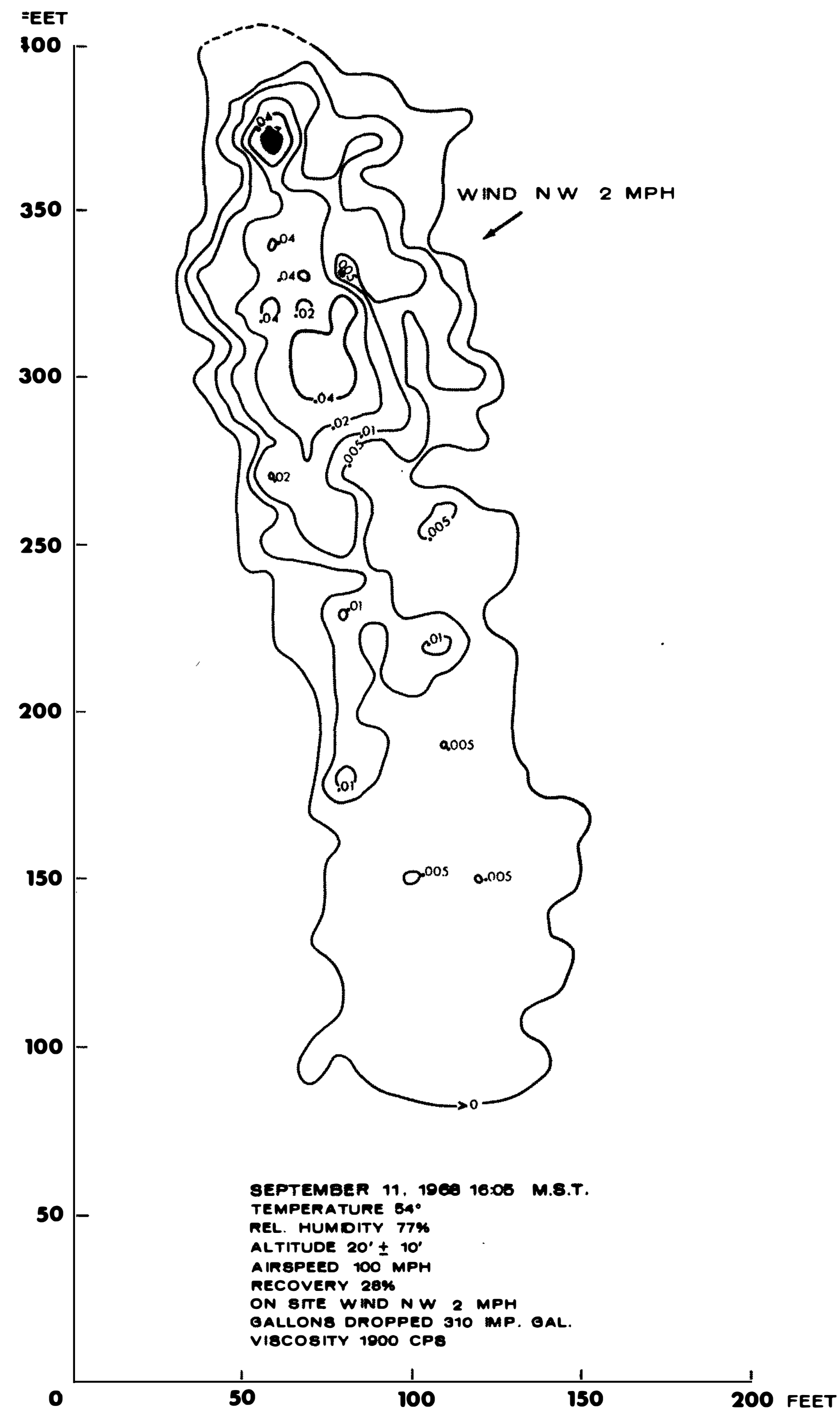


FIGURE 9. LODGEPOLE PINE. FIRE-TROL 100. THRUSH COMMANDER

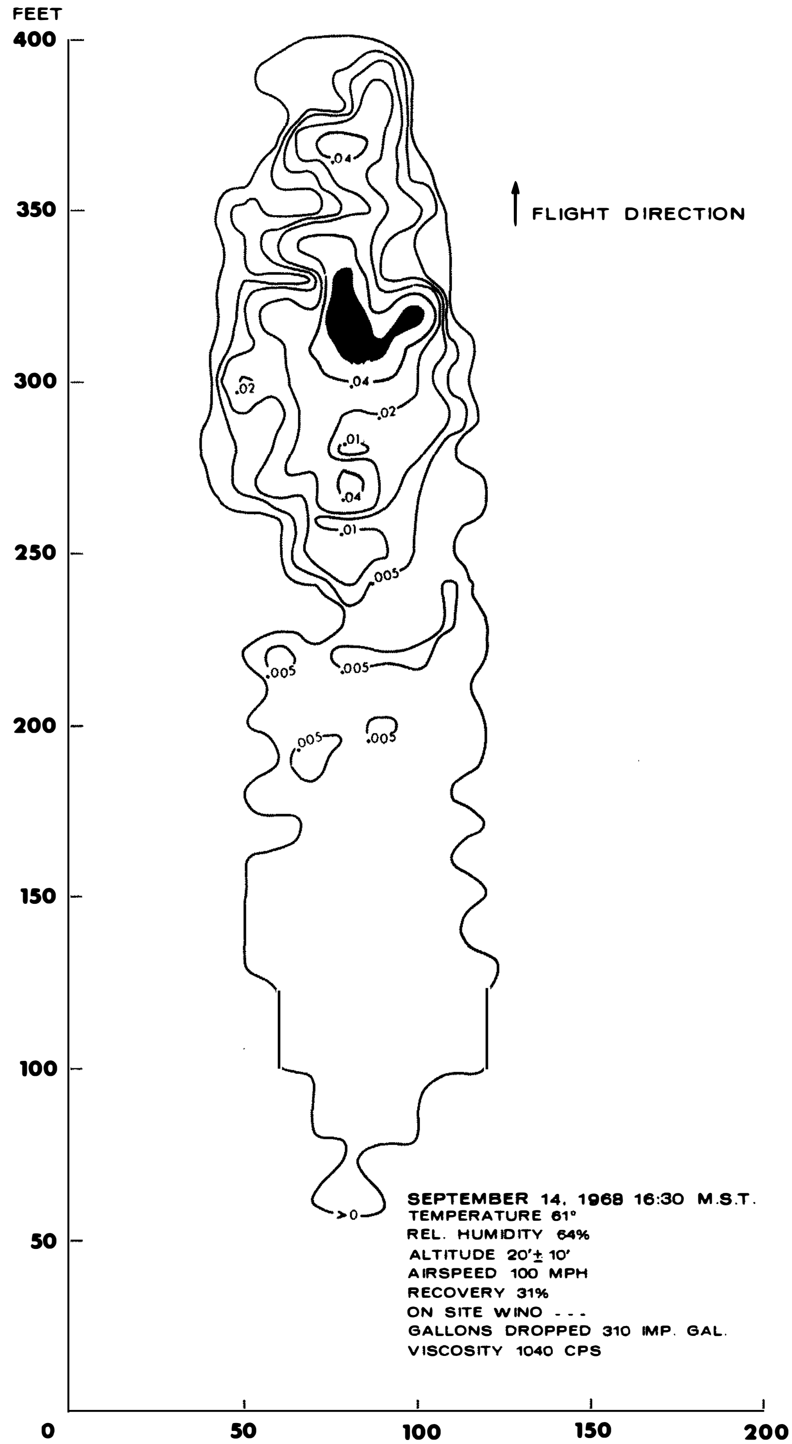


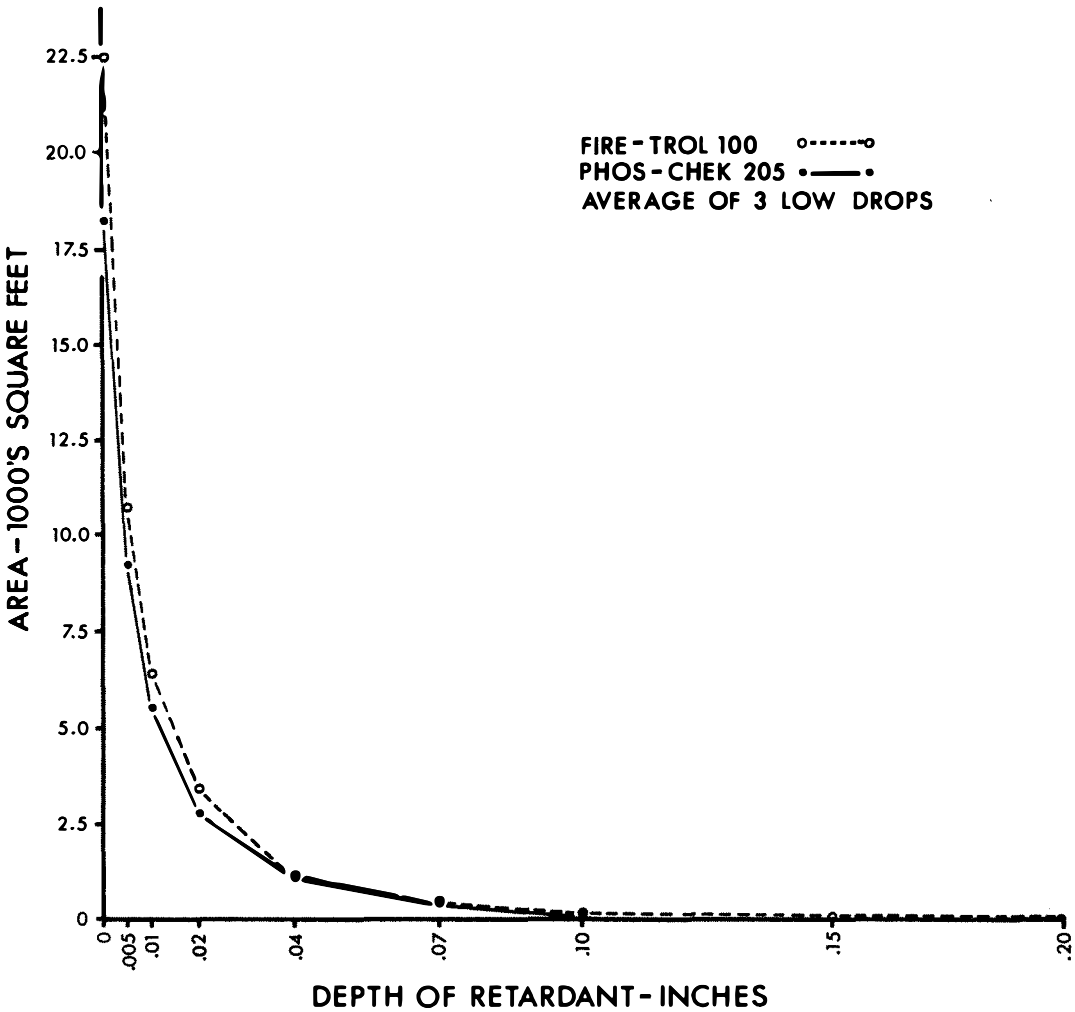
FIGURE 10. LODGEPOLE PINE. PHOS - CHEK 205. THRUSH COMMANDER

White Spruce-Aspen Stand

The ground distribution patterns for Fire-Trol and Phos-Chek were similar for the low drops in the white spruce-aspen stand. The areas for Fire-Trol were larger than that for Phos-Chek in most contours, although the differences were not great (Fig.11, Table 8). The pattern lengths for both retardants were the same for most levels (Fig.11, Table 9). Amount of retardant reaching the forest floor in the low drops averaged 40% for Fire-Trol and 33% for Phos-Chek (Table 8). The variability in stand composition at the two plots likely accounted for this difference.

For both retardants, areas and lengths of the contour levels less than .04" were greater for the high drop than for the corresponding low drops. The amount of retardant reaching the ground in the high drop for both Fire-Trol and Phos-Chek was about the same as for the low drops (Tables 8 and 9).

Ground distribution patterns in the white spruce-aspen stand were smaller than those in the open field but larger than those in the lodgepole pine stand. Examples of the patterns are shown in Figures 12 and 13.



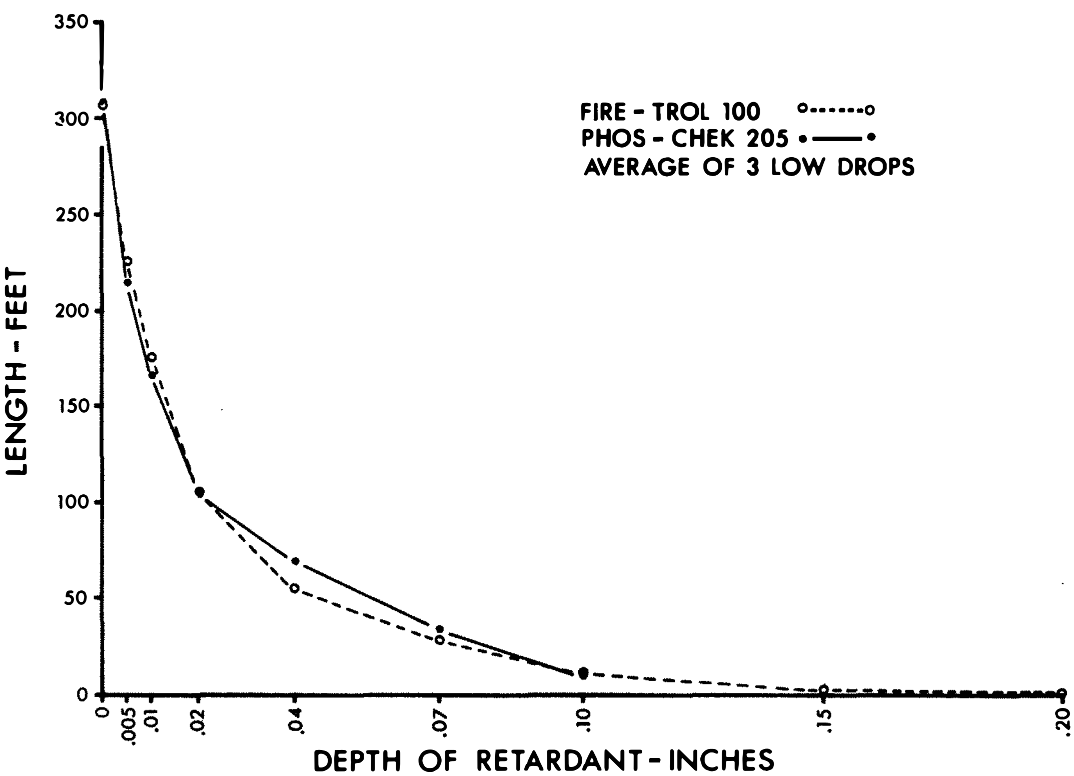


Figure 11. Area and length of contour levels for ground distribution patterns in white spruce - aspen.

Table 8. Contour areas and percentage ground recovery for Fire-Trol 100 and Phos-Chek 205 ground distribution patterns in white spruce-aspen stand

Retardant and drop no.[1]	Drop type[2]	Viscosity (cps)	Contour (depth in inches)									Ground recovery (%)
			>0	.005	.01	.02	.04	.07	.10	.15	.20	
Fire-Trol 100			Area in squre feet									
1	L 1	1,850	26,672*	12,700*	8,008	4,432	2,065	872	328	148	40	59
2	L 2	2,000	20,184	10,136	6,116	2,400	572	128	--	--	--	32
5	L 2	1,950	20,632	9,438	4,920	1,884	880	360	104	--	--	30
Average		1,933	22,496	10,757	6,348	2,905	1,173	453	144	49	13	40
4	H 1	1,850	20,128*	12,004*	9,308*	5,384	2,552	492	--	--	--	55
Phos-Chek 205			Area in square feet									
5	L 2	1,270	18,716	8,076	5,022	2,424	516	8	--	--	--	25
8	L 1	1,550	18,180*	9,844*	6,056	3,268	1,744	760	104	--	--	41
9	L 2	1,410	17,804	9,728	5,496	2,860	1,184	352	24	--	--	33
Average		1,410	18,233	9,216	5,525	2,851	1,148	373	43	--	--	33
1	H 1	950	18,460	13,060	9,408	5,004	1,432	24	--	--	--	44

[1]Indicates drop number as listed in Table 2.
[2]L = low drop (20± 10'); H = high drop (60± 10'); 1 and 2 indicate grid system plot.
*Part of contour fell outside of grid.

Table 9. Contour length for Fire-Trol 100 and Phos-Chek 205 ground distribution patterns in white spruce-aspen stand

Retardant and drop no.[1]	Drop type[2]	Viscosity (cps)	Contour (depth in inches)								
			>0	.005	.01	.02	.04	.07	.10	.15	.20
Fire-Trol 100			Length in feet								
1	L 1	1,850	351*	246*	192	112	70	37	20	11	7
2	L 2	2,000	269	201	155	108	48	23	--	--	--
5	L 2	1,950	302	223	176	99	46	24	15	--	--
Average		1,933	307	223	174	106	55	28	12	4	2
4	H 1	1,850	222*	186*	178*	148	106	47	--	--	--
Phos-Chek 205			Length in feet								
5	L 2	1,270	320	186	139	99	49	3	--	--	--
8	L 1	1,550	299*	232*	183	104	72	56	23	--	--
9	L 2	1,410	308	231	178	112	89	42	10	--	--
Average		1,410	309	216	167	105	70	34	11	--	--
1	H 1	950	252	211	199	142	106	11	--	--	--

[1]Indicates drop number as listed in Table 2.
[2]L = low drop (20± 10'); H = high drop (60± 10'); 1 and 2 indicate grid system plot.
*Part of contour fell outside of grid.

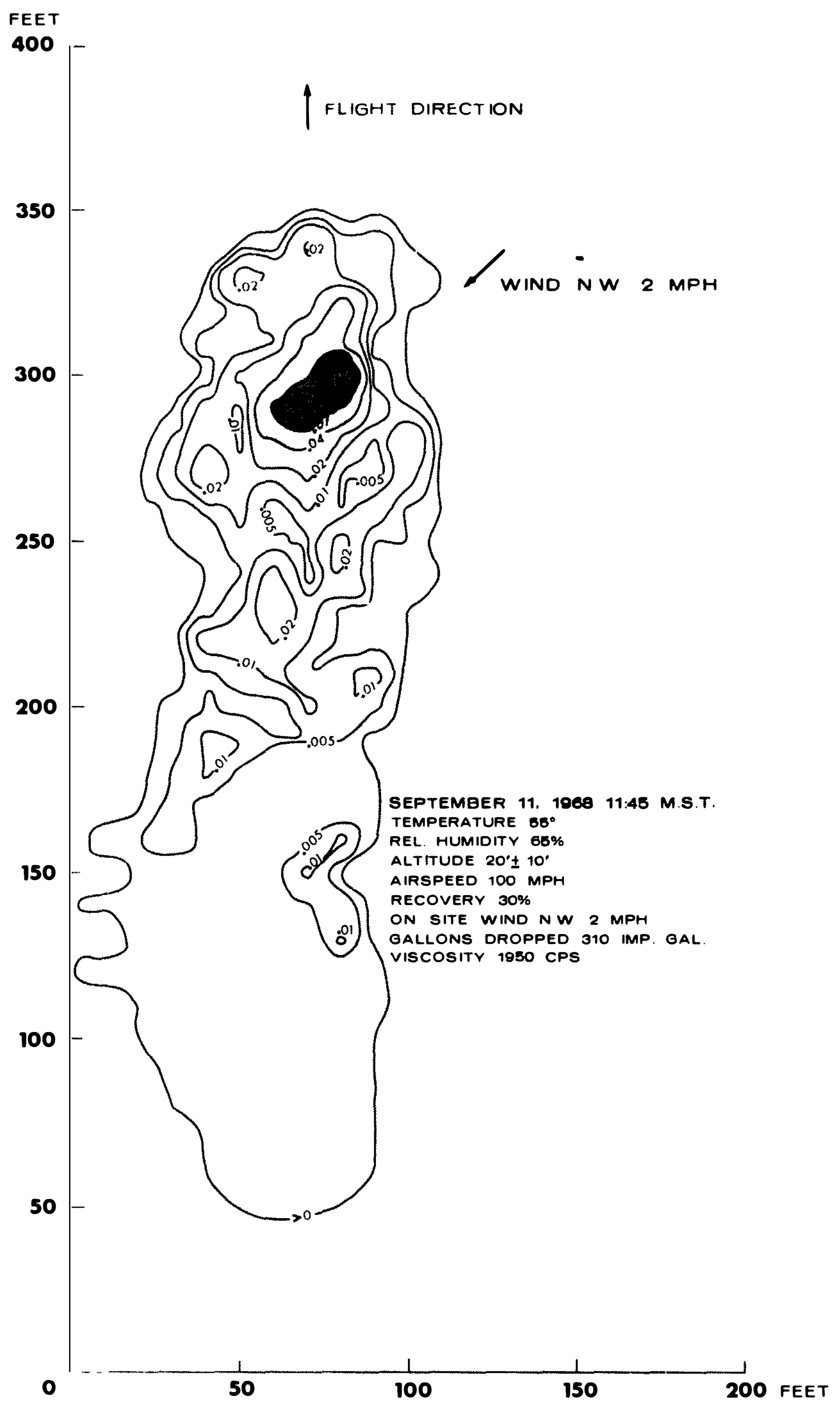


FIGURE 12 WHITE SPRUCE - ASPEN. FIRE - TROL 100. THRUSH COMMANDER

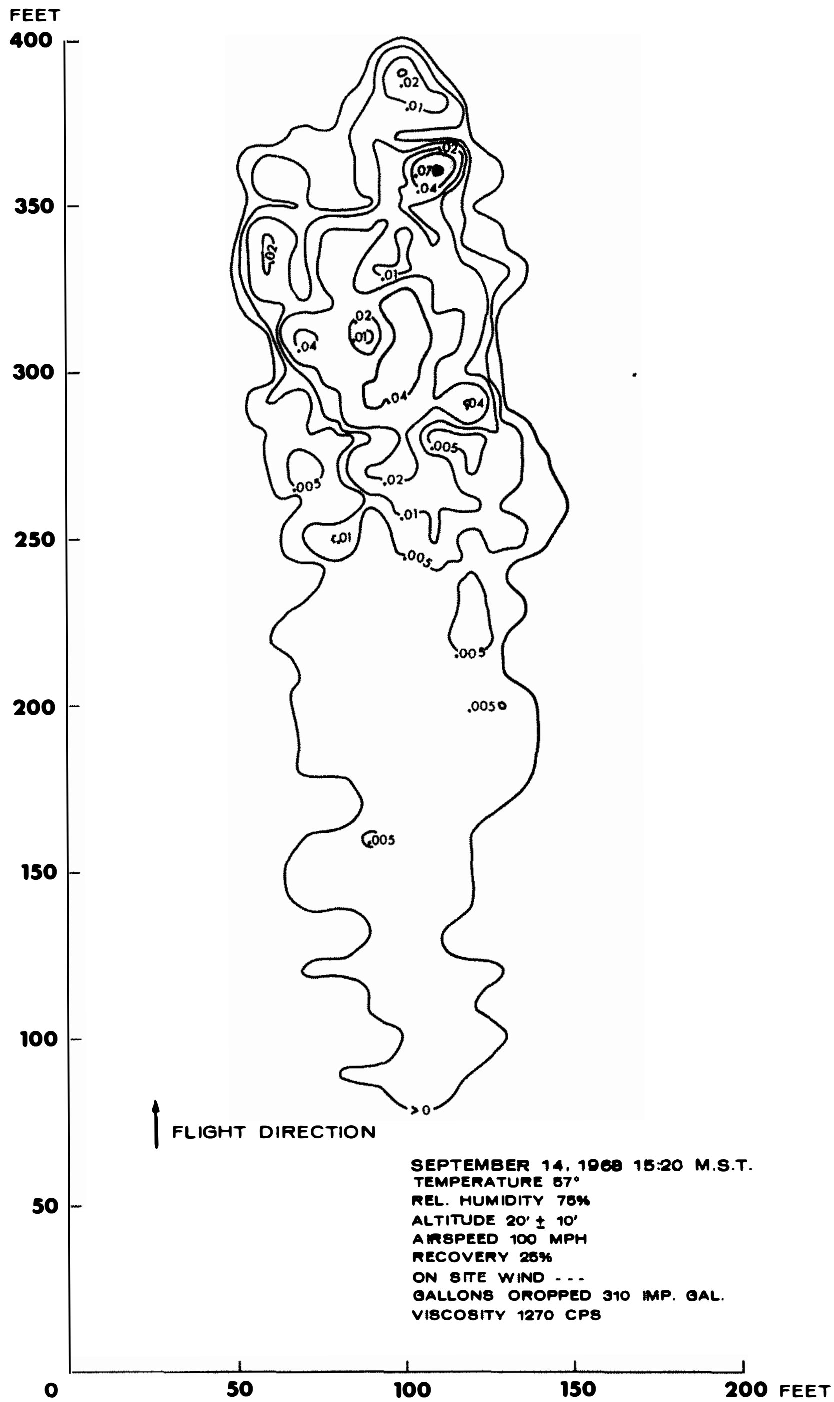


FIGURE 13. WHITE SPRUCE- ASPEN, PHOS-CHEK 205, THRUSH COMMANDER

DISCUSSION OF RESULTS

The tree canopy likely caused the difference in the ground recovery rates between the low and high drops in the lodgepole pine stand. On the low drops, the retardant was released from 20 ± 10 ft above the tree canopy, or 83 ± 10 ft above the ground. The majority of the retardant mass hit the tree canopy in bulk form, and to reach the ground had to travel both horizontally and vertically through the stand. In the high drops, the retardant was released from 60 ± 10 ft above the tree canopy, or 123 ± 10 ft above the ground. The retardant had time to disperse within the falling mass and vertical free-fall of droplets was present before contact with the canopy was made. Impact with the tree crowns was less violent.

The low drops had to pass through a much larger fuel surface area (almost 100% crown closure) than did the high drops (50% crown closure) to reach the ground, thus greater amounts of retardant were likely retained by the crowns with the low drops.

There was no appreciable difference in the amount of Fire-Trol or Phos-Chek recovered on the ground, particularly with the low drops. Thus, the amount of each retardant retained in the tree canopy was also the same. In the open field drops, 18% and 17% of Fire-Trol and Phos-Chek respectively were not recovered on the ground, and were lost to evaporation and/or drift (Table 3). In the low stand drops, a significant amount of this loss was likely intercepted and retained by the tree crowns, but measurement of the exact amount was not possible.

Table 9 summarizes the amount of each retardant reaching the ground and retained by the tree canopy; for the latter values, an arbitrary 5% loss to evaporation and/or drift before the retardant mass reached the top of the tree crowns was selected.

Table 9. Ground recovery and tree canopy retention for Fire-Trol and Phos-Chek air drops.

	Fire-Trol		Phos-Chek	
Site[1]	Recovered on[2] ground (%)	Retained by tree canopy (%)	Recovered on[2] ground (%)	Retained by tree canopy (%)
Open field	82	-	83	-
Lodgepole pine	29	66	28	67
White spruce-aspen	40	55	33	62

[1] Drops in forest stand 20 ± 10 ft above tree canopy.

[2] Average of three drops.

Although the crown penetration characteristics of Fire-Trol and Phos-Chek were similar, observation indicated that their crown retention characteristics differed. Phos-Chek, with its gum-thickener, appeared to coat more surface area on the crown fuels than did clay-thickened Fire-Trol. After a Phos-Chek drop, retardant solution dripped from tree crowns and ran down tree branches and stems for at least 10 minutes; this did not occur with Fire-Trol. Phos-Chek penetrated the forest-floor fuels to a greater degree than Fire-Trol.

Under the ideal drop conditions encountered, the air drop characteristics of the two retardants were similar. The results indicate that Fire-Trol slurry with a viscosity of approximately 2000 cps was comparable to a Phos-Chek solution of about 1200 cps. The effect that an increased wind speed and/or higher drop altitude would have on the respective drop characteristics was not determined.

The air drop tests indicated that the tank of the Thrush is not designed to produce the best ground distribution pattern. The hopper-shaped tank caused two separate retardant masses to form (Figures 3, 6 and 7).

APPLICATION OF RESULTS

Quantitative information on the minimum amounts of retardant required to stop fires of varying intensity in different fuel types is limited. However, for retardants such as Fire-Trol and Phos-Chek, between 2 and 4 U.S. gal (1.6 and 3.2 Imp gal) per 100 sq ft are required for most fuel types (Anon.,1967). The minimum application rate will be lower for light fuels and low-intensity fires, and higher for heavy fuels and high-intensity fires.

Table 10 shows the length of fire-line built by the Thrush airtanker at a drop speed of approximately 100 mph. The figures indicate the length of continuous line established on the ground to a minimum width of 10 ft.

Table 10. Ground fire-line built by Thrush airtanker

	Retardant depth (in)		
Site[1]	.02	.04	.07
	Length of ground fire-line (ft)		
Open	145	95	70
Lodgepole pine	80	35	15
White spruce-aspen	90	55	30

[1] Drop height: open field 85 ± 10 ft; forest stands 20 ± 10 ft above tree canopy.

If .04 inch of retardant is required to stop a fire burning in an open area, e.g., logging slash, the Thrush would build a continuous, effective fire-line 95 ft long. The fire-line in the lodgepole pine stand would be 35 ft; in the white spruce-aspen stand, 55 ft. In the forest stands, the retardant line established in the tree canopy is longer than that on the ground. The effect that the retardant in the lower concentration levels in the drop pattern has on the fire is not taken into consideration, although it likely reduces the fire intensity to some extent.

Analysis of the limited data for the high drop on the forest stands indicates that drops from 60 ± 10 ft above the tree canopy produce lengths and areas of ground fire-line equal to or greater than the low drops for retardant concentrations of .04 inch and less. If the objective is to "fire-proof" an area, particularly to prevent crowning, a drop higher than 20 ft above the tree canopy is desirable.

These air drop tests indicate that the capability of the Thrush airtanker is limited. In denser or taller forest stands, more than one retardant load would likely be required on the same spot. The limited line-building capability of the Thrush also indicates that the airtanker should be operated in a group of at least three, as borne out by the present operational use of the aircraft.

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APPENDIX

Description of the Stand and Grid System

The lodgepole pine stand averaged 5.9 inches dbh, 63 ft in height, and had a basal area of 166 sq ft/acre. Crown closure was estimated as 50%. The white spruce-aspen stand averaged 6.2 inches dbh (white spruce 7.5 inches, aspen 4.9 inches), 80 ft in height, and had a basal area of 124 sq ft/acre. Crown closure was estimated as 35%. The deciduous trees were fully leafed.

Containers to collect the retardant in the open field consisted of open-ended enamel cans 2.87 inches in diameter and 4.31 inches high, nailed and taped on 18-inch long, 1.5 x 1.5-inch wooden stakes; in the stands, open-topped cans with a 6-inch spike spot-welded to their bottoms were used (Figure 1). Containers in the open field were driven into the ground to a depth of 6 inches, so that the tops of the cans were a uniform 12 to 13 inches above the surface of the ground. The containers in the stand were placed into the forest floor. Collection of the retardant mixture was made with 10 oz plastic-lined paper cups which fitted snugly into the can containers. Each container was identified by a letter and number; lateral rows were labelled A-R and longitudinal columns 1-41.

The corners and centre of the open field grid were marked with bright orange 2 x 2 ft flags to facilitate aerial identification. Multi-colored flagging was placed along the centre line of the grid to designate line of flight. The grid systems in the forest stands were established so that the line of flight was parallel to a road or seismic line. A weather balloon was used to identify the centre of these grids.

Drop Specifications

For fast collection after a drop, the paper cups were labelled with the appropriate co-ordinate letter and number and placed into corresponding containers. After each drop, cups containing any retardant slurry or solution were capped within 10 minutes of the drop with tight-fitting plastic lids to prevent evaporation, and collected. For additional drops in the open, new cups were labelled to replace those collected. A direct reading balance was used to weigh the retardant cups to the nearest 0.1 gram. Possible errors that may have resulted with the procedure used are discussed in detail by MacPherson (1967).

Air temperature, relative humidity, and wind speed and direction was recorded at 4½ ft immediately prior to each drop. The release height of the aircraft over the open field site was measured by two Haga altimeters. Dummy runs were made until the predesignated drop altitude was obtained. Release heights for the drops on the forest stand were estimated by the pilot.

Grigel, J. E.

1971. Air drop tests with Fire-Trol 100 and Phos-Chek 205 fire retardants.

Information Report NOR-X-8; 41 p.; Northern Forest Research Centre, Canadian Forestry Service, Department of the Environment, 5320 - 122 Street, Edmonton 70, Alberta, Canada.

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