AIRTANKER EVALUATION IN THREE CANADIAN PROVINCES 1965-1967

by

B. S. Hodgson and E. C. Little

FOREST FIRE RESEARCH INSTITUTE
OTTAWA, ONTARIO
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CANADIAN FORESTRY SERVICE
DEPARTMENT OF FISHERIES AND FORESTRY
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Abstract

Field data measuring airtanker performance while fighting forest fires in the provinces of British Columbia, Manitoba and Ontario, 1965 - 67 are analyzed. The data presented in this study were derived from individual airtanker evaluation reports of action taken by 141 airtankers on 491 forest fires.

This study was made to supply information from which interested personnel could draw their own conclusions. Several of the more important features have been examined in each question.

Acknowledgements

The basic information contained in this study came from the reports completed by the forest protection staff of the British Columbia Forest Service, the Manitoba Department of Mines and Natural Resources and from the Ontario Department of Lands and Forests. Without their efforts, this study could not have been made.

A special word of appreciation is due to G.S. Chester, Project Leader 1964-65 who was responsible for the development and initial progress of the project. Thanks are also due to W.T. Foster and L. Affleck, Ontario Department of Lands and Forests; to W.C. Phillips, R.L. Fielder and D.H. Owen, British Columbia Forest Service and to R.R. Ross, Manitoba Department of Mines and Natural Resources who has provided unflagging interest.

Special acknowledgements are due to the pilots and staff, Protection Division, Department of Lands and Forests, Ontario who extended their cooperation to the wildfire investigation team in 1965; to the Kenora and Sioux Lookout District staff and to John K. Cleaveley of the Minaki Division, Kenora District, Ontario.

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Airtanker Evaluation 1965 - 1967
in three Canadian Provinces

by

B.S. Hodgson and E.C. Little[1]

INTRODUCTION

The Associate Committee on Forest Fire Protection of the National Research Council of Canada is composed of representatives from the Federal, Provincial, educational and industrial segments of Canada who are concerned with forest fire control.

In 1964 the recommendations of the Committee were:

"That members of the Associate Committee cooperate with proposals put forth by officers of the National Aeronautical Establishment for additional investigation into the use of aircraft for forest fire control - primarily as used in direct fire suppression."
The principal requirements were:

(a) provision of one or more officers from the provincial organizations, with one officer from the National Research Council and one from the Department of Forestry, to form a team to draw up "Airtanker Evaluation Study Forms", for use by all forest protection agencies in Canada using aircraft for water bombing.

(b) to assign at least one man per province and possibly two or three, to assist in the introduction and use of the new evaluation forms.

(c) assistance in the quick completion of the forms and submission of them to central agencies.

(d) assistance in arranging for a small investigation team to interview pilots, fire bosses and other forest protection personnel in a subjective study of the efficiency of airtankers.

(e) assistance to this same team to observe going forest fires.

Although most of the provincial officials were in favour of using a national airtanker form, they felt that observers (as outlined in the requirements part "b"), should come from outside the provincial staffs. They indicated that this study would burden provincial field personnel with additional duties and on this basis, some provinces declined to participate.

Sample airtanker report forms were produced by Mr. G.S. Chester[2] and

(1) Research Officer formerly with the Forest Fire Research Institute, now Assistant Fire Protection Officer, Forestry Commission, Hobart, Tasmania, Australia and Research Technician, Forest Fire Research Institute, Ottawa, respectively.

(2) Research Officer formerly with the Department of Forestry & Rural Development, Ontario Region, Richmond Hill, Ontario, now with Canadian Forest Products Ltd., Beaver Cove, B.C.

were circulated for comment to forest protection organizations across Canada. After assessing these returns, Mr. Chester made changes to accommodate the users' needs. To give the study a reasonable base, the forms were to be filled out by the participating provinces for three fire seasons, by which time sufficient data would be available for a preliminary analysis. On the basis of this analysis, a decision would be made to continue or terminate the use of these reports. (Appendix 4-h and 4-i)

The provinces of Ontario, Manitoba and British Columbia agreed to participate in the study and forms were sent out for the 1965 and subsequent fire seasons, (Appendix 4-a to 4-e). By the spring of 1968 the Forest Fire Research Institute had received forms from Ontario 1965-66; Manitoba 1965-67 and British Columbia 1965-67.

It should be pointed out that many provinces were already using evaluation reports of their own in order to obtain some measure of airtanker effectiveness.

ASSESSMENT

In the field of fire control the lack of standards for comparative purposes made measurements of new techniques very difficult. As no Canada-wide standards for airtanker use had been established in the past, measurements and comparisons of this new technique against other fire fighting methods was difficult. Test procedures that could be adequately used by convenient statistical methods were minimal.

Some of the information requested on the forms was subjective and presented a multitude of problems in reporting consistency. In common with past attempts made elsewhere, analysis evaluations were not too satisfactory. The Burning Index, based primarily on weather variables, came close to measuring the fire intensity (control difficulties). The factors that produced the fire control problems, were difficult to assess in relation to each other. The amount of influence one airtanker action had on one part of the fireline was difficult to relate to the overall change (or lack of change) in the fire behaviour or rate of spread.

Airtanker evaluation forms were printed in two formats:-

1- Airtanker Evaluation "AIR", to be filled out by the air observer flying above the fire (Appendix 4a, 4b, 4c).

2- Airtanker Evaluation "GROUND", to be filled out by the sector or fire boss on the ground (Appendix 4-d and 4-e).

Both "air" and "ground" reports were completed in the field by a large number of individuals, each man reporting the airtanker action from his own particular position near the attack area. The degree of consistency was not entirely satisfactory and no uniform or complete assessment of the overall operation could be made from the report form alone. Some additional information was obtained from the provinces making the survey and a few inconsistencies were evaluated.

Unfortunately, some of the essential data on the original forms as designed by Chester (Appendix 4-h and 4-i) and necessary for airtanker distribution analysis, were not always included on all forms to all provinces.

e.g. Question #23 (Airtanker location at time of call) and Q-#24 (Getaway time from base) were not asked on the Ontario and Manitoba "Aircraft" forms. The subjective nature of some questions of course received subjective answers and precluded an accurate numerical valuation. This fault probably lay in the wording of the question on the form. e.g. Q-#16 (Penetration); Q-#17 (Effectiveness); Q-#19 (Attack significance).

The general opinion was that the report questions were very difficult to answer for general field personnel, unfamiliar with airtanker use on the fireline. If a trained and experienced special observer had been used, the questions could have been made more detailed and pertinent. On the other hand, if the questions were too few and too simple, much of the data would not have been recorded and thus would have been lost.

CODING OF AIRTANKER REPORTS

An airtanker action was defined as "the distinct use of an airtanker at a particular time in a given locale".

Each fire was given an accession number and all reports concerning this particular fire were given this number. If a fire continued for many days, all reports were coded under this same fire number. Separate entries were made for each airtanker type in order to facilitate a co parison of types. If evaluation forms were returned by the air and the ground observer for a particular action as was expected in the original concept of the study, these data were combined to form a single entry. If a difference in recorded data was evident, then precedence was given to the data from the "Ground" form. During analysis and evaluation, the more conservative estimates were selected as opposed to those which were considered to be overly optimistic -- when two reports were found to be in conflict. Only the most obvious inconsistencies were discounted.

Data from the field were entered on a code worksheet in numerical form. These numbers were then punched on I.B.M. cards and a simple computer program was written to compile the input data and produce a printout suitable for evaluation. Individual errors were discovered and corrected during cross checks but undoubtably some errors may still remain in the data.

In a study such as this one, the great diversity of answers, especially those that were subjective, could not be readily handled by tabulation unless they were broadly grouped. A considerable amount of tedious back checking to the original forms had to be carried out to achieve the required groupings.

Below each question heading in the body of the report, the numeric figure is the total number of valid returns received for that question followed by the total possible answers that could have been received. e.g. Question #-1 Aircraft Type 678/716 (95%).

The above means that of 716 possible answers, 678 were entered on the report form and 38 were left blank.

It must be emphasized that all the figures used in this report, unless indicated otherwise, were from action reports received for processing by the Forest Fire Research Institute, Ottawa from the three participating provinces of Ontario, Manitoba and British Columbia.

The writers of this report have made a conscientious effort to remain unbiased. A probing attitude has been maintained regarding the reported success of an air attack.

All answers or conclusions reached in this study were based on data derived from the evaluation reports received from the cooperating provinces. It is realized that this study is not a complete coverage of airtanker use on forest fires during that period.

SUMMARY OF NUMBER OF AIRTANKERS - FIRES AND ACTION REPORTS BY PROVINCE AND YEAR

Year Prov.	Total		Airtanker Action		# Fires for which reports were rec'd	Number of Action Reports Received				
	# A.T. available	# Fires recorded	# Fires	% of all fires		Total	Air	Gd.	Air & Ground	Provincial Reports
1965 Ont.	45	1218	57	4.7	38	89	18	61	10	-
Man.	2	225	15	6.7	10	15	15	-	-	-
B.C.	16	2685	187	7.0	94	138	76	39	23	-
Total	63	4128	259	6.3	142	242 100%	109 45%	100 41%	33 14%	- 0%
1966 Ont.	47	1921	102	5.3	21	25	8	14	3	-
Man.	2	235	35	14.9	30	66	66	-	-	-
B.C.	13	1967	86	4.4	25	27	20	4	3	-
Total	62	4123	223	5.4	76	118 100%	94 80%	18 15%	6 5%	- 0%
1967* Man.	2	638	73	11.4	55	80	77	2	1	-
B.C.	14	3216	353	11.0	218	276	106	83	52	35
Total	16	3854	426	11.1	273	356 100%	183 51%	85 24%	53 15%	35 10%
1965/67 * Grand Total	141	12,105	908	7.5	491	716 100%	386 54%	203 28%	92 13%	35 5%

* Ontario 1967: no reports received

Table 1

TABLE 2

Forest Fire Occurrence Frequency, Ontario, Manitoba and British Columbia

1965-1967*

Summary of the number of forest fires - 3 year period*

Monthly

	# Fires	3 month period	% all fires (3 year period)
June	1958	23.5%	16.2%
July	3484	41.8%	28.8%
Aug.	2885	34.7%	23.8%
Total	8327	100.0%	68.8%

Three year total 1965-1967*

Year	Ontario		Manitoba		B.C.		Total	
	#	%	#	%	#	%	#	%
1965	1218	10.0	225	1.9	2685	22.2	4128	34.1
1966	1921	15.9	235	2.0	1967	16.2	4123	34.1
1967	*	*	638	5.2	3216	26.6	3854	31.8
Total	3139	25.9	1098	9.1	7868	65.0	12105	100.0

* Ontario 1967 not included.

INDEX TO QUESTIONS

Question Number	Topic
1	Aircraft type
2	Fire behaviour - before and after air action
3	Size of fire at attack
4	Method of attack
5	Target
6	Direction of attack
7	Retardant used
8	Ground control started
9	Any danger to men
10	What is airtanker trying to do
11	Length of line attempting to control
12	Drop height above canopy
13	Time of first drop
14	Number of drops
15	Round trip time
16	Penetration of canopy
17	Effectiveness of airtanker action
18	Reason for stopping
19	Was the attack significant
20	Did airtanker return (to the same sector of the fire)
21	Number of drops
22	Reason for stopping
23	Airtanker location at time of call
24	Getaway time from base
25	Distance from pick-up point to fire
26	Distance to refuel
27	Wind speed and wind direction
28	Weather effect on operations
29	Topography - slope
30	Topographic effect on operations
31	G neral remarks and comments
32	Exposure
33	Fuel type
34	Tree species
35	Height of tallest tree
36	Diameter of tallest tree
37	Stand density
38	Regrowth and species
39	Regrowth height
40	Regrowth distribution
41	Ground fuels
42	Distribution of ground fuels
43	Damage to vegetation

Table 3

ACTUAL NO. RETURNS RECEIVED
AIRTANKER EVALUATION FORMS
ONTARIO, MANITOBA, BRITISH COLUMBIA,
1965-6-7

QUESTION	Question No.	1965				1966				1967				GRAND			%
		O	M	BC	TOT	O	M	BC	TOT	O	M	BC	TOT	TOTAL	No Answ.	TOT Answ'd	Answer
Airtanker Type	1	89	15	138	242	25	66	27	118	-	80	276	356	716	38	678	95
Fire Behaviour	2	89	15	138	242	25	66	27	118	-	80	276	356	716	16	700	98
Size Fire Attack	3	53*	15	138	206	2	66	27	95	-	1	276	277	578	36	542	94
Method attack	4	89	15	138	242	25	66	27	118	-	80	276	356	716	42	674	94
Target	5	28	15	138	181	11	66	27	104	-	78	276	354	639	31	608	95
Direction	6	28	15	99	142	11	66	23	100	-	78	193*	271	513	45	468	91
Retardant used	7	28	15	99	142	12*	66	25*	103	-	78	233*	311	556	9	547	98
Gd. Control	8	89	15	138	242	25	66	27	118	-	80	276	356	716	30	686	96
Any Danger Men	9	71	-	62	133	19*	2*	7	28	-	5	135	140	301	24	277	92
What Airtanker Doing	10	89	15	138	242	25	66	27	118	-	80	276	356	716	18	698	97
Length line	11	89	15	138	242	25	66	27	118	-	80	276	356	716	262	454	63
Drop height	12	89	15	138	242	25	66	27	118	-	80	276	356	716	52	664	93
Time 1st Drop	13	89	15	138	242	25	66	27	118	-	80	276	356	694	132	562	81
# Drops	14	89	15	138	242	25	66	27	118	-	80	276	356	716	55	661	92
Round Trip Time	15	89	15	138	242	25	66	27	118	-	80	276	356	716	161	555	78
Penetration	16	71	-	62	133	19*	1*	8*	28	-	5	137*	142	303	10	293	97
Effectiveness	17	71	-	62	133	19*	1*	7	27	-	5	142*	147	307	4	303	99
Reason for Stopping	18	89	15	138	242	25	66	27	118	-	80	276	356	716	58	658	92
Attack Signif.	19	71	15*	62	148	19*	66*	9*	94	-	5	188*	193	435	25	410	94
Did Airtanker Return	20	28	15	1*	44	11	66	-	77	-	78	10*	88	209	25	184	88
# Drops (Return)	21	3*	2	0*	5	1	7*	-	8	-	16*	3*	19	48	16	32	67
Reason for Stopping	22	3*	2	0*	5	1	7*	-	8	-	15*	4*	19	48	16	32	67
Airtanker Loc. at time call	23	-	15	99	114	-	66	23	89	-	-	158	158	361	19	342	95
Getaway Time	24	-	15	99	114	-	66	23	89	-	-	158	158	361	65	296	82

QUESTION	Question No.	1965 O	1965 M	1965 BC	1965 TOT	1966 O	1966 M	1966 BC	1966 TOT	1967 O	1967 M	1967 BC	1967 TOT	GRAND TOTAL	GRAND No Answ.	GRAND TOT Answ'd	% Answer
Distance to pickup	25	28	15	100	143	11	66	23	100	-	78	185	263	506	37	469	93
Distance to refuel	26	-	15	99	108	-	66	23	89	-	-	158	158	361	49	312	86
Wind Dir. & Speed	27	2	15	1	18	1	66	2	69	-	6	96	102	189	3	186	98
Weather Effect	28	28	15	99	142	11	66	23	100	-	78	158	236	478	33	445	93
Slope	29	71	-	5	76	20	4	5	29	-	5	96	101	206	7	199	97
Topographic Effect	30	28	15	11	54	17	66	1	84	-	78	21	99	237	15	222	94
Remarks	31	89	15	138	242	25	66	27	118	-	80	276	356	716	197	519	72
Exposure (Aspect)	32	71	-	-	71	17	-	1*	18	-	5	90	95	184	19	165	90
Fuel Type	33	89	15	10	114	25	66	3	94	-	80	126	206	414	6	408	99
Species	34	71	-	2*	73	17	-	-	17	-	5	6	11	101	60	41	41
Ht. Tallest Tree	35	71	-	-	71	17	1	-	18	-	5	99	104	193	51	142	74
Tree Diam.	36	71	-	-	71	17	1	-	18	-	5	1	6	95	52	43	45
Stand Density	37	71	-	6	77	17	1	-	18	-	6	84	90	185	51	134	72
Regrowth	38	71	-	-	71	17	1	1	19	-	5	-	5	95	53	42	44
Regrowth Height	39	71	-	-	71	17	-	-	17	-	5	-	5	93	73	20	22
Distribution	40	71	-	-	71	17	-	-	17	-	5	-	5	93	72	21	23
Ground Fuels	41	71	-	-	71	18*	1*	-	19	-	5	-	5	95	20	75	79
Distribution	42	71	-	-	71	17	-	1*	18	-	5	-	5	94	56	38	40
Damage to Veg.	43	-	-	62	62	-	-	7	7	-	3*	135	138	207	45	162	78

* Raised Total From Outside Forms or Inferred Data.

	TOTAL	No Answ.	TOT Answ'd
GRAND TOTAL	17055	2088	14967
%	100.0	12.2	87.8

Table 3

AIRTANKER TYPES INCLUDED IN THIS STUDY

Table 4

Code	Common Name	Built by	Model No.	Type	(*) Carrying Capacity (Imp. Gals.)	General or Former use aside from firebombing role
1	Canso Catalina	Consolidated	PBY-5-A & -6-A	Amphibian	800	Wartime sea patrol bomber. Freight hauling.
2	Avenger	Grumman	TBM	Wheeled	500	Wartime Navy dive bomber. Airspray application.
3	Beaver (1)	DeHavilland	DHC-2	Floats	90/120	STOL aircraft, bush flying
4	Otter (2)	DeHavilland	DHC-3	Floats	160-180	STOL aircraft, bush flying
6	Mars	Martin	JRM	Flying Boat	6,000	Wartime military supply
7	Super Canso	Consolidated	PBY-5-A	Amphibian	1,000	Same as Canso, with larger engines
10	Helicopter	Bell	47	Floats	45(3)	Fire scouting, moving men & material
11	Vertol	Boeing		Wheeled	275	
13	Helicopter	Not named				
14	Helicopter	Hiller	12-E		90	

(*) 1 Imperial gallon:- 1.2 U.S. gallons
4.5 litres
10.0 pounds

(1) The Beaver was in the process of being converted from the Mark I with a 450 hp, nine cylinder radial engine driving a two blade propeller to the Mark III Turbo-Beaver with a 578 shp, PT6A-6 turboprop engine driving a three blade propeller. (Jane's 1966-67).

(2) Tanks used during this period were belly mounted, roll-over type with capacity of 160-180 gallons. Later Otter models use enlarged floats that contain tanks having 230 gallons capacity.

(3) All the helicopters listed carried buckets suspended beneath the fuselage. Bucket capacity varied from 45 to 275 gallons, depending on the available lift of the machine.

Question #1 Aircraft type

678/716 (95%) i.e. 678 reports received of a possible 716.

Airtanker Type	% Reports	Ontario	British Columbia	Manitoba
Canso	55.2	x	x	x
Avenger	30.7		x	
Otter	10.0	x	x	
Beaver	2.4	x		
Helicopter	1.6	x		
Mars	0.1		x	

During the time of the study there were 141 airtankers available to the participating provinces which were used on 908 forest fires indicating an average usage of 6.4 fires attacked per airtanker. This figure does not indicate the great range of airtanker use by the individual provinces in certain years, which ranged from 1.3 to 36.5 fires attacked per airtanker. Airtankers were used on 7.5% of all forest fires in the participating provinces.

The Canso, Mars and Avenger were used exclusively for fire bombing while the Beaver, Otter and helicopters had multi-purpose roles during the fire season and had a higher priority for transporting men and material or for fire scouting, than for fire bombing. This latter explanation accounts for the low utilization of some airtankers (1.3 and 2.2 fires attacked per airtanker).

An airtanker is primarily a support tool, forming part of an integrated fire control organization used to hold or retard the forest fire spread until crews are able to contain the fire on the ground. A common term used to describe this is -- "it buys time".[(1)] Airtankers are not the complete answer to the fire suppression problem and probably never will be, but they are an effective weapon when used in the early stages of fire development. The range of effectiveness varies from extremely effective on small fires to ineffective on large fires (Linkewich, 1968).

All three provinces sign contracts with private carriers for a minimum number of hours for specific airtanker types for preset time periods each year. These periods vary with the provinces but usually cover from middle June to the end of August. From the evaluation reports received, the earliest call was 7th May (Ontario) and the latest was 2nd November (B.C.).

(1) Personal communications: British Columbia Forest Service, Victoria, B.C.; Dept. Mines and Natural Resources, Winnipeg, Manitoba: Dept. Lands and Forests, Toronto, Ontario.

Airtanker types operating under charter agreements

Province	Canso	Avenger	Helicopter
Ontario	x		x
Manitoba	x		
British Columbia	x	x	

The original intent of the study was that "Air" and "Ground" airtanker evaluation forms were to be returned for each fire. However, more than one form was submitted for only 16% of the fires attacked. Of these 78 fires, 23 had two different types of airtankers in use during the course of the fire and 20 of these 23 had airtankers of different types flying on the same day. Some airtankers worked on a fire for long periods -- up to ten continuous days in some cases. There were instances of airtankers apparently being kept on fires after the real threat had passed, but these were not common. Occasionally airtankers were called as a last resort (see Q-#3) and this decision could be traced to a probable lack of information about the tanker's capabilities, or to the "can't do any harm" type of action call.

The multiple-action report fires fell into two categories:

1 - The fire lasted more than one day but the same type of airtanker worked on that fire until released (71%).
2 - The fire lasted more than one day and more than one type of airtanker worked on that fire until recalled.

No single airtanker type could be scored above another as each had it's own advantages and disadvantages suited to the user's needs. No attempt was made here to rate airtanker types other than to list their load-carrying capacity. (Hodgson, 1967).

See Appendix 5 for drop patterns of:-
a - Twin Otter - drop #6
b - Avenger - Phoschek - drop #13
c - Canso - drop #2.

It should be noted that the DeHavilland DHC-6 Twin Otter, having a drop capacity of 400 I. gallons was in service with the Ontario Department of Lands and Forests in 1967. No action reports were received for this airtanker. The Canadair CL-215 with a drop capacity of 1200 I. gallons was not available for fire bombing duties. The first drop tests for this new airtanker were conducted in May, 1968.

It was noted that a number of airtankers of the same type were used on the same fire. It has been found that two airtanker loads dropped in close succession have a cumulat ve effect on fire behaviour and are often more than twice as effective as a single drop of the same total volume (Chester, 1965). The B.C. Forest Service makes use of this principle in the southern portion of the province.

From the list below, it can be seen that flights of two and three airtankers are sent to a fire as routine procedure.

# Airtankers Same Type	Percent
2	57
3	39
4	2
5	0
6	2
	100

The above figures represent 121 reports and are mainly from British Columbia.

Photo #1

Martin Mars with side dumping doors, dropping 6000 I. gallons water/Gelgard mixture on a fire in Cowichan District, Vancouver Island, B.C. June, 1967. Photo courtesy MacMillan Bloedel Limited, Vancouver, British Columbia.

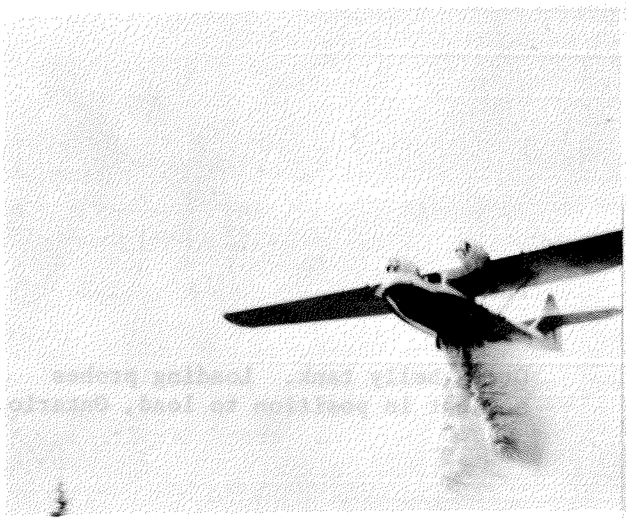


Photo #2

Consolidated Canso dropping 800 I. gallons water/gelgard mixture, Manitoba, 1967.

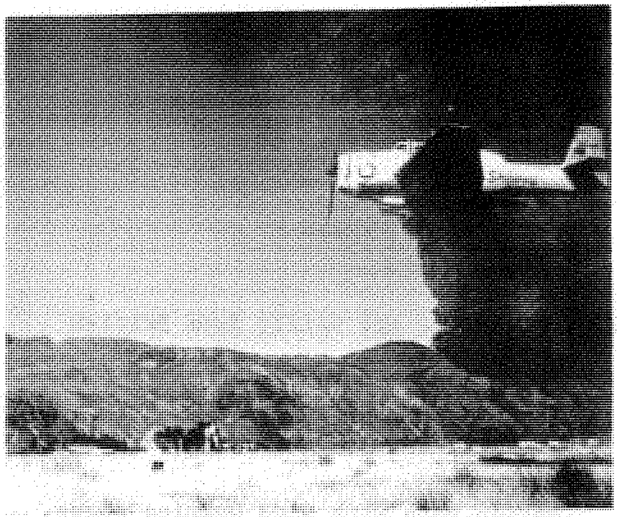


Photo #3

Grumman Avenger dropping 500 I. gallons Bentonite retardant, British Columbia.

Photo #4

DeHavilland Otter dropping 160 I. gallons from float-mounted tanks, Ontario.

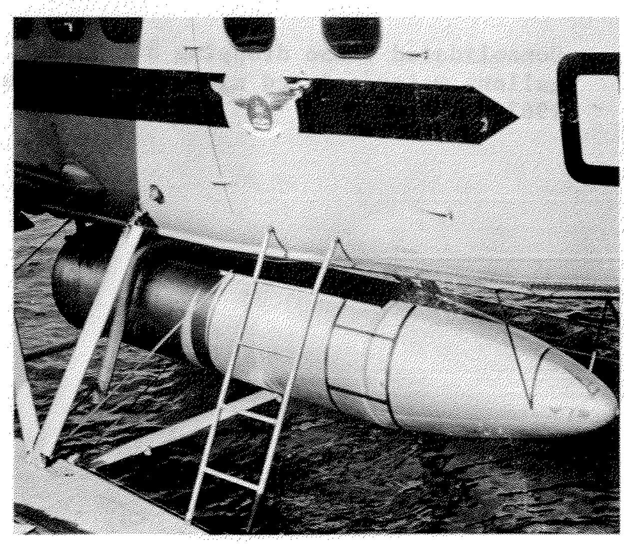


Photo #5

Otter belly tank. Loading probes are not in position to load, Ontario.

Photo #6

DeHavilland Beaver with integral in-float tanks, dropping 140 I. gallons water, Ottawa, Ontario, 1967.

Photo #7

Boeing Vertol Helicopter with 275 I. gallon bucket, Ontario.

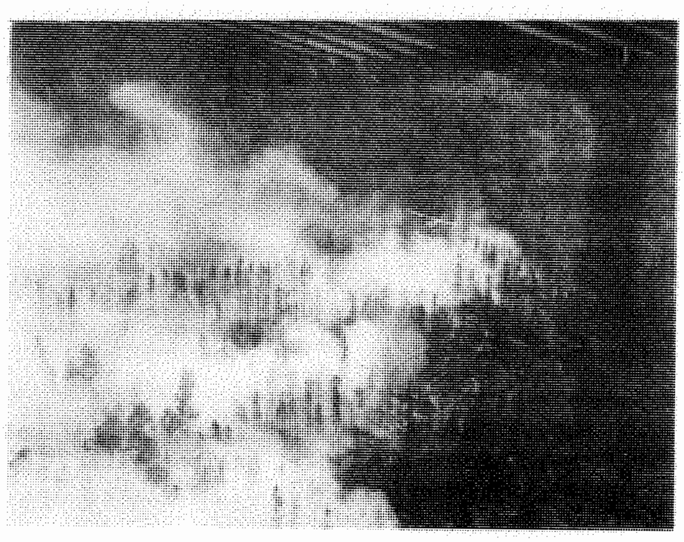


Photo #8

Hiller 12 H Helicopter with 45 I. gallon bucket, Ontario.

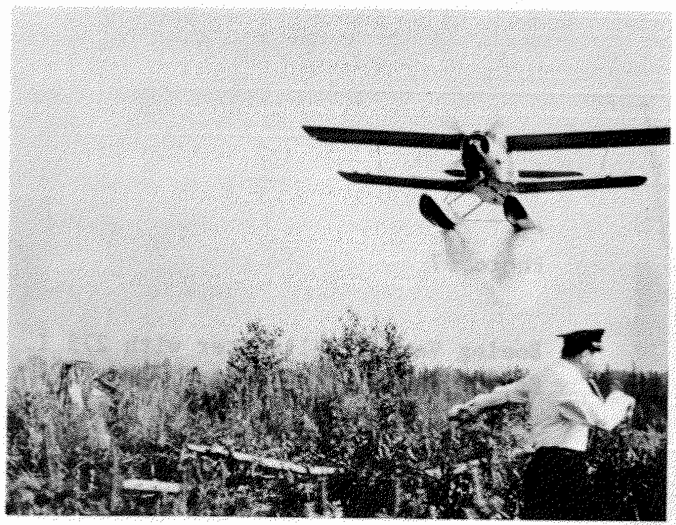


Photo #9

Russian Antonov 2-N multi-use airtanker with in-float tanks dropping 220 I. gallons, 1968. Photo courtesy J.C. Macleod, Canadian Forestry Service.

Question #2 Fire Behaviour, Before and After Air Action
700/716 (98%)

There were five levels of fire activity outlined on the airtanker evaluation form. The observer checked the appropriate box at the time the airtanker arrived and at the time the airtanker was called away. The differences in these levels of fire activity were indicators of the effectiveness of the airtanker actions.

Code	Fire Activity Level
0-	Was equated to "little or no smoke seen".
1-	Smoldering
2-	Slow surface
3-	Fast surface
4-	Flareup crown
5-	Running crown

In regard to crowning, it was implied that a fast surface fire was also in progress (Van Wagner 1968) and so three combinations can be obtained:-

Code 3 fast surface fire with no crowning.
Code 4 fast surface fire with occasional flareup and crowning.
Code 5 fast surface fire with running crown fire.

In order to follow the tables listed, a few examples are given:-

e.g. Before action - fast surface fire (rated 3)
After action - smoldering fire (rated 1)

This was coded as 31 and represented a change in fire activity of two levels (from 3 to 1) in a downward direction, representing reduced fire activity. Conversely 23 would represent a one level increase in fire activity - slow surface to fast surface fire. Of the 700 valid returns, 82% indicated varying degrees of reduced fire activity. Those reports in which the fire activity remained the same, e.g. 11; 22 etc. indicated that the airtanker action did not have any effect in reducing the fire behaviour (17%) yet it must be noted that the situation did not worsen. These actions could be considered as "buying time" operations.

Seven evaluation reports (1%) noted an increase in fire activity. In these cases the airtanker was attempting to establish fire guards and to cool hot spots in coniferous areas. The very large amounts of heat emitted by these fires made the use of short term retardants ineffective.

Fire Behaviour in the Area the Airtanker was Attempting to Control

		On Arrival			On Departure		
Condition	Code	# Reports	%	Cum. %	# Reports	%	Cum. %
Little or no smoke	0	--	--	--	7	1.0	1.0
Smoldering	1	16	2.3	2.3	357	51.0	52.0
Slow surface	2	265	37.9	40.2	260	37.1	89.1
Fast surface	3	208	29.7	69.9	33	4.7	93.8
Flareup crown	4	183	26.1	96.0	30	4.3	98.1
Running crown	5	28	4.0		13	1.9	
		700	100.0		700	100.0	

If the fire condition after attack was noted as "little or no smoke" or "smoldering", this part of the fire was considered to be under control. If the fire condition after attack was "slow surface" (code 2), this part of the fire was considered to be nearing control. The conditions in code 3, 4 and 5 should be considered as not under control.

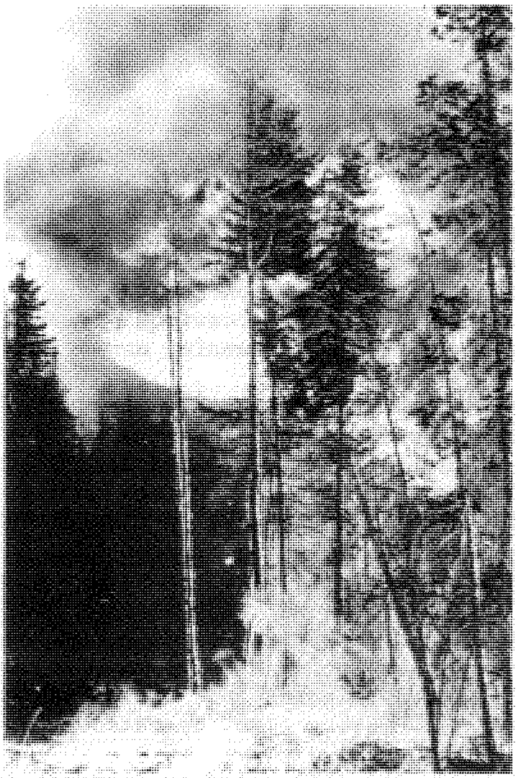


Photo #10 Surface fire with occasional torching

Rating of fire area under attack at time airtanker left drop zone:-

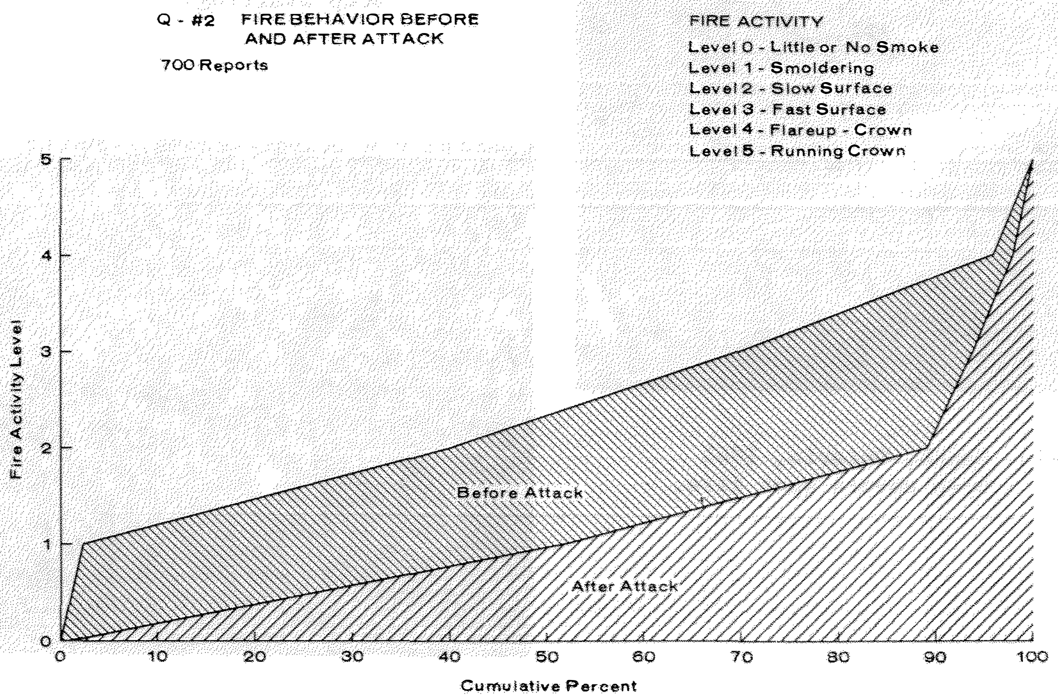
Fire under control	52.0%	
Fire nearing control	37.1%	89.1%
No control	10.9%	

The successfulness of an airtanker attack should be attributed to the airtanker's efforts alone or to the combination of air and ground attack in the ratio of 55 to 45 (Q-#8).

Fire Behaviour After Airtanker Action

% LEVEL CHANGED (700 Reports)							
	1	2	3	4	5	TOTAL	# REPORTS
REDUCED	47.0	25.0	8.9	1.0	0	81.9	573
NO EFFECT	2.0	7.7	2.3	4.1	1.0	17.1	120
INCREASED	0.6	0.1	0.3	0	0	1.0	7
TOTAL						100.0	700

e.g. 47.0% of all reports indicated that the fire activity was reduced by one level, which could have been from a 4 to a 3 or a 3 to a 2 level. The 0.1% represents a two level increase in fire activity which could have been from a 3 to a 5.



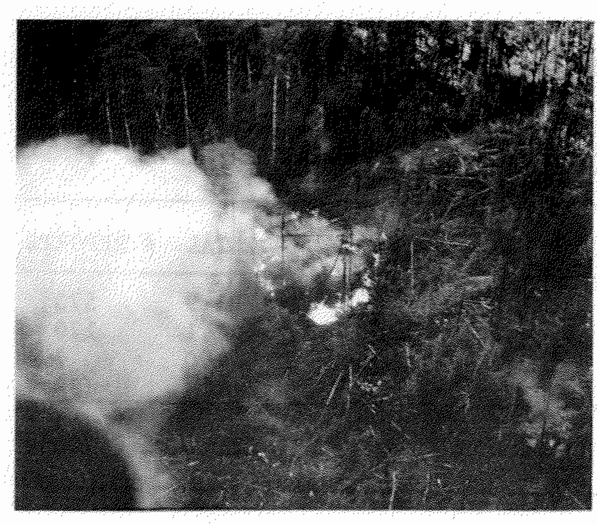


Photo #11 Jump fire in heavy blowdown - 75 feet diameter.

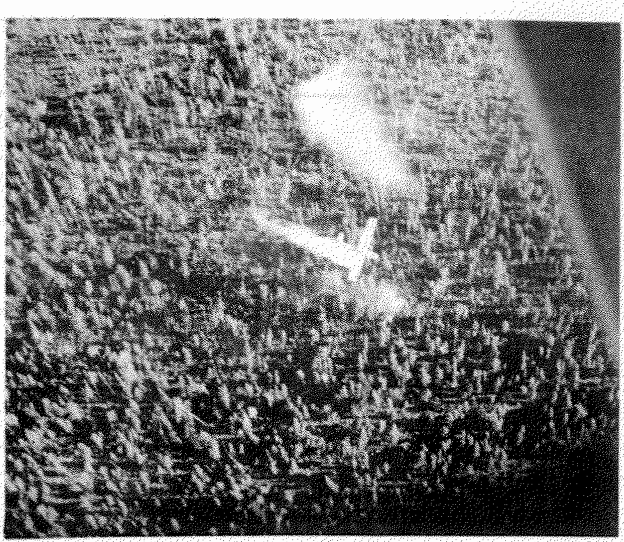


Photo #12 Canso, Ontario, 1965
Drop starting.

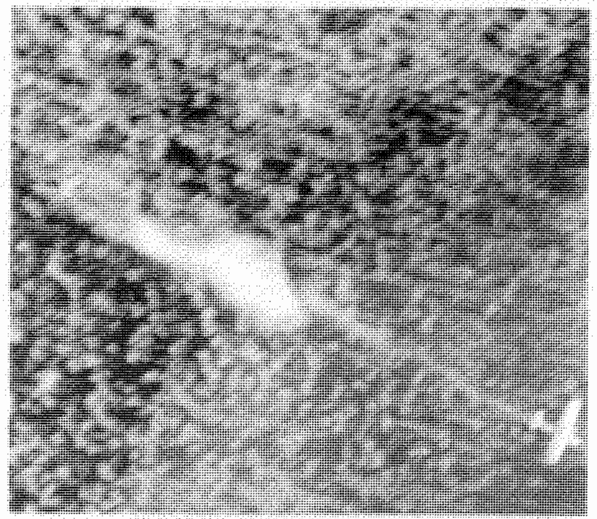


Photo #13 Canso, Ontario, 1965
Drop covers spot fire.

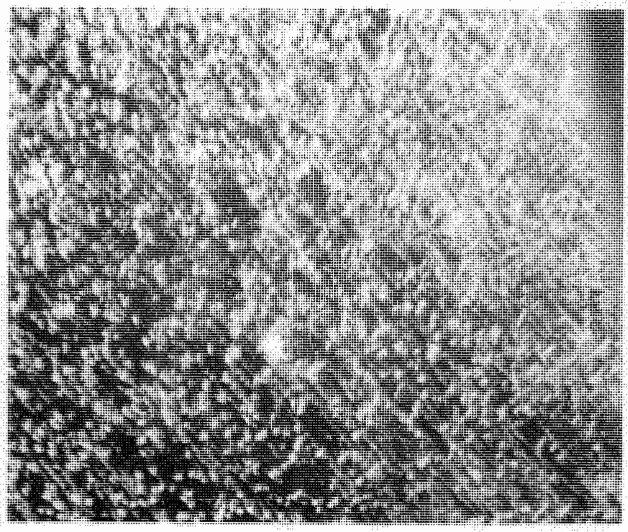


Photo #14 Canso, Ontario, 1965
Spot fire immediately after drop.

Photo #15

Otter, Ontario, 1965 Approach target upwind.

Photo #16

Otter, Ontario, 1965 Direct hit.

Photo #17

Otter, Ontario, 1965 Turn away to avoid hill.

Question #3 Fire size at attack (acres).
542/578 (94%)

For the Provinces studied, 55% of all fires were smaller than 1/4 acre in area when extinguished and 89% were 10 acres or less. (Lockman).

Comparison of yearly average fire size to 10 year average (acres)

Province	1965	1966	1967	Area Protected / Year
Ontario (10 yr. av.)	16 (135)	7 (118)	43 (96)	204,000 sq. miles
Manitoba (10 yr. av.)	74 (1458)	26 (1473)	505 (1379)	128,000 sq. miles
British Columbia (10 yr. av.)	114 (231)	28 (228)	76 (207)	366,000 sq. miles

It can be seen that the annual averages are all well below the previous ten year averaged fire size.

From the airtanker evaluation reports, the following statistics appeared.

Fire Size at Time of Attack

Fire Size	less than 1 ac.	1-5	6-10	11-50	51-100	101-200	201-500	501-1000	>1000 ac.
% Total	30.1	33.2	8.3	11.1	3.1	4.8	1.7	1.3	6.4%
Cum. Total	30	63	72	83	86	91	92	94	100%

Fifty percent of the fires were 2.54 acres or less in size at the time of attack and 63% were 5.0 acres or less, indicating optimum use of airtankers for the initial attack.

For the surprisingly large (6.4%) number of fires greater than 1000 acres when attacked, several possible reasons for that attack are listed below:

1- Work on hot spots and jump fires at and beyond the main fire perimeter.
2- Loaded airtanker to cruise ahead of the main fire to find and attack any jump fires, especially those that have crossed natural barriers such as lakes, swamps or rivers.
3- Help in holding parts of the fire flank adjacent to high value areas such as farm buildings, villages, bridges or forest plantations.
4- Reduce the contracted number of flying hours on credit.
5- To raise the morale of ground firefighters.
6- Use as a last resort, "Can't do any harm" philosophy.
7- Called in desperation by management when a fire is running out of control.

The activities of airtankers are examined in Q-#10.

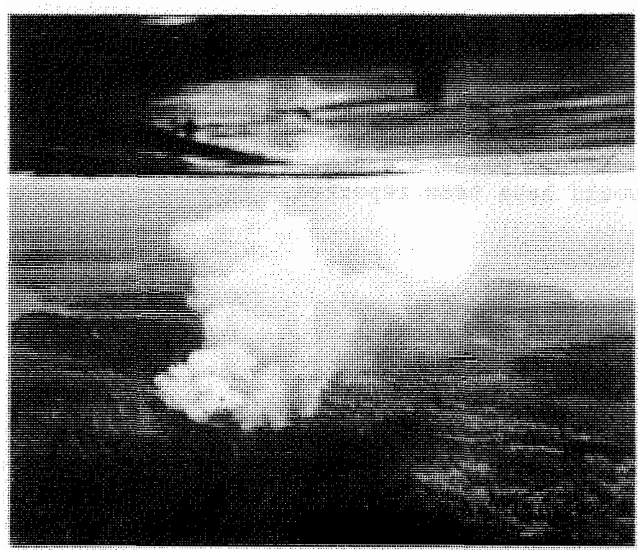


Photo #18

Portal Lake fire, Ontario, 1965, seven hours after detection. Smoke height 1400 feet, area 16 acres. Otter at left. Five airtankers made 267 drops on this fire over a four day period. Fire grew to >500 acres.

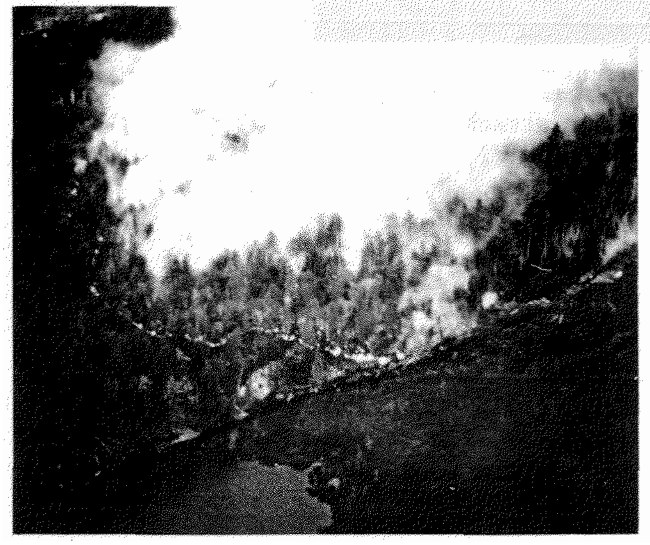


Photo #19

Fire advance into wind

Question #4 Method of Attack
674/716 (94%)

Two methods were used, the direct and the indirect attack. Ninety nine percent of the returns indicated that the airtanker attacked the fire directly and 1% were indirect attacks.

In talking to pilots across Canada, the indirect attack was favoured by those pilots dropping fire retardant but this was not the case according to the returns received. There seemed to be some doubt in the minds of the men filling out the airtanker evaluation form as to the meaning of the question. If the term "bombing the green" had been used in the question, perhaps a better and more representative number of indirect attacks would have been reported.

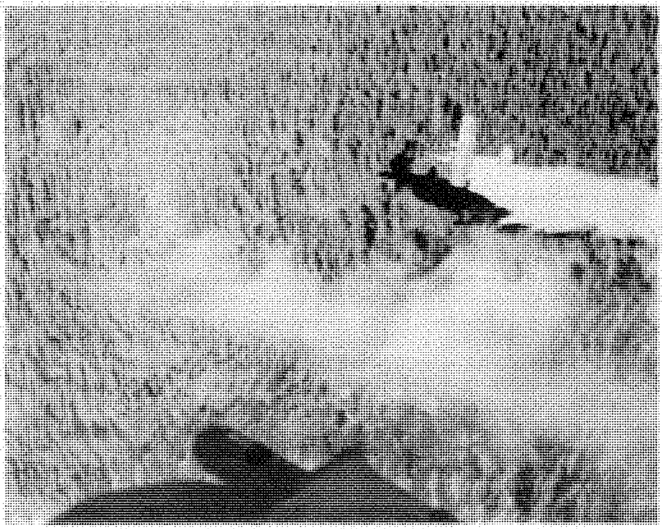


Photo #20 Canso attack

Question #5 Target
608/639 (95%)

No clear choice of target was apparent to most observers and a random selection of attack points was indicated.

Nineteen percent of the returns indicated that the fire was less than 1/4 acre, which compares favourably with Q-#3 which noted that 30% of the returns listed fires less than one acre in area.

A single drop constituted only 5% of the returns and the study average was 8.3 drops per report. Because many drops were made during each action, it is apparent that the target varied as the attack progressed. If the observer noted that the "head and flanks" received airtanker action, there was no way that he could separate these into "head" and into "flanks" on that report form. This fact should be bourne in mind when examining the figures below.

Distribution of Targets

Target	%
Head & Flanks	24.0
Head	21.4
Small Fire	19.2
All Ways	17.3
Flanks	12.8
Flank & Rear	3.3
Rear	1.8
Head & Rear	0.2
Total	100%

It should be noted that pilots take instruction from the ground or from bird dog officers and frequently have little choice in the selection of a target. The only choice that the pilot can make independently is the direction of attack (Q-#6) and the drop height (Q-#12).

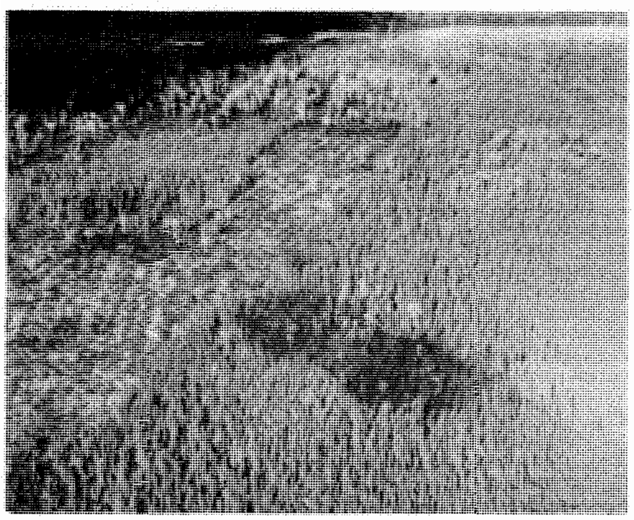


Photo #21

Fire escaped from slash into green timber.

Question #6 Direction of attack (in relation to wind direction).
468/513 (91%)

The previous question (Q-#5) indicated that the "head and flanks" target plus the "head" represent 45% of the direction of attack on the target in relation to the fire itself. Question #6 shows that 46% of the attacks were "into" and "into and across" the wind, which compares favourably with Q-#5.

An airtanker drop into the wind tends to hold the main mass of the load together much better, thus delivering a more compact drop pattern (Hodgson). Many pilots consider that it is safer to be able to fly out into a relatively smoke-free area after dropping but this also means that the pilot must approach the fire through smoke prior to the drop.

The personal preferences and techniques of the pilot have more to do with the direction of attack than the fire control officer's orders which, for example, could ask for "drops at the head and on the west flank". The direction of attack would be the pilot's decision after considering the weather, topography, visibility, escape route and aircraft flight characteristics.

Q-#6

Direction	%
Into Wind	29.3
Into and Across	16.7
Across	16.0
All Ways	11.3
Downwind	10.7
Down and Across	9.2
Into and Down	6.6
Calm	0.2
Total	100%

Q-#5

Target	%
Head & Flanks	24.0
Head	21.4
Small Fire	19.2
All Ways	17.3
Flanks	12.8
Flank & Rear	3.3
Rear	1.8
Head and Rear	0.2
Total	100%

Question #7 Retardant Used
547/556 (98%)

From the chart below it is apparent that for the 1965-67 period, half the drops contained chemical.

Retardant	% use	Canso	Avenger	Otter	Beaver	Helic.	Mars	Mixed Weight lbs/gal.
Water	53.5	x		x	x	x	x	10.0
Seawater		x					x	10.2
Gelgard "F"	12.2	x					x	10.0
Bentonite	20.8		x					11.0
Phos Chek	3.8		x					11.3
Fire Trol 100	0.9		x					13.3
Chemical (unsp.)	8.8							
Total	100%							

In the chart below, the high percentage shown for Bentonite 1967 is misleading. In earlier years, Bentonite was the only slurry used extensively in British Columbia, but as new chemicals were introduced the term "Bentonite" has stayed in the minds of some firefighters as the word used for all retardant mixtures. The figures below illustrate retardant volumes used in British Columbia, courtesy of the British Columbia Forest Service, Victoria, B.C.

	Long Term Retardants Used in British Columbia (Imp. Gals.)					
	1967	(%)	1968	(%)	1969	(%)
Fire Trol 100	700,000	(56)	196,300	(70)	480,000	(68)
Phos Chek 202	133,000	(11)	60,000	(22)	218,100	(31)
Bentonite	421,500	(33)	23,000	(8)	10,000	(1)
Total gals.	1,254,500		279,300		708,100	
# Fires (*)	3,216		1,647		2,332 (est)	

(*) Airtankers were used on about 8% of all fires in British Columbia (Table 1). It is apparent that the introduction of long term retardants and chemicals into aerial firefighting work is progressing at a rapid pace. In Manitoba the use of Gelgard "F" has advanced from none in 1965 to 23% in 1967. (1).

See APPENDIX 1 for retardant composition.

(1)

Personal communication, Forest Protection Division
Department of Mines and Natural Resources
Winnipeg, Manitoba

Photo #22 Retardant coated ground fuels, Kamloops, B.C. -- Phos Chek.

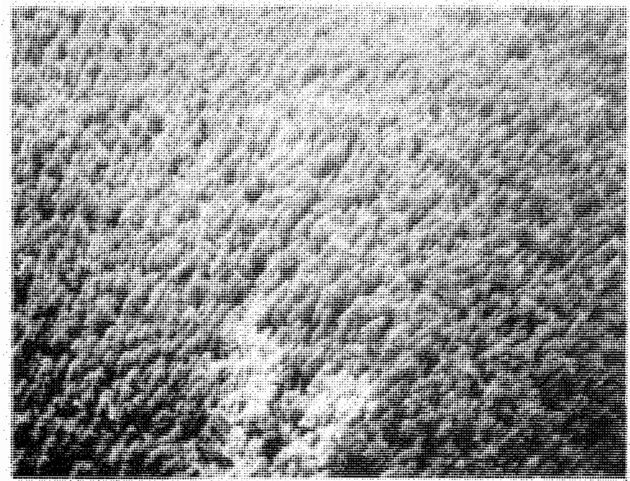


Photo #23 Retardant coated fuels as seen from the air, Kamloops, B.C.

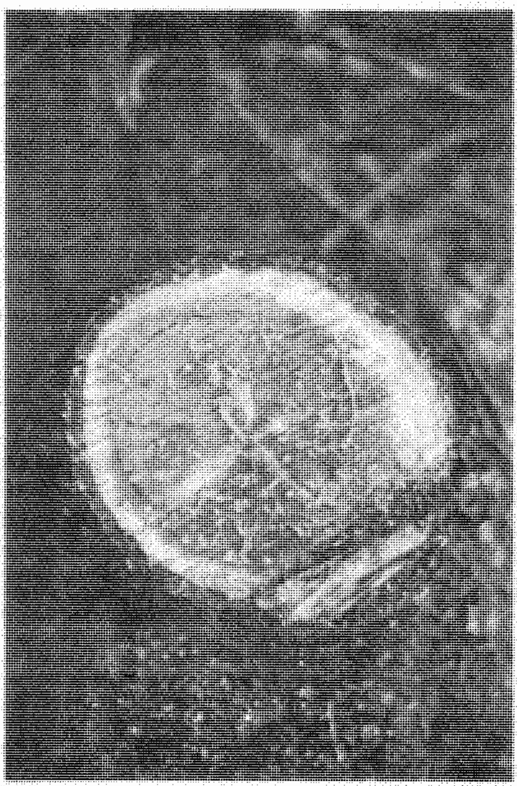


Photo #24 Gelgard from Canso drop, Cochrane District, Ontario.

Question #8 Has ground control started
686/716 (96%)

The question was asked on the form in this manner:-
"Are ground crews at the fire site and are they working on the same section of the fire which the aircraft is attacking?"

Thirty-six percent of the returns indicated that no ground control measures had started and these airtanker actions can be called, in the true sense, initial attack. A further 19% indicated that crews were on the fire but not working on that section of the perimeter that the airtanker was attempting to hold, making a total of 55% (no men in drop area).

Ground crews were working on the fire in the airtanker drop zone in 44% of the reports. This information gives rise to the question of the safety of the men working in the drop area and Q-#9 deals with this aspect of the problem.

# Returns	Percent	Has ground control started
250	36.4	No.
132	19.3	Yes, ground crew not working on same sector.
268	39.1	Yes, ground crew is working on the same sector.
36	5.2	Yes (unqualified).
686	100.0	Total valid returns.

Photo #25 Ground control has started.

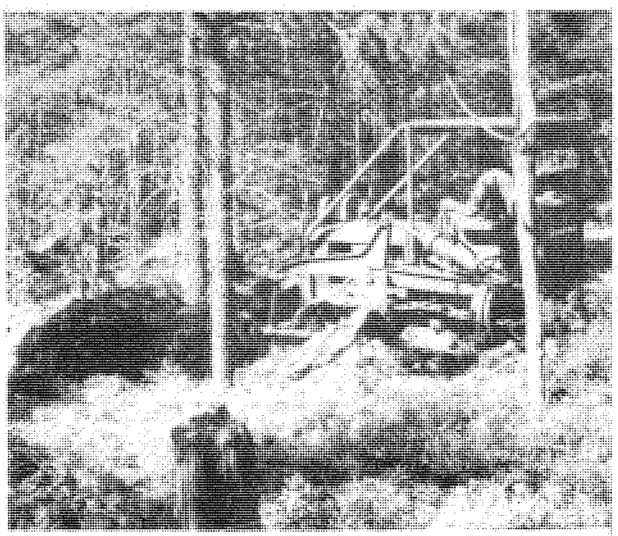


Photo #26 Small bulldozer in Jack Pine/ Labrador Tea area.

Question #9 Any danger to men
277/301 (92%)

This question was asked on the "Ground" forms in this manner: "Was it considered dangerous for men to work in the drop zone" (Yes) (No) If "yes", explain ______.

The question could be interpreted in three ways:

1 - Men ould have been hurt while working in the drop zone - as a consequence of air action.
2 - There was a chance that if men had been working in the drop zone, they might have been hurt as a result of the air action.
3 - Even if airtankers were not dropping, it could have been dangerous for men to work in the drop zone due to the fire activity alone.

It can be seen that 1.1% of these returns have fallen into the 3rd interpretation of the question.

Percent	Danger
67.9	No
16.3	Yes (unqualified)
7.2	Yes, breaking tops or snags
2.9	Yes, low altitude impact of water
1.8	Yes, flying debris
1.4	Yes, rocky surface
1.4	Yes, slippery conditions caused by retardant
0.7	Yes, fast spreading fire
0.4	Yes, burning trees falling continuously
100.0	

Two thirds of the observers reported that there was no danger to men while one third noted that there was (or could have been) some danger to men in the drop zone. The main danger appears to be from breaking tops and snags (see Q-#43) falling on people following a low altitude drop. The danger to men from a falling mass of water is low. Some fire retardant chemicals contain ammonium constituents that can cause irritation to the eyes, to cuts or to the skin when this material comes in contact with the body.

Photo #27 Canso drop from low level overturned black spruce, Portal L. Ontario.

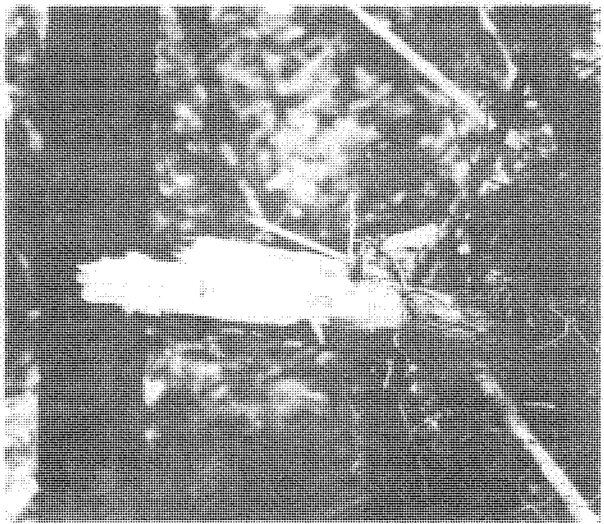


Photo #28 Jack pine top broken off by airtanker drop. Size: 3.7" diam. x 11.5' long.

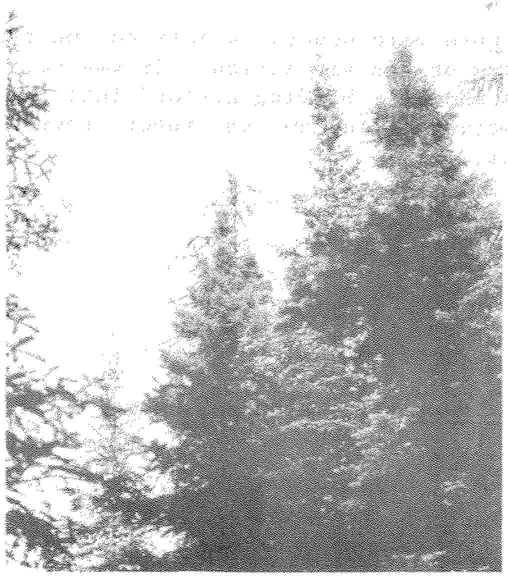


Photo #29 Canso drop broke off top of white spruce chiko 50' above ground level. Diameter was 8 inches at break.

Question #10 What is the airtanker trying to do
698/716 (97%)

The airtanker was trying to control the fire with a combination of "cooling hot spots" and "line holding action" in 65% of the reports.

One percent of the returns indicated a complete wetting of all visible fire by blanketing the area. This is not a true concept of airtanker use, nor is it profitable. Perhaps the pilot was instructed to bomb at his discretion and continued to do so because he was not ordered to stop. This would represent a "won't do any h rm" type of air action. It could also mean that the pilot did not recognize that the fire as no longer dangerous and that fire spread was not being changed by further air action.

If a fire in black spruce muskeg country has gone underground in deep sphagnum, no amount of water dropped by an airtanker would penetrate down into the burning zone. In such cases the airtanker should be sent back to base and the ground crews should dig out the fire with hand tools.

Percent	Airtanker is trying to:-
33.5	Cool hot spots and line holding action
18.6	Take holding action along section of line
17.2	Hold small fire (1/4 acre or less)
12.5	Cool hot spots
9.2	Hold spot fire and line holding action
5.0	Hot spots, spot fires and line holding combination
1.4	Hold jump fire
1.3	Cool hot spots and jump fires
1.3	Wet all visible ground fires (blanket the area)
100.0	Total

As was explained in Q-#5 (Target), there were several points on the fire line that the airtanker attacked during the time of the air action. It was not possible to separate the 33.5% "cool hot spots and line holding action" into two parts. This would only be possible if the observer filled out one report form for each drop, which was not the case in this study.

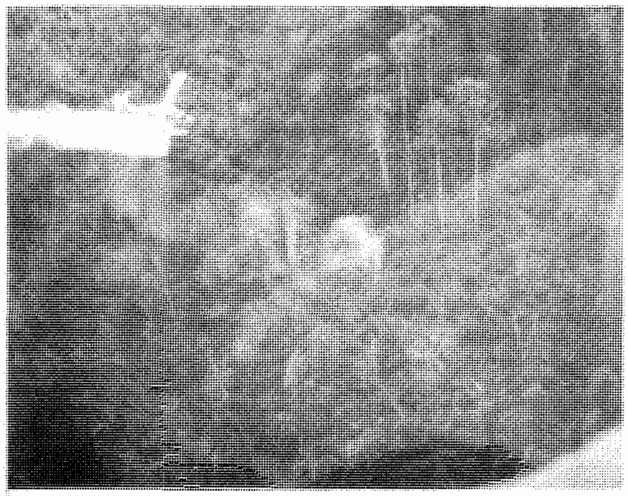


Photo #30

Spot fire, 6:30 pm, Otter.

Question #11 Length of line airtanker is attempting to control (feet).
454/716 (63%)

Seventy-five percent of the returns indicated a line length of less than one quarter mile (1320'). The two highest single returns (14% each) were 300' and 1000'.

In Ontario and British Columbia, 50% of the attacks were made to control a line length of 500' or less while in Manitoba this was 1000' or less.

The great range of lengths in the answers received might be construed as a misunderstanding of the question. The 300' could be the estimate of the length laid dow in one airtanker drop (Appendix 5). There were some answers indicating lengths of over 10,000' (0.9%). It appeared that the observers filling out the reports, overestimated the effective length of control possible by an airtanker. Some of the longer lengths may represent the actual perimeter of the fire and not that portion of the fire that the airtanker was trying to control. From Q-#10, 65% of the reports noted that the airtanker was trying to cool hot spots and take line holding action. If these hotspots were thinly spread along 1000' of fire perimeter, a longer line length would be reported by the observer.

The rate of increase in the perimeter of a fire varies approximately as the square of the wind velocity and the fire will advance 3 to 4 times as fast with the wind as against the wind. (Wright, 1932).

Length of fireline airtanker is trying to control

Percent	Length of line (feet)	Cumulative percent
43.1	100 - 500	43.1
30.6	600 - 1000	73.7
5.1	1100 - 1500	78.8
9.9	1600 - 2000	88.7
1.7	2100 - 2500	90.4
3.3	2600 - 3000	93.7
1.3	3100 - 4000	95.0
1.1	4100 - 5000	96.1
3.0	5100 - 7000	99.1
0.9	10,000 and up	100.0

Photo #31

Canso holding line in heavy blow-down.

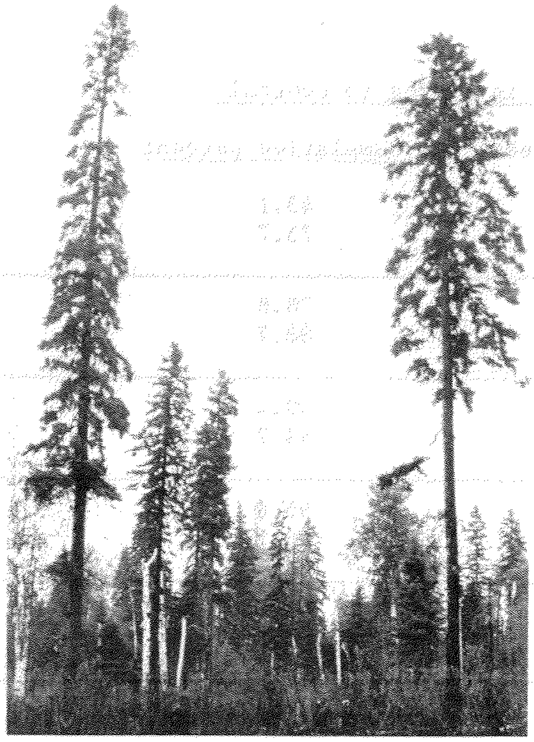


Photo #32 Surface fire in foreground. White spruce at left 103' ht. x 29.4 dbh.

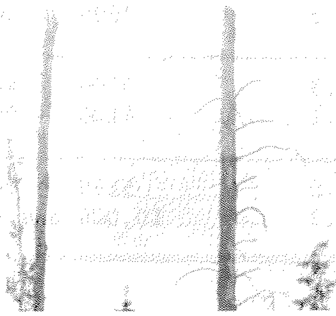


Photo #33 Chikos are very hard to see and are a constant danger to low flying airtankers.

Question #12
664/716 (93%)

Drop height above canopy (feet)

Most drops were made within the 50' - 100' range and 90% of the drops were carried out below 100 feet. During discussions in the field, it was stated that the drop height is up to the individual pilot's judgement. To determine a safe drop height, the pilot must consider the tallest local obstacle and adjacent topographic features. The flight path to be followed should not cause undue strain on the pilot or airtanker.

Some pilots felt that a very low drop was a very good drop. This supposition is not necessarily true. If the fire boss wants to have a load spread over a longer length of fireline in order to cover a maximum number of feet of fire edge per drop, the pilot must maintain sufficient height to allow the load to breakup in the air first. It should be noted that a load dropped from a greater height will also erode and evaporate more and that less volume will fall on the ground. A very low drop will produce a high concentration (per foot of fireline) but over a shorter length of fireline. Low drop action by airtankers is good firefighting practice when used on small fires of one acre or less. The load placement accuracy may also have a bearing on how high or low the drop is made. See Q-#35 (height of tallest tree) for further information.

Averaged Airtanker Drop Height (feet)

Ont.	Man.	B.C.	Averaged
67	76	65	68

A summary of airtanker and other flight accidents is tabled in APPENDIX 2. The crash cause "aircraft struck a tree" was attributed to 11 of the 13 deaths recorded for firebombing work.

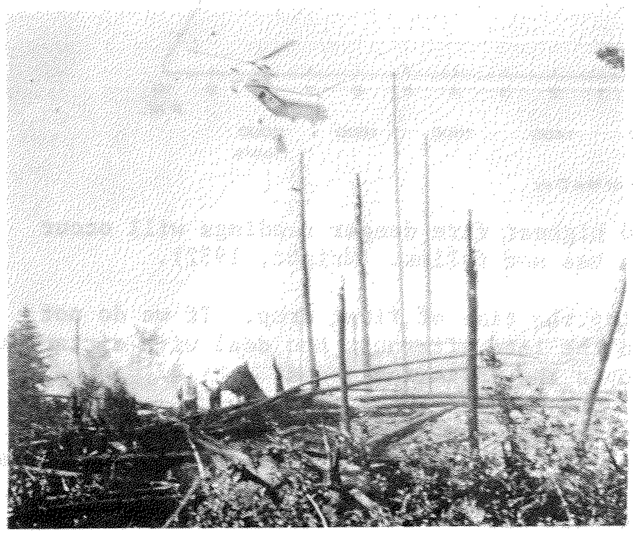
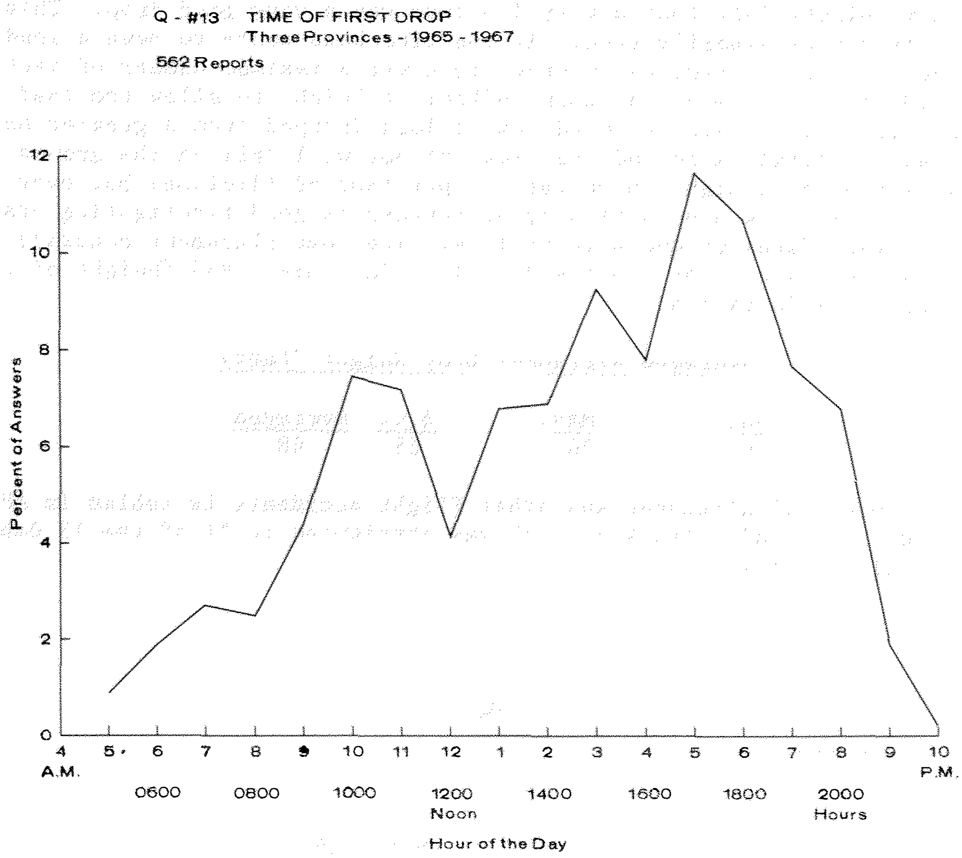


Photo #34

Helicopters tend to drop from greater heights than fixed wing aircraft.

Question #13 Time of first drop
562/694 (81%)

Airtankers began to take initial action on fires at all hours of the day -- from 5 am to 10 pm. Fifty three percent of the first drops were made between 12:31 and 6:30 pm and 61% from 12:31 to 7:30 pm. A graph showing the hour at which the airtanker made the first drop indicated two definite peaks. A minor peak at 10 am was followed by a noon low which gradually built up to a second peak at 5 pm. Half the initial actions had been made by 3:15 pm.



The lowest relative humidity and highest fire danger readings will occur between 2:30 and 4:00 pm each day, if rain has not fallen. (Wright, 1932).

There are many factors influencing the time of first drop. If we do not consider that the fire could have begun in the late afternoon and deal with airtanker functions after the call was received we note the following items:

1 - (Q-#24) Getaway time was 14.3 minutes or less for 50% of the reports.
2 - (Q-#23) Airtanker was 53 miles or less (27 min.) from the fire at the time of call in 50% of the reports.
3 - (Q-#25) Distance from pickup point to fire was 7.1 miles or less in 50% of the reports, which breaks down to:
 -a- Search for pickup lake 10 min.
 -b- Approach and pickup time 3 min.
 -c- Fly 7.1 miles to fire 4 in.

Summarized:			
	Start engines and take off	14 minutes	
	Fly to fire site	27 "	
	Locate pickup lake	10 "	
	Approach and load	3 "	(*)
	Fly to fire	4 "	
	Total	58 "	

It can be seen that for 50% of the reports, the total elapsed time from call to first drop would be 58 minutes or less. To reach the 5 pm peak of activity, the call would have been made at 4 pm.

The amount of time taken from "fire sighted" to "airbase called" can vary from 5 to 30 minutes or more.

(*) Avenger excepted.

Q estion #14 N ber of drops (First Action)
661/716 (92%)

The figure used in this question represent the number of drops observed and may not be the total actually dropped on a fire, or for a particular action report. This question is divided into two parts.

Part A

The number of drops reported per action report.

Part B

The number of drops reported per fire from all action reports.

Part A

These figures represent percentages of the number of drops per action report. e.g. There were 58 reports noting 6 drops which represent 58 parts of the 661 reports (8.8%) and stands at 53.0% in the cumulative percentage total number of reports.

The number of drops per action report varied from 1 to 52.

# Drops	Percent of 661 reports	Cumulative Percent
1	5.1	5.1
2	13.1	18.2
3	8.6	26.8
4	11.8	38.6
5	5.6	44.2
6	8.8	53.0
7	5.4	58.4
8	6.1	64.5
9	3.3	67.8
10	3.5	71.3
11	2.6	73.9
12	3.0	76.9
13	2.6	79.5
14	2.0	81.5
15	1.9	83.4
16	1.7	85.1
17	1.1	86.2
18	1.8	88.0
19	0.9	88.9
20	1.3	90.2
21-30	6.6	96.8
31-40	2.0	98.8
41-50	1.0	99.8
>50	0.2	100.0

The average number of drops per report was 8.3

Part B

This part of Q-#14 examines the number of drops per fire from all action reports. These figures include drops from all airtankers sending reports of action on a fire.

Airtanker actions have ranged from a single drop to an extended period during which three airtanker types made a total of 68 drops over a period of 67 days. The maximum number of drops reported for a single airtanker on one fire was 122, (Super Canso, 1967). This airtanker was required to hold 3,000 feet of inaccessible flank over a four day period.

The maximum number of drops per fire by airtanker types are listed below:-

393	Cansos
122	Super Canso
108	Avengers
68	Otters
40	Beavers
10	Helicopter with bucket.

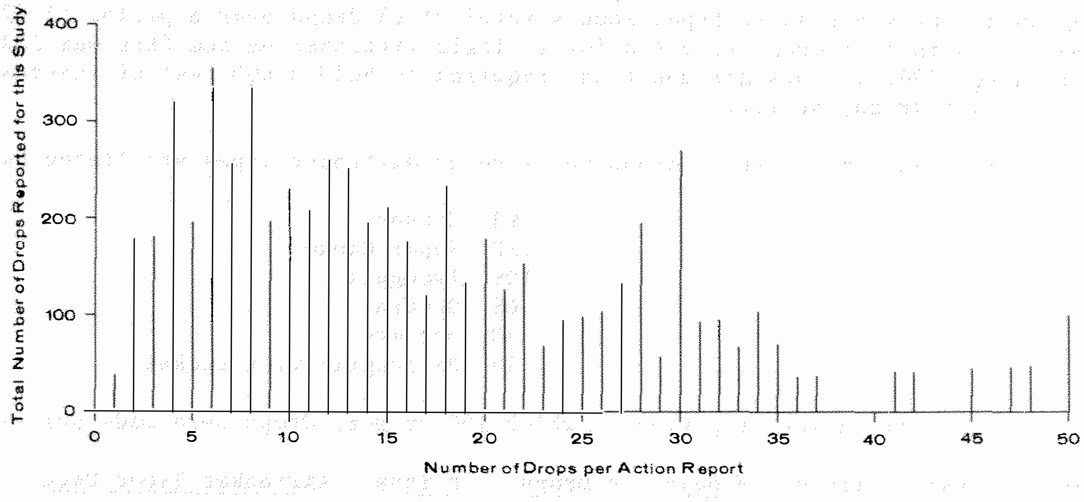
Seven fires were reported in which 100 or more drops were made per fire:-

Province	Year	Fire #	# Days	# Drops	# Tons	Airtanker Types Used
5	1966	4	10	393	1,572	Cansos
5	1967	45	5	278	1,112	Cansos
8	1967	97	4	122	610	Super Canso
5	1966	23	4	131	524	Cansos
4	1965	16	5	163	457	Cansos, Otters
4	1965	35	4	150	382	Cansos, Otters
8	1967	13	9	108	270	Avengers

The average number of reports per fire was 1.35
The average number of drops per fire was 14.5
The average number of I. gallons per drop was 648.

No. drops per fire	Percentage of total no. fires	Cumulative percent
0-4	40.32	40.32
5-9	26.48	66.80
10-19	17.52	84.32
20-49	11.61	95.93
50-99	2.65	98.58
100 plus	1.42	100.00

Q - #14
Q - #21 TOTAL NUMBER OF DROPS PER ACTION REPORT
693 Reports



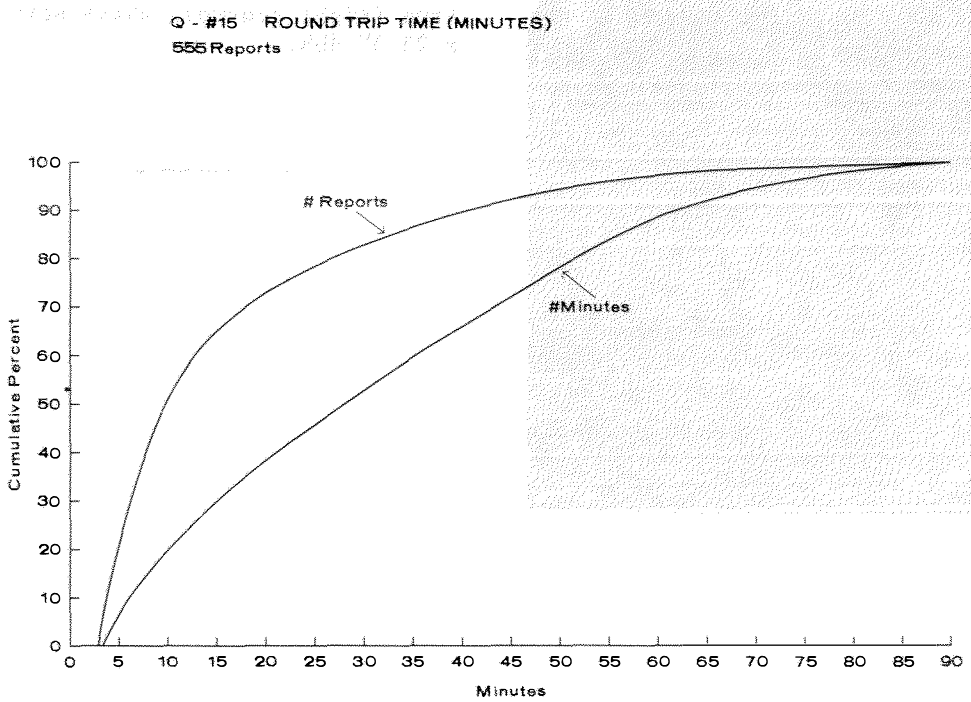
Question #15 Round trip time
555/716 (78%)

The round trip time is the travel time from loading point to the fire and return, in minutes. For water pickup aircraft it is the time to load from the lake, takeoff, fly to the fire, drop the load and return to the lake for another scoop-loading. For land based aircraft (e.g. Avenger) it is the time taken to load with chemical retardant, takeoff, fly to the fire, drop the load and return to base.

Fifty percent of the returns listed 10 minutes or less and the largest single percentage (12) was for a 5 minute round trip time. The time range varied from 3 minutes to 90 minutes. With a lake one mile from the fire, an airtanker working with no difficulties such as terrain or weather, should have a cycle time of 4 to 5 minutes.

Reports listing 3 minutes could be explained if the fire was located between two lakes or very close to a lake. The 90 minute times were for two aircraft dropping in tandem on a 200 ft. fireline as part of a 7 acre fire, the terrain being extremely steep. The observer noted that the air action was not effective because the $1\frac{1}{2}$ hours between drops allowed the fire to rekindle.

Average round trip time from all reports was 17.87 minutes. The total reported round trip flying time was 165.3 hours.



Round Trip Time averaged by aircraft types

Airtanker	Minutes
Canso	10.56
Avenger	26.84
Beaver	6.21
Otter	6.22
Mars	8.00
Super Canso	12.06
Helicopters	5.89

If the averaged number of drops per fire was 14.55 (Q-#14B) and the averaged round trip time was 17.87 minutes (Q-#15), it can be calculated that the average fire would have airtankers taking direct action for a period of 4.33 hours.

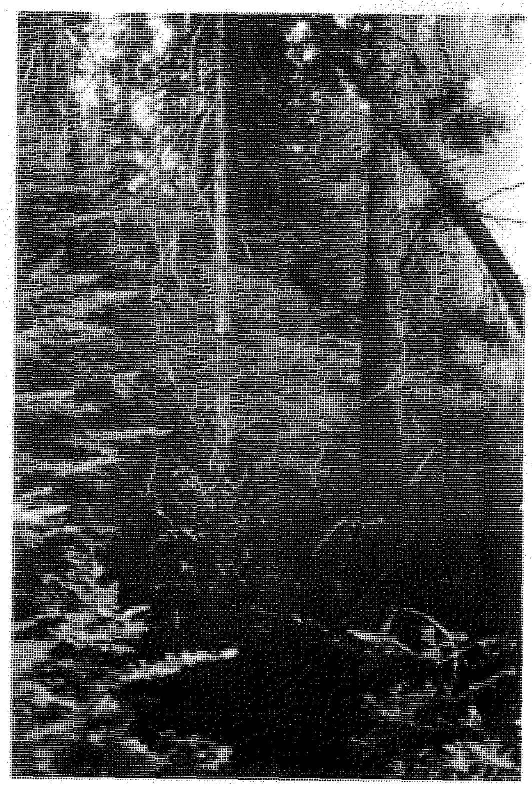


Photo #35

Overmature white and black spruce stand with thick balsam fir understory. Estimated 50% of drop reached to tops of young growth, 10% to ground. Tallest tree (right centre), white spruce 99' x 23.3" dbh.

Question #16 Penetration (of canopy)
293/303 (97%)

The answers were very subjective with only 7% of the returns giving reasons to qualify the answers.

Penetration

Class	%	Description of Vegetation
Good	83	Scattered open timber; cutover slash; light ground cover.
Fair	13	Open crowns; young growth.
Poor	4	Dense timber.

It can be seen that when the drop penetration was "good" in the estimation of the observer, it was closely related to the type of growth in the drop zone.

When Q-#16 is compared to Q-#37 (stand density), it can be seen that these two are related. Good penetration (83%) compares favourably to "Open" plus "Medium" (84%) stand density.

Q-#16 Penetration

Class	Percent
Good	83
Fair	13
Poor	4
	100

Q-#37 Stand Density

Class	Percent	
Open	33	
Medium	51	84%
Dense	16	
	100	

From tests conducted in Alberta it was noted that the addition of a short-term retardant does not significantly increase the canopy penetration capabilities of a dropped load over a load of plain water. (1)

(1) Personal communication: J.E. Grigel, Canadian Forestry Service, Edmonton, Alberta.

Question #17 Effectiveness (of airtanker action)
303/307 (99%)

This question was not defined on the report forms and as a result many answers were subjective. The majority indicated that the placement accuracy of the drops was the measure of effectiveness.

From the point of view of the observer on the ground, effectiveness was measured in terms of how much the drops reduced the fire activity. From the pilot's or air observer's point of view, drops made on the fire at the points requested by ground control or the Bird Dog Officer, were reported as 100% effective if they hit the target as instructed.

Class		Qualifications
Drop effective	70%	placed where requested
Partially effective	24%	close to requested area
Not effective	6%	in the wrong place, for a variety of reasons

If the effectiveness is compared to Q-#2 (Fire behaviour before and after action), the above percentages are related to the state of the fire when the airtanker left the area.

Q-#2 Fire Activity		Q-#17 Effectiveness		Q-#2 Fire state on leaving area	
Reduced	82%	Effective	70%	Under control	52%
No effect	17%	Partly	24%	Nearing	37%
Increased	1%	Not effective	6%	No control	11%

Photo #36

Torching trees brought to surface fire by air action, Manitoba.

Question #18 Reason for Stopping
658/716 (92%)

A wide range of answers were received for this question and to consolidate these, they were reduced to nine groups.

Percentage		Answer Group
43.8		Gained control
8.5		Held fire (temporary control)
6.8		Ground crew took over
13.4		Sent to other action
	72.5	These can be considered successful actions
6.1		Left area to refuel
12.0		Left due to darkness or weather conditions
1.8		Poor visibility, area too smoky
3.6		Mechanical problems; radio, engines, dropping equipment etc.
	23.5	These are reasons applied to the airtanker functions
4.0		No control
	4.0	

There is some question about the reasons for "Sent to other action", being included with the "successful" total. A few reports stated that the fire was out of control, and the airtanker was sent away. In this situation the report was entered with the "No control" group as this reason supercedes the "Sent to other action" group.

Temporary control (held fire), which is all that the airtanker is attempting to achieve, fits the concept of early initial attack and holding action but accounted for only 8.5% of the replies.

The 4% no control attained was listed as non-effectiveness, a hopeless situation, fire breaking away from control or fire out of control. This percentage was much lower than expected.

Weather problems (13.8%) were as might be expected. From Q-#13 it can be seen that the time of the first drop in 2% of the reports was after 8 pm. and darkness would be the reason for stopping in these cases.

It is interesting to note that 85.5% of the drops were made by aircraft more th n 20 years old. This percentage when compared with the 3.6% mechanical breakdown, contradicts much recent speculation about the expected life of some airtankers.

Question #19 — Was the Attack Significant
410/435 (94%)

Airtankers were significant in helping to control reported fires in 82% of the action reports, mainly by cooling, slowing fire spread, stopping fire spread, stopping fire spread to adjacent areas and enabling ground crew access.

Percentage		Reason
41.7		Yes (unqualified)
18.3		Cooled fire, enabling access
15.1		Stopped or slowed spread, prevented spreading into adjacent high hazard area
7.1		Doused fire, smoldering when left
	82.2	Helped in control of fire
14.4		No (unqualified)
1.2		Drop interval too long
0.2		Fire spread too rapid
1.5		Adverse weather or fire conditions
0.5		Preferred to let the area burn
	17.8	Airtanker of no help in controlling the fire

If Q-#19 is compared to Q-#2 (Fire behaviour as a result of airtanker action) it is seen that these two percentages are very close when reduced to simple totals.

Q-#19		Q-#2	
Reason	Percent	Reason	Percent
Helped in control of fire	82.2	Reduced fire activity	81.9
No help in control of fire	17.8	Did not reduce fire activity	18.1

It should be concluded that the observer's estimate of the significance of the air attack was an accurate measurement of the change in fire behaviour. Although Q-#19 had only 410 replies (as compared to 700 for Q-#2) an accurate general picture of the fire state emerged in both cases.

Question #20 Did the Airtanker return to the same sector of the fire
184/209 (88%)

Occasionally this question covers the situation in which the fire is considered to be under control, the airtanker has left and is called back because the fire has again begun to spread. The question also covers cases when the airtanker was forced to leave the fire due to darkness or weather and is requested to make early drops the following morning (overnight call or request).

Of the call back requests, 35% were for follow-up action the next day.

Possibility	% of All Returns
No	73.9
Yes	16.9
Next day	9.2

Of the "Yes" Returns	
Next day	35.4%
Yes	64.6%

It has been noted in Q-#18 (Reason for stopping) that the airtanker left the fire because of weather or darkness in 12% of the reports. If rain did not enter into the situation to change the fire advance, it is common for fire-fighting personnel to leave an "overnight request" for action by the airtanker the following morning.

Question #21 Number of drops (made when airtanker returned to the fire)
32/48 (67%)

This question is part of Q-#20. The reports indicate that the airtankers returned 48 times and that 32 of these returns were valid.

Fifty percent of these returns were for 11 or less drops per report. The number of drops made on return sorties varied from 1 to 35.

# Drops	# Reports	
1	1	
2	3	
3	3	
4	2	
5	2	
6	1	
8	2	
11	2	50% of reports
12	1	
13	2	
14	1	
15	1	
18	1	
19	1	
22	1	
25	2	58% of drops
27	1	
28	2	
30	1	
34	1	
35	1	
	32	

See Q-#14 part "B" for # drops/fire.

Question #22 Reason For Stopping (on return request)
32/48 (67%)

This question must be considered with Q-#20 and Q-#21. When compared with Q-#18 (Reason for stopping), there does not appear to be any similarity except for the "ground crew took over" group.

Q-#18 Percentage	Q-#22 Percentage	Answer Group
43.8	25.0	Gained control
8.5	3.1	Held fire (temporary control)
6.8	9.4	Ground crew took over
13.4	0.0	Sent to other action
72.5	37.5	Considered successful actions
6.1	12.5	Left area to refuel
12.0	40.6	Left due to darkness or weather
1.8	0.0	Poor visibility, area smoky
3.6	0.0	Mechanical problems, radio, engines etc.
23.5	53.1	Considered not successful actions
4.0	9.4	No control

As only 32 replies were received for this question, not much weight should be attached to the percentages for Q-#22. It appears that only 1/3 of the call back actions were successful and more than 1/2 were not successful. It should be noted that the answer "left to refuel" plus "left because of darkness" rated 18% (Q-#18) vs 53% (for Q-#22) which indicated that the airtanker probably was recalled late in the day when the fuel supply was running low and night was fast approaching. As a general rule airtanker pilots dislike landing, especially on water, after dark as vertical height estimation is difficult. The use of the aircraft's landing lights had been tried experimentally on firebombing actions, but it was found that tall trees were difficult to distinguish and the flights were abandoned.

Question #23 Airtanker location at the time of call
342/361 (95%)

Unfortunately, this question was asked only on forms supplied to Manitoba 1965-66 and to British Columbia in 1965-66-67, thus Ontario is not represented.

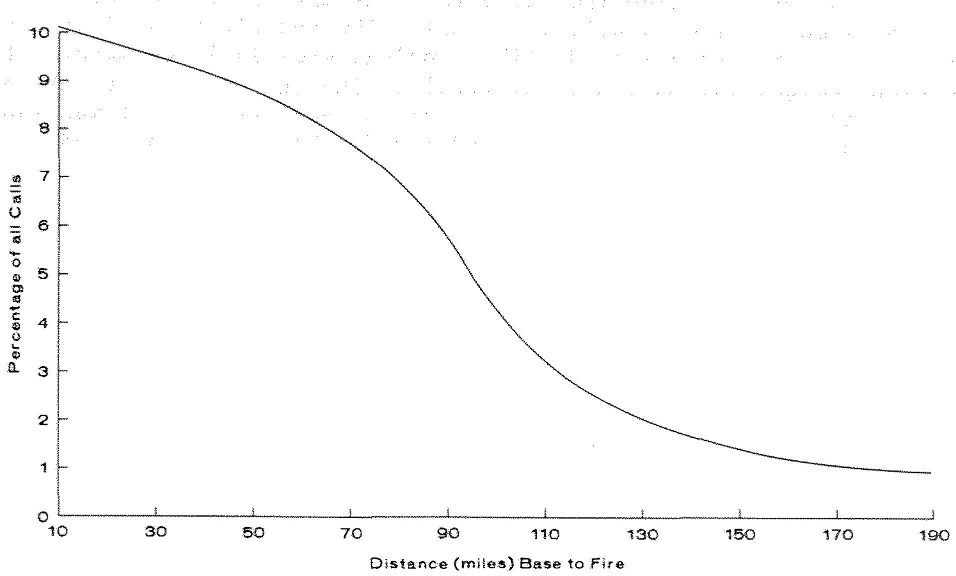
From sources other than this study, it is known that Ontario tries to operate it's airtankers within a limit of 50 miles from base to fire where possible.

There was a great range of distances recorded that varied from less than 10 miles (11.1%) to a single case of an airtanker flying 530 miles from base to a fire. (*)

The results indicate an even spread of call distances from less than 10 miles up to 95 miles. For call distances greater than 95 miles from base to fire, the percentages dropped sharply. Fifty percent of the calls were to fires 53 miles or less from the airtanker base.

(*) The 530 miles occurred when an airtanker was called from a main repair base to the northern part of the Province to save a fire crew camp. This particular fire grew from 1,000 acres to 15,000 acres in three days. The camp was saved by airtanker action when all tents and equipment were soaked by air drops, (personal communication, E. Stechishen, Canadian Forestry Service, Ottawa, Ontario).

Q - #23 AIRTANKER LOCATION AT TIME OF CALL
342 Reports



Distance (Miles)	Percent	Cum. %	Miles	Percent	Cum. %
10	11.1	11.1	140	2.0	
20	8.5	19.6	150	2.3	92.5
30	9.1	28.7	160	2.1	
40	9.1	37.8	170	1.2	
50	9.9	47.7	180	0.3	
60	8.2	55.9	190	1.2	
70	6.1	62.0	200	0.3	97.6
80	8.4	70.4	240	0.6	
90	8.2	78.6	270	0.3	
100	3.8	82.4	290	0.3	
10	1.7		400	0.9	99.7
120	2.6		530	0.3	
130	1.5				

Photo #37 Martin Mars flying boat anchored, Sproat Lake B.C.

Question #24 Getaway time from base
296/361 (82%)

As noted in Q-#23 (airtanker location at time of call), only Manitoba 1965-66 and British Col mbia 1965-67 were asked this question.

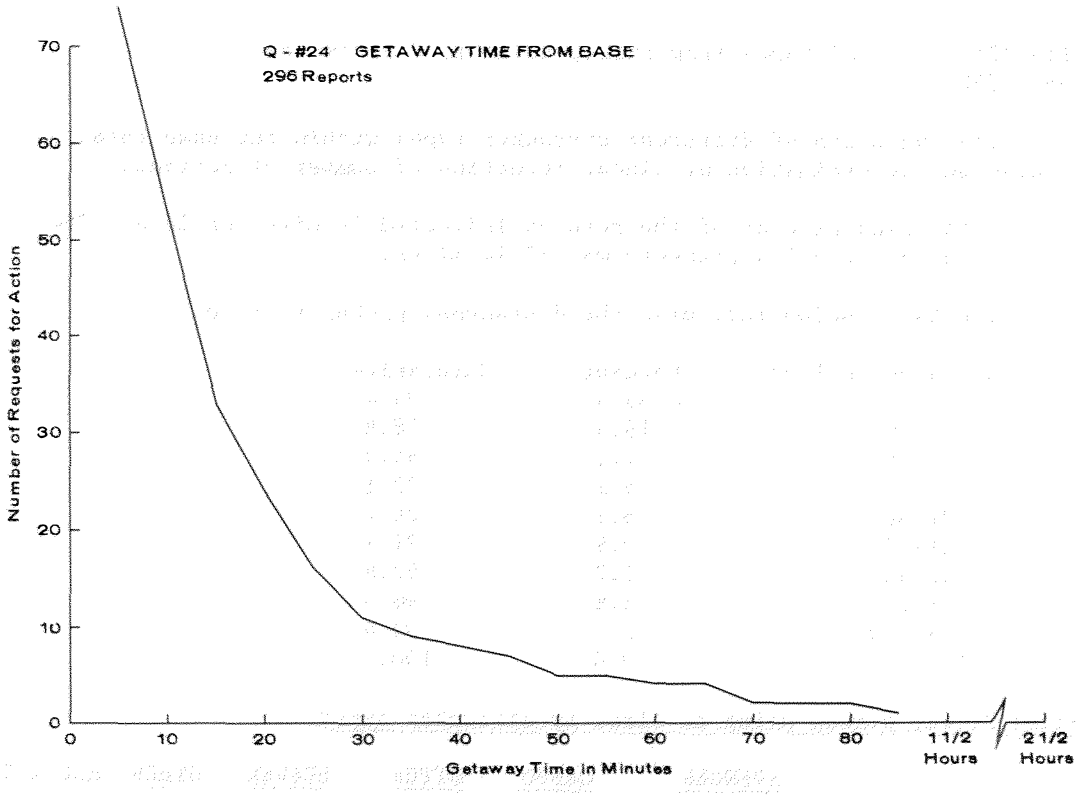
A considerable number of the requests for airtanker action (10.5%) involved diversion of the airtanker while in the air, working on a fire or enroute to a destination. In the case of a diversion, the air dispatcher concluded that the current action of that airtanker was not absolutely necessary in the control of that particular fire. After assessing the situation, the dispatcher then ordered the airtanker to another fire where air action could have a greater potential of effectiveness.

Fifty percent of the getaway times were less than 15 minutes. This short period reflects an active state of preparedness within the aerial firefighting section of the forest protection agencies. Several of the longer times were "first of the season" calls that were made well in advance of the contract starting date. It is to the credit of the charter companies that every effort was made to aid the provincial forest firefighting staff at any time during the fire season irrespective of airtanker charter date limits.

Getaway time (minutes)	Cum lative % of all calls
5 or less	25
14.3 or less	50
39 or less	75
60 or less	84

An overnight request (10%) was defined as a call made late in the day for the airtanker to start action on a fire the following morning. Often the lateness of the call would not allow sorties to be made that day or that airtanker action on a fire was terminated due to darkness or weather and the pilot was requested to resume dropping the following morning.

Generally the reasons for delay were listed as mechanical problems or aircraft refuelling. These delays were not frequently encountered.



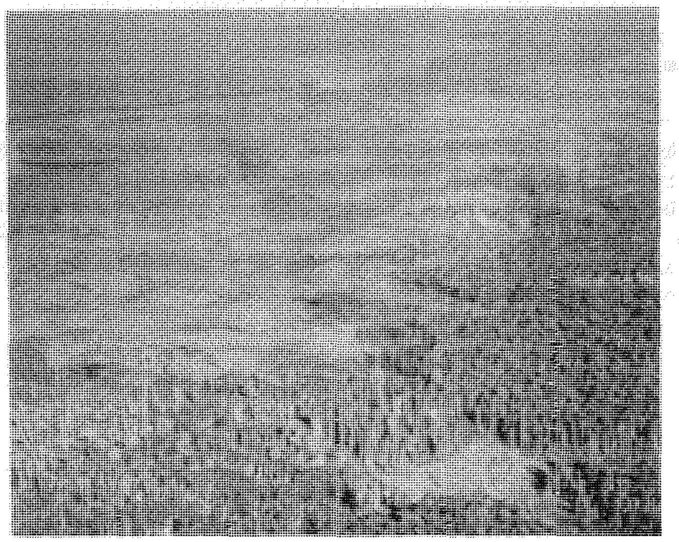


Photo #38 Pickup lake less than one mile from fire for Canso action.

Question #25 Distance from pickup point to fire (miles)
469/506 (93%)

The inclusion of different airtanker types within the same total complicates any determination of linear reduction of number of actions.

Fifty nine percent of the returns indicated 10 miles or less. The averaged distance for all airtankers was 17.14 miles.

The table below indicates the distances, pickup to fire.

Distance (miles)	Percent	Cumulative %
1-5	39.4	39.4
6-10	19.4	58.8
11-15	7.1	65.9
16-20	6.2	72.1
21-30	8.1	80.2
31-40	10.9	91.1
41-50	1.7	92.8
51-75	3.8	96.6
76-100	2.8	99.4
101 plus	0.6	100.0

Distances Flown, pickup point to fire, by airtanker types:

Type	AVENGER	CANSO	OTTER	BEAVER	OTHER	ALL A/Tankers
% of all returns	30.7	55.2	10.0	2.4	1.7	100.0
Averaged distance	38.4	10.1	3.2	3.1	---	17.14
Max. distance reported	135	60	7	11	---	135
Averaged distance for 50% of the returns only (miles or less)	33.0	5.3	2.0	2.0	---	7.1

It can be seen that the first 50% of the returns represent very low values. The Avenger must return to a base for each load and thus cannot make use of adjacent lakes that could be very close to the fire. The Avenger also was sent to some distant fires and this would make the distances as noted in Q-#23 (Airtanker location at the time of call) similar to the distances in Q-#25. This situation would not apply to scoop-loading airtankers.

Question #26 Distance to refuel (miles)
312/361 (86%)

Unfortunately these returns cover only:

Manitoba	1965 & 1966	Canso
B.C.	1965 & 1967	Canso, Super Canso, Avenger, Mars, Otter
B.C.	1966	Super Canso only

Fifty percent of the returns indicate 40 miles or less to refuel and 75% indicate 70 miles or less.

Averaged Distances to Refuel by Airtanker Types (Man. and B.C.)

Type	Q-#26	Q-#25
Canso	64	10
Super Canso	45	
Avenger	42	38
Otter	10	3
Mars	60	40
All Returns	51.6	17.1

It can be seen that the Avenger is closely tied to the reloading base, as would have been expected with this airtaker. The other airtankers being able to scoop-load, have demonstrated that the pickup point/distance to base ratio is quite large. Ontario (which is not represented in the above data) has attempted to maintain as a maximum, a 50 mile radius of action from base. It can be seen that this figure compares favourably with the two province average of 51.6 miles. The number of hours flying time between refuelling stops varies with the aircraft types. Because of maximum "all up weight" restrictions, some aircraft cannot fully load the drop tanks when all the fuel tanks are full. A tanker in this situation would have to fill the tanks to 80% of capacity for the first few drops and gradually increase the pickup weight as the fuel was consumed.

The longest distance to refuel was 230 miles, which involved an airtanker that began flying at 4:05 am to arrive at a fire 140 miles from base. After working on this fire (560 miles of flying) the airtanker was diverted to a second fire 90 miles from the first. After logging 215 miles the airtanker requested a return to base (230 miles). Total miles flown was 1235. Total hours flying in direct fire-fighting action was 6 and 4:15 hours were spent in ferry and reconnoiter time.

Refuelling distances grouped by 50 mile increments

Distance (miles)	Percent of total	Cumulative percent
1-50	62.6	62.6
51-100	30.2	92.8
101-150	5.7	98.5
151-200	1.2	99.7
over 200	0.3	100.0

Question #27	Wind Speed	Wind Direction
186/189 (98%)	169/189 (89%)	162/189 (86%)

Wind speed is of prime importance in this study as it is one of the determining factors in load placement and distribution on the fireline. Wind speed can also dictate, to a certain extent, the size of lake to be used by water scooping aircraft.

Eighty one percent of the returns show wind speeds of 15 mph or less and this appears to be the cut-off windspeed for water loading airtankers.

From personal observation, the authors have seen smaller aircraft cease water bombing when whitecaps developed on the pickup lake, while a Canso continued loading and dropping. Windspeeds in excess of 20 mph cause high waves that produce excessive pounding forces on the hull, floats and probes during scoop loading. Most pilots feel that continued operations in the face of this pounding is an abuse of the aircraft and crew. It is common for pilots to request permission to divert to other activities until the wave swell and wind strength have subsided.

Wind direction is of little importance in this study, (See Q-#5, target)

Wind Speed	# Returns	%	Cum. %
Calm	20	11.8	11.8
5	65	38.5	50.3
10	34	20.1	70.4
15	18	10.7	81.1
20	12	7.1	88.2
25	13	7.7	95.9
over 25	7	4.1	100.0
	169	100.0	

Wind Direction	# Returns	%
N	23	14.2
NE	6	3.7
E	12	7.4
SE	26	16.0
S	17	10.5
SW	19	11.7
W	43	26.6
NW	16	9.9
	162	100.0

If these related questions are compared, a close correlation appears.

Q-#18 Reasons for Stopping	Q-#28 Weather effect on operations	Q-#27 Wind Speed
14%	17%	19%
Darkness, smoke, weather, poor visibility	High winds and turbulence	Winds in excess of 15 mph

Question #28 Weather effect on operations
445/478 (93%)

Two-thirds of the returns indicated that weather had no effect on operations.

The outstanding weather effect noted was 17% for high gusty winds and turbulence (see Q-27). Smoke and poor general visibility was listed in 6% of the replies and loading difficulties on water pickup, a further 4%. Glare of the sun on the water, or it's position relative to the drop area, had a minor effect on the operation of the aircraft.

Type of weather effect experienced	Percent of total
No	66.5
Yes (unqualified)	1.8
Turbulence and high winds	17.3
Lightning	2.5
Smoke, poor visibility	6.1
Rain, hail	0.9
Glare	0.9
Fire heat *	0.2
Loading difficulties	3.8

* Fire heat causes visible distortions on the horizon and on the target making treetops, chicos and hills difficult to distinguish. Flying in such conditions can become extremely dangerous. Excessive heat also causes reduced piston engine performance and should be taken into account by all pilots.

Photo #39 Wind speed 28 mph over backing fire, Ontario.

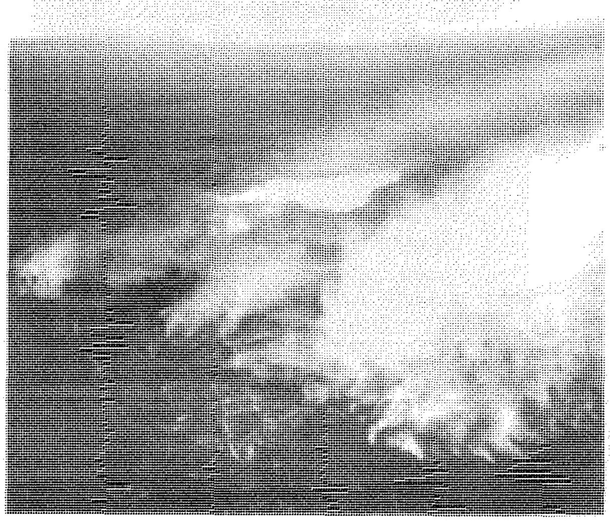


Photo #40 Wind dropped at 8 pm. Note how smoke is drawn into the fire centre before rising. Surface wind - calm.

Question #29 Topography (slope)
199/206 (97%)

From the reports received, 86% of the fires attacked by airtankers were burning on level, gentle or moderate slopes. The remaining 14% were fought on slopes greater than 60%, and were mainly in British Columbia.

Slope	%	Cum. %
Level	26.1	26.1
Gentle	28.6	54.7
Moderate	31.7	86.4
Steep	13.6	100.0

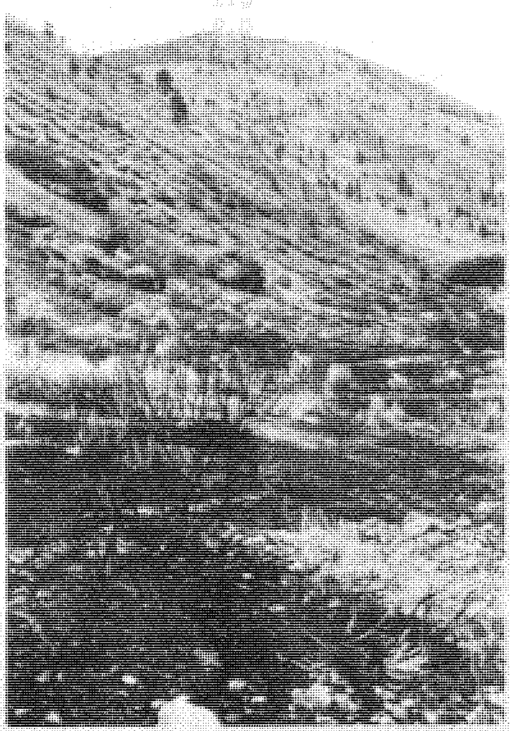


Photo #41 Slope 35 degrees, Kamloops, B.C.

Question #30 Topographic effect on operations
222/237 (94%)

The land shapes had no effect on three-quarters of the operations.

Effect	Percentage		
No	78.4	No	78.4%
Yes (unqualified)	5.0	Yes	21.6%
Position of fire	4.5		
Steep terrain	6.8		
High rocky hills	2.2		
Poor approaches (ountainous)	3.1		
	100.0		

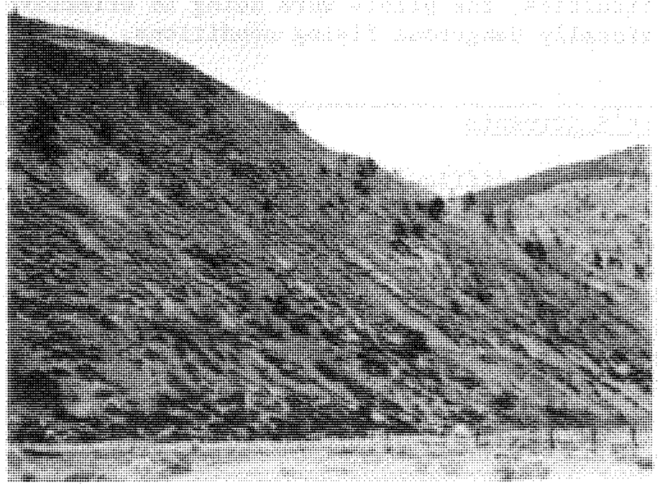


Photo #42 The Avenger dropped retardant forming a fire line on the slope parallel to the base of the grade and stopped fire advance uphill from the base of the slope.

Question #31 General Remarks and comments
519/716 (72%)

Where comments could be freely given and opinions expressed, this question was poorly answered. The 519 comments were coded into 42 classes. Unfortunately these classes proved to be unwieldly and very scattered in content and subsequently were reduced to more meaningful groups.

Percent	Major groupings	Q-#2 (Fire Behaviour)	
80.8	Action successful or partly successful	Fire level reduced	81.9%
17.3	Action not successful	No effect or increased	18.1%
1.9	No drops made, no action required.		

The majority of the returns stated simply either "good effect" or "good accuracy" or "no difficulties". This type of comment was not very instructive but it did indicate that airtanker pilots are capable men. In spite of smoke, low level flying and other difficulties, the pilots were doing an effective job in the face of marginal and occasionally dangerous flying conditions.

Percent	Observer's comments
41.0	Good effect, no difficulties, good accuracy
9.4	Held the fire under difficult conditions
6.9	Held the fire enabling ground access
4.0	Stopped fire spread - little smoke
3.7	Cooled hot spots
1.9	Slowed rate of spread
6.6	Good effect in spite of communications problems
7.3	Miscellaneous (good) effect
80.8	Total
6.6	Poor results, lack of follow up
3.9	Heat and wind too high for effective control
1.9	Fire too large, called away
1.7	Difficult to/or could not find reported fire
1.0	Refuel distance too great or ceased dropping too soon
2.2	Miscellaneous (poor) effect
17.3	Total
1.9	No action necessary - no drops made.
100.0	Grand total

Question #32 Exposure
165/184 (90%)

Forty percent of the reported fires were fought on southerly facing slopes (SW, S, SE). Seventy five percent of the reported fires were located on the West through South to East-facing slopes.

Fire Site Exposure Distribution

Percent	Exposure
24.2	S
18.2	E
17.0	W
10.3	SW
9.7	N
7.3	NE
6.1	SE
3.6	NW
3.6	Level

Photo #43

Fuel types that burned are black. Fire advanced through black spruce swamp at centre and across poplar ridge to Alfred Lake, at right. Ontario.

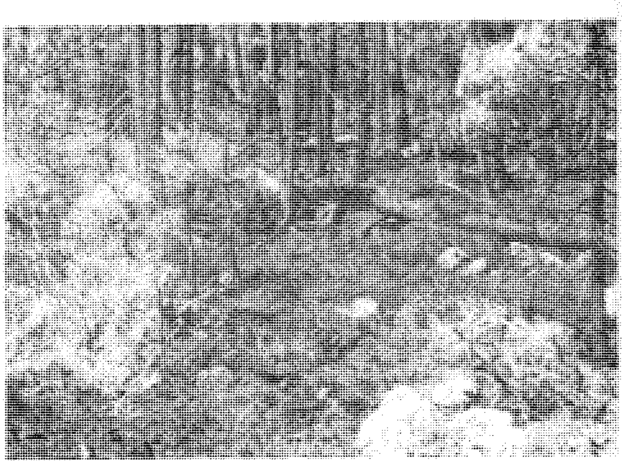


Photo #44

Fire path through black spruce swamp sphagnum moss (see photo #43).

Question #33 Fuel Type
408/414 (99%)

The distribution percentage of fuel type reports was fairly even, as noted in the table below:

Percent of total	Province
27	Ontario
39	Manitoba
34	British Columbia
100	Total

There were 23 fuel type classes noted on the report forms. To make these data easier to analyse, they were reduced to five main headings.

Percentage	Heading
61.8	Standing coniferous
7.8	Coniferous slash
10.3	Standing timber
8.8	Non-standing timber
11.3	Lower vegetation
100.0	Total

Coniferous fuels formed the bulk of the fuels identified at 70%.

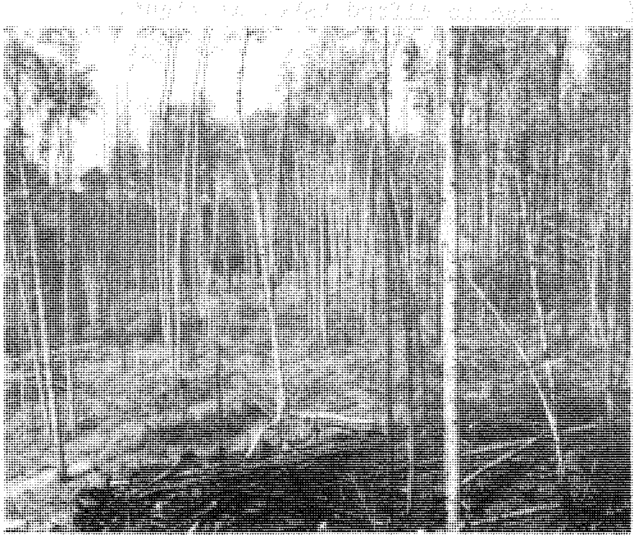


Photo #45

Fuel pattern equals fire pattern in slash, Ontario.

Photo #46

Slash fuels, wS; bS; jP; bF with residual white birch that produced "sailers" that caused jump fires. Ontario.

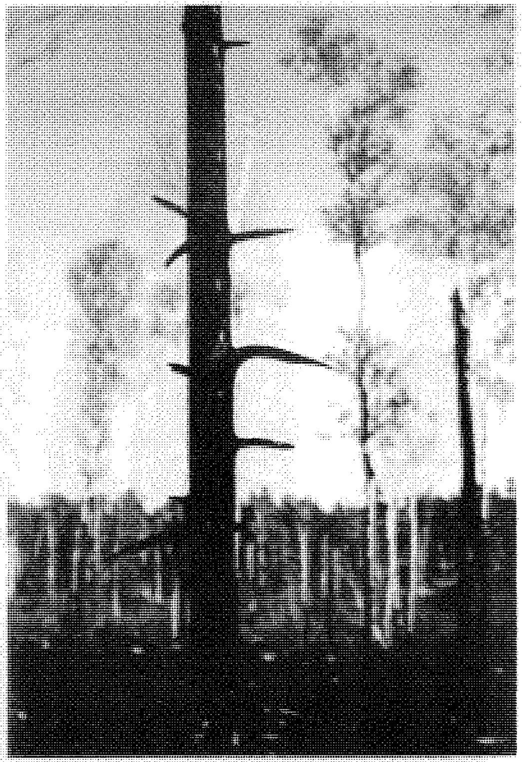


Photo #47

Fuel type was coniferous slash.

Question #34 Tree Species
41/101 (41%)

The main fuels were identified and separated into 8 classes. As would be expected, conifers accounted for 78% of the species reported and deciduous trees made up the remaining 22%.

Percentage	Tree Species
43.9	Black Spruce
22.0	Jack Pine
9.8	White Pine
2.4	Balsam Fir
78.1	Coniferous total
9.8	Poplar
7.3	White Birch
2.4	Yellow Birch
2.4	Oak
21.9	Deciduous total

The above species listing reflects the 71% of the returns from Ontario. Evaluation reports listing tree species were received from the Provinces in the following percentages:-

Percent of total	Province
71	Ontario
19	Manitoba
10	British Columbia
100	Total

Photo #48

Tallest tree is 103'. Surface fire in overmature stand.

→

Question #35 Height of tallest tree (feet)
142/193 (74%)

The tallest tree was chosen because the airtanker obviously cannot fly below this height without risking a collision.

The three Province average tallest tree height was 71.4 feet.

From Q-#12 (drop height above canopy) it was found that the drop height average was 68.2 feet. In order to reach the ground, the average airtanker load must fall 139.6 feet. The average tallest tree heights were:

Ont.	Man.	B.C.	All	
51	60	80	71	feet.

Percentage classes of tallest tree heights reported

Height	Percent	Cum. %
10	2.1	2.1
20	2.1	4.2
30	4.9	9.1
40	5.6	14.7
50	12.7	27.4
60	12.0	39.4
70	11.3	50.7
80-100	18.3	69.0
over 100	31.0	100.0
Total	100.0	

Question #36 — Diameter of the Tallest or Largest Tree (inches)
43/95 (45%)

Returns Received from Provinces

Ont.	Man.	B.C.	Total
88%	12%	0%	100%

This question was not asked on the B.C. for s.

It must be noted that most of the data below were from Ontario and only five reports were from Manitoba.

D.B.H. up to and including 12"	78.5%
D.B.H. from 13 to 24"	21.5%

The diameter of the tallest tree did not mean much to the study, but it was an indicator of the fuel loading in the drop zone. The average tallest tree D.B.H. was 10.2" and the average tallest tree height (Q-#35) was 71 feet. Black spruce was the most common species reported (Q-#34) at 44% of all reports.

Although the single tree study listed below compares trees larger than the averaged trees in Q-#35 and Q-#36, these black spruce do give a picture of the probable fuel loading and the drop penetration d fficulties in the areas.

Black Spruce (Ontario Sites)		Closed stand*	Open stand*
D.B.H. (inches)		11.7	11.1
Height (feet)		65	50
Max. Crown width (feet)		21	23
Max. crown area (sq. ft.)		346	415
Fuel weights (green condition)			
Branch and needles	(pounds)	534	745
Stem	(pounds)	950	616
Total	(pounds)	1484	1361

(*) Forest Management Institute, Ottawa.

Question #37 Stand Density
134/185 (72%)

Report Frequency by Provinces

Ont.	Man.	B.C.	Total
28%	5%	67%	100%

This question was made up in three parts and is self explanatory.

Density	Percent of Reports
Open	33
Medium	51
Dense	16
	100

From Q-#16 (penetration of canopy) it was shown that these two questions are interrelated.

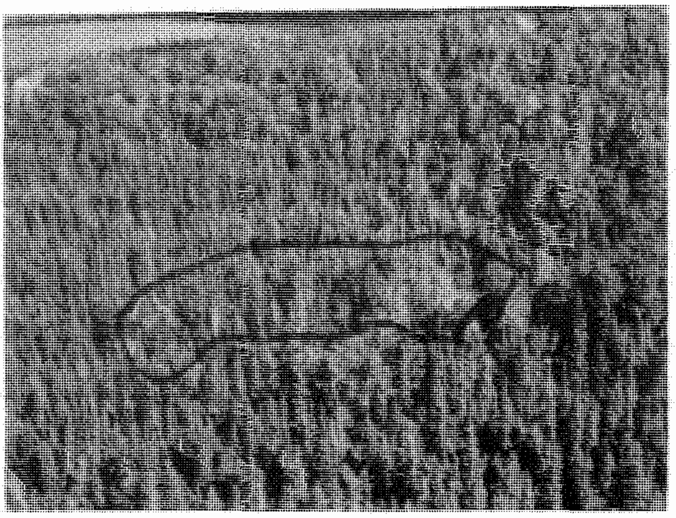


Photo #49 Spot fire is circled in this dense coniferous stand, Ontario.

Question #38 Regrowth and species
42/95 (44%)

The great bulk of the replies indicated that Ontario made use of this question most extensively. The single reply from British Columbia was obtained from data on one of their own airtanker forms, as this question was not asked on the B.C. forms supplied for their use by the Federal Department of Forestry.

Report frequency by Provinces

Ont. 86% Man. 12% B.C. 2%

Young growth present under the main stand

No	50.0%	
Yes (unqualified)	4.7%	
Yes Spruce Fir White Pine Jack Pine		 14.3% 14.3% 4.8% 0.0%
Conifer total	33.4%	
Birch & Poplar Hard Maple		9.5% 2.4%
Deciduous total	11.9%	
Total	100.0%	

Photo #50

Thick young growth and scrub in an old cutover area. Vertol helicopter dumping 275 I. gallon bucket in background.

Question #39 Regrowth height (feet)
20/93 (22%)

Replies to Q-#39 were received in the following proportion.

Ont. 85% Man. 15% B.C. 0%

Question not asked on B.C. forms

The averaged height of regeneration under the main stand gained from these few replies was 11 feet.

Height grouping	Percent
0- 5 (ft.)	--
6-10	60
11-15	30
16-20	--
21-30	5
30 plus	5
Total	100%

Photo #51

Young growth stopped fire advance.

Question #40 Regrowth distribution

21/93 (23%)

Replies to Q-#40 were received in the following proportions.

Ont. 86% Man. 14% B.C. 0%

Total 100%

Question not asked on B.C. forms.

The distribution of the young growth was:

Scattered	52%
Dense	19%
Clumps	29%
Total	100%

Question #41 Ground fuels
75/95 (79%)

Replies to Q-#41 were received in the following proportions.

Ont. 93% Man. 7% B.C. 0%

(Not asked on the B.C. form)

The ground fuels were originally grouped into 9 classes but to simplify comprehension, these were reduced to 4 classes.

Percent	Grouping	Material described
48	Fines	Needles, leaves, dry grass, dry ferns, moss
15	Twigs	Twigs and small sticks
36	Logs	Logs and branchwood 4" or larger
1	Continuous	
100%		

It can be seen that 63% of the ground fuels were of a readily flammable type, excepting the Ontario Sphagnum moss. These fuels are capable of burning rapidly but are also more easily controlled by airtanker action.

It would appear that proper use of the airtanker was made by attacking forest fires in these types of fuel, taking into account the fuel's high rate of spread capability. The air action would certainly buy time for ground crews and reduce the resulting total area burned.

Question #42 Distribution of fuels
38/94 (40%)

Replies to Q-#42 were received in the following proportion.

Ont. 92% Man. 8% B.C. 0%

(Not asked on the B.C. form)

Fuel distribution on the ground was divided as shown below.

Common	42%
Scattered	58%
Piled	0%
	100%

It can be seen that no airtankers were called to fire perimeters where the fuels were considered to be piled on the ground.

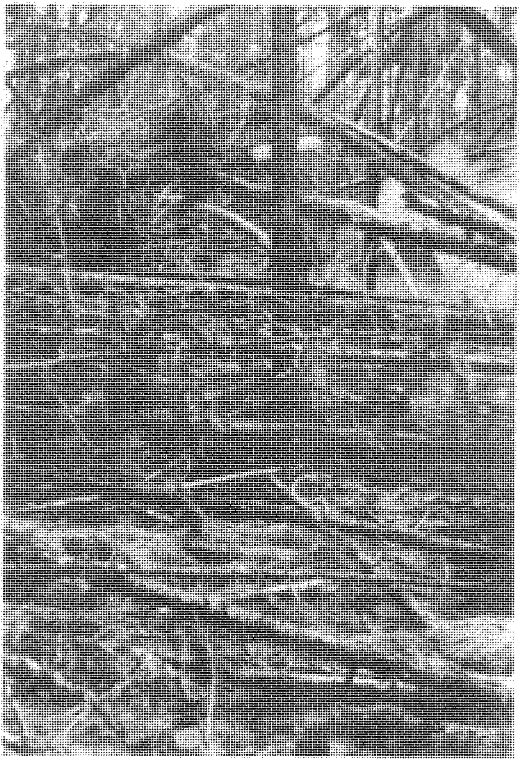


Photo #52

Overturned trees caused by very low Canso drops, Ontario.

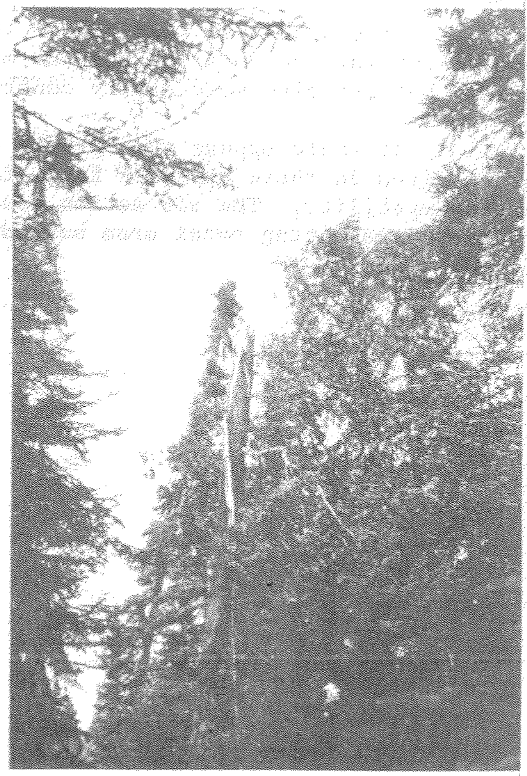


Photo #53

Canso drop damage.

Question #43 Damage to Vegetation
162/207 (75%)

This question was asked only on the B.C. forms and 98% of the returns for this question were from B.C.

Damage to Vegetation

87.7%	No
0.6	Yes (unqualified)
4.3	Trees knocked over
7.4	Breaking tops and snags
100.0	Total

Damage was confined to breaking tops and in some cases, overturning trees. Breaking tops and snags constitute a danger to men working in the drop area. From Q-#9 (Danger to men) B.C. considered that 42% of the drops were, or could have been, dangerous to men in the area.

Breaking tops and Snags

Q-#43	(damage to vegetation)	7.4%
Q-# 9	(danger to men)	7.2%

In Manitoba and Ontario black spruce country, trees can be overturned by very low level drops.

Photo #54

More than 100 black spruce overturned by low Canso drops on spot fire (see photo #49)

Photo #55

Canso drop damage to shallow-rooted black spruce.

SUMMARY

The airtankers examined in this study varied in size from the 6000 gallon Mars to the Bell 47-G with a 45 gallon bucket. The smaller airtankers received a higher priority for the transport of men and materials than for fire bombing. Airtankers were used to attack 7.5% of all the fires in the reporting provinces. Eighty two percent of the actions reduced the fire activity by a significant amount and 17% held the fire at the same level. The remaining 1% represented fires that were basically out of control and airtanker action did little to change the level of fire behaviour.

At the time of attack, 63% of the fires were 5 acres or less in area and half the fires were 2.54 acres or smaller when attacked, indicating optimum use of airtankers. Nine percent were greater than 100 acres in size (a high percentage) which indicated that the airtanker was called too late to be really effective in reducing the fire activity.

The use of a flight of two or three airtankers dropping in close succession was routine procedure in some areas. The target of "fire head" and "fire flanks" received an equal number of attacks. Sixty-five percent of the actions were to "cool hot spots and take line holding action". One third of the pilots favoured an "into wind" direction of attack and only 10% chose "downwind". Half the reports noted the length of fireline the airtanker was trying to control was 600 feet or less but 25% listed lengths in excess of 1300 feet which could indicate that the airtanker was asked to perform in excess of its capabilities.

Fifty six percent of the forms noted that no men were working in the attacked sector of the fire at the time of the first drop. This fact indicated that a proper early use of the airtanker was being carried out. The remaining 44% of the forms noted that ground control had started at the time of the first drop but only 6.8% of the reports listed "ground crews took over", when the airtanker ceased dropping. This latter percentage is surprisingly low. Sixty eight percent of the replies indicated that it would not have been dangerous for men to work in the drop zone, even though ground crews were not working on the same sector as the airtanker in 56% of the reports. Eighty eight percent of the reports listed "no damage to vegetation" as a result of airtanker action. The daily mean time of the first drop was 3:15 pm but the peak of first drop activity occurred from 4:30 to 6:30 pm. Fifty six percent of the drops were made after 2:30 pm and the averaged drop height was 68 feet above the tree canopy.

For half the reports, the distance from base to the fire was 53 miles and required 58 minutes to deliver the first drop. Fifty percent of the getaway times were less than 15 minutes. This short period reflects an active state of preparedness within the aerial firefighting section of the forest protection agencies. Several of the longer times were "first of the season" calls that were made in advance of the contract starting date. It is to the credit of the charter companies that every effort was made to aid the provincial forest firefighting staff at any time during the fire season, irrespective of the airtanker charter date limits. Half the reports showed that the distance from pickup point to the fire was 7.1 miles or less and that the distance to refuel was 40 miles or less from the fire.

Two thirds of the returns indicated that weather had no effect on operations, that 70% of the wind speeds were 10 mph or less and that land shapes had no effect on three quarters of the operations.

Seventy percent of the fuels were coniferous and the average tallest tree was 71 feet high. The drop penetration was directly related to stand density. Eighty three percent of the forms listed canopy penetration to be "good".

The averaged round trip times varied by airtanker types with a high of 29.45 minutes for the Avenger to a low of 6.43 for the Beaver and an all-airtanker average of 13.15 minutes. Fifty percent of the reports averaged 10 minutes or less, round trip time.

Half the reports noted six drops per action and the number of drops per fire averaged 14.5 (9,400 I. gallons). Half of all the drops contained some type of retardant, a percentage that is rapidly rising in Canada. The maximum number of drops reported by a single airtanker on one fire was 122. The maximum number of tons of fire retardant or water dropped on one fire was 1,572 while the minimum was a single drop (180 gallons).

It must be concluded that airtanker attacks on forest fires produce favourable results in at least 80% of the actions. This percentage would probably rise if airtankers were more plentiful and were called to fires in the very early stages of their development.

From the airtanker evaluation forms, it was noted that air action had the following effects:-

		Percent of replies received
Q - #2	Attack reduced the fire activity level	82%
Q - #2	Attack had no effect on the fire	4%
Q - #17	Attack was judged to be effective	70%
Q - #19	Attack was significant in helping to control the fire	82%
Q - #31	Attack was beneficial to firefighters	81%

The airtanker when called back to a fire, returned to the same sector that had been attacked earlier (26%). Thirty seven percent of all the return attacks were considered successful but 41% were terminated due to darkness or bad weather. On the return attack, half the airtankers dropped 11 loads or less.

The prime function of an airtanker is to aid in controlling forest fires in conjunction with ground crew support. If called to action soon after a fire is reported, airtankers can often attack and contain forest fires before they reach less manageable proportions. The basic advantage of airtankers as opposed to other fire suppression tools, is rapid response capability.

The airtanker is not the complete answer to the forest fire suppression problem. It is an effective tool when used on the right fire at the right time i.e. in the early stages of fire development. The range of effectiveness varied from very effective on small fires to ineffective on large fires. In the future, new developments can be expected in airtanker design, loading and delivery systems and in chemical fire retardants, making the airtanker an even more effective and profitable fire control tool.

APPENDIX 1

Fire Retardant Chemicals commonly carried by airtankers

In recent years the addition of chemicals to improve the extinguishment properties of water has been used in aerial forest fire control in Canada. Wetting agents to reduce surface tension permitting deeper penetration were initially tried. Later, clays with their water-holding capacity were added to produce retardants that coated the fuels with a thick moist layer. More recently fire retardant mixtures have been developed that rely on chemical rather than mechanical means to slow the burning processes.

The duration of water retention of the various chemicals depends primarily on the environment in which they are applied. This duration period is modified by the retardant's viscosity and the original thickness of the moisture layer.

Short term retardants lose their properties as soon as the moisture level has been reduced to zero. Long term retardants are still effective after all the moisture has evaporated, as the thin layer of chemical continues to retard burning of the fuel. A laboratory evaluation indicated that a long term retardant when fully dried out, was nearly twice as effective in reducing the rate of fire spread than was a short term retardant when two-thirds of the original moisture was still present. (Hardy, 1962).

WATER

Water is the basic ingredient of all fire retardant mixes. Plain or with Gelgard injected from an on-board system, it is most frequently used by probe-type airtankers making quick pick-ups from water surfaces near the fire. This use of water does allow airtankers to make more drops per unit time and thus apply a higher volume per hour than mixtures that require the airtanker to return to base for loading. It is however, the least effective of the short term retardants as it only temporarily cools down the fire.

GELGARD F (Improved)

A synthetic organic polymer produced by Dow Chemical Company, Gelgard in the insoluble powder form, can absorb water in amounts 100 to 1000 times its own weight. It is not a chemical retardant but serves only to hold water in a viscous two phase mixture. Mixing ratio is 0.01 to 0.04 pounds per I.gallon of water depending on hardness and temperature. It is incompatible with salt water and thus cannot be used on sea loading operations.

Gelgard powder is carried aboard the airtanker and can be metered into the drop tanks of probe-type aircraft as it skims and loads from the water surface. Overmixing or high speed shear reduces the Gelgard's effectiveness.

For visibility, a red dye is usually added to the mixture, which is not subject to bacterial deterioration. The mixture is non-toxic and non abrasive but it is however, very slippery and can create a potential hazard to walking personnel on the fire line.

CLAYS: (Bentonite, Montmorillonite)

Bentonite clay slurry is a short term retardant in which effectiveness is dependent on the water content. The effectiveness as a retardant lasts about one to two hours under normal summer drying conditions. It is a high-swelling type available in powder or granular form. Because it is an off-white to light brown colour, a red dye is often added for pilot visibility on the fuels. Normal mixing ratio is 0.9 to 1.0 pounds per I. gallon giving a viscosity range of 1500 to 2500 centipoise, depending on water characteristics. Bentonite will not readily mix with other fire retardant salts. Mixing time for this abrasive slurry varies from 4 to 15 minutes depending on the type of batch mixer used. Although Bentonite slickness presents fire line safety problems, it is non corrosive and non toxic.

FIRE-TROL 100

Fire-Trol 100 is a 15% by weight ammonium sulfate solution thickened with attapulgite clay to 1400-2000 centipoise and manufactured by Arizona Agrochemical Company. Proper concentrations are necessary to avoid a mixture that may result in the breakdown of the inhibiting effect of the slurry to a point below adequate levels for effective fire control. The mixing ratio is 3.33 lbs. per I. gallon of water. High shear mixing is mandatory to obtain the proper viscosity but once obtained, it can be stored indefinitely. Slurry preparation requires 4 - 6 minutes in a batch type mixer. It can cause corrosion to metal surfaces and good housekeeping by washing down aircraft, pumps, tanks and valves is essential.

A red dye is commonly added to the mixture for better aerial visibility.

PHOS-CHEK

Manufactured by the Monsanto Company, Phos-Chek contains 10% diammonium phosphate (DAP) by weight, thickened with sodium carboxymethylcellulose (CMC) to 800 - 1200 centipoise. A 10% solution should contain 1.37 pounds of chemical per I. gallon of water to produce the proper viscosity. The manufacturers advise that the specified concentrations be used to avoid adverse effects. Contamination by residue of other material may cause irreparable loss of viscosity. Red pigments are added at the batch mixer for better aerial visibility.

COSTS (1969 prices *)

Material	Per 100 I. gallons of solution
Water	$
Gelgard F Improved	3.75
Bentonite	3.00
Fire-Trol 100	20.00
Phos-Chek 202	20.00

(*) British Columbia Forest Service, Handbook No. 1.

APPENDIX 2

Ten year record of Canadian aircraft and crew losses, 1960-1969.
A C C I D E N T S

(Forest Fire Protection)

DATE	PROV.	F	TYPE OF ACCIDENT	AIRCRAFT MAKE & MODEL
25-07-60	B.C.	-	Wheels up landing	Boeing B17G Fortress
22-07-60	B.C.	1*	Collision trees	Boeing B75N1 Stearman
23-06-61	B.C.	4*	Collision trees	Martin JRM-3 Mars
26-06-61	Ont.	-	Collision water	de Havilland DHC3 Otter
14-06-62	B.C.	-	Engine failure, collided with trees	Cessna 195
31-07-63	B.C.	1	Collision trees	Grumman TBM-3 Avenger
64			Accident free	
23-06-65	Nfld.	1*	Overshoot, hit shore	Consolidated PBY5A Canso
03-08-65	Alta.	-	Collision trees	Boeing A-75 Stearman
12-08-66	Alta.	-	Groundloop	Boeing A-75N1 Stearman
13-07-67	N.W.T.	-	Engine failure, collided with trees	Cessna 180H
16-07-67	B.C.	2*	Collision trees	Consolidated PBY5A Super Canso
22-07-67	B.C.	-	Undershoot, tail rotor struck log	Hiller UH12E Helicopter
26-07-67	P.Q.	1	Collision trees	Cessna 180E
08-08-67	B.C.	1*	Collision rising terrain	Grumman TBM3 Avenger
06-08-67	B.C.	-	Loss of control, contacted rocks	Bell 47G3B Helicopter
02-05-68	B.C.	-	Landed with nose gear up	Consolidated PBY5A Canso
08-08-68	B.C.	2*	Collision trees	Consolidated PBY5A Canso
11-08-68	B.C.	-	Landed with landing gear unlocked	Piper PA-24 Comanche
01-03-69	Chile	-	Collision rising terrain	Consolidated PBY5A Canso
26-07-69	B.C.	3	Midair collision with glider	Bell 47 Helicopter
03-08-69	N.W.T.	-	Engine failure, collision water	de Havilland DHC3 Otter
25-08-69	Sask.	-	Collision, submerged log	Consolidated PBY5A Canso
18-07-69	Sask.	2*	Collision trees	de Havilland DHC2 Beaver

F fatal
* on fire bombing work

Issued by
DEPARTMENT OF TRANSPORT
Aircraft Accident Investigation
Division

APPENDIX 3

Index to photographs

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11	2	Jump fire
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20	4	Canso attack
21	5	Target from slash to green standing timber
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34	12	Helicopter drop
35	16	Penetration difficult through overstory
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37	23	Martin Mars flying boat base
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39	27	Fire in 28 mph wind conditions
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42	30	Topography dictates direction of attack
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48	35	Tallest tree presents problems
49	37	Dense stand
50	38	Regrowth can advance or retard fire spread
51	39	Young growth stopped fire advance
52-55	43	Damage to vegetation as a result of air drops

AIRTANKER EVALUATION FORM

Aircraft

A. GENERAL.
Fire Name________________ Date________________19______
Fire Number________________ Aircraft (type & number)________
District (or Region)________ Map Location________________

B. FIRE BEHAVIOUR (for area of air attack only-worst conditions found)

	Fire Character (Check appropriate sections)				
				Crown	
	Smoldering	Slow Surface	Fast Surface	Running	Flare-up (Torching)
Before Action					
After Action					

C. ATTACK

1. Size of fire at attack____________acres.
2. Target: Head(__) Flank (__) Rear (__) Small fire (under ¼ acre) (__)
3. Method of attack: Direct(__) Indirect (__)
4. Has ground control started: Yes (__) No(__)
   If "Yes" is/are the airtanker(s) working on the same section of the fire as the ground crew? Yes(__) No (__)
5. What was the airtanker trying to do:
   Hold small fire (under ¼ acre) (__)
   Cool hot spots (__) Hold jump (spot) fire (__)
   Establish guard along section of fire edge (__)
   Other (specify)________________________
6. Approximate length of fire edge airtanker is attempting to control: __________feet.
7. Estimated drop height above canopy: Low (under 50 feet) (__)
   Medium (50 to 100 feet) (__)
   High (over 100 feet) (__)
8. Direction of attack: Into wind (__) Downwind(__) Crosswind (__)
9. Effectiveness: How many drops were made before the fire was held or action stopped on section of fire edge being attacked?

Start of drop	End of sequence	Number of drops
________(Hr/Min)	________(Hr/Min)	________
________(Hr/Min)	________(Hr/Min)	________
________(Hr/Min)	________(Hr/Min)	________
		Total:________

Round Trip Time________Min.
Reason for concluding action________________________
(achieved control, other actions, weather, etc.)
If dropping was not continuous, please give reasons.

____

____

____

10. Did aircraft return later to drop again on sa e section of fire edge?
    Yes (__) No (__) Why?________________________

Start of drop	End of Sequence	Number of drops
________	________	________
________	________	________
________	________	________
		Total:________

Round Trip Time (if different from above)____________________Min.
Reason for stopping____
(Achieved control, weather, etc.)
If dropping was not continuous, please give reasons.

____

NOTE: If when tanker returns, weather, fuel or other conditions have changed please indicate on appropriate section of another form and attach.

If any portion of the data requested below is identical with that already placed on forms compiled for a previous action, please identify the action (e.g. see drops made at 10.30) and leave appropriate sections below blank.

D. WEATHER (take at fire if possible)
Wind speed ______MPH Wind direction____________________________
Turbulence: Nil(__) Light (__) Moderate (__) Severe(__)
Did weather conditions exist or develop which made dropping either difficult or impossible? (turbulence, wind speed or direction, etc.)
Yes (__) No (__). If "Yes" describe:____________________________

E. TOPOGRAPHY (in area of air attack)
Did topographic features (position of fire on slope, steep or mountainous terrain etc.) make dropping either difficult or impossible?
Yes (__) No (__)
If "Yes" explain____

F. FUELS (in area of air attack)
Coniferous (pine, spruce, etc.)...........................(__)
Mixedwoods (coniferous and hardwoods together).............(__)
Hardwoods..(__)
Slash (date of cutting if known 19__)......................(__)
Burn (date if known 19__)..................................(__)
Blowdown...(__)
Brush..(__)
Grass..(__)

G. SERVICE
Airtanker requested at _____(Hr:Min) Departed______(Hr:Min)
Arrived______________(Hr:Min) Reason for delay (if any) ___________
Location of airtanker at time of request__________________________
Distance from fire____
Refueling: Location__________________Distance from fire____________
Retardant used: Water (__) Chemical (specify)______________________
Pick-up point of water (or chemical)_______________________________
Distance from fire ____________miles

H. GENERAL
1. Was the airtanker action significant in the control of a fire?
Yes (__) No (__) Explain_______________________________________

____

____

2. Comments on accuracy of drops, elapsed times, damage to tree cover, mechanical difficulties, communications, etc.)

AIR TANKER EVALUATION FORM
Ground

A. GENERAL

Fire number ______________ Date ______________ 19 ____

District ______________ Aircraft (Type) ______________

B. FIRE BEHAVIOUR - For area of air attack only - worst conditions found.

Fire Character (Check appropriate sections)					
	Smoldering	Slow Surface	Fast Surface	Crowning: Running	Crowning: Flare-up
Before Action					
After Action					

C. ATTACK

1. Method of attack: Direct (____) Indirect (____)

2. Has ground control started? Yes (____) No (____)
   If "Yes" is/are the air tanker(s) working on the same section of the fire as the ground crew?
   Yes (____) No (____)

3. What was the air tanker trying to do?
   Hold small fire (¼ acre or under) (____)
   Cool hot spots (____) Hold jump fires (____)
   Take holding action along section of fire edge (____)

4. Length of the fire edge tanker is attempting to control ________ ft.

5. Drop Height above canopy - Low (under 50') (____) Med. (50-100') (____)
   High (over 100') (____)

6. Drops were: Where you wanted them (____)
   Usually where you wanted them (____)
   Not where you wanted them (____)
   Explain (if necessary) ______________________________

7. Penetration through crowns to fire: Good (____) Fair (____)
   Poor (____)
   Explain ______________________________

8. Was tanker action effective (____) Partly effective (____) Ineffective (____)
   Why?/(Fire behaviour, topography, etc.) ______________________________

   No. of drops observed ________ Time of first drop ________
   Round trip time ________ Time of last drop ________

   Reason for stopping ______________________________
   (Achieved control, other actions, etc.)

9. Was it considered dangerous for men to work in the drop zone
   Yes (____) No (____)
   If "Yes" why ______________________________

NOTE: If any portion of the data requested below is identical with that already placed on forms completed for a previous action, please identify the action (e.g. see drops made at 10:30) and leave appropriate sections below blank.

D. WEATHER (at fire or pick-up point of water or chemical)
   Did weather conditions exist or develop which made dropping either difficult or impossible? (turbulence, wind speed or direction etc.)
   Yes (____) No (____)
   If "Yes" describe ______________________________

E. TOPOGRAPHY
   Did topographic features (position of fire on slope, steep or mountainous terrain etc.) make dropping either difficult or impossible?
   (Yes (____) No (____)
   If "Yes" explain ______________________________

F. FUELS (for area or air attack only)
   Coniferous (pine, spruce, etc. .... (____)
   Mixedwoods (conifers & Hardwoods .... (____)
   Hardwoods .... (____)
   Slash .... (____)
   Blowdown .... (____)
   Brush .... (____)
   Grass .... (____)

G. SERVICE
   Retardant used: Water (____) Chemical(s) (specify) ______________ (____)
   Pick up point of water (or chemical)

   ______________________ Distance from fire ________ mi.

H. GENERAL REMARKS
   (Comments on accuracy of drops, elapsed times, damage to tree cover, etc.)

AIR TANKER EVALUATION FORM — APPENDIX 4-c

Aircraft

A. GENERAL Target Number ____________ Date ____________ 19__

Fire Name ____________

Fire Number ____________ Aircraft (type & number) ____________

District (or Region) ____________ Map Location ____________

B. FIRE BEHAVIOUR (for area of air attack only - worst conditions found)

		Fire Character (Check appropriate sections)			
		Slow Surface	Fast Surface	Crown Running	Crown Flare-up (Torching)
Before Action					
After Action					

C. ATTACK

1. Size of fire at attack ____________ acres.
2. Target: Head (__) Flank (__) Rear (__) Small fire (under ¼ acre) (__)
3. Method of attack: Direct (__) Indirect (__)
4. Has ground control started: Yes (__) No (__)
   If "Yes" is/are the air tanker(s) working on the same section of the fire as the ground crew? Yes (__) No (__)
5. What was the air tanker trying to do: Hold small fire (under ¼ acre) (__)
   Cool hot spots (__) Hold jump (spot) fire (__)
   Establish guard along section of fire edge (__)
   Other (specify) ____________________________ (__)
6. Length of fire edge air tanker is attempting to control ____________ ft.
7. Drop height above canopy:
   Low (under 50 ft.) (__) Medium (50-100 ft.) (__) High (over 100 ft.) (__)
8. Direction of attack: Into wind (__) Downwind (__) Crosswind (__)
9. Effectiveness: How many drops were made before the fire was held or action stopped on section of fire edge being attacked? ________ Drops.
   Time of first drop (Hr:Min) ________ Round trip time ________ Min.
   Time of last drop (Hr: Min) ________
   Reason for stopping ____________________________
   (Achieved control, other actions, weather, etc.)

D. WEATHER (at fire or pick-up point of water or retardent)

Did weather conditions which made dropping either difficult or impossible exist or develop? (turbulence, wind speed or direction, etc.) Yes (__) No (__)

If "Yes" describe: ____________________________

E. SERVICE

Air tanker requested at ________ Hr:Min. Departed ________ Hr: Min.

Arrived ________ Hr:Min. Reason for delay (if any) ____________

Location of air tanker at time of request ____________

Distance from fire ____________

Refueling: Location ____________ Distance from fire ____________

Retardant used: Water (__) Chemical (specify) ____________ (__)

Pickup point of water (or chemical) ____________

Distance from fire ____________

F. GENERAL REMARKS

(Comments on accuracy of drops, elapsed times, damage to tree cover, mechanical difficulties, communications, etc.)

____

____

BC(1965)

D. TOPOGRAPHY (in area of air attack)
1. Slope: Gentle (____) Moderate (____) Steep (____)
2. Exposure: (level or N, NE, etc.) ________________

E. FUELS (for area of air attack)

1. Type:
- Coniferous (spruce, pines, etc.) .... (____)
- Mixedwoods (conifers & hardwoods).................. (____)
- Hardwoods .... (____)
- Slash (date of cutting 19 ...) .... (____)
- Burn (date of cutting 19 ...) .... (____)
- Blowdown (date 19 ...) .... (____)
- Insect kill (date 19 ...) .... (____)
- Brush .... (____)
- Grass .... (____)
- Other (specify) .... (____)

2. Characteristics: Where applicable - cruiser's approximations

a. Species present in the stand: (fuel type - Sb, B, Pj, etc.) in order of importance:

____

b. Height of tallest tree: ________ ft.
c. Diameter (dbh) of tallest tree ________ in.
d. Stand is: Open (____) Medium (____) Dense (____)
e. Reproduction of tree species under main stand.
Yes (____) No (____)
If yes: Species: ________
Average height: ________ ft.
Distribution:
Scattered (____) Dense (____) Clumps (____)

f. Ground fuels: (Check appropriate sections)
Needles or leaves ________ (____)
Grass ________ (____) dry (____) green (____)
Ferns ________ (____) dry (____) green (____)
Other (describe) ________ (____)
Small twigs and sticks ________ (____)
Large logs (4" or larger ________ (____)
Distribution: Common (____)
Scattered (____)
Piled (____)

F. GENERAL
1. Was the tanker action significant in the control of the fire?
(Yes (____) No (____)

Explain ____________________

2. Other comments (elapsed times, special problems, effectiveness of retardants, etc.) ____________________

AIR TANKER EVALUATION FORM
Aircraft

A. GENERAL
Fire Number ________ Date ________ 19 ____

District ________ Aircraft (Type) ________

B. FIRE BEHAVIOUR - For area of air attack only - worst conditions found.

	Fire Character (at scene of attack) Check appropriate sections				
	Smoldering	Slow Surface	Fast Surface	Crowning Running	Crowning Flare-up
Before Action					
After Action					

C. ATTACK

1. Target: Head (___) Flank (___) Rear (___) Small Fire (under ¼ acre) (___)

2. Method of attack: Direct (___) Indirect (___)

3. Has ground control started: Yes (___) No (___)
If "Yes" is/are the air tanker(s) working on the same section of the fire as the ground crew? Yes (___) No (___)

4. What was the air tanker trying to do:
Hold small fire (¼ acre or under) (___) C 1 hot spots (___)
Take holding action along section of fire-edge (___) Hold jump fire (___)

5. Length of fire edge tanker is attempting to control _____ ft.

6. Drop height above canopy; Low (under 50') (___) Med. (50-100') (___)
High (over 100') (___)

7. Direction of attack: Into wind (___) Downwind (___) Crosswind (___)

8. Effectiveness: How many drops were made before the fire was held or action stopped on section of fire edge being attacked? _____ Drops

Time of first drop ____ Hr/min. Round Trip Time ____ Min.

Reason for stopping ________________
(Achieved control, other actions, etc.)

____

9. Did aircraft return later to drop again on same section of fire?
Yes (___) No (___) If "Yes" number of drops ____ Time of 1st drop ____

Reason for stopping ________________

Round trip time (if different from above) ________________

NOTE: If when tanker returns, weather, fuel or other conditions have changed please indicate on appropriate sections of another form and attach.

AIR TANKER EVALUATION FORM
Ground

A. GENERAL

Fire Name ____________ Date ____________ 19___
Fire Number ____________ Aircraft (type & number ____________
District (or Region) ____________ Map Location ____________

B. FIRE BEHAVIOUR (for area of air attack only - worst conditions found)

Fire Character (Check appropriate sections)					
	Smoldering	Slow Surface	Fast Surface	Crown: Running	Crown: Flare-up (Torching)
Before Action					
After Action					

C. ATTACK

1. Size of fire at attack ____________ acres.
2. Target: Head (__) Flank (__) Rear (__) Small fire (under ¼ acre) (__)
3. Method of attack: Direct (__) Indirect (__)
4. Has ground control started? Yes (__) No (__)
   If "Yes" is/are the air tanker(s) working on the same section of the fire as the ground crew? Yes (__) No (__)
5. What was the air tanker trying to do?
   Hold small fire (under ¼ acre) (__)
   Cool hot spots (__) Hold jump (spot) fire (__)
   Establish guard along section of fire edge (__)
   Other (specify) ____________ (__)
6. Length of fire edge air tanker is attempting to control ____________ ft.
7. Drop height above canopy. Low (under 50 ft. (__)
   Medium (50 to 100 ft) (__) High (over 100 ft) (__)
8. Drops were: Where they were wanted (__) Usually where they were wanted (__)
   Not where they were wanted (__) Explain (if necessary) ____________
9. Penetration through the crowns: Good (__) Fair (__) Poor (__)
   Explain (if necessary) ____________
10. Was tanker action: Effective (__) Partly effective (__) Ineffective (__)
    Explain (if necessary) ____________
    Number of drops observed ____________ Time of first drop (Hr: Min) ____________
    Time of last drop (Hr: Min) ____________
    Round trip time ____________ Min.
    Reason dropping stopped or observation ceased ____________
    (Achieved control, weather, etc.)
11. Did the drops damage the tree cover in any way? Yes (__) No (__)
    Explain (if necessary) ____________
12. Was it considered dangerous for men to work in the drop zone? Yes (__) No (__)
    Explain ____________

D. GENERAL

1. Was the air tanker action significant in the control of the fire?
   Yes (__) No (__) Explain ____________
2. Other comments (elapsed times, communications, etc.) ____________

BC (1965)

AIRTANKER EVALUATION

APPENDIX 4-f

Air Observer

Date of action__________________ 19___ Fire__________________

District__________________ Aircraft type__________________

Location at time of request__________________ Distance to fire______ mi.

Time requested______ hrs. Departed______ hrs. Reason for delay, if any

____

Fire Behaviour - for area of air attack only, worst conditions found

	Smoldering	Slow Surface	Fast Surface	Crowning Running	Crowning Flare-up
Before Action					
After Action					

Size of fire at attack__________ ac. Attacked Head(___) Flank(___) Rear(___)

Airtanker is trying to: Hold a small fire(___) Cool hot spots(___) Hold jump fires(___) Hold fire edge section(___) Other__________________

Ground control started Yes(___) Is airtanker working on the same section of the fire as the crew Yes(___) No(___) Ground control started No(___)

Any danger to men Yes(___) No(___) Line length a/c trying to control________ ft

Time of 1st drop______ hrs. Number of drops______ Round trip time______ min.

Distance, lake to fire______ mi. Retardant used Yes(___) No(___) Reason for stopping__________________

weather, achieved control, to other action etc.

Was action effective(___) Partly effective (___) Ineffective(___) Reasons______

____

Distance to refuel______ mi.

Did a/c return No(___) Yes(___) Number of drops______ Next day(___)

Weather - at fire or at loading point

Wind speed______ mph. Air temp.______ F Weather effect on operations: High gusty winds(___) Smoke & general visibility(___) Water pickup difficulties (___)

Other__________________

Remarks & comments: Good effect, no difficulties(___) Held fire under difficult conditions(___) Poor results, lack of follow-up either by a/c(___) or by ground crews(___) Other__________________

____

Fuels - Standing coniferous(___) Coniferous slash(___) Standing timber(___)

Non standing timber(___) Minor vegetation(___)

Manitoba 1969 (aircraft)

____
observer

AIRTANKER EVALUATION

Ground Observer

Date of Action________________19____ Fire______________________

District______________________Aircraft Type____________________

FIRE BEHAVIOUR, for area of air attack only: worst conditions found.

	Smoldering	Slow Surface	Fast Surface	Crowning Running	Flare-up
Before Action					
After Action					

1. Has ground control started? Yes(___) No(___)
   If "Yes" is/are the airtanker(s) working on the same section of the fire as the ground crew? Yes(___) No(___)

2. What was the airtanker trying to do?
   Hold small fire (1/4 acre or less) (___)
   Cool hot spots(___) Hold jump fires(___)
   Take holding action along section of fire edge(___)
   Other______________________________

3. Length of fire edge airtanker is attempting to control(__________) feet

4. Drops were: (___) Where you wanted them
   (___) Usually where you wanted them
   (___) Not where you wanted them
   Explain(if necessary)______________________

5. Drop height above canopy: Low(___) Med(50-100'(___) High 100'+(___)

6. Was airtanker action effective(___) Partly effective(___)
   Ineffective(___) Reasons______________________

7. Number of drops observed________ Time of first drop________hrs
   Time between drops__________min. Time of last drop ________hrs
   Reason for stopping______________________
   ____
   achieved control, to other action etc.

8. Was it considered dangerous for men to work in the drop zone
   Yes(___) No(___) If "Yes" -Why______________________

Manitoba 1969 (Ground)

9. Wind Calm(___) 5 mph or less(___) 10 mph(___) 20 mph(___)
   greater than 20 mph(___) Rising(___) Falling(___) Variable(___)

10. Slope: Level(___) Gentle(___) Moderate(___) Steep(___)

11. Fuels (for area of air attack)
    (___) Standing Coniferous
    (___) Coniferous slash
    (___) Standing timber
    (___) Non standing timber
    (___) Minor vegetation

12. Remarks and comments______________________

____
Observer

NOTE: All entries will describe conditions at the scene of the airtanker action.

AIRTANKER EVALUATION FORM

Airtanker Report

A. GENERAL

Fire Name ____________ Date ____________
District ____________ Aircraft (Type) ____________
Fire Number ____________ Evaluator ____________
Photographs taken No (___) Yes (___) Identifying Numbers ____________

B. WEATHER

Wind Speed ____________ mph Wind Direction ____________
Turbulence Nil (___) Light (___) Moderate (___) Severe (___)
Visibility ____________ Miles ____________ If less than 5 miles state reason ______

C. TOPOGRAPHY

Terrain: Flat (___) Rolling (___) Mountainous (___)
Elevation ____________ Ft. (ASL) Exposure (flat or N, NE, etc.) ____________

D. FUELS

Coniferous (spruce, pine, etc.) (___)
Hardwood (___)
Mixed woods (conifers & hardwoods) (___)
Slash (___)
Old burn (___)
Brush (___)
Grass (___)

E. FIRE BEHAVIOUR (Air Observer Only)

	Rate of Spread (Ft/Min)	Flame Height (Ft)	Character (Check)					
			Smoldering	Slow Surface	Fast Surface	Crowning		Spotting
						Running	Flare-up	
Before Action								
After Action								

F. ATTACK

Size of Fire: At Attack ________ (Ac.) Final ________ (Ac.)
Phase: Initial Attack (___) Support Action (___)
Target: Head (___) Flank (___) Rear (___) Spot (___)
Direction of Attack: Into wind (___) Downwind (___) Crosswind (___)
Method of Attack: Direct (___) Indirect (___)
Tactical Objective:
Holding Spot Fire (less than ¼ Ac.) (___) Cooling Hot Spot (___) Delaying Advance of fire (___)
Is Tanker Working: Directly with Ground Crews (___)
Independent of Ground Crews (___)
Rate of Fire Spread: Fast (___) Moderate (___) Slow (___)

F. ATTACK (cont'd)

Length of Fire Front being Attacked (if under ¼ acre - write spot__________
Retardant Used: Water (___) Chemicals(s) (Specify)________________(___)
Pick-up Point of Water (or Chemical)_______Distance from Fire__________Miles
Effectiveness: How many drops were made before fire was controlled or action stopped on section of fire front being attacked____________
Time of First Drop (Hr:Min)_________Time of Last Drop (Hr:Min)____________
Total Drop Time___________ Frequency of Drops (Average)___________/Hr.
Reason for Stopping____
(Achieved Control, Other Actions, etc.)
If more than one drop was required please indicate why (Circle appropriate numbers)

Burned Through	1	Difficult Target	6	Mechanical Trouble (Aircraft)	11
Spotted Across	2	Turbulence	7	Height or Speed of Aircraft	12
Flanked	3	Poor Visibility	8	Too Long Between Drops	13
Pilot Error	4	Obstructions	9	Inadequate Ground Crew Follow-up	14
Fire Intensity	5	Poor Communications	10	Other (Specify)	15

Was airtanker follow-up action necessary: Yes (___) No (___)
If yes, please complete appropriate sections on new copy of form and attach.

G. REMARKS

(Comments on accuracy of drops, special problems, elapsed times, etc.)

____

____

____

____

____

NOTE: All entries will describe conditions at the scene of the airtanker action.

AIRTANKER EVALUATION FORM

Ground Report Form

A. GENERAL

Fire Name ______________ Fire Number ________ Date ________
District ______________ Evaluator ________ Title ________
Photographs taken No (___) Yes(___) Identifying Numbers ________

B. WEATHER

Station ______________ Time of Observation ________
(Take at fire if possible) Distance from fire ________ miles
Temperature: Dry Bulb _____ Wet Bulb _____ Relative Humidity ________
Wind Speed ________ mph Direction: ________ Gusty: Yes (___) No(___)
Max. ______ mph
Danger Index ________ Hazard Index ________ Drought Index ________
(If applicable)

C. TOPOGRAPHY (at drop scene)

Elevation (ASL) ________ Ft. Slope ________ % Exposure (Flat or N,NE, etc) ________

D. FUELS (at drop scene) -- Check one

1. Type: Mature or Overmature (___) Slash (date of cutting 19__) (___)
Immature (___) Burn (date of burn 19__) (___)
Reproduction (___) Brush (___)
Grass (___)
Blowdown (date 19__) Insect Kill (date 19__) (___)

2. Characteristics. (where applicable)
Species present in stand (fuel type S_b, B, P_j, etc.)
(in order of importance) ________________
Height (of tallest tree) ________ Ft.
Diameter (dbh) (of largest tree) ________
Stand is: Open (___) Medium (___) Dense (___)
Reproduction under main stand:
Yes (___) No (___)
If yes: Species ________
Average Height ________
Distribution: Scattered (___)
Dense (___)
Clumpy (___)

Ground Material
Needles or Leaves (___) Moss (___) Grass: Green (___) Dry (___)
Low Brush: Height ________ Ft.
Large Logs (4" +) Yes (___) No (___)
If yes: Diameter of logs ______ In.
Distribution: Scattered (___)
Clumpy (___)

E. FIRE BEHAVIOUR

	Rate of Spread (Ft/Min)	Flame Height (Ft)	Character (Check)					
			Smoldering	Slow Surface	Fast Surface	Crowning		Spotting
						Running	Flare-up	
Before Action								
After Action								

F. ATTACK

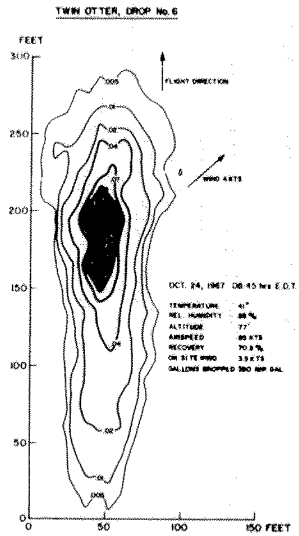
1. Time of Fire Discovery (Month, Day, Hour)____________
2. Time of Arrival of Ground Crew (Month, Day, Hour)____________
3. Aircraft: Type____________ Number____________
4. Phase: Initial Attack (___) Support Action (___)
5. Target: Head (___) Flank (___) Rear (___) Spot (___)
6. Method of Attack: Direct (___) Indirect (___)
7. Tactical Objective:
   Holding Spot Fire (___) Cooling Hot Spot (___) Delaying Advance of Fire (___)
8. Is the Tanker(s) Working Directly with the Ground Crew (___)
   Independent of the Ground Crew (___)
9. Length of fire front being attacked____________
10. Accuracy: Good (___) Fair (___) Poor (___)
    If not Good, apparent reason (Undershot, Overshot, etc.)
11. Retardant Used: Water (___) Chemical (Specify)____________
12. Swath: Parallel to Front (___) At angle (___) On Spot (___)
13. Penetration through crowns to fire Good (___) Fair (___) Poor (___)
14. Effectiveness:
    How many drops were made before the fire was controlled or action stopped on section of fire front being attacked____________
    Time of First Drop (Hr:Min)_____ Time of Last Drop (Hr:Min)____________
    Total Drop Time____________ Frequency of Drops (average)____________
    Reason for stopping____________
    (Achieved control, other actions, etc.)
    If more than one drop required, please indicate why: (circle appropriate numbers)

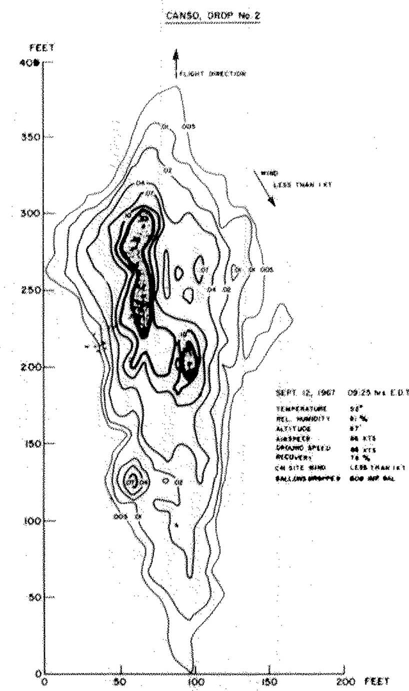
Burned Through	1	Difficult Targer	6	Mechanical Trouble (aircraft)	11
Spotted Across	2	Turbulence or Wind	7	Height or speed of aircraft	12
Flanked	3	Poor Visibility	8	Too long between drops	13
Pilot Mistake	4	Obstructions	9	Inadequate ground crew followup	14
Fire Intensity	5	Poor Communications	10	Other (specify)______	15

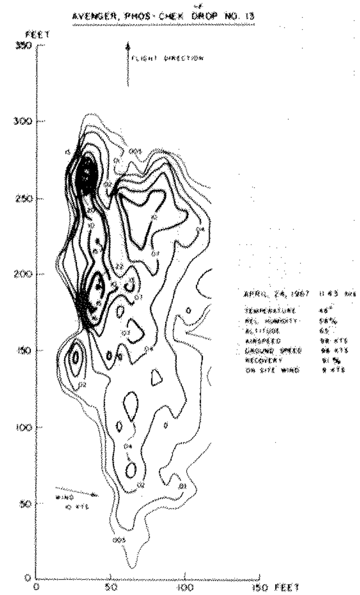
15. Was Airtanker Follow-up Action Necessary: Yes (___) No (___)
    If yes, please complete appropriate sections on new copy of form and attach.

G. REMARKS

(Comments on accuracy of drops, special problems, elapsed times, etc.)







Airtanker Drop Patterns

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