U. S. FOREST SERVICE
RESEARCH NOTE PSW-155

PACIFIC SOUTHWEST
FOREST & RANGE EXPERIMENT STATION
1967
P.O. Box 245 Berkeley, California 94701

Air Tankers in Southern California Fires . . .

effectiveness in delivering retardants rated

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ABSTRACT: Eleven air attack experts were asked to rate 12 models of fixed-wing tankers and light helitankers for effectiveness in delivering chemical fire retardants under 21 typical situations. They rated fixed-wing tankers as more effective in strong wind crosswinds, and downwind approaches, but helitankers as more effective in narrow canyons and on steep slopes. Certain models were considered better performing than others in specific situations. The study provides the dispatcher with some guidelines on the type and model of aircraft to send out in given situations.

OXFORD: 432.3

RETRIEVAL TERMS: air tankers; fixed-wing tankers; helitankers; helicopters; effectiveness ratings; fire suppression; fire retardants; fire control; Southern California.

Dropping fire retardants by aircraft to aid in control of forest fires is standard practice in much of the United States. The technique is gaining wider use each year. Fixed-wing air tankers are most commonly used but rotary-wing tankers, or helitankers, are emerging as an important fire control tool. Each type of air tanker has its own performance characteristics, tank capacity, retardant pattern, turnaround time--and ultimate effect on stopping the fire. All models are expensive to operate and maintain. The dispatcher faces a real problem in deciding which type and model of air tanker is best and most economical in a given situation.

To provide the dispatcher with some guidelines, we asked 11 air attack experts with the National Forest and helicopter industry to rate the relative effectiveness of 12 models of air tankers for delivering fire retardants under 21 conditions in southern California. The opinion survey did not rate the relative effectiveness of air tankers in actually stopping a fire. Nor did it determine their productivity in quantitative terms, such as length of line built per hour per aircraft. Instead, it rated only the relative ability of the air tanker to deliver its load of retardant over the fire in the most advantageous position for changing the fire environment.

Most of the experts we interviewed considered fixed-wing tankers more effective than helitankers in strong winds, crosswinds, and on downwind approaches to target. Helitankers were rated more effective in narrow canyons and on steep slopes. Certain models of air tankers of both types appear to perform better than others in specific situations. But no single model was rated most effective in all situations.

GENERAL GUIDELINES

General guidelines for air tanker use are found in U.S. Forest Service Manuals and Handbooks (1965a; 1965b). They deal mainly with safe operating procedures, hazardous situations, and targets to be avoided, and economical use. Most of the Regional Fireline Notebooks of the Forest Service (1963) list typical targets and recommended aircraft for each. However, these lists are rather general and do not consider all pertinent factors. Many are outdated. And none lists more than one of the several models of helitankers now in use.

Current targeting guidelines are based largely on the observed performance of the various models of air tankers in a variety of actual fire

situations rather than on results of controlled tests (Miller and Reinecker 1957; Noyes 1965; Phillips 1964; Reinecker and Phillips 1959).[1] Rating terms include "effective," "ineffective," and "not needed." Each situation is different so replication is not possible.

AIR TANKER OPERATIONS

To date, air tankers have been used primarily in two ways: (a) in initial attack to hold the fire until the arrival of ground forces, and (b) in "spot" situations later in the fire to supplement other forces. The effect of air attack is difficult to isolate and predict for several reasons. Air tankers are seldom used as the primary means for building a fireline. And their effect is to make the fuel less flammable rather than to remove it as do handcrews, bulldozers, and most other forces. Furthermore, there are many inaccuracies inherent in aerial delivery.

Perhaps the best and most definitive method for determining air tanker productivity would be to conduct controlled and replicated drop tests on fires under actual field conditions. A limited amount of work of this type has been done in the East by Storey et al. (1959) and in the West by Davis et al. (1962). However, this type of experiment is very expensive. There also remains the problem of rating the combined and separate effects of air attack, handcrews, and ground equipment because air attack is seldom used alone.

For some time to come it would seem that we must rely largely on expert opinion for estimating air attack effectiveness. Maloney and Greulich[2] are now using the opinion survey technique to study the number and placement of air tankers needed to help protect State-owned lands in California from fires.

PROCEDURE

In the absence of quantitative data on air tanker effectiveness and because of the small likelihood of obtaining any in the near future, we decided to use an opinion survey technique to rate air tanker effectiveness.

We concluded that the five most important environmental factors influencing air tanker effectiveness were as follows (each factor consists of from three to six rating categories):

Environmental Factor	Rating Categories
Terrain	Flat (drop along ridge or with contour) Rolling Mountainside (wide canyon) Rocks and gullies Narrow canyon (upper) Narrow canyon (lower)
Slope	0 - 15 percent 16 - 39 percent 40 - 99 percent 100 percent
Fuel type	Grassland Woodland-grass Woodland Brush Timber
Wind direction*	Head Cross Downwind
Wind speed	1 - 10 m.p.h. 11 - 25 m.p.h. 26 - 35 m.p.h.

*With respect to direction of approach of aircraft.

[1] U.S. Forest Service. Air tanker retardant drop evaluation study. 1964. (Unpublished report on file in Div. Fire Control, U.S. Forest Service, Washington, D.C.)

[2] Maloney, J.E., and Greulich, F.E. A mathematical model of the aerial tanker fire retardant delivery system of the California Division of Forestry. Fire Econ. Working Paper No.11. 1966. (Unpublished report on file, School of Forestry, Univ. Calif., Berkeley).

The following rating scale was chosen:

Numerical Rating	Adjectival
1	Very poor
2	Poor
3	Fair
4	Good
5	Excellent

The seven models of fixed-wing tankers and the five models of helitankers included in the survey were as follows:[3]

Fixed-wing tankers	Helitankers
North American AJ-2	Alouette II
Grumman AF	Bell G3B
Boeing B-17	Bell G3B-1
Grumman F7F	Hiller 12E
North American F15	Hiller 12E4
Consolidated PBY	
Grumman TBM	

Eleven persons experienced in aerial fire control in southern California were asked to complete rating forms. The nine different positions on four National Forests and one private helicopter company that they represented were as follows:

	Number
National Forests:	
Forest Fire Control Officer	1
District Ranger	1
District Fire Control Officer	3
District Assistant Fire Control Officer	1
Helitack Foreman	1
Helitack Squad Leader	1
Zone Air Unit Pilot	1
Private industry:	
Chief Pilot	1
Pilot	1

We contacted each person individually and asked him to rate only those types and models of air tankers he was familiar with. He was to consider the individual performance of each air tanker for each environmental category. He was not specifically requested to rate fixed-wing tankers against helitankers.

All 11 of those contacted replied. Each person rated between 2 and 11 of the 12 different air tanker models included in the study. One person who selected five models failed to rate two of them for all environmental factors. Because not all respondents rated all models of air tankers or the same models, a simple arithmetical averaging of the data seemed the most feasible way to determine a consensus.

RESULTS AND DISCUSSION

The findings[4] in this survey essentially confirmed the views already held about the relative effectiveness of helicopters and fixed-wing aircraft. Such opinions have been developed through practical experience gained by dispatchers in southern California forests. Forest managers and dispatchers can use the ratings in the survey with data on retardant tank capacities, trip turnaround time, and rental costs to predict relative effectiveness of an aircraft in helping suppress a fire.

COMPARISONS BETWEEN TYPES

Fixed-wing tankers as a group were considered more effective than helitankers in operating in various wind speeds and wind directions. They were also rated higher in effectiveness than helitankers in flying over targets on low slopes and easier terrain. However, helitankers excelled on the steeper slopes and rougher terrain. They are, in fact, more effective in canyons, rough terrain, and on steep slopes. Helicopters can get down into canyons, close to slopes, and drop at very slow speeds. But

[3] Commercial enterprises or products are mentioned solely for information. No endorsement by the U.S. Department of Agriculture is implied.

[4] Tables detailing results of the survey, as they apply to conditions in southern California, are available on request to the Director, Pacific Southwest Forest and Range Experiment Station, P.O. Box 245, Berkeley California 94701.

wind can limit helitanker operations--even more than those of fixed-wing tankers.

In general, fixed-wing tankers were rated more effective than helitankers in the lighter fuel types, grassland, woodland-grass, and woodland. Helitankers were rated higher in the two heaviest timber fuel types--mainly because they can get in close at low speed and pinpoint their target.

COMPARISONS AMONG MODELS

The crux of the study was how one model aircraft was rated against another in effectiveness in getting into position over the target. To make such comparisons easier, it was convenient to compare aircraft performance at the extremes of severity of the environment.

The most severe situation for fixed-wing models in this survey was a timbered target on a slope exceeding 100 percent near the bottom of a narrow canyon with a 26 to 35 m.p.h. wind blowing and a downwind approach. In this situation the AF model tanker was rated highest on three of the five categories. The PBY tanker was rated least effective.

Among helitankers in the same set of circumstances, except substituting mountainside terrain, the Bell G3B-1 model was rated highest; the Hiller 12E, the lowest.

The least severe situation for fixed-wing tankers in the survey was a grass fuel target on flat terrain with a 0 to 10 m.p.h. wind blowing and an upwind approach. In this situation, the AJ-2 model tanker was rated highest; the F7F, lowest. Among helitankers in the same set of circumstances, except substituting narrow canyon lower terrain, the Aloutte was rated highest; the Bell G3B, the lowest.

LITERATURE CITED

Davis,J.B.,Dibble,D.L., and Singer,K.L.
1962. *Tests of fire retardant chemicals at Plum Creek.* Calif. Div. Forestry, 26 pp., illus.

Miller,H.R., and Reinecker, H.P.
1957. *Air tanker report--California 1957.* Fire Control Notes 19(2):53-56, illus.

Noyes, F.H.
1965. *An evaluation of air tanker operations in north coastal California during 1964.* Calif. Div. Forestry, Fire Control Exp. 11, 18 pp.

Phillips, C.B.
1964. *Fighting forest fires with air tankers, 1963.* Calif. Div. Forestry, Fire Control Exp. 7, 33 pp., illus.

Reinecker, H.P., and Phillips, C.B.
1959. *Fighting forest fires with air tankers, 1958-59.* Calif. Div. Forestry, 149 pp., illus.

Storey,T.G., Wendel,G.W., and Altobellis,A.T.
1959. *Testing the TBM aerial tanker in the southeast.* U.S. Forest Serv. Southeastern Forest Exp. Sta., Station Paper 101, 25 pp., illus.

U.S. Forest Service.
1963. *Fireline notebook.* U.S. Forest Serv., FSH2, 5135.7, Region 5, 121 pp., illus.

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1965a. *Helitack guide.* U.S.Forest Serv.,Region 5,155 pp., illus.

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1965b. *Use of air tankers.* U.S.Forest Serv., Region 5, Supplement 16, FSM 5122.25, 4 pp.

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