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RESEARCH REPORT NO. 10
Probability of Effective Post-Attack
Fire Fighting in Wildlands

11p -

by

Craig C. Chandler and Mark J. Schroeder

March, 1965

Support Systems Division
Research
Office of Civil Defense

PREFACE

This report is an example of an operations-type application of the results of two OCD Research sponsored studies.

It demonstrates the possibility of generating planning- and operationally-oriented data through rearrangement of research data to meet the specific needs of an operational study. Also this report provides a usable data input to the Five City Study.

John F. Christian
Research Analyst

PROBABILITY OF EFFECTIVE POST-ATTACK FIRE FIGHTING IN WILDLANDS

by

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In the event of nuclear attack, thermal radiation from nuclear weapons may start fires over large areas of the United States. The potential of such fires to cause material damage and loss of life in cities is obvious. In rural and wildland areas they will destroy crops and other natural resources. They may disrupt communication, power transmission, and transportation networks, and produce sufficient smoke to eliminate visual navigation or reconnaissance capability by aircraft. This paper presents an assessment of the wildland fire threat and suggests the probable effectiveness of conventional fire fighting forces in materially reducing the damage from post-attack fires in wildlands.

The behavior of outdoor fires is primarily determined by weather conditions and by the type and amount of flammable fuel. A previous pair of studies conducted by the Forest Service for the Office of Civil Defense determined the weather conditions necessary for the initiation and spread of wildland fires,[1] and the frequency of these "burning indexes" by months for selected locations throughout the United States.[2] The data which follow have been obtained directly from these two studies.

Under certain conditions wildland fuels will not sustain ignition from the radiant fluxes associated with nuclear explosions. Under slightly different conditions, ignition will occur, but the resulting fires will not spread and will go out by themselves unless the weather becomes more favorable for combustion. And if fire weather is critical, the initial fires will spread so rapidly as to overwhelm conventional fire defenses. But within these limits there is a broad spectrum of weather and fuel situations where organized fire control efforts can be expected to result in a significant reduction in post-attack fire damage to both natural and man-made resources. Table I presents the probability that each of these burning conditions will be found on any given day in any section of the United States where there are sufficient natural fuels to permit fire spread. Fuel classification maps are not available for many sections of the United States. In some sections, particularly the Southwest, the

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1/ Chandler, C.C., T.G. Storey, and C.D. Tangren. Prediction of Fire Spread Following Nuclear Explosions, U.S. Forest Service Research Paper PSW-5, 1963.

2/ Schroeder, M.J. and others. Synoptic Weather Types Associated With Critical Fire Weather. Pacific Southwest Forest Range Experiment Station. Unnumbered Report. 1964.

weather is conducive to fire spread but fuels are scanty. Table I values represent the effects of weather alone, and hence are conservative in their estimate of "safe" conditions. The classes in Table I are defined as follows:

Fire Out (FO):	Sustained ignition in natural fuels will not occur.
No Spread (NS):	Sustained ignition will occur, but the resulting fires will not spread beyond the radius of initial ignition and will go out by themselves unless the weather becomes more favorable for combustion.
Actionable (Act.):	Fires will start and spread but their intensity and rate of spread will be such that successful control efforts are possible.
Critical (C):	Fire spread and intensity will be such that successful control efforts are unlikely.

The criteria for the non-ignition and "no spread" values were determined in reference (1). The criteria for "critical" fire weather were determined from the opinions of experienced fire weather specialists and represent the conditions under which existing wildland fire control organizations experience difficulty in controlling normal peacetime fires. Unlike the "Fire Out" and "No Spread" categories, which were determined objectively, the distinction between "actionable" and "critical" is based on judgment. A massive coordinated firefighting operation may be successful in saving a particular strategically important structure or installation under even the most adverse weather conditions. But we feel it unlikely that a significant, overall reduction in post-attack fire damage can be achieved under conditions where peacetime fires are touch-and-go.

The probabilities in this and the following tables were obtained from the probabilities at individual stations, and there are, of course, differences between stations even within a region. These variations are not presented in this short paper but can be obtained from the original data.

Some fires occurring under "no spread" conditions will also need fire control action, for they will persist to spread and do damage if the weather following the nuclear attack changes for the worse. Table II presents the probability that firefighting efforts will be both necessary and effective on fires resulting from a nuclear explosion.

Lastly, Table III presents, for the United States as a whole the probabilities that organized wildland fire control efforts will be either unnecessary, effective, or futile.

These tables can be used in several ways for defense planning. They apply directly to the effects of a single weapon. For example, if a nuclear weapon were to be exploded near Portland, Oregon, in August, there is a 30% probability that the adjacent forests would not be ignited at all, a 45% chance that fires would start and immediately spread, but only 2 chances in 100 that fires would be violent enough to defy organized firefighting efforts.

Because weather patterns will vary within a region at any given time the tables may also be used (less reliably) to predict the effects of multiple strikes and to determine the probable need f [illegible] e control forces. For example, only one third of the strikes in [illegible] Northeastern United States in September can be expected to result in wildland fires requiring organized fire control action.

Looking at the problem from the opposite viewpoint the probability of being able to minimize fire damage may be obtained. By summing the probabilities for "Fire Out", "No Spread", and "Actionable" categories in Table I, this information may be obtained by regions. And for the continental United States it may be obtained from Table III by adding the probabilities for categories A and B. For example, in August, the probability of being able to minimize fire damage in the continental United States is .27 plus .59 or .86.

TABLE I

PROBABLE FIRE BEHAVIOR

Fire Out (Fire won't start)
No Spread (Fire will start but won't spread and will go out if weather stays same)
Actionable (Fire needs action and is controllable)
Critical (Fire uncontrollable until weather changes)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Average
						Northeast Region 1/							
FO	.85	.82	.66	.48	.37	.37	.32	.38	.40	.45	.68	.78	.55
NS	.14	.15	.25	.23	.24	.28	.31	.32	.36	.34	.24	.21	.25
Act	.01	.03	.09	.29	.38	.35	.36	.30	.24	.21	.08	.01	.20
C	.00	.00	.00	.00	.01	.00	.01	.00	.00	.00	.00	.00	.00
						Southeast Region							
FO	.53	.44	.35	.26	.24	.25	.34	.28	.29	.37	.43	.52	.36
NS	.33	.34	.32	.28	.31	.34	.30	.39	.38	.29	.31	.35	.33
Act	.14	.22	.33	.45	.44	.40	.36	.33	.33	.34	.26	.13	.31
C	.00	.00	.00	.01	.01	.01	.00	.00	.00	.00	.00	.00	.00
						Lake States Region							
FO	.95	.91	.74	.46	.32	.29	.27	.32	.34	.45	.77	.92	.56
NS	.05	.09	.22	.24	.26	.34	.36	.36	.33	.28	.16	.08	.23
Act	.00	.00	.04	.29	.40	.36	.37	.31	.32	.26	.07	.00	.20
C	.00	.00	.00	.01	.02	.01	.00	.01	.01	.01	.00	.00	.01
						Ohio & Middle Mississippi Valley Region							
FO	.73	.59	.47	.32	.26	.25	.23	.24	.21	.29	.53	.73	.40
NS	.20	.27	.29	.28	.35	.33	.36	.30	.24	.29	.21	.17	.27
Act	.07	.14	.24	.39	.40	.41	.40	.45	.54	.40	.25	.10	.32
C	.00	.00	.00	.01	.01	.01	.01	.01	.01	.02	.01	.00	.01

1/ Regional boundaries are described in Schroeder, M. J. and Others. Synoptic---

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Average
						West Gulf States Region							
FO	.53	.40	.35	.30	.30	.27	.30	.23	.28	.27	.37	.50	.34
NS	.26	.37	.32	.32	.33	.25	.25	.24	.22	.26	.30	.31	.29
Act	.21	.22	.33	.37	.37	.48	.45	.52	.48	.46	.33	.19	.36
C	.00	.01	.00	.01	.00	.00	.00	.01	.02	.01	.00	.00	.01
						Southern Plains Region							
FO	.39	.39	.30	.27	.31	.15	.11	.08	.14	.22	.28	.39	.26
NS	.20	.15	.11	13	.13	.12	.12	.12	.11	.15	.14	.14	.14
Act	.35	.37	.43	.45	.45	.56	.61	.62	.57	.49	.48	.39	.47
C	.06	.09	.16	.15	.11	.17	.16	.18	.18	.14	.10	.08	.13
						Northeastern Plains Region							
FO	.93	.89	.69	.35	.25	.26	.23	.29	.29	.29	.59	.87	.49
NS	.06	.09	.21	.22	.21	.25	.32	.31	.19	.25	.17	.11	.20
Act	.01	.02	.10	.40	.49	.47	.43	.38	.47	.42	.24	.02	.29
C	.00	.00	.00	.03	.05	.02	.02	.02	.05	.04	.00	.00	.02
						Northwestern Plains Region							
FO	.73	.66	.58	.34	.27	.27	.12	.12	.16	.22	.47	.69	.39
NS	.15	.19	.21	.19	.17	.15	.13	.11	.09	.14	.21	.17	.16
Act	.12	.15	.20	.41	.48	.46	.57	.54	.53	.50	.28	.14	.36
C	.00	.00	.01	.06	.08	.12	.18	.23	.22	.14	.04	.00	.09
						Northern Rockies & Northern Intermountain Region							
FO	.90	.76	.49	.23	.19	.13	.03	.05	.10	.30	.61	.85	.39
NS	.06	.18	.35	.31	.26	.22	.07	.05	.10	.20	.22	.11	.17
Act	.04	.06	.16	.45	.53	.59	.72	.72	.70	.46	.16	.04	.39
C	.00	.00	.00	.01	.02	.06	.18	.18	.10	.04	.01	.00	.05
						Central Intermountain Region							
FO	.72	.58	.35	.16	.11	.04	.02	.04	.03	.10	.38	.60	.24
NS	.17	.23	.19	.15	.11	.04	.04	.05	.05	.11	.18	.23	.13
Act	11	.18	.42	.55	.56	.50	.43	.45	.52	.64	.41	.16	.43
C	[illegible]	.01	.04	.14	.22	.42	.51	.46	.40	.15	.03	.01	.20

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Average
						Southwest Region							
FO	.19	.11	.07	.03	.01	.01	.05	.07	.03	.07	.09	.18	.08
NS	.16	.11	.06	.04	.04	.02	.07	.08	.03	.07	.12	.16	.08
Act	.52	.56	.42	.35	.23	.18	.40	.54	.43	.53	.59	.55	.44
C	.13	.22	.45	.58	.72	.79	.48	.31	.51	.33	.20	.11	.40
						Pacific Northwest Region							
FO	.96	.90	.83	.58	.55	.43	.32	.30	.39	.65	.83	.95	.65
NS	.03	.08	.14	.14	.22	.30	.20	.23	.21	.21	.13	.05	.16
Act	.01	.02	.03	.18	.23	.26	.45	.45	.38	.13	.04	.00	.18
C	.00	.00	.00	.00	.00	.01	.03	.02	.01	.01	.00	.00	.01
						Northern & Central California Region							
FO	.82	.58	.37	.27	.20	.11	.05	.04	.06	.18	.38	.62	.31
NS	.12	.29	.31	.27	.21	.15	.13	.13	.13	.14	.21	.20	.19
Act	.06	.1[illegible]	.31	.45	.56	.65	.70	.68	.70	.62	.40	.18	.45
C	.00	.00	.01	.01	.03	.09	.12	.15	.11	.06	.01	.00	.05
						Southern California Region							
FO	.53	.48	.46	.45	.42	.10	.19	.09	.11	.31	.30	.38	.32
NS	.16	.14	.17	.17	.15	.40	.25	.34	.30	.16	.16	.14	.21
Act	.28	.34	.30	.34	.28	.26	.21	.19	.25	.27	.30	.34	.28
C	.03	.04	.07	.04	.15	.24	.35	.38	.34	.26	.24	.14	.19

TABLE II

PROBABILITY OF FIREFIGHTING FORCES BEING BOTH NEEDED AND EFFECTIVE

Region	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Average
Northeast Region 1/	.01	.03	.11	.36	.47	.45	.47	.40	.33	.28	.10	.01	.25
Southeast Region	.19	.29	.44	.58	.58	.54	.47	.46	.46	.44	.34	.18	.41
Lake States Region	.00	.00	.05	.36	.51	.49	.50	.43	.43	.34	.08	.00	.25
Ohio & Middle Mississippi Valley Region	.08	.18	.31	.50	.54	.55	.55	.59	.67	.52	.30	.12	.41
West Gulf States Region	.26	.31	.44	.49	.49	.60	.56	.65	.59	.58	.43	.25	.47
Southern Plains Region	.43	.44	.49	.53	.52	.65	.70	.72	.65	.58	.56	.46	.55
Northeastern Plains Region	.01	.02	.10	.49	.60	.59	.57	.50	.57	.54	.28	.02	.35
Northwestern Plains Region	.14	.18	.24	.50	.58	.55	.67	.62	.60	.59	.35	.16	.43
Northern Rockies & Northern Intermountain Region	.04	.07	.22	.59	.67	.73	.78	.77	.78	.56	.20	.04	.46
Central Intermountain Region	.13	.22	.51	.65	.65	.54	.47	.50	.57	.73	.49	.20	.51

1/ Regional boundaries are described in Schroeder, M. J. and Others. Synoptic---

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Average
					Southwest Region							
.62	.65	.47	.39	.27	.20	.46	.61	.45	.59	.68	.66	.51
					Pacific Northwest Region							
.01	.02	.03	.21	.28	.34	.55	.56	.46	.16	.05	.00	.21
					Northern & Central California Region							
.07	.17	.41	.57	.68	.76	.81	.80	.81	.72	.49	.22	.55
					Southern California Region							
.33	.39	.36	.40	.34	.46	.35	.38	.43	.35	.39	.41	.38

TABLE III

PROBABLE NEED FOR AND EFFECTIVENESS OF WILDLAND FIREFIGHTING
CONTINENTAL U. S. (unweighted average)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Average
A.	.82	.76	.64	.44	.37	.31	.26	.27	.28	.41	.60	.79	.51
B.	.16	.21	.31	.48	.53	.55	.59	.59	.58	.50	.35	.19	.41
C.	.02	.03	.05	.08	.10	.14	.15	.14	.14	.09	.05	.02	.08

A. Firefighting forces unnecessary

B. Firefighting forces effective

C. Firefighting forces futile