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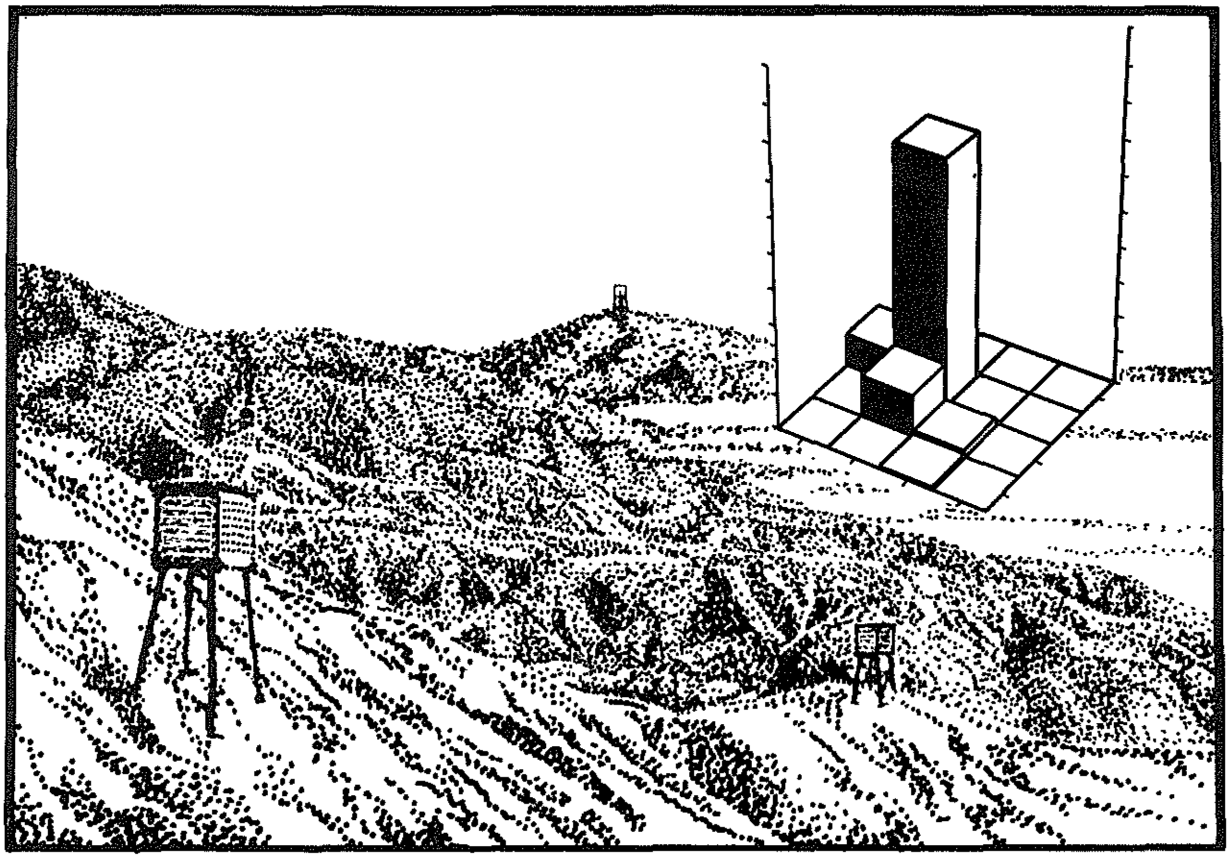
Changes in Fire Weather Distributions: Effects on Predicted Fire Behavior

Lucy A. Salazar **Larry S. Bradshaw**



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Data that represent average worst fire weather for a particular area are used to index daily fire danger; however, they do not account for different locations or diurnal weather changes that significantly affect fire behavior potential. To study the effects that selected changes in weather databases have on computed fire behavior parameters, weather data for the northern Rocky Mountains were treated as probability distributions, then used in computer simulation to estimate distributions of rate-of-spread (ROS) and fireline intensity (FLI). Sensitivity of ROS and FLI to weather input changes was analyzed by varying the source and amount of weather data, and diurnally adjusting temperature and relative humidity. In eight representative cases, a minimum amount of data produced the lowest cumulative probabilities of ROS and FLI, and data from a higher elevation produced the highest values. For long-term planning, within the region studied, a small subset of weather data distributions was adequate for estimating probabilistic distributions of ROS and FLI. Joint probabilities of ROS and FLI differed substantially among test cases. Fire behavior values obtained with observed data were higher than those obtained with diurnally adjusted data. The simulation techniques used are appropriate for use in long-term fire management planning models.

Retrieval Terms: fire weather, fire behavior, probabilistic fire modeling, wildfire

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Average worst fire weather conditions used to predict daily fire danger are inadequate to simulate the range of possible events needed for long-term planning. We studied the effects that selected changes in weather databases have on computed fire behavior parameters in the northern Rocky Mountains. Cumulative and joint probability distributions of rate-of-spread and fireline intensity were computed from a base and four alternative weather files for eight test cases. Fire environment descriptors (fuel, slope, aspect, and time-of-year) varied among the test cases.

Weather files were stratified by two elevation and two time-of-year classes. The time-of-year classes were used to estimate live fuel moisture for fuel complexes with live fuels. Daily values of six fire weather elements were broken into subjective classes to facilitate computing unique combinations of the six elements. Each unique combination (weather day) was integrated with fire environment descriptors defined by the test case to compute a fire behavior value for that weather combination and test case. The output values were weighted by frequency of occurrence of a particular weather combination.

Changes in fire behavior distributions resulting from different weather files were analyzed for each case. One of the alternative weather files contained once-daily observations of weather elements; the others contained elements adjusted for diurnal and spatial variation in addition to the once-daily observations. Two of the alternative weather files contained data from fewer weather stations than did the base file. The fourth alternative weather file was from a higher elevation band.

The once-daily and the high-elevation alternatives resulted in more extreme fire behavior than did the base or the other two alternatives for all cases. Fire behavior distributions derived from the base and its alternatives differed less within each test case than between cases. Cases with more flammable fuel complexes varied more among the base and alternative weather files than did cases with less flammable fuel complexes.

In terms of probabilistic long-term planning needs within the study area, the source and amount of weather data were not critical factors in producing differences in fire behavior distributions of rate-of-spread and fireline intensity. The number of stations providing weather data was reduced substantially below the number available without a considerable change in the distributions of rate-of-spread and fireline intensity. Any of the four weather alternatives tested, including weather from only one station, were adequate for predicting the fire behavior of the test cases exhibiting low-intensity, slow-spreading fires. Depending on the resolution of the planning model, small weather subsets could also sufficiently represent higher intensity, faster spreading fires. Further analysis is necessary to determine this optimum subset of weather data, which would be based on output resolution requirements, fuel complexes, and geographical area. The techniques used in this study are appropriate for use in long-term fire management planning models.

The development of organized protection against wildfires has led to increasing effort to determine the most efficient placement and use of firefighters and equipment. The Fire Economics Evaluation System (FEES) is a long-term planning model being developed at the Pacific Southwest Forest and Range Experiment Station (Mills and Bratten 1982). It is designed to estimate the economic efficiency, fire-induced changes in resource outputs, and risk characteristics of a specified range of fire management program options. Fire behavior is one input to the economic evaluation process; modeling or computer simulation of suppression effectiveness and the resulting effect of fire is also part of that process.

To predict fire behavior, fire planners use fire behavior variables such as rate-of-spread (ROS) and fireline intensity (FLI). ROS describes the forward rate-of-spread of a fire, and FLI describes the difficulty of controlling it in terms of the heat it generates. These two variables are markedly affected by weather conditions, including windspeed, temperature, and relative humidity. They are also affected by slope, elevation, aspect, time-of-day, time-of-year, and type and amount of fuel. Therefore, site-specific and timely weather data are needed to determine real-time fire behavior for both fire suppression and prescribed burning.

An extensive spatial network of fire weather stations throughout the United States provides weather data once a day for the National Fire Danger Rating System (NFDRS) (Deeming and others 1977). When possible, fire weather is measured at the peak fire danger time (midafternoon), and at an open location, at midslope, on a southerly or westerly exposure. The NFDRS indexes the daily fire danger on the basis of 24-hour average-worst fire spread conditions for a particular area; however, the archived data are inadequate for simulating an entire fire season's probable range of events. Fires occurring on locations or at times not typified by average-worst conditions also need to be taken into account. For example, diurnal changes in weather may significantly affect fire behavior potential.

At lookout stations in Idaho, maximum temperatures were lower by 10° to 17° F (5.5 to 9.4° C) and minimum temperatures higher by about 4° F (2° C) than those at valley stations (Larsen 1922). The average daily wind velocity at mountain stations was about three times that at the valley stations. Day and night wind velocities at higher stations differed less than they did at valley stations. Relative humidity was lower at night and higher during the day at higher elevations.

The effect of differences in altitude, aspect and time of day on fire behavior in the Northern Rocky Mountain Region have been documented to determine where and when to measure fire danger under "average-bad" conditions (Hayes 1941, 1942, 1944). The studies used only median daily values for August and did not account for daily and seasonal variations. Findings included these:

- Three altitudinal zones differed in fire behavior characteristics: low zone, below 3,000 feet (915 m); thermal belt, 3,000-4,000 feet (915-1,220 m); high zone, above 4,000 feet (1,220 m).
- Four diurnal periods differed in fire behavior characteristics: night, 2200-0600 local standard time (l.s.t.); morning transition, 0600-1000 l.s.t.; day, 1000-1800 l.s.t.; and evening transition, 1800-2200 l.s.t.
- Single daily measurements made at a valley bottom station at 1200 or 1700 l.s.t. and at a 5,500-foot (1,677 m) south slope station at 1400 l.s.t. represented "average-bad" conditions for the Northern Rocky Mountain Region.
- Three daily measurements of weather improved the accuracy of "average-bad" fire danger ratings.
- Each of the three sets of data taken at different sites and hours of the day provided similar estimates of the fire danger at other places and hours.

The data used in those studies were later analyzed by the principal component and cluster techniques (Furman 1978). Fuel moisture attributes for seven locations on the mountain ridge spanning 3300 feet (1000 m) elevation on two aspects in northern Idaho were grouped in the analysis. The results showed grouping by valley bottom, midslope, and mountaintop.

For 23 weather stations in the Rocky Mountain forest of southern Alberta, Canada, minimum relative humidity in summertime did not vary significantly at elevations up to 1000 feet (305 m) above a valley bottom (MacHattie 1966). Above that, relative humidity appeared to increase. Nightly maximum humidity varied most near the valley bottom.

Various studies have evaluated the extrapolation of weather data to other sites (Campbell 1972), differences between weather data taken at fire weather stations as opposed to airport stations (Mitchem and Pigg 1970, Simard 1969), and methods to refine a network to an optimum number of fire weather stations (Fujioka and Fosberg 1981, Furman 1975, Innes 1969, King and Furman 1976, Knorr 1942, Morris 1940). Most of these studies evaluated weather data in terms of fire danger and average-worst conditions, which have different optimization criteria than does probabilistic fire behavior modeling. Also, because methods for deriving fire danger indexes have changed during the course of these studies, their results cannot be directly compared.

Frandsen and Andrews (1979) emphasized the importance of evaluating distributions of fire behavior parameters so that more realistic assessments of effects can be formulated. Fire environment descriptors of fuels, slope, aspect, and distributions of weather variables have been used to estimate cumulative and joint probability distributions of rate-of-spread (Albini 1976, Rothermel 1972) and fireline intensity (Byram 1959).

This paper reports a study of the effects that selected changes in weather databases have on computed fire behavior parameters for eight test cases within the northern Rocky Mountains. The simulation techniques used in this study are appropriate for use in long-term fire management planning models.

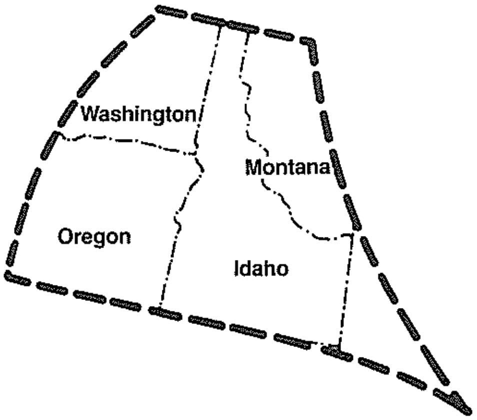


Figure 1—The Northern Rockies and Northern Intermountain region comprised the study area (Schroeder and others 1964).

METHODS

Selecting Weather Stations

The Northern Rockies and Northern Intermountain region (Schroeder and others 1964) *(fig. 1)* made up the study area. Within this area over 300 Forest Service weather stations have data archived in the National Fire Weather Data Library (NFWDL) (Furman and Brink 1975). Because of the enormous amount of weather data available and associated processing costs, the number of eligible stations was initially reduced by eliminating those no longer in service, those with abnormally small amounts of data due to sporadic collection over the years or short fire seasons, and those with less than 10 years of data *(fig. 2)*. The data from the remaining stations were considered to be adequate for use in long-term planning because of their seasonal completeness and long coverage.

Stations were grouped into four strata: 0-4500 feet (1372 m) elevation and above 4500 feet to approximate valley and mountaintop weather, and April to June and July to September to typify spring and summer fire seasons in the study area. The thermal belt was not accounted for because of the incapability of including inversion events in our modeling scheme.

Windspeed, temperature, relative humidity, daily temperature extremes, and precipitation amount "represented" a day of weather because of their reliable presence in the weather data library and their significant effects on fire behavior. Averages of each of these six parameters, across all days of weather for all stations within a stratum, were clustered by the CLUSTER routine within the Statistical Analysis System (SAS) (Helwig and Council 1979). Averages were used because of the great amount of data involved.

Cluster analysis is used when no *a priori* or theoretical classification information about the data is available. Clustering methods attempt to maximize the Euclidean distance between clusters in a step-by-step process. Each observation (in this study a set of six averaged weather parameters) is initially placed in its own cluster. The two closest clusters are then combined into one; and the two closest of the new set are combined, and so on (Helwig and Council 1979). No satisfactory method exists for determining the number of clusters for any type of cluster analysis (Everitt 1979). In this analysis the criterion used for choosing the number of clusters was data processing cost, and the resulting numbers were different for each of the four strata.

Within each cluster, the station that had the most weather days was subjectively chosen as the representative station for that cluster. In some cases this station may have had the most complete record because it was accessible rather than because it was typical of the surrounding area. Therefore, caution should be exercised when using this method in other analyses. A weather file for representative weather stations was created for each of the four strata:

Elevation (ft)	Time of year	Stations	Weather days
0-4,500 (1,372 m)	April-June	33	24,268
0-4,500	July-September	13	25,422
> 4,500	April-June	26	14,918
> 4,500	July-September	20	30,899

These base data files contained the entire archived record for all days of entry.

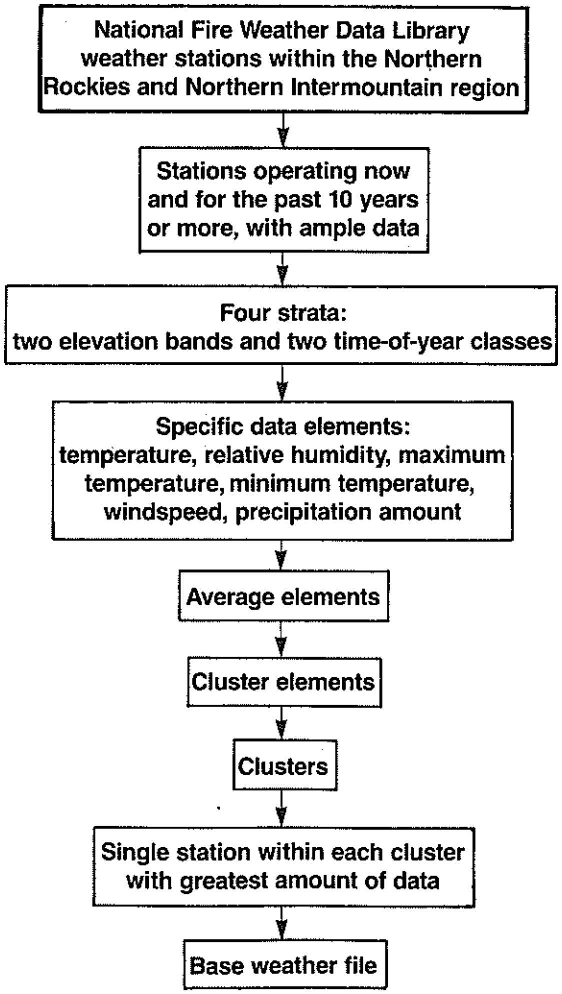


Figure 2—To reduce the large amount of data available, weather stations were eliminated by a selection procedure.

Converting Weather Data to Probability Distributions

The base weather files were processed through the FIREWX computer program adapted from the National Fuels Appraisal Project (Radloff and others 1982) by Bradshaw (1982). FIREWX uses NFDRS fuel moisture subroutines (Deeming and others 1977), to derive unique combinations for selected ranges of the following parameters with their associated probabilities:

- 1-hour fuel moisture (percent)
- 10-hour fuel moisture (percent)
- 100-hour fuel moisture (percent)
- Herbaceous fuel moisture (percent)
- Woody (shrub) fuel moisture (percent)
- Windspeed (mi/h, 20-foot [6 m], 10-minute observed average)

To compute fuel moistures for situations other than those defined by the typical NFDRS weather station collection time and place, fuel moisture adjustment tables were used (Rothermel 1983). This fuel moisture adjustment required a reference temperature and relative humitidy, which were used to locate base fine (1- and 10-hour) fuel moisture in a table. The base fine fuel moisture was then adjusted as a function of time of year, time of day, slope, aspect, and a fuel-type shading factor (shaded versus exposed).

Reference temperatures at times other than the fire weather observation time were estimated by a diurnal temperature model (McCutchan 1979). The model uses the first two harmonics of a Fourier series to predict temperature at time "t" with the two independent variables being the day's temperature range and average temperature. Relative humidity at time "t" was then estimated by assuming a constant airmass and by conserving specific humidity from the observed relative humidity. If maximum and minimum temperatures were missing from a day's weather record, fine fuel moistures were derived directly from adjustments of the observation time fine fuel moistures.

Windspeed also fluctuates diurnally, but a diurnal windspeed model compatible with FIREWX was not available. Each day's observed windspeed was used for all time-of-day classes. Wind reduction factors specific to a fuel model (in terms of percentages of the observed windspeeds) were used to reduce the observed 20-foot (6 m) windspeed to midflame windspeed (Baughman and Albini 1980) required by the fire model. Windspeeds for NFDRS stations are recorded as 10-minute averages, and therefore, momentary gusts were not evaluated.

Analyzing Fire Behavior Distributions

Sensitivity analysis of computed fire behavior distributions was in terms of two weather data manipulations: varying the source and amount of weather data, and diurnally adjusting temperature and relative humidity. The four alternative data files were defined as follows:

Alternative file:	Source of data
I	Five fire weather stations, Lolo National Forest, Montana
II	One fire weather station, Lolo National Forest
III	Observed weather only
IV	Higher elevation stations

The Lolo National Forest was subjectively chosen as a representative forest within the Northern Rockies and Northern Intermountain region. The breakdown of the subsets of weather stations was as follows:

Elevation (ft)	Time of year	Stations	Weather days
0-4,500 (1,372 m)	April-June	5	4,063
0-4,500	July-September	5	9,710
4,036 (1,230 m)	April-June	1	321
4,036	July-September	1	2,288

Fire weather distributions were not directly compared because only the notation of a change in the total number of unique weather combinations was possible. Individual unique weather combinations were not compared because they sometimes exceeded 3,000. The base and four alternative weather files were processed instead by a fire behavior computer program (Radloff and others 1982) adapted by Bradshaw (1982). It calculates joint probabilities and expected values of ROS and FLI from weather data, fuel model (Albini 1976), aspect, and slope class (0-39 pct, 40-79 pct, 80-100 pct). Midpoints of the slope classes were used in the fire behavior computations. The effect of different weather files on expected values and joint probabilities of ROS and FLI were then compared.

To facilitate the use of diurnally adjusted weather, daytime was approximated by the hours from 0500 to 2000 l.s.t. and divided into four subclasses: 0500-0759, 0800-1159, 1200-1559, and 1600-1959. Each subclass was weighted based on its frequency of occurrence at time of discovery on Forest Service Individual Fire Report forms (Form 5100-29) for the study area during 1970 to 1981. Subclasses were stratified by elevation band, time-of-year class, aspect, slope class, and fuel model derived from cover type. For modeling purposes, "cover type in vicinity of origin" on fire report forms was converted to fuel model. This conversion was based on the form entry of "fuel type in vicinity of origin," which is a relative ranking of ROS and resistance to control. Each fuel model was also assigned a ranking of these two parameters. A cross tabulation of cover type by these two rankings resulted in a distribution of fuel models for each cover type. Modeled fire behavior for these subclasses was weighted by their frequency percentages to delineate daytime fire behavior. This weighting scheme, therefore, emphasizes the situation-specific fire behavior occurring during those time-of-day classes when fires were discovered. The resulting weighted adjusted daytime fire behavior was compared with the unadjusted behavior derived solely from observed weather.

Table 1—*Slope, aspect, fuel model, and time-of-year class for eight test cases, 0-4500 ft (1372 m) elevation in the northern Rocky Mountains*

Case	Slope (pct)	Aspect	Fuel model[1] (percentage and description)	Time of year
1	0-39	N	2/9—2(40 pct)—open pine with grass understory and 9(60 pct)-long-needle pines	Apr.-June
2	40-79	N	8—healthy short-needle confier stand	Apr.-June
3	0-39	N	10/8—10(40 pct)-decadent short-needle conifer stand and 8(60 pct)-healthy short-needle conifer stand	Apr.-June
4	0-39	S	12/11—12(40 pct)-medium loading slash and 11(60 pct)-low loading slash	Apr.-June
5	0-39	N	2/9—2(40 pct)-open pine with grass understory and 9(60 pct)-long-needle pines	July-Sept.
6	40-79	N	8—healthy short-needle conifer stand	July-Sept.
7	0-39	N	10/8—10(40 pct) decadent short-needle conifer stand and 8(60 pct)-healthy short-needle conifer stand	July-Sept.
8	0-39	S	12/11—12(40 pct)-medium loading slash and 11(60 pct)-low loading slash	July-Sept.

[1] Albini (1976).

RESULTS AND DISCUSSION

Because of the many possible situations, results are presented for only eight cases that best represent a wide range of potential fire behavior *(table 1)*. Six of the eight cases involved the two-fuel model concept (Rothermel 1983) primarily because of the known heterogeneity of natural fuel beds. Fuel model percentages were subjectively determined to represent typical fuel bed arrays within the study area. The following standards apply when modeling fire behavior using the two-fuel model concept (Rothermel 1983). The wind reduction factor from the model with the greater percentage of areal coverage is used to compute ROS and FLI for both fuel models. If coverage is equal, the minimum reduction factor is used. ROS is predicted for each fuel model, then weighted by the areal percentage of the respective fuel model to produce one ROS value. FLI is not weighted; the maximum computed FLI for the two fuel models is used.

Cumulative Probabilities

When comparing the eight cases, note the differences in scale among some of the graphs in *figures 3* and *4*. ROS and FLI for cases 2 and 6 appear to differ substantially among alternatives, but the maximum values for ROS (3.0 ft/min [0.015 m/s]) and FLI (12 BTU/s/ft [41.5 kW/m]) are small. In all cases, alternative II had the lowest cumulative values for ROS *(fig. 3)* and FLI *(fig. 4)*. Alternative IV produced consistently higher values for both fire behavior parameters. These results substantitate earlier findings (Furman 1978; Hayes 1941, 1942, 1944; Larsen 1922) and show the effect that higher elevation patterns have on fire behavior. Overall the similarity among each base and its four alternatives was considerable. Fuel model was a notable cause of differences between cumulative probabilities of ROS and FLI. Lower severity fuel models (8 and 10/8) showed smaller differences (cases 2, 3, 6, and 7 in *figs. 3* and *4*), whereas, higher severity fuel models (2/9 and 12/11) had greater differences (cases 1, 4, 5, and 8 in *figs. 3* and *4*).

Percentile values of weather and fire behavior are frequently used in presuppression planning to rank the historical risk associated with certain fire management situations. A given fire behavior percentile value (90th, for example) indicates that 90 percent of the days in the sample exhibited behavior characteristics of the 90th percentile value or less. For ROS *(table 2)* and FLI *(table 3)*, these values indicate that, as above, smaller differences are found in the less severe fuel models (cases, 2, 3, 6, and 7) and larger differences in the higher severity fuel models (cases, 1, 4, 5, and 8) between alternatives. These differences in the 90th percentile values show the significance of fuel model selection in presuppression planning.

Joint Probabilities

To facilitate comparing joint probabilities of ROS and FLI, values were broken down subjectively into four classes to reflect relative ranking of fire behavior:

Rank:	ROS		FLI	
	ft/min	*(m/s)*	*BTU/s/ft*	*(kW/m)*
Low	0 - 2.5	(0.012)	0 - 100.0	(346)
Medium	2.51 - 12.5	(0.062)	100.1 - 500.0	(1,730)
High	12.51 - 25.0	(0.125)	500.1 - 1,000.0	(3,459)
Extreme	> 25.0		> 1,000.0	

Contingency tables were derived for the eight test cases from the base and four alternative data files and represented by three-dimensional histograms *(fig. 5)*. No major cell differences were shown by any of the eight base files and their alternatives, but—as would be expected—fire behavior differed substantially among the test cases. The majority of ROS and FLI values for cases 2, 3, 6, and 7 (fuel models 8 and 10/8) were consistently in the lowest ranks. Values for only fuel model 12/11 (cases 4 and 8) were in the higher categories.

Root mean square differences (RMSD's) among the base data and alternatives were also computed *(table 4)* as a convenient method of mathematically evaluating overall differences in joint probabilities. Because of their nonstatistical nature, RMSD's were only compared relatively. Certain differences and trends in RMSD's were evident. Both fuel models 8 (cases 2 and 6) and 10/8 (cases 3 and 7) showed low ROS and FLI, and different weather inputs did not substantially alter the fire behavior for these test cases. All RMSD's for fuel model 8 were less than 0.004 and for fuel model 10/8 were less than 0.014 *(table 4)*.

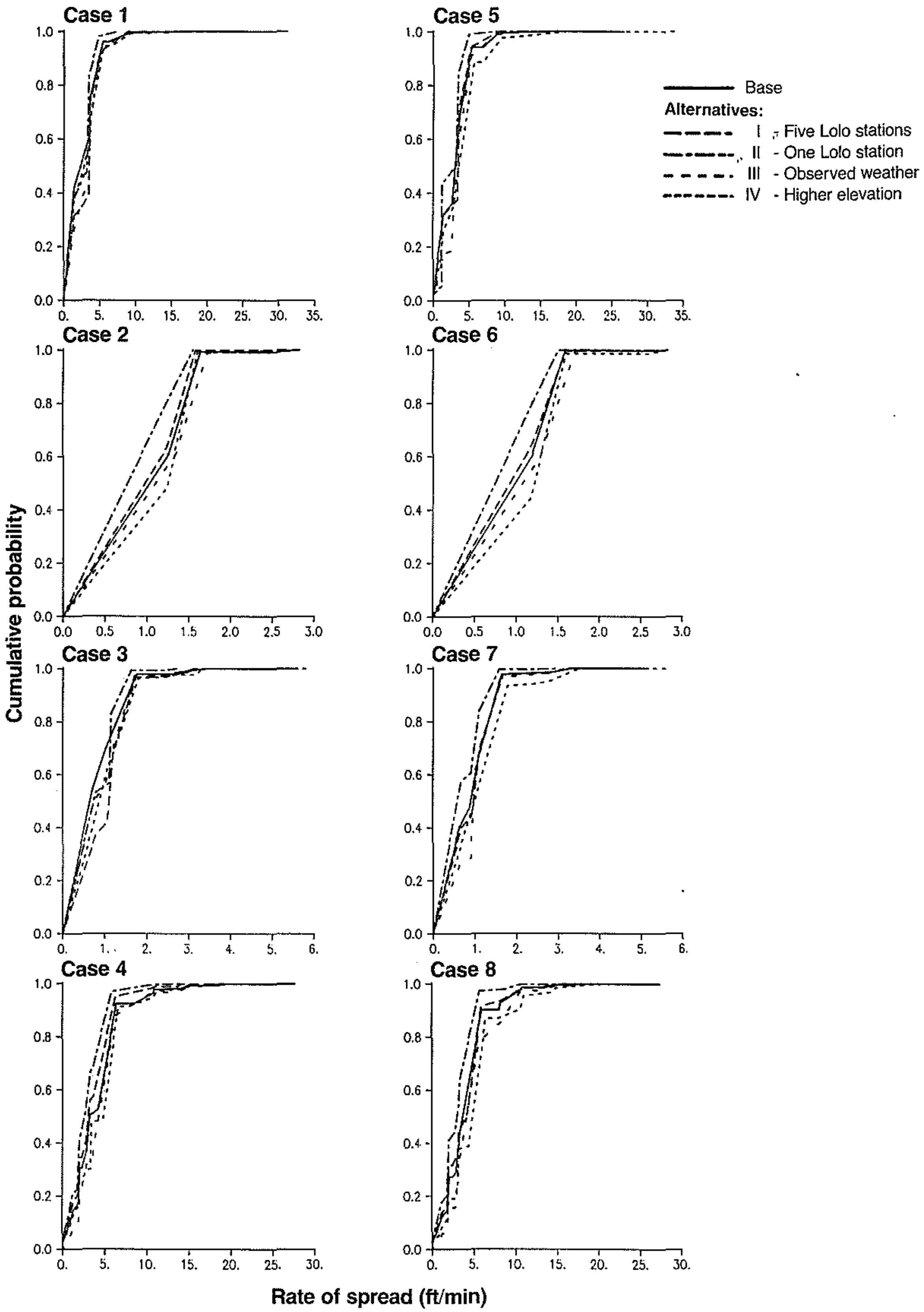


Figure 3—Cumulative probabilities of rate-of-spread were similar for each base weather file and four alternative files. Note the difference in scale among the graphs. (1 ft/min = 0.005 m/s)

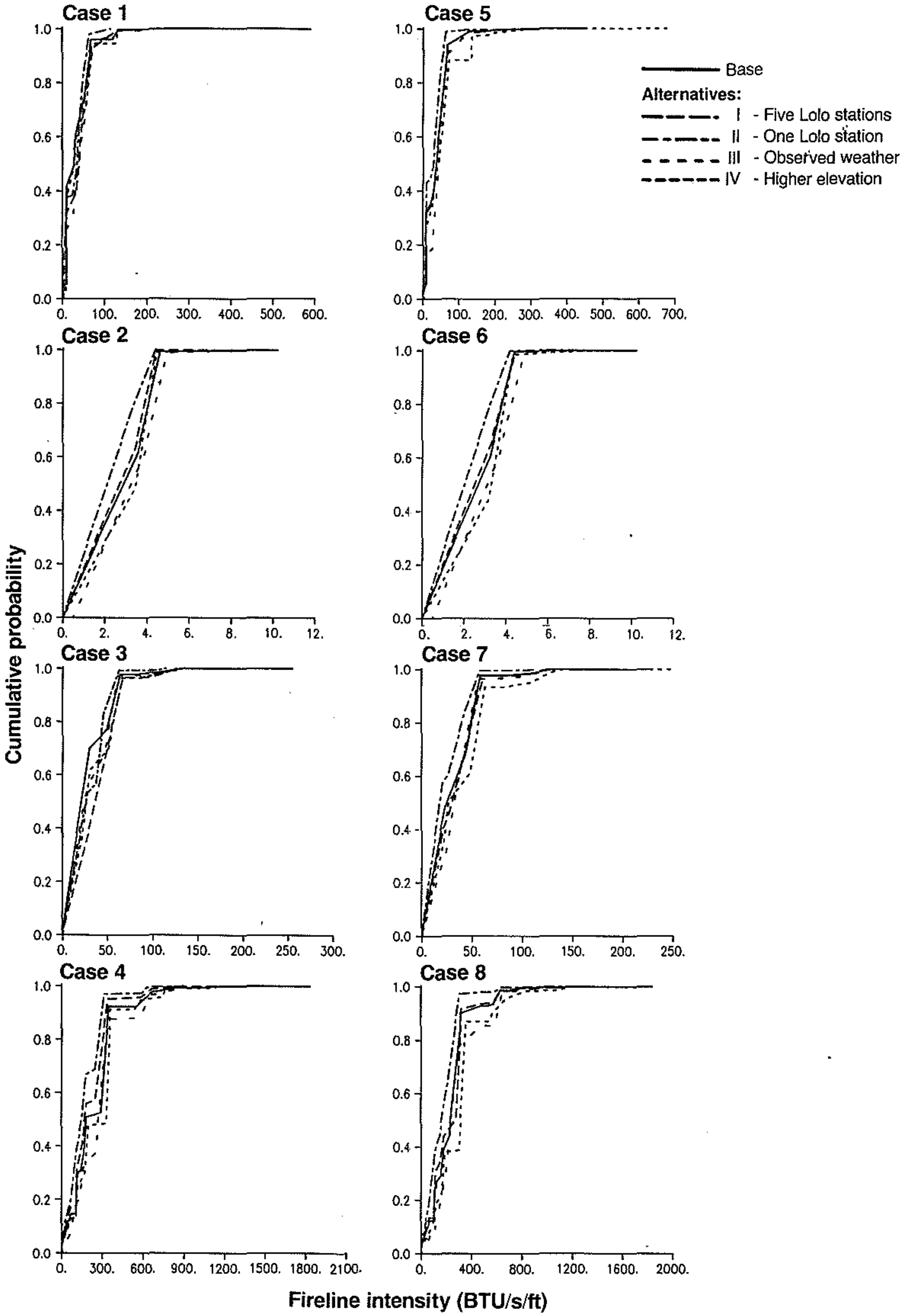


Figure 4—Cumulative probabilities of fireline intensity were similar for each base weather file and four alternative files. Note the difference in scale among the graphs. (1 BTU/s/ft = 3.4592 kW/m)

Table 2—*Ninetieth percentile rate-of-spread values (ft/min)*[1] *from base and four alternative weather files for eight test cases in the northern Rocky Mountains*

Weather file	Test cases 1	2	3	4	5	6	7	8
Base	4.94	1.55	1.55	6.27	5.07	1.48	1.50	5.97
Alternatives								
I Five Lolo stations	5.05	1.49	1.61	5.94	4.95	1.48	1.52	5.87
II One Lolo station	4.12	1.39	1.36	5.30	3.99	1.34	1.28	5.22
III Observed weather	5.17	1.64	1.58	7.40	5.20	1.60	1.49	9.16
IV Higher elevation	5.26	1.54	1.66	6.57	7.36	1.52	1.72	10.31

[1] Rate-of-spread of 1 ft/min = 0.005 m/s.

Table 3—*Ninetieth percentile fireline intensity values (BTU/s/ft)*[1] *from base and four alternative weather files for eight test cases in the northern Rocky Mountains*

Weather file	Test cases 1	2	3	4	5	6	7	8
Base	64.62	4.34	62.93	344.48	65.05	4.08	54.65	322.75
Alternatives								
I Five Lolo stations	68.84	4.15	62.67	329.30	66.54	4.09	56.65	319.48
II One Lolo station	56.67	3.88	61.09	298.05	53.91	3.69	48.84	286.63
III Observed weather	66.74	4.68	57.84	594.98	66.48	4.55	53.29	608.87
IV Higher elevation	68.38	4.26	62.47	358.84	133.66	4.13	61.66	570.14

[1] Fireline intensity of 1 BTU/s/ft = 3.4592 kW/m.

Fuel models 2/9 and 12/11 exhibited more varied fire behavior with higher RMSD's and more cells of the contingency table being filled. The range of RMSD's is 0.001 to 0.053 for fuel model 2/9 and 0.009 to 0.033 for fuel model 12/11 *(table 4).*

No one alternative consistently had the smallest RMSD for all eight test cases. Alternative I had the smallest RMSD for four of the test cases, with values ranging from 0.001 to 0.032 *(table 4).* Considering the small amount of data within Alternative II, it performed well with small RMSD's, ranging from 0.001 to 0.034 *(table 4).* The greatest discrepancies again occurred for fuel models 2/9 and 12/11 (cases 1, 4, 5, and 8).

Alternative III had the highest overall RMSD's. The range was from 0.001 to 0.053 with four RMSD's greater than 0.025 *(table 4).* These values are still small, but they do indicate that diurnal weather adjustments can affect fire behavior predictions, especially in the cases of faster spreading, higher intensity fuel models.

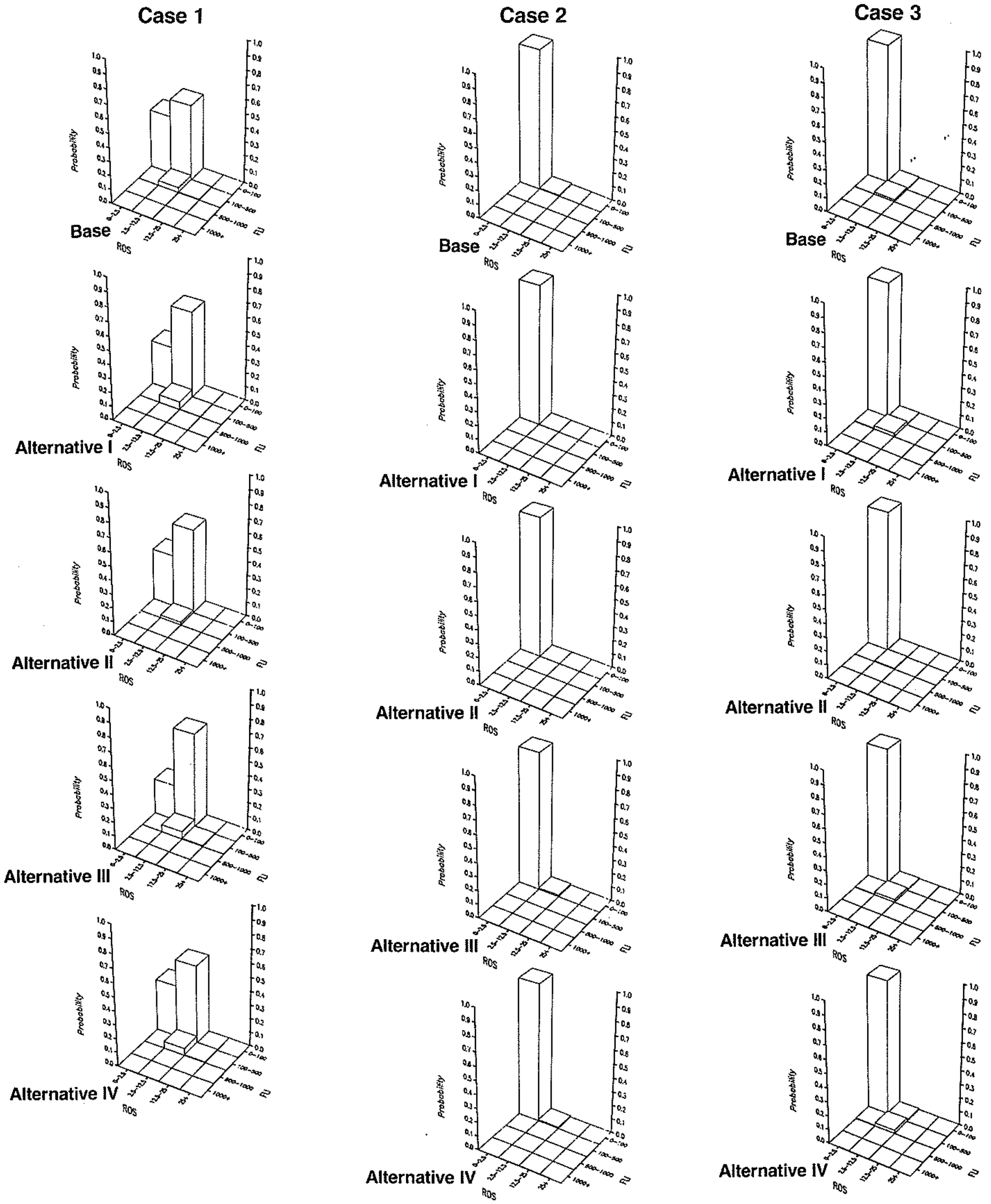
Alternative IV provided comparable results across all test cases with the best performance in the April-June stratum. This could be due to greater variations of weather patterns between elevation bands during the summer months.

The implications of these results go beyond long-term planning needs. Adjusting observed midafternoon temperature and relative humidity to other times of day and processing an entire day's weather gives managers a broader perspective than do average worst conditions. A diurnal windspeed adjustment would further enhance perspective, and a compatible diurnal windspeed model is being investigated. Ranges of fire behavior parameters allow for a better assessment of both wildfire and prescribed burning situations. Joint probabilities of ROS and FLI would improve the ability to evaluate long-range planning situations by allowing fire managers to consider suppression effectiveness and fire effects simultaneously.

The noncritical nature of the amount of weather inputs for long-term fire management planning indicated that real-time fire needs may be more important for placing weather stations or determining the number to maintain. For example, if long-term planning and suppression readiness needs were met by a small number of strategically placed stations recording diurnal weather (Furman 1982), mobile diurnal stations could be used for real-time fire behavior needs, such as prescribed burns and escaped fires. These mobile stations could also improve the forecasting of mesoscale phenomena, which are often the cause of extreme fire behavior that results in loss of life and resources (Chandler 1976).

Table 4—*Root mean square differences in rate-of-spread and fireline intensity contingency tables among four alternative data files when compared to the base data set for eight test cases in the northern Rocky Mountains*

Case	Alternatives I Five Lolo stations	II One Lolo station	III Observed weather	IV Higher elevation band
1	0.032	0.020	0.053	0.013
2	.002	.003	.001	.001
3	.004	.005	.002	.004
4	.009	.025	.027	.013
5	.001	.034	.047	.019
6	.001	.001	.001	.004
7	.001	.006	.004	.014
8	.012	.033	.026	.016



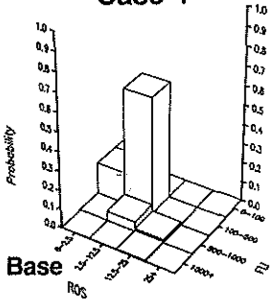
Case 1

Case 2

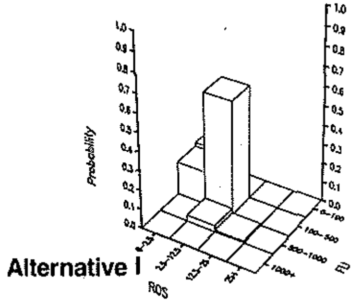
Case 3

Figure 5—Three-dimensional histograms depict contingency tables for rate-of-spread (ROS) and fireline intensity (FLI) derived from base data files and four alternative files (Alternatives: I—five Lolo stations, II—one Lolo station, III—observed weather, IV—higher elevation stations).

Case 4



Base



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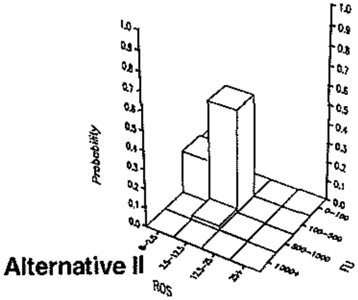

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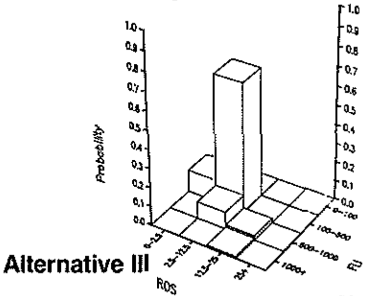

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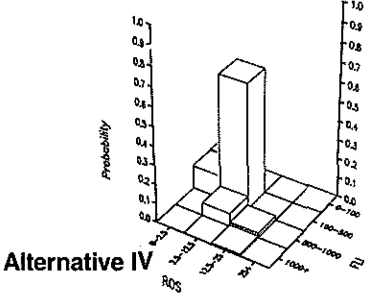
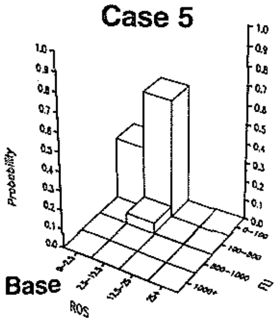


Alternative IV

Case 5



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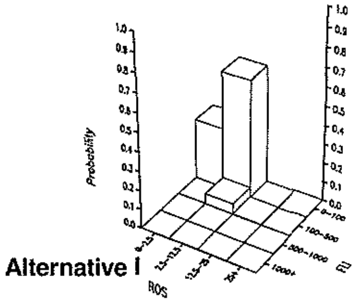

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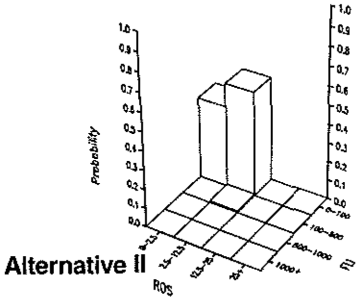

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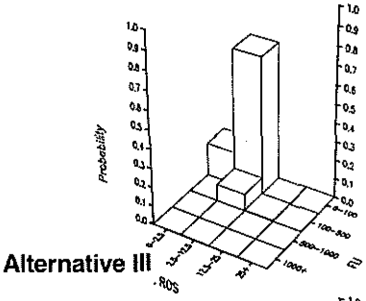

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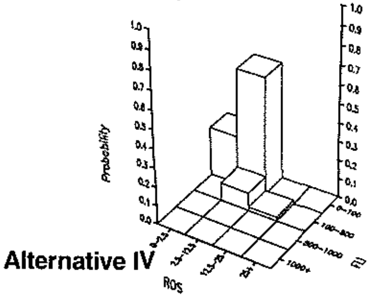
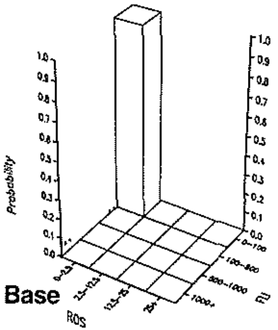


Alternative IV

Case 6



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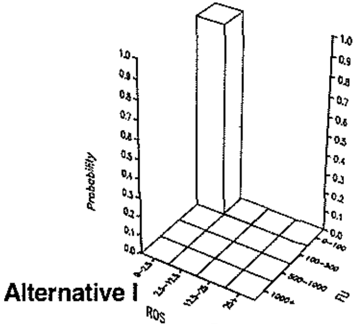

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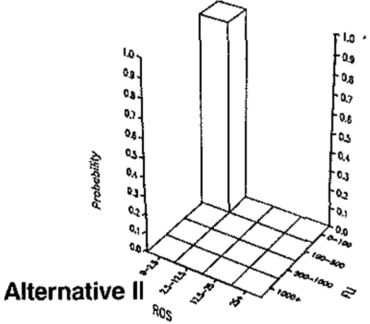

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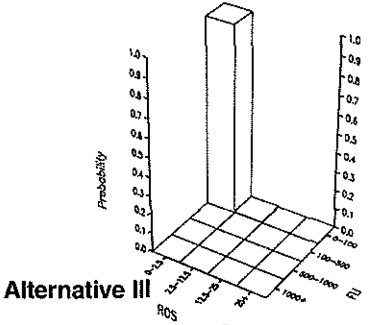

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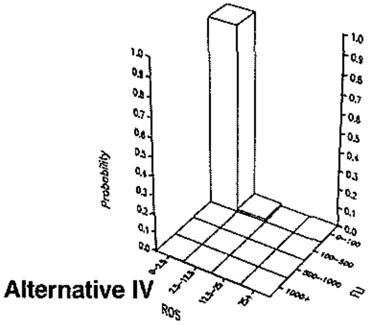
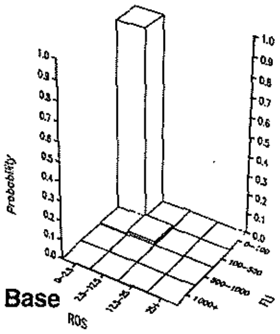


Alternative IV

Case 7



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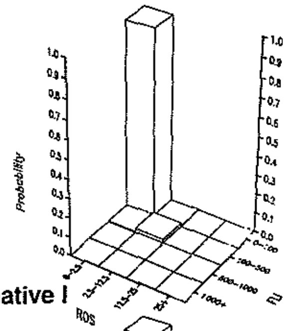

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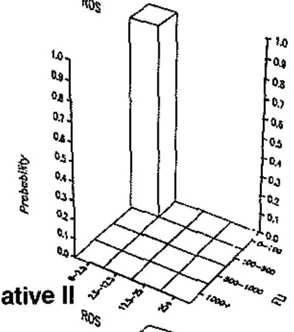

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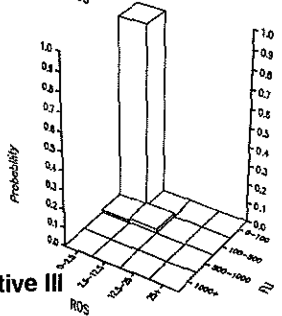

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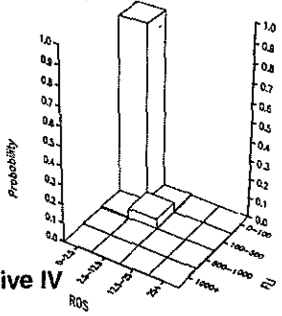
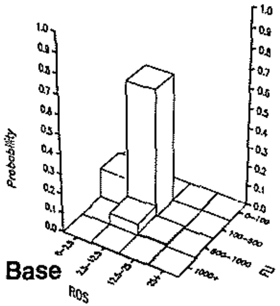


Alternative IV

Case 8



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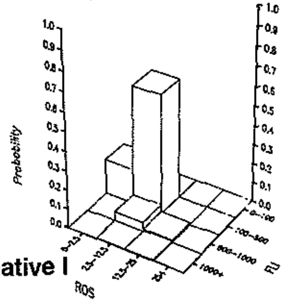

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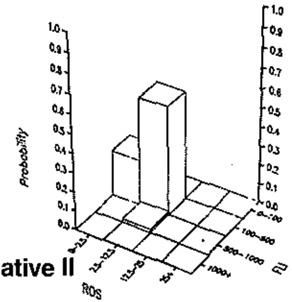

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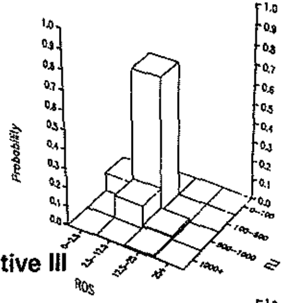

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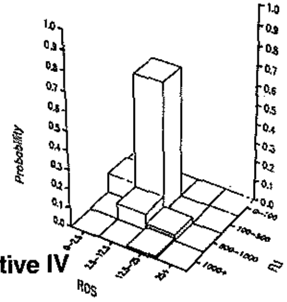

Alternative IV

CONCLUSIONS

For probabilistic long-term planning needs, within the Northern Rockies and Northern Intermountain region, the source and amount of weather data were not critical factors in predicting distributions of rate-of-spread and fireline intensity. The number of weather stations can be substantially reduced below the maximum determined to be available, without a considerable change in the probabilistic distributions of the fire behavior parameters of rate-of-spread and fireline intensity. Suppression effectiveness and fire effects would have to be subsequently modeled to determine whether management decisions would change on the basis of the results. Any of the four alternative data files tested, including weather from only one station, would be adequate for predicting the fire behavior of the test cases showing lower intensity, slower spreading fires. Depending on the resolution of the planning model, smaller weather subsets could also sufficiently represent higher intensity, faster spreading fires. Further analysis is necessary to determine this optimum subset of weather data, which would be based on output resolution requirements, fuel models, and possibly geographic region.

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