

The Haines Index and Idaho Wildfire Growth¹

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Introduction

The growth of wildfires is related to three broad factors: fuel type, topography, and weather. The National Fire Danger Rating System and the Fire Behavior Prediction System combine these factors to predict the probability and severity of wildland fires. However, these systems have mixed results in predicting extreme fire behavior conditions characterized by intense crowning and spotting. Extreme fire behavior is rare, but when it occurs, fires burn with intense heat and spread rapidly, endangering life and property.

An atmospheric index, the Lower Atmospheric Severity Index (LASI) developed in 1988 by Donald Haines, a research meteorologist with the USDA Forest Service, addresses the problem of how weather promotes extreme fire behavior conditions. This index uses the environmental lapse rate (temperature difference) within a layer of air coupled with its moisture content to determine a LASI number.

This paper compares the values of LASI or the Haines Index, as we will call it, with what occurred on recent large Idaho fires in an attempt to determine its predictive capabilities with regard to large fire growth.

Haines Index—Background Information

Research conducted earlier on fires

¹A related article, "Evaluation of Idaho wildfire growth using the Haines Index and water vapor imagery," was published in the preprint of the proceedings of the Fifth Conference of Mountain Meteorology, 1990 June 25-29; Boulder, CO. Boston, MA: American Meteorological Society: 187-193.

Extreme fire behavior, with crowning and long-range spotting, was exhibited by the fire when the Haines Index number was 5 or 6. But when the index lowered to 4 or less, fire activity significantly diminished.

in the Eastern United States had identified unstable air and low moisture as major contributors to fire severity. Haines contacted wildland fire management units throughout the country requesting information on their worst fire situations over a 20-year period. Information was received from 30 States regarding 29 major fires in the West and 45 fires in the East. Data from one to three radiosonde stations closest to each fire were examined to determine air-mass lapse rates and moisture values over the fires. (Radiosonde weather stations launch instrumented balloons that measure atmospheric temperature, relative humidity, pressure, and wind.) The 0000 GMT/1800 MDT temperature and dewpoint profile for the evenings on which the fires were reported were constructed for one of three layers between 950 and 500 millibars (approximately 2,000 and 18,000 ft msl), depending upon the elevation of the fire. Due to large differences in elevation across the United States, three combinations of atmospheric layers were used to construct the LASI.

Figure 1 shows a map of the United States divided into three regional elevations. Much of the Eastern United States, excluding the Appalachian Mountains, uses a low-elevation index computed from 950-850 millibar data (approximately

2,000 and 5,000 ft msl). A mid-elevation index was developed for the Great Plains and the Appalachian Mountains using 850-700 millibar data (approximately 5,000 and 10,000 ft msl). A high-elevation index is used for the mountainous Western United States using 700-500 millibar data (approximately 10,000 and 18,000 ft msl).

Comparing large fires and nearby upper air data, Haines developed his Lower Atmospheric Severity Index, which indicates the potential for large fire growth. Temperature lapse rate—stability—and moisture values are combined, resulting in the Haines Index using:

$$\begin{aligned} \text{Haines Index} &= \text{Stability} + \text{Moisture} \\ &= (Tp_1 - Tp_2) + (Tp_1 - Tdp_1) \\ &= A + B \end{aligned}$$

where T is the temperature at two pressure surfaces (p_1, p_2); and Tp_1 and Tdp_1 are the dry bulb temperature and dewpoint temperature at a lower level. All temperature values are written in centigrade.

Illustrated in table 1 are the lapse rate and moisture limits used in the low-, mid-, and high-elevation Haines indexes.

The Haines Index equals the sum of factor A (stability) and factor B (moisture):

Haines Index	Class of day (potential for large fire)
(A + B) 2 or 3	very low
4	low
5	moderate
6	high

Haines found that only 10 percent of large fires occurred when the class

of day was very low (Haines Index 2 or 3) though 62 percent of the fire-season days fell in the very low class. Forty-five percent of the fires were associated with the high-class days (Haines Index 6), while only 6 percent of the days fell in that class.

Instability and dry air are key parameters that must be present to result in a high Haines index number. Instability can be caused by either warming the lower levels of the airmass or by cooling the upper levels. When warming below and cooling aloft occur at the same time, the airmass rapidly destabilizes. In the Western United States, this occurs when cooling, associated with an upper trough of low pressure, moves over a surface thermal trough or "heat low." An increase in moisture usually accompanies the upper trough, but at times a "tongue" of very dry air wraps around the leading edge of the upper trough resulting in low relative humidities at the surface. Figure 2 displays a typical weather pattern that produces a high Haines Index in the Western United States: a thermal trough at the surface, a 500-millibar trough moving onto the West Coast, and a "tongue" of dry air across the Sierra Nevada Range into the Great Basin and Northern Rockies. This is the classic pattern associated with the "breakdown of the 500-millibar ridge." Nimchuk and Janz (1984) state that the breakdown of the 500-millibar ridge is clearly associated with severe wild-fire behavior. However, not every "breakdown of the 500-millibar ridge" will produce extreme fire weather conditions—both instability and dry air must be present. Haines has addressed these two parameters

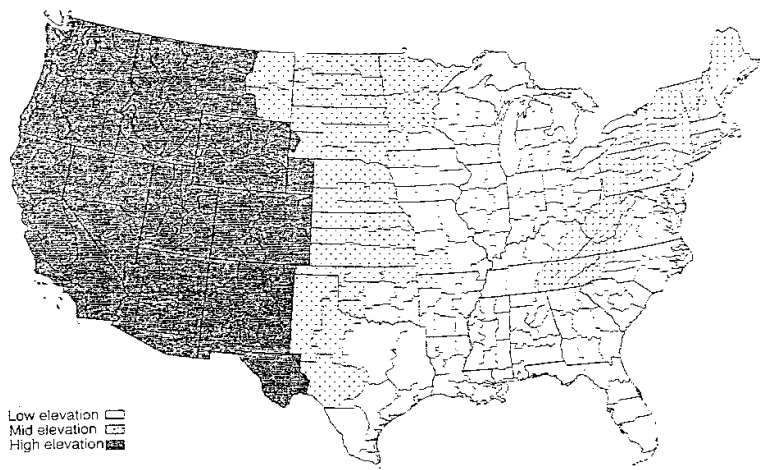


Figure 1—Map of the United States divided into three regional elevations (Haines 1988).

Table 1—Stability and moisture limits in the low-, mid-, and high-elevation Haines indexes

Elevation	Stability term	Moisture term
Low	950–850 mb °T	850 mb °T – dewpoint
	A = 1 when 3 °C or less	B = 1 when 5 °C or less
	A = 2 when 4–7 °C	B = 2 when 6–9 °C
Mid	850–700 mb °T	850 mb °T – dewpoint
	A = 1 when 5 °C or less	B = 1 when 5 °C or less
	A = 2 when 6–10 °C	B = 2 when 6–12 °C
High	700–500 mb °T	700 mb °T – dewpoint
	A = 1 when 17 °C or less	B = 1 when 14 °C or less
	A = 2 when 18–21 °C	B = 2 when 15–20 °C
	A = 3 when 22 °C or more	B = 3 when 21 °C or more

in developing his index.

Idaho Wildfires and the Haines Index

The Haines Index is the first attempt to construct a formal fire-weather index based upon features of the lower atmosphere. Does it work? To answer that question, wildfires in central Idaho (fig. 3) were investi-

gated in an attempt to correlate the Haines Index and large fire growth. One of these wildfires was the devastating Lowman Fire of late July and early August of 1989.

The Lowman Fire

The Lowman Fire was one of many fires that started on the Boise National Forest during an outbreak of

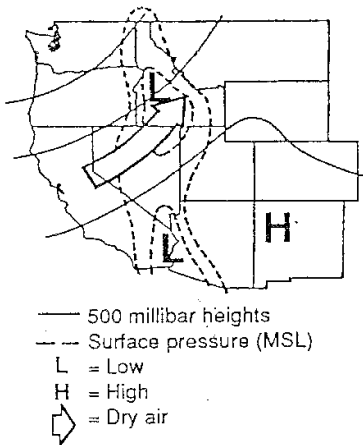


Figure 2—Typical synoptic situation that produces a moderate to high Haines Index value.

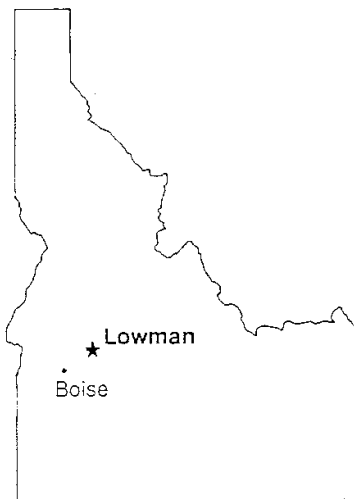


Figure 3—Map of Idaho with wildfire locations.

dry lightning on July 26, 1989. The fire spread only a short distance the following day, but by July 28, fire

activity began to increase. Extreme burning conditions developed the afternoon of July 29. (See fig. 4.) Crowning and spotting pushed the fire 5.75 miles (9 km) to the northeast. The fire burned through the eastern edge of the small town of Lowman destroying 25 buildings and a number of vehicles and closing State Highway 21. All residents of Lowman were evacuated. Fortunately there were no injuries or deaths. The fire continued to spread toward the northeast during the next 3 days, but at a lower rate. Cooler temperatures and higher relative humidities moved over the fire August 2 with very little acreage lost after that date. The size of the Lowman Fire (over 46,000 acres or 18,616 ha), its extreme fire behavior, and the loss of homes and personal belongings will make the Lowman Fire one to remember for

many years.

The rate of spread (ROS) exhibited by the Lowman Fire is plotted against the Haines Index in figure 5. On the morning of July 29 (from the 0600 MDT Boise radiosonde), the Haines Index number 6 (fig. 6) indicated a high potential for large fire growth. At approximately 1400 MDT, the fire made a rapid run toward the northeast at well over 75 chains (1,508 m) per hour. Temperature at the time was between 90 and 95 °F (32 and 36 C°) with the relative humidity as low as 8 percent. Surface winds were measured at 5 to 10 miles per hour (8 to 16 km/h) with occasional gusts to 15 miles per hour (24 km/h), but were much stronger near the fire front due to strong indrafts into the smoke column. For the next 3 days, the Haines Index fell to 5, still indicating a

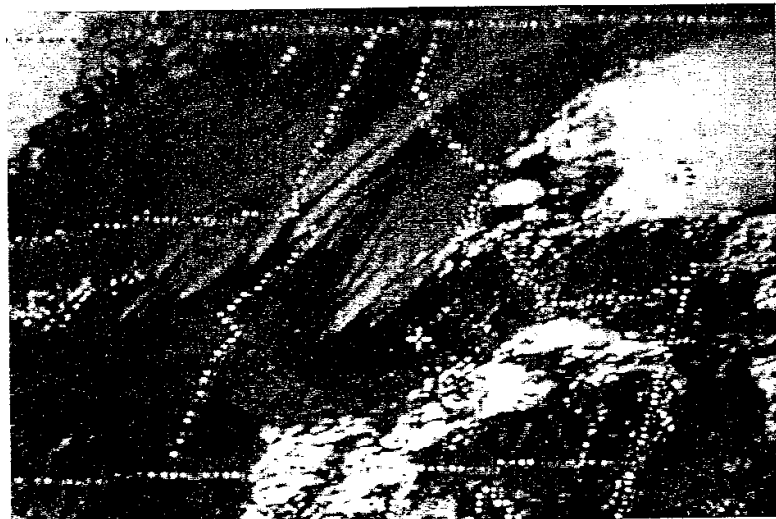


Figure 4—Late afternoon satellite picture showing large smoke plumes from fires in central Idaho and northeast Oregon.

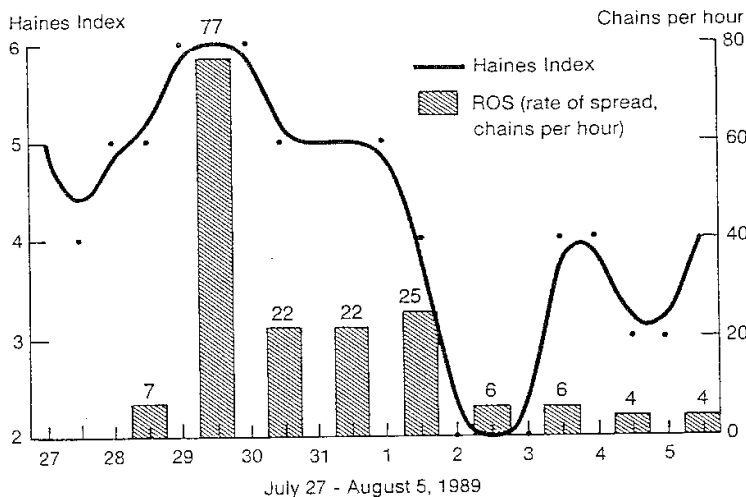


Figure 5—Haines Index compared with rate of spread (ROS) for Lowman Fire, July 27 to August 5, 1989. Key: 6 = high, 5 = moderate, 4 = low, and 2-3 = very low.

moderate potential for large growth. Although the ROS dropped to 25 chains (503 m) or less per hour, the fire continued to move too quickly to fight effectively. The Haines Index (fig. 7) dropped into the low-very low range August 2, resulting in a significant drop in the fire's ROS (5 chains (101 m) or less per hour).

Extreme fire behavior, with crowning and long-range spotting, was exhibited by the fire when the Haines Index was 5 or 6, but when the index lowered to 4 or less, fire activity significantly diminished.

1990 Results

During the 1990 fire season, the Boise Fire Weather Office included the Haines Index in the daily fire weather forecasts. A computer-generated map of Haines Index

values across the Western United States was also produced twice a day, based upon the 0600 and 1800 MDT upper air data. The Haines Index was then compared with the acreage burned on the Boise Fire Weather District (Southern Idaho, western Wyoming, and extreme southeast Oregon) to see if there was a correlation between days in which the index was in the high category and the occurrence of large fires. Between July and September, the Haines Index was 6 (high potential for large fire growth) on only 6 percent of the days. Over 75 percent of the burned acreage occurred on these days. The Haines Index was 2, 3, or 4 (very low or low potential) on 68 percent of the days. Only 7 percent of the acreage burned on those days. Needless to say, fire activity on the Boise Fire Weather District in 1990 verified the Haines Index.

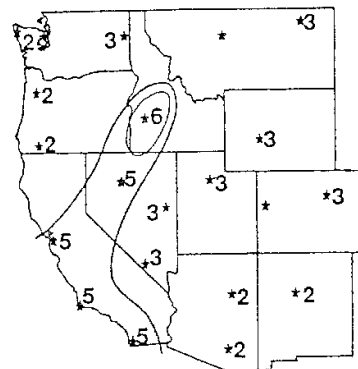


Figure 6—Haines Index map for 0600 MDT, July 29, 1989. Solid contour indicates a value of 5 or greater; dashed contour, 6. (The Great Falls, MT, and Grand Junction, CO, data are missing for July 19, 1989.)

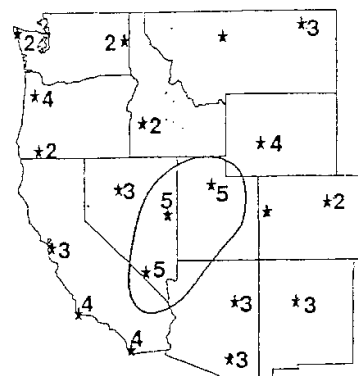


Figure 7—Haines Index map for 0600 MDT, August 2, 1989. Solid contour indicates a value of 5. (The Great Falls, MT, and Grand Junction, CO, data are missing for August 2, 1989.)

Summary

The Haines Index, which combines values for instability and dry air, is a valuable indicator of the potential for large fire growth. Dry air affects fire

behavior by lowering fuel moisture, which results in more fuel available for the fire and by increasing the probability of spotting. Instability affects fire behavior by enhancing the vertical size of the smoke column, resulting in strong surface winds as air rushes into the fire to replace air evacuated by the smoke column. This is the mechanism by which fires create their own wind. When the Haines Index number is 5 or 6, the probability of extreme fire behavior (crowning and spotting) significantly increases. Fire behavior is usually low, with only minimal fire growth, when the index number is 4 or less. The Haines Index is best suited to volume-dominated fires; that is, fires where the power of the fire is greater than the power of the wind or the atmosphere. Wind is not a parameter of the Haines Index. The index has yet to be tested on fires driven by winds, such as Santa Ana and Sundowner where the power of the wind is greater than that of the fire. ■

Literature Cited

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Acquisition Guidelines for FEPP

Staying within the authority and intent of the legislation authorizing the lending of Federal Excess Personal Property (FEPP) to the State Foresters to help meet the national need for rural and wildland fire protection capability and resources can sometimes be confusing. Under this legislative authority, State Foresters and their fire service cooperators have acquired trucks, tools, and other items directly related to fire suppression.

Here is some guidance for program managers on what types of items are unacceptable for acquisition as FEPP and the circumstances in which FEPP items can be used.

Unacceptable Items for FEPP Program

The following types of items cannot be acquired as FEPP in this program: Hazardous materials, recreational and athletic equipment, nonfire protective clothing, firearms, office machines, sedans, cameras, paint, cement mixer trucks, asphalt spreaders, trash compactor trucks, street sweepers, bucket trucks and cherry pickers, truck-mounted posthole diggers, and appliances (special authorization necessary).

Acceptable Items for FEPP Program Fire Suppression Activities

In addition, State Foresters can acquire for loan to fire service cooperators, including State conservation camps and inmate crews, *only* those items which are designed for, or can be modified for, *direct use in fire suppression activities*. These will normally be limited to the following: Trucks, tanks, firetools, winches, hoses, nozzles, air compressors,

breathing apparatus, protective clothing, tactical communication systems, trailers, generators, vehicle parts and tires, light bars and sirens, and materials to fabricate and maintain these items. *This list does not include furniture, building materials, office supplies and equipment, or handtools.*

These lists are not comprehensive. Other items not listed here could possibly come up for decision.

Agreements in Place

Each cooperator must have an agreement in place with the State Forester that outlines the terms and conditions of the loan of property before the State Forester authorizes a specific loan and delivers the property.

Further information on the FEPP program can be obtained from the regional or Washington Office FEPP manager. ■

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