FEWG – A WORKING GROUP FOR NCDFR MTM

NC Fire Danger Technote 01 – January 6th, 2009

Fire Danger in North Carolina: "Weather Patterns & Fuel Conditions Contributing to Large Fire Growth"

Information for Division personnel and the Forest Protection Program

Fish Day Fire May 1994

NCDFR Fire Research & Development has noted that wind profiles and the Haines Index need to be an essential part of a Fire Danger Operating Plan. A strategic plan initiating this effort has been prepared and presented to 13 NCDFR Districts. The daily process of identifying and notifying fire-fighting personnel of weather patterns that support large fire growth is essential. The presence of Byram's or Brotak's wind profiles, a Haines Index rating of 4 or higher, cold front passages, and trough positions, are weather factors which, when combined with receptive fuels, have lead to large wildfires with extreme fire behavior. Applying this information and past experience, fire fighters can make informed decisions as to strategy and tactics, readiness and placement of fire fighting resources, and their safety.

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Critical Weather Factors Contributing to Extreme Fire Behavior and Large Fire Growth

1. Dewpoint Depression - the amount of moisture in the air, ≥ 10 degrees Centigrade @ 850mb.
2. Temperature lapse rate ≥ 7 degrees Centigrade @ 950 - 850 mb.
3. Frontal passages within ± 200 miles (pre or post cold front passage) that possess strong winds (surface @ 9 kts. & upper @ 34 kts.), tight pressure gradients and little or no precipitation.
4. Presence of intense upper level troughs @ 500 mb level (~ 5,500m) within ± 300 miles. Trough radius of curvature < 640 km & in the SE section.
5. Strong winds above the nocturnal inversion.
6. Low level jets (≤ 3000 ft. jetpoint).
7. Sea breeze fronts.
8. Byram or Brotak wind profiles.
9. Haines Index > 4

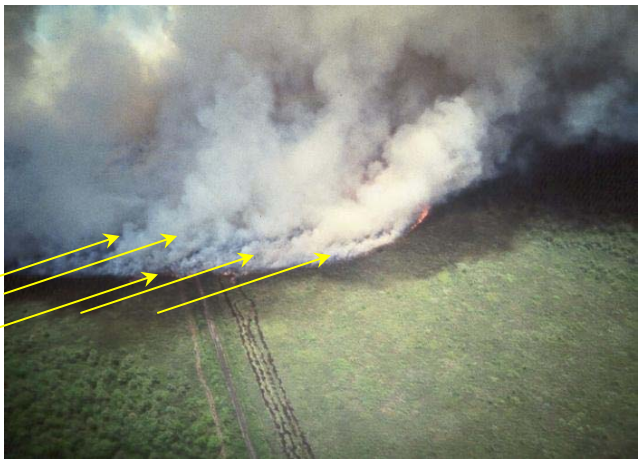
Coastal plain fires in the NC have frequently occurred in the months of March, April, and May. Yet, they have also occurred in June, August, September, November, December and January. From 1963 to 1972, there were 19 major and project fires in NC (appendix 1) sharing several common weather factors. Two of these, Byram's and Brotak's wind profiles have distinctive characteristics and are extremely well documented. Byram's Profile is a reverse wind speed profile with a low-level jet, while Brotak's profile is a very strong wind speed profile (appendix 2). It is the purpose of this paper to:

1) Identify typical weather factors that have repeatedly influenced NC's fire danger and fire behavior on wildfires,
2) Increase the awareness of fire suppression personnel about these factors,
3) And enhance personnel safety.

Wind profiles, frontal passages, trough formations, low upper air moisture and strong winds aloft are critical fire weather factors. These individually or in combination, can elevate fire danger to an extreme level. The daily review of these factors and the Haines Index (HI) would be very helpful in assessing the day's fire danger. The HI is a new concept at NC's disposal. It is available daily from the National Weather Service and can be provided in the daily Fire Weather Forecast. Although it is not currently used, the HI is a measure of atmospheric fire risk associated with large fire growth potential. Review of previous and current research papers concerning past fires in NC indicate that the HI is statistically significant. In NC, large fires have consistently occurred when the HI has reached a level 4 or higher. Conversations with researchers Donald Haines, and Brian Potter, and presentations before the NWCG Fire Danger Working Team have resulted in the effort to fine-tune this index for national and local use.

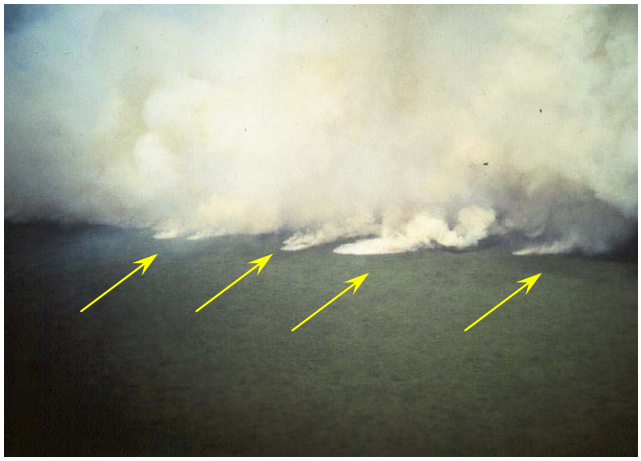
NC's past fire history contains many examples. In March 1971 the Air Force Bomb Range Fire consumed 29,300 acres while in May 1994 the Fish Day Fire consumed 25,000 acres. Although these two separate fires were decades apart, they were under the influence of some of the same critical fire weather factors. In both instances, Byram's & Brotak's wind profiles (appendix 2) and a Haines Index of 4 to 5 were present and resulted in severe fire behavior. These two fires and the other fires that were noted in appendix 1 shared many common weather denominators. Early identification of these weather events and notification of their expected occurrence can foster better preparations and adjustments for fire suppression action and fireline safety.

A major fire run on the Fish Day Fire, 1994. The combined effect of the Byram's & Brotak's Wind Profiles, the pocosin's Energy Release Component (NFDRS value of 57), & low fuel moistures with reverse moisture levels between the 1hr. and 10 hr. timelag fuels generate two counter-rotating vortices. The wind profiles have been identified and documented in the literature through the research efforts of Byram, Wade, and Brotak. These profiles are troublesome & dangerous for firefighters. Using the descriptive terms established in 1958 (adverse, questionable, & favorable) can be misleading. They require further emphasis during training sessions or warrant a revision.



Extreme fire behavior is exhibited in the formation of multiple horizontal vortices on the fire's flank. If these vortices roll beyond the fire's perimeter, the fire suppression effort becomes extremely dangerous for fire fighters.

Horizontal vortices on the fire's flank create new spot fires well beyond the fire's perimeter. Aerial reconnaissance is critical & necessary at this time. Pilots need to be sure that this information is passed on in order to provide for firefighters' safety



Vortices on the flank collapse. The spot fires begin their fire runs and join the main body of the fire.

Fish Day Fire Division Indigo flanking action by NCDFR strike team. Fuels & exhibited fire behavior under the influence of critical fire weather factors eventually leading to a burnover / near miss event. The state of the fuels and burning conditions are described in appendix 3.

The Fire Danger Program is responsible for increasing the awareness and understanding of historical climatological values that have contributed to large fire growth in North Carolina. Dewpoint depression (upper air moisture), instability (temperature change with altitude) and the departure from normal trends need to be recognized especially when they elevate fire danger. Reviewing the research efforts by Haines, Brotak, & Potter, the dewpoint depression is a major contributing factor in elevating NC's fire danger. As of March 15, 1999 repeated cold front movements across the state were made up of excessively dry upper air. The relative humidity was as low as 2% at approximately 600 ft. above the surface, while at the surface the relative humidity was 19-27 %. Byram's and Brotak's wind profiles were present as well. On this particular day wildfire activity was up and the resulting wildfire intensities necessitated the use of air tankers to assist in the fire suppression effort.

With the information and technology that is available today, it would be prudent for fire management and fire suppression forces to be informed on these critical fire weather factors. This can come from review of the morning & evening soundings, front & trough positions, the daily & historical trend values of NFDRS, & the Haines Index. Improving the transfer of this information enhances the information base of NCDFR's fire organization. Because burning conditions and the potential for extreme fire behavior can be more accurately anticipated and planned for, more informed decisions are possible. The chances of being surprised by events on wildfires can be minimized.

Recommendations

Historically, twenty previously documented forest fires including the Fish Day Fire, have shared several critical fire weather factors. These factors have influenced burning conditions on initiating or ongoing fires resulting in large forest fires. These critical weather factors contributing to extreme fire behavior and large fire growth include:

1. Dewpoint Depression of ≥ 10 degrees Centigrade (or 50°F) @ 850mb level.
2. Temperature lapse rate ≥ 7 degrees Centigrade (or 44.6°F) @ 950 - 850 mb levels.
3. Position and/or location of frontal passages possessing strong winds and of intense upper level troughs @ 500 mb level with a trough radius of curvature < 640 km (or 398 miles).
4. Strong winds above the nocturnal inversion.
5. Sea breeze fronts.
6. Pre-frontal and post-frontal (cold) passage associated with Byram (reverse wind speed and low level jet) & Brotak (surface @ 9 kts. (or 10.45mph) & upper air @ 34 kts. (or 39 mph)) wind profiles.
7. Haines Index of ≥ 4.

The following actions are recommended:

1. Routinely supply or alert operation rooms to the presence of Byram's or Brotak's wind profiles, the Haines Index of a level 4 or higher, and the presence, location, and tracking of cold fronts and troughs. These critical fire weather factors are historically linked to large fire growth in NC. This information can be acquired from the NWS and incorporated into the Fire Weather Forecast and forecast updates.

2. Review and train personnel on the concepts and significance of these critical weather factors (Haines, Brotak & Bryam) and expected severe fire behavior especially horizontal vortices. This should include how they relate to planning and readiness, and the implementing of safe strategy and tactics.

3. Continue the effort to establish an interagency network of NFDRS RAWS and develop the beneficial by products of archiving weather data into WIMS.

4. Support and join the interagency research effort to examine and fine-tune the Haines Index for national and local use.

5. Initiate a research effort to examine large fires that have occurred since 1972 in order to update existing historical information and investigate common factors that may be present.

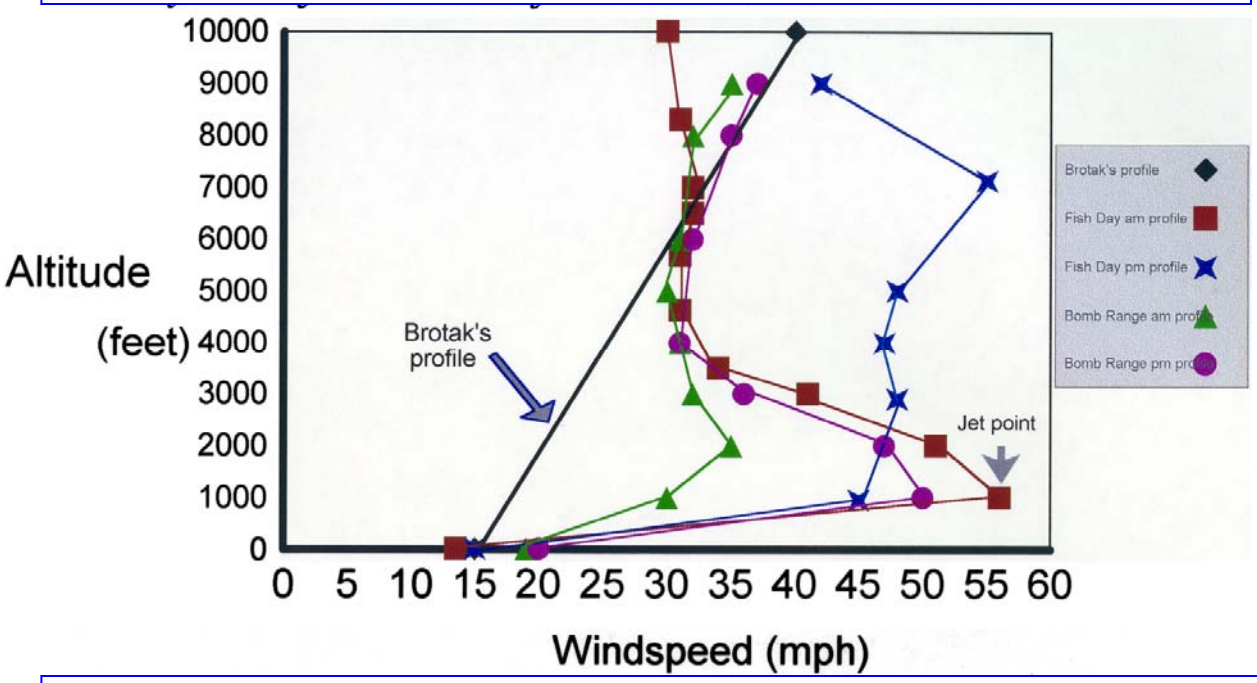
6. Continue the acquisition of historical data sets to create an information base for the production of the dynamic NWCG FDWT Fire Danger Rating Fire Fighters Pocket Card.

Appendix 1

Date	Acreage Burned	Weather Pattern
4 / 4/ 63	**23,200**	Following a dry cold front passage
4 / 4-5/63	**15,300**	Following a dry cold front passage
4 /4-5/ 18/ 63	**37,000**	Prior to cold frontal passage, & Following a dry cold front
4 / 4/ 63	**44,200**	Following a dry cold front passage
4 / 4-5/ 63	**7,100**	Following a dry cold front passage
4 / 4-5/ 63	**6,200**	Following a dry cold front passage
4/ 23-26/ 63	**26,500**	Prior to cold frontal passage, &Following a dry cold front
4 / 13/ 65	**5,000**	Following a dry cold front
4 / 1-10/ 66	**5,800**	Prior to cold frontal passage & Following a dry cold front & Warm sector of a low
4 / 1-5/ 66	**17,000**	Prior to cold frontal passage, & Following a dry cold front & Warm sector of a low
4 / 1-7/ 66	**9,400**	Prior to cold frontal passage, & Following a dry cold front
4 / 2-4/ 67	**5,100**	Prior to cold frontal passage, & Following a dry cold front
4 / 3-4/ 67	**8,000**	Prior to cold frontal passage, & Following a dry cold front
5 / 8-13/ 69	**14,700**	Warm sector of a high, & Prior to cold frontal passage & Following a dry cold front
12/ 4-5/ 70	**6,300**	Following a dry cold front passage
3 /22-23/71	**29,300**	Prior to a cold front passage, & Following a dry cold front
4 / 12-15/71	**5,800**	Prior to a cold front passage & Following a dry cold front
4 / 18-21/71	**14,400**	Following dry cold frontal passage
4 / 16-18/72	**18,500**	Prior to a cold front passage, & Following a dry cold front

Note: The Weather Pattern column also reflects the presence of Brotak's or Byram's wind profiles and upper level troughs. These fires also had a Haines Index of greater than 4.
The Fish Day Fire experienced these same severe fire weather patterns as well as a Haines Index, which reached a level 5.

Byram and Brotak Wind Profiles
Troublesome wind profiles for major wildfires in North Carolina.



In 3 of the 4 Byram profiles there is a characteristic reverse wind speed profile associated with a low-level jet point. This point is usually at< 3,000 feet. In each fire situation the criteria for Brotak's profile is also met. Historically, when either of these profiles are present the development or chance of a major wildland fire is increased.

Appendix 3

National Fire Danger Rating System

Describing Fire Danger by Components & Indexes

The Fish Day Fire was under the influence several critical fire weather factors. Troublesome wind profiles were recorded by the upper air sounding analysis conducted at 7:00 am. The state of fuels and burning conditions were clearly indicated in the calculated 1:00pm (1300 Hrs.) NFDRS Components and Indexes and the NFDRS fuel moistures. The fire danger readings resulted in 3 new maximum peak values ever recorded as they surpassed the previous historical values.

Catherine Lake RAWS	**NFDRS Values For 5/26/94**	**Old Historical Maximum Peak Values for May**
Ignition Component	**57**	**50**
Spread Component	**102**	**84**
Energy Release Component	**57**	**63**
Burning Index	**162**	**156**
Build Up Index (BUI)	**46**	**not known**
Keetch Byram Drought Index	**320**	**not known**

The 1 hr. and the 10 hr. fuels were very easily ignitable and their moisture levels were reversed. The 10 hr. fuels were drier than the 1 hr. fuels (fine fuels) and the 100 hr. fuels were more indicative of a normal 10 hr. fuel moisture level.

Catherine Lake RAWS Calculated 1300 Hr. NFDRS Fuel Moistures

1hr. = 8.1 % **10hr. = 6.6 %** **100hr. = 12.8 %** **1000hr. = 21.7 %**

The Keetch Byram Drought Index was still at a moist level of 320, while the Build Up Index was at precarious level of 46. In NCDFR policy & procedure, one of the elements identified for Blow Up conditions is a BUI > 40. Taking into consideration these 1300 hr. NFDRS values and fuel moistures, the 1hr., 10 hr., and the 100 hr. fuels were readily available to burn and extreme fire behavior was to be expected.

Literature Referenced

1. Wade, Dale D., and Ward, Darold E.
   1973. An Analysis of the Air Force Bomb Range Fire. Southeast Forest Experiment Station,
   USDA Forest Service Res. Paper. SE-105, 38 pp.

2. Brotak, E. A.
   1992. Low Level Weather Conditions Preceding Major Wildfires.
   Fire Management Notes Volumes 53-54, Number 3, p23-26.

3. Brotak, E.A., and Reifsnyder, W.E.
   1977. An Investigation of the Synoptic Situations Associated with Major Wildland Fires.
   Journal of Applied Meteorology, September 1977, Vol. 16, No.9 p 867-870.

4. Byram, G. M.
   1954. Atmospheric conditions related to blowup fires.
   USDA Forest Service Station. Paper 35, 31p.

5. Haines, D.A.
   1988. A lower atmospheric severity index for wildland fires.
   National Weather Digest. 13(2): P23-27

6. Haines, D.A.
   1982. Horizontal Roll Vortices and Crown Fires.
   Journal of Applied Meteorology. Vol.21, No.6 p 751-763.

7. Haines, D.A.
   1983. Wind tunnel generation of horizontal roll vortices over a differentially heated surface.
   Nature Vol. 306 24 November 1983 p 351-352.

8. Potter, B.E.
   1996. Atmospheric Properties Associated with Large Wildfires.
   Int. J. Wildland Fire 6(2): p71-76, 1996.

9. Potter, B.E.
   Conversations concerning the statistics of meteorological variables relevant to wildfire occurrence in NC.