Wildland Fire Behavior Case Studies and Analyses: Value, Approaches, and Practical Uses

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Since 1936, the Washington Office of the USDA Forest Service has published a periodical devoted to articles dealing with a very wide range of fire management topics. The name of this journal has changed through the years, from *Fire Control Notes*, to *Fire Management*, to *Fire Management Notes*, and finally to *Fire Management Today*.* A good many of the 243 issues that have been published in the past 67 years have included a fire-behavior-related article. With the passage of time, however, many of these articles have become "buried," found only by the most intrepid researchers on the shelves of major libraries.

In an effort to unbury the past and to increase both institutional memory and organizational learning within the wildland fire community, the authors approached the editorial staff of *Fire Management Today* with the idea of republishing a selection of these past fire-behavior-related articles. We are pleased that they took us up on our suggestion.

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* For more on the history of *Fire Management Today*, see Hutch Brown, "How Did *Fire Control Notes* Become *Fire Management Today*?" *Fire Management Today* 60(1) [Winter 2000]: 8–14.

In an effort to unbury the past and to increase both institutional memory and organizational learning within the wildland fire community, we are reprinting past articles on fire behavior.

This special issue of *Fire Management Today* begins a series of three consecutive issues with articles related to fire behavior. This issue contains the first of two installments of articles involving fire behavior case studies and analyses of wildfires; examples pertaining to prescribed fires are not included (e.g., Custer and Thorsen 1996). The 19 case studies and analyses in this issue are presented in chronological order, from 1937 to 1967. The third issue in this series will be devoted to aids, guides, and knowledge-based protocols involved in forecasting wildland fire behavior for safe and effective fire suppression.

General Value of Case Studies

The importance of documented case studies or histories of wildland fires has been repeatedly emphasized by both fire managers and fire researchers (e.g., Byram 1960; Thomas 1994; Turner and others 1961). As long-time Forest Service wildland fire researcher/administrator Craig Chandler (1976) has noted, "Time and time again case histories have proven their value as training aids and as sources of research data." The authors strongly support this notion and have endeavored to reflect it in our individual work areas in fire research and fire management, respectively (Alexander and Lanoville 1987; Thomas 1991).

The idea of relying on wildfires as a possible source of data is especially pertinent to empirically based schemes for quantitative fire behavior prediction that rely on this kind of information in whole or in part (e.g., Alexander 1985; Forestry Canada Fire Danger Group 1992; Rothermel 1991). This fact is especially significant at the extreme end of the fire intensity scale, where experimental fires are exceedingly difficult to arrange (Alexander and Quintilio 1990; Cheney and others 1998).

Information gleaned from wildland fire behavior case studies has also proved of value in testing and evaluating various fire models, theories, decision aids and support systems, and management guidelines (e.g., Anderson 1983; Haines and others 1986; Nelson 1993; Pearce and Alexander 1994). For example, Lindenmuth and Davis (1973) used an observation of the initial run of the Battle Fire, a 28,400-acre

(11,500-ha) fire that occurred May 14–20, 1972, on the Prescott National Forest, AZ, to assess the performance of their empirically based model for predicting fire spread in Arizona's oak chaparral fuel type.

Approaches to Case Studies

There are many examples in North America and elsewhere where fire researchers and fire managers have attempted to observe and document the behavior of free-burning fires, using various types of data collection methods and monitoring equipment, on an ad hoc or a more formal basis (e.g., Barney and others 1978; Barrows 1961; Billing 1986; Schaefer 1957; Traylor 1961*). These efforts extend back many years (Gisborne 1929) and continue into the 21st century (e.g., Burrows and others 2000).

Fire behavior researchers are rarely in the right place at the right time to observe and document the behavior of forest and range fires. While there have, of course, been some exceptions (e.g., Sneeuwjagt 1974; Stocks and Flannigan 1987), including escapes from outdoor experimental fires (Alexander and others 1991; Stocks 1987), for the most part fire operations personnel tend to be in the best position to make and record key observations. Probably the most concerted and systematic effort by fire researchers to observe and record actual fire behavior was made by the Forest Service's Southern Forest Fire Laboratory in Macon, GA, from the late 1950s to early 1970s (DeCoste and Sackett 1966; Sackett and DeCoste 1967). This was no doubt due in large part to George Byram's (1960) influence.

Some limited documentation has also been undertaken by fire managers and fire researchers serving as fire behavior officers or specialists/analysts on various wildland fire incidents (e.g., Johnson 1964; McCaw, Maher, and Gillen 1992; Norum 1982; Thomas 1991). Fire researchers have also been involved in many "after-the-fact" investigations (e.g., Butler and Reynolds 1997; Fogarty and others 1996; McCaw, Simpson, and Maher 1992). Van Wagner (1971) has pointed out that "some valuable reference data can be collected by being in the right place at the right time. It is, in fact, quite feasible to obtain good data by visiting the scene of a … fire shortly after it has occurred, while its history is still fresh both on the ground and in the mind of the fire boss."

Byram (1954) made extensive use of the case study method of individual fires in his research into blowup fire behavior. As he notes, "Some of the observations and details of behavior are written down in fire reports, but most of the information is still in the memories of men who worked on the fires. Fire behavior may, therefore, be difficult to reconstruct at times, especially on fires which occurred a number of years ago. Usually, however, a surprising amount of detail can be obtained by talking with men who were on the fires and by going over the fire area with them."

A final possibility is the hindsight analysis of major wildland fire incidents in the light of present-day knowledge and tools using existing historical information to establish the fire's chronology and general behavior. The reports of Haines and Sando (1969), Stocks and Walker (1973), Street and Alexander (1980), and Rothermel (1993) are good examples of this approach to case studies.

Pragmatic Value of Case Studies

A practical fire manager, always interested in the control of wildfires and the ignition of prescribed fires, might ask: What is the use of historical fire behavior case studies? How can old documents help fire management personnel become better managers of forest and range fires, in all their forms? Beyond the recreation of a "good read," what utility do these articles offer? How can old essays become relevant for a 21st-century firefighter?

The old articles will only seem dated if we fail to make use of them. There are two primary reasons to thoroughly study these fire behavior case studies:

- To learn from them and thereby lessen the chance of making the same mistake again; and
- To prepare ourselves not to be surprised to the point of distraction by a fire's surprising behavior in a particular fuel type under a given weather condition.

Not making the same mistake twice and being prepared to be surprised will go a long way toward creating a highly reliable firefighting organization where safety truly matters.

Unless we actively learn from past wildland fires, then the only way we can gain additional fire behavior knowledge is to actually experi-

* A summary of this work can be found in R.E. Traylor, "Correlation of Weather to Fire Spread in Grass and Brush Fuels on the Snake River Plains in Southern Idaho," *Fire Control Notes* 22(4) [Fall 1961]: 118–119.

ence a fire's behavior or to model the fire's behavior on a computer at our desk. Even the most active fire behavior analyst (FBAN) rarely gets enough near-real-time opportunities to predict the spread and intensity in every fuel complex or to complete a prediction enough times to become good at it (Thomas 1994). The best learning scenario for a practicing fire behaviorist is a combination of all three learning techniques: actively using case studies, getting field experience, and practicing computer modeling. Each is a distinct mode of learning and adaptation; when combined, they become a powerful model for continuous learning.

Case study knowledge, coupled with experienced judgment and fire behavior modeling, is also considered an effective operational technique or procedure for appraising fire potential (Brown 1978). Burrows (1984) maintains that most wildland firefighters base their expectations of how a fire will behave largely on experience and, to a lesser extent, on fire behavior guides. If this is indeed the case, then it is worth reiterating the points made by Forest Service fire research pioneer Harry T. Gisborne (1948) about experienced judgment: "For what is experienced judgment except opinion based on knowledge acquired by experience? If you have fought forest fires in every different fuel type, under all possible kinds of weather, and if you have remembered exactly what happened in each of these combinations, your experienced judgment is probably very good. But if you have not fought all sizes of fires in all kinds of fuel types under all kinds of weather then your experience does not include knowledge of all the conditions." Presumably then, case studies can help supplement and thereby strengthen (but never replace) a person's experience level.

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> *–Craig Chandler (1976)*

Safety Value of Case Studies

As we read through this chronological selection of articles, especially the accounts of forest fires where firefighters lost their lives or there were near-misses or unforeseen blowups, we can ask ourselves and our crews whether we have fully grasped the major "lessons learned" from these past fire behavior events. Excellent methods of using past fire behavior knowledge from case studies to increase wildland firefighter safety in the future are the staff ride (Alexander 2002; Thomas and Cook 2002),* the sand box exercise (Euler 1946), yearly fire refreshers (e.g., the 2001 USDI Bureau of Land Management Fireline Safety Refresher videos), and weekly tailgate safety meetings.

For example, one of these articles could be handed out each week to members of an organized fire crew. The crew would be given time to read and ponder the article. Then, in a group setting, with the fire foreman (i.e., hotshot superintendent, smokejumper-in-charge, local fire management officer, etc.) acting as facilitator, the crew could be led through a series of questions that the article has inspired. For example:

- Is there something that we can apply to our current situation?
- Have we learned all that this old fire has to teach us?
- Could the same situation occur today?
- What are we going to do differently after reading this case study?

This process, if faithfully followed throughout a fire season, would increase both mindfulness and resilience (Weick and Sutcliffe 2001), the two hallmarks of individuals and their organizations determined to do everything they can to control and use wildland fire safely.

Both authors have used case studies to lead training sessions in the classroom. One of us (Thomas) has also used the technique in the field at the site of past fires. In June 1994, a group of FBANs on a visit to the site of the 1949 Mann Gulch Fire were asked, using existing historical case study information as a starting point for a fire behavior prediction, if they could have prevented the firefighter fatalities that occurred on this infamous fire. Using the available historical fire information, a similar question was asked of a large group of fire management personnel on a staff ride of the 1990 Dude Fire (Thomas and Cook 2002). In both of these examples, many of the students said that these "training" sessions were some of the best they had ever attended. Using case studies or histories, an "old" fire's fire behavior came alive.

* For more on the staff ride technique, see the various articles on the Dude Fire Staff Ride in *Fire Management Today* 62(4) [Fall 2001].

> "A surprising amount of detail can be obtained by talking with men who were on the fires and by going over the fire area with them."
>
> *–George Byram (1954)*

Another benefit of having these articles available again is for their use within fuel specialist reports used in environmental assessments. Fuel specialists are increasingly called upon to justify why an interdisciplinary team recommended one fire hazard abatement technique over another. These case histories, especially the descriptions of fire behavior in a given fuel type (e.g., Helms 1979), could be cited in those reports (or hyperlinked to a main database), saving much analysis time. The fuels specialist would not have to explain how a fire might burn in a given fuel type, for she or he would have a published account to cite or hyperlink to.

Learning Contribution

A learning organization has been defined as one that is "skilled at creating, acquiring, interpreting, transferring, and retaining knowledge, and at purposefully modifying its behavior to reflect new knowledge insights" (Garvin 2000). Fire behavior case studies go a long way toward preparing a foundation for organizational learning; in so doing, they follow the true spirit of learning implied in this definition. Simply put, our fire management culture, now dominated by a learning pattern of trial and error, would become a learning culture, one in which a systematic study of the past through the use of case studies would become a routine procedure.

This special issue of *Fire Management Today* devoted to fire behavior, and the two others that will follow, are in keeping with the ideals and sentiment expressed by Roy Headley (1936) in the very first issue of *Fire Control Notes*. Headley, who cofounded the journal as the head of the Forest Service's Division of Fire Control (the predecessor of today's Fire and Aviation Management), called for integrating and sharing "the experience, thinking, and experiments" of the many people engaged in wildland fire management. To this end, Headley envisioned *Fire Control Notes* as "a common meeting ground, a clearing-house of developments." In this sense, *Fire Management Today*, by republishing the past (and thereby reviving it for the future), has rediscovered its own unique niche.

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References

Alexander, M.E. 1985. Estimating the length-to-breadth ratio of elliptical forest fire patterns. In: Donoghue, L.R.; Martin, R.E., eds. Proceedings of the Eighth Conference on Fire and Forest Meteorology; 1985 April 29–May 2; Detroit, MI. SAF Publ. 85–04. Bethesda, MD: Society of American Foresters: 287–304.

Alexander, M.E. 2002. The staff ride approach to wildland fire behavior and firefighter safety awareness training. Fire Management Today. 62(4): 25–30.

Alexander, M.E.; Lanoville, R.A. 1987. Wildfires as a source of fire behavior data: A case study from Northwest Territories, Canada. In: Postprint Volume, Ninth Conference on Fire and Forest Meteorology; 1987 April 21–24; San Diego, CA. Boston, MA: American Meteorological Society: 86–93.

Alexander, M.E.; Quintilio, D. 1990. Perspectives on experimental fires in Canadian forestry research. Mathematical and Computer Modelling. 13(12): 17–26.

Alexander, M.E.; Stocks, B.J.; Lawson, B.D. 1991. Fire behavior in black spruce–lichen woodland: The Porter Lake Project. Inf. Rep. NOR–X–310. Edmonton, AB: Forestry Canada, Northern Forestry Centre.

Anderson, H.E. 1983. Predicting wind-driven wild land fire size and shape. Res. Pap. INT–305. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station.

Barney, R.J.; Noste, N.V.; Wilson, R.A. 1978. Rates of spread of wildfire in Alaskan fuels. Res. Note PNW–311. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station.

Barrows, J.S. 1961. Natural phenomena exhibited by forest fires. In: Berl, W.G., ed. Proceedings of the International Symposium on the Use of Models in Fire Research; 1960 November 9–10; Washington, DC. Publ. 786. Washington, DC: National Academy of Sciences—National Research Council.

Billing, P. 1986. Operational aspects of the infra-red line scanner. Res. Rep. No. 26. Melbourne, VIC: Victoria Department of Conservation, Forests & Lands, Fire Protection Branch.

Brown, J.K. 1978. Fuel inventory and appraisal. Paper presented at the USDA Forest Service National Fire-Danger and Fire-Weather Seminar; 1972 November 14–16; Missoula, MT.

Burrows, N.D. 1984. Predicting blow-up fires in the jarrah forest. Tech. Pap. No. 12. Perth, WA: Forests Department of Western Australia.

Burrows, N.; Ward, B.; Robinson, A. 2000. Behavior and some impacts of a large wildfire in the Gnangara maritime pine (Pinus pinaster) plantation, Western Australia. CALMScience. 3: 251–260.

Butler, B.W.; Reynolds, T.D. 1997. Wildfire case study: Butte City Fire, southeastern Idaho, July 1, 1994. Gen. Tech. Rep. INT–GTR–351. Ogden, UT: USDA Forest Service, Intermountain Research Station.

Byram, G.M. 1954. Atmospheric conditions related to blowup fires. Stn. Pap. No. 35. Asheville, NC: USDA Forest Service, Southeastern Forest Experiment Station. [Reprinted as: National Fire Equipment System Publication NFES 2565 by the National Wildfire Coordinating Group, Boise, ID.]

Byram, G.M. 1960. A problem analysis and proposed research program for the Southern Forest Fire Laboratory. Macon, GA: USDA Forest Service, Southeastern Forest Experiment Station, Southern Forest Fire Laboratory.

Chandler, C.C. 1976. Meteorological needs of fire danger and fire behavior. In: Baker, D.H.; Fosberg, M.A., tech. coords. Proceedings of the Fourth National Conference on Fire and Forest Meteorology; 1976 November 16–18; St. Louis, MO. Gen. Tech. Rep. RM–32. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 38–41.

Cheney, N.P.; Gould, J.S.; Catchpole, W.R. 1998. Prediction of fire spread in grasslands. International Journal of Wildland Fire. 8: 1–13.

Custer, G.; Thorsen, J. 1996. Stand-replacement burn in the Ocala National Forest—A success. Fire Management Notes. 56(2): 7–12.

DeCoste, J.H.; Sackett, S.S. 1966. Baptism by fire. Southern Lumberman. 213(2656): 169–170.

Euler, D.H. 1946. The sand box as a fire-control training tool. Fire Control Notes. 7(1): 37–39.

Fogarty, L.G.; Jackson, A.F.; Lindsay, W.T. 1996. Fire behaviour, suppression and lessons from the Berwick Forest Fire of 26 February 1995. FRI Bull. No. 197, For. Rural Fire Sci. Tech. Ser. Rep. No. 3. Rotorua and Wellington, NZ: New Zealand Forest Research Institute and National Rural Fire Authority.

Forestry Canada Fire Danger Group. 1992. Development and structure of the Canadian Forest Fire Behavior Prediction System. Inf. Rep. ST–X–3. Ottawa, ON: Forestry Canada, Science and Sustainable Development Directorate.

Garvin, D.A. 2000. Learning in action: A guide to putting the learning organization to work. Boston, MA: Harvard Business School Press.

Gisborne, H.T. 1929. The complicated controls of fire behavior. Journal of Forestry. 27: 311–312.

Gisborne, H.T. 1948. Fundamentals of fire behavior. Fire Control Notes. 9(1): 13–24.

Haines, D.A.; Main, W.A.; Simard, A.J. 1986. Fire-danger rating and observed wildfire behavior in the northeastern United States. Res. Pap. NC–274. St. Paul, MN: USDA Forest Service, North Central Forest Experiment Station.

Haines, D.A.; Sando, R.W. 1969. Climatic conditions preceding historically great fires in the North Central Region. Res. Pap. NC–84. St. Paul, MN: USDA Forest Service, North Central Forest Experiment Station.

Headley, R. 1936. Fire Control Notes offers its services. Fire Control Notes. 1(1): 3–4 [reprint: Fire Management Today. 60(1): 6–7].

Helms, J.A. 1979. Positive effects of prescribed burning on wildfire intensities. Fire Management Notes. 40(3): 10–13.

Johnson, V.J. 1964. Chronology and analysis of the Hughes Fire, 1962. Res. Note NOR–8. Juneau, AK: USDA Forest Service, Northern Forest Experiment Station.

Lindenmuth, A.W., Jr.; Davis, J.R. 1973. Predicting fire spread in Arizona's oak chaparral. Res. Pap. RM–101. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

McCaw, L.; Maher, T.; Gillen, K. 1992. Wildfires in the Fitzgerald River National Park, Western Australia, December 1989. Tech. Rep. No. 26. Perth, WA: Department of Conservation and Land Management.

McCaw, L.; Simpson, G.; Mair, G. 1992. Extreme wildfire behaviour in 3-year-old fuels in a Western Australian mixed eucalyptus forest. Australian Forestry. 55: 107–117.

Nelson, R.M., Jr. 1993. Byram's derivation of the energy criterion for forest and wildland fires. International Journal of Wildland Fire. 3: 131–138.

Norum, R.A. 1982. Predicting wildfire behavior in black spruce forests of Alaska. Res. Note PNW–401. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station.

Pearce, H.G.; Alexander, M.E. 1994. Fire danger ratings associated with New Zealand's major pine plantation wildfires. In: Proceedings of the 12th Conference on Fire and Forest Meteorology; 1993 October 26–28; Jekyll Island, GA. SAF Publ. 94–02. Bethesda, MD: Society of American Foresters: 534–543.

Rothermel, R.C. 1991. Predicting behavior and size of crown fires in the Northern Rocky Mountains. Res. Pap. INT–438. Ogden, UT: USDA Forest Service, Intermountain Research Station.

Rothermel, R.C. 1993. Mann Gulch Fire: A race that couldn't be won. Gen. Tech. Rep. INT–299. Ogden, UT: USDA Forest Service, Intermountain Research Station.

Sackett, S.S.; DeCoste, J.H. 1967. A new mobile fire laboratory. Fire Control Notes. 28(4): 7–9.

Schaefer, V.J. 1957. The relationship of jet streams to forest wildfires. Journal of Forestry. 55: 419–425.

Sneeuwjagt, R.J. 1974. Evaluation of the grass fuel model of the National Fire Danger Rating System. M.S. thesis. Seattle, WA: University of Washington.

Stocks, B.J. 1987. Fire potential in the spruce budworm-damaged forests of Ontario. Forestry Chronicle. 63: 8–14.

Stocks, B.J.; Flannigan, M.D. 1987. Analysis of the behavior and associated weather for a 1986 northwestern Ontario wildfire: Red Lake No. 7. In: Postprint Volume, Ninth Conference on Fire and Forest Meteorology; 1987 April 21–24; San Diego, CA. Boston, MA: American Meteorological Society: 94–100.

Stocks, B.J.; Walker, J.D. 1973. Climatic conditions before and during four significant forest fire situations in Ontario. Inf. Rep. O–X–187. Sault Ste. Marie, ON: Canadian Forestry Service, Great Lakes Forest Research Centre.

Street, R.B.; Alexander, M.E. 1980. Synoptic weather associated with five major forest fires in Pukaskwa National Park. Int. Rep. SSD–80–2. Toronto, ON: Environment Canada, Atmospheric Environment Service, Ontario Region.

Thomas, D.A. 1991. The Old Faithful Inn fire run of September 7, 1988. In: Andrews, P.L.; Potts, D.F., eds. Proceedings of the 11th Conference on Fire and Forest Meteorology; 1991 April 16–19; Missoula, MT. SAF Publ. 91–04. Bethesda, MD: Society of American Foresters: 272–280.

Thomas, D. 1994. A case for fire behavior case studies. Wildfire. 3(3): 45, 47.

Thomas, D.; Cook, W. 2002. Dude Fire staff ride. Fire Management Today. 62(4): 4–5.

Traylor, R.E. 1961. Correlation of weather to fire spread in grass and brushland fuel types on the Snake River Plains of southern Idaho. M.S. thesis. Missoula, MT: Montana State University.

Turner, J.A.; Lillywhite, J.W.; Pieslak, Z. 1961. Forecasting for forest fire services. Tech. Note No. 42. Geneva, Switzerland: World Meteorological Organization.

Van Wagner, C.E. 1971. Two solitudes in forest fire research. Inf. Rep. PS–X–29. Chalk River, ON. Canadian Forestry Service, Petawawa Forest Experiment Station.

Weick, K.E.; Sutcliffe, K.M. 2001. Managing the unexpected: Assuring high performance in an age of complexity. San Francisco, CA: Jossey-Bass—A Wiley Company.