Northwest Science Forum

Northwest Science Forum provides an opportunity to articulate and discuss scientific issues in a less structured format than peer-reviewed articles. The Forum publishes short articles, opinion pieces, and letters with a focus on science and natural resource issues in the Pacific Northwest. Although the Forum is not peer-reviewed, it is edited for format and clarity. Articles should generally be less than 2000 words and contain minimal literature citations. Letters in response to articles are particularly encouraged; the original author will normally be given a chance to respond to the letter as well. There are no page charges or reprints associated with the Forum, and participants need not be members of the Northwest Scientific Association. Please send all submissions, including two hard copies and an electronic copy (any recent version of Word or WordPerfect) to the Editor.

James K. Agee, Division of Ecosystem Science and Conservation, College of Forest Resources, Box 352100, University of Washington, Seattle 98195

The Severe Weather Wildfire—Too Hot To Handle?

Whether the weather is cold
Or whether the weather is hot
We must weather the weather
Whatever the weather
Whether we like it or not

This clever limerick of unknown origin, told to me decades ago by my college fire professor, laments the uncontrollable nature of weather. Recently, statements of the inevitability of catastrophic wildfires under severe weather revived the memory of that poem. These claims, that I will call the "weather hypothesis," suggest that large, severe fires are driven by extreme weather events and intensely burn through forests regardless of the condition of their fuels. One implication of this hypothesis is that fuel treatments are therefore useless as a preventive measure against such wildfires. It is time to clarify the relative role of fuels and weather in wildfires and to evaluate the role of silvicultural treatments in mitigating the hazard of severe wildfires.

Let us first define some terms and phrases commonly used in these debates. A *large* wildfire is one of great size; the word does not imply, in and of itself, catastrophe or damage of any kind. *High-intensity* and *low-intensity* fires define energy release rates; these are physical descriptors of the fire, not its ecological effects. *High-severity* and *low-severity* fire refer to the ecological effects of fires, usually on the dominant organisms of the ecosystem. Large, high-intensity fires are often fires of high-severity; large, low-intensity fires are usually, but not always, fires of low-severity. Some forest types historically had infrequent, high-intensity fires, while other had very frequent, low-intensity fires. In both types of ecosystems, fires could be large. The ecological effects of frequency, intensity, extent, season, and synergistic interactions with other disturbances, such as insects and disease, classified into generalized levels of fire severity, are known as fire regimes (Agee 1993).

Recent statements in the scientific literature and popular press suggest that recent large, severe wildfires in western North America are largely due to extreme weather. The long-accepted view of fire behavior as a function of fuels, weather, and topography has changed for some from an equilateral fire triangle, where each factor can be significant, to a distorted isosceles triangle with the wide base being the weather contribution to fire behavior. This "weather hypothesis", that all large, severe wildfires are more weather-dependent than fuel-dependent, is found in statements such as the following:

> Forest fire behavior is determined primarily by weather variation among years rather than fuel variation associated with stand age. (Bessie and Johnson 1995)

> Fire behavior should be directly related to regional patterns of weather that influence fuel moisture contents and wind speeds, rather than ecosystem properties that affect fuel loads and structure. (Bessie and Johnson 1995)

> There is increasing evidence that climatic conditions such as severe drought, not fuels, ultimately control fire size and intensity...The point is that climatic conditions are the most important factor in nearly all large fires. (*Cascadia Times*, May, 1996)

> ...thinning has done little to slow the spread or intensity of flames in most big western fires.... In most big fires "there is no relationship between the condition of the stand before the fire, and whether it burns or not"... (*Portland Oregonian*, January 12, 1997)

While the two latter statements may not flow directly from the Bessie and Johnson paper, people discussing this topic with me have cited this paper as evidence for the "weather hypothesis." Bessie and Johnson do an excellent job in establishing weather as a primary factor affecting wildfire size in subalpine forests near the boreal forest ecotone in Alberta, and the title of their paper clearly states that it focuses on subalpine forests. As none of the tree dominants are fire-resistant (all are thin-barked), these fires are also high-severity fires. However, the implied generality of some statements in the paper have encouraged others, including those quoted in the popular press, to conclude that the results of this study are applicable everywhere. Evidence from studies in other areas suggests that these statements should not be generalized to all forest types.

Let's examine three forest types where the "weather hypothesis" might be evaluated, and reasons why it may or may not fit each type. The first two are forest types where the "weather hypothesis" might be accepted: western subalpine forests, and moist coastal forests of Douglas-fir (*Pseudotsuga menziesii*)/western hemlock (*Tsuga heterophylla*), both with a historically high-severity fire regime. The third forest type is widespread in the western U.S.: mixed-conifer, with a variety of dry-site conifers present, usually with ponderosa pine (*Pinus ponderosa*) as a dominant, and Douglas-fir, white fir (*Abies concolor*), or grand fir (*Abies grandis*) as possible codominants in this historically low-severity fire regime. Here the "weather hypothesis" is clearly refuted in favor of what might be called the "fuel hypothesis": reduction of fuels limits fire severity.

The "weather hypothesis" can be accepted for subalpine forests, where fires are infrequent, often intense, and of high-severity. Fire behavior in subalpine forests is complicated by the erratic, often weather-driven nature of these fires (Agee 1993). Fire behavior in average years does appear to be affected by forest structure (Romme and Despain 1989); older stands support crown fire, while younger stands do not. The 1972-1987 experience with natural fires at Yellowstone suggests that fuels were a significant variable affecting fire behavior. However, in long fire-return interval ecosystems like Yellowstone, most of the area burned over past centuries was concentrated in just a few years (Romme 1982). The year of extreme weather, such as 1988, will result in much more area burned and a behavior seemingly independent of the fuel situation (Agee 1993, Bessie and Johnson 1995). As none of the tree dominants are fire-resistant, large fires, being intense and often crowning, are also severe fires. In the long run, regional weather patterns are critically important, and the "weather hypothesis" can be accepted here.

In Douglas-fir/western hemlock forests, fires are infrequent, often intense, and usually of high-severity, although fire behavior will vary by stand age (Agee and Huff 1987, Agee 1993). Early seral stages are most flammable, and can support a "vicious cycle" (Isaac 1940) of reburns, with each reburn fostering thicker stands of flammable bracken fern (*Pteridium aquilinum*). Large burns such the 1902 Yacolt fire (Washington) and 1933 Tillamook fire (Oregon) have reburned in part 4-6 times, mostly from human causes. While this evidence supports a "fuel hypothesis," the early seral flammable stage is a brief window of time in this forest type. While fuel dynamics differ over the rest of the sere, large fire events are probably the result of short-term but extreme changes in drought, lightning frequency, or east (foehn) wind patterns (Agee 1993). With the evidence we now have available, the "weather hypothesis" appears to fit better than a "fuels hypothesis" in this forest type, although not as clearly as in subalpine forests. Fuels are an important factor in fire behavior, particularly in early seral stages, but fuel differences appear to be overwhelmed by extreme weather in significant, large fire events in older Douglas-fir/western hemlock forests.

While the first two forest types might suggest that the "weather hypothesis" in indeed robust, the third forest type provides ample evidence that fire severity, even in large fires, can be fuel dependent. Mixed-conifer forests of several types that have ponderosa pine as a dominant had a historical fire regime of frequent fires, typically of low-intensity and low-severity (Agee 1993). Forest stands were open, had low fuel loads, and large gaps between surface fuels and tree crowns. If any forest type had the "friendly flame", this was the one: fire, by consuming fuel at frequent intervals, limited the intensity and severity of the next fire. We know from tree-ring reconstructions that fires in these forests were frequent (Dieterich 1980, Savage and Swetnam 1990, Wright 1996). The presence of large, multiple-scarred pines and associated thick-barked species strongly implies that low-intensity, low-severity fires occurred over centuries and included many severe fire weather episodes. While fire severity appears to have remained low even in the presence of severe weather, fire size (independent of severity) may have been larger under regional weather patterns that fostered fire spread (Swetnam and Betancourt 1990).

Fire exclusion during the 20th century has altered landscape architecture, linking high fuel loads vertically within stands and spatially across the landscape. Fireline intensity has increased in mixed-conifer forests, with crown fires more common and 100% tree mortality now common. While it is true that *today*, large, severe fires in these forest types are driven by extreme weather that overwhelms fire suppression forces, this is not the pattern of the past, and statements such as those quoted at the beginning of this paper do not apply to forest structures that occurred historically and for which we *could* manage in the future: sustainable, firesafe, visually beautiful forests of large, widespread trees with ground carpets of wildflowers. Our fire severity problems in these dry forests are not inevitability the result of severe weather but are a legacy of our misguided 20th century forest management over millions of hectares of the western United States.

Salvage logging, such as that authorized by the recent "salvage rider" legislation in Congress, has been proposed as a solution to reduce fuel ladders that result in high-severity fires in forests that historically experienced low-severity fires. First of all, "salvage" is a poor word to use in describing forest restoration treatments: it conjures up the auto junkyard, where pieces of cars are removed before the residual is crushed and recycled. Secondly, if we change only the name of logging operations without attention to the factors affecting fire intensity and severity, the fire severity problem may just get worse.

Can logging fuel-laden forests help reduce fire severity? Some critics have cited Weatherspoon and Skinner (1995) as evidence that doing no forest treatment for fuels in these drier forests might be the best treatment. Weatherspoon and Skinner evaluated the 1987 fires in northwestern California and defined damage by crown scorch evident on aerial photos, a fairly direct measure of severity (not intensity). Over the ranges of forest types they evaluated, the found the least damage in old-growth, unlogged stands, with more damage in partially-cut stands, and the most damage in partially-cut stands that had no post-logging fuel treatment. The partial-cuts they evaluated were typically overstory removals, where the large trees were removed, leaving smaller trees. Even if fire intensity did not vary across unlogged and logged stands, damage would be greater in the logged stands because smaller residual trees will have thinner bark and crowns closer to the ground, making them more susceptible to cambial damage, crown scorch, and mortality from fire. The major implication of this study is less an argument against logging than an argument against the types of logging and fuel treatments that were done in the past. To reduce fire damage from wildfires, future thinning operations must concentrate on small trees with operations called low thinning, removing the trees that have invaded these sites since fire exclusion began, and cleaning up the debris. Markets now exist for much of this small material, and if a steady supply were available new mills could be built, providing jobs and restoring forests simultaneously (heaven forbid, possibly a win-win situation!). By leaving the largest trees and treating fuels, fire tolerant forest conditions are created, so that fire severity can be significantly reduced. This is not salvage, but restoration.

Secretary of the Interior Bruce Babbitt made a historic speech in February, 1997, calling for changes in Federal fire policy, and landscape-level forest treatment to reduce wildfire hazards, including thinning and prescribed burning. These treatments are sensible where a "fuel hypothesis" is valid, in our drier forests with low-severity fire regimes where ponderosa pine was dominant or codominant, but they must be applied with attention to those factors affecting fire intensity and severity (van Wagtendonk 1996). Such treatments are probably least valid in subalpine forests, coastal forests, and other high-severity fire regimes, where the "weather hypothesis" appears more likely to be valid.

Attempts to apply either the "fuel hypothesis" or "weather hypothesis" to all western landscapes are as misguided as our now-abandoned attempts this century to develop a grand, unified model of plant succession. Ironically, it was the presence of disturbance in ecosystems, and the inability of rigid models to address disturbance, that ended the search for the unified plant succession model. Let us not repeat the same mistake now with our views on disturbance in ecosystems: there is not a one-size-fits-all approach. Although the physical principles of fire apply everywhere, different forest types with unique organisms and fuel types, and differing environments, will assure that fire behavior will have a range of important contributing factors: not always fuel, not always weather. That old limerick probably needs to be updated:

Whether the weather is cold
Or whether the weather is hot
Topography and fuels
Are part of the rules
Whether we like it or not

Literature Cited

Agee, J.K. 1993. Fire ecology of Pacific Northwest forests. Island Press. Washington, D.C.

Agee, J.K., and M.H. Huff. 1987. Fuel succession in a western hemlock/Douglas-fir forest. Can. J. For. Res. 17: 697-704.

Bessie, W.C., and E.A. Johnson. 1995. The relative importance of fuels and weather on fire behavior in subalpine forests. Ecology 76: 747-762.

Dieterich, J.H. 1980. Chimney Springs forest fire history. USDA Forest Service General Technical Report RM-220.

Isaac, L.A. 1940. Vegetation succession following logging in the Douglas-fir region with special reference to fire. J. Forestry 38: 716-721.

Romme, W.H. 1982. Fire and landscape diversity in subalpine forests of Yellowstone National Park. Ecological Monographs 52: 199-221.

Romme, W.H., and D. Despain. 1989. Historical perspective on the Yellowstone fires of 1988. Bioscience 39: 695-699.

Savage, M. and T.W. Swetnam 1990. Early nineteenth century fire decline following sheep pasturing in a Navajo ponderosa pine forest. Ecology 71: 2374-2378.

Swetnam, T.W., and J.L. Betancourt. 1990. Fire-Southern Oscillation relations in the southwestern United States. Science 249: 1017-1020.

Van Wagtendonk, J.W. 1996. Use of a deterministic fire growth model to test fuel treatments, pp. 1155-1166 *in* Sierra Nevada Ecosystem Project, Final Report to Congress, vol. II, Assessments and Scientific Basis for Management Options. Centers for Water and Wildland Resources, University of California, Davis.

Weatherspoon, C.P. and C.N. Skinner. 1995. An assessment of factors associated with damage to tree crowns from the 1987 wildfires in northern California. Forest Sci. 41: 430-451.

Wright, C.S. 1996. Fire history of the Teanaway River drainage, Washington. Unpublished Master of Science thesis. University of Washington, Seattle, WA.