The Effects of Climatic Change and Wildland Fires on Air Quality in National Parks and Wilderness Areas

Don McKenzie

How will climatic change and wildfire management policies affect public land management decisions concerning air quality through the 21st century? As global temperatures and populations increase and demands on natural resources intensify, managers must evaluate the trade-offs between air quality and ongoing ecosystem restoration. In protected areas, where wilderness values are paramount, public land agencies have adopted the policy of using wildfires to benefit natural resources, allowing naturally ignited fires to burn unless they present additional threats, such as fire risk to structures or degraded air quality.

Effects on Air Quality

Fire effects on air quality can be both local and regional. Smoke exposure at fires and immediately downwind from fires can cause respiratory problems even in healthy people, but exposure is especially problematic for those with asthma or other chronic respiratory problems. Particularly hazardous are the particulate emissions smaller than 2.5 microns (2.5 x 10-6 m) in diameter ($PM_{2.5}$), which can be breathed more deeply and cross protective membranes in the lungs. These same particulates and other elements of the smoke plume can impair visibility hundreds of miles downwind from emissions sources (Malm 1999). In the Western United States, regional haze from fires and other sources reduces visibility in most of the protected areas at some time during a typical year. The worst days, in terms of visibility, are usually associated with smoke from wildfires.

To maintain air quality, we need to understand not only present-day emissions from fires but also how conditions may change over time in response to future climatic changes, land use, and management strategies. Fire regimes will likely evolve in response to temperature increases and associated vegetation changes (McKenzie and others 2004). The annual area burned by wildland fire is expected to increase across the Western United States

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Yosemite (left) and Glacier (right) National Parks experiencing near-pristine (top) and severely degraded (bottom) visibility. Photos courtesy of the IMPROVE Web site. [Web site <http://vista.cira.colostate.edu/IMPROVE/>.]

Don McKenzie is a research ecologist for the Pacific Wildland Fire Sciences Lab, Forest Service, Seattle, WA.

and Canada (Flannigan and others 1998, McKenzie and others 2004, Gedalof and others 2005).

Fires in many ecosystems are already becoming larger and more severe than under historical conditions because of increasingly severe fire weather, unnatural fuel buildup from fire suppression, or both (Agee 1997, Allen and others 2002). Increases in area burned and fire severity increase biomass consumption, smoke emissions, and atmospheric dispersion of particulates and aerosols that produce regional haze.

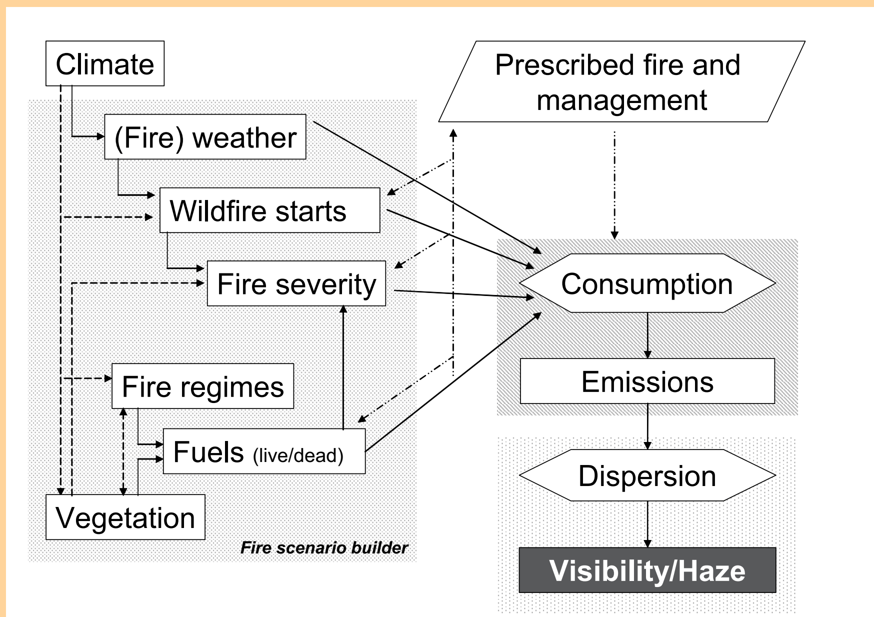
Air Quality Trade-Offs

There are many obstacles to returning the Nation's wildlands to their natural fire regimes, as noted by other authors in this issue. In many regions, such as the Pacific Northwest, air quality restrictions are one of the major impediments even to well controlled prescribed fires. These restrictions are based on the hazard of smoke exposure to local communities. Local effects, and the prospect of generating unacceptable visibility impairment in protected areas many miles away, make the management of wildfires for resource benefits less available as a fire management tool.

In one study, colleagues and I simulated smoke dispersion and regional haze from the wildland fires of 2003 in the Pacific Northwest with an integrated model of fire starts, combustion, emissions, and dispersion. We found that wildland fires in Oregon and Washington produced significant regional haze downwind at Glacier National Park in Montana and the Bob Marshall and Selway-Bitterroot Wilderness Areas in Montana and Idaho (fig. 1).

Fire Scenario Builder: A Tool for Predicting Regional Haze From Wildland Fire

Haze-producing emissions are sensitive to weather patterns and the nature of fire occurrence, which can be offset by management efforts. The fire-scenario builder uses real-time regional meteorology to simulate regional haze under current conditions and allows for the projection of wildfire events. A fuel-mapping module links vegetation data to a fuel classification system. A framework of emission, consumption, dispersion, and trajectory models reads the fire event data and the fuel mapping and calculates smoke emissions, plume rise, and regional-scale dispersion. Associated research is reported in McKenzie and others (2006).



Thinking Locally, Reacting Globally

Fire managers in national parks and wilderness areas are faced with background levels of reduced air quality, which exacerbate the conflict between air quality and other wilderness management goals. The contribution of wildfires to haze, in particular those wildfires allowed to burn as a natural ecological process, may be overestimated in some areas, leading to management choices hostile to the expansion of the use of wildfires for resource benefits. In some cases, wildfires may be the sole source of smoke, whereas in others it may be a minor contributor alongside agricultural and industrial pollution and haze from distant wildland fires.

Climate Change and the Use of Wildfires as an Ecological Process

How will wildland fire affect visibility in the future? With a warming climate, statistical models and simulation models suggest that wildland fire areas will increase in

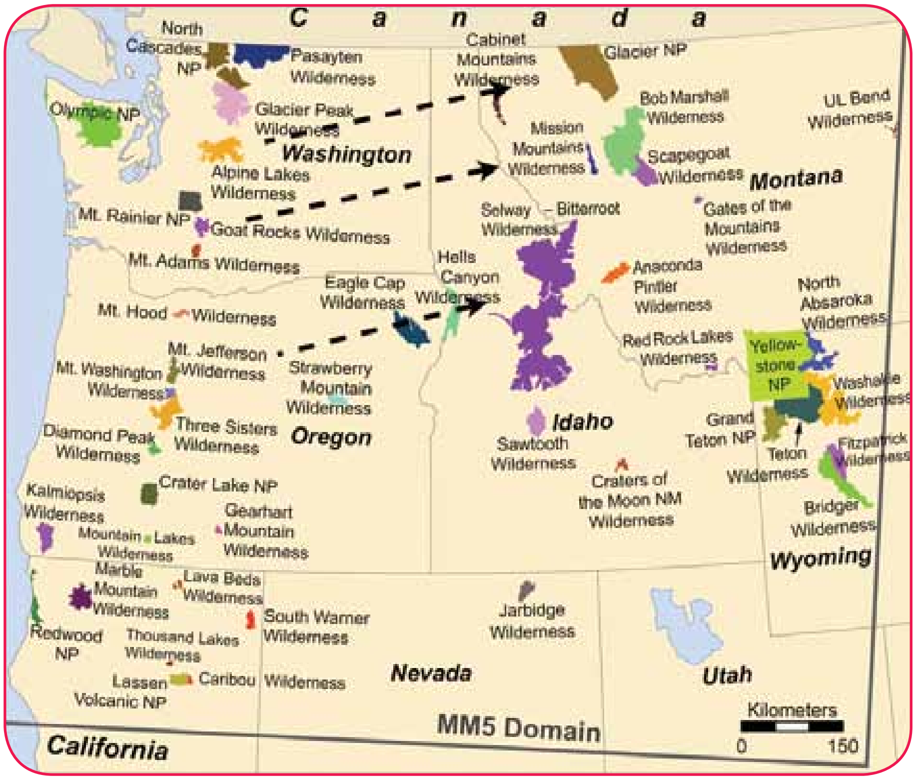


Figure 1—*Class I wilderness areas in the Pacific Northwest. Arrows indicate approximate flow patterns of smoke emissions from wildland fires in Washington and Oregon. From McKenzie and others 2006.*

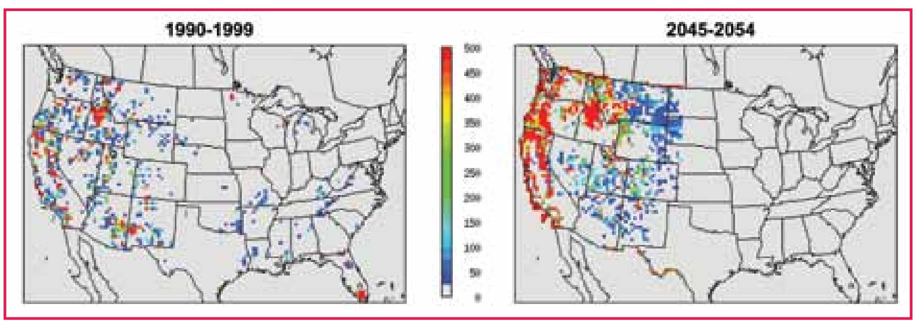


Figure 2—*Total emissions of $PM_{2.5}$ (tons) from wildland fires simulated over a future decade (2045–2054) compared to estimates from fire records (1990–1999). Simulations were restricted to the West; the observational data covered the conterminous United States.*

the Western United States (fig. 2). We can, therefore, also expect the contribution of fire to regional haze and reduced visibility to increase.

Emissions are projected to increase, especially in the westernmost States. Given current patterns of smoke dispersion, in which haze from fires in Washington, Oregon, and California significantly degrades visibility in national parks and wilderness areas to the east, Idaho and Montana will continue to be affected by regional haze, thereby compromising the role of naturally ignited wildfires as an ecological process.

Given the expected complexity of future management and policy decisions, multidisciplinary approaches are needed to guide management alternatives in the face of dynamic ecosystems and a warming climate. Examining prescribed fire scenarios or other means of fuel reduction allows us to estimate the potential value of fuel treatments on multiple-use lands for enabling ongoing application or expansion of managing wildfires for resource benefits in protected areas. Understanding trade-offs between air quality and ongoing ecosystem restoration, and precise quantitative estimates of the effects of fuel treatments, will help land managers across the West make informed choices.

References

Agee, J.K. 1997. The severe weather wildfire: Too hot to handle? Northwest Science. 71: 153–157.

Air Resource Specialists, Inc. 2004. WinHaze Visual Air Quality Modeler, version 2.9.6. Fort Collins, CO.

Allen, C.D.; Savage, M.; Falk, D.A.; Suckling, K.F.; Swetnam, T.W.; Schulke, P.; Stacey, P.B.; Morgan, P.; Hoffman, M.; Klingel, J.T. 2002. Ecological restoration of southwestern ponderosa pine ecosystems: A broad perspective. Ecological Applications. 12: 1418–1433.

Flannigan, M.D.; Bergeron, Y.; Engelmark, O.; Wotton, B.M. 1998. Future wildfire in circumboreal forests in relation to global warming. Journal of Vegetation Science. 9: 469–476.

Gedalof, Z.; Peterson, D.L.; Mantua, N. 2005. Atmospheric, climatic, and ecological controls on extreme wildfire years in the northwestern United States. Ecological Applications. 15: 154–174.

IMPROVE (Interagency Modeling of Protected Visual Environments). 2004. [Web site <http://vista.cira.colostate.edu/improve/Data/IMPROVE/improve_data.htm>]

Malm, W.C. 1999. Introduction to Visibility. Fort Collins, CO: National Park Service and the Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University. Available at <http://vista.cira.colostate.edu/improve/Education/intro_to_visibility.pdf> (accessed on 2 January 2009).

McKenzie, D.; Gedalof, Z.M.; Peterson, D.L.; Mote, P. 2004. Climatic change, wildfire, and conservation. Conservation Biology. 18: 890–902.

McKenzie, D.; O'Neill, S.M.; Larkin, N.; Norheim, R.A. 2006. Integrating models to predict regional haze from wildland fire. Ecological Modelling. 199: 278–288. ■

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Share Your Story...

This issue of Fire Management Today explores the new Interagency Guidance for Implementation of Federal Wildland Fire Management Policy. Striving to achieve sound natural resource management, apply the best available science, and collaborate among agencies, wildland fire management agencies changed their strategy in 2009 to allow fires to be managed concurrently for multiple objectives and to allow boundaries of fire management objectives to shift as fires move across the landscape. Along with this new implementation guidance come stories of success—acres burned, fires contained, and resource goals attained—and stories of frustration—communication errors, funding complications, and challenging management scenarios.

Share your stories from the 2009 and 2010 fire seasons and your lessons learned about managing wildfire for resource benefits with the FMT community. Send photos, excerpts, and articles to Monique LaPerriere, managing editor, at FireManagementToday@fs.fed.us.

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