Wildfire Impacts on Water Quality

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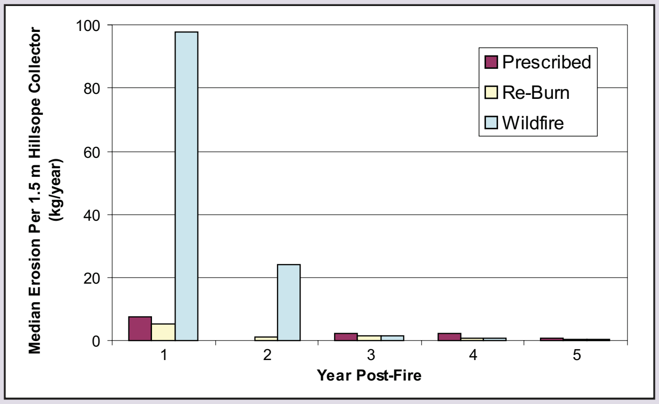
Much of the attention paid to wildfire and its impacts on the hydrologic cycle focuses on increased danger from flooding and mudslides during the immediate post-fire period. While threats to human health and safety posed by floods, debris flows, and mudslides certainly cause the greatest concern, water quality impacts and their associated risks are nonetheless critical for water utilities and regulatory agencies to address. Important questions are:

- What impact does wildfire have on surface water quality?
- How long does the impact last?
- How far away from burned areas can water quality impacts be felt?
- What beneficial uses can be affected by the changes in water quality induced by wildfire?
- How can adverse impacts of wildfire on water quality be prevented, mitigated, or otherwise minimized?

The quality of surface waters can be examined in terms of physical, chemical, and biological characteristics. Here we consider only the impacts of fire on physical and chemical water properties, based on research in the coniferous forests and chaparral watersheds of California. Biological impacts are inferred from the changes in the physical and chemical properties of surface waters.

Physical Impacts on Water Quality

Most impacts on the physical characteristics of fire-impacted streams are evidenced by changes in sediment load. Increased sediment flows following a fire can impact both ecological health and drinking water operations. The large quantities of post-fire sediment can overwhelm the biological habitat available for aquatic organisms such as fish, as well as organisms that depend on water for some life stage, such as amphibians and insects. This problem of habitat disturbance after a fire has motivated the U.S. Fish and Wildlife Service, the Forest Service, and the Park Service to focus on habitat protection and removal of threatened and endangered species from riparian systems following severe wildfires in Arizona and California.



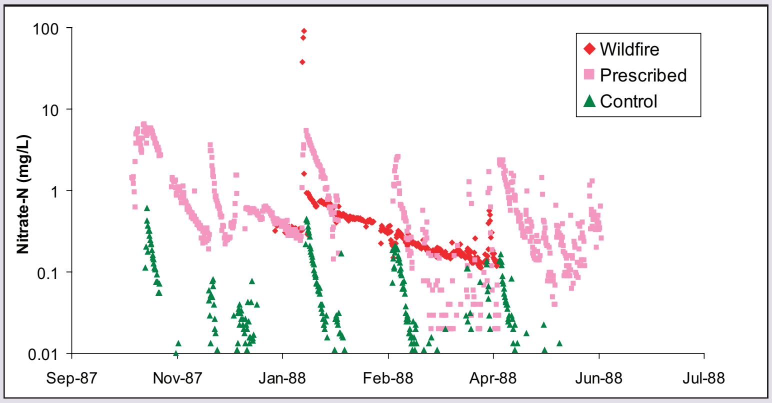
Post-fire sediment load data from the Santa Monica Mountains of Southern California. The prescribed fire occurred in 1988 and data for that fire represent the five years following that fire. The re-burn data are for the same locations as the prescribed fire data except following a wildfire that burned the entire watershed in 1993. The wildfire data are for sites that did not burn in 1988 but did burn in 1993 (from Wohlgemuth et al., 1999).

Large post-fire sediment fluxes impact drinking water systems two ways. First and perhaps foremost is the danger that reservoirs, infiltration basins, and treatment works will be filled, damaged, or otherwise disrupted by sediment. Second, high sediment load is likely to increase pre-treatment processing needs (and costs) for suspended sediment removal. These impacts are highest in areas immediately adjacent to fires. However, as recently documented by the Santa Ana Watershed Project Authority (www.sawpa.org), after the fall 2003 wildfires in Southern California, treatment works and reservoirs as far as 100 miles from the fire can be affected by increased sediment loads, particularly in the suspended fraction.

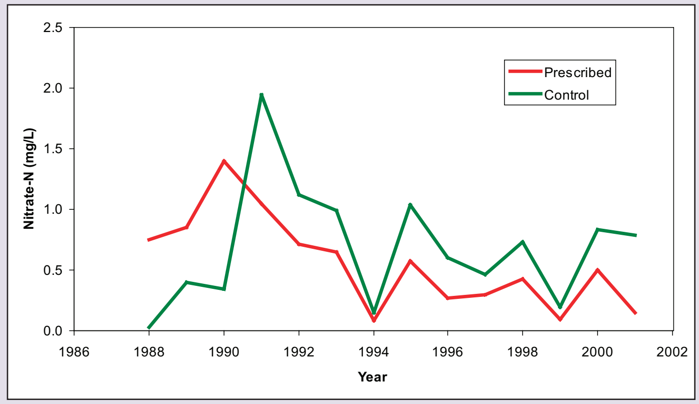
Management techniques can mitigate damages from post-fire sediment export. Permanent and temporary debris basins can be constructed to catch sediment, and earth-moving operations can be performed periodically to clean out basins and maintain their capacity. These methods are expensive in terms of both capital construction costs and maintenance costs. Increasing the fire frequency in a given area through prescribed fires has also been found to reduce post-fire sediment export (see chart above). Loomis et al. (2003) showed that since frequent fire reduces overall sediment loads, Los Angles County could save more than $24 million in annual debris basin cleanout costs through the use of prescribed fires.

Chemical Water Quality

The impacts of wildfire and prescribed burns on chemical composition of streams are not well-documented, but studies suggest that nutrient loads, particularly phosphorus and nitrogen, increase after fires, and that the effect may be greater



Seasonal variation in nitrate-N concentrations for two burned watersheds (wildfire and prescribed) and one control watershed. The fires both occurred in fall 1984; these data represent the fourth wet season after that fire. The two burned watersheds still have significantly elevated Nitrate-N concentrations compared to the control watershed.



Long-term nitrate-N concentrations from the San Dimas Experimental Forest burn study of Riggan et al. (1994) and continuing data, following a prescribed fire in fall 1984. For the first seven years, concentrations were higher in the burned watershed; the trend reversed in 1991.

from wildfires than from prescribed burns. Phosphorus export increases after wildfires, and to a lesser extent after prescribed fires. Since phosphorus is carried primarily in the sediment load, most of the increase is due to higher post-fire erosion rates, although some phosphorus is concentrated in ash as well.

Nitrogen is exported primarily as nitrate, and post-fire concentrations can exceed the federal drinking water standard of 10 milligrams per liter. A key study on the impact of fire on nitrate export in chaparral ecosystems was conducted at the San Dimas Experimental Forest (SDEF) in Glendora, California by Riggan and others (1994). The study involved six watersheds: two were kept unburned as control watersheds, two were burned under typical prescribed conditions, and two were burned under simulated wildfire conditions. The initial data following the fire in the winter of 1985 showed an increase in nitrate export with an increase in fire severity. Results three years after the fire indicated that fire increased nitrate concentrations in streams during the post-fire period, to concentrations as much as 10 times the federal drinking water standard (see chart above left) and that severity was not as critical in the longer term. Long-term data from SDEF also show that elevated nitrate concentrations can persist for up to 10 years after a fire; however, nitrate concentrations in previously burned watersheds were lower than their unburned counterparts (see chart above right). Note that all watersheds at the San Dimas experimental forest have elevated nitrate concentrations due to their proximity to the city of Los Angeles.

The effects of high nitrate concentrations on drinking water can spread beyond an area's immediate resources. Mountain areas of Southern California and elsewhere in the West provide what is generally considered the highest quality drinking water, which is often used to dilute drinking water resources impacted by industrial, urban, or agricultural activities. High nitrate concentrations in these "cleaner" waters can compromise the ability of water managers to control drinking water quality.

The results of the SDEF research suggest that wildfires may have a greater impact on water quality than prescribed fire; other studies have demonstrated the relatively benign effects of prescribed fire on water quality (Stephens et al., 2004; Richter et al., 1982). Taken together, these findings indicate that more frequent use of prescribed fire may have a beneficial impact on long-term water quality management in the western United States.

References

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