UI Extension Forestry Information Series

Fire No. 21

Wildfire and Water

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Water. Cool, clean, plentiful water. In Idaho, as in all the western United States, water rights, water quantity, and water quality are at the center of many of our environmental challenges. Idaho's 93,000 miles of rivers and streams deliver broad aesthetic, ecological, and economic benefits by supporting wildlife and fish habitat, recreation, hydroelectricity, irrigation, industry, and transportation.

The term *water quality* refers to the biological, chemical, and physical characteristics of water. It is used to indicate the condition of water relative to the needs of one or more living species, including any human need or purpose. And when there is a fire in the forest, water quality and quantity can both be affected.

*"Though the fire blackened many miles along the Middle Fork of the Salmon River, today the water is sparkling in the sun and flowing clear. We see a fish swirl to the surface and snag a bite to eat …" **

Photo by Yvonne C. Barkley, University of Idaho Extension

Watersheds

The area of land that drains water, sediment, and dissolved materials to a common outlet is called a *watershed*. The term *watershed condition* is used to indicate the health of a watershed in terms of its hydrologic function and soil productivity. *Hydrologic function* is the ability of a watershed to receive and process precipitation into stream flow without ecosystem deterioration and is intimately tied to the processes that make up the hydrologic cycle and those that contribute to erosion.

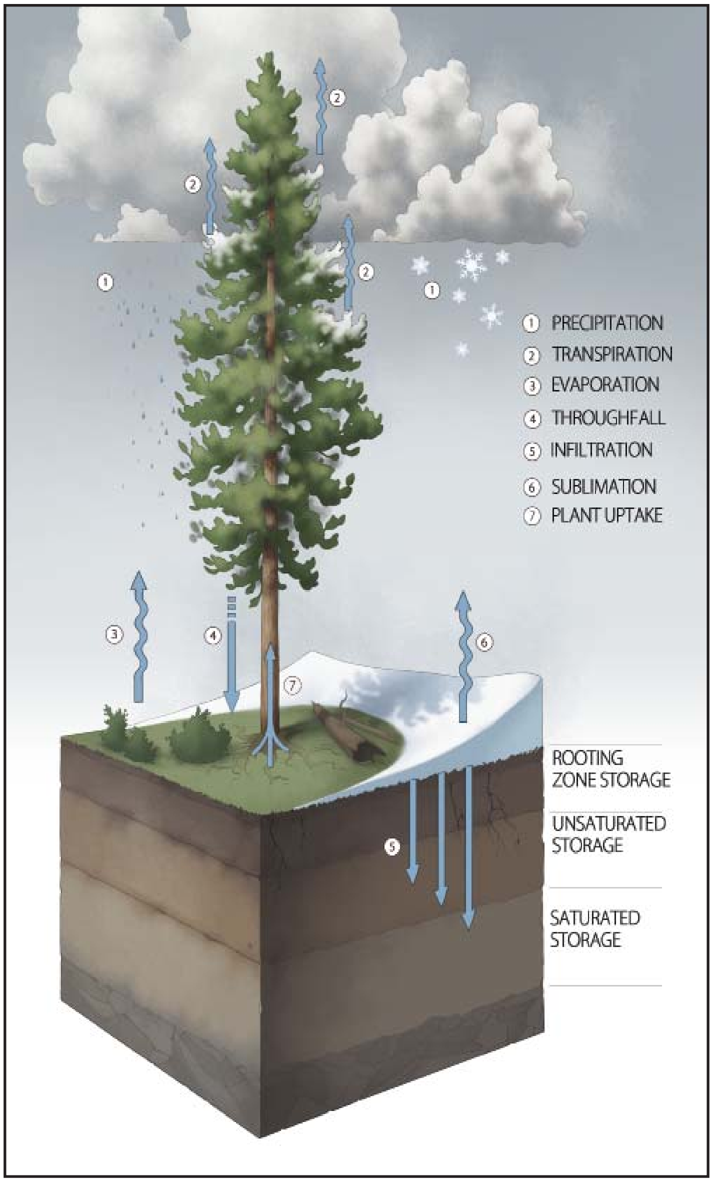
The hydrologic cycle

The *hydrologic cycle* is made up of interrelated components that are difficult to evaluate individually. Fire and its effects on interception, transpiration, evapotranspiration, infiltration, soil water storage, and runoff will affect both the quantity and quality of water within a watershed.

Precipitation is an important influence on flow in forest streams. Defined as "water from the atmosphere that reaches plants, the ground, or water bodies," precipitation is deposited in many forms, including rain, snow, sleet, hail, and condensation such as dew and frost.

Interception refers to all precipitation caught before it reaches the ground. Both natural and constructed surfaces intercept precipitation and each surface has different characteristics and abilities to intercept moisture. For example, waxy conifer needles and rough surfaces intercept water more efficiently than broad leaves and smooth surfaces. Leafless periods provide less interception than a full canopy during the growing season and dense vegetative structures more so than sparse. Water at interception sites eventually changes to water vapor and is lost to the atmosphere by evaporation.

**Journal entry from the author's September, 2000 post-fire visit to the Pistil Creek Ranch, Frank Church River of No Return Wilderness, ID.*



Transpiration is the "uptake of soil water by plants and its evaporation to the atmosphere through leaves and other plant surfaces." Transpiration can be likened to breathing - plants "inhale" water through their roots and "exhale" water vapor through leaves to the atmosphere.

Evapotranspiration is water lost to the atmosphere by the combined effects of interception, transpiration, and direct evaporation from ground surfaces and water bodies.

Infiltration is the amount of water that can be absorbed by soil in a given time period and is determined by the percent ground cover, vegetative cover type, soil volume-weight, and amount of dead organic material and other protective cover.

Overland flow or *surface runoff* is water from precipitation that moves over the ground surface, and *subsurface* or *groundwater flow* is any water that flows through the soil and underground rock crevices.

A healthy watershed will allow precipitation to infiltrate into the soil, which limits overland flow and erosion. Transpiration and interception are often reduced after a wildfire, while the rate at which water can infiltrate into the soil often decreases. This sets the stage for increased overland flow and erosion.

Because melting snow has slower soil percolation rates than water, Inland Northwest snow packs contribute significantly to soil-stored moisture. Snow accumulation has been found to be inversely proportional to the amount of vegetative cover and in smaller openings, more snow will accumulate on the ground during the winter than in the surrounding forest. This can be beneficial if spring melting is gradual, but if there is a rain-on-snow event or rapid heating, has greater potential to cause flooding and catastrophic events such as mudslides and debris avalanches.

When burned areas are approximately four times larger than the height of the surrounding cover, snow accumulations can decreased due to wind scour, further decreasing contributions to stored-soil moisture.

Erosion

Erosion is defined as "the movement of individual soil particles by wind or water." This is a natural process occurring on landscapes at different rates and scales, depending on geology, topography, vegetation, climate, and weather.

Burns along streams and rivers affects not only the land, but the water that flows through it.

Photo by Yvonne C. Barkley, University of Idaho Extension.

Erosion is a function of available forces, the amount of protection on the soil surface, and the type of the soil, and is usually described by three components: detachment, transport, and deposition. *Detachment* is influenced how easy individual soil particles are detached (soil erodibility) as well as slope gradient and slope length. Overland flow, gravity, wind, and animal activity *transports* detached soil particles from one place to another, which are then deposited (*deposition*) at the bottom of slopes, in areas of vegetation and surface litter, behind rocks, or in streams or rivers.

Surface erosion is the movement of individual soil particles, usually by water flowing over exposed soil surfaces, and occurs when precipitation exceeds soil infiltration rates. Some soil types are more susceptible to erosion than others, either because particles are more easily detached or moved, or because of lower infiltration rates.

Mass wasting includes debris flows and debris avalanches. Debris flows and avalanches are dramatic forms of mass wasting and can deliver massive amounts of sediment to streams. *Debris avalanches* are rapid, shallow soil mass movements from steep hill slope areas. If enough water is present, debris avalanches become *debris flows*, which are rapid downslope mass movements of a slurry of soil, rocks, and organic debris directly to stream channels.

These terms are often combined or used interchangeably because most debris avalanches are initiated by excess soil water and almost immediately turn into debris flows. When debris avalanches/flows reach steep stream channels, they become a mass movement of large volumes of water mixed with soil, rock, and organic material called *debris torrents*.

Slumps and *earthflows* are slow mass movements that usually occur in areas with deep, fine-textured soils, moving only inches per year.

Another type of erosion, called *dry ravel*, is best described as dry grain flowing downhill. Occurring in semiarid ecosystems, gravity moves soil grains, aggregates, and rock material down-slope, often in huge quantities. Dry ravel can be triggered by animal activity, earthquakes, wind, and even by the thermal expansion of soil grains, and often settles in dry streambeds, where it is easily transported into streams during subsequent precipitation events.

The amount of erosion after a burn will be dependent on each storm event, the severity of the burn, the slope, soil type, and condition of the watershed before the burn. Erosion may be fast or may continue to occur over several years after a burn as the root systems of burnt vegetation decay, further decreasing soil stability.

The health and wealth of a stream environment are reflections of the condition and function of the surrounding land.

Photo by George Holmes, Valent USA Corporation, Bugwood.org.

Fire and Aquatic Ecosystems

Over the last 200 years, many changes have been made to most of the aquatic environments of the Inland Northwest. In a period from 1811 to 1859, beaver were extensive trapped for the fur trade and almost obliterated these water makers from western environments. Mining, grazing, logging, and farming caused further change, as did the expansion of industry and urban areas. Today, many aquatic and riparian environments of the Inland Northwest are substantially and perhaps irreversibly changed in both physical and biological structure and function.

Pulse disturbances

The health and wealth of a stream environment are reflections of the condition and function of the surrounding land. Good hydrologic conditions are preserved in watersheds that have greater than 75 percent ground cover, with two percent or less of rainfall becoming surface runoff, resulting in little erosion. Stream flow response to precipitation is slow and is sustained between storms. Riparian vegetation provides shade, which aids in temperature regulation of stream water, intercepts excess nutrients before they can enter the stream environment, and prevents or decreases deposition of soil and silt into the water.

Fish will rapidly reoccupy fire-effected stream reaches when their movements are not limited by barriers such as poorly designed road crossings and culverts, diversions, or dams.

Photo courtesy of USDA Forest Service Southern Research Station , USDA Forest Service, SRS, Bugwood.org.

Wildfire effects on streams and rivers are often described as *pulse disturbances* - initially severe but generally short-lived. The intensity of a fire will have different effects on stream environments and the five-year period after a major wildfire is one of transition.

High-intensity burns usually result in:

- increased stream flow and sedimentation;
- higher stream water temperatures resulting from lost riparian vegetation that provided shade and erosion protection;
- a temporary increase in primary production due to increased light; and
- increased nutrient levels, often resulting in a shift in aquatic invertebrate communities from species that process leaf litter and debris to species that scrape and graze attached algae from rocks and gravel.

The full recovery of aquatic communities is often dependent on the presence of intact communities upstream and downstream from burned areas. Idaho streams support both migratory and resident fish. Fish that reside in small mountain streams year-round may migrate upstream in spring and summer to access cooler, more oxygenated water, returning downstream to overwinter in deeper pool habitats. Fish will generally reoccupy fire-affected areas rapidly when their movements are not limited by barriers such as poorly designed road crossings and culverts, diversions, or dams.

Channel erosion and sedimentation

Unmanaged stream ecosystems are altered by episodic floods and drought and are in a constant state of adjustment. Erosion is a natural and on-going process and its effects on a stream are highly variable. The addition of eroded material into streams is a common result of fire and increases stream sediment deposition. This added material combined with increased streamflow then leads to increased channel erosion. Over time, these two forces result in a stream environment evolving until it reaches a new equilibrium.

Although sediment occurs naturally in streams, changes in the amount and type can severely affect aquatic communities. Excess fine sediment can fill in pore spaces between cobbles where fish lay their eggs, and is some cases, clog and abrade fish gills, and suffocate eggs and aquatic larvae living on the bottom. In some regions, over 60 percent of total landscape sediment production is fire-related. Much of that sediment loss can occur the first few years after a wildfire, though in some cases, sediment accumulations and incision may take decades or even longer to recover to prefire conditions.

Nutrients, dissolved oxygen, and temperature

There can be a dramatic increase in in-stream nutrient levels the first year after a burn. Nutrients such as nitrogen, phosphorus, and potassium are needed for plankton and algal growth, plants that form the food base for fish. But excess amounts of these nutrients can cause algae blooms, which, when alive, decrease

Sculpin, a nongame fish species, is an indicator of excellent water quality.

Photo by Bruce Kinkead, Couer d'Alene Tribe.

Large woody debris plays a role in hydraulics, sediment routing, and channel morphology of streams and is an important component of fish habitat.

Photo by Yvonne C. Barkley, University of Idaho Extension.

light penetration, and when dead and decomposing, decrease amounts of dissolved oxygen.

Dissolved oxygen is a basic requirement for healthy aquatic ecosystems. Most fish and aquatic insects "breath" oxygen dissolved in the water. Water absorbs oxygen directly from the atmosphere and from plants as a result of photosynthesis. The ability of water to hold oxygen is influenced by temperature and salinity, and decreases with increasing water temperatures.

Temperature also governs many biochemical and physiological processes in cold-blooded aquatic organisms, and increased temperatures can increase metabolic and reproductive rates throughout the food chain. The water temperature at a particular spot is determined by the temperature of the water upstream, processes within the stream reach, and the temperature of overland flow and runoff. Many aquatic species can only tolerate a limited temperature range and a shift of minimum and maximum temperatures within a stream can have critical effects on species composition.

Large woody debris

Nutrient concentrations can also increase from the addition of large amounts of woody debris to the stream environment. *Large woody debris* plays a role in hydraulics, sediment routing, and channel morphology of streams and is an important component of fish habitat. It can dissipates some of the energy generated by flowing water.

Inputs of leaf and needle litter may decline in the first five years after a wildfire if the canopy and surrounding riparian vegetation has been completely burned or removed. Large woody inputs often increase in the short-term as a result of wind throw but generally remain stable during the first decade or more. Recruitment from dead standing wood in riparian areas is critical to maintain large in-stream wood in the long-term. If all the trees in a particular area are killed, it could take hundreds of years before large woody debris begins to fall into the stream channel.

In some cases, excess burnt debris may need to be removed to protect infrastructure such as culverts and bridges, but generally, postfire woody debris should be left in the stream environment. Removal could result in changes in channel morphology, scouring of the channel bed, increases in stream flow velocities and sediment loads, an export of nutrients out of the ecosystem, and a deterioration of biotic habitats.

*"I realized today that some people see the time after a burn as the end of the book, while others see it for what it is, the beginning of the next chapter."**

Photo by ©Karen Wattenmaker.