

**Climatic Controls on Fire-Induced Sediment Pulses in Yellowstone National Park
and Central Idaho: A Long-Term Perspective**

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Abstract

Fire management addressing post-fire erosion and aquatic ecosystems tends to focus on short-term effects persisting up to about a decade after fire. A longer perspective is important in understanding natural variability in post-fire erosion and sedimentation, the role of these processes in structuring habitat, and future expectations in light of a warming climate and environmental change. In cool high-elevation forests of northern Yellowstone National Park, stand ages indicate infrequent large stand-replacing fires. In warmer low-elevation forests of the Payette River region of Idaho, fire-scarred tree-rings record frequent low-severity fires before 1900; stand-replacing fires and resulting debris flows in recent decades are usually attributed to 20th-century fire suppression, grazing, and other land uses. In both areas, however, tree-ring records extend back only about 500 years. We use ¹⁴C-dated geologic records to examine spatial and temporal patterns of fire-induced sedimentation and its relation to climate over the last 10,000 years. We review sedimentation processes in modern post-fire events, which vary in magnitude and impact on stream systems depending on burn severity, basin geomorphology, and the timing and characteristics of post-fire storms. Modern deposits also provide analogs for identification of fire-related deposits in alluvial fans. In Yellowstone, episodes of fire-induced sedimentation occurred at intervals of about 300-450 years in the last 3500 years, indicating a regime of infrequent high-severity fires. Millennial-scale variations in the fire-sedimentation record appear to relate to hemispheric-scale climatic change. Fire-related sedimentation is rare in Yellowstone during cooler episodes (e.g., the Little Ice Age ~1200-1900 AD), probably because effectively wetter conditions prevented most fires from spreading. During some of the same cool periods, the Payette region

experienced light surface fires and frequent, small pulses of fire-induced sediment. Between 900 and 1200 AD, however, large fire-related debris flows occurred in both study areas, coincident with the Medieval Warm Period. During that time, drought may have limited grass growth in xeric Payette-region forests, restricting surface fire spread and allowing understory shrubs and trees to create ladder fuels. Although fire suppression and land-use effects are clearly involved in recent catastrophic fires in the Payette region, a warming climate and severe drought are probable contributors to major stand-replacing fires and post-fire sedimentation, both past and present. Restoration and maintenance of conditions prior to European settlement may be unrealistic because of the potent influence of climate, and the incidence of severe fires will likely increase in both areas with future warming.

Keywords: fire, conifers, erosion, debris flows, climate, drought, Yellowstone, Idaho