CALIFORNIA FIRE SCIENCE CONSORTIUM

Research Synthesis for Resource Managers

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Biological and Geomorphic Responses to Wildfire in Steep Chaparral Watersheds in Southern California

McMahon, C., Cooper, S.D., and Wiseman, S.W., 2024, Postfire stream responses to spatial fire patterns in riparian and upland zones, in Florsheim, J.L., O'Dowd, A.P., and Chin, A., eds., Biogeomorphic Responses to Wildfire in Fluvial Ecosystems: Geological Society of America Special Paper 562, p. 1-25.
https://doi.org/10.1130/2024.2562(01)

Florsheim, J.L., and Chin, A., 2024, Disturbance and recovery of physical elements of habitat in relation to post-wildfire channel sedimentation, southern California Transverse Ranges, in Florsheim, J.L., O'Dowd, A.P., and Chin, A., eds., Biogeomorphic Responses to Wildfire in Fluvial Ecosystems: Geological Society of America Special Paper 562, p. 57-77.
https://doi.org/10.1130/2024.2562(04)
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https://pubs.geoscienceworld.org/gsa/books/edited-volume/2498/Biogeomorphic-Responses-to-Wildfire-in-Fluvial

Management Implications

- Wildland Southern CA streams responded to and recovered from wildfires naturally without restoration intervention.
- Post-fire storms led to runoff, erosion, and sediment deposition processes necessary for native habitat and successional sequences, whereas the re-establishment of the riparian canopy, where opened by fire, was necessary for the recovery of stream biodiversity and food webs.
- Resistance and resilience of riparian vegetation to wildfire depended on the availability of water, emphasizing the need to protect or enhance perennial flow regimes.

Wildfire biogeomorphology is an integrative discipline that addresses biological and geomorphic responses to wildfire. Acquiring knowledge of wildfire biogeomorphology given today's changing climate and land uses presents research challenges. In southern California, warmer and drier climates and associated changes in precipitation and wind patterns, soil and foliar moisture, vegetation and fire characteristics, and encroaching human development set the stage for complex post-fire responses and recovery trajectories, as well as situation-specific management efforts. The prediction and management of post-fire responses should be informed by spatial wildfire patterns, biogeomorphic connections among watershed areas, and the time since fire (Florsheim and Chin, 2022). The two studies synthesized here report biological and geomorphic changes in steep streams in the southern California Transverse Ranges following wildfire.

In McMahon et al (2024), remote sensing and geophysical methods applied to 26 burned and unburned study basins showed that vegetation responses differed between mesic riparian and adjacent, drier upland areas. Initial fire extent and severity were greater in upland than riparian areas, and greater along intermittent than perennial streams, likely owing to lower leaf water content at upland or intermittent sites. Upland and riparian vegetation had similar overall recovery trajectories, being stalled by a prolonged drought and requiring about 8 years to return to pre-fire levels. In upland environments, however, local patchiness in regrowth patterns was greater, and the spatial completeness of vegetation recovery after 13 post-fire years was lower. Recovery of the riparian canopy where it burned was reversed during a prolonged drought along intermittent stream reaches. It continued to proceed apace along perennial stream reaches, however, indicating the importance of streamflow in riparian ecosystem recovery after fire.

In Florsheim and Chin (2024), detailed field measurements along a small, steep stream following two wildfires decades apart illustrated natural disturbance and recovery cycles in stream geomorphology. Increased post-fire runoff and erosion supplied a large volume of sediment to downslope and downstream channels. The timing and intensity of rainfall in the first several years following the fires affected interactions between vegetation re-establishment and erosion and sedimentation processes on hillslopes and in channels. After the 1985 Wheeler Fire, "dry ravel" hillslope erosion processes provided a large volume of small-sized sediment to channels before the rainy season started. This sediment was then transported and deposited downstream during the first post-fire storm, almost entirely burying step-pool bedforms. A month later, a second storm flow eroded most of the gravel, re-exposing the steps. Decades later, the 2017 Thomas Fire burned the same watershed and was followed within weeks by an intense rainstorm, with sediment burying the step-pool geomorphology. Subsequent storm flows during the first winter after the Thomas Fire did not remove all deposited sediment, suggesting that the recovery of stream form was strongly affected by climatic variability. Consequently, the recovery times for channel forms and substrate grain size distributions apparently vary from within a wet season to across multiple years, depending on post-fire precipitation patterns.

In the study of 26 stream sites over 12 years (McMahon et al., 2024), vegetation burn patterns (see above) were combined with long-term stream monitoring data to determine the effects of riparian versus upland burn patterns on stream physical, chemical, and biological characteristics. These analyses suggested two scales of fire impacts on streams in small steep watersheds. First, extensive large-scale (basinwide) upland burning increased runoff, sediment deposition (as in the detailed geomorphological study), nutrient concentrations, and organic matter (leaves, organisms) wash-out in streams over short time periods (weeks to 2 years). Second, extensive local (~100 m) riparian burning increased light, temperature, filamentous algae, and algae-eating invertebrate levels and reduced levels of leaf litter and leaf-eating invertebrates. Local impacts of riparian burning on streams varied from short-term (months to a few years) algal-related responses (e.g., algal blooms, high algivore levels), presumably owing to increased flow, light, and nutrient levels, to long-term effects (up to 5 - 11 years) on leaf litter, leaf eater, and tadpole levels.

Suggested Reading:

Bixby, R. J., S. D. Cooper, R. E. Gresswell, L. E. Brown, C. N. Dahm, and K. A. Dwire. 2015. Fire effects on aquatic ecosystems: an assessment of the current state-of-the-science. Freshwater Science 34: 1340-1350. (doi: 10.1086/684073)

Florsheim, J.L., Chin, A., 2022. Geomorphic Responses to Wildfire in Fluvial Systems, In: Shroder, J.J.F. (Ed.), Treatise on Geomorphology, vol. 9: Anthropogenic Geomorphology (2nd Ed): Cambridge, Massachusetts, Elsevier, Academic Press, pp. 478–503. ISBN: 9780128182345 doi.org/10.1016/B978-0-12-818234-5.00045-6.

Verkaik, I., M. Rieradevall, S. D. Cooper, J. M. Melack, T. L. Dudley and N. Prat. 2013. Fire as a disturbance in Mediterranean climate streams. Hydrobiologia 719: 353-382

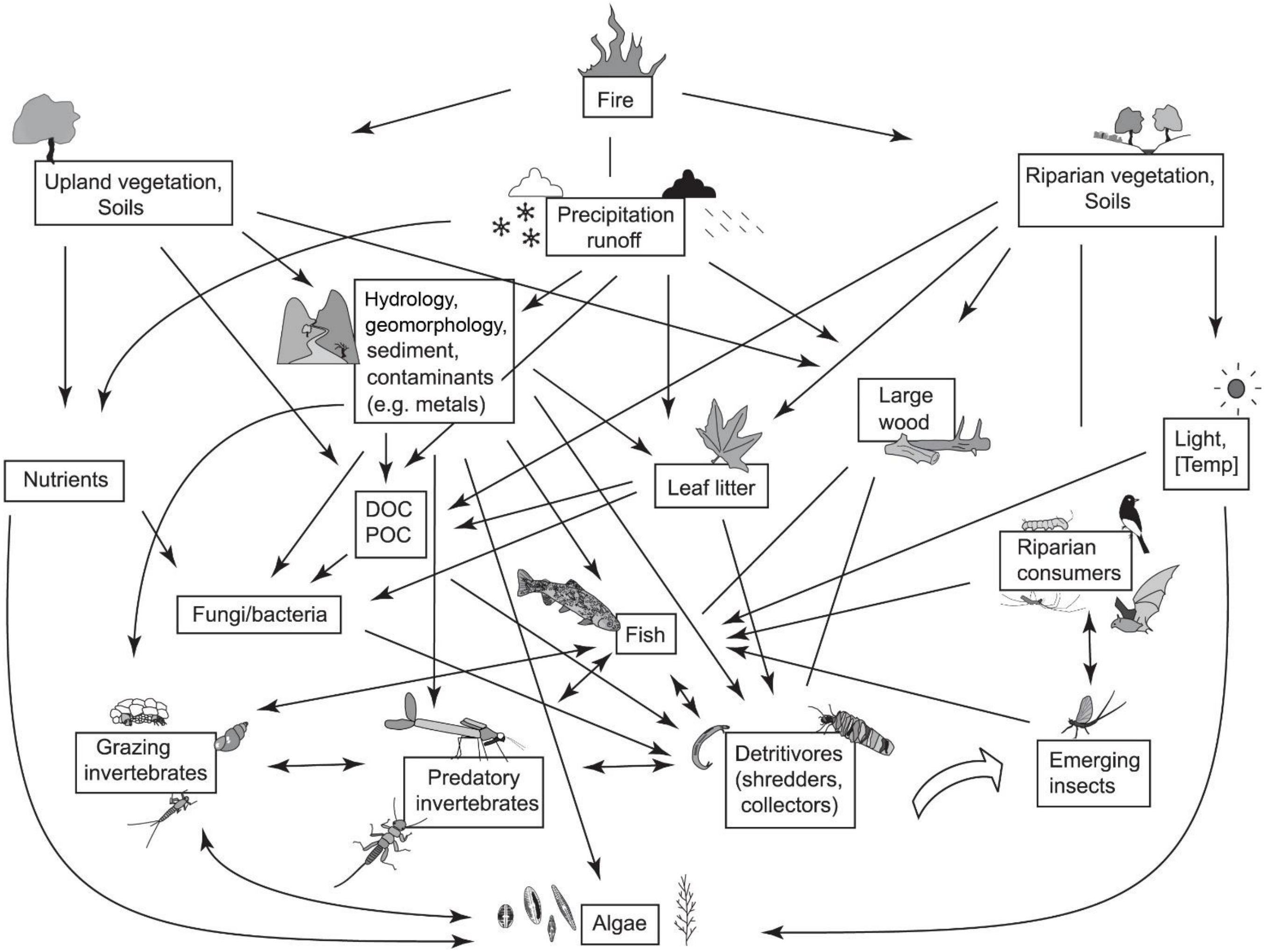

Figure 1. Path diagram showing probable cause-effect relationships leading from fire to stream variables. Lines without arrows indicate factors associated with each other, unidirectional arrows point from driver to response variables, and double-headed arrows indicate consumer-resource interactions. Temp = temperature, DOC = dissolved organic C, POC = particulate organic C. Modified from Bixby et al. 2015, original and modified versions by S. Wiseman.