CALIFORNIA FIRE SCIENCE CONSORTIUM

Research Brief for Resource Managers

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Restoring wildfire improves forest drought resistance

Boisramé, Gabrielle, Sally Thompson, Brandon Collins, and Scott Stephens. 2017. Managed Wildfire Effects of Forest Resilience and Water in the Sierra Nevada. Ecosystems 20: 717–732
https://link.springer.com/article/10.1007/s10021-016-0048-1

A history of fire suppression in the Sierra Nevada of California has led to the growth of dense forests with high water demands (reducing the amount of water available downstream), high fuel loads (increasing the risk of large fires), and a lack of diversity in land cover (reducing the types of habitat available and increasing competition between trees). Sierra Nevada landscapes are historically adapted to frequent wildfire, and restoring wildfire has the potential to cause a win-win-win situation in which fire risk is reduced, water yield increases, and forest health improves.

Yosemite National Park contains a watershed with a unique fire history: In 1972, after decades of suppressing all forest fires, land managers decided to let lightning fires burn within the Illilouette Creek Basin. It has now been over 40 years since wildfire was returned to this landscape. During that time, 75% of the vegetated areas have burned in at least one of the 19 fires. This provides a rare opportunity to study the impact of frequent fires on a mountain watershed. Our paper studies changes in land cover, water, and forest health within the Illilouette Creek Basin that have resulted from its unique fire management.

Management Implications

- Comparisons between burned and unburned watersheds show that restoring fire likely led to increased annual streamflow.
- Drought-related tree mortality due to disease and insect outbreaks is less common in burned forests than adjacent unburned forests.
- Frequent, mixed severity wildfires created a more diverse landscape with more meadows and shrublands and less tree cover than under fire suppression.
- In some areas, fire appears to have caused an increase in soil moisture.

Wildfires have created substantial changes in land cover within the Illilouette Creek Basin over the years. Vegetation maps created from aerial photography show that in 1969 the watershed was mostly uniformly covered with dense conifer forest (Figure 1). Since fire has been reintroduced to this system, the landscape has become more fragmented in terms of its vegetation types. This fragmentation reduces the ability of fire to spread, and creates a wider variety of habitat for plant and animal species.

Forest cover decreased by 22% while dense grassland, which includes wetlands and other areas of dense grasses and flowers, increased three-fold due to wildfire. Shrubland areas increased 24%. These types of land cover change have been shown to alter winter snowpack depth

and retention (Stevens 2017), increase water availability downstream, and reduce water stress in forests (Grant et al 2013).

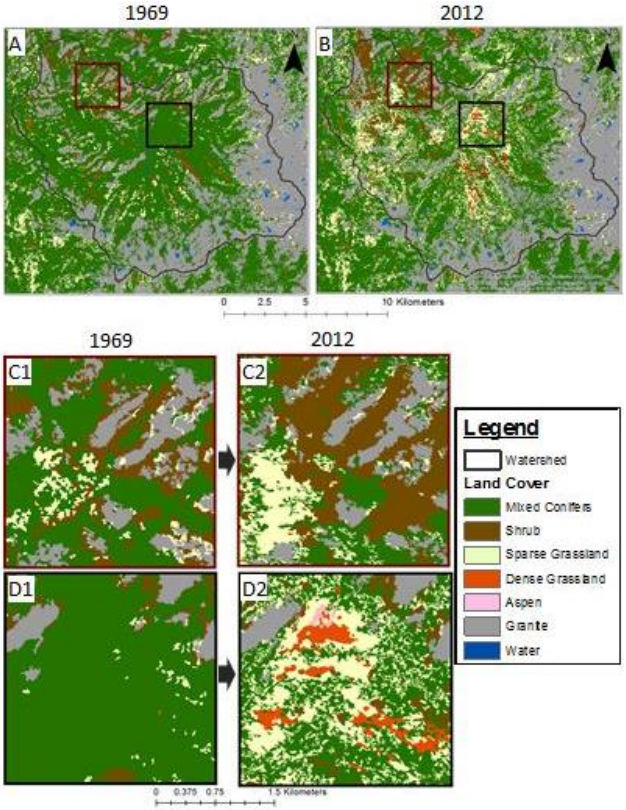

Figure 1: Maps of land cover in 1969 (after 100 years of fire suppression) and 2012 (40 years after fire regime change). Insets show close-ups of areas with different types of vegetation change.

Additionally, long term stream gages and weather stations were used to compare the Illilouette Creek Basin's hydrology to nearby watersheds with similar weather and geology, but have remained fire suppressed since the early 1900s. These analyses reveal that streamflow from this watershed is between 3% and 21% higher than would be expected if fire suppression had continued to the present day.

Field measurements suggest that soil moisture is increasing in many (though not all) of the areas in this watershed where forest has burned and been replaced by vegetation other than trees. Multiple areas that were forested in 1969 now support dense meadows of vegetation that would not survive without high soil moisture.

In 2014 and 2015, large numbers of trees in the Sierra Nevada died due to the historic drought (ten million trees in 2015 alone). Within the Illilouette Creek Basin, however, the forests made it through the drought relatively unscathed. Maps of drought-related tree mortality showed that, compared to the Illilouette, watersheds in the same elevation range which had experienced little to no fire had a higher proportion of trees die due to drought (Table 1). This suggests that decreased tree density resulting from fires led to reduced competition between the remaining trees, which were then healthier and better able to survive the drought.

Watershed	Dead/km^2 2014	Dead/km^2 2015	Ratio 2014	Ratio 2015
ICB	**4.0**	**12.9**	**1.0**	**1.0**
MF Stanislaus	8.9	13.8	2.2	1.1
SF Stanislaus	153.8	325.8	38.1	25.2
Cole Creek	15.1	174.6	3.7	13.5
Bridalveil	123.0	676.9	30.5	52.4
Chilnualna	8.8	304.8	2.2	23.6
USF Merced	20.4	61.0	5.1	4.7
Total	**47.6**	**287.7**	**11.8**	**22.3**

Table 1: Drought-related tree mortality (in terms of dead trees per km^2 of forest) during the summers of 2014 and 2015 in the ICB compared to similar watersheds with fire suppressed landscapes. The "Ratio" columns give the proportion of tree mortality in each region to that in the ICB, showing that all regions have a higher density of drought-related tree mortality than the ICB.

Overall, restoring wildfire to the Illilouette Creek Basin has increased the diversity of its landscape, increased streamflow, increased soil moisture in localized areas, and improved forest health.

Suggestions for further reading:

Stevens, Jens T. 2017. Scale-dependent effects of post-fire canopy cover on snowpack depth in montane coniferous forests. Ecological Applications in press

Grant G.E., Tague C.L., Allen C.D. 2013. Watering the forest for the trees: an emerging priority for managing water in forest landscapes. Frontiers in Ecology and the Environment 11(6):314–21

Moore J. 2015. Aerial detection survey - April 15th-17th, 2015. Forest Service: Technical report. United States Department of Agriculture