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SMART PRACTICES AND ARCHITECTURE FOR PRESCRIBED FIRE

Research Brief for Resource Managers

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Impacts of Repeated Prescribed Burns on Fuel and Forest Conditions in the Sierra Nevada

Levin JI, Collins BM, York RA, Foster DE, Fry DL, Stephens SL. 2020. Forest stand and site characteristics influence fuel consumption in repeat prescribed burns. International Journal of Wildland Fire 29(2) 148-159. https://doi.org/10.1071/WF19043

Fuel consumption during prescribed burns is variable at small scales, and depends on both prescription parameters and measurable stand characteristics (fuel bed structure, species composition, canopy cover, etc.). Although the influence of prescription parameters is fairly well understood, the influence of stand characteristics is not. Further, there has been little examination of the impact of repeated burning on fuel consumption, despite the importance of this factor to achieve certain forest and fuel structures.

This study focused on better understanding the role of stand characteristics and burn entry number in fuel consumption. Researchers focused on three specific questions:

1. How does fuel consumption differ between first and repeat burns in a fire-excluded Sierra Nevada mixed conifer forest?
2. Which measurable characteristics affect fuel consumption, and how may that vary by burn number and stand?
3. Can these characteristics be used to predict fuel consumption?

Management Implications

- Different objectives may be achieved during different burn entries. First-entry burns may have higher rates of consumption, while "maintenance burning" may not be achieved until a third-entry burn.
- Managing for increased pine composition can help increase consumption in repeat burns.
- Inherent variability between stands will result in variable fuel consumption, regardless of how many other factors managers can control.

To answer these questions, data were collected during three prescribed burn treatments over 16 years (Table 1) at Blodgett Forest Research Station near Georgetown, CA, as part of the long-term Fire and Fire Surrogate Study. Researchers gathered plot-level information about overstory trees, ground fuels, surface fuels, shrub cover and snags, as well as the burn entry number for each plot.

A stepwise model was used to determine which factors were important to consider when estimating fuel consumption. The factors included: species composition (expressed in terms of basal area proportion for pine, fir, and incense-cedar), basal area of snags, basal area of live trees, percentage canopy cover, percentage cover of deer brush, pre-burn total fuel load, burn number, slope, aspect, and stand. Analysis also considered the interactions between species composition and burn number, as researchers suspected that the accumulation of fuel present for first-entry burns may prevent any of the subtle effects related to different needle morphology from being expressed.

Results of the analysis indicated that total fuel load, proportion of overstory pine, slope, canopy cover, basal area of live trees, burn number, and stand all influenced fuel consumption at the plot level. Analysis also revealed a strong positive relationship between fuel load and consumption, and interactions between percentage basal area pine and burn number.

Consumption across all stands and burns averaged 45%, with fuel consumption highest in the first burn, and in the duff and 1000-hour fuels. The influence of stand on fuel consumption was significant, but variable, indicating there were other stand-to-stand differences not explained by the factors considered for this analysis.

Findings from this study pointed to four primary drivers of fuel consumption:

1. Fuel load
2. Burn number (1st, 2nd or 3rd entry)
3. Basal area of pine species
4. Individual stand heterogeneity

As the total fuel load increased, the proportion of consumption also increased, indicating how important fuel availability is to burn efficacy.

Burn number impacted fuel consumption as well, beyond what can be explained by differences in pre-burn fuel loads. Burns 1 and 2 experienced highest consumption, while burn 3 experienced significantly lower consumption. Authors suggest this may be a result of decreased fuel continuity with each successive burn, which would reduce consumption regardless of pre-burn fuel loads as fire would have a more difficult time traveling across the landscape.

Consumption was also affected by the interaction between burn number and species composition – specifically percentage of basal area of pine species. Burns 2 and 3 had a strong positive relationship between percentage of pine and fuel consumption, with burn 1 showing the opposite relationship. A possible explanation of these contrasting effects is that consumption in burn 1 may have been tied to fine woody accumulation, which tends to be greater in areas with higher proportions of fir and lower proportions of pine.

Finally, there was a significant difference in stand-to-stand fuel consumption beyond what was explained by the factors pertaining to stand structure used by the model. While authors noted that future studies should seek to further explore stand-level differences, they also note that the heterogeneous structure created by the variability between stands if often viewed as beneficial from an ecological standpoint.

Other drivers of fuel consumption noted in this study included canopy cover, which negatively impacted consumption, and basal area of live trees, which positively impacted consumption. An explanation for these opposing effects may be that a stand with higher basal area and lower canopy cover indicates a forest structure composed of fewer, larger trees. Whereas in a stand with high canopy cover and low basal area, the forest is likely composed of many, small trees that may decrease solar radiation on the fuel bed and increase relative humidity and fuel moisture.

Fuel consumption during prescribed fire is inherently variable, and some acceptance of variable outcomes is necessary when conducting prescribed fires. However, better understanding the role of stand characteristics and burn number can offer managers and policymakers valuable insight into the drivers of fuel consumption in repeat burns. These insights can help managers set goals for prescribed burns, and improve burn efficacy in some instances. Policymakers can take this information into account when revising or creating legislation and regulations pertaining to prescribed fire.

Further Reading:

Collins, B.M., S.L. Stephens, and R.A. York. 2019. Perspectives from a long-term study of fuel reduction and forest restoration in the Sierra Nevada. Tree Rings 29: 7-9

Table 1. Prescribed-burn weather conditions

Blodgett Forest weather station data for the periods during which each prescribed-burn treatment occurred. All data are from the onsite Blodgett Forest weather station except fuel moisture, which is from the nearby Bald Mountain and Hell Hole Remote Automated Weather Stations

Burn number	Date	Temperature (°C)	Relative humidity (%)	Wind speed (km h^{-1})	10-h fuel moisture (%)
Burn 1	23 Oct–6 Nov 2002	8	35	0–7	7–10
Burn 2	8 Oct–10 Oct 2009	10	48	0	5–6
Burn 3	30 Oct–1 Nov 2017	17	35–45	1–2	5–7