Supplementary Material:

*Study Site and Plot Site Selection*

In 2016 we collected data on forest stand structure, fire severity, and pre- and post-fire tree mortality on 50 plots within the ~60,000 ha 2015 Rough Fire footprint in the southern Sierra Nevada. Plots were located on the Sierra and Sequoia National Forests in mixed-conifer vegetation at elevations ranging from 1138 to 2180 m. Dominant trees within plots were ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*P. Jeffreyi*), incense-cedar (*Calocedrus decurrens*), and white fir (*Abies concolor*). Cold wet winters and warm dry summers characterize the region, and the mean annual precipitation of ~108 cm falls largely as snow (Minnich 2007).

At the time of the Rough Fire much of California, including the southern Sierra Nevada, was experiencing its fourth year of severe drought. Tree mortality increased during each year of the drought but 2015 saw extremely elevated levels of tree mortality statewide (an estimated 27.6 million trees were killed in 2015 and 3.2 million trees in 2014), and the southern Sierra Nevada was one region with some of the highest levels of mortality (Moore et al. 2016). Aerial detection surveyors attributed most of the pre-fire conifer mortality within the Rough Fire perimeter to the mortality agents shown in Table 1 (US Forest Service 2016a).

Research plot centers were located on a 400 m grid constrained by the following criteria: 1) within 400 m of areas of conifer mortality (minimum 25 dead trees/ha) documented within two years prior to fire by US Forest Service Aerial Detection Surveys (US Forest Service 2016a); 2) a minimum of 100 m from roads and salvage harvesting; 3) outside of areas where prescribed burns or other direct fire-fighting activity occurred during the Rough Fire; and 4) outside of riparian areas.

Table 1. The five insects most commonly listed as conifer mortality agents pre-fire (2010 through 2015) within the Rough Fire perimeter in the US Forest Service Aerial Detection Survey dataset (US Forest Service 2016a), listed in descending order of mapped area. Mortality on incense-cedar was attributed to drought.

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| --- | --- | --- |
| **Common Name** | **Scientific Name** | **Host Species in Study Area** |
| Western pine beetle | *Dendroctonus brevicomus* | *Pinus ponderosa* |
| Mountain pine beetle | *D. ponderosae* | *P. ponderosa, P. lambertiana, P. contorta* |
| Fir engraver | *Scolytus ventralis* | *Abies concolor, A. magnifica* |
| Jeffrey pine beetle | *D. jeffreyi* | *P. jeffreyi* |
| California flatheaded borer | *Melanophila californica* | *P. ponderosa, P. jeffreyi* |

*Field Data*

At each 11.3m radius (~0.04 ha) circular plot, surveyors recorded aspect, slope, topographic position, an estimate of pre-fire shrub cover, tree basal area using a 20 factor gauge, and the following parameters on up to 10 randomly selected conifers ≥25 cm diameter at breast height (DBH): tree species, DBH, height of pre-mortality live crown base determined from looking at branch structure post fire, mean bole char height, torch height (height to which needles or leaves were consumed by fire), percentage of tree crown that was torched, and mortality status. Six plots had >10 trees eligible for sampling, and the number of trees not sampled was recorded.

We worked with US Forest Service entomologist Beverly Bulaon to adapt established methods of determining mortality status (Harvey et al. 2013) to mixed-conifer forests under recent and current insect attack. Surveyors observed all visible parts of the tree for signs of insect infestation, and for dead trees, removed a sufficient area of bark with a hatchet to examine the cambium and inner bark, on multiple sides of the tree if necessary. Trees were designated as: 1) dead ≥ 3 years prior to fire, 2) red phase dead at the time of fire (trees retaining red needles at the time the fire) due to insect attack, 3) red phase dead at the time of fire without evidence of insect attack, 4) live at the time of fire and killed by fire, 5) live at the time of fire and subsequently killed by insects, 6) under insect attack but still retaining green needles at time of sampling, and 7) live at sampling, no evidence of insect attack.

*Spatial and Remote Data*

Plot burn date was determined using ArcGIS Desktop 10.5 by overlaying plot locations on daily fire progression layers obtained through the National Interagency Fire Center website of incident specific data: <http://ftp.nifc.gov/incident_specific_data/>.

Weather data obtained from the single portable Remote Automated Weather Station installed within the fire perimeter were provided by Sequoia National Forest staff. Each plot was assigned a value for temperature, wind speed, maximum wind gust speed, and relative humidity based on the daytime (10:00 – 17:00) average of hourly values for the plot burn date.

Topographic Relative Moisture Index (TRMI, an index ranging from 0=xeric to 60=mesic), which indicates relative soil moisture availability among sites in mountainous terrain, was calculated from four metrics based on the methods described in Parker (1982). We used field measurements of aspect, slope, and topographic position (valley bottom, lower slope, middle slope, upper slope, ridge top), and derived slope curvature values from a 10-m resolution digital elevation model of the project site using ArcGIS Desktop 10.5.

A remotely sensed fire severity metric, Relative differenced Normalized Burn Ratio (RdNBR) (Miller and Thode 2007), was obtained for each plot from the 30-m resolution raster dataset provided by Region 5 of the US Forest Service (US Forest Service 2016b). Extended assessment RdNBR values based on post-fire imagery taken one year after fire were used. Bilinear interpolation, which uses the value of the four nearest pixel centroids to calculate a weighted average, was used to derive RdNBR values for each plot in ArcGIS Desktop 10.5.

*Analysis*

We used random forest analysis to identify potentially influential topographic, weather, vegetation, and pre-fire tree mortality variables on three fire severity metrics: RdNBR, torch percentage (the proportion of tree needles consumed by fire), and percentage of live tree basal area killed by fire. The variables of potential importance to fire severity included in the analysis were elevation, Beers transformed aspect (Beers et al. 1966), slope, TRMI, temperature, relative humidity, wind speed, maximum wind gust speed, estimated pre-fire shrub cover (from looking for recently burned shrub skeletons), tree density, stand basal area (live and dead), dominant tree genus (*Pinus*, *Abies*, or *Calocedrus*), percentage of plot basal area in the red phase immediately pre-fire and the percentage of trees in the red phase immediately pre-fire. For analysis, we grouped trees in the red phase at the time of fire due to insect and non-insect mortality into a single category of red phase at the time of fire (36.6% of sampled trees). We excluded trees that were designated as dead ≥3 years prior to fire from this initial analysis (4.6% of sampled trees) in order to focus on effects of red phase infestation.

We conducted three replicates of the random forest analysis for each of the three fire severity response variables, using a different random seed for each replicate and specifying 5000 trees. We verified that importance rankings were stable for all replicates. Variables were considered important if the importance value was greater than the absolute value of the lowest negative score (Strobl et al. 2009). We conducted partial dependence analysis to examine how the magnitude of influence of important predictor variables (as identified by random forest analysis) varied over different levels of the predictor (Friedman 2001). Analyses were conducted in R version 3.3.3 (R Core Team 2017) using the “party” package for random forest and the “edarf” package for partial dependence.

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