Attachment A

Literature on fire hazard in open vs. closed canopy forest in the Sierra Nevada:

* According to the Forest Service (<http://www.fs.fed.us/postfirevegcondition/index.shtml>), for 8 of the 14 largest fires on National Forests in the Sierra Nevada since 2008 (i.e., Cub Complex, BTU Lightning Complex, Piute, American River Complex, Chips, Rim, Aspen and Rough fires), outside of wilderness and within Forest Service boundaries, more evergreen open canopy forest burned at high severity than evergreen closed canopy forest (Table 1).
* Collins et al. (2011, page 84) compared the effectiveness of three different diameter limits on flame length across a landscape over a 30 year period (Figure 1). Their results suggest that across the landscape, there was virtually no difference in conditional burn probability between stands that had a 12 inch, 20 inch, or 30 inch diameter limit.



Figure 1. “Mean conditional burn probabilities across the Last Chance landscape for which simulated flame lengths are >2 m. Three diameter-limited thinning scenarios along with a no treatment scenario are reported. Each scenario was modeled into the future based on output from the Forest Vegetation Simulator, using our 2007 field inventory plot data as a baseline. Probabilities are based on 5,000 randomly placed ignitions simulated using RANDIG (see Methods for explanation). **Note that the [results of the] three thinning scenarios are nearly indistinguishable**, with the exception of a slight departure for the 30.5-cm scenario in 2037.” (From Collins et al. 2011, page 84, emphasis added).

* Agee and Skinner (2005, page 9) state: “Some effective fuelbreaks had only surface fuels and ladder fuels treated, with residual canopy cover exceeding 60–70%. Even though canopy bulk density was insignificantly reduced, fire severity was significantly reduced, suggesting that reductions in canopy bulk density are not always needed to reduce wildfire severity.”
* Thompson and Spies (2009, page 1690) found that (Figure 2), “Open tree canopies with high levels of shrub-stratum cover were associated with the highest levels of tree crown damage, while closed canopy forests with high levels of large conifer cover were associated with the lowest levels of tree crown damage.”



Figure 2. Partial dependence plots from random forest predictions of total crown damage on percent shrub cover; total damage on large conifer cover; conifer damage on percent shrub-stratum cover, and hardwood damage on elevation. Partial dependence is the predicted value of the response based on the value of one predictor variable after averaging out the effects of the other predictor variables in the model. From Thompson and Spies (2009, page 1690)

* Fry et al. (2015) found that the higher canopy cover forests of the Sugar Pine study area were more resilient to fire than the lower canopy cover forests of the Last Chance study area. Treatment of 29 percent of one of the study areas, which included a 16 inch diameter limit for tree removal applied to a significant portion of the treatment area, reduced modeled fire size from 3,200 acres to about 123 acres and conditional burn probability was reduced by about half after treatment.
* North et al. (2009, page 24) states: “What is achieved by thinning intermediate sized (20- to 30-in d.b.h.) trees? Some research suggests that for managing fuels, most of the reduction in fire severity is achieved by reducing surface fuels and thinning smaller ladder-fuel trees (see summaries in Agee et al. 2000, Agee and Skinner 2005, Stephens et al. 2009). What is considered a ladder fuel differs from stand to stand, but typically these are trees in the 10- to 16-in d.b.h. classes. If trees larger than this are thinned, it is important to provide reasons other than for ladder-fuel treatment.”

**References**

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