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Communication

Sierra Nevada fire severity conclusions are robust to further analysis: a reply to Safford *et al.*

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Safford *et al.* (this issue) question our finding in *IJWF*, in Hanson and Odion (2014) ('H&O'), that fire severity has not increased in Sierra Nevada forests. Safford *et al.* ('SMC') suggest that our inclusion of national park and private lands, prescribed burns and forest types with relatively infrequent fire regimes (e.g. lodgepole pine (*Pinus contorta*) and red fir (*Abies magnifica*)) could potentially have influenced our findings, and that restricting the analysis to US Forest Service lands, and forest types with frequent fire regimes (mixed-conifer, ponderosa pine (*Pinus ponderosa*) and Jeffrey pine (*Pinus jeffreyi*)), might have resulted in an increasing trend in high-severity fire 1984–2010. We note, initially, that Miller *et al.* (2009), Miller and Safford (2012) and Mallek *et al.* (2013), cited by SMC, all included national park lands and private lands (e.g. ~20% of fires were on private lands in Miller *et al.* 2009 (tables 1 and 2), almost identical to the amount in H&O), and prescribed fires comprised a negligible 0.15% of the high-severity fire analysed in H&O. Although we believe inclusion of all land ownerships is appropriate, as our purpose in H&O was to investigate patterns across the whole landscape, the points raised by SMC are worthy of evaluation and we appreciate that SMC brought them to our attention. In that spirit, we tested the approach promoted by SMC, and re-analysed our data for 1984–2010, using the methods described in H&O, but with the analysis restricted to wildland fires in mixed-conifer, ponderosa pine and Jeffrey pine forests on US Forest Service lands. We found no trend in high-severity fire area ($z = 1.00$, $P = 0.317$) or proportion ($z = 0.47$, $P = 0.638$).

Second, SMC suggest that the Mann–Kendall (M-K) non-parametric trend test we used has 'very low' statistical power relative to parametric tests they previously used, citing Helsel and Hirsch (2002), Yue *et al.* (2002) and Dickson *et al.* (2005). However, SMC do not accurately characterise these sources. Yue *et al.* (2002, fig. 8) specifically found that, with non-parametric data (SMC and H&O agree the Sierran fire severity data are non-parametric), the M-K test has much higher statistical power than parametric tests (see also Önöz and Bayazit 2003). Helsel and Hirsch (2002) concluded that M-K performs 'either as well or better' than parametric tests for non-normal data. Wiedemeier *et al.* (2005) (cited by SMC as Dickson *et al.* 2005) did not conclude findings of no trend with M-K are 'usually a statement that the available data are not sufficient to discern a trend', as SMC state. Rather, Wiedemeier *et al.* (2005) merely articulated a statistical tautology that weak patterns may not appear when data are very poor or insufficient, which is not the case for our 27-year analysis. Indeed, Wiedemeier *et al.* (2005) recommend use of M-K, and call it 'robust'.

Third, SMC note the post-time-series vegetation data used in Miller *et al.* (2009), Miller and Safford (2012) and Mallek *et al.* (2013) are based on 'potential' vegetation, hypothesising that conifer forest would not be remapped as non-conifer after high-severity fire. This is a reasonable hypothesis. However, in H&O, we investigated this question and found that, in fact, areas mapped as conifer forest in these potential vegetation datasets are, as a matter of actual practice, frequently remapped as non-conifer vegetation (mostly shrub) years after high-severity fire. Our quantitative analysis in H&O found that this effect occurs to a disproportionate, and statistically significant, degree in the earlier years of the time series, causing relatively more high-severity fire in conifer forest to be excluded in the earlier years than in more recent years, and leading to the appearance of an increasing trend in fire severity even if none actually exists.

The foregoing addresses the major issues raised by SMC. We address what we view as less central, but not unimportant, criticisms raised by SMC in Table 1.

Recent studies have found that current rates of high-severity fire, including in frequent-fire forest types, are often substantially lower than historical rates (Odion and Hanson 2013; Baker 2014; Odion *et al.* 2014; Hanson and Odion in press). This raises a conservation concern for the many rare and declining wildlife species positively associated with the unique, and highly bio-diverse, habitat created by high-severity fire: 'complex early seral forest' – particularly given frequent post-fire logging of this habitat (DellaSala *et al.* 2014; Hanson 2014). This broader ecological context is relevant to evaluations of fire patterns and trends.

Table 1. Responses to minor points by Safford *et al.* (SMC)

SMC comment	Our response
SMC criticise the 1977 Cal-Veg vegetation data used in H&O, noting it was coarser in scale than current versions and citing Goodchild *et al.* (1991) regarding 63% commission error.	The fairly coarse resolution of the 1977 data was consistent throughout our time series and thus could not have affected our trend results. SMC's citation of Goodchild *et al.* (1991) is misleading. The 63% commission error had nothing whatsoever to do with high-severity fire analysis. Rather, it pertained to the ability of the 1977 dataset to distinguish between very closely related forest types, such as ponderosa pine and mixed-conifer pine (which is dominated by ponderosa pine), which is not relevant to findings in Hanson and Odion (2014) (H&O) regarding high-severity fire in forest strata. Moreover, the overall conifer forest commission error was only 21% (Goodchild *et al.* 1991, table 7), which is more relevant to the analysis in H&O, because it was not the purpose of our investigation to distinguish closely related forest types.
SMC claim that 'nowhere in Hanson *et al.* (2010) are any methods or results presented' to indicate that the high-severity fire threshold of RdNBR = 641 equates to ~70% basal area mortality of trees (Hanson *et al.* 2010 was cited in the methods of H&O).	The findings of Hanson *et al.* (2010) are clearly shown in table 1 of that study, and the methods are clearly described immediately below that table. Hanson *et al.* (2010) note that the field validation data used for the analysis regarding actual on-the-ground tree mortality were provided by Jay Miller, an SMC coauthor. The 70% basal area figure in H&O is extrapolated from the results in table 1 of Hanson *et al.* (2010). SMC's statement that RdNBR of 641 equates to 89% basal area mortality is based on a regression that was not subjected to standard goodness-of-fit test, and that overstates mortality at higher RdNBR values, as found in Hanson *et al.* (2010).

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