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Supplementary material

Altered vegetation structure from mechanical thinning treatments changed wildfire behaviour in the wildland–urban interface on the 2011 Wallow Fire, Arizona, USA

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This document contains supplementary methods and results.

Randomization methods

As demonstrated by Kennedy and Johnson (2014), fire severity exhibited a strong spatial signal in the Wallow Fire as the fire burned toward the WUI communities. This spatial autocorrelation in severity is likely intrinsic, i.e., a characteristic of the contagious process of fire spread and severity that cannot be accounted for with other explanatory variables. These data are also highly anisotropic, where there is a particular direction of the spatial autocorrelation (plots down fire along a transect). Taken together (spatial autocorrelation that is anisotropic), the severity data violate assumptions of both standard regression (OLS) that assume independent data, and most spatially explicit methods that account for spatial autocorrelation but assume isotopy (e.g., simultaneous auto regression).

Fortin and Payette (2002) recommend using restricted randomization to evaluate the relationship between spatially autocorrelated data. A toroidal shift is used in the randomization process, such that the horizontal interactions (spatial relationships) for the spatially autocorrelated response variables are maintained, while the pairs of response and predictor variables are randomized (Fortin and Jacquez, 2000). This is accomplished by choosing a random lag value for each transect, then shifting the explanatory variables by that lagged value (Fig. S1). Plots at the end of the transect are shifted by wrapping around to the front of the transect (the torus). So the change in fire severity between plots 1 and 2 does not change, thereby maintaining the spatial correlation structure in fire severity. The explanatory variables associated with each plot are randomized by the lag value. For each new configuration the model is fit between the response and explanatory variable. In this manner a null distribution of these relationships is estimated, and the observed statistic is compared against this null distribution as described above.

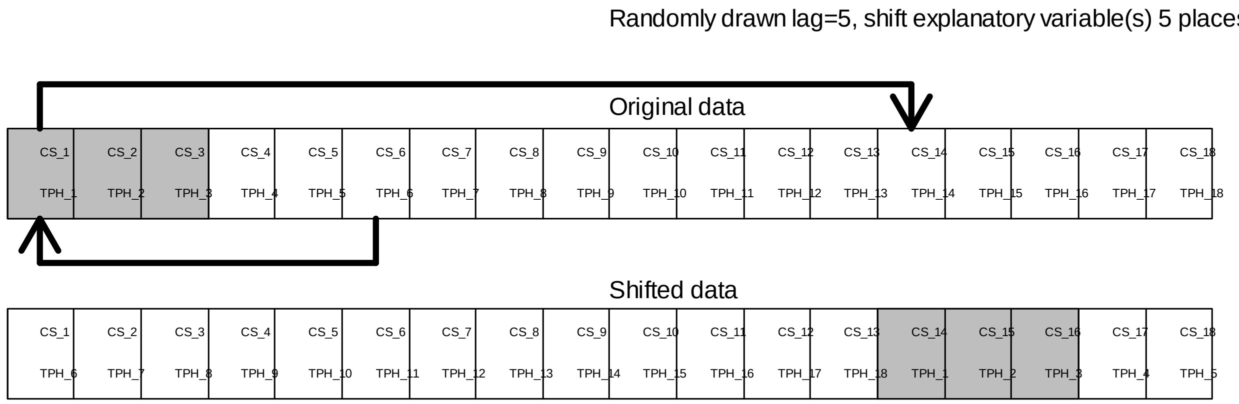

Fig. S1. Schematic for restricted randomization, where the shaded boxes are originally untreated plots. For a random lag of 5, each explanatory variable is shifted five plots towards the untreated area. If a shift of 5 places the variable outside of the transect, it is shifted the appropriate amount at the lower end of the transect. For example, for a random lag of 5, the first plot (TPH_1) is shifted to a placement 5 from the end of the transect (in this case becomes associated with CS_14). The second plot (TPH_2) is shifted to a placement 4 from the end of the transect (in this case, CS_15). Note that the order of both the explanatory and response variable is maintained in the randomization, it is only the association between the explanatory and response variable that is randomized.

p-values:

For each randomization test a p-value is estimated based on the rank of the observed statistic among the null distribution (including the observed). For example, for a right-tailed F-test where the observed statistic is F_{obs} and n_{sim} randomizations are performed, the p-value is estimated as:

$$\hat{p} = \frac{\sum_j I(F_{obs}<F_j)}{n_{sim}+1}$$

where $j = 1, \ldots, n_{sim}$ and $I(F_{obs}<F_j)$ is an indicator function that takes a value of 1 if the statement is true, 0 otherwise (i.e., the observed value of the statistic is less than the randomly generated value). If the observed statistic is in the tail of the null distribution (more extreme than 5% of the null distribution for alpha=0.05), then there is evidence that the observed statistic is not observed by chance.

Supplementary results

Remotely sensed burn severity

Below we give results for RdNBR, to compare to the dNBR results provided in the main text. Overall patterns and conclusions do not differ between the two remotely sensed severity metrics.

Table S1. Simple linear regression slope and intercept of RdNBR related to distance from treatment edge on the fireside of the fuel treatment. The intercept is the expected value of RdNBR at the treatment edge, the slope is the expected change in RdNBR with increasing distance to treatment edge, with a positive slope implying RdNBR is lower closer to the treatment edge and higher further from the treatment edge. Models are estimated with pixels within 500 m of treatment edge in untreated forest on the fireside of the fuel treatment.

Coefficient		Estimate	Std error	t-stat	p(t)
Intercept	AP2	148.1	16.5	9.0	<0.001
	AP6	629.8	17.5	35.9	<0.001
	NU	718.5	6.04	118.9	<0.001
Slope	AP2	0.99	0.06	17.8	<0.001
	AP6	-0.05	0.06	-0.84	0.40
	NU	0.20	0.021	9.7	<0.001

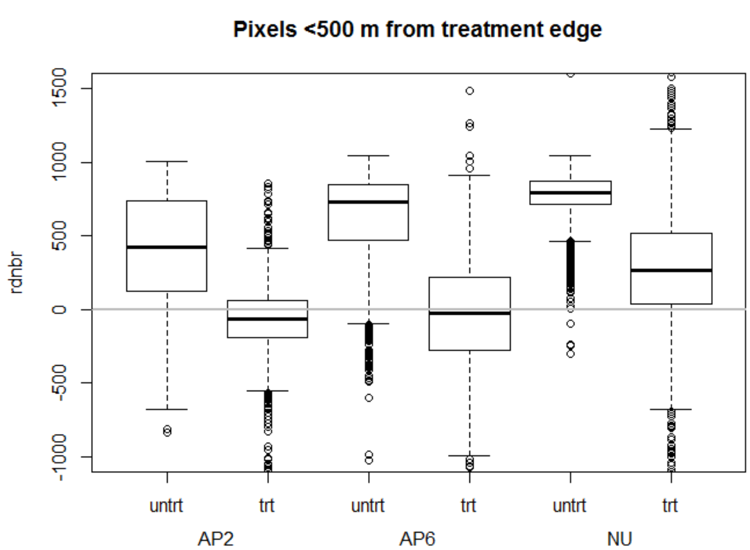

Fig. S2. Distribution of RdNBR values comparing untreated (untrt) and treated (trt) units in each treatment unit.

Edge structure of vegetation variables

Next we give supplementary results for the vegetation structure randomization tests including only the first three plots on either side of the treatment boundary (Table S3), to investigate vegetation structure at the treatment edge. Figures of the distribution of vegetation structure along the transect are also provided (Fig. S3).

Table S2. Results for randomization 2-sample t-test (2-tailed) including only the first three plots on either side of the treatment boundary. A significant result indicates a change in the stand structure variable between untreated and the first three plots in the treated. Values are the mean with the standard deviation in parentheses. *** = $p<0.01$;; ** = $p<0.05$; * = $p<0.10$

	CBH	CBD	BA	QMD	TPH	CC
AP2 Untreated	1.46 (0.97)	0.26*** (0.07)	48.5*** (11.6)	22.5 (2.3)	1306.9*** (560.3)	59.1*** (10.8)
AP2 First 3 treated	2.17 (2.03)	0.06 (0.03)	16.1 (7.4)	24.1 (16.6)	286.9 (319.9)	19.7 (8.3)
AP6 Untreated	0.91 (0.73)	0.15*** (0.06)	31.8*** (13.1)	16.6 (6.8)	1009.6*** (442.5)	49*** (12.1)
AP6 First 3 treated	1.41 (1.60)	0.04 (0.02)	10.2 (5.8)	12.6 (9.9)	275.3 (327.1)	16.5 (6.5)
NU Untreated	0.46 (0.27)	0.18*** (0.06)	30.6*** (8.6)	11.4*** (3.9)	1560.9*** (974.7)	55.4*** (7.5)
NU First 3 treated	0.53 (0.14)	0.04 (0.03)	8.3 (4.1)	5.6 (1.8)	329.5 (221.4)	18.1 (6.6)

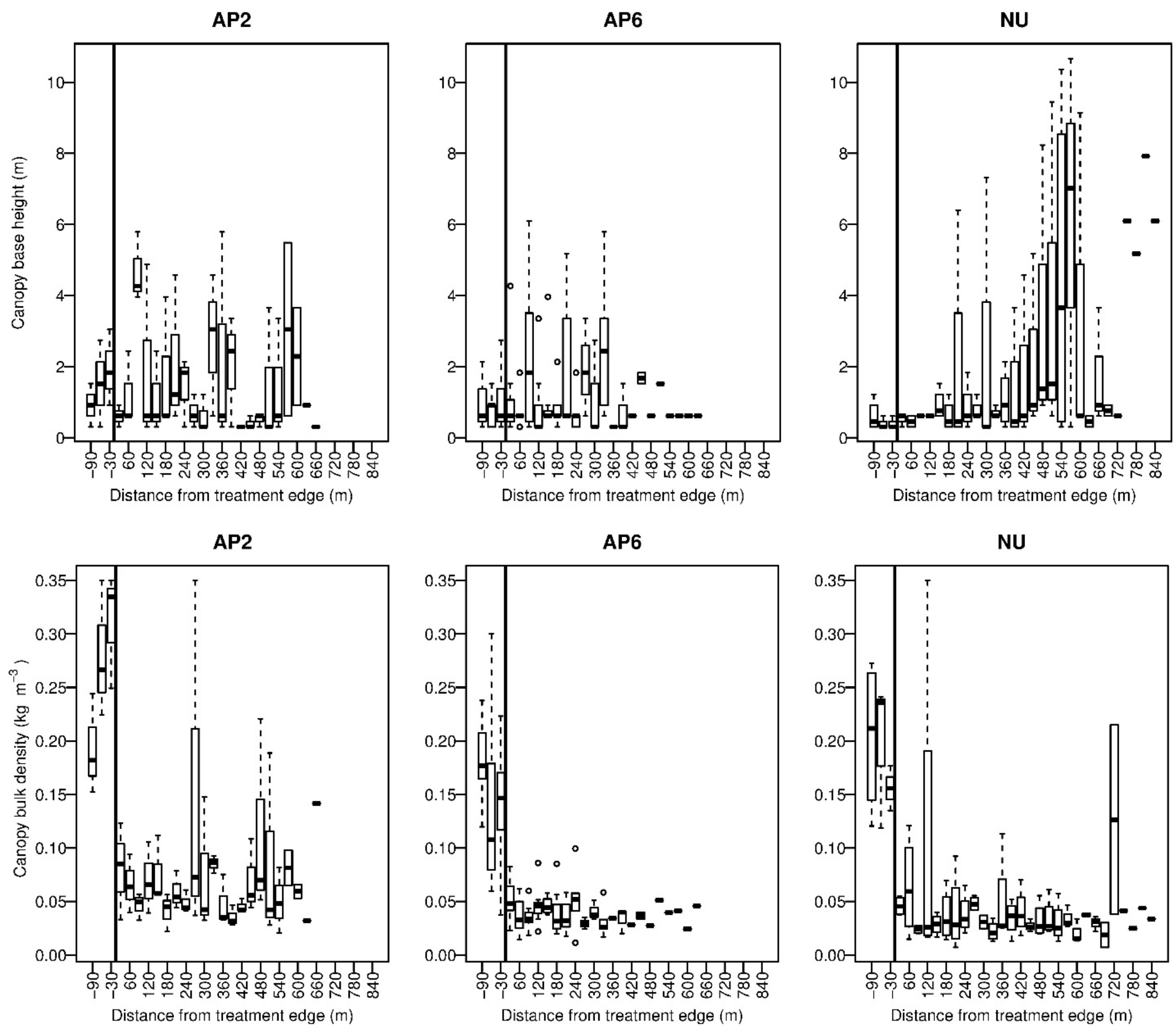

Fig. S3 Spatial distribution of vegetation structure variables, moving along the transects from untreated into treated forest. The solid vertical line is at the treatment boundary.

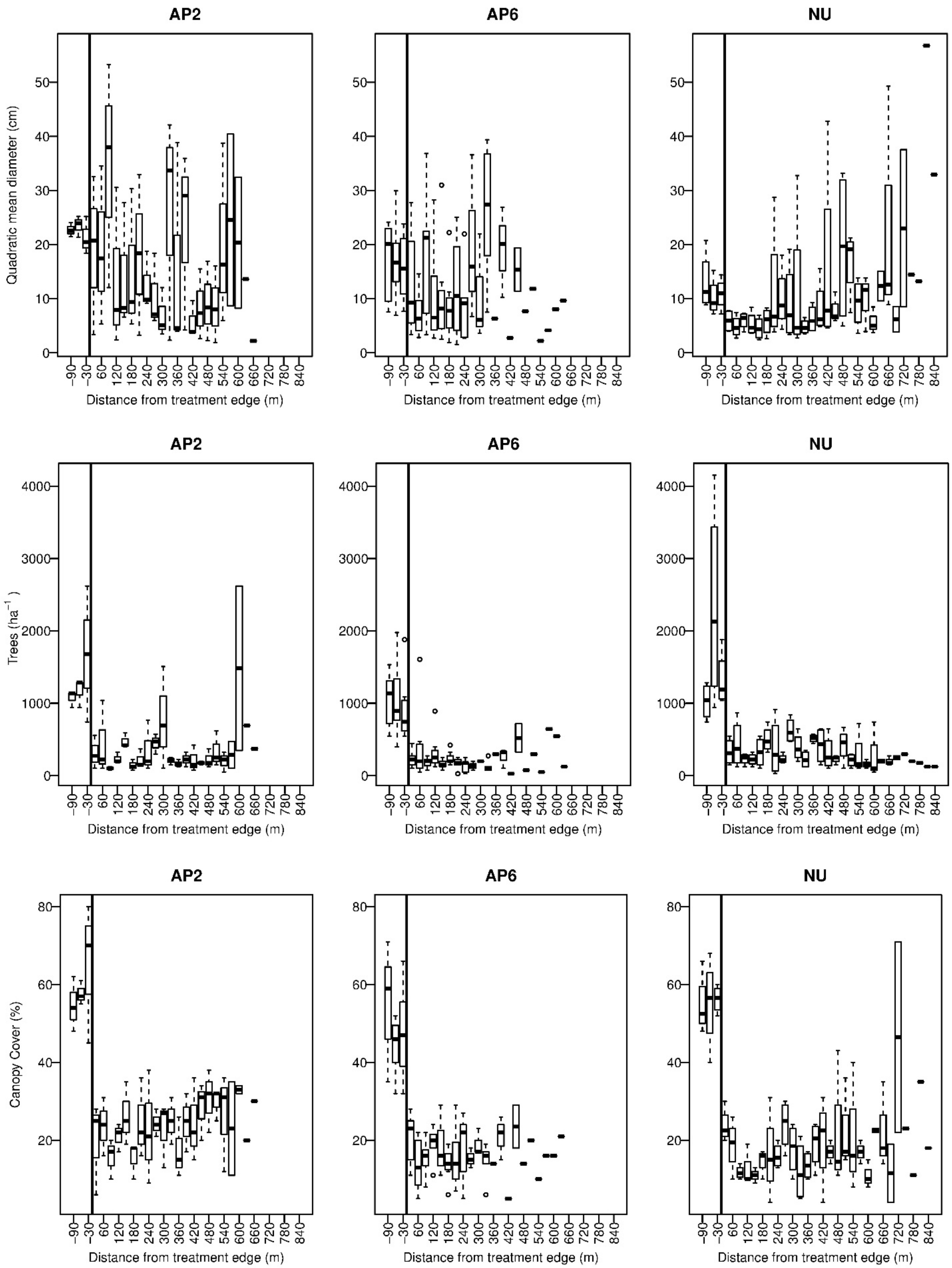

Fig. S3 (cont.) Spatial distribution of vegetation structure variables, moving along the transects from untreated into treated forest. The solid vertical line is at the treatment boundary.

Severity predicted by stand structure

Lastly we provide curves of predicted BCR and BSI3 for each stand structure variable, where only those relationships deemed significant are pictured (Fig. S4). See main text Fig. 4 for CS.

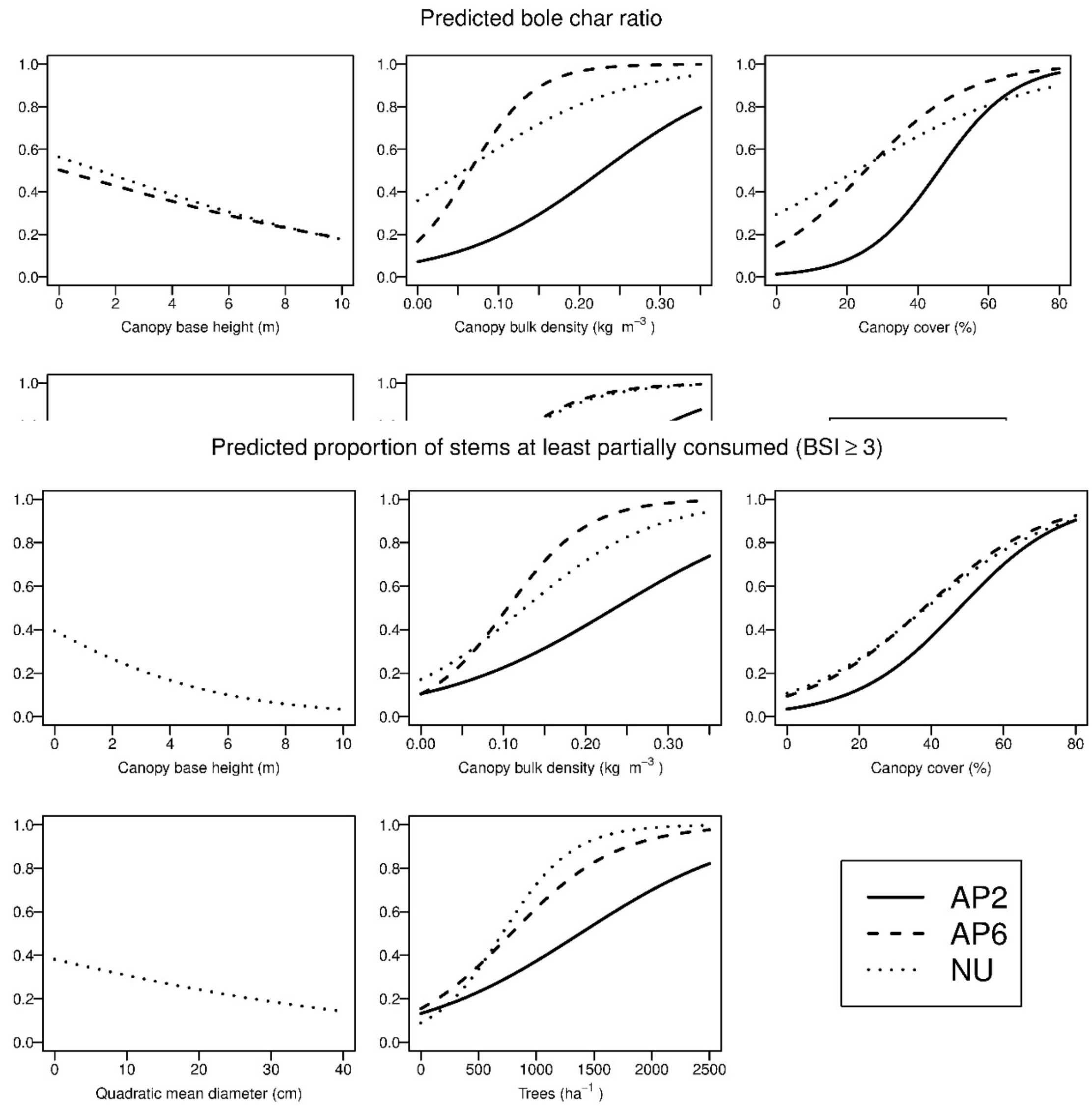

Fig. S4. Predicted BCR and BSI3 for significant relationships with stand structure variables.