10.1071/WF24014
International Journal of Wildland Fire

Supplementary Material

Avoid getting burned: lessons from the McKinley wildfire in rural Alaska, USA

Jennifer I. Schmidt[A,*], *Matthew Berman*[A] and *Christine F. Waigl*[B]

[A]University of Alaska Anchorage, Institute of Social and Economic Research, Anchorage, AK 99508, USA

[B]University of Alaska Fairbanks, International Arctic Research Center, Fairbanks, AK 99775, USA

*Correspondence to: Email: jischmidt@alaska.edu

Appendix S1. Definitions, sources, and summary statistics for variables included in the study. Aerial imagery from 2017 and 2020 was used as referenced below. Burn severity was calculated using the normalized burn ratio (dNBR) with Sentinel-2 (10m). Quadrants used were: northern (315° - 45°), eastern (45° - 135°), southern (135° - 225°), and western (225° - 315°). MSB refers to the Matanuska-Susitna Borough property assessment office.

Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
burned	Building burned	0=no, 1=yes	aerial imagery, created	325	0.52	0.5	0	1
point_x	Longitude center of a building	decimal degrees	created	325	205612.7	714.22	204323.5	207405.2
point_y	Longitude center of a building	decimal degrees	created	325	1341169	3234.5	1334862	1345572
dist2start	Distance to fire starting point	meters	created	325	4606.64	3260.79	257.27	10818.54
first_day	Within fire perimeter on day 1	0=no, 1=yes	VIIRS	325	0.4	0.49	0	1

Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
on_junkyrd	Junkyard on the property	0=no, 1=yes	aerial imagery, created	325	0.06	0.23	0	1
byjunkyd	Junkyard adjacent to the property	0=no, 1=yes	aerial imagery, created	325	0.09	0.29	0	1
blddist_m*	Distance to nearest building	meters	created	325	18.32	33.01	0	258.23
near_bldg	Building within 30m	0=no, 1=yes	aerial imagery, created	325	0.57	0.5	0	1
dst2bnbldm	Distance to nearest burnt building	meters	created	325	193.94	413.08	0	3706.66
brnblldg30m	Burned building within 30m	0=no, 1=yes	aerial imagery, created	325	0.49	0.5	0	1
brnbdlg100m	Burned building within 100m	0=no, 1=yes	aerial imagery, created	325	0.62	0.49	0	1

Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
bldbf10m	Number of buildings within a 10m buffer	count	aerial imagery, created	325	0.83	0.85	0	4
bldbf30m	Number of buildings within a 30 m buffer	count	aerial imagery, created	325	2.32	1.81	0	8
bldbf100m	Number of buildings within a 100m buffer	count	aerial imagery, created	325	7.46	5.25	0	24
parc10m	Number of neighboring parcels within a 10m buffer of the building	count	aerial imagery, created	325	0.46	0.64	0	5
parc30m	Number of neighboring parcels within a 30m buffer of the building	count	aerial imagery, created	325	1.52	1.38	0	11

Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
parc100m	Number of neighboring parcels within a 100m buffer of the building	count	aerial imagery, created	325	6.5	4.95	0	32
pvegcov10m	Percent of tree cover within 10m	percent (0-100)	aerial imagery, created	325	12.46	11.7	0	79
pvegcov30m	Percent of tree cover within 30m	percent (0-100)	aerial imagery, created	325	29.6	19.07	0	78
vegcov100m	Percent of tree cover within 100m	percent (0-100)	aerial imagery, created	325	46.07	17.29	0	87
firewise	Undetectable vegetation within 10m of building	0=no, 1=yes	aerial imagery, created	325	0.11	0.32	0	1

Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
firewise1	Undetectable vegetation within 30m of building	0=no, 1=yes	aerial imagery, created	325	0.36	0.48	0	1
exposure	Average merged wildfire exposure value for the parcel	wildfire exposure	created	325	53.51	27.55	0	99.15
expo30m	Average merged wildfire exposure value within a 30m buffer	wildfire exposure	created	325	59.81	15.24	22.5	99.75
expo100m	Average merged wildfire exposure value within a 100m buffer	wildfire exposure	created	325	61.28	12.35	31.22	99.28

Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
expo500m	Average merged wildfire exposure value within a 500m buffer	wildfire exposure	created	325	67.89	8.5	54.46	90.44
n100mbf	Average merged wildfire exposure within the northern quadrant of a 100m buffer around the building	wildfire exposure	created	325	63.5	14.56	26.2	97.8
e100mbf	Average merged wildfire exposure within the eastern quadrant of a 100m	wildfire exposure	created	325	63.52	13.6	26	99.3

Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
	buffer around the building							
s100mbf	Average merged wildfire exposure within the southern quadrant of a 100m buffer around the building	wildfire exposure	created	325	59.81	14.75	24.63	100
w100mbf	Average merged wildfire exposure within the western quadrant of a 100m buffer around the building	wildfire exposure	created	325	58.54	15.59	26.25	100

Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
ex30b100s	Average 100m wildfire exposure value within a 30m buffer	wildfire exposure	created	325	58.58	16.13	20	99.75
ex30b500s	Average 500m wildfire exposure value within a 30m buffer	wildfire exposure	created	325	59.1	11.56	37	90
e100b100s	Average 100m wildfire exposure value within a 100m buffer	wildfire exposure	created	325	60.35	12.87	29.72	99.28
e100b500s	Average 500m wildfire exposure	wildfire exposure	created	325	59.41	11.29	37.68	89.6

Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
	value within a 100m buffer							
e500b100s	Average 500m wildfire exposure value within a 100m buffer	wildfire exposure	created	325	67.18	8.75	53.21	90.35
e500b500s	Average 500m wildfire exposure value within a 500m buffer	wildfire exposure	created	325	60.2	10.09	42.91	86
mex30b100s	Maximum 100m wildfire exposure value within a 30m buffer	wildfire exposure	created	325	63.18	15.88	22	100

Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
mex30b500s	Maximum 500m wildfire exposure value within a 30m buffer	wildfire exposure	created	325	60.1	11.42	37	90
me100b100s	Maximum 100m wildfire exposure value within a 100m buffer	wildfire exposure	created	325	78.38	12.81	43	100
me100b500s	Maximum 500m wildfire exposure value within a 100m buffer	wildfire exposure	created	325	62.2	11.16	40	92
me500b100s	Maximum 500m wildfire exposure	wildfire exposure	created	325	96.52	3.51	78	100

Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
	value within a 100m buffer							
me500b500s	Maximum 500m wildfire exposure value within a 500m buffer	wildfire exposure	created	325	73.09	10.23	53	95
dnbrmean	Average burn severity for the parcel	dNBR	Sentinel-2 (10m)	325	452.95	249.19	0	834.17
dnbr10m	Average burn severity within a 10m buffer	dNBR	Sentinel-2 (10m)	325	354.64	223.32	-136	815
dnbr30m	Average burn severity within a 30m buffer	dNBR	Sentinel-2 (10m)	325	448.55	173.17	2.67	843.44
dnbr100m	Average burn severity within a 100m buffer	dNBR	Sentinel-2 (10m)	325	529.68	112.76	177.42	780.2

Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
dnbr500m	Average burn severity within a 500m buffer	dNBR	Sentinel-2 (10m)	325	591.33	70.92	433.58	737.93
dnbr10mnb	Average burn severity in a 10m buffer, excluding building footprint	dNBR	Sentinel-2 (10m)	325	433.49	174.33	17.78	853.16
dnbr30mnb	Average burn severity in a 30m buffer, excluding building footprint	dNBR	Sentinel-2 (10m)	325	462.63	159.87	96.04	854.35
dnbr100mnb	Average burn severity in a 100m buffer, excluding building footprint	dNBR	Sentinel-2 (10m)	325	531.14	110.49	178.15	776

Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
dnbr500mnb	Average burn severity in a 500m buffer, excluding building footprint	dNBR	Sentinel-2 (10m)	325	591.35	71.31	437.21	739.35
hv30b100s	Average 100m hazardous vegetation value within a 30m buffer	hazardous vegetation	created	325	53.99	25.13	4	100
hv30b500s	Average 500m hazardous vegetation value within a 30m buffer	hazardous vegetation	created	325	42.05	32.7	1.5	100
hv100b100s	Average 100m hazardous vegetation	hazardous vegetation	created	325	60.84	14.67	21.72	100

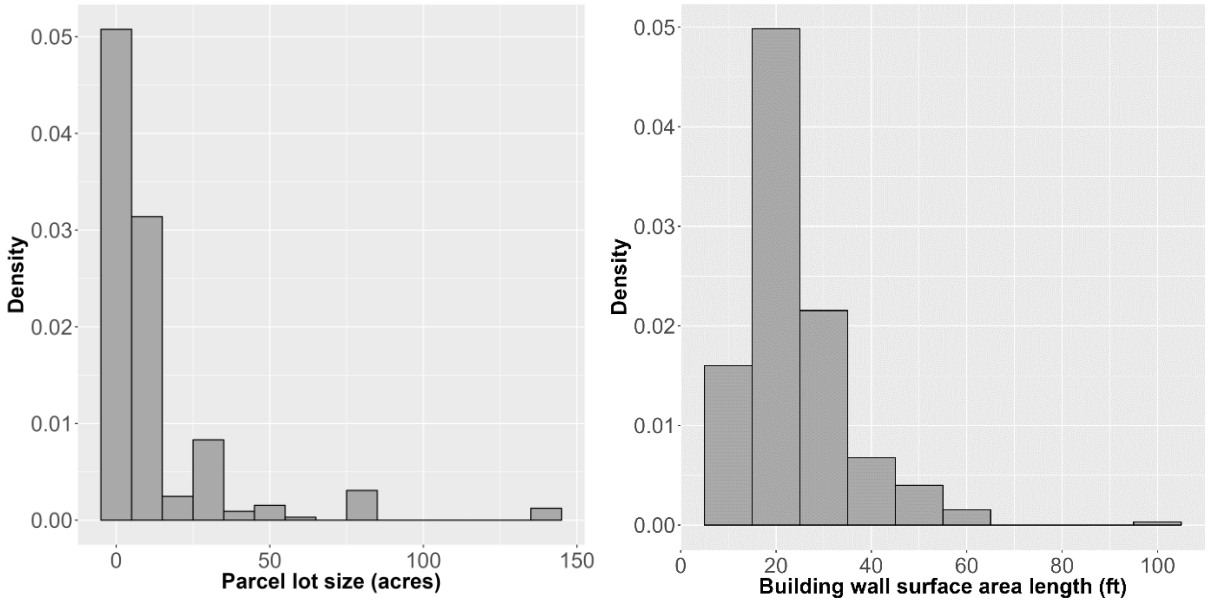
Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
	value within a 100m buffer							
hv100b500s	Average 500m hazardous vegetation value within a 100m buffer	hazardous vegetation	created	325	59.41	11.29	37.68	89.6
hv500b100s	Average 500m hazardous vegetation value within a 100m buffer	hazardous vegetation	created	325	68.37	8.57	54.7	90.81
hv500b500s	Average 500m hazardous vegetation value within a 500m buffer	hazardous vegetation	created	325	60.07	11.3	38.79	89.52

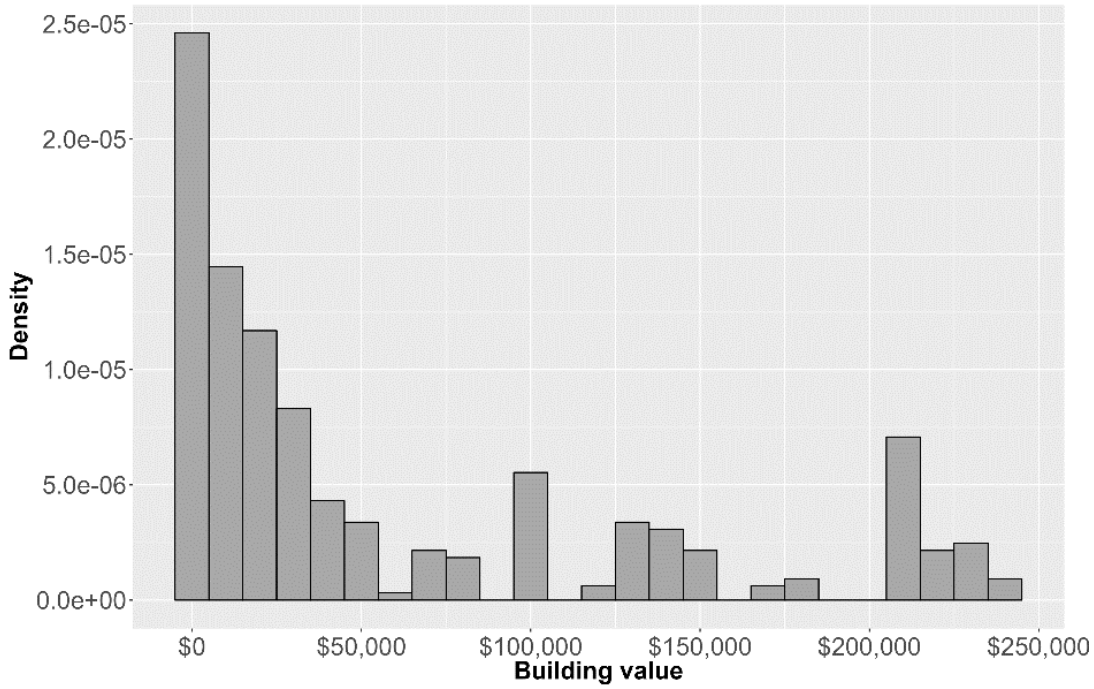
Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
mv30b100s	Maximum 100m hazardous vegetation value within a 30m buffer	hazardous vegetation	created	325	72.79	26.75	30	100
mv30b500s	Maximum 500m hazardous vegetation value within a 30m buffer	hazardous vegetation	created	325	64.58	37.72	6	100
mv100b100s	Maximum 100m hazardous vegetation value within a 100m buffer	hazardous vegetation	created	325	97.62	8.34	50	100
mv100b500s	Maximum 500m hazardous vegetation	hazardous vegetation	created	325	62.2	11.16	40	92

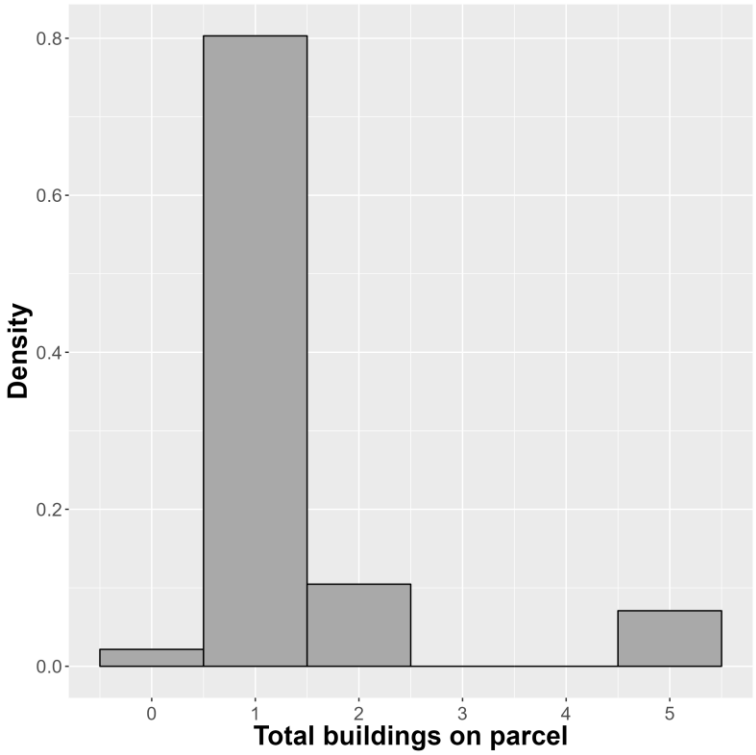
Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
	value within a 100m buffer							
mv500b100s	Maximum 500m hazardous vegetation value within a 100m buffer	hazardous vegetation	created	325	100	0	100	100
mv500b500s	Maximum 500m hazardous vegetation value within a 500m buffer	hazardous vegetation	created	325	100	0	100	100
acres	Parcel lot size	acres	MSB	325	10.96	21.6	0.91	141.56
landvalue	Land value	$	MSB	325	22192.31	16298.08	0	85200
bldgvalue	Building value	$	MSB	325	61977.23	74845.85	0	243200

Variable	*Definition*	*Units*	*Data source*	*Valid obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
resunit	Number of residential units	Number	MSB	325	1.01	1.03	0	4
mhunit	Mobile home on the property	0=no, 1=yes	MSB	325	0.09	0.29	0	1
commercial	Commercial building	0=no, 1=yes	MSB	325	0.27	0.44	0	1
units	Total buildings on parcel	Number	MSB	325	1.37	1.06	0	5
bldsqfeet	Building size	sq. feet	MSB	325	688.25	794.05	81.59	9217.9
bldwall	Building wall perimeter	feet	MSB, sq. root of bldg. sq. feet	325	23.87	10.9	9.03	96.01

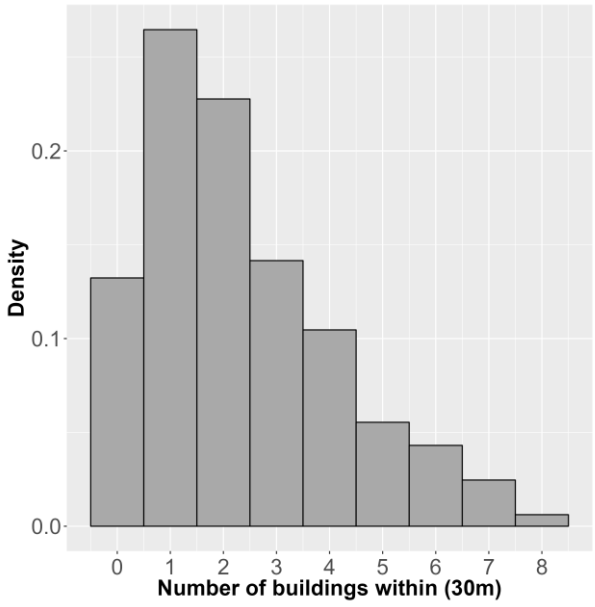
Appendix S2. Histograms of variables selected in the logistic and generalized spatial two-stage least squares (GLS) regressions. Parcels that have zero units represent where the Matanuska-Susitna assessment database (January 2019) indicated no buildings on the parcel, but aerial imagery just before the McKinley wildfire (August 2019) indicated a building was present.

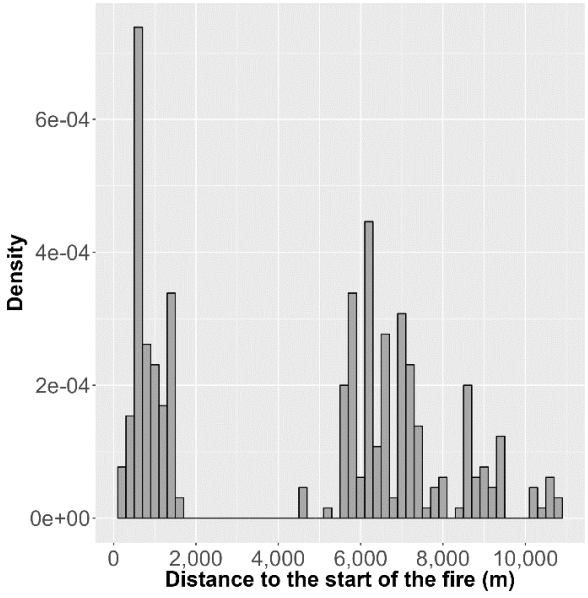




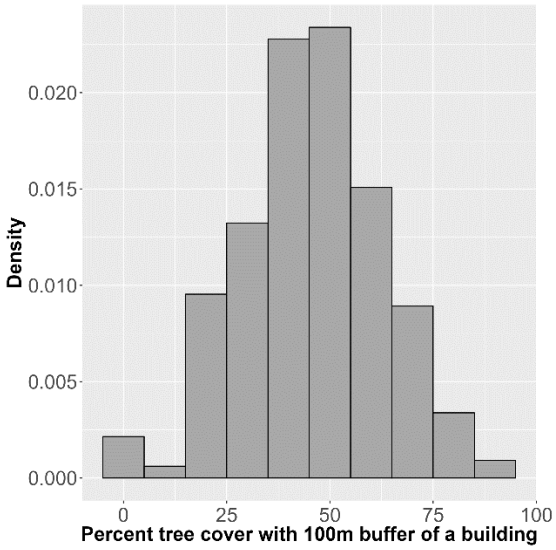

Density
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
Total buildings on parcel

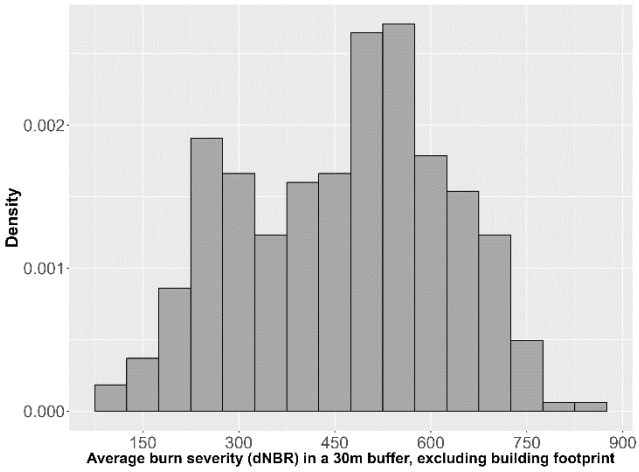
781


Density
0.2
0.1
0.0
0
1
2
3
4
5
6
7
8
Number of buildings within (30m)

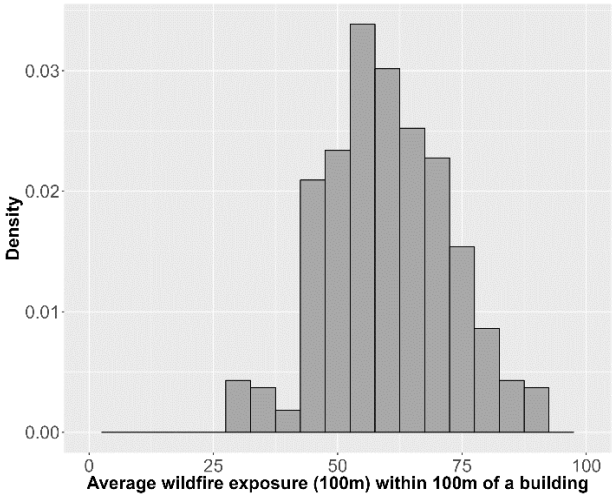

Density
6e-04
4e-04
2e-04
0e+00
0
2,000
4,000
6,000
8,000
10,000
Distance to the start of the fire (m)

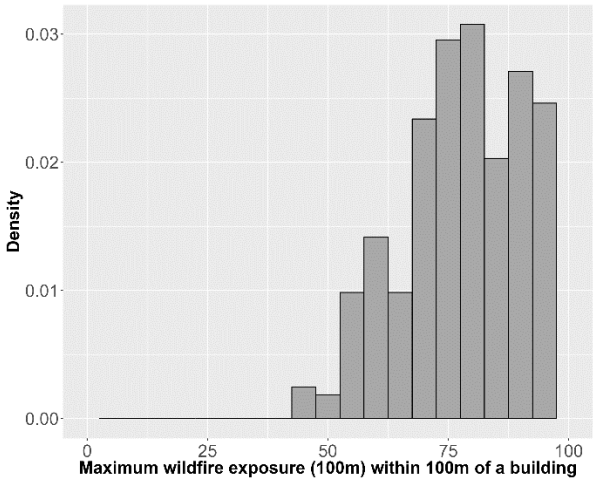
782


Density
0.020
0.015
0.010
0.005
0.000
0
25
50
75
100
Percent tree cover with 100m buffer of a building

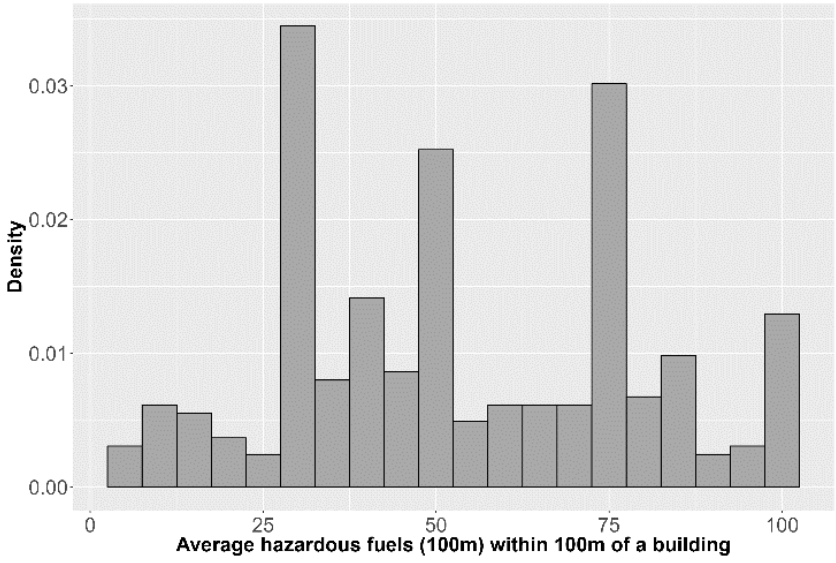

Density
0.002
0.001
0.000
150
300
450
600
750
900
Average burn severity (dNBR) in a 30m buffer, excluding building footprint

783


Density
0.03
0.02
0.01
0.00
0
25
50
75
100
Average wildfire exposure (100m) within 100m of a building


Density
0.03
0.02
0.01
0.00
0
25
50
75
100
Maximum wildfire exposure (100m) within 100m of a building

784


Density
0.03
0.02
0.01
0.00
0
25
50
75
100
Average hazardous fuels (100m) within 100m of a building

785

Appendix S3. Comparison of burn severity on the ground with remote sensed data.

Composite burn index (CBI) plots are the preferred method to collect on the ground information about burn severity in Alaska (Murphy et al., 2008; Smith et al., 2021). We used a protocol modified specific for Alaska (Barnes et al., 2020; Key & Benson, 2006) on 63 plots within and around (< 500m) of the McKinley wildfire perimeter. Ground and overstory CBI values were assessed tabulated to calculate the overall plot CBI score. The Normalized Burn Ratio (NBR) and differenced NBR (dNBR) were calculated using Senintel-2 Copernicus S2 data and a google earth engine script (SPIDER, 2020). The dNBR map was used to stratify the sampling locations by four burn severity classes: high (4.9 km^2, 22 plots), moderate (high = 6.4 km^2, 24 plots), low (1.7 km^2, 10 plots), and unburned (0.2 km^2, 7 plots). Linear regression was used to estimate the relationship between dNBR and the CBI score (Figure A1).

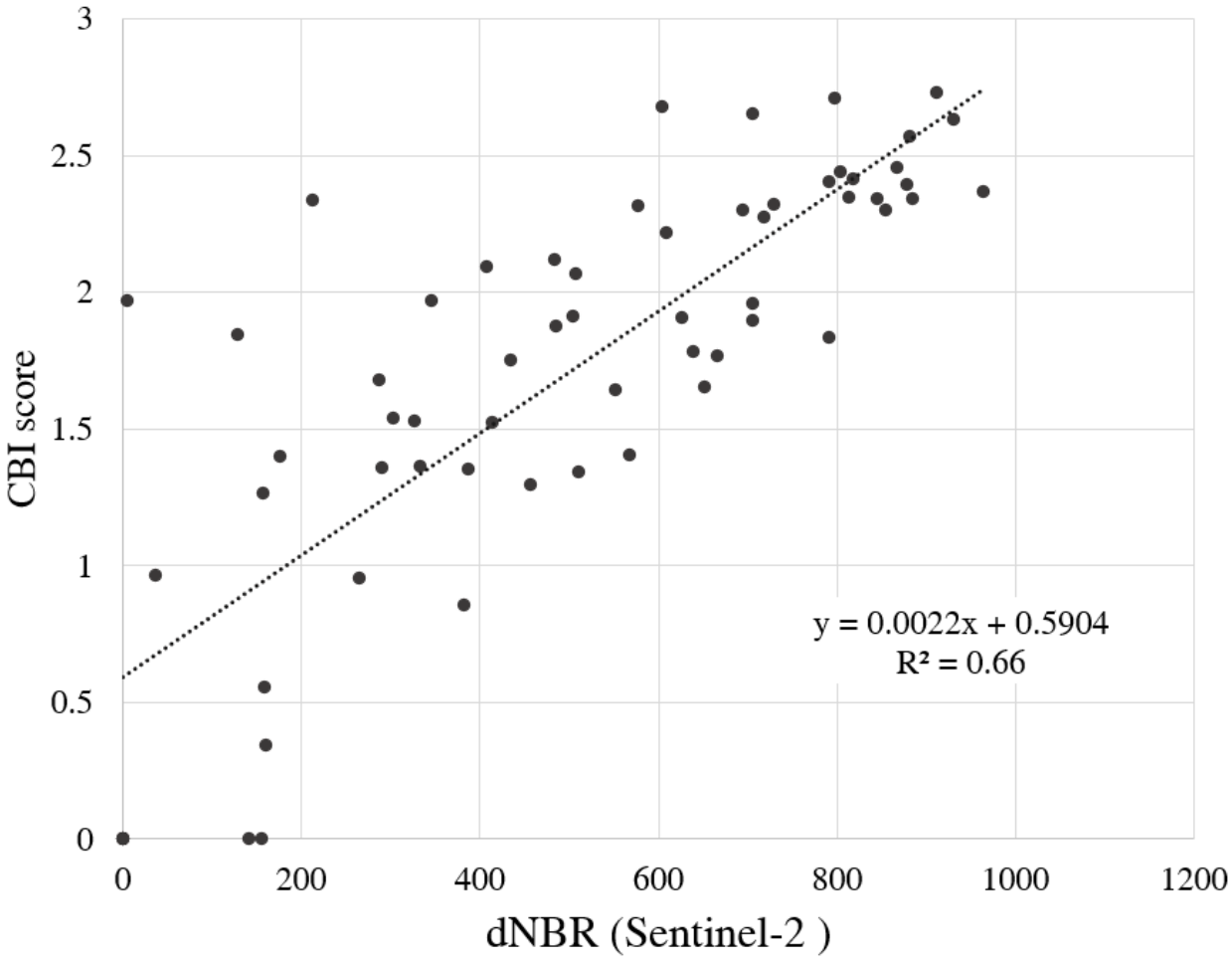


Figure S1. Linear regression result between differenced Normalized Burn Ratio (dNBR) as derived from Sentinel-2 data and composite burn index (CBI).

References:

Barnes, J. L., McMillan, J. S., & Hrobak, J. L. (2020). NPS Alaska fire and fuels circular plot monitoring protocal, version 1.0. . https://irma.nps.gov/DataStore/DownloadFile/637331

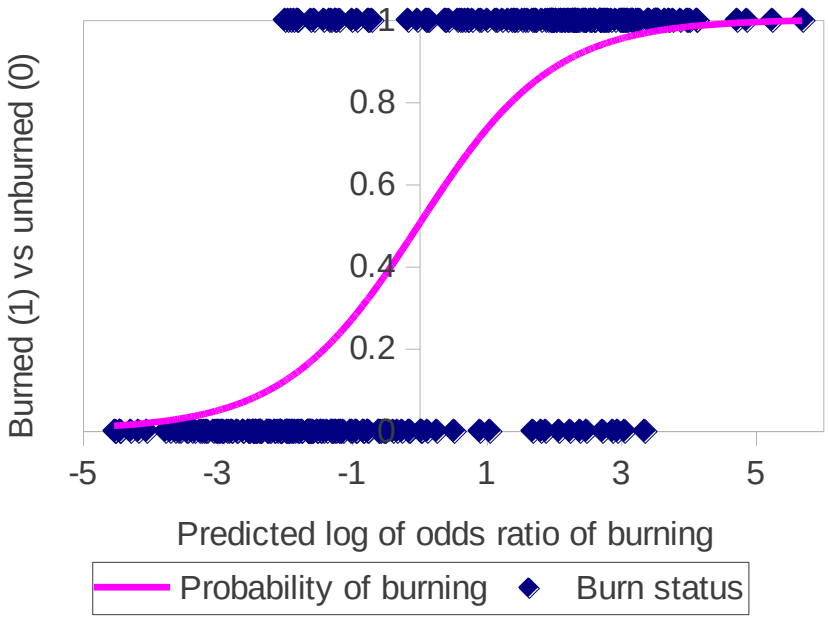
Key, C. H., & Benson, N. C. (2006). Sampling and Analysis Methods. In D. C. Lutes, R. E. Keane, J. F. Caratti, C. H. Key, N. C. Benson, S. Sutherland, & L. J. Gangi (Eds.), FIREMON: Fire Effects Monitoring and Inventory System (Vol. General Technical Report RMRS-GTR-164-CD, p. LA-1-55). USDA Forest Service, Rocky Mountain Research Station.

Murphy, K. A., Reynolds, J. H., & Koltun, J. M. (2008). Evaluating the ability of the differenced Normalized Burn Ratio (dNBR) to predict ecologically significant burn severity in Alaskan boreal forests. International Journal of Wildland Fire, 17(4), 490-499. https://doi.org/10.1071/wf08050

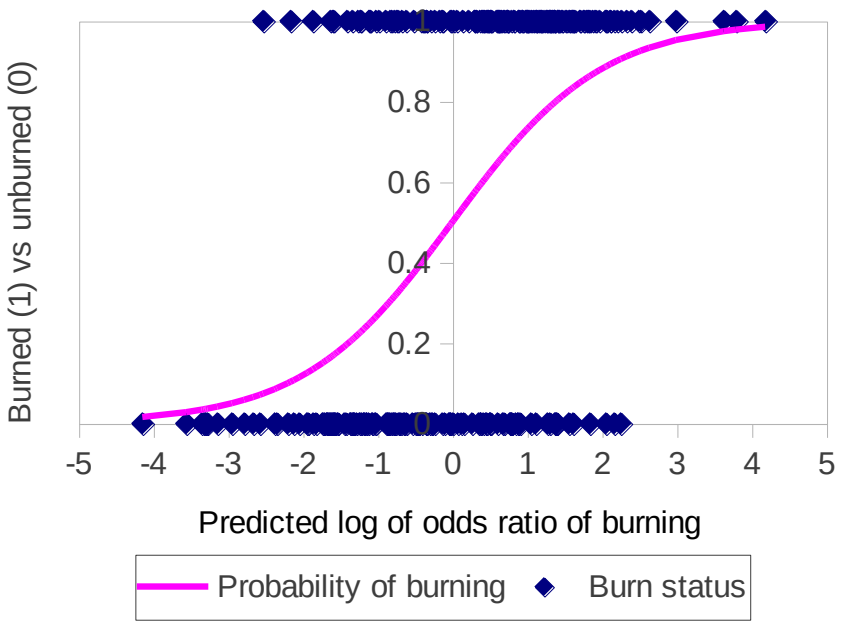
Smith, C. W., Panda, S. K., Bhatt, U. S., Meyer, F. J., Badola, A., & Hrobak, J. L. (2021). Assessing Wildfire Burn Severity and Its Relationship with Environmental Factors: A Case Study in Interior Alaska Boreal Forest. Remote Sensing, 13(10), Article 1966. https://doi.org/10.3390/rs13101966

SPIDER. (2020). Step by Step: Burn Severity mapping in Google Earth Engine. United Nations Platform for Space-based Information for Disaster Management and Emergency Response. https://www.un-spider.org/advisory-support/recommended-practices/recommended-practice-burn-severity/burn-severity-earth-engine

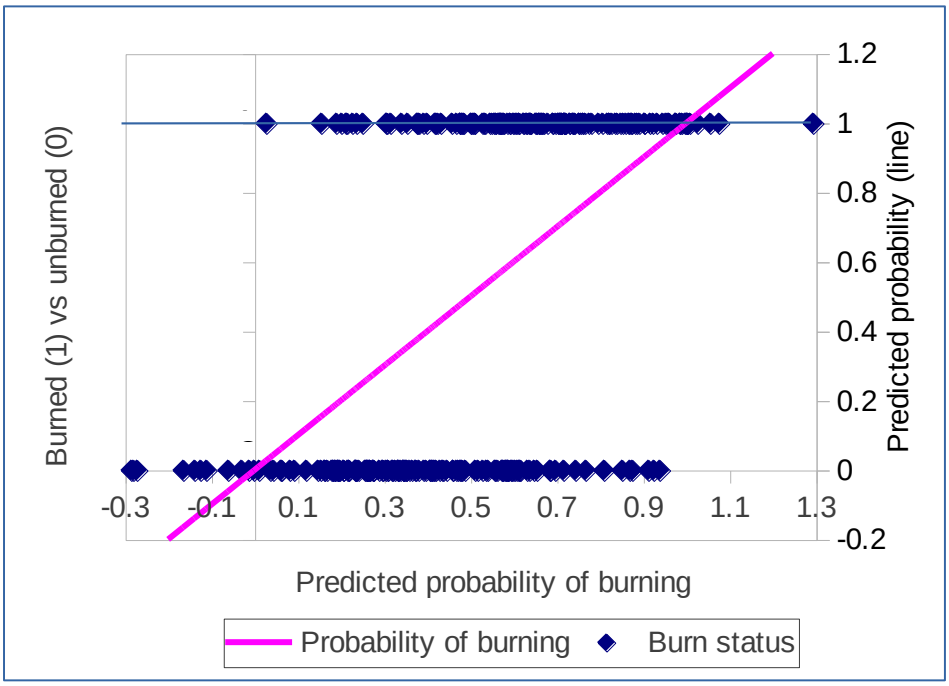
Appendix S4 Figure A. Predicted probability of burning vs. burn status for buildings within the McKinley Fire perimeter. Predicted probability of burning calculated from equation results shown in Table 2, column 1.



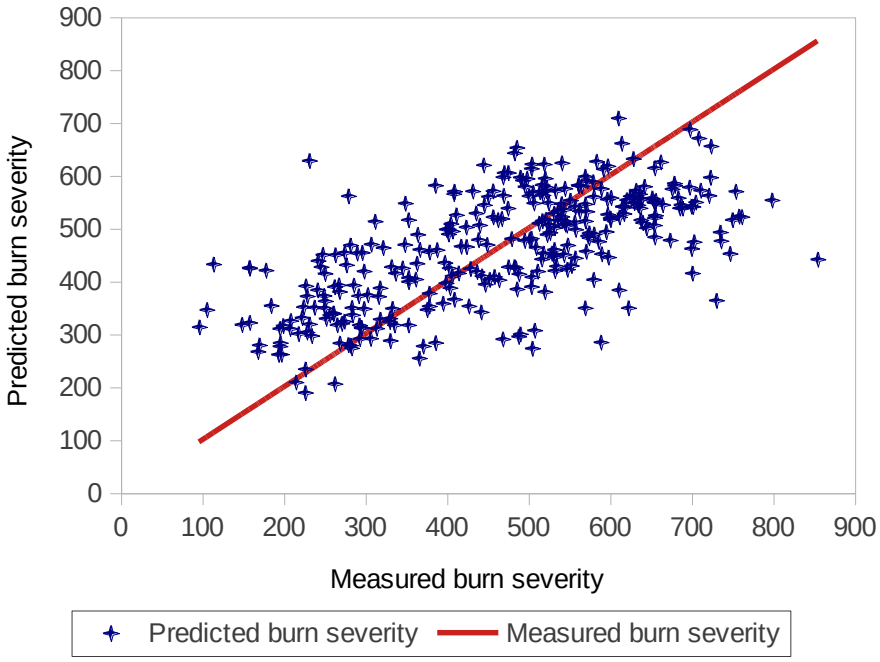
Appendix 4 Figure B. Predicted probability of burning vs. burn status for buildings within the McKinley Fire perimeter. Predicted probability of burning calculated from equation results shown in Table 2, column 2.



Appendix 4 Figure C Predicted probability of burning vs. burn status for buildings within the McKinley Fire perimeter. Predicted probability of burning calculated from equation results shown in Table 2, column 3. The adjustment for spatial autocorrelation fits linear regression for the probability of burning which may predict probabilities less than zero or greater than one.



Appendix 4 Figure D. Predicted burn severity vs. measured burn severity within 30m of buildings within the McKinley Fire perimeter. Predictions from equation results are shown in Table 2, column 4.



Appendix 4 Figure E Predicted probability of burning vs. burn status for buildings within the McKinley Fire perimeter. Predicted probability of burning calculated from equation results shown in Table 2, column 5. The adjustment for spatial autocorrelation fits linear regression for the probability of burning which may predict probabilities less than zero or greater than one.