Unequal Treatments: Federal Wildfire Fuels Projects and Socioeconomic Status of Nearby Communities *

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Abstract

With wildfires becoming more severe and more damaging in the western U.S., fuels management projects intended to reduce the severity of wildfire are becoming an increasingly important management tool. Yet, the statutory requirements for federal agencies to incorporate public input in their siting decisions combined with the greater political efficacy of wealthier, more educated communities has the potential to lead to inequities in their distribution. In this paper, we show that the likelihood of a community receiving a nearby fuels management project is greater for wealthier, whiter, and more educated communities, even after controlling for differences in risk from wildfire. We further investigate the CLFRP, a cost-share program operated by the US Forest Service. Communities near CLFRP projects tend to have higher socioeconomic status. However, participation in cost-share programs does not appear to depend critically on wealth since we find no difference in the wealth of communities near CLFRP projects compared to all US Forest Service fuels projects, including those with no matching requirements. Rather, the racial makeup and educational attainment of communities is more strongly associated with nearby cost-share projects.

1 Introduction

Wildfires cause substantial property damages and are a significant source of particulate matter, other air pollutants (McClure and Jaffe, 2018; Jaffe and Wigder, 2012), and greenhouse gas emissions (Van Der Werf et al., 2017).[1] Since the 1970s, wildfire activity in the western United States has been increasing (Westerling, 2016a), along with suppression costs and damages (Calkin et al., 2005; Buechi et al., 2021). In 2018, federal agencies in the US spent $3.14 billion fighting wildfire, more than a five-fold real increase since 1985.[2] Most of these costs were incurred in the western U.S., where forests and grasslands are relatively dry and fire prone.[3] In 2019, 72% of the acreage burned in the western US was on federal land.[4] The increase in wildfire activity in the western US is attributed to the combined effects of climate change (Westerling et al., 2006; Abatzoglou and Williams, 2016) and high levels of combustible materials ("fuel loads") within western forests (Arno et al., 1995; Keane et al., 2002; Naficy et al., 2010). High fuel loads are, in part, the result of fire suppression during the twentieth century, and have been linked to larger and more severe wildfires (Schoennagel et al., 2004).

Fuels management reduces fuels loads on the landscape by means of mechanical thinning and controlled burns. It is the primary tool used on federal lands to reduce the severity of wildfires and risks to neighboring communities. Between 2009 and 2018, the US Forest Service and the Department of the Interior land management agencies (e.g., Bureau of Land Management) spent approximately $500 million per year on fuels projects. Although the location and scale of fuels projects is based on principles of scientific management, the agencies have considerable discretion when allocating projects. As well, public pressure can play an important role in agency decision-

[1]Over the period 1997-2016, global emissions from all biomass burning are estimated at 2.2 GtCyr^{-1} compared to global emissions from fossil fuel combustion and land-use change of 11 GtCyr^{-1} (Friedlingstein et al., 2019).

[2]National Interagency Fire Center, http://www.nifc.gov/fireInfo/fireInfo_documents/SuppCosts.pdf

[3]State and federal lands account for almost one-half of the total area of the 11 western states (Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming).

[4]https://fas.org/sgp/crs/misc/IF10244.pdf

making (Sabatier et al., 1995; Johnson and Watts, 1989; Anderson et al., 2013). Both the National Environmental Policy Act (1970) and the National Forest Management Act (1976) require public participation, thereby allowing communities near federal lands opportunities to comment on and influence proposed fuels management projects. The discretion given to federal agencies, together with the potential for community influence, raise the possibility that communities will be treated unequally. This paper analyzes what determines the location of federal fuels management projects, considering specifically whether the socio-economic characteristics of a community influence whether fuels projects get sited on nearby federal lands.

This paper builds on previous work in Anderson et al. (2022, hereafter, APW). In that study, we used salient wildfires, which raise public demands for fuels management on nearby federal lands, to test for unequal representation in agency decision-making. We find that federal land management agencies have a higher probability of allocating fuels projects near communities that have experienced a nearby wildfire and that the effect predominates among higher socio-economic status communities. For example, our results indicate that a one standard deviation increase in the percentage of the community above the poverty line and the percentage with a college education increases the likelihood of the community receiving a fuels treatment by, respectively, 40 and 30 percent over the baseline rate of treatment. We interpret these findings as evidence of inequity in agency response to communities. Our empirical design rules out a number of alternative explanations, including statutory requirements, Congressional oversight of agencies, and agency preferences, as well as differences among communities in fire risk and the value of vulnerable assets.

The goal of the current paper is to explore and extend the results in APW. We do this by providing additional background information on federal fuels treatments, including maps of project locations and demographic characteristics of nearby communities. In addition, we incorporate an explicit measure of wildfire hazard (the conditions leading to larger and more severe fires) to show the effects of both risk and demographics on the locations of fuels projects. Finally, we conduct a new analysis of the U.S. Forest Service's Collaborative Forest Landscape Restoration Program (CFLRP). The CFLRP is a cost-share program that allows communities to leverage public funds to conduct forest restoration projects on National Forest System lands, including those that reduce wildfire risks.[5] We evaluate how community demographics are correlated with the likelihood of having a CLFRP project nearby, with the goal of better understanding the role of public pressure in influencing decisions by federal land management agencies. We expect that communities able to mobilize and contribute resources for fuels projects through the CFLRP will be better equipped to influence agencies through the public participation process. We find that wealthier, whiter, and more educated communities have a greater likelihood of being close to a CLFRP fuels management project (except in very low risk areas). When we compare CLFRP projects to all U.S. Forest Service hazardous fuels projects, including those without cost share, we find that the wealth of nearby communities is similar. In contrast, communities near CLFRP projects are whiter and more educated than communities near the full set of hazardous fuels projects. This suggests that wealth is not the critical factor for securing projects requiring cost share, but that race and education do play a role.

The next section provides a detailed background on wildfire management, followed by a section describing the data sources and methods we use in this analysis. Then, we present results that demonstrate how socioeconomics factors are associated with fuels management projects, and particularly associated with fuels management projects facilitated by the CFLRP. We conclude by providing a summary of our results, considering the environmental justice implications of these findings, and discussing future research directions.

[5] In addition to fuels management for wildfire, restoration encompasses a broad range of management activities intended to restore ecological function (e.g., removal of diseased trees).

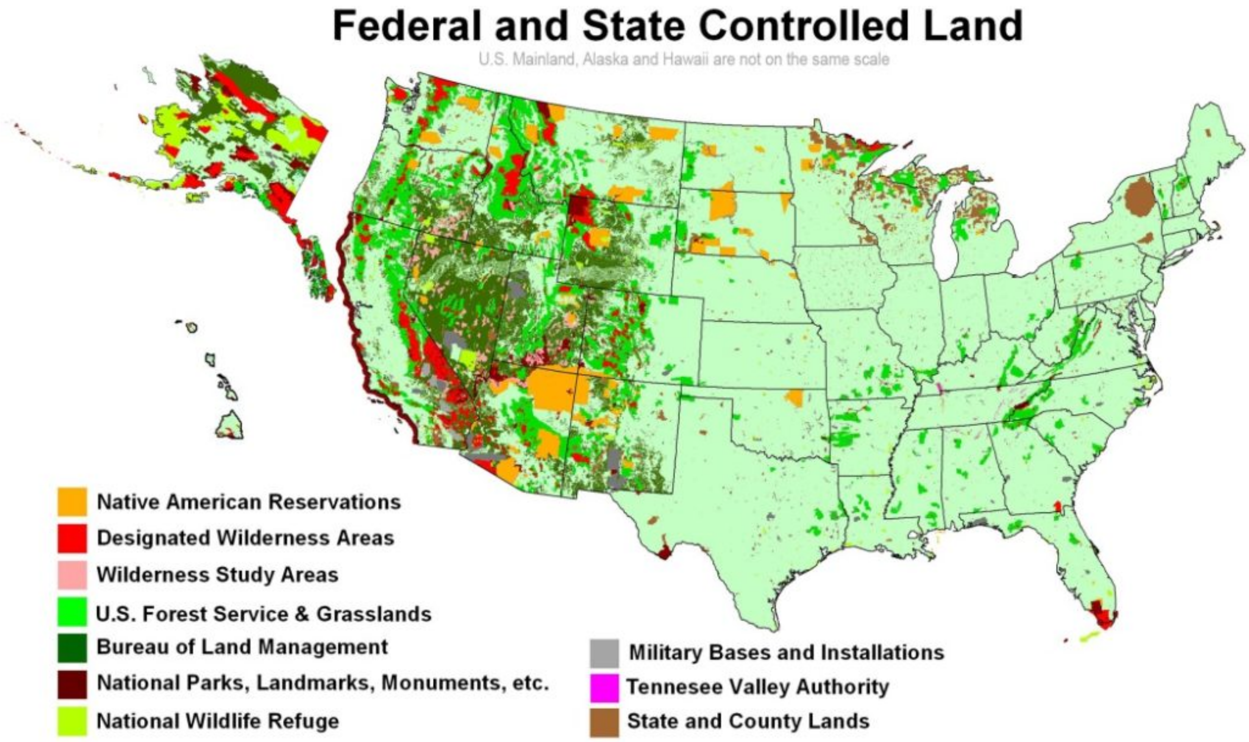
2 Background

2.1 Managing wildfire in the western U.S.

Federal agencies manage 250 million hectares of wildlands in the U.S., and 88% of public lands in the contiguous U.S. are in the western U.S. (Figure 1). In recent decades, the threat of wildfire has increased in this region (Dennison et al., 2014; Westerling, 2016b), owing to factors including climate change (Moritz et al., 2012; Westerling et al., 2006; Yue et al., 2013), the expansion of the wildland urban interface (WUI) (Radeloff et al., 2018), and historical fire suppression (Arno et al., 1995; Keane et al., 2002; Naficy et al., 2010). For much of the twentieth century, the U.S. Forest Service (USFS) and other public agencies took aggressive steps to exclude fire from western forests through fire suppression. This led to a build-up of "ladder fuels," which carry fire from a forest's understory to its canopy and can contribute to larger and more severe wildfires in some dry western forests. Due to increases in wildfire hazard, federal spending on wildfire management has risen in recent decades (Figure 2). Federal agencies spend approximately $6 billion annually controlling wildfire (Hoover, 2020), and approximately one-half of the USFS budget is now dedicated to fire management (Thompson et al., 2015).

Of this wildfire spending, roughly $0.6 billion is allocated to fuels management projects, which involve removing fuels from the landscape through mechanical thinning and controlled burns (Hoover, 2020; Agee and Skinner, 2005). The goal of these projects is to reduce the severity of wildfires (Stephens et al., 2009) by returning the forest to conditions under which high intensity fires are less likely. Removing understory vegetation can reduce the likelihood that trees will burn in high-severity canopy fires (Agee and Skinner, 2005). Fuels reduction projects within dry forests of the western U.S. are effective in reducing fire intensity, especially when prescribed fire and thinning are used together (Kalies and Kent, 2016). There is also evidence that strategically-placed fuels

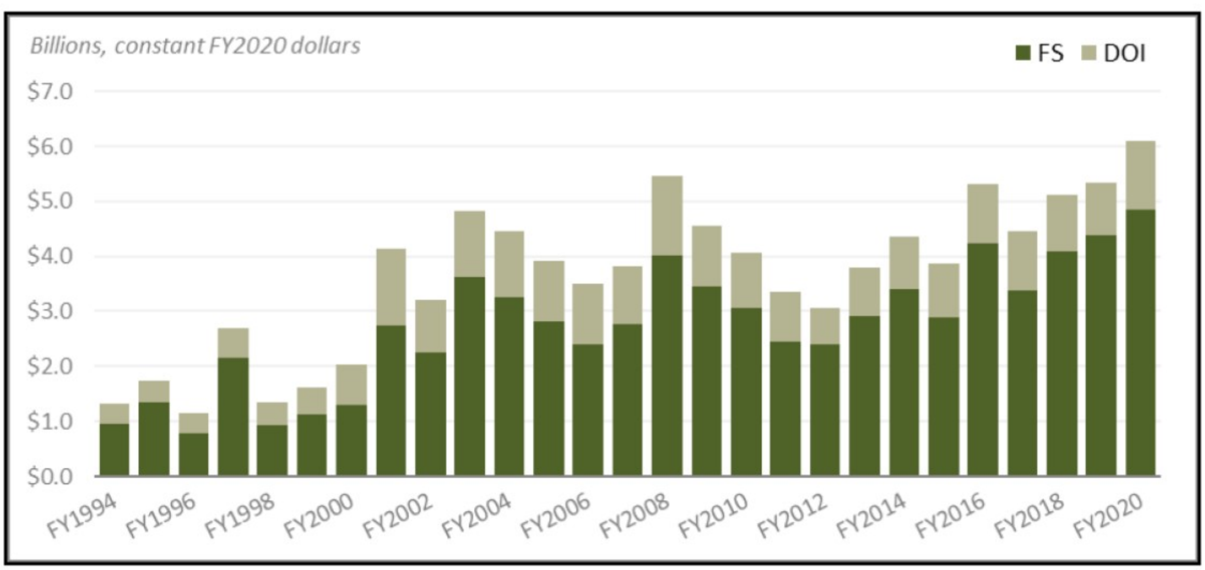
Figure 1: Public lands in the United States



projects (Schoennagel et al., 2017) can help prevent damage to homes and structures by reducing fire severity (Kennedy and Johnson, 2014) and allowing firefighters to defend homes (Bostwick et al., 2011). Despite the effectiveness of fuels treatments, the federal land management agencies face a monumental challenge. The USFS estimates that 85 million acres of National Forest land, almost one-half of the total area, are in need of forest restoration (Buford et al., 2015). Currently, approximately 2–4 million acres of National Forest land are restored each year.

The USFS and other agencies emphasize scientific management at the same time that they respond to public input (Sabatier et al., 1995; Johnson and Watts, 1989; Anderson et al., 2013). Participatory decision-making structures have been enshrined in law governing federal land management at least since the National Environmental Policy Act (NEPA) of 1970 (Force et al., 2002; Stern et al., 2010). The National Forest Management Act of 1976 mandates that the public be allowed to comment on forest management plans. As well as also requiring a public comment period, NEPA requires an Environmental Impact Statement (EIS) for any federal action that is found to have the potential to significantly impact the environment. In preparing EISs, which offer analysis of potential courses of action, managers report proactively seeking to accommodate competing interests (Stern et al., 2010). Likewise, this openness to public input is reflected in this description of how federal fuels management is planned and evaluated: "we plan fuel management projects with multiple partners, including other Federal agencies, Tribes, States, counties, local organizations, and private landowners" (US Department of Interior, 2021). In interviews with district rangers from Region 1 during the summer of 2011, they often indicated that NEPA facilitated public comment on the projects. According to Hakanson (2010), forest managers often have an eye toward the public role in the NEPA process from a fuels project's conception. And communities often channel their social capital after disasters toward lobbying of government agencies (Chamlee-Wright and Storr, 2011), such as when landowners in the Bitterroot Valley petitioned the Forest Service for fuels treatments after the Roaring Lion Fire (Backus, 2017).

Figure 2: Federal spending on wildfires



Source: Hoover (2020)

Even well-intentioned programs may facilitate inequitable outcomes. In addition to analyzing the distribution of fuels management projects more generally, we give particular attention to the Collaborative Forest Landscape Restoration Program (CFLRP), a cost-share program created by Congress in 2009 that allows communities to partner with the USFS on landscape-scale forest restoration projects. According to the USFS, 23 proposals from communities received funding over 10 years and resulted in fuels treatments on 3.8 million acres of land (USFS, 2020). This represented 19% of the agency's total hazardous fuels treatments between FY 2013 and FY 2019. These collaborative projects required a match of $1.80 for every $1 spent by the USFS, with the funds coming from private and non-USFS government sources, as well as in-kind contributions. The program offers potential cost-savings to communities at the same time that it may perpetuate inequities because of the extensive investments in community organizing and funding required.

2.2 Mechanisms and evidence for inequity in agency implementation

Legislatures face a basic tradeoff between political control and technical competence when they delegate authority to agencies (Bawn, 1995; Ringquist et al., 2003). Broadly speaking, agency implementation decisions are a function of agency preferences, including preferences derived from agency expertise, as well as political factors, the balance of which is determined in part by the legislature's decisions about adminstrative procedures (Epstein and O'Halloran, 1994). An agency makes decisions on the basis of the authority delegated to them by the legislature in organic statutes or particular legislation, the current political landscape (Wood and Bohte, 2004), public input (Anderson et al., 2013), and the agency's own preferences (Anderson and Potoski, 2016). Any one of these components could contribute to inequity (Dion et al., 1998; Scholz and Wang, 2006; Konisky, 2009). In practice, it is impossible to separately observe each contribution to agency decisionmaking. As a result, it is often difficult to identify the source of inequity.

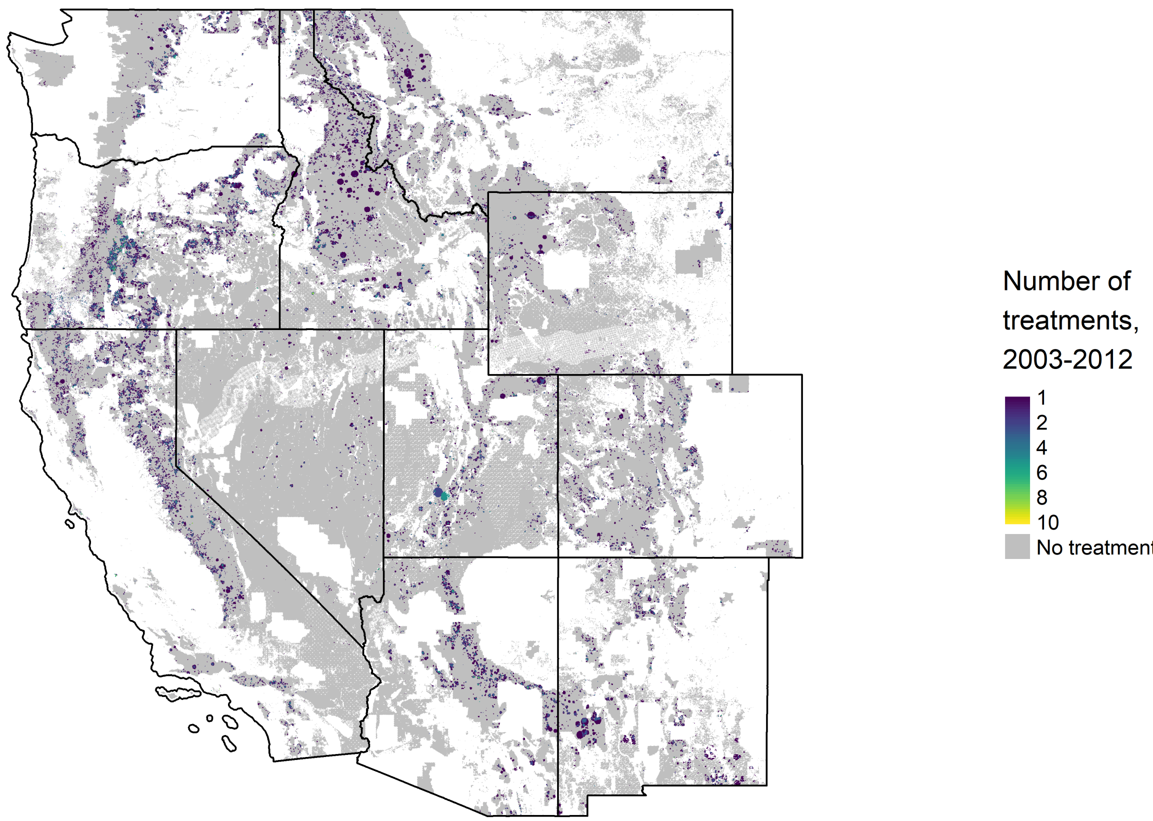
Agency responses to the public may lead to inequitable outcomes when (1) policy preferences differ across groups and (2) government response varies across groups (Wlezien and Soroka, 2011). Since the first condition is generally taken as given, research has focused on examining the second condition. Political participation varies across groups (e.g., Verba et al., 1995), with higher socio-economic status (SES) individuals participating at higher rates. Wealthier individuals (Rosenstone and Hansen, 1993; Ojeda, 2018; Erikson, 2015), white residents (Griffin et al., 2019; Bowler and Segura, 2011), and more highly educated people (Rosenstone and Hansen, 1993; Nie et al., 1996) participate in politics at higher rates. These groups may apply greater pressure to politicians and government officials. Another reason to expect that government officials might respond differentially to high SES groups is that government officials tend to be relatively high income, highly educated individuals, and they may be more sympathetic to the views of similar individuals (Page et al., 2013).

3 Data and Methods

Data on fuels treatment locations come from the National Fire Plan Operations and Reporting System (NFPORS). The NFPORS dataset records the point location (latitude and longitude), dates, and area of all fuels reduction projects conducted by the USFS, BLM, and NPS during the years 2003-2011. Since NFPORS does not provide fuels project boundaries, we used reported point locations and project areas to impute project boundaries, under the assumption that project boundaries are circular.[6] We divided public lands in the western U.S. into a 1 sq. km grid, and identified public land grid cells as receiving fuels projects when their centroids intersected imputed fuel project boundaries. Figure 3 provides a map of fuels treatments on public lands near WUI

[6]We make this assumption out of convenience and because NFPORS data does not include spatial data describing the precise area treated. While the assumption is clearly incorrect, we argue that it minimizes error, since circles are the most compact shape.

Figure 3: USFS, BLM, and NPS Fuels Treatments (2003-2011)



Note: Together, colored areas and areas shaded in grey represent US Forest Service, Bureau of Land Management, and National Park Service lands in the western US. Non-shaded lands represent lands in other ownership, including private lands, state lands, and Federal lands managed by other agencies.

communities in the western US from 2003-2011. More information on the construction of the data set is included in Wibbenmeyer et al. (2019).

In further analysis, we use two additional data sets of fuels treatments conducted by the USFS only. Data on the location of CFLRP projects is available for the period 2010-2020.[7] For comparison, we also consider data on all hazardous fuels treatments (HFT) conducted by the USFS. In contrast to the NFPORS data, polygon shapefiles are available for the CFLRP and HFT data sets. However, areas of treatment polygons frequently do not correspond to the reported treated area.[8]

[7]https://data.fs.usda.gov/geodata/edw/datasets.php

[8]In addition, the website for CFLRP indicates that the polygon layer may exclude some CFLRP projects and include

Therefore, as for the NFPORS data, we impute project boundaries using a circle of the project's reported size drawn around the project centroid.[9] For both data sets, we exclude activities that are not directly related to fuels removal or reduction (e.g., thinning to promote desired species). The CFLRP and all HFT data sets include similar fuels management projects on National Forest lands, but only the CLFRP projects involve cost-share with nearby communities.

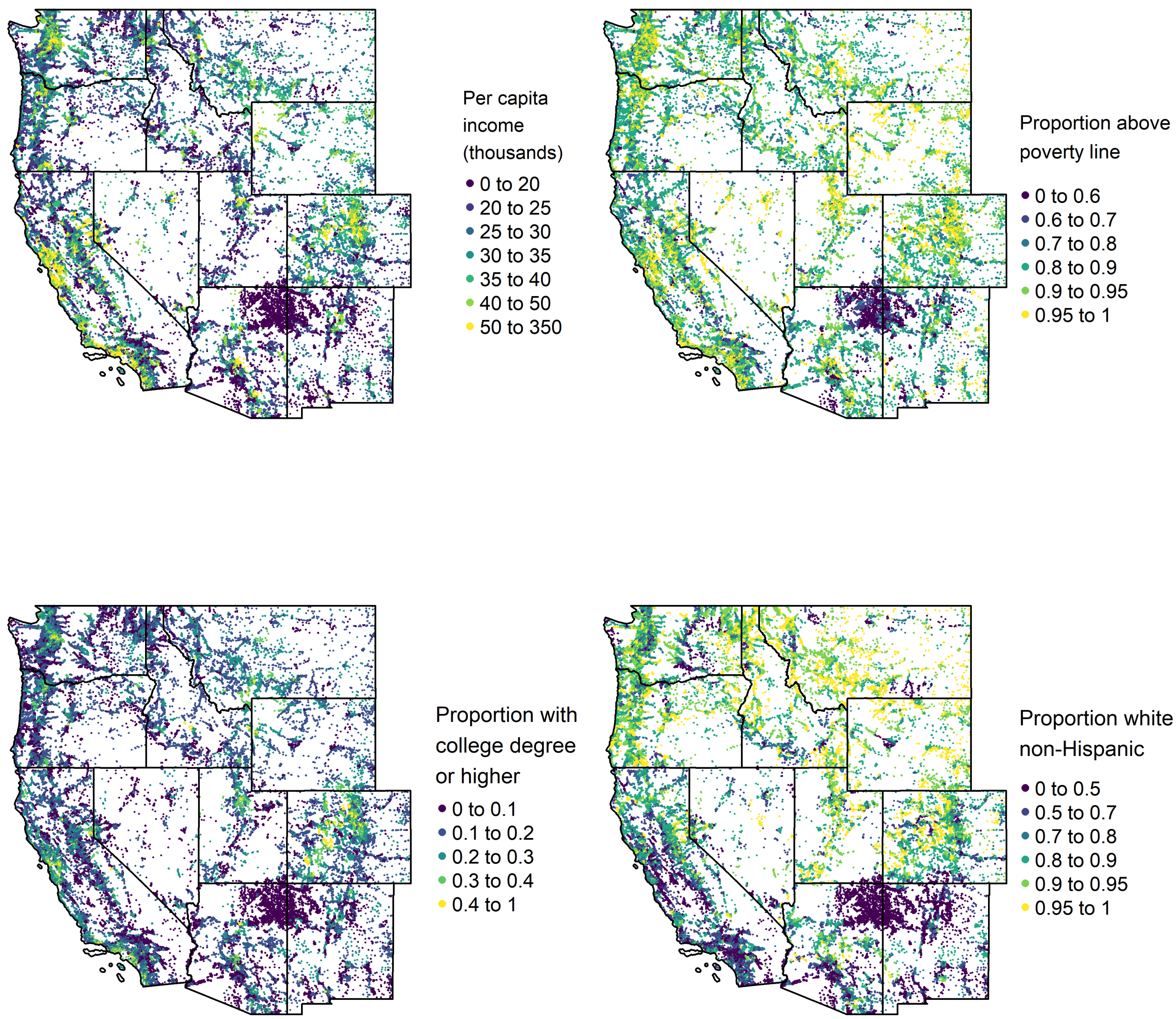
Communities are defined by US Census blocks. We focus specifically on blocks classified in 2000 as wildland urban interface (WUI) (Radeloff et al., 2005), defined as areas where houses are intermingled with or adjacent to undeveloped wildland vegetation (e.g., trees, shrubs). We focus on WUI communities because, in the western U.S., these communities are likely to face the highest risks from wildfire. Because we are interested in determinants of public fuels management project locations, we further limit our sample of Census blocks to those within 5 km of public lands managed by the USFS, Bureau of Land Management (BLM), or National Park Service (NPS). The USFS, BLM, and NPS together manage approximately 1.5 million square kilometers of land in the western US and are responsible for 93 percent of federal fuels management projects within the timespan of the NFPORS data. We collected a series of variables describing each Census block's demographic characteristics: income, education, rental rates, and race and ethnicity variables measured at the Census tract level and population density measured at the Census block level (US Census Bureau, 2000). Since our primary fuels treatment data span the years 2003-2011, we use demographic variables from the 2000 Census.[10] Maps of the geographic distribution of our four selected demographic variables (per-capita income, percent of population above poverty line, white

some non-CFLRP projects.

[9]This method was recommended to us by Mark Adams (personal communication, January 21, 2022), who processed the same data using a similar procedure in Adams and Charnley (2020).

[10]We also use 2000 Census data in our CFLRP analysis, which uses data from later years, since our data on the set of public land grid cells near each WUI Census block—necessary for identifying which blocks received treatments nearby—are constructed based on the 2000 Census geography. Our use of 2000 Census data in place of more recent should affect our CFLRP analysis only to the extent that it affects the blocks that are ranked above or below the median in our four selected SES demographic measures (see section 4).

Figure 4: Distribution of four demographic measures associated with SES across WUI communities in the western US



Note: Each point represents a wildland-urban interface Census blocks.

non-Hispanic, and college educated) across WUI Census blocks in the western US are provided in Figure 4.

The placement of fuels projects is likely to depend in part on wildfire risk, the likelihood of damage from fire to structures and other assets on the landscape. Dillon (2015) provides 270 million estimates of grid-cell-level Wildfire Hazard Potential (WHP). Although not a direct measure of risk, WHP indicates areas where vegetation treatments are needed to reduce the intensity of future wildfires. In our analyses, we use the 2012 measure of WHP converted to a numerical scale using octiles from 1 (lowest risk) to 8 (highest risk).[11] Figure 5 shows WHP for the entire region in 2018. Comparison of Figure 3 and Figure 5 suggests that wildfire hazard is an important determinant of the placement of fuels treatments, as places with high rates of treatment also tend to be high hazard places (e.g., Sierra Mountain foothills in California, northern Idaho, and central Arizona).

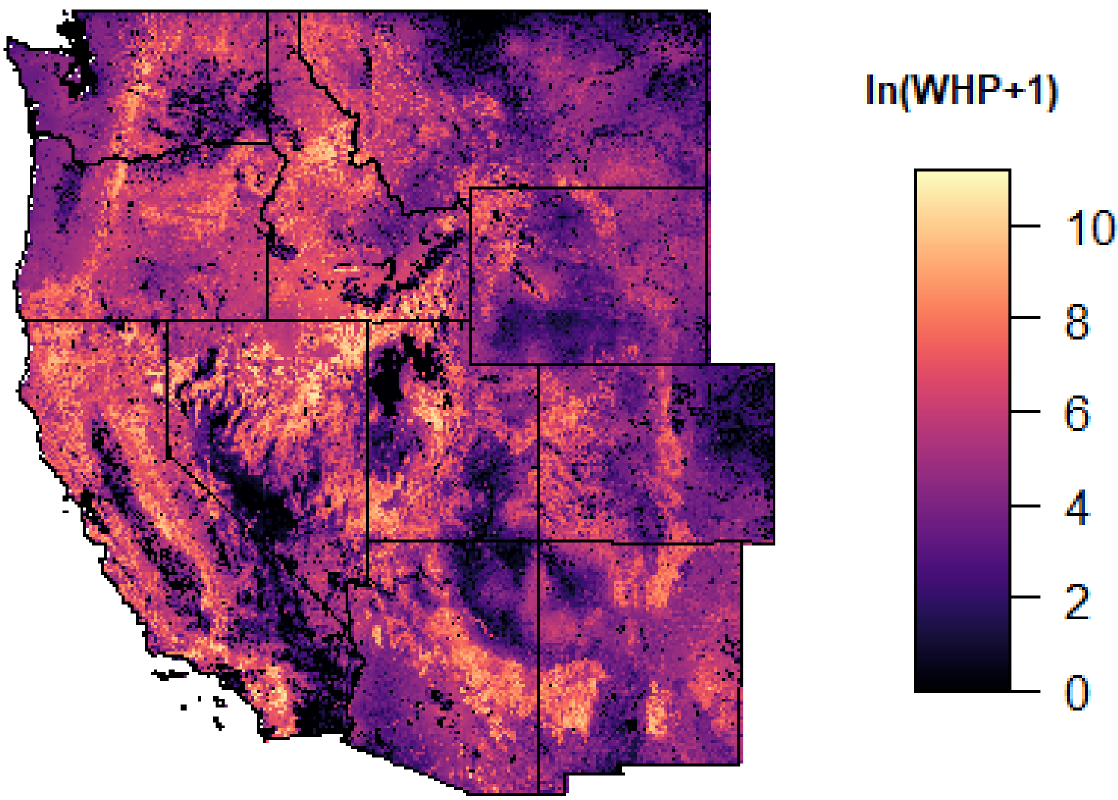
In addition to maps showing the location of fuels treatments and socio-economic characteristics of WUI blocks, we quantify the relationship between fuels treatments, socio-economic status, and risk using the following linear probability model, which we estimate with NFPORS data on all federal lands fuels treatments:

$$treat_{it} = \alpha_0 + \alpha_1 SES_i + \alpha_2 hden_i + \sum_{j=2}^{j=8} \beta_j I[whp_i = j] + \sum_{j=2}^{j=8} \gamma_j I[whp_i = j] \times SES_i + \varepsilon_{it} \qquad (1)$$

where $treat_{it}$ is an indicator variable for whether the federals lands near block i receive fuels treatments in year t, SES_i is an indicator of socio-economic status in block i (e.g., income), $hden_i$ is the housing density in block i, $I[whp_i = j]$ is an indicator variable for the WHP category of block i, and ε_{it} is a random disturbance term. The model in Equation (1) measures the direct effect on the likelihood of fuels treatments of socio-economic status (α_1) and risk (the β_j) and the interaction of risk and socio-economic status (the γ_j), which allows the effect of socio-economic variables to vary by WHP category. To estimate Equation 1, we pool fuels treatment data for the

[11] Future versions of this paper will make use of earlier data, which is available for 2008. For now, we note that if implementation of fuels projects near high hazard areas causes us to systematically under-measure WHP in areas that received fuel treatments from 2003–2012, our estimates of the relationship between WHP and fuels treatment rates should be biased downward.

Figure 5: Wildfire Hazard Potential indicates areas where vegetation treatments are needed to reduce the intensity of future wildfires. Shown here is the 2018 version of the measure in logarithms.



period 2003-2011 and estimate separate models for federal lands within 2, 5, and 10 km of WUI blocks. These are alternative definitions of "nearby."

To better understand the mechanisms behind any inequities we uncover in the first analysis, we evaluate the SES of communities that receive CFLRP projects nearby. CFLRP projects require communities to organize, propose projects, and secure resources in the form of matching payments. If we find that CFLRP projects are also associated with higher SES communities, this suggests that our main findings may be due to the ability of high SES communities to better mobilize and take advantage of government programs. We compute the percentage of WUI blocks near CFLRP projects that have high SES, measured as being in the top 50th percentile of per capita income, percent above poverty line, percent white non-Hispanic, or percent college educated. For comparison, we produce the same measures for all hazardous fuels treatments conducted by the USFS. This helps to identify which SES characteristics are important in explaining participation in cost-share programs.

4 Results

To investigate whether the demographics of a community are associated with differences in fuels treatment allocations, Table 1 shows the summary statistics for the whole sample of communities (WUI census blocks) and then separates those communities according to whether they ever received a nearby fuels treatment during the time period of our data. Those that received a fuels treatment are, on average, wealthier, have higher levels of education, and have a higher proportion of white residents. They also tend to have lower population. As expected if the federal land management agencies are managing in ways that reduce wildfire risk, communities that have received fuels management projects have higher WHP. This demonstrates why it is important to control for wildfire hazard when seeking to understand whether communities with higher SES receive fuels treatment projects at greater rates. If wealthier residents sort into higher risk areas, perhaps because of the amenities that are correlated with higher wildfire risk, then the relationship between demographics and management could be spurious.

Table 2 shows results from the regression in Equation 1 where effects of per capita income and WHP are estimated for different distances from a community. In most cases, the coefficient estimates are positive and significantly different from zero at the 0.1% level. This indicates that the likelihood of fuels management is increasing in per capita income and WHP, and that the effects of income are magnified in more risky locations (the omitted category corresponds to the lowest WHP). The exception to this pattern is in the most risky locations (the 7th and 8th octiles),

Table 1: Demographics of Communities With and Without Fuels Projects within 2 km

	Overall	No fuels projects	> 0 fuels projects
Per capita income (dollars)	20881.49	20643.09	22681.25
Proportion above poverty line	0.87	0.87	0.88
Proportion college grad.	0.23	0.22	0.26
Proportion white non-Hispanic	0.78	0.77	0.86
Proportion Hispanic	0.14	0.15	0.09
Population (thousands)	47.65	49.36	34.70
Proportion own place of residence	0.74	0.74	0.75
Wildfire hazard potential	496.37	429.49	1001.30
Number of observations	296571	261882	34689

where the effects of income are somewhat muted. However, in some cases the coefficients on the interactions between per capita income and WHP in the 7th and 8th octiles are indistinguishable from zero.

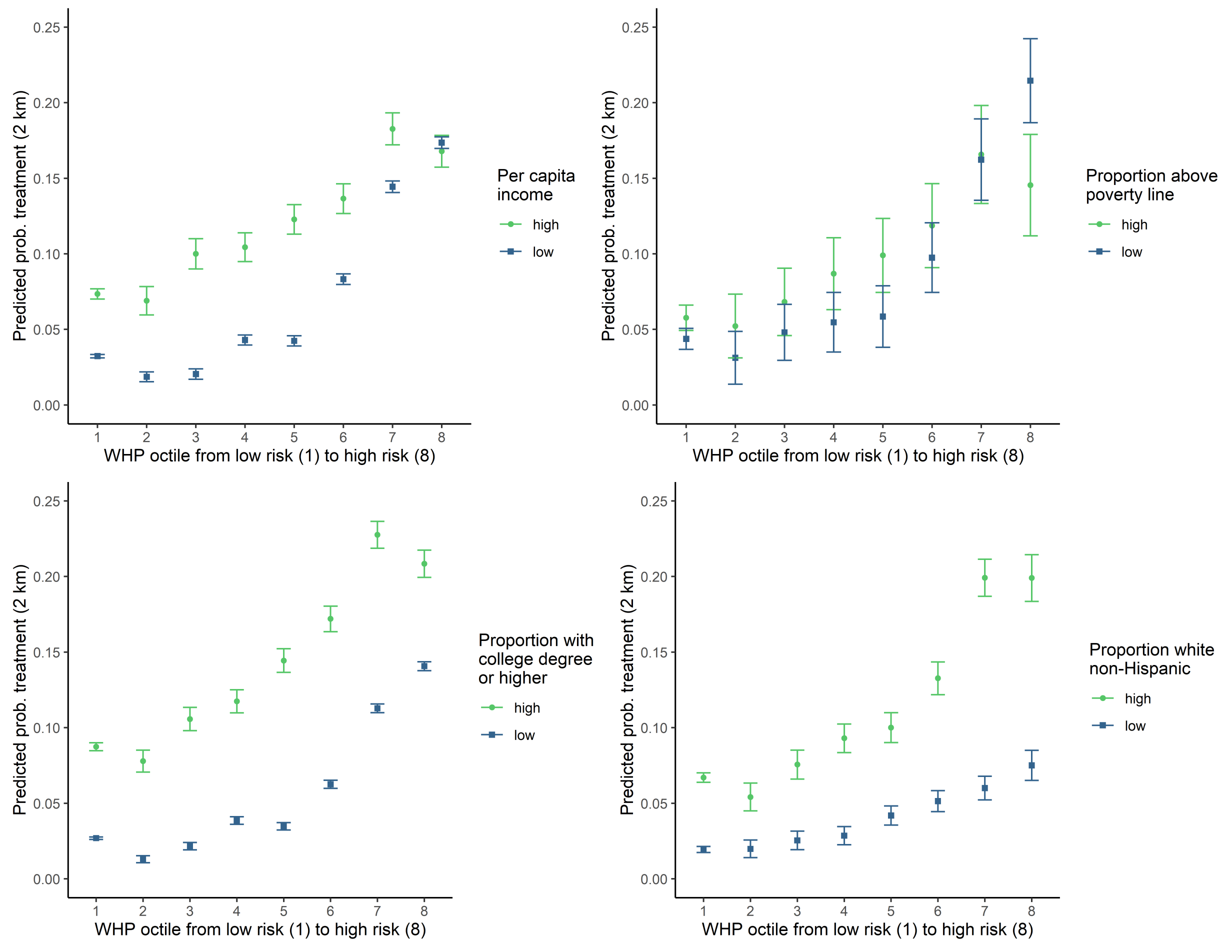
To provide a clearer picture of the relationship between fuels treatments, SES status, and risk, Figure **??** shows the predicted probability of treatment for federal lands within 2 km of a community with high (green) or low (blue) SES for the various levels of WHP estimated in Equation 1 (coefficient estimates for the remaining demographic measures are reported in Tables 3-5 found in the Appendix). For each panel, high and low SES communities are those in which the selected demographic variable is two standard deviations above the mean and two standard deviations below the mean, respectively.

For example, the upper left panel of the figure indicate that until a community reaches the highest level of risk, high income communities have a greater likelihood of receiving a fuels management project nearby. This pattern appears to be driven by wealthier communities being more likely to receive treatment, since an alternative measure of income — percentage above the poverty line (upper right panel) — demonstrates a different relationship. In this case, there are very few heterogeneous effects of poverty status across levels of risk. In fact, in the highest risk places, communities with a lower percentage of the community above the poverty line receive more fuels

Table 2: Linear probability model of the relationship between per capita income and the likelihood communities in areas with varying wildfire hazard potential (WHP) receive nearby hazardous fuel treatments.

	Any treatment - 2 km	Any treatment - 5 km	Any treatment - 10 km
Per cap. income (thousands)	0.0010**	0.0017**	0.0009**
	[0.0001]	[0.0000]	[0.0000]
Housing density (hundreds)	0.0003**	0.0002**	0.0002**
	[0.0000]	[0.0000]	[0.0000]
2nd octile - WHP	-0.0153**	-0.0344**	-0.0355**
	[0.0026]	[0.0021]	[0.0020]
3rd octile - WHP	-0.0138**	-0.0251**	-0.0141**
	[0.0025]	[0.0020]	[0.0020]
4th octile - WHP	0.0089**	0.0094**	0.0057**
	[0.0024]	[0.0020]	[0.0020]
5th octile - WHP	0.0082**	0.0130**	0.0267**
	[0.0024]	[0.0020]	[0.0021]
6th octile - WHP	0.0492**	0.0715**	0.1074**
	[0.0023]	[0.0020]	[0.0021]
7th octile - WHP	0.1105**	0.1483**	0.1879**
	[0.0023]	[0.0020]	[0.0021]
8th octile - WHP	0.1400**	0.2039**	0.2474**
	[0.0023]	[0.0021]	[0.0022]
2nd octile - WHP × Per cap. income (thousands)	0.0002*	0.0007**	0.0011**
	[0.0001]	[0.0001]	[0.0001]
3rd octile - WHP × Per cap. income (thousands)	0.0009**	0.0013**	0.0012**
	[0.0001]	[0.0001]	[0.0001]
4th octile - WHP × Per cap. income (thousands)	0.0005**	0.0006**	0.0015**
	[0.0001]	[0.0001]	[0.0001]
5th octile - WHP × Per cap. income (thousands)	0.0010**	0.0012**	0.0016**
	[0.0001]	[0.0001]	[0.0001]
6th octile - WHP × Per cap. income (thousands)	0.0003**	0.0000	0.0003**
	[0.0001]	[0.0001]	[0.0001]
7th octile - WHP × Per cap. income (thousands)	-0.0001	-0.0002*	0.0003**
	[0.0001]	[0.0001]	[0.0001]
8th octile - WHP × Per cap. income (thousands)	-0.0011**	-0.0021**	-0.0019**
	[0.0001]	[0.0001]	[0.0001]
Constant	0.0320**	0.0724**	0.1766**
	[0.0014]	[0.0011]	[0.0011]
No. of obs.	1137750	2193990	2965710
R-squared	.0276	.0336	.0339

Figure 6: Probability of treatment in high and low SES WUI communities, by wildfire hazard



Note: Figure plots predicted probabilities based on equation 1 (and 95% confidence intervals), that high and low SES WUI Census blocks with any public lands nearby (within 2 km) will receive a fuel treatment on those lands in a given year. High and low SES Census blocks are defined here as those two standard deviations above and below the mean, respectively, for four selected demographic characteristics.

management projects. It should be noted that there is little variation across communities in the percentage of households above the poverty line, which limits our ability to distinguish differences in fuels treatments.

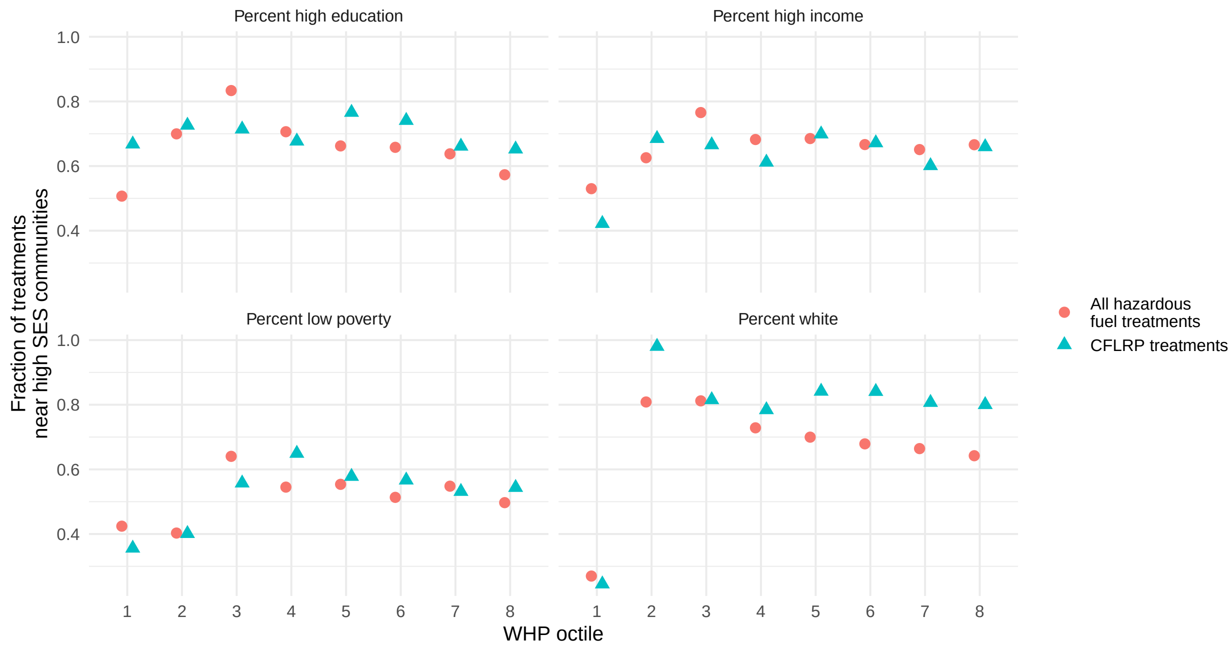
Education and race results (lower left and right panels, respectively) mirror the per capita income results. Across the risk spectrum, communities with higher levels of education and a higher proportion of white residents are more likely to receive fuels management projects. Together, these results demonstrate that communities with higher SES, whether measured by income, race, or education, receive more fuels management projects.

To gain additional insights into these inequities, we examine the SES of communities near CLFRP projects (Figure 7). The figure shows, by WHP bins, the percentage of WUI blocks near CFLRP treatments that have high SES, measured as being above the 50th percentile in per capita income, percent low poverty, percent white non-Hispanic, and percent college educated. With the exception of the lowest risk bins in a few cases, the percentages are above 50 percent, indicating that WUI blocks near CLFRP projects are more likely to have high SES.[12] This pattern is especially pronounced for education and race. WUI blocks near CLFRP projects are, respectively, approximately 70 and 80 percent highly educated and white. These results are consistent with higher SES communities have greater political efficacy, which better enables them to leverage funds from the federal government for risk-reducing fuels treatments.

We also find that communities near CLFRP projects are wealthier, which may reflect the greater ease that wealthier communities are likely to have in meeting the cost-matching requirements of the CLFRP. It does not appear, however, that it is the cost-sharing ability of communities themselves that is the critical determinant of participation in cost-share programs since the incomes of communities near CLFRP projects are similar to those of communities near all USFS HFT projects, which include those without cost share. Figure 7 also reports the characteristics of communities near all USFS hazardous fuels treatments, including those without cost-share requirements. The percentages of high income and low poverty communities near CLFRP projects are similar to those near all USFS fuels treatments. The only characteristic that is more strongly associated with CFLRP projects is race. In high risk areas (WHP 5 and greater) the percentage of predominantly white communities is about 15 percentage points higher near CLFRP projects than near all USFS fuels

[12] Confidence intervals, not shown, are small and indicate that point estimates above 50% are significantly different from 50%.

Figure 7: Fraction of all hazardous fuel treatments and CFLRP fuels treatments near high SES communities.



Note: The y-axis measures the share of fuels treatments near high SES WUI blocks, where high SES communities are defined as those above the median in the four selected demographic demographic variables.

projects.

5 Discussion

The GAO estimates that nearly 100 million acres are in need of treatment to reduce the risk of catastrophic wildfire. Yet in recent years, only about three million acres have been treated each year (GAO, 2019). Because wildfire is an increasing problem under climate change and because government resources to manage it are limited, understanding the distribution of resources is critical to reducing damages in an equitable way.

We find that WUI communities located near federal fuels treatments are, on average, wealthier, whiter and more educated. For example, the per-capita income of communities receiving a positive number of fuels treatments is about $2000 higher than communities that receive no fuels treatments.

It is also the case that fuels treatments are allocated to places with higher risk, as proxied by WHP. However, when we control for risk we find that the effects of SES persist. Per-capita income, percent above poverty line, percent white non-Hispanic, and percent college educated are all positively correlated with the likelihood of receiving fuels treatments even with flexible controls for risk included in the regression. Moreover, the effects of the SES variable tend to be amplified in riskier places.[13]

Comparison of high and low SES communities — measured as two standard deviations above and below the mean for a given characteristic, respectively — gives a sense of the magnitudes. The probability of a fuels treatment within 2km is about 10 percentage points higher for a high income compared to a low income community, with the exception of the highest risk areas for which there is no statistical difference. The differences are more pronounced for education and race. Highly educated communities have about a 15-20 percentage point greater probability of receiving fuels treatments. The probability is about 10 percentage points higher for the whitest communities, except in the more risky places where the difference is about 25 percentage points.

The main findings of this paper – that communities with higher SES, and therefore likely higher political efficacy, receive more federal fuels management projects intended to reduce the severity of wildfire near them – are indicative of an inequitable distribution of federal resources. One possible defense of this pattern from a values at risk perspective is that the value of housing in wealthier places is likely to be higher. Thus, channeling resources to wealthier places may have higher expected value in terms of reducing housing loss. Yet, the disutility from the loss of a house is likely to be as great or greater for a low income household than it is for a high income household, in part because in the U.S. the household share of income spent on housing rises as

[13]The exception is the highest risk locations in the case of per-capita income and percent above poverty line.

income falls.[14] And the loss of the higher value home may be more likely fully insured.[15] As a result, even if this allocation is efficient from a values at risk perspective, it remains inequitable from the perspective of harm to low income communities. Whether it is income, education, race, or a correlate of these — the value of housing at risk — distributing fuels management projects according to these characteristics is likely to be inequitable and regressive.

This paper provides new evidence on the mechanisms that may lie behind these results. We evaluated the characteristics of communities located near CLFRP projects, a USFS program that requires cost-share at the local scale for projects on federal lands. Similar to our results for all federal fuels projects, we find that communities near CLFRP projects tend to be wealthier, white, and more educated. One would expect wealthier communities to be better able to provide matching funds for projects. Nevertheless, we do not find differences in per-capita income and low poverty for communities near CLFRP projects compared to all USFS projects, including those without cost-share. This suggests that the cost-sharing abilities of communities themselves are not the critical determinant of CLFRP project locations. Indeed, the funds need not come from community members themselves, but rather from local and state government and other stakeholder organizations. However, we do find evidence that fuels projects with cost share are more associated with racial makeup and educational attainment of communities compared to all fuels projects. The importance of education makes sense given that the CLFRP strives to implement "science-based" projects. Overall, our results are consistent with wealthier, whiter, and more educated communities being better able to mobilize and secure public funds to address collective action problems.

Our paper is highly relevant to current policy priorities. Executive Order 14008, issued by President Biden in the opening days of his administration, directed agencies to make environmental

[14] See, e.g., https://www.jchs.harvard.edu/sites/default/files/reports/files/Harvard_JCHS_Americas_Rental_Housing_2020.pdf

[15] According to the insurance industry, many homes in the U.S. are underinsured. While no data was found on the characteristics of underinsured households, it is well documented that underinsurance in health care is correlated with SES.

justice a part of their missions,[16] and as much as $200 million in funding for environmental justice initiatives have been proposed in the Senate.[17] In support of these policy goals, future research should continue to explore the differential responses of government agencies, including identifying more clearly the mechanisms driving inequitable responses. Research should seek to identify if inequality arises from a lack of community mobilization due to SES, biased bureaucratic responses on the basis of SES, or other possible drivers. More research on patterns of response should be paired with a deeper understanding of community mobilization and how organizations play a role in that mobilization (Han, 2020). An improved understanding of community mobilization may provide insights into strategies that lower SES communities can use to achieve the political efficacy demonstrated by more privileged communities (Verba et al., 1995).

[16] https://www.govinfo.gov/content/pkg/FR-2021-02-01/pdf/2021-02177.pdf

[17] https://www.appropriations.senate.gov/news/majority/chairman-leahy-releases-remaining-nine-senate - appropriations-bills

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6 Appendix

Table 3: Linear probability model of the relationship between proportion above poverty line and the likelihood communities in areas with varying wildfire hazard potential (WHP) receive nearby hazardous fuel treatments.

	Any treatment - 2 km	Any treatment - 5 km	Any treatment - 10 km
Pct. above pov. line	0.0435**	0.0441**	0.0240**
	[0.0064]	[0.0046]	[0.0045]
Housing density (hundreds)	0.0003**	0.0002**	0.0002**
	[0.0000]	[0.0000]	[0.0000]
2nd octile - WHP	-0.0293**	-0.0944**	-0.1817**
	[0.0095]	[0.0074]	[0.0075]
3rd octile - WHP	-0.0106	-0.0969**	-0.1441**
	[0.0096]	[0.0077]	[0.0079]
4th octile - WHP	-0.0294**	-0.1290**	-0.1955**
	[0.0101]	[0.0080]	[0.0082]
5th octile - WHP	-0.0432**	-0.1157**	-0.1950**
	[0.0099]	[0.0081]	[0.0082]
6th octile - WHP	0.0365**	0.0174*	-0.0524**
	[0.0100]	[0.0083]	[0.0085]
7th octile - WHP	0.1390**	0.0967**	0.0905**
	[0.0102]	[0.0085]	[0.0089]
8th octile - WHP	0.3449**	0.3902**	0.5121**
	[0.0097]	[0.0088]	[0.0097]
2nd octile - WHP × Pct. above pov. line	0.0220*	0.0861**	0.1937**
	[0.0109]	[0.0085]	[0.0086]
3rd octile - WHP × Pct. above pov. line	0.0193	0.1125**	0.1785**
	[0.0109]	[0.0088]	[0.0090]
4th octile - WHP × Pct. above pov. line	0.0566**	0.1740**	0.2659**
	[0.0115]	[0.0092]	[0.0093]
5th octile - WHP × Pct. above pov. line	0.0826**	0.1773**	0.2926**
	[0.0112]	[0.0092]	[0.0094]
6th octile - WHP × Pct. above pov. line	0.0226*	0.0640**	0.1901**
	[0.0113]	[0.0094]	[0.0097]
7th octile - WHP × Pct. above pov. line	-0.0328**	0.0560**	0.1182**
	[0.0115]	[0.0096]	[0.0101]
8th octile - WHP × Pct. above pov. line	-0.2590**	-0.2593**	-0.3439**
	[0.0110]	[0.0100]	[0.0109]
Constant	0.0142*	0.0668**	0.1740**
	[0.0056]	[0.0040]	[0.0040]
No. of obs.	1137590	2193730	2965350
R-squared	.0266	.032	.0343

Table 4: Linear probability model of the relationship between proportion with a college degree and the likelihood communities in areas with varying wildfire hazard potential (WHP) receive nearby hazardous fuel treatments.

	Any treatment - 2 km	Any treatment - 5 km	Any treatment - 10 km
Pct. college or greater	0.1179**	0.2851**	0.2426**
	[0.0041]	[0.0032]	[0.0031]
Housing density (hundreds)	0.0002**	0.0001**	0.0001**
	[0.0000]	[0.0000]	[0.0000]
2nd octile - WHP	-0.0127**	-0.0239**	-0.0313**
	[0.0020]	[0.0016]	[0.0016]
3rd octile - WHP	-0.0049*	-0.0134**	-0.0115**
	[0.0020]	[0.0016]	[0.0016]
4th octile - WHP	0.0170**	0.0232**	0.0183**
	[0.0019]	[0.0016]	[0.0016]
5th octile - WHP	0.0111**	0.0263**	0.0330**
	[0.0018]	[0.0016]	[0.0016]
6th octile - WHP	0.0418**	0.0744**	0.0989**
	[0.0018]	[0.0016]	[0.0016]
7th octile - WHP	0.0881**	0.1345**	0.1784**
	[0.0018]	[0.0016]	[0.0017]
8th octile - WHP	0.1146**	0.1815**	0.2297**
	[0.0018]	[0.0016]	[0.0017]
2nd octile - WHP × Pct. college or greater	-0.0007	0.0027	0.0634**
	[0.0074]	[0.0060]	[0.0058]
3rd octile - WHP × Pct. college or greater	0.0394**	0.0532**	0.0959**
	[0.0073]	[0.0061]	[0.0060]
4th octile - WHP × Pct. college or greater	0.0069	-0.0156**	0.0743**
	[0.0071]	[0.0060]	[0.0059]
5th octile - WHP × Pct. college or greater	0.0748**	0.0432**	0.1134**
	[0.0069]	[0.0059]	[0.0059]
6th octile - WHP × Pct. college or greater	0.0605**	-0.0172**	0.0596**
	[0.0069]	[0.0060]	[0.0060]
7th octile - WHP × Pct. college or greater	0.0879**	0.0338**	0.0623**
	[0.0068]	[0.0061]	[0.0063]
8th octile - WHP × Pct. college or greater	0.0009	-0.1085**	-0.1095**
	[0.0068]	[0.0063]	[0.0065]
Constant	0.0274**	0.0457**	0.1426**
	[0.0011]	[0.0008]	[0.0008]
No. of obs.	1137540	2193650	2965280
R-squared	.0312	.0437	.0421

Table 5: Linear probability model of the relationship between proportion white non-Hispanic and the likelihood communities in areas with varying wildfire hazard potential (WHP) receive nearby hazardous fuel treatments.

	Any treatment - 2 km	Any treatment - 5 km	Any treatment - 10 km
Proportion white non-Hispanic	0.0730**	0.1334**	0.1716**
	[0.0030]	[0.0021]	[0.0020]
Housing density (hundreds)	0.0004**	0.0003**	0.0003**
	[0.0000]	[0.0000]	[0.0000]
2nd octile - WHP	0.0052	-0.0024	-0.0632**
	[0.0044]	[0.0033]	[0.0032]
3rd octile - WHP	0.0024	-0.0009	-0.0386**
	[0.0043]	[0.0033]	[0.0033]
4th octile - WHP	-0.0021	-0.0063	-0.0259**
	[0.0043]	[0.0033]	[0.0032]
5th octile - WHP	0.0146**	0.0198**	0.0103**
	[0.0042]	[0.0033]	[0.0032]
6th octile - WHP	0.0117**	0.0260**	0.0353**
	[0.0044]	[0.0034]	[0.0034]
7th octile - WHP	-0.0106*	-0.0210**	-0.0045
	[0.0046]	[0.0036]	[0.0036]
8th octile - WHP	0.0126*	-0.0384**	-0.0472**
	[0.0056]	[0.0047]	[0.0050]
2nd octile - WHP × Pct. white non-Hispanic	-0.0203**	-0.0254**	0.0592**
	[0.0054]	[0.0041]	[0.0040]
3rd octile - WHP × Pct. white non-Hispanic	0.0039	-0.0003	0.0611**
	[0.0052]	[0.0040]	[0.0041]
4th octile - WHP × Pct. white non-Hispanic	0.0258**	0.0335**	0.0769**
	[0.0052]	[0.0040]	[0.0040]
5th octile - WHP × Pct. white non-Hispanic	0.0162**	0.0217**	0.0624**
	[0.0051]	[0.0040]	[0.0040]
6th octile - WHP × Pct. white non-Hispanic	0.0517**	0.0552**	0.0959**
	[0.0052]	[0.0041]	[0.0041]
7th octile - WHP × Pct. white non-Hispanic	0.1405**	0.2002**	0.2434**
	[0.0055]	[0.0044]	[0.0044]
8th octile - WHP × Pct. white non-Hispanic	0.1172**	0.2283**	0.2928**
	[0.0066]	[0.0056]	[0.0059]
Constant	-0.0061*	0.0016	0.0633**
	[0.0024]	[0.0017]	[0.0016]
No. of obs.	1137730	2193960	2965660
R-squared	.0309	.0419	.0481