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Max Nielsen-Pincus
Portland State University, maxnp@pdx.edu

Cassandra Moseley
University of Oregon

Krista Gebert
USDA Forest Service

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RESEARCH ARTICLE

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fire

The Effects of Large Wildfires on Employment and Wage Growth and Volatility in the Western United States

Max Nielsen-Pincus, Cassandra Moseley, and Krista Gebert

We examined the effect of large wildfires on economic growth and volatility in the western United States. We matched wildfire data with quarterly employment and earnings growth data to assess the specific effect of wildfire on employment and wage growth in western US counties. Wildfires generally tended to exhibit positive effects on employment and wage growth in the quarter(s) during which suppression efforts were active. However, this effect transitioned to increased economic volatility following a wildfire. The effect of wildfire also varied by the type of county in which wildfire occurred. The amount of suppression costs invested locally had the strongest influence on employment growth, indicating that there may be room for augmenting how local economies experience wildfire either through the development of community capacity or by addressing barriers to local spending in federal wildfire policy.

Keywords: employment, per worker earnings, suppression costs, local economy

In the western United States, like many regions globally, wildfire has increased in magnitude and frequency over recent decades (Running 2006, Flannigan et al. 2009). Climate change, wildfire suppression, and expansion of the wildland urban interface are commonly viewed as the major drivers of this change (Theobald 2005, Westerling et al. 2006, Gude et al. 2008). The increase in wildfire hazard is reflected in the federal government's spending on wildfire suppression, which has risen to more than $1.5 billion per year since fiscal year 2000—a 250% increase over the annual average for 1990 to 1999 (Gebert and Black 2012).

Our objective in this paper is to generalize the effect of large wildfires and their related suppression efforts on local employment and wage growth and volatility in the western United States. Economic growth is a function of changes in labor, capital, and technology (Case and Fair 1992) and is typically measured through changes in economic activity (e.g., gross domestic product). Increases in employment, capital replacement and substitution, and investment in adaptation all contribute to economic growth (Skidmore and Toya 2002). Volatility is another measure of economic conditions. An economy with low economic volatility indicates a more stable economic climate, one in which firms are more likely to accurately plan for long-term trends in employment and investment. An economy with higher variability in growth over time exhibits greater volatility, presenting both firms and workers with greater risk in making decisions to migrate or leave, to expand, or to invest in the local economy.

Economic growth in the American West is also tied to the presence of environmental, social, and cultural amenities (Shumway and Otterstrom 2001, Frentz et al. 2004, Radeloff et al. 2010). The quality of life afforded by these amenities attracts business owners, workers, and retirees. But changing economic conditions can also highlight conflicts and vulnerabilities as communities adapt to their changing economic and cultural conditions (Fortman and Kusel 1990, Beyers and Nelson 2000, Smith and Krannich 2000). Cutter et al. (2003) defined social vulnerability as the susceptibility of a population to a hazard and its ability to respond. They identified both employment loss and rapid growth as indicators of natural hazard vulnerability. Places experiencing employment loss have greater numbers of people in need of services and

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Affiliations: *Max Nielsen-Pincus (maxnp@pdx.edu), University of Oregon, Eugene, OR; current address: Portland State University, Portland, OR. Cassandra Moseley (cmoseley@uoregon.edu), University of Oregon. Krista Gebert (kgebert@fs.fed.us), USDA Forest Service.*

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constrained resources with which to provide those services (Morrow 1999). Places experiencing rapid growth lack the social networks and infrastructure needed to adequately support a growing population (Cutter et al. 2003). These underlying vulnerabilities may affect a community's ability to attract resources during a wildfire and leave communities with less capacity to engage in broader adaptation to wildfire risks and hazards (Donovan et al. 2011, Ojerio et al. 2011). Natural hazards like large wildfires may influence local economic resilience by contributing to the boom-and-bust socioeconomic cycles experienced in much of the western United States. Natural hazards can expose economic vulnerabilities due to adding volatility to local seasonal employment patterns, the remodeling of local institutions, and broader societal and economic trends (Force et al. 2000, Carroll et al. 2011).

Wildfires can strain community development efforts and create distributional inequities and conflict over fire management and recovery decisions (Kumagai et al. 2004, Carroll 2005, Burchfield 2007, Abt et al. 2008). Relatively little is known, however, about wildfire's impacts on aspects of economic growth. Graham (2003) found that Colorado's 2002 Hayman wildfire had both positive and negative effects on employment and wages in several service sectors in the area impacted by the Hayman wildfire. Butry et al. (2001) found that the 1998 wildfires in northeastern Florida reduced tourism revenues in four counties by over $138 million. To date, however, most research on the economic impacts of wildfire has focused on single case studies and individual economic sectors. The general effect of wildfire on broad employment and wage growth and volatility is unknown.

Other natural disasters, such as hurricanes and tornadoes, are generally accepted to have net positive effects on economic growth rates (Tol and Leek 1999, Ewing et al. 2009). In particular, however, the effects of hurricanes and other destructive natural hazards on the labor market are likely to be dynamic over time with immediate contraction as workers and business owners flee disaster areas, followed by growth as the recovery and reconstruction effort begins, and eventually returning to pre-event growth levels (Ewing et al. 2003, Belasen and Polachek 2008). Ewing et al. (2003) identified employment volatility as a potential risk following natural disasters, surmising that the uncertainties associated with disaster and recovery may be reflected in increased variance in local economic growth; however, they did not detect increased volatility following a destructive tornado in Fort Worth, Texas.

There are reasons, however, to expect that wildfire may not influence employment and wage growth in the same way as other natural hazards. Unlike many other natural hazards (e.g., hurricanes, tornados, earthquakes), a wildfire can last for weeks or months and lead to the allocation of federal, state, and private resources devoted to wildland fire suppression during and immediately following the event. Consequently, we might expect wildfires to concentrate their economic effects during and immediately after the wildfire. Furthermore, although wildfires destroyed over 10,000 homes in the United States between 2002 and 2006 (Gude et al. 2008), the property losses from wildfire are relatively small compared to the physical capital lost by some large hurricanes, earthquakes, or tornadoes. Instead, large wildfires can damage natural capital, impacting the long-term future values of market goods like timber (Butry 2001). Nonmarket ecosystem services like water quality, recreation, and wildlife habitat may also be improved in the longer term to the extent that wildfire promotes ecological function (Machlis et al. 2002). Longer-term effects may depend heavily on the intensity of the wildfire, the rate of return on the natural capital lost or benefited, and local investment made in postfire adaptation and mitigation.

In the short and medium term, wildfires may exert two opposing forces on the local economy. First, wildfire may cause general disruptions to commerce and business activities (Rose and Lim 2002, Graham 2003). For example, tourism may slow as visitors stay away from areas inundated with smoke, areas where water quality is threatened, or areas where property is at risk. Commerce in service sectors may also slow due to evacuations or other interruptions to normal business patterns. Second, wildfires may boost economic activity as suppression efforts require a large volume of labor and other resources. Most of the expenditures associated with wildfire suppression efforts fall in two categories: wages and benefits for public sector firefighting personnel and contract payments to private sector firms to provide suppression crews and equipment or support services (e.g., food and commissary services, shower facilities, etc.; Graham 2003, Prestemon et al. 2008). The investment in human capital during wildfire suppression efforts may make substantial short-term contributions to employment growth in local communities if the labor resources are sourced locally. Losses of physical capital may result in longer-term investment in human capital or adaptation strategies as a means of reducing future wildfire risks. The effect of wildfire may then depend on whether the economic and social attributes of the local economy are able to absorb some of the resources needed to participate in the suppression effort and whether that economy is able to participate in postfire recovery, restoration, and adaptation activities that may contribute to longer-term economic growth. Some local economies may have more capacity to play a role in suppression and recovery efforts based on underlying social and economic characteristics (Nielsen-Pincus et al. 2012).

Management and Policy Implications

Employment and average wage growth in local economies are affected by wildfires that require expensive suppression efforts. Although large wildfires lead to initial improvements in the growth rate of local employment and average wages, the effects of wildfire also increase postwildfire variability. Specifically, wildfires tend to amplify seasonal trends in employment and wage growth, leading to higher highs and lower lows. In the longer term, large wildfires appear to contribute to the boom-and-bust economic cycles that reinforce existing social and economic inequities and vulnerabilities, especially in places that are prone to recurrent large wildfires. The participation of local resources in wildfire suppression and recovery efforts can augment how local communities experience wildfire and its economic effects. However, on average wildfire suppression events spend less than 10% of expenditures with local resources. Identifying the policy and local community-based factors that govern the local investment during suppression efforts may help move wildfire-affected communities toward a more resilient economic future. Improving local capacity to participate in suppression, recovery, mitigation, and adaptation efforts may be an important community development strategy for building a fire-adapted local economy and ecosystem.

We examined local employment and wage growth to understand how large wildfires affect local economies. Specifically, we ask three questions: (i) What is the general effect of a wildfire on county-level growth in employment and per worker earnings? (ii) What is the effect of wildfires on labor market volatility? (iii) Are there interactions between the effect of wildfire on county level labor market growth and (a) economic specialization in specific sectors (e.g., government, services), (b) status as a metropolitan or nonmetropolitan recreation county, (c) the number of wildfires experienced, (d) the total costs of wildfire, and (e) the total costs of the wildfire that were spent locally or regionally?

Methods

To answer these questions, we fit generalized autoregressive conditional heteroskedasticity (GARCH) models to predict county-level growth and volatility in employment and average wages in 413 western US counties between 2004 and 2008. For county-level growth, we used labor market data from the Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages (QCEW), which is an employer-reported count that covers 98% of all US jobs. To fit the regression models, we used both wildfire and county attributes as predictor variables. We examined only the largest wildfire suppression events reported by the USDA Forest Service, including the number of events, their timing, total costs, and local spending. For county-level economic and social characteristics, we used county-level data published by the USDA Economic Research Service (EconomicResearchProject [ERS]) that reflects differences in local economic specialization based on earnings in different economic sectors, as well as housing and lodging data (Johnson and Beale 2002). These broad-scale classifications identify counties as specialized in federal and state government sectors, services, nonmetropolitan recreation, and others. In the following sections we detail the procedures used each aspect of our research.

Employment and Wage Growth

We collected county-specific quarterly earnings and employment data from the US BLS QCEW. Quarterly employment and average earnings per worker are the basis for our dependent variables. We difference the quarterly employment and earnings values and then log the differences to examine the change in the growth rate rather than absolute levels of change, which may vary systematically across counties. We also calculated the average employment and average worker earnings growth rates for each state in the western United States and used the respective state averages as a covariate in each regression to control for individual state business cycle and economic trends.

Wildfire Incidents

We obtained all records from the National Interagency Fire Management Integrated Database (NIFMID) for which the Forest Service was the lead protection agency and for which the federal suppression expenditures were greater than $1 million. We used the fire ignition location to determine the county in which the wildfire occurred, and the initial attack and suppression end dates to determine the quarter or quarters in which the wildfire was being actively suppressed. We summarized the wildfire incident observations by county and quarter and merged this summary data into our panel of labor market data with quarter-specific indicators of whether a wildfire occurred in the county. We also summarized the number of fires occurring in each county during each quarter, the quarterly total suppression expenditures for all wildfires occurring in each county, and the total of suppression expenditures for wildfires in all adjacent counties. Finally, we created an indicator of whether wildfire was a recurrent event in a given county (i.e., different wildfires occurred in a given county during more than one quarter).

Suppression Spending

NIFMID data included the total suppression costs to the Forest Service for each wildfire but did not provide more detailed accounting. We used the fire suppression accounting codes in the NIFMID database to request financial information for a subset of 134 wildfires from the Forest Service's Foundation Financial Information System. We obtained a data set of all recorded transactions charged to each wildfire accounting code as of Nov. 19, 2010. Each transaction was recorded with the amount of the transaction and the zip code of the person or firm receiving funds. We used the zip code information to identify whether the transaction occurred with a person or firm located in the same county of the wildfire or a different county. We summed the value of all local transactions for each quarter.

County Indicators

We used the US Census definition of metropolitan counties (counties with an urban area with population greater than 50,000) to test for differences between rural and urban counties. We used Johnson and Beale's (2002) classification of nonmetropolitan recreation counties to represent counties where amenity growth and its economic implications are substantial (Gosnell and Abrams 2011). Finally, we used the USDA ERS county typology to identify basic economic differences among counties, including those specializing in service or federal and state government sectors. To examine whether wildfire occurred more commonly in certain types of counties we summarized wildfire events by county types and conducted a chi-square test of independence between the county indicators and the occurrence of large wildfires.

Regression Modeling

We fit GARCH models to the employment and wage growth data. The GARCH model is appropriate for quarterly growth data because it can incorporate both autocorrelation (i.e., the effect of past growth on current growth) and nonconstant variance (i.e., volatility). Employment and average wage growth both may vary over time in response to other local conditions, past growth, and past volatility. To fit the model to this type of data a mean model and a variance model were estimated simultaneously. The mean model was specified as follows

$$y_t = \boldsymbol{x_t}\boldsymbol{\beta} + \varepsilon_t - \varphi_1 y_{t-4}, \qquad (1)$$

where y_t is the dependent variable, $\boldsymbol{x_t}$ is a vector of regressor variables, $\boldsymbol{\beta}$ is a vector of regression coefficients, and $\boldsymbol{\varphi_1}$ is an autoregressive coefficient controlling for growth values from the same quarter of the previous year. In this specification, the autoregressive parameter's sign is reversed compared to most regression coefficients, such that a negative sign indicates a positive effect of past growth on current growth. A conventional regression model assumes the prediction errors are normally distributed and cancel each other out, such that $\varepsilon_t \sim N(0,\sigma)$. However, quarterly employment and growth data commonly vary in ways that violate this standard assumption (e.g., periods of stability and periods of volatility). To address this

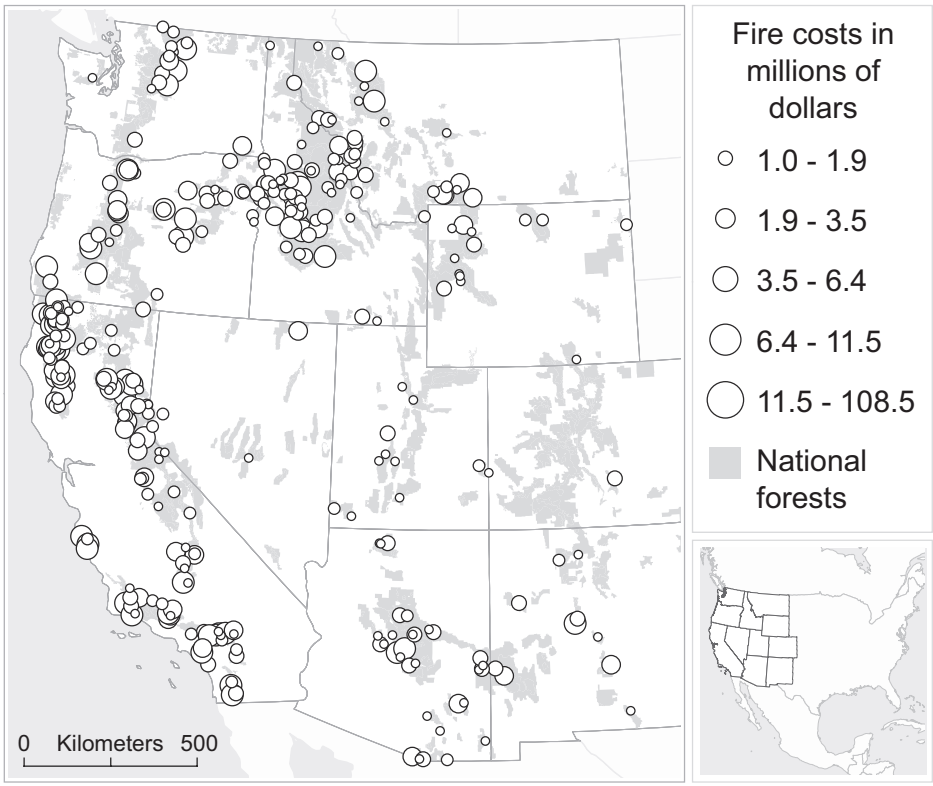


Figure 1. Large wildfires in the western United States from 2004–2008.

violation, we specified an error process that incorporates past volatility and intervention effects that account for recent wildfires, such that $\varepsilon_t \sim N(0, h_t^2)$. This time-variant and conditional heteroskedasticity is specified in Equation 2

$$h_t^2 = \alpha_1 \varepsilon_{t-4}^2 + \gamma_1 h_{t-1} + \eta_1 \pi_t + \eta_2 \tau, \quad (2)$$

where the coefficients α_1 and γ_1 represent the effects of a past residuals and volatility, respectively, on the current variance. The intervention variable π_t specified that a wildfire occurred within the past four quarters (1 year), and η_1 is the coefficient on the recent wildfire intervention variable. A second intervention variable *(τ)* specifies that wildfire was recurrent in a given county (i.e., different wildfires were observed during more than one quarterly observation), indicating that the county was relatively more prone to wildfire than other counties. The coefficient η_2 represents the effect of recurrent wildfires on employment volatility. Employment and average wage growth exhibited evidence of autoregressive conditional heteroskedasticity and so the GARCH model specified by Equation 2 was estimated for all models.[1]

Finally, to illustrate employment and wage volatility associated with large wildfires, we fit Equation 1 with a vector of lagged regression variables ($x_{t0}, x_{t+1}, \ldots x_{t+m}$,) indicating whether a wildfire occurred in the current quarter (t) or past quarters ($t + 1, \ldots, t + 8$), to represent that lagged effects of wildfire for up to 2 years on quarterly employment and wage growth. Fitting Equation 1 with the temporal lags allowed us to visualize postfire volatility by plotting the lagged parameter estimates and confidence envelope.

Results

Wildfires in the Western United States

From 2004 to 2008, there were 362 large wildfires, each of which the Forest Service spent $1 million or more on wildfire suppression; 346 of these occurred in the 11 contiguous western states (Figure 1). Together, these 346 wildfires cost the Forest Service $2.41 billion (Table 1). Nearly two-thirds of these large wildfires occurred in California ($n = 137$), Idaho ($n = 49$), and Oregon ($n = 41$). These large fires affected 122 western US counties; 64 of these counties experienced recurrent wildfire. For example, Siskiyou County, California experienced a total of 21 large wildfires over our 5-year study period.

According to the ERS classifications, 33 (27%) out of 122 wildfire-affected counties are metropolitan and 47 (40%) are nonmetropolitan recreation-based counties, accounting for 101 (29%) and 150 (43%) of the large wildfires, respectively. The remaining 95 (27%) wildfires all occurred in 42 (34%) rural counties with economies not specialized in recreation. Thirty wildfire-affected counties (25%) had economies that specialized in federal or state government employment, and 27 (22%) had economies specializing in services such as retail trade, finance, and real estate. Wildfires occurred disproportionately in more counties with service-based economies (chi-sq = 4.83, $P = 0.028$), counties with federal and state government-dependent economies (chi-sq = 3.15, $P = 0.076$), and nonmetropolitan counties with recreation-based economies (chi-sq = 28.30, $P < 0.0001$; these counties have nearly twice the public land as other types of counties). Our analysis of suppression spending records from the subset of 134 large wildfires indicated that approximately 91% of expenditures were spent on resources that originated outside of the county experiencing the wildfire. Local spending ranged from an average of 4.3% of total suppression costs in counties specializing in farming, mining, and manufacturing to 12.7% in service-specialized counties.

Table 1. Summary of large wildfires in the western United States from 2004 to 2008.

Wildfires for which USFS suppression costs exceeded $1 million	Number of wildfires		Number of counties affected by wildfire		Total suppression costs ($ millions)		Local transactions by wildfire* (%)
	346	100%	122	100%	2411	100%	8.6%
By state							
Arizona	31	9%	11	9%	107	4%	10.1%
California	137	40%	32	26%	1300	54%	9.3%
Colorado	2	<1%	2	2%	5	<1%	1.2%
Idaho	49	14%	14	11%	278	12%	3.6%
Montana	32	9%	14	11%	147	6%	8.2%
New Mexico	10	3%	6	5%	47	2%	4.3%
Nevada	4	1%	4	3%	14	1%	<0.1%
Oregon	41	12%	19	16%	283	12%	9.2%
Utah	10	3%	7	6%	18	1%	10.1%
Washington	17	5%	6	5%	176	7%	11.1%
Wyoming	13	4%	7	6%	34	1%	7.3%
County population type							
Metropolitan	101	29%	33	27%	895	37%	12.9%
Nonmetropolitan	245	71%	89	73%	1,517	63%	6.8%
Recreation (nonmetropolitan)	150	43%	47	38%	1,026	43%	6.6%
County economic specialization							
Federal and state government	81	23%	30	25%	419	17%	5.2%
Farming, mining, manufacturing	46	14%	20	16%	209	9%	4.3%
Services	69	20%	27	22%	471	20%	12.7%
Unspecialized	150	43%	44	36%	1313	54%	9.8%

* Proportion of total suppression costs that were spent locally in the county where the wildfire occurred.

County-Level Quarterly Employment and Per Worker Earnings Growth

In general, western US counties experienced seasonally adjusted employment growth from 2003 through mid-2006, stagnated, and then began contracting in 2008 as the housing crisis and Great Recession took hold of the US economy (Figure 2). Counties that experienced large wildfires during the study period exhibited a more volatile growth pattern than those that did not. Growth in wildfire-affected counties in the pre-2006 period was more rapid than in counties that never experienced wildfire, and wildfire-affected counties experienced greater contraction in the post-2006 period than those counties that did not experience a wildfire during our study period. Furthermore, service, federal and state government, and nonmetropolitan recreation specialized counties that experienced wildfire also all exhibit this pattern of greater volatility over the 5-year period than those counties of the same classification that were not affected by wildfire.

The Effect of Wildfires on Local Economic Growth

The effect of a wildfire varied by type of county, by the amount of total suppression costs spent locally, and whether we measured employment or wages. Wildfires tended to change the patterns in economic growth above and beyond the dynamic expected by seasonal and broader state business cycles (Table 2). In general, large wildfires tended to increase county-level quarterly employment and wages during the quarter of the wildfire.

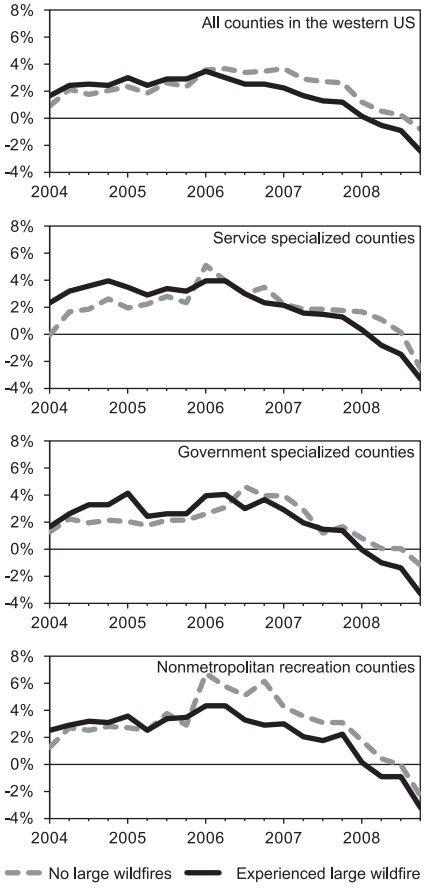


Figure 2. Quarterly growth in seasonally adjusted employment in western US counties affected and not affected by wildfire (2004–2008).

The generalized effect of a wildfire on employment growth was about a 1.0% increase in employment and a 0.8% increase in average wages during the quarter of a wildfire. When we controlled for the economic characteristics of the counties experiencing wildfires and for characteristics of the wildfires, we identified a more nuanced view. During wildfires, nonmetropolitan recreation-specialized counties experienced an increase in employment growth that is nearly half a point greater than the generalized increase. In contrast, metropolitan counties experienced no significant change in growth and service-specialized counties experienced a drop of over 2.0% in employment during wildfires. Counties specialized in federal or state government employment did not exhibit an employment growth effect from wildfires; however, these counties did exhibit a nearly 2.7% average wage increase when wildfire occurred. The generalized effect of wildfire on average wages was primarily due to increases in wages in federal and state government counties as no other wildfire effects or geographic interactions were significant.

Though the occurrence of a wildfire in a

Table 2. Employment and per worker earnings growth autoregressive conditional heteroskedasticity (ARCH) regression parameters[1] and model fits.

	Employment growth—wildfire only		Employment growth—wildfire interactions		Per worker earnings growth—wildfire only		Per worker earnings growth—wildfire interactions	
Mean model								
Constant	−0.021	***	−0.021	***	−0.001		0.009	
State growth	1.348	***	1.325	***	0.694	***	0.685	***
Treatment county	0.006	***	0.004	**	−0.002		−0.004	
Wildfire	0.010	***	−0.011		0.008	**	−0.011	
Wildfire*metro county			0.008				−0.006	
Wildfire*recreation county			0.014	**			0.001	
Wildfire*service county			−0.020	***			0.003	
Wildfire*government county			0.008				0.027	***
Number of wildfires[2]			0.014				0.013	
Suppression expenditures ($M)			<−0.001				<0.001	
Local suppression expenditures ($M)			0.010	***			−0.002	
Neighboring suppression expenditures ($M)			<0.001	**			<0.001	
AR(4)	−0.329	***	−0.316	***	−0.485	***	−0.487	***
Variance model								
ARCH	0.337	***	0.361	***	0.131	***	0.123	***
GARCH	0.663	***	0.639	***	0.870	***	0.877	***
1 year postfire[3]	0.00013	***	0.00012	***	0.00019	***	0.00018	***
Recurrent wildfire[3]	0.00017	***	0.00017	***	<0.00001		<0.00001	
N, groups	8260, 413		8260, 413		8260, 413		8260, 413	
Log likelihood	14 936		14 999		13 244		13 246	
HQC	−24 588		−24 636		−28 094		−28 021	
AIC	−29 030		−29 132		−25 646		−25 626	
R-square	0.328		0.329		0.414		0.415	

[1] Regression parameters not shown here include dummy variables for each county, and main effects for county geography variables included in interactions.
[2] The number of wildfires is specified as the natural log plus one.
[3] Variance model estimates for intervention variables are in reported in variance units; in the text we report these coefficients in standard deviation units to make them more interpretable.
Note: Growth rates are represented as the difference between the logged values of employment (or average wages) at $time_t$ and $time_{t-1}$.
*$P \leq 0.10$; ** $P \leq 0.01$; ***$P \leq 0.001$.

given county affected employment and wages, neither the number of wildfires that occurred in a given county during a given quarter nor the total costs of the wildfire suppression efforts had any significant effect on quarterly employment or wage growth. However, we found a very different picture when considering the effect of suppression costs spent locally. Federal expenditures on local resources to contribute to the suppression effort had a significantly positive effect on employment growth with an approximate 1.0% increase in employment growth per $1 million spent locally. Local suppression spending had the largest impact on local employment growth of all wildfire effects and geographic interactions we tested. The amount of suppression expenditures spent in neighboring counties also had a significant effect on employment growth, although the effect size was less than one-tenth of a percent increase in employment per $1 million spent on neighboring suppression efforts.

The Effect of Wildfires on Local Economic Volatility

In addition to positively affecting employment and average wage growth during a wildfire, we found that wildfires also tended to increase employment and average wage volatility in the year following a wildfire. Employment volatility was even greater, in general, in counties that experienced recurrent wildfire. Being classified as a fire-prone county, however, did not create additional volatility in average wage growth. In the year following a large wildfire, there was a 1.1% increase in the standard deviation (SD) of employment growth and an approximate 1.4% increase in the SD of average wage growth (Table 2, wildfire-only models; note volatility effects in Table 2 are estimated in variance units; here we report estimates in SD units to make them more interpretable). Counties that experienced recurrent wildfires exhibited a SD around their employment growth rate that was 1.3% greater than other counties across the entire study period.

Counties that had wildfires exhibited an amplification of their seasonal patterns (Figure 3) in the postfire period. The increased volatility in the labor market following a wildfire is illustrated by the lagged effects of wildfire on employment and average wage growth over a 2-year period, which clearly indicate that wildfires amplify seasonal patterns in employment and wage growth above the expected seasonality. Although the general effect of a wildfire on employment and average wage growth is positive during the period of the wildfire, local economies exhibited greater employment losses following a wildfire than would have been expected by normal seasonality. These losses continued for two quarters and were then followed by greater-than-expected seasonal gains in the third and fourth quarter following a wildfire. This cycle was then repeated in the second year following a wildfire, although to a lesser and sometimes nonsignificant magnitude. Average wage growth also exhibited a pattern reflecting seasonal amplification, but the effect was typically marginal even though the variance model suggested a significant increase in average wage growth variance in the year following a wildfire.

Discussion

Our primary findings were that (i) wildfires resulted in an immediate positive effect on local economic growth, (ii) local economic growth is strongly influenced by local spending on wildfire suppression, (iii) large

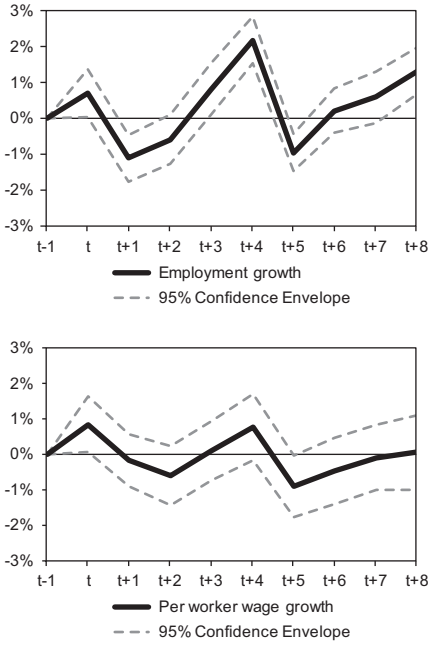


Figure 3. Average predicted quarterly difference in employment and earnings growth (with 95% confidence envelope) over a 2-year period following a large wildfire.

wildfires occurred in counties that exhibited greater underlying vulnerability, and (iv) wildfires exacerbate existing vulnerabilities by amplifying existing seasonal employment and wage trends.

In general, county-level employment grew more than would otherwise be expected during quarters when large wildfires occurred. The immediate positive impact on local employment held true for all types of counties except service-specialized counties, which typically lost employment during wildfires. Although these counties also experienced the greatest average of local suppression investments, the overall employment loss may be the result of wildfire-induced disruptions to commerce and business activities, loss of tourism, or evacuation (Rose and Lim 2002, Graham 2003, Paveglio et al. 2008). Average earnings also grew during wildfires, but the effect was largely due to average wage growth in counties specializing in federal or state government employment. In counties with considerable government employment, the effect of wildfires was to increase the pay of existing employees (likely via overtime and hazard pay). In other types of counties, businesses with the capacity to engage in suppression activities added employees, rather than increasing the pay of those already working, to meet the increased demand. In contrast to other natural hazards, such as hurricanes and tornadoes, which typically lead to economic growth during the recovery period (Tol and Leek 1999, Belasen and Polachek 2008, Belasen and Polachek 2009, Ewing et al. 2009), growth during large wildfires is likely the result of the large investment by government agencies in active suppression efforts to avoid property damage and loss of life.

Investments in local suppression resources as measured by the total amount paid to local vendors and workers had a strongly positive influence on employment growth, whereas the total costs of suppression efforts did not. Where state and federal agencies spend wildfire suppression funds was the most important factor influencing changes in employment during a wildfire. As with other federal investments in natural resources, the amount of that investment captured locally is not uniform and may be affected by differences in local capacity and public policy (Moseley 2006, Davis et al. in press). There is significant variation in local spending in our sample of large wildfires (ranging from nearly nothing to tens of millions of dollars), suggesting that there may be latitude in the contracting process for wildfire suppression and, consequently, how communities experience a wildfire. Furthermore, there is also some evidence that recent changes in federal wildfire contracting policy may be inadvertently limiting the ability of local contractors to get access to local suppression efforts (Davis et al. 2013). Federal wildfire suppression policy and local capacity to participate in suppression or supporting efforts likely play a large role in the economic impacts of wildfires.

Counties that experienced large wildfires exhibited a different underlying growth pattern over the 5-year study period. The difference in growth hinges on the wildfire-affected counties experience of the Great Recession: Generally, wildfire-affected economies experienced stronger growth prior to 2006 and accelerated stagnation and contraction from 2006 to 2008. The underlying vulnerabilities of these counties may be further exacerbated by wildfires. Although economic growth does occur during periods of wildfire, this growth transitions into volatility in the year following a wildfire or, in the case of places that experience recurrent wildfires, for longer. The volatility suggested by our regression model is illustrated by the amplification of existing seasonal economic trends (recall Figure 3), which can make firms and workers more reluctant to move to a volatile area because reduced certainty about the future makes decisionmaking more risky and more costly (Ewing et al. 2003). As such, large wildfires may reinforce and amplify the boom-and-bust economic cycles experienced in many western US communities by affecting the productivity of local amenity and extractive resources and interacting with broader trends of local socioeconomic change. Recent examples of intentionally set wildfires (e.g., the 2002 Rodeo–Chediski fire, see Carroll et al. 2005), ignited in hopes of securing work or other economic benefits, demonstrate a perverse incentive in the local economics of wildfire. Postfire economic volatility may be much more influential on longer-term economic trajectories than any work garnered through the suppression effort. Employment and wage volatility may then reinforce the underlying economic and social vulnerabilities of many wildfire-affected counties (Cutter et al. 2003).

Conclusion

Our research shows that, in recent years, economic growth and volatility have been impacted by the occurrence of wildfires that require large and expensive suppression efforts. Immediate growth due to wildfire suppression efforts comes at the expense of increased economic volatility persisting for up to 2 years or more following a wildfire. If trends in the increasing occurrence and severity of wildfire continue, local employment and wage growth in much of the American West could be challenged to avoid the boom-and-bust reality that reinforces existing social and economic inequities and vulnerabilities. Investing in local resources to participate in wildfire suppression and recovery efforts can help augment how local communities experience wildfire and its economic effects. Identifying the policy and local community-based factors that govern the local investment in suppression efforts is a key step toward moving wildfire-affected communities toward a more resilient economic future. Community development strategies that focus on improving local capacity to participate in suppression, recovery, mitigation, and adaptation efforts may be an important strategy for building a more fire-adapted local economy and ecosystem. An evaluation of the influence of federal wildfire policy on the development of local and external market development related to wildfire suppression may help identify po-

tential barriers to utilizing local community capacity during suppression events.

Endnote

1. Initial testing of the model controlled quarterly growth for effects of the Great Recession (the final year of our study period). The effect was not significant, indicating that while the great recession influenced growth trends (Figure 2) it had less impact on seasonal patterns. As such the variable was dropped from the model.

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