13 PHYSICAL AND ENVIRONMENTAL FACTORS AFFECTING ILEC SERVICE QUALITY

Principal observations and takeaways

- Telephone service outages appear to be highly dependent upon weather conditions, specifically, the amount of precipitation in the area served.
- The strong relationship between rainfall and the rate of service outages provides a strong indication that the ILEC distribution networks are not as robust as they need to be, and clearly lack the resiliency to withstand significant weather events.
- Overall, we observed little correlation between the incidence of major wild fires and ILEC service quality. Wildfires occur mainly during hot summer and fall months when rainfall is minimal, whereas OOS incidents arise during the periods of heaviest precipitation, which occurs during late fall and winter months.

PHYSICAL AND ENVIRONMENTAL FACTORS
AFFECTING ILEC SERVICE QUALITY

TABLE OF CONTENTS

Tables and Figures

Introduction

In Chapter 4, we observed that 16.8% of the roughly 5-million AT&T out-of-service conditions over the 2010-2017 Phase 1 study period had been attributed to "Heavy Rain," "Weather," "Moisture," or "Wet Plant." Over the Phase 2 2018-2019 period, that number almost doubled, to 29.6%. In our Phase 1 Report, we provided details of our preliminary examination of the potential interaction of adverse weather – principally precipitation – upon the incidence of Out of Service (OOS) Trouble Reports. We had observed a seemingly erratic pattern of out-of-service incidents that, rather than exhibiting minimal variation over time, showed instances of Trouble Reports resulting in a customer's loss of telephone service that appeared to be highly variable from one period to the next. Moreover, similar month-to-month and quarter-to-quarter variation were observed both with respect to AT&T California and Verizon/Frontier California, and across multiple wire centers, suggesting that some exogenous or outside condition or event was having a similar effect upon the ILECs' networks across a fairly broad geographic area. We hypothesized that one such exogenous source might well be weather or other environmental factors. In an attempt to explain the source of this variation, ETI compared the incidence of out-of-service trouble reports with weather conditions extant at the time, specifically, with the amount of precipitation that occurred in the area being served by a given wire center. Our analysis was, however, limited, and covered only the greater Los Angeles area.

Effects of precipitation on out-of-service incidents

In Phase 1, we examined the pattern of AT&T and Verizon/Frontier out-of-service incidents, respectively, in the greater Los Angeles area with the number of inches of precipitation experienced in the Los Angeles area on a monthly basis. We calculated the "coefficient of determination" (R^2) between these two series. R^2 represents the percentage of variation in the "dependent" variable (the number of out-of-service incidents) that can be explained by variation in the independent or "explanatory" variable (inches of precipitation). For AT&T, the R^2 was 0.4221, indicating that roughly 42.21%, of the variation in the incidence of an out-of-service condition is attributable to the amount of rainfall occurring in any given period. The *t*-statistic associated with the Precipitation coefficient was 8.29, placing the computed relationship between inches of precipitation and out-of-service incidents well in excess of the 99% confidence level. For Verizon/Frontier, the R^2 was almost the same, at 0.3976, and the *t*-statistic associated with the Precipitation coefficient was 7.75, also placing the computed relationship between precipitation and out-of-service incidents well in excess of the 99% confidence level. Weather conditions may help to explain the variations in OOS situations, but they do not explain the long-term upward trends both in numbers and average duration that the data appear to suggest.

For Phase 2, we have been asked to extend this analysis to cover the full 2010-2019 time frame, and to study a broader geographic area covering all of California. To accomplish this, we compiled precipitation statistics from the National Oceanic and Atmospheric Administration's ("NOAA") Global Summary of the Month ("GSOM") dataset. GSOM provides detailed estimates of various meteorological measurements on a monthly basis sourced from weather stations across the United States. The US Census Bureau has divided California into ten (10)

"Census Regions," as illustrated in Figure 13.1 below. Table 13.1 identifies the individual counties that are included within each Census Region.

Table 13.1

CALIFORNIA CENSUS REGIONS

Census Region	Counties
1 Superior California	Butte, Calusa, El Dorado, Glenn, Lassen, Modoc, Nevada, Placer, Plumas, Sacramento, Shasta, Sierra, Siskiyou, Sutter, Tahama, Yolo, Yuba
2 North Coast	Del Norte, Humbordt, Lake, Mendocino, Napa, Sonoma, Trinity
3 San Francisco Bay Area	Alameda, Contra Costa, Marin, San Francisco, San Mateo, Santa Clara, Solano
4 Northern San Joaquin Valley	Alpine, Amador, Calaveras, Madera, Mariposa, Merced, Mono, San Joaquin, Stanislaus, Tuolumne
5 Central Coast	Monterey, San Benito, San Luis Obispo, Santa Barbara, Santa Cruz, Ventura
6 Southern San Joaquin Valley	Fresno, Inyo, Kern, Kings, Tulare
7 Inland Empire	Riverside, San Bernardino
8 Los Angeles County	Los Angeles
9 Orange County	Orange
10 San Diego – Imperial	Imperial, San Diego

Source: NOAA GSOM dataset; ETI analysis of AT&T California Out-of-Service incidents 2010-2019

ETI identified NOAA weather station locations first by county, then aggregated these by averaging total monthly precipitation for all of the counties included within each of the ten Census regions. We then aggregated individual wire center Trouble Report statistics by county and then by Census Region.

We prepared two graphs for each Census Region. The first graph in each set is a time-series plot of monthly inches of precipitation (blue line) and monthly out-of-service reports per 100 access lines (red line). The second graph in each set provides a scatter diagram of the independent variable (monthly inches of precipitation) on the *x*-axis and the dependent variable (monthly OOS per 100 access lines) on the *y*-axis, along with a plotted regression line. The regression equation is also provided, along with the Coefficient of Determination R^2 and *t*-statistic as computed for the regression. Figures 13.2 through 13.11 provide graphs for each Census Region's monthly precipitation rate (in inches) and the monthly rate of OOS incidents per 100 access lines for AT&T California over the full 2010-2019 period (120 months). Figures 13.12 through 13.21 provide similar graphs for each Census Region for areas served by Frontier California over the 2016 through 2019 period (45 months).

Tables 13.2 and 13.3 below provide the calculated Coefficients of Determination (R^2) and *t*-statistics for each of the ten Census Regions and for each of AT&T California and Frontier California, respectively. For convenience, we have also indicated the Figure number for the graphs associated with each Census Region.

Figure 13.1

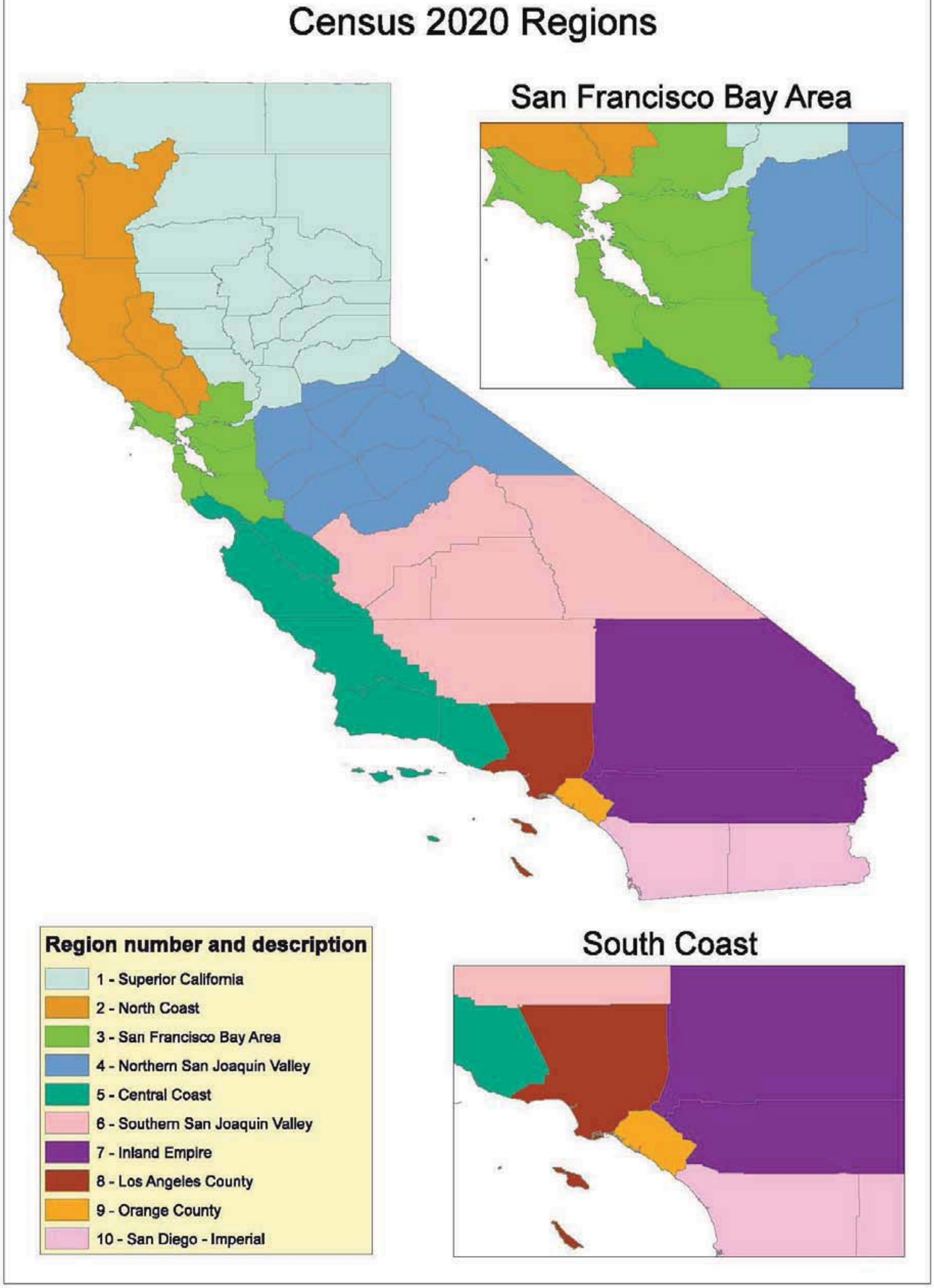

Census 2020 Regions
San Francisco Bay Area
South Coast
Region number and description
1 - Superior California
2 - North Coast
3 - San Francisco Bay Area
4 - Northern San Joaquin Valley
5 - Central Coast
6 - Southern San Joaquin Valley
7 - Inland Empire
8 - Los Angeles County
9 - Orange County
10 - San Diego - Imperial

Table 13.2

AT&T CALIFORNIA
RELATIONSHIP BETWEEN PRECIPITATION AND OUT-OF-SERVICE INCIDENTS
2010-2019

Census Region	Figures	No. of Wire Centers	Coefficient of Determination R^2	*t*-statistic
1 Superior California	13.2	107	.676	15.696
2 North Coast	13.3	58	.490	10.655
3 San Francisco Bay Area	13.4	99	.756	19.138
4 Northern San Joaquin Valley	13.5	53	.564	12.365
5 Central Coast	13.6	54	.592	13.077
6 Southern San Joaquin Valley	13.7	65	.403	8.922
7 Inland Empire	13.8	13	.378	8.477
8 Los Angeles County	13.9	69	.520	11.308
9 Orange County	13.10	32	.507	11.008
10 San Diego – Imperial	13.11	60	.466	10.154

Source: NOAA GSOM dataset; ETI analysis of AT&T California Out-of-Service incidents 2010-2019

Table 13.3

FRONTIER CALIFORNIA
RELATIONSHIP BETWEEN PRECIPITATION AND OUT-OF-SERVICE INCIDENTS
2016-2019

Census Region	Figures	No. of Wire Centers	Coefficient of Determination R^2	*t*-statistic
1 Superior California	13.12	4	.471	3.187
2 North Coast	13.13	17	.500	6.553
3 San Francisco Bay Area	13.14	4	.652	8.969
4 Northern San Joaquin Valley	13.15	13	.206	3.343
5 Central Coast	13.16	20	.457	6.014
6 Southern San Joaquin Valley	13.17	38	.545	7.171
7 Inland Empire	13.18	53	.618	8.336
8 Los Angeles County	13.19	37	.746	11.238
9 Orange County	13.20	4	.587	7.812
10 San Diego – Imperial	13.21	2	.099	2.178

Source: NOAA GSOM dataset; ETI analysis of Frontier California Out-of-Service incidents 2016-2019

The results for both ILECs and across all ten Census Regions are both striking and consistent. For AT&T California, the Coefficients of Determination R^2 varied between a low of .378 for the Inland Empire Region to a high of .756 for the San Francisco Bay Area Region. The high *t*-statistics for all ten Census Regions confirm that these correlations are statistically significant at the 99.9% confidence level. As noted, the Coefficient of Determination is interpreted as the percentage of variation in the Dependent Variable (OOS Incidents in this case) that is explained by variations in the Independent Variable (Inches of Precipitation). Thus, for the Bay Area, 75.6% of all AT&T California Out-of-Service incidents can be attributed to the effects of precipitation. Even in the largely desert Inland Empire Region, 37.8% of AT&T California OOS incidents are attributable to precipitation.

For Frontier California, the Coefficients of Determination R^2 varied between a low of .099 for the San Diego / Imperial Region to a high of .746 for the Los Angeles County Region. The high *t*-statistics for seven of the Census Regions are statistically significant at the 99.9% confidence level; two others are statistically significant at the 99% level, and one at the 97.5% level. Note, however, that four of the ten Frontier Census Regions each have 4 or fewer wire centers, thus reducing the statistical significant of the calculated results. The Region with the lowest R^2 – San Diego – has only two Frontier wire centers, such that no statistical significance can legitimately be ascribed to this result. It is difficult to draw meaningful statistical inferences where the number of observations is as small as four or less, so for these four Census Regions the results are at best inconclusive.

The calculated regression lines for each Census Region identify the mathematical relationship extant between Inches of Precipitation and OOS per 100 Access Lines. For example, the regression equation for the San Francisco Bay Area is conputed as:

$$y = 0.741 + 0.147\,x$$

where

y = OOS per 100 Access Lines

x = Monthly Inches of Precipitation

The "*y*-intercept" value here is 0.741, which is interpreted as estimating that in a month with zero inches of precipitation, the predicted number of OOS per 100 Access Lines would be 0.741. In a month with, for example, three (3) inches of precipitation, the predicted number of OOS per 100 Access Lines would be 0.741 + 3 x 0.147, or 1.182 OOS incidents per 100 Access Lines.

From a visual inspection of the scatter points on each of these graphs, it is also evident that the calculated relationship is essentially linear over the typical range of precipitation.

In certain cases, out-of-service incidents attributable to adverse weather conditions may be deemed beyond ILEC management's control, resulting in such events being "excluded" for purposes of GO 133-C/D service quality measurements and tracking. But while the precise dates and extent of such conditions cannot be known in advance, *this analysis confirms that the observed relationships extant between precipitation and OOS incidents is consistent both over time and across a broad spectrum of geographic areas. The fact that these events will arise at some point over time is thus well known and highly predictable, and certainly should be a major consideration in the engineering and construction of telecommunications distribution networks*.

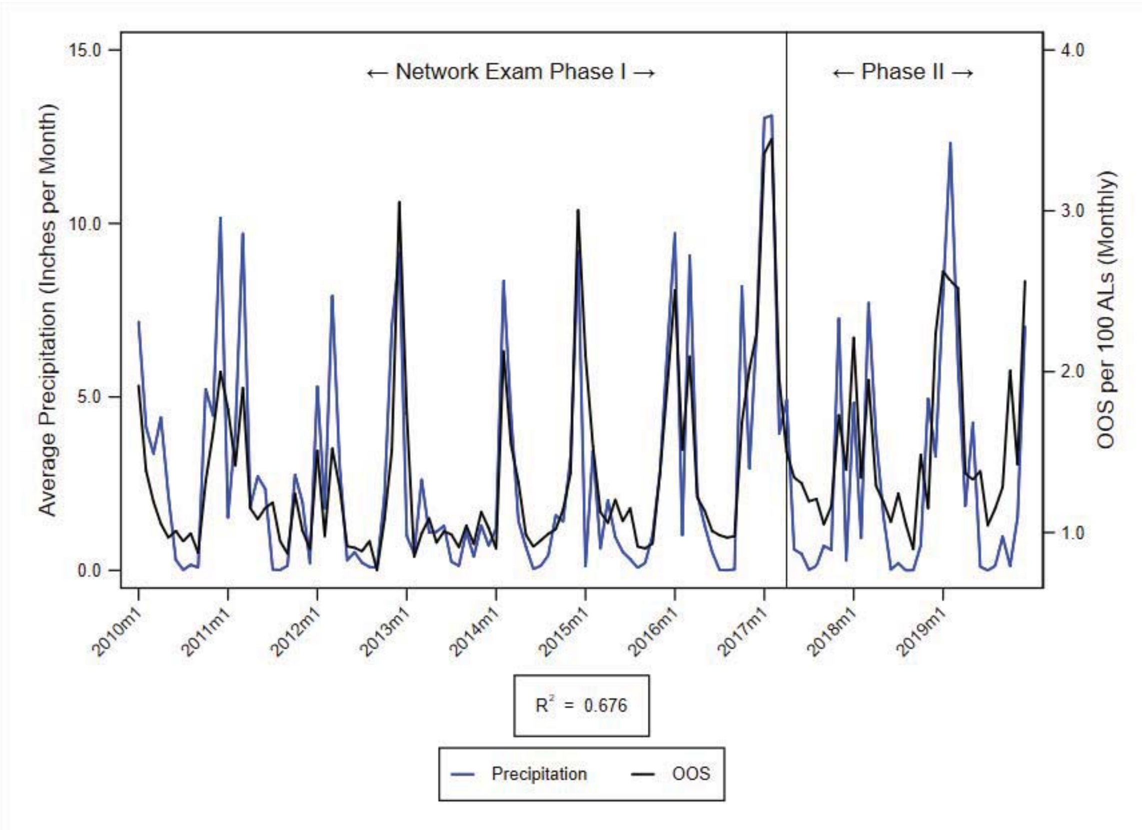
The strong relationship between rainfall and the rate of service outages provides compelling evidence that both ILECs' California distribution networks are not as robust as they need to be to account for local weather conditions over time. Weather or any other environmental factors that "caused" a particular out-of-service incident may (arguably) make that event "beyond management's *immediate* control," but the design and construction of the distribution network should certainly account for these types of weather conditions. And that is certainly well within the scope of "management's control" and responsibilities.

From a cost/benefit standpoint, there is an economic tradeoff between the up-front investment in constructing robust and weather-resistant network facilities and the ongoing amount of money that will need to be spent on maintenance for service restoration in the event of a weather-related outage. While the quantification of that tradeoff is outside of the scope of this study, the Commission may want to consider developing an engineering economic assessment of that relationship as a basis for establishing some minimum outage rates associated with adverse weather conditions. In that regard, the "public interest" in that economic trade-off likely differs considerably from that of the ILEC. The ILEC's decision process is limited to its own internalized costs and benefits – what ongoing maintenance savings will it realize for each additional amount spent on network construction. From the public's perspective, the trade-off must necessarily include broader economic and public safety considerations that fall outside of the economic trade-offs confronting the carriers..

☞ Telephone service outages appear to be highly dependent upon weather conditions, specifically, the amount of precipitation in the area served.

☞ The strong relationship between rainfall and the rate of service outages provides a strong indication that the ILEC distribution networks are not as robust as they need to be, and clearly lack the resiliency to withstand significant weather events.

Figure 13.2. REGION 1 SUPERIOR CALIFORNIA (AT&T)



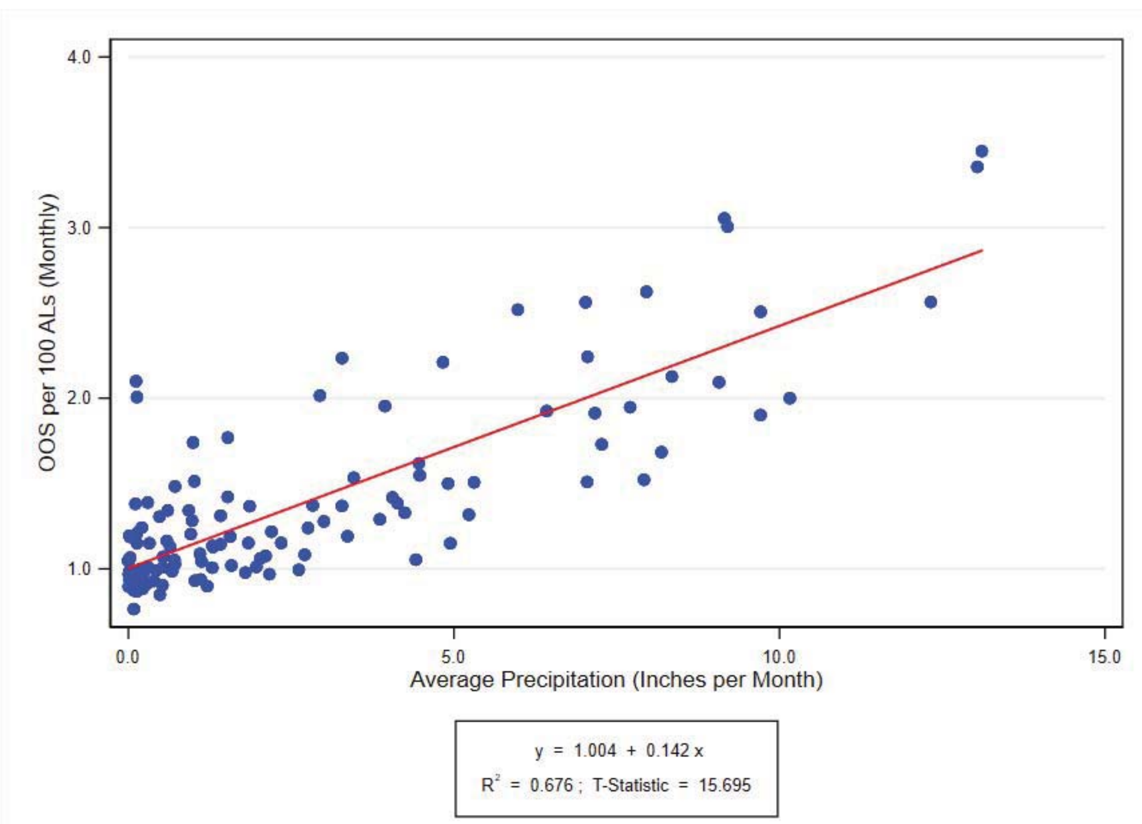


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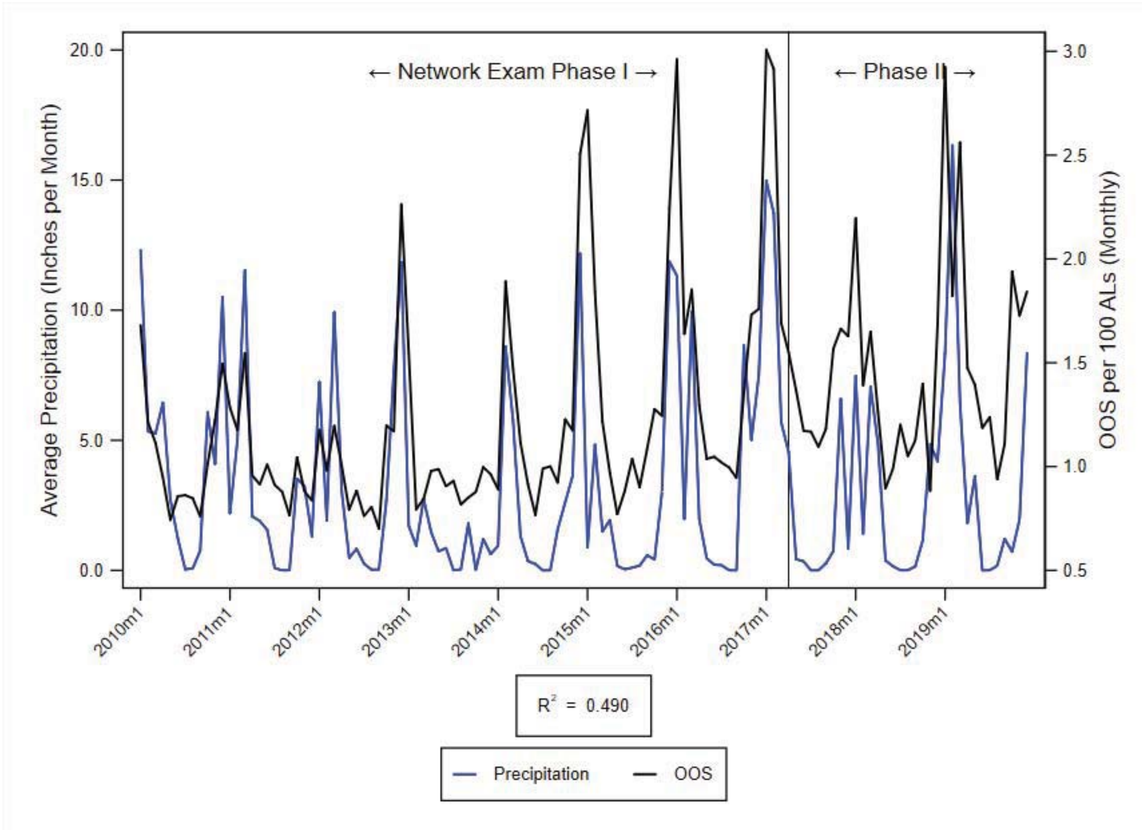
Figure 13.3. REGION 2 NORTH COAST (AT&T)



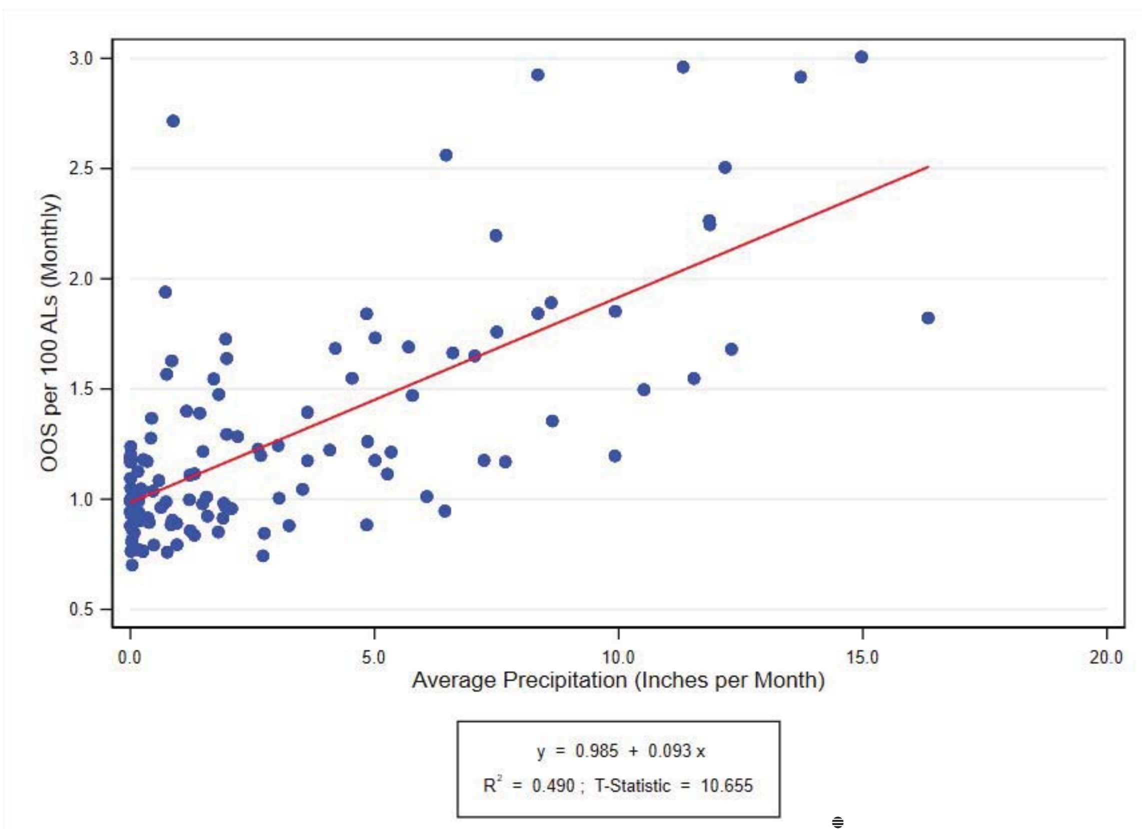
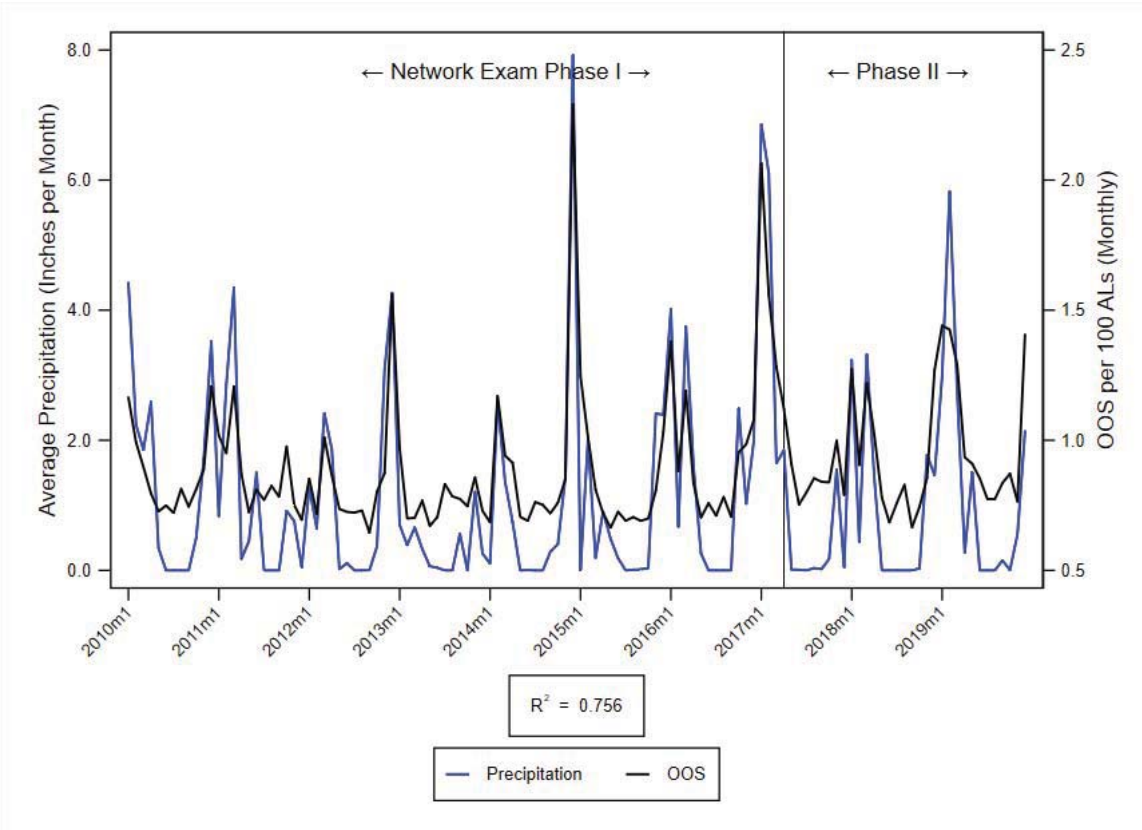


Figure 13.4. REGION 3 SAN FRANCISCO BAY AREA (AT&T)



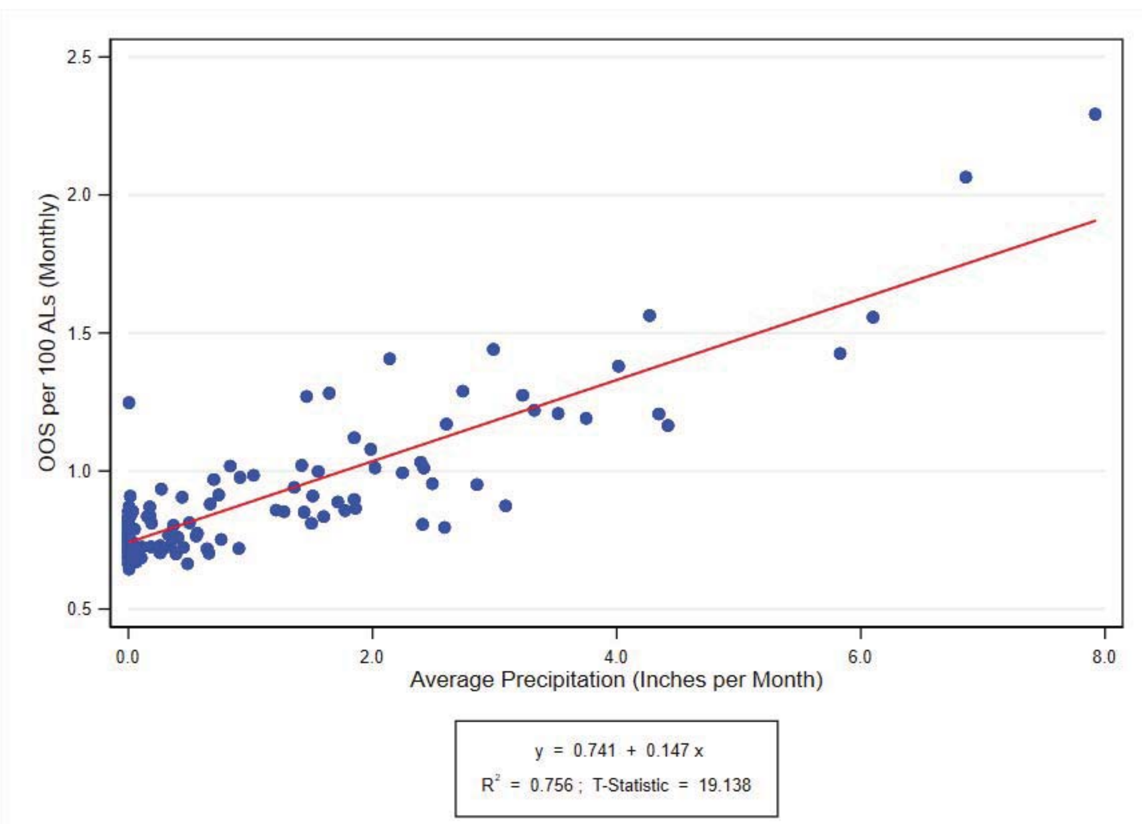


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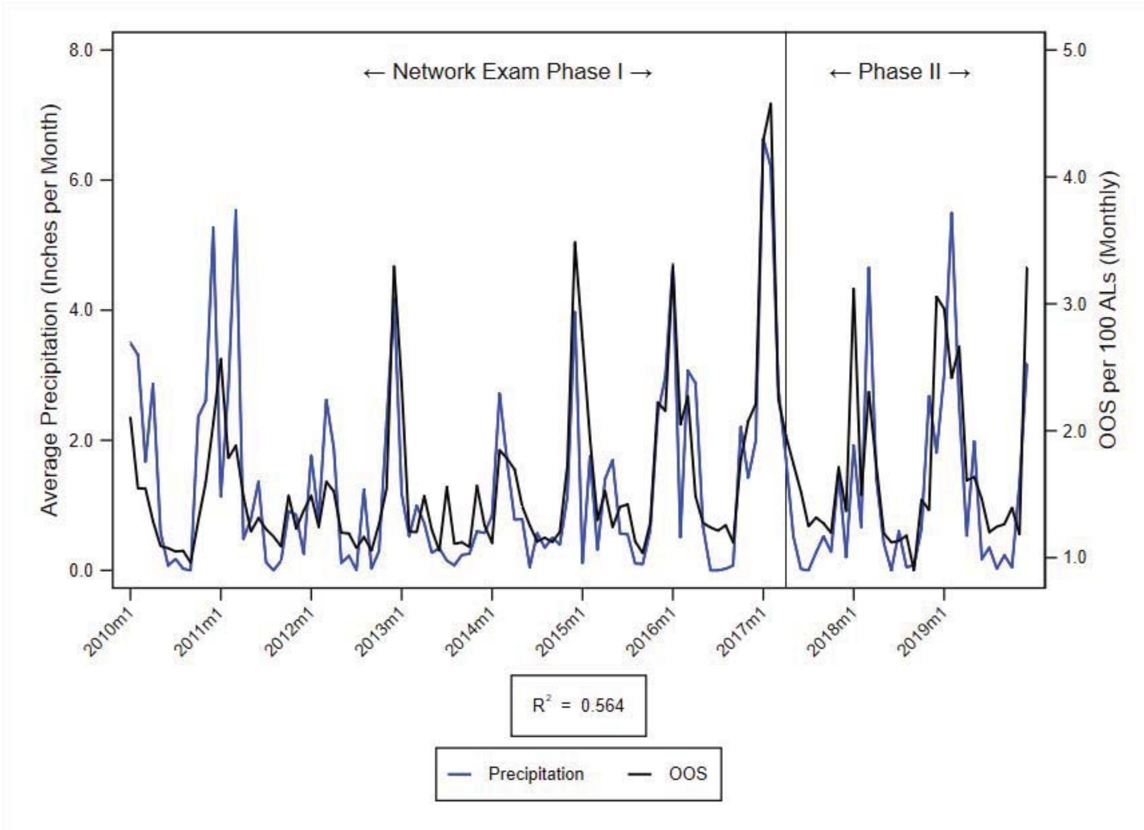
Figure 13.5. REGION 4 NORTHERN SAN JOAQUIN VALLEY (AT&T)



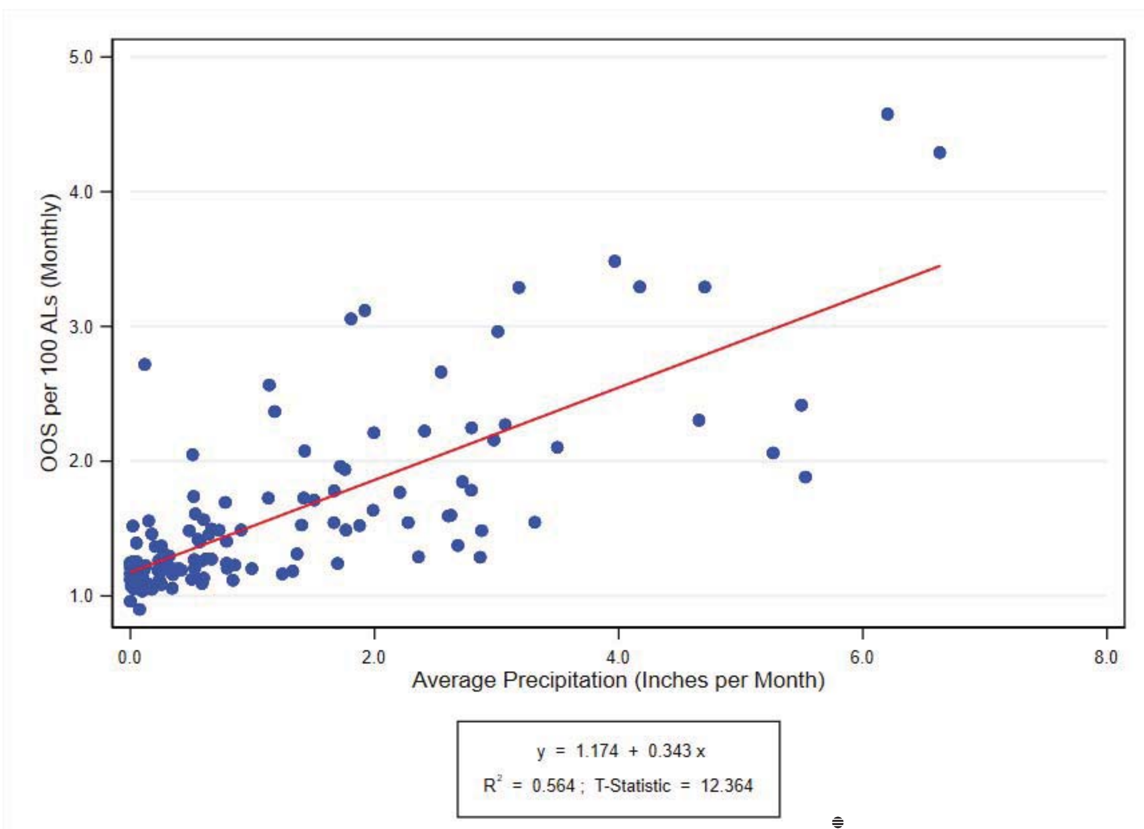


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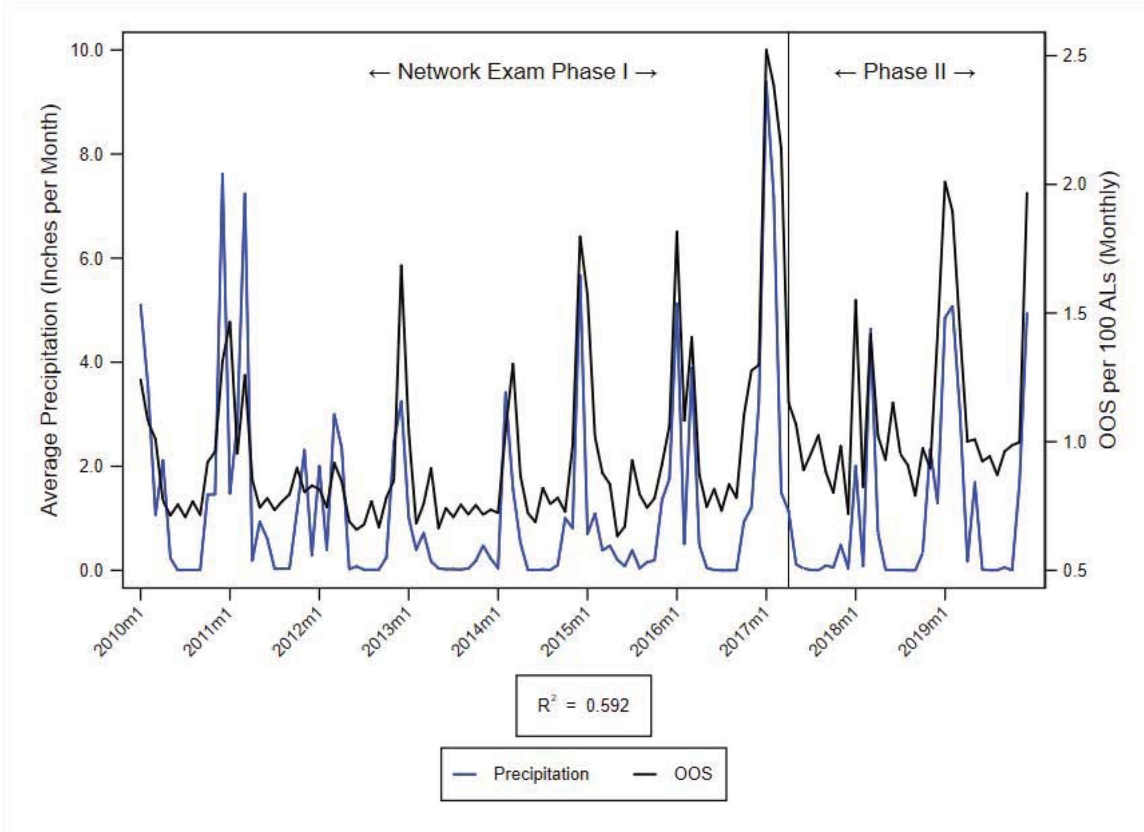
Figure 13.6. REGION 5 CENTRAL COAST (AT&T)



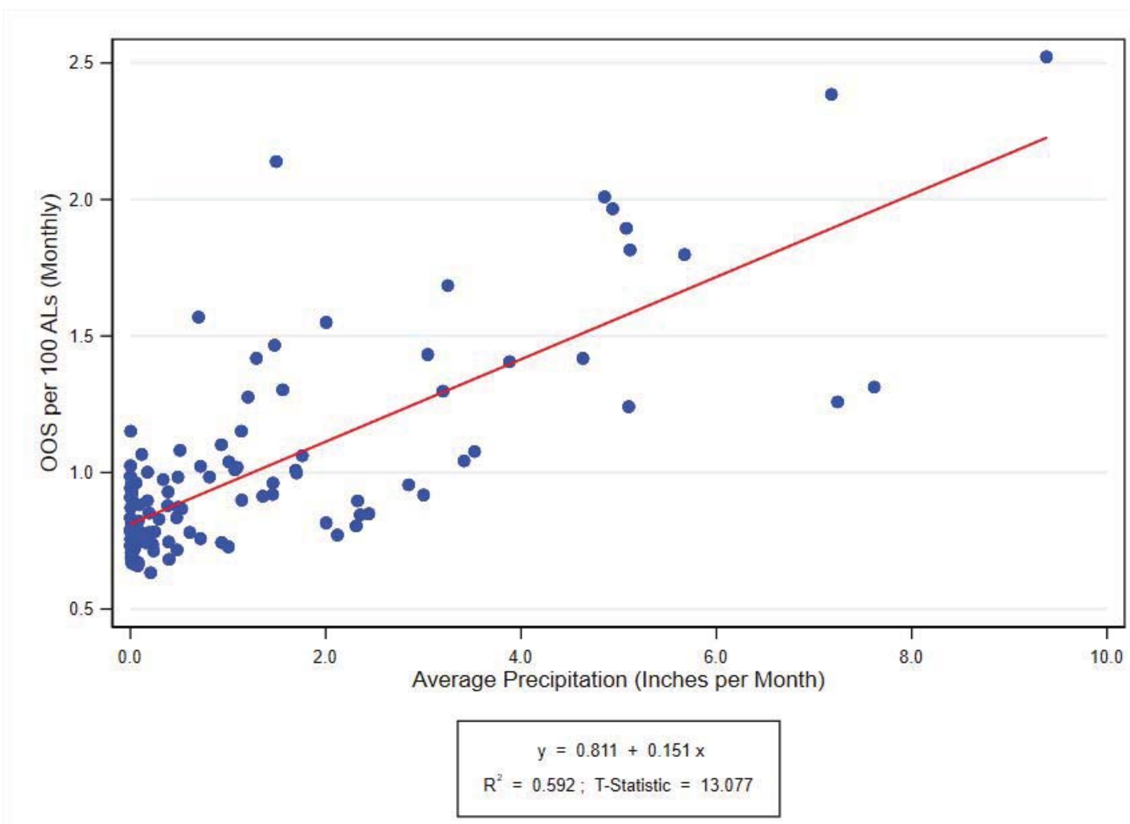
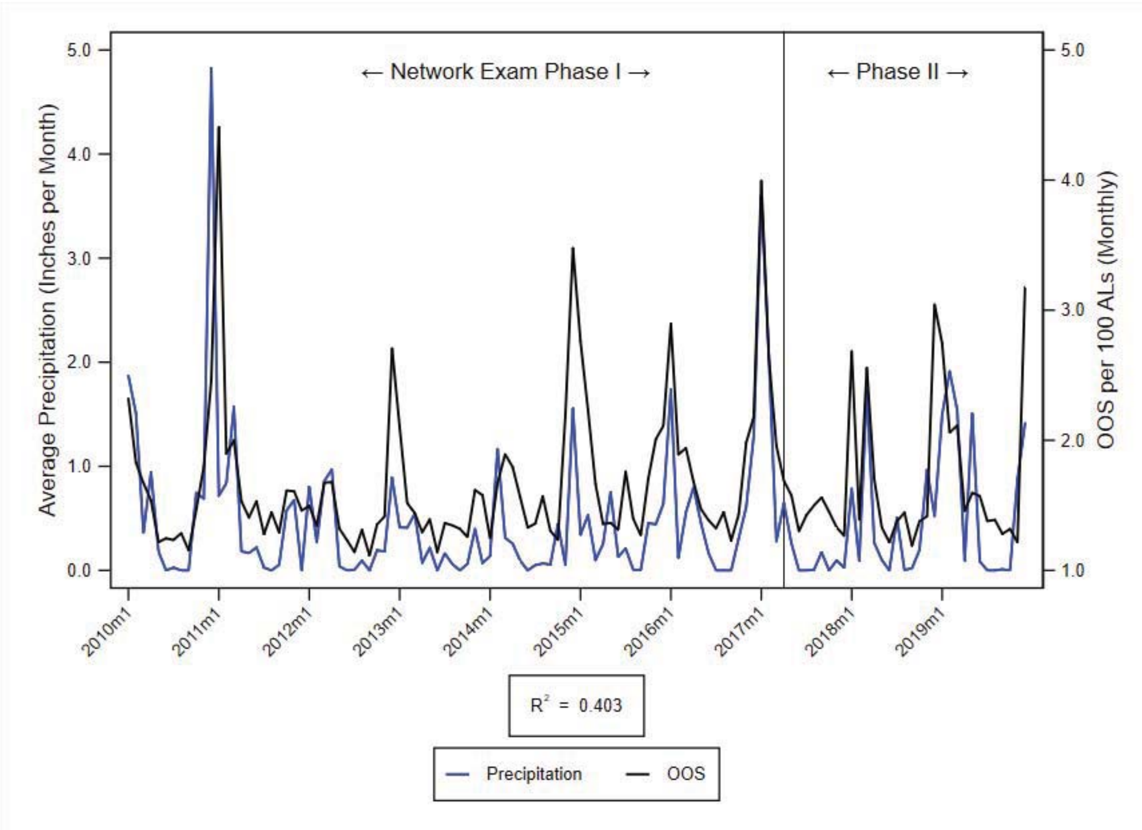


Figure 13.7. REGION 6 SOUTHERN SAN JOAQUIN VALLEY (AT&T)



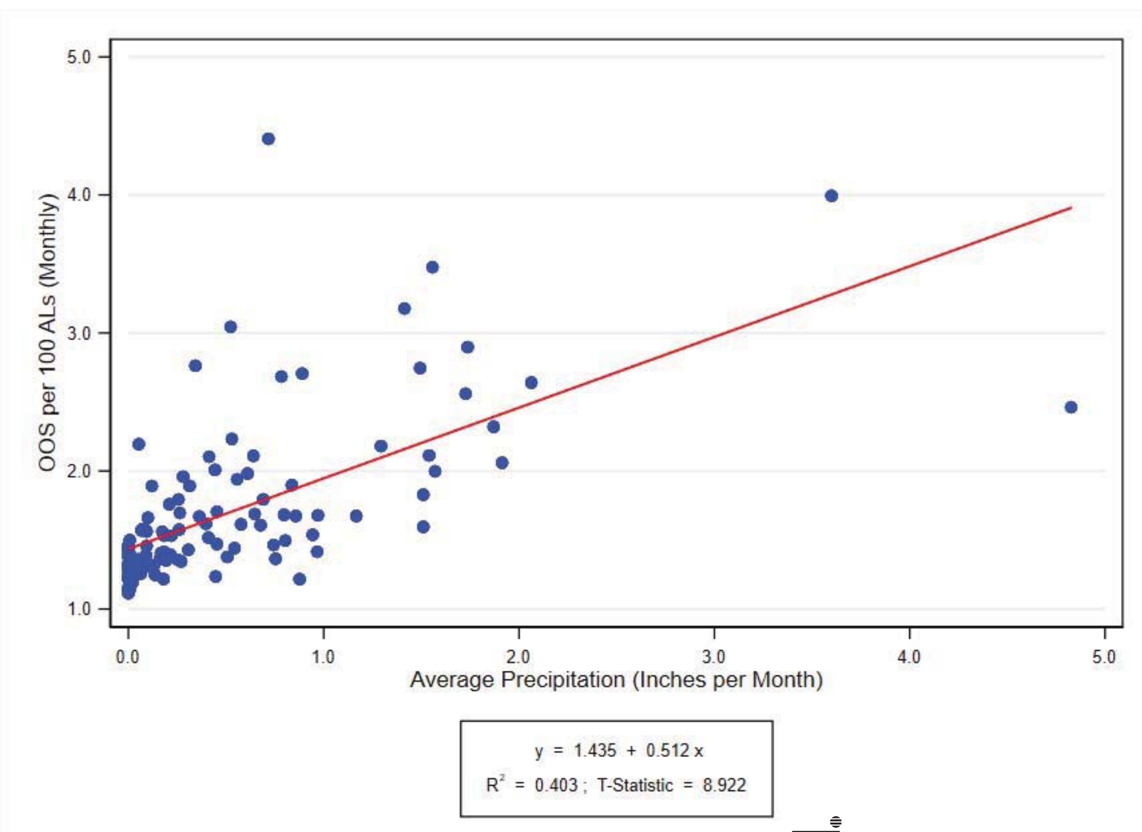


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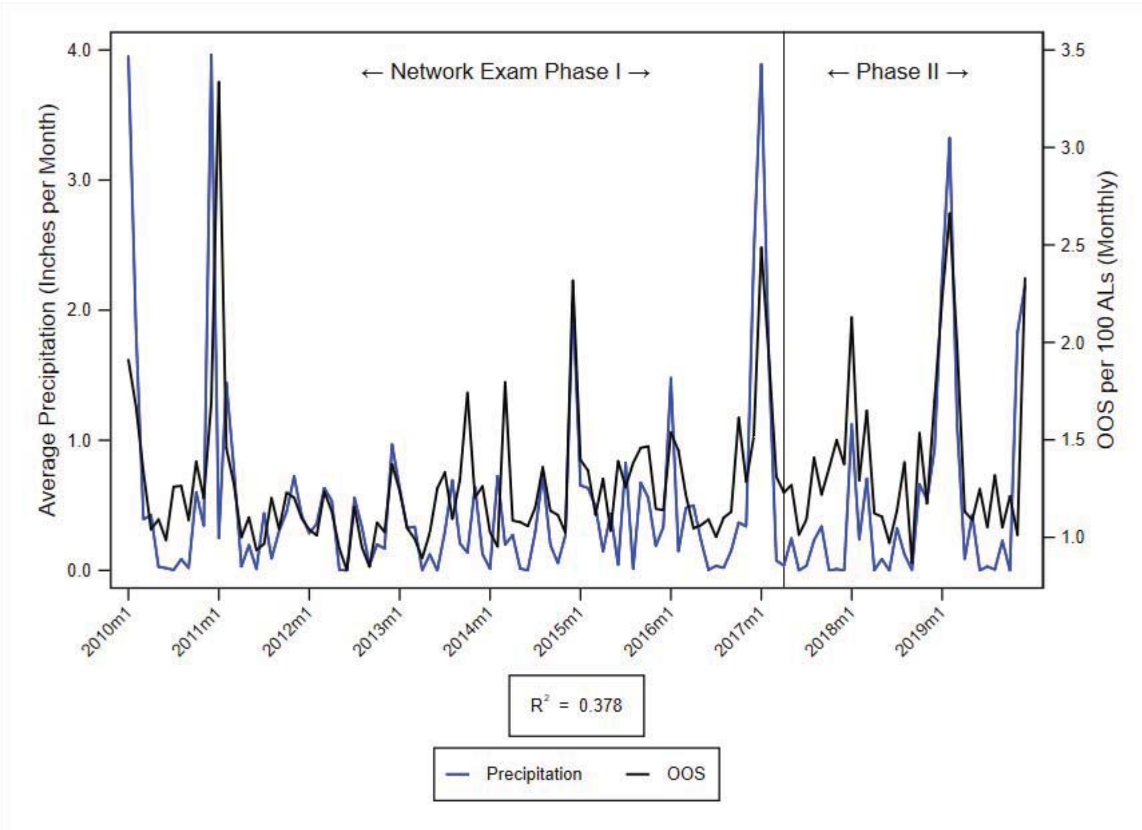
Figure 13.8. REGION 7 INLAND EMPIRE (AT&T)



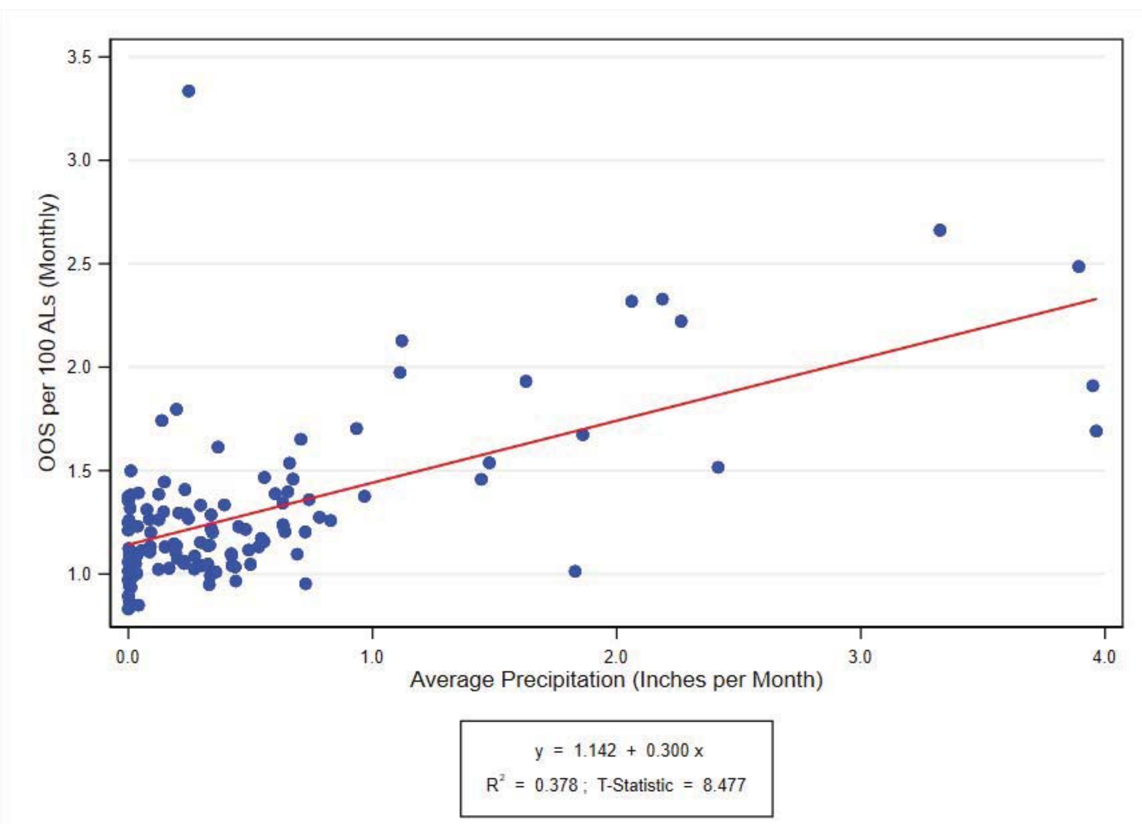
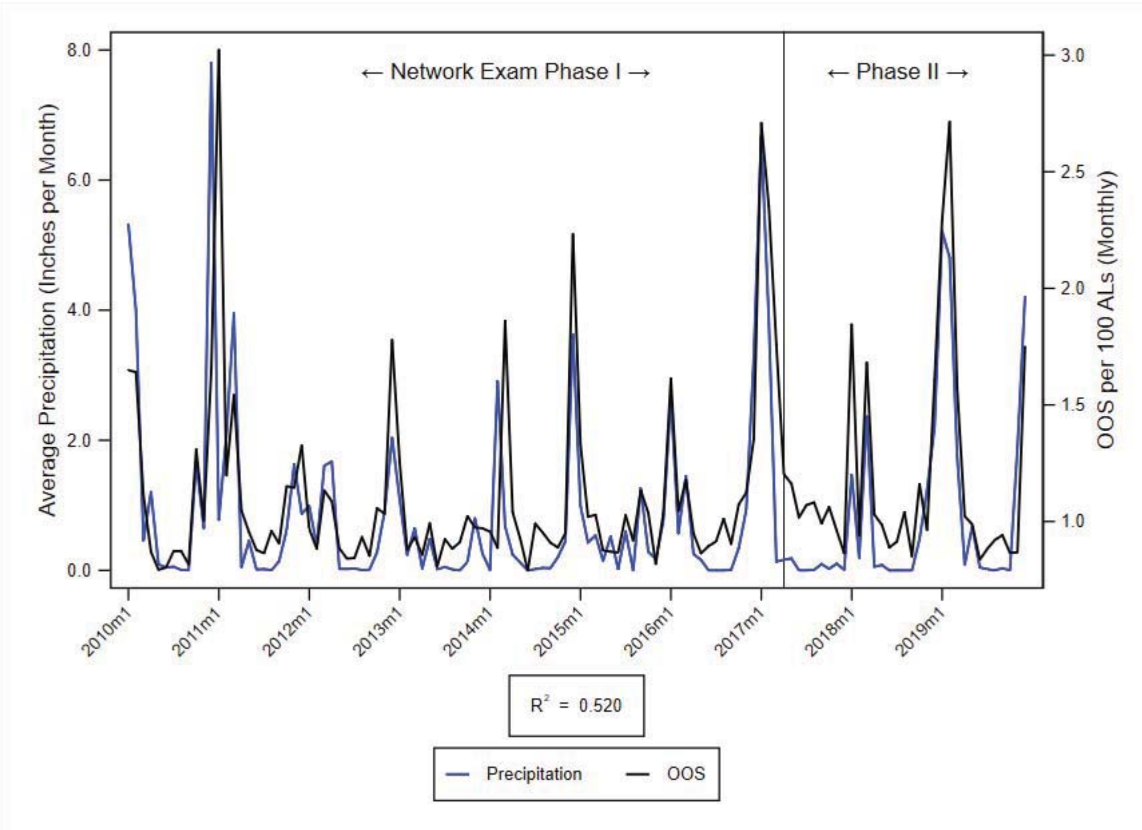


Figure 13.9. REGION 8 LOS ANGELES (AT&T)



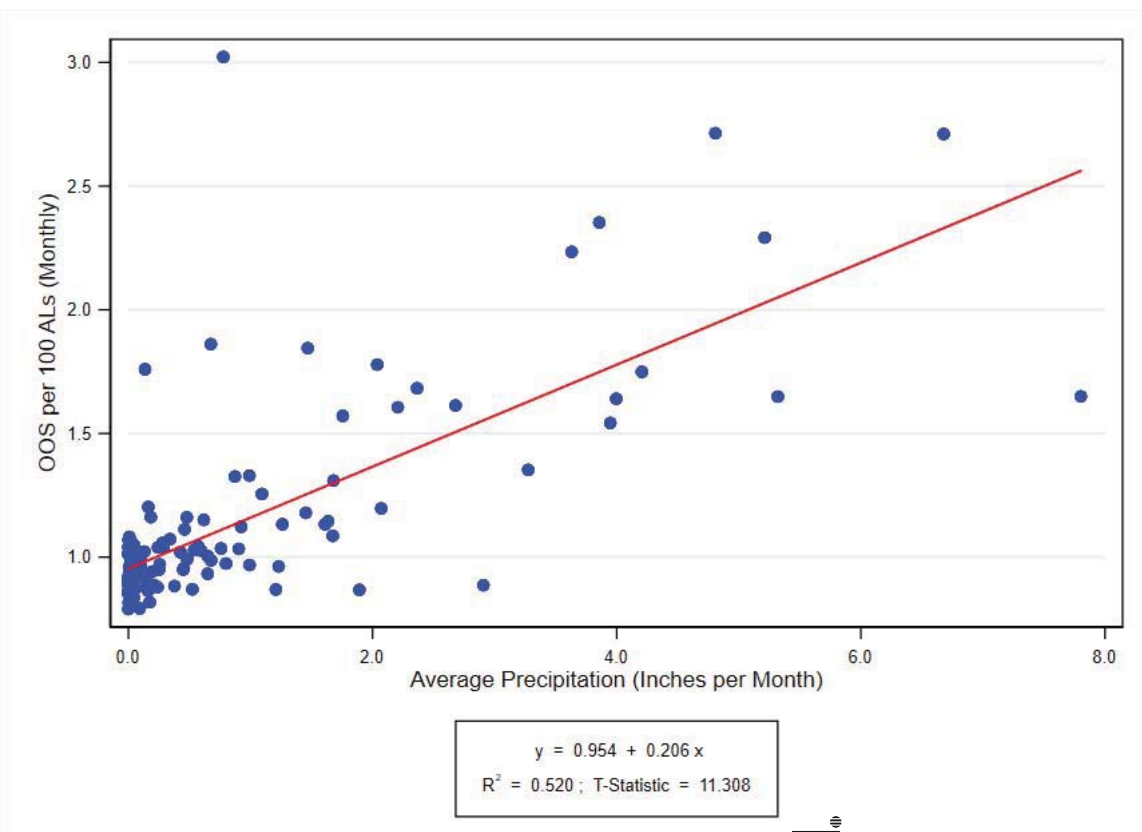
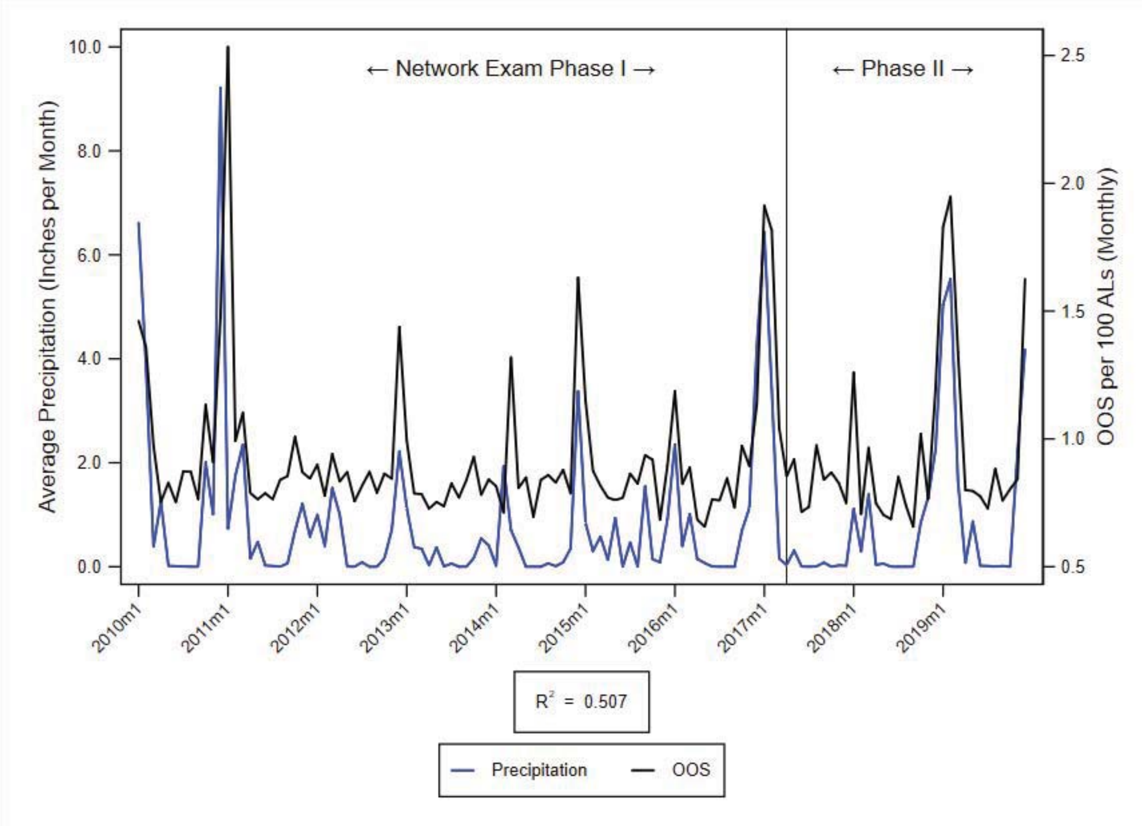


Figure 13.10. REGION 9 ORANGE (AT&T)



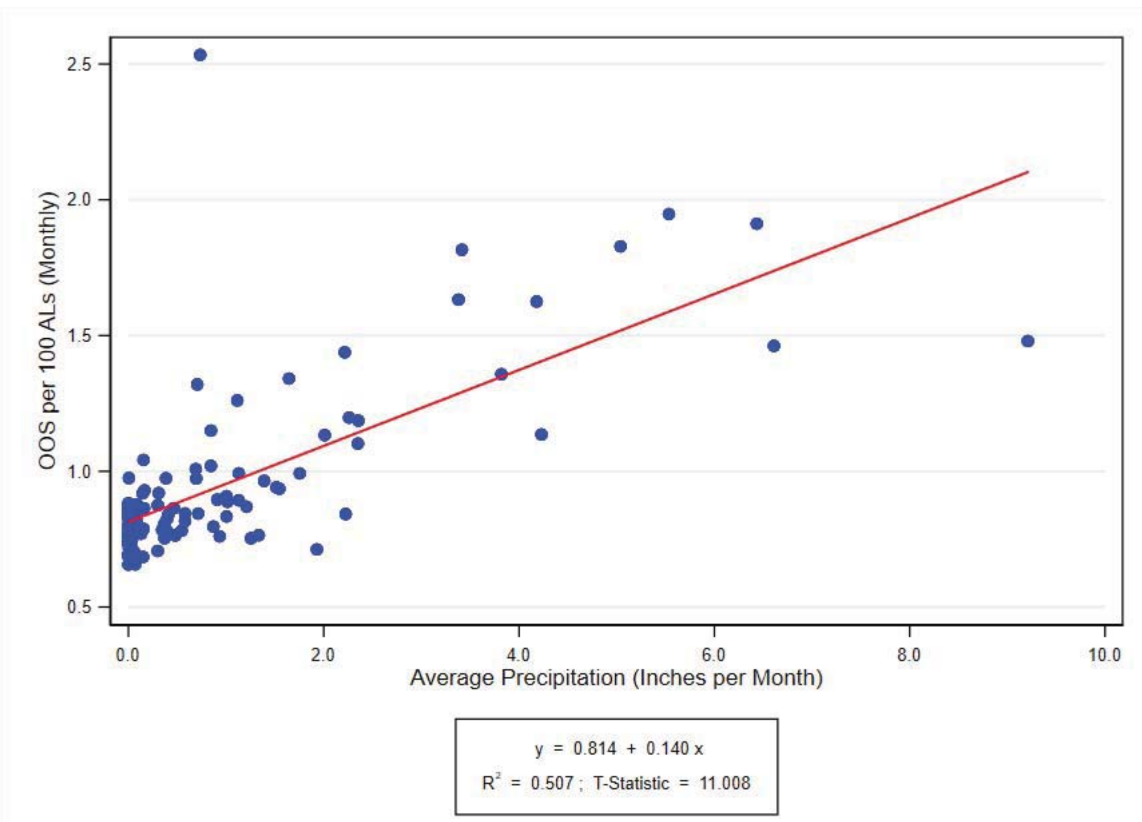


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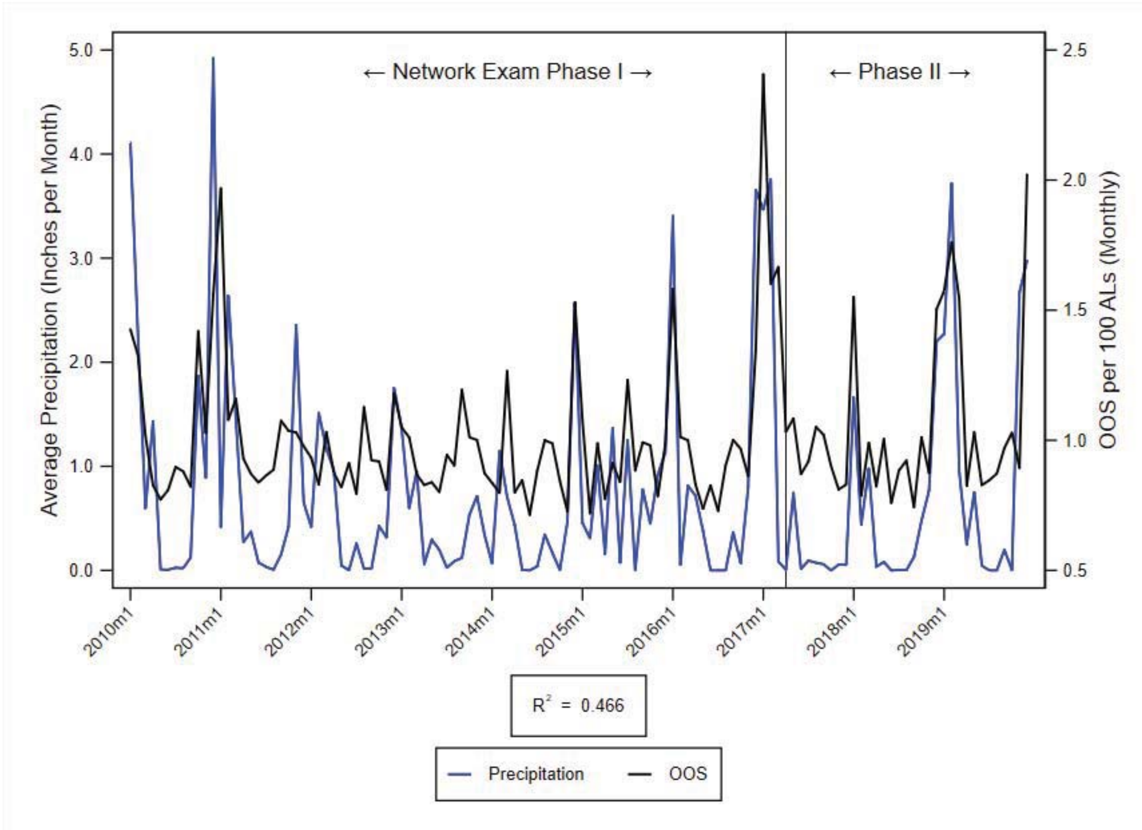
Figure 13.11. REGION 10 SAN DIEGO-IMPERIAL (AT&T)



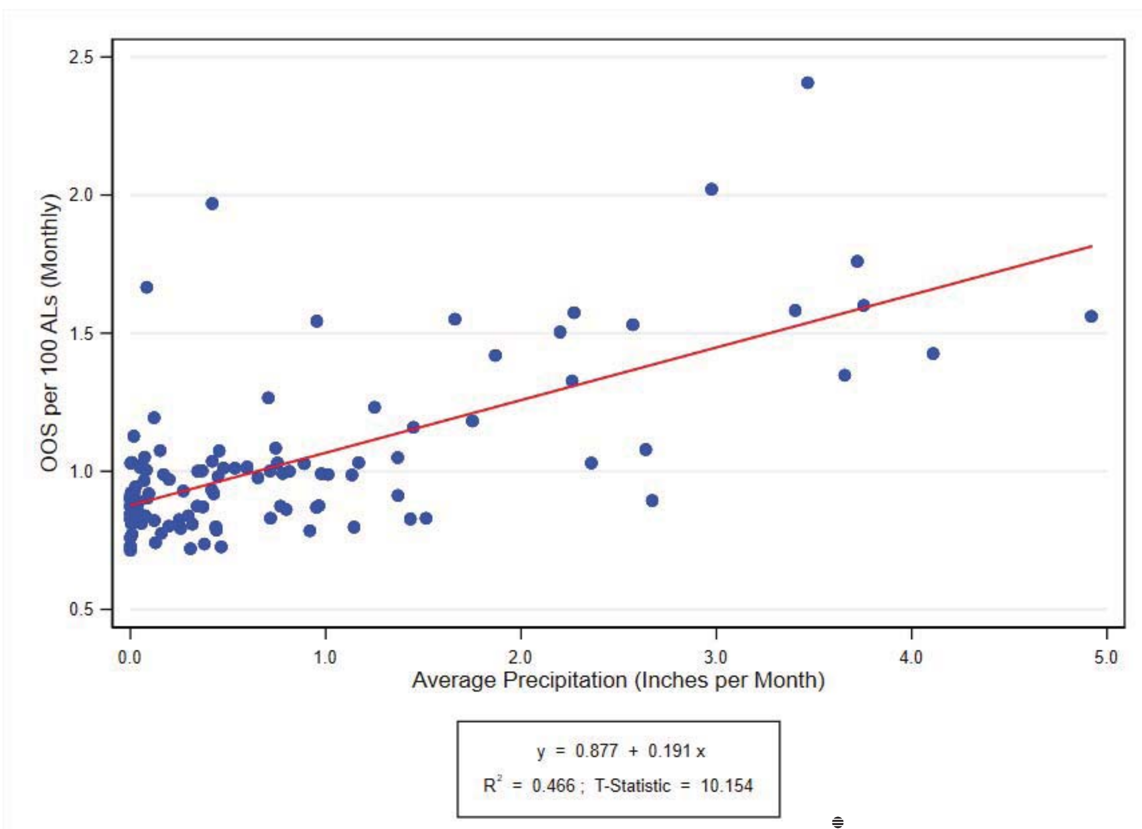


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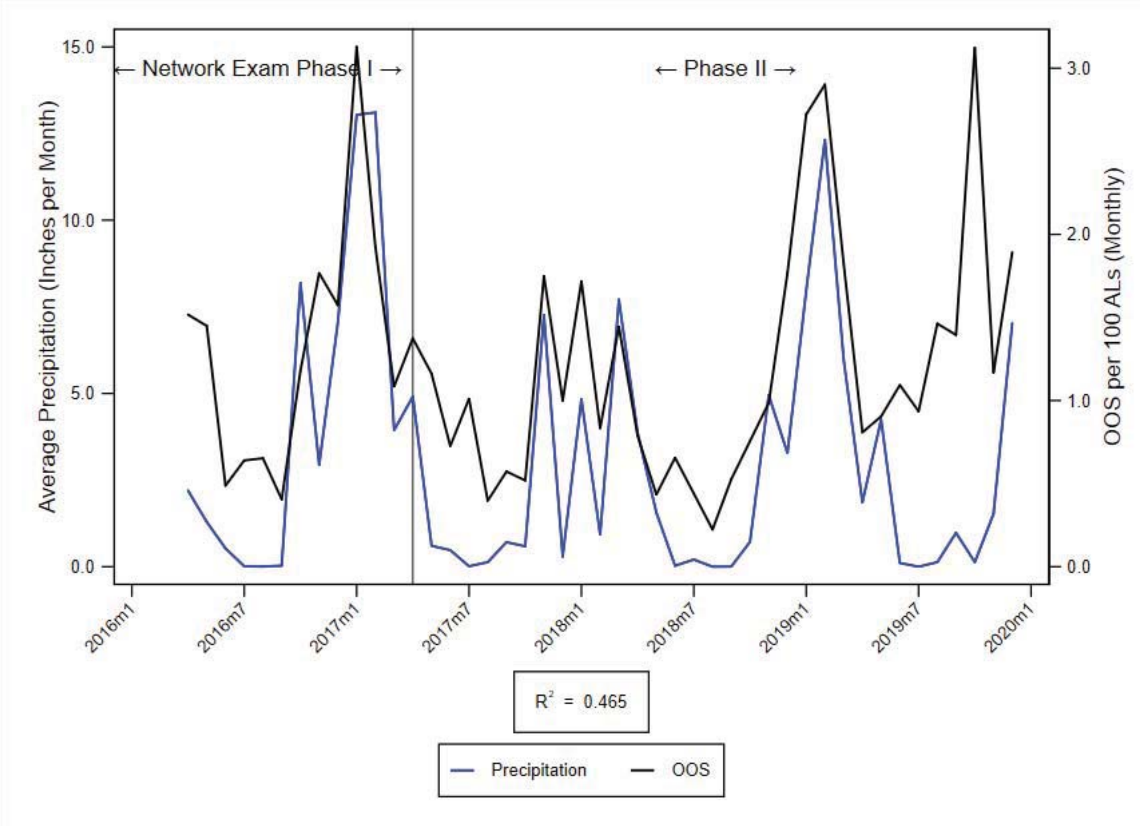
Figure 13.12. REGION 1 SUPERIOR CALIFORNIA (FTR)



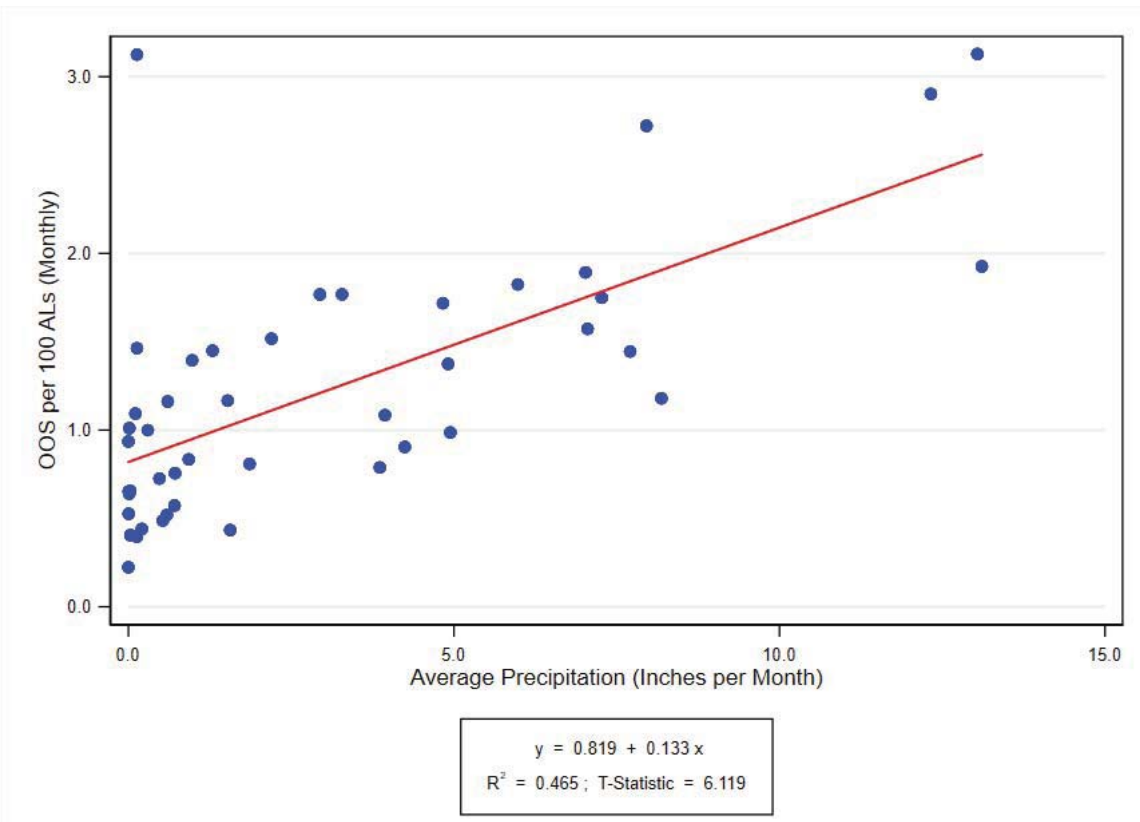
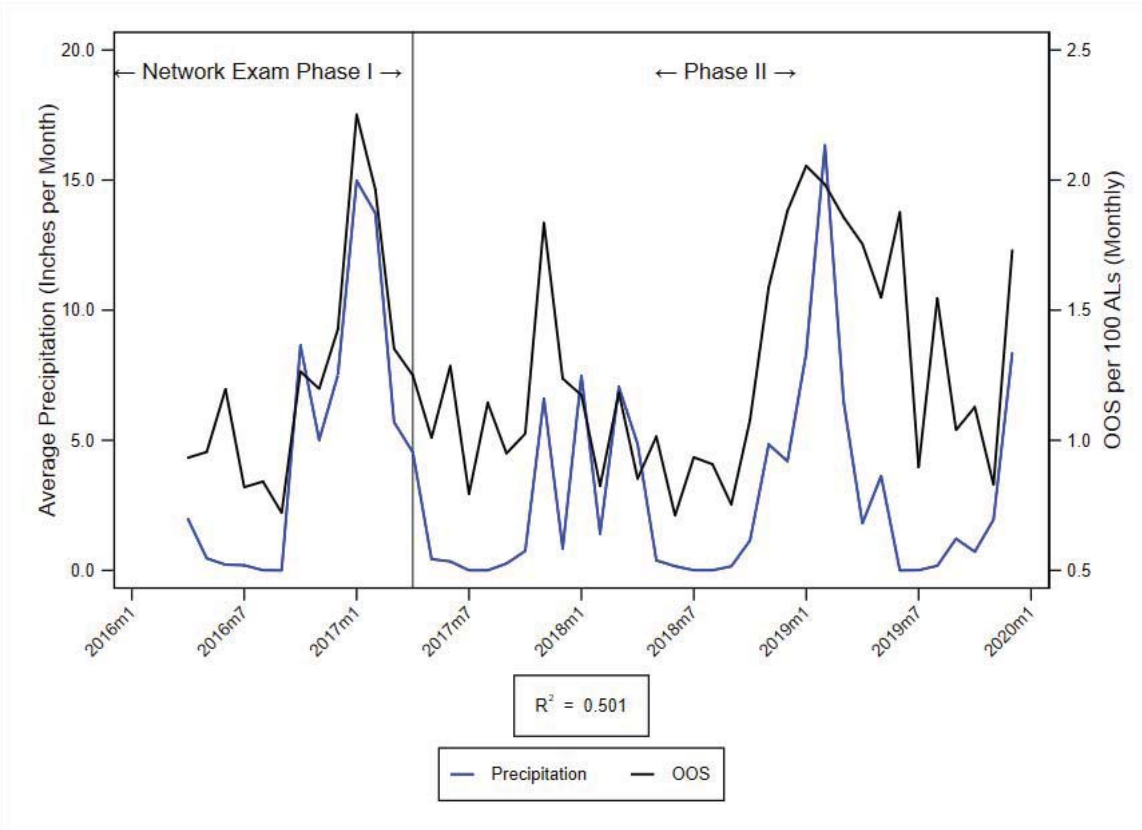


Figure 13.13. REGION 2 NORTH COAST (FTR)



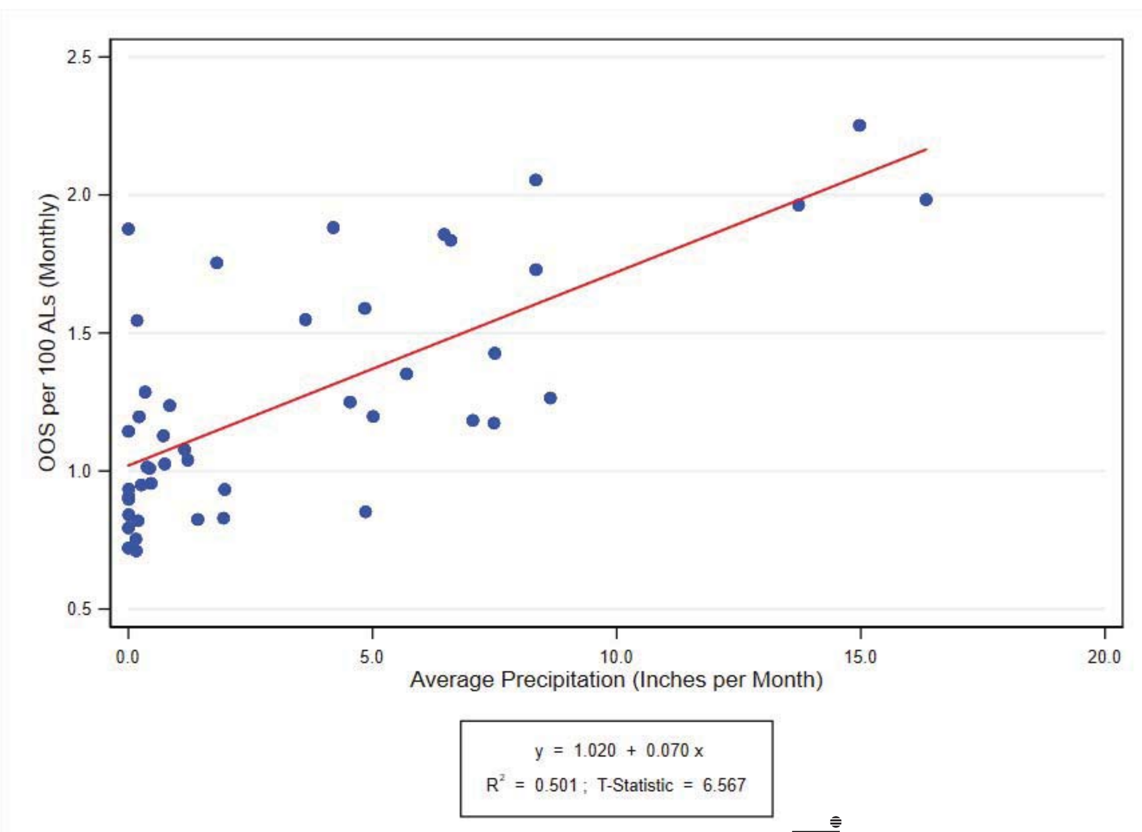
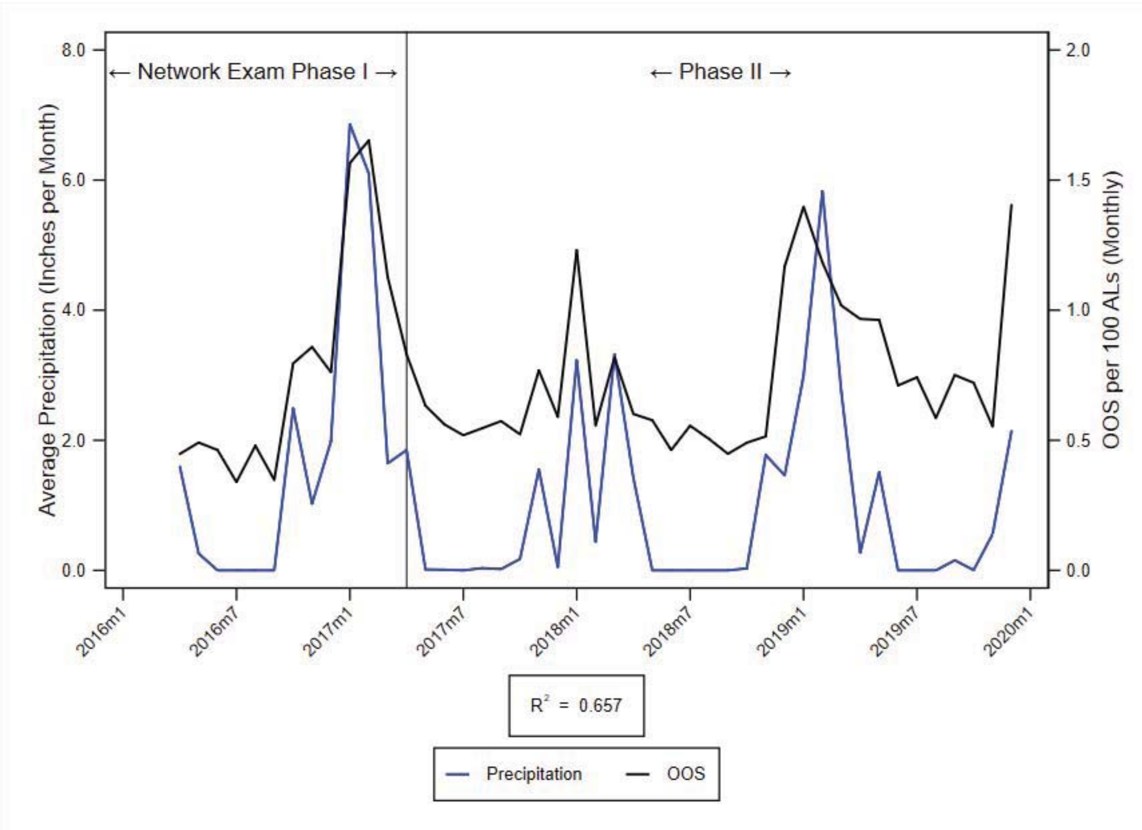


Figure 13.14. REGION 3 SAN FRANCISCO BAY AREA (FTR)



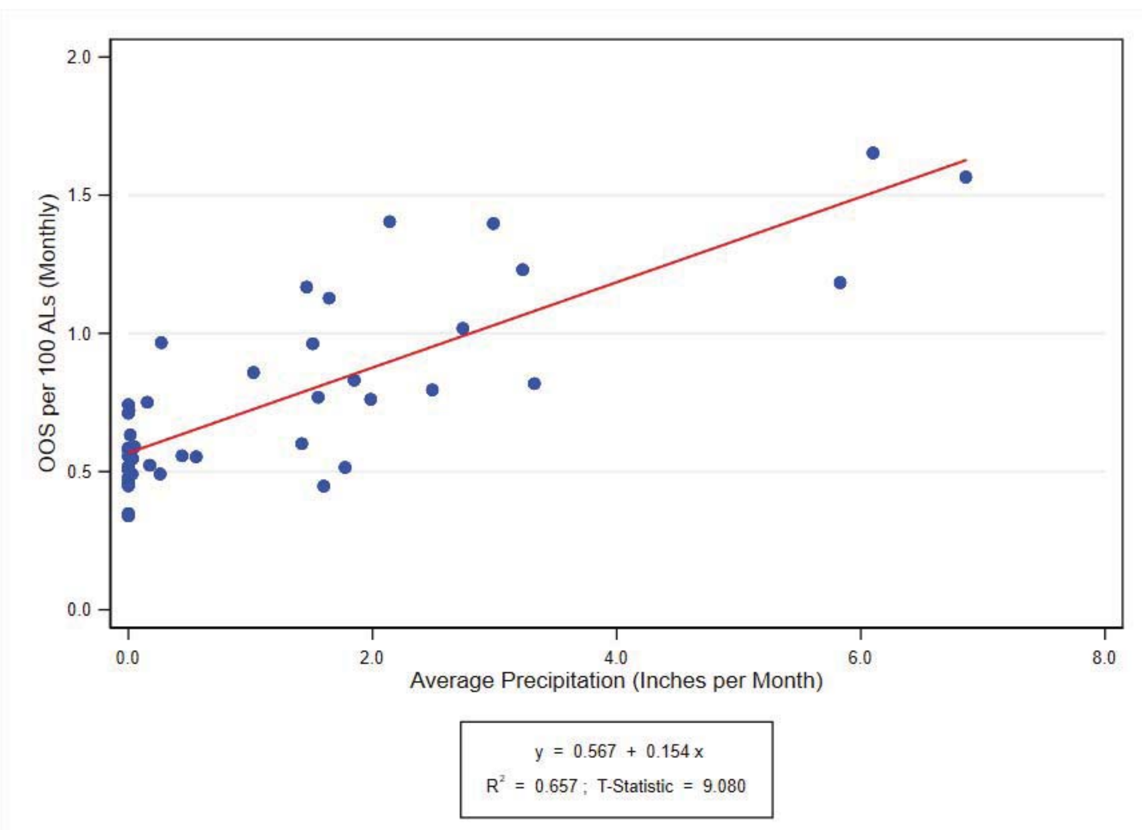
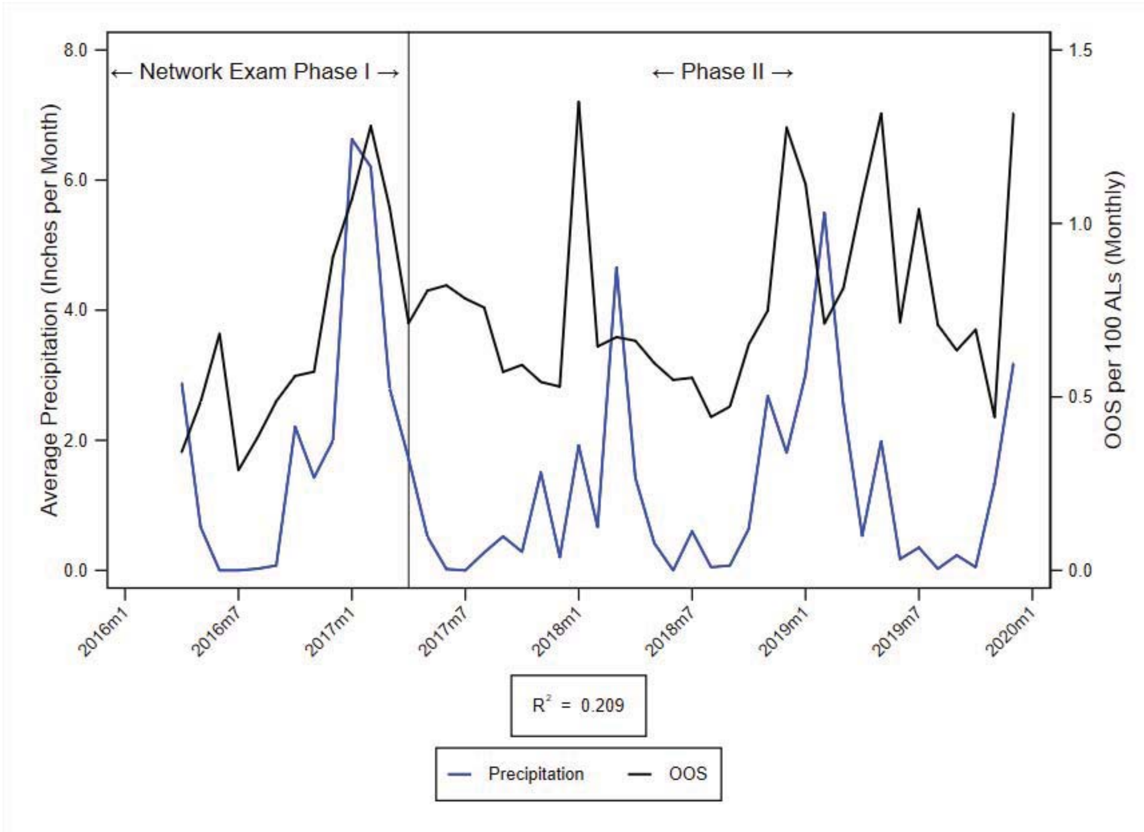


Figure 13.15. REGION 4 NORTHERN SAN JOAQUIN VALLEY (FTR)



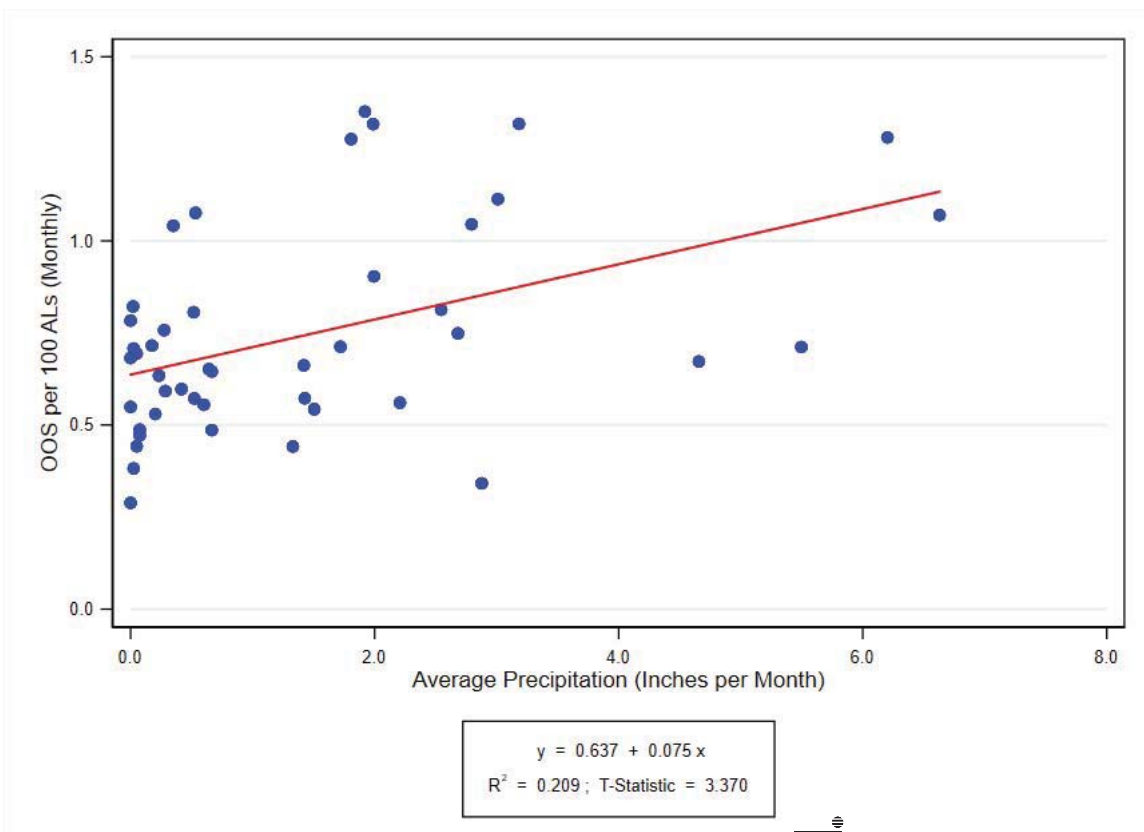


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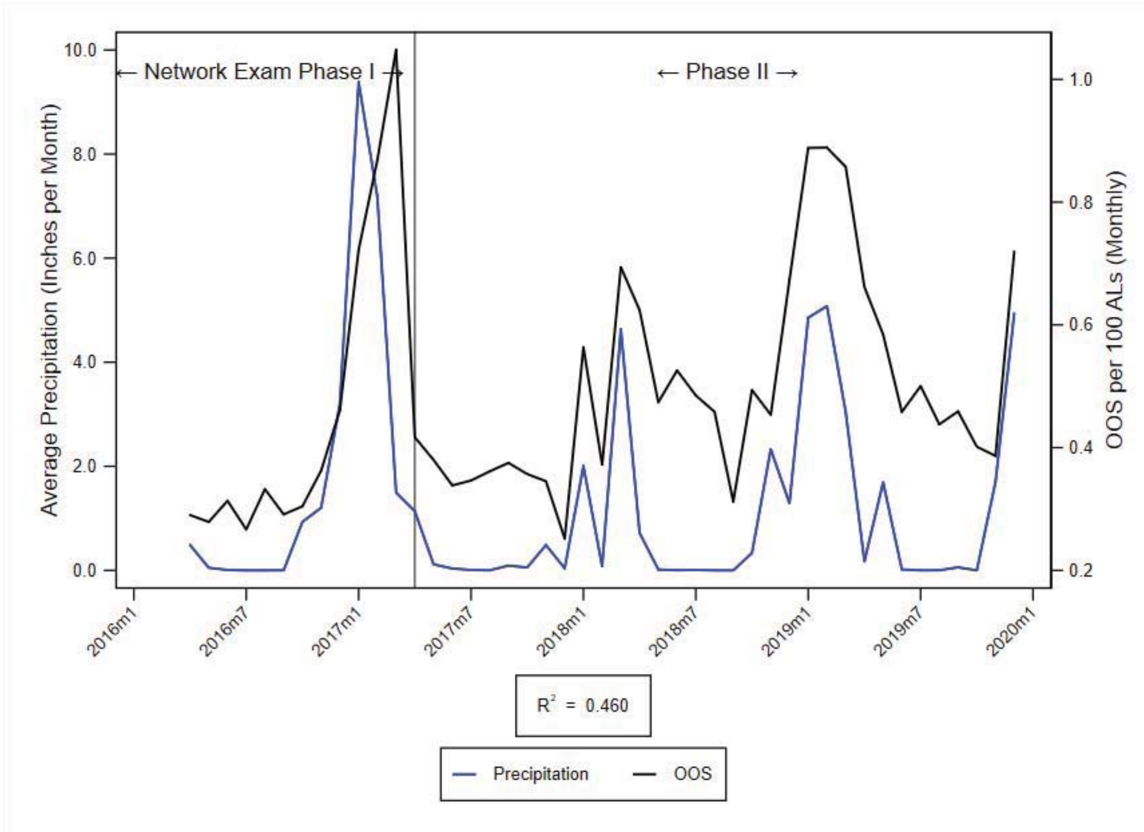
Figure 13.16. REGION 5 CENTRAL COAST (FTR)



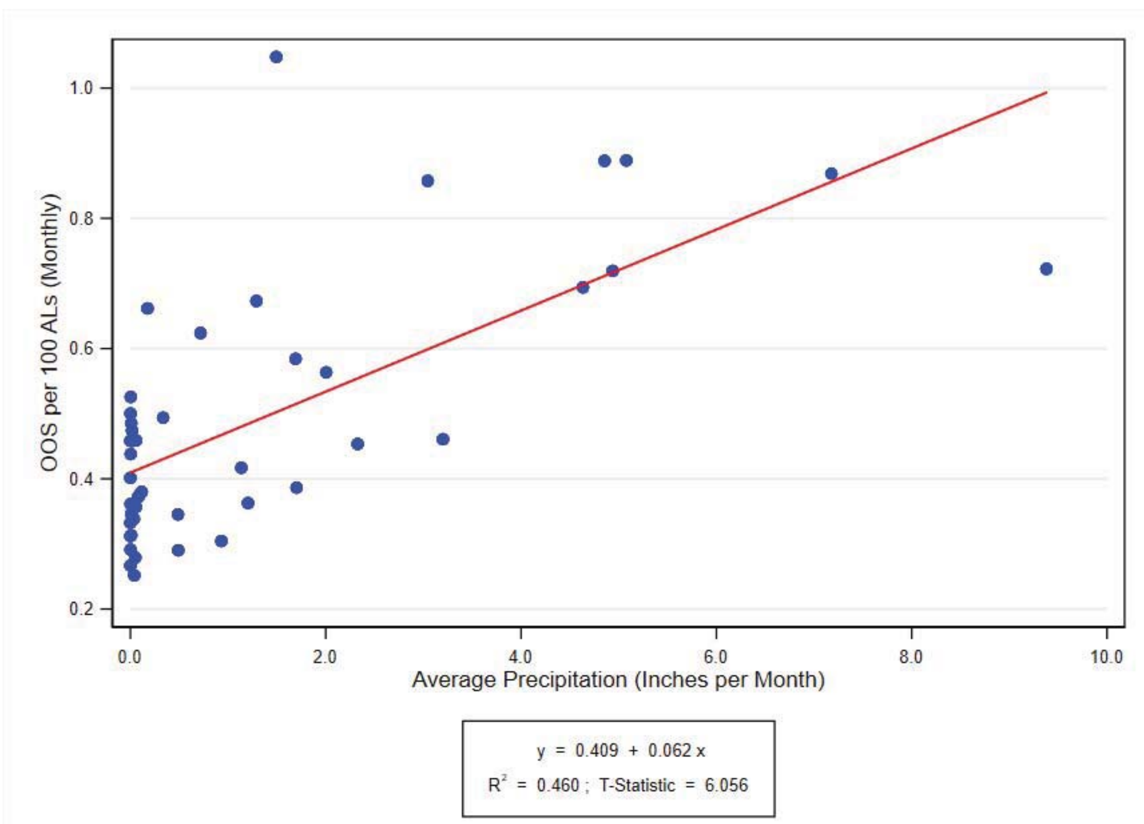
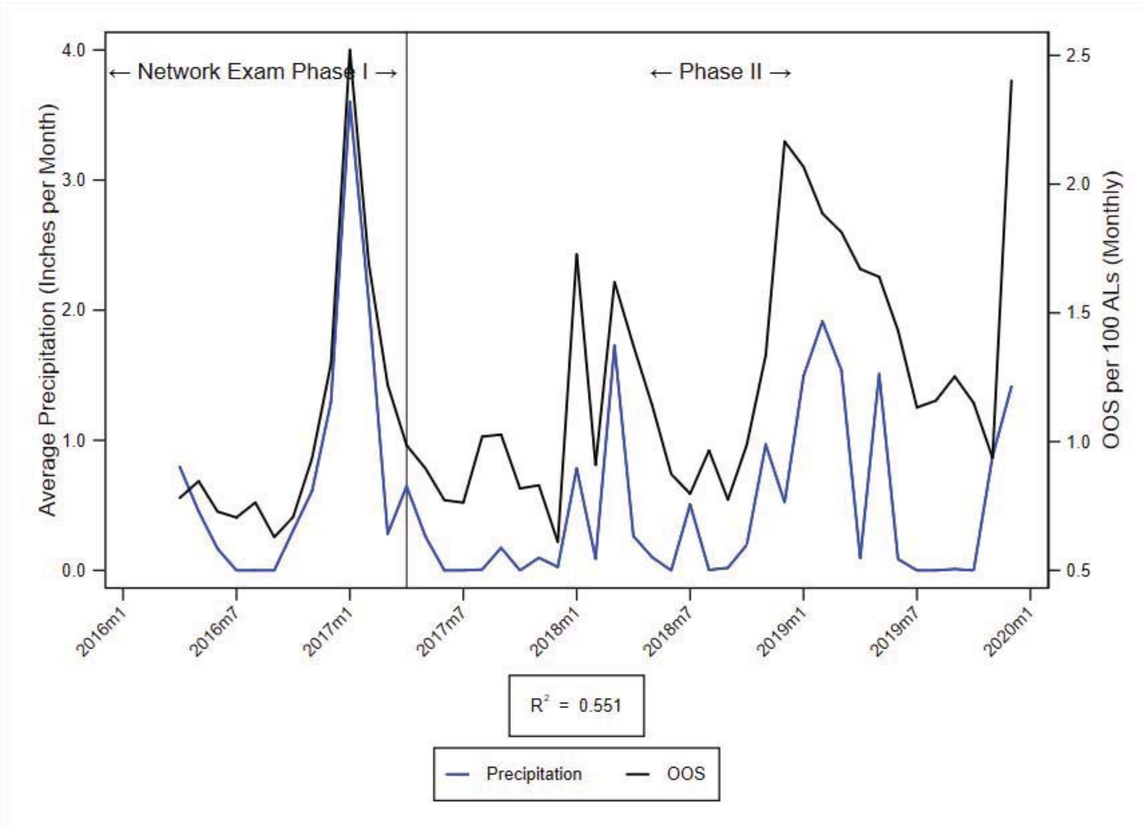


Figure 13.17. REGION 6 SOUTHERN SAN JOAQUIN VALLEY (FTR)



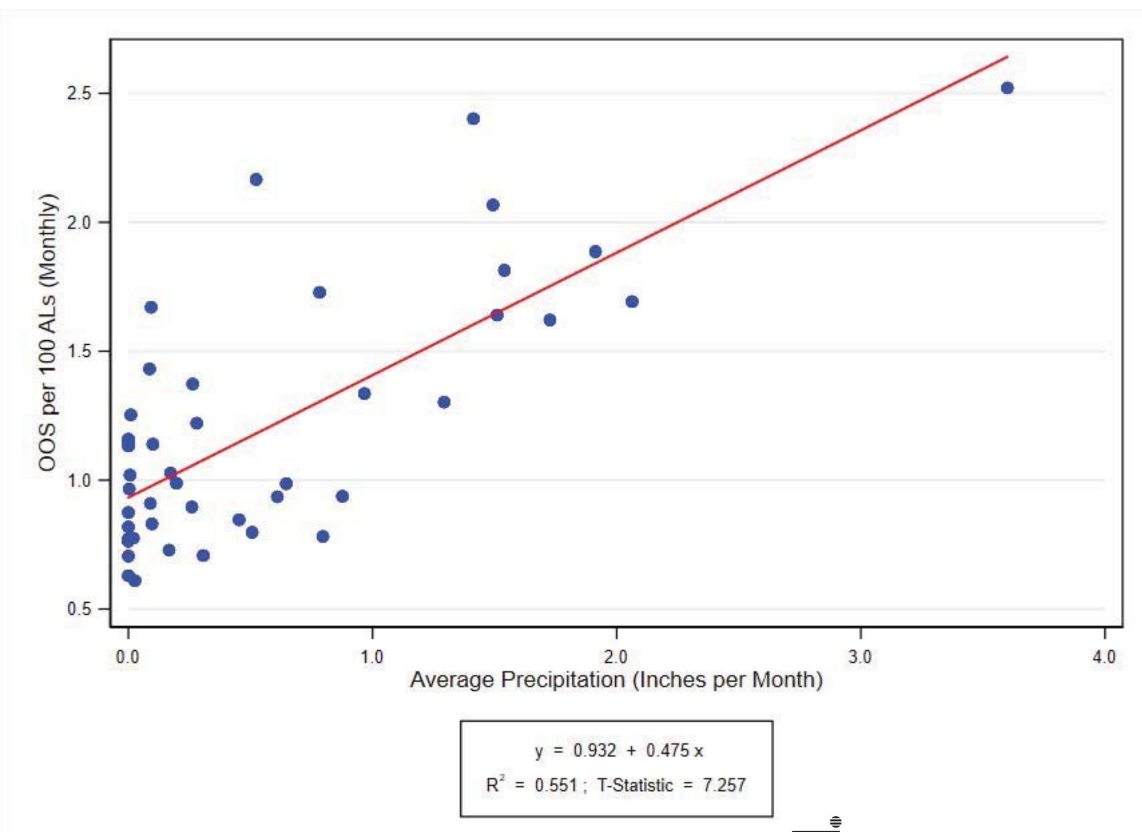


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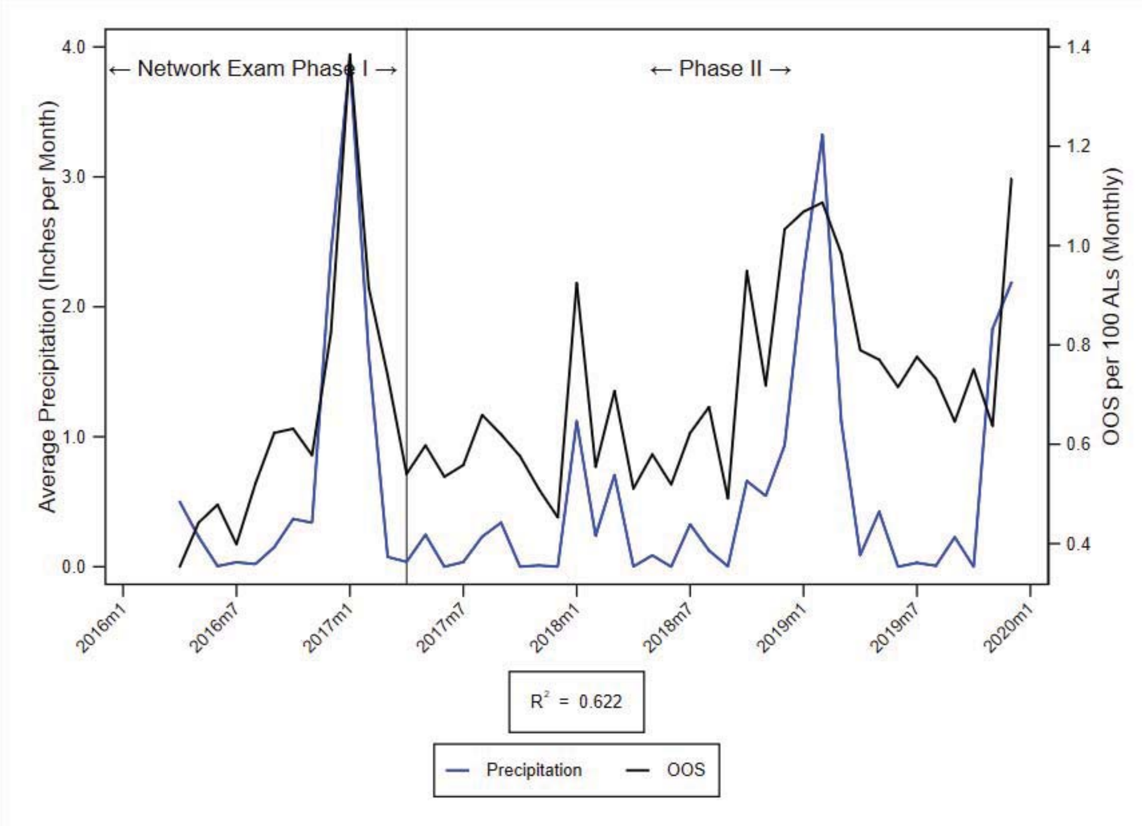
Figure 13.18. REGION 7 INLAND EMPIRE (FTR)



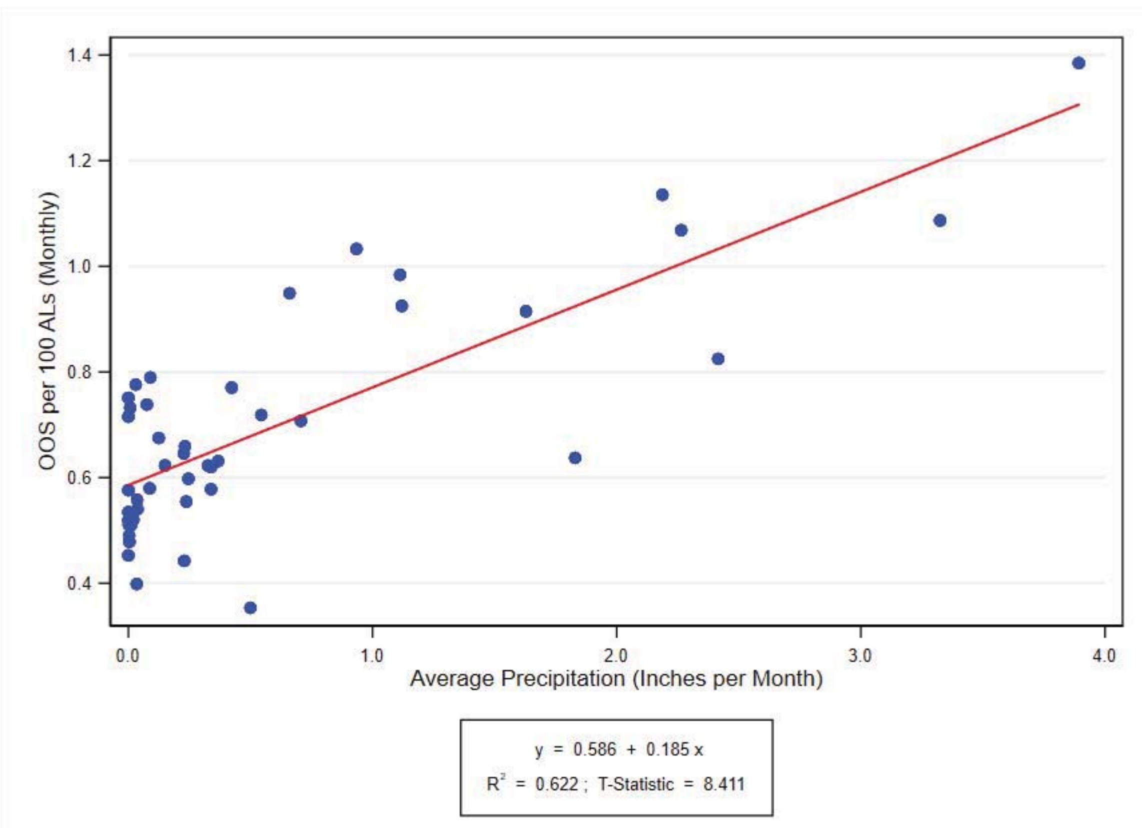
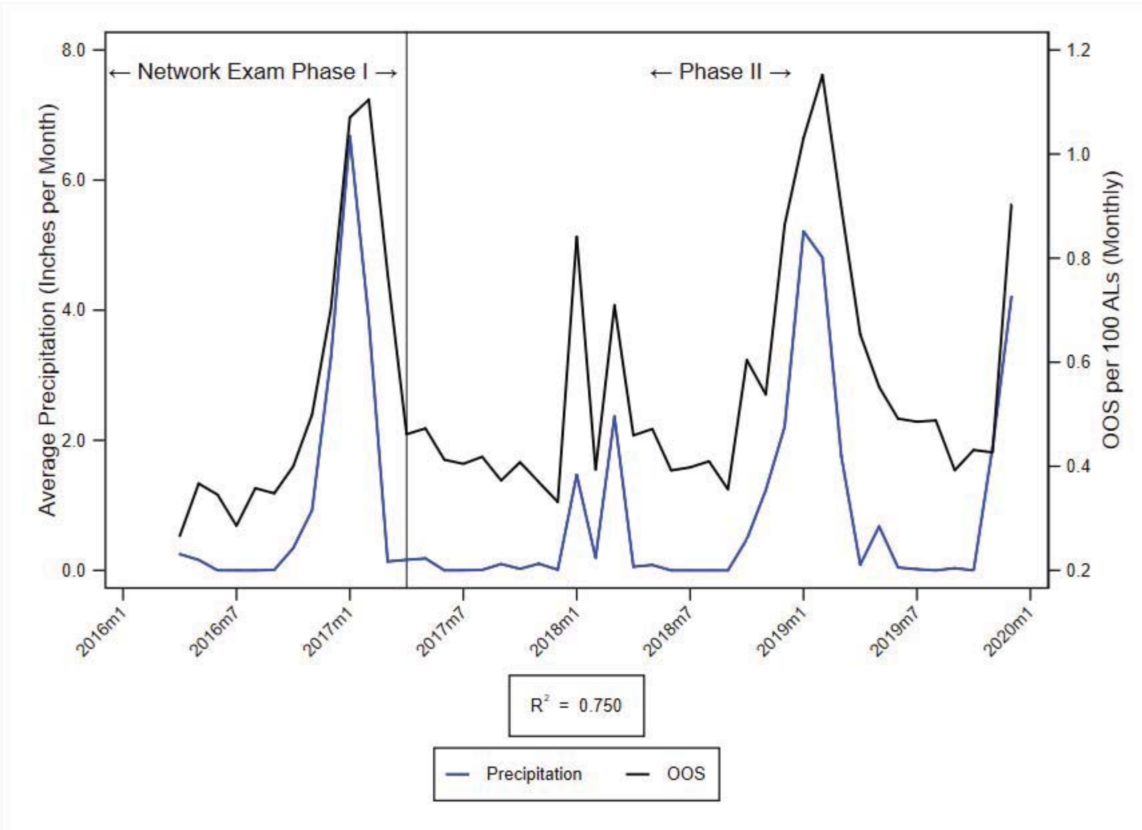


Figure 13.19. REGION 8 LOS ANGELES (FTR)



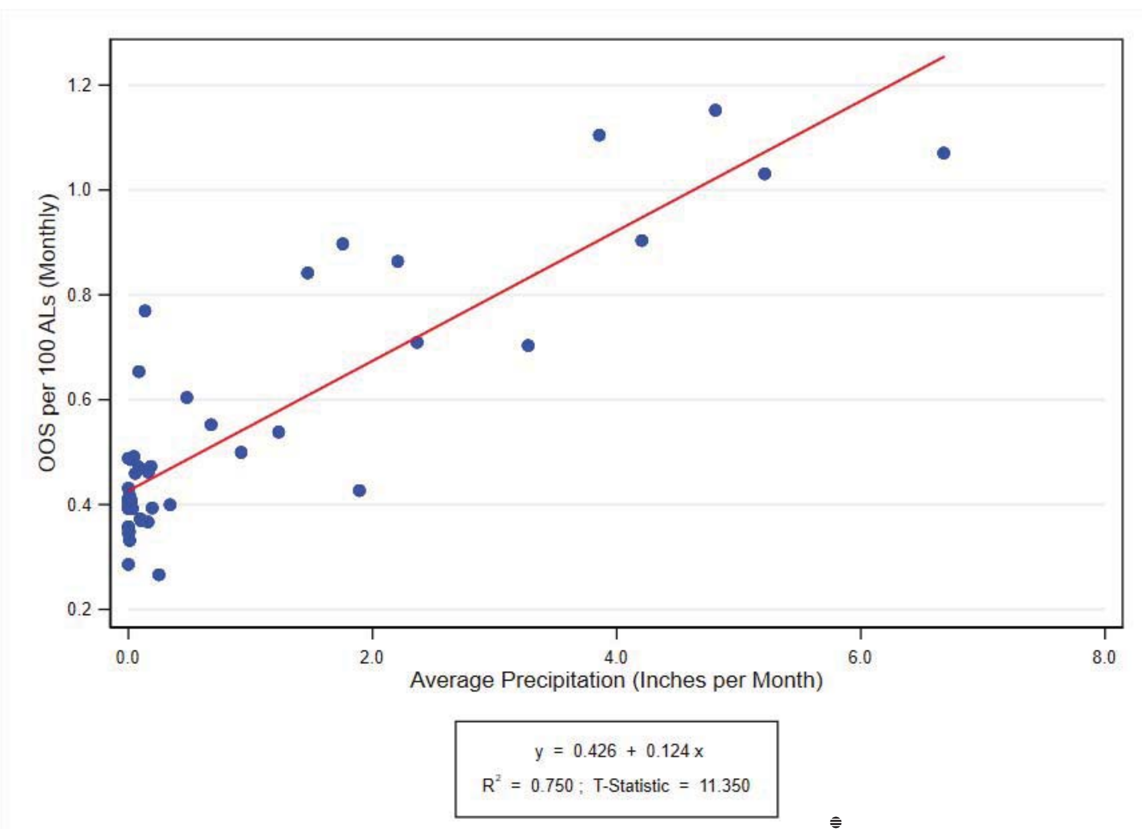
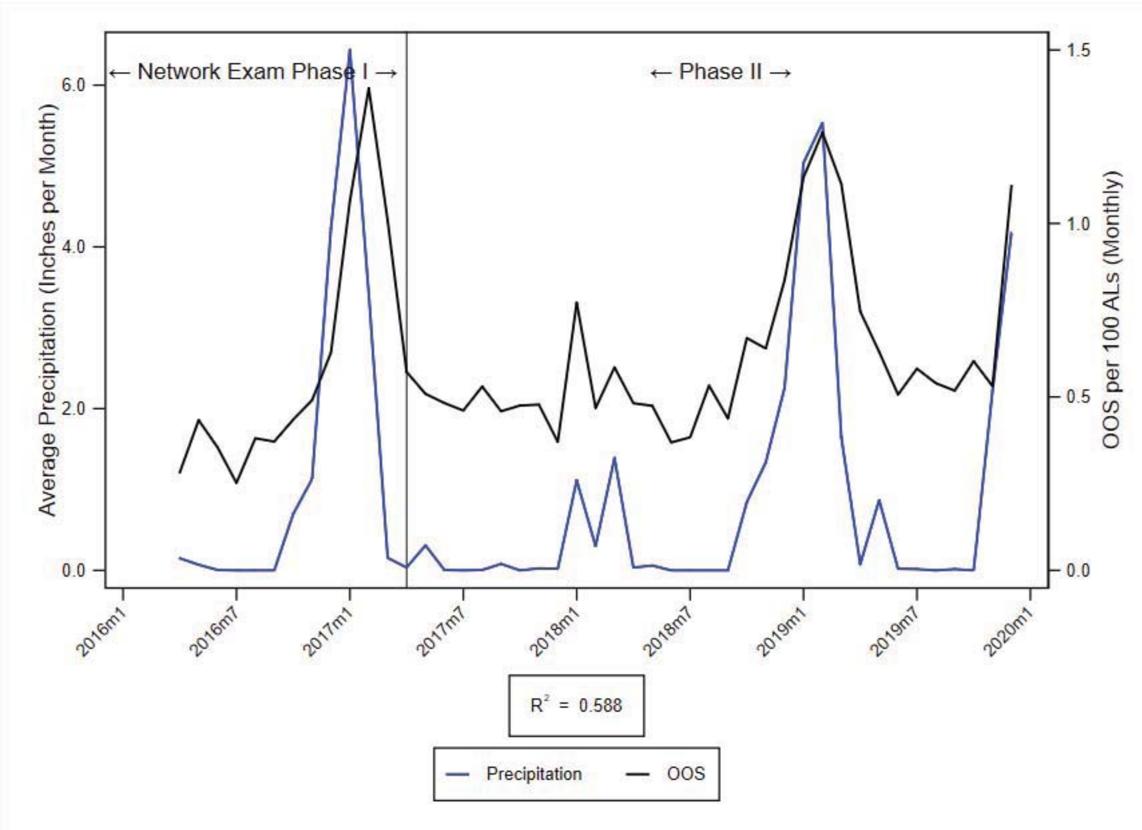


Figure 13.20. REGION 9 ORANGE (FTR)



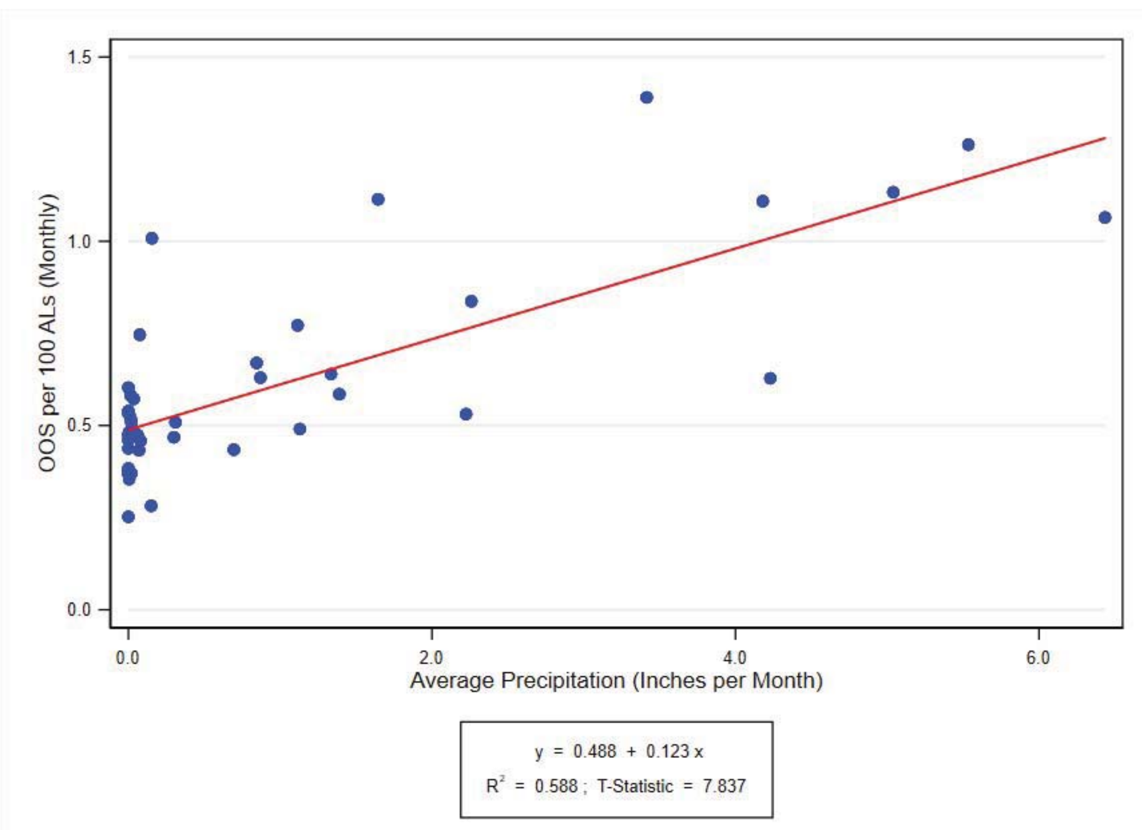
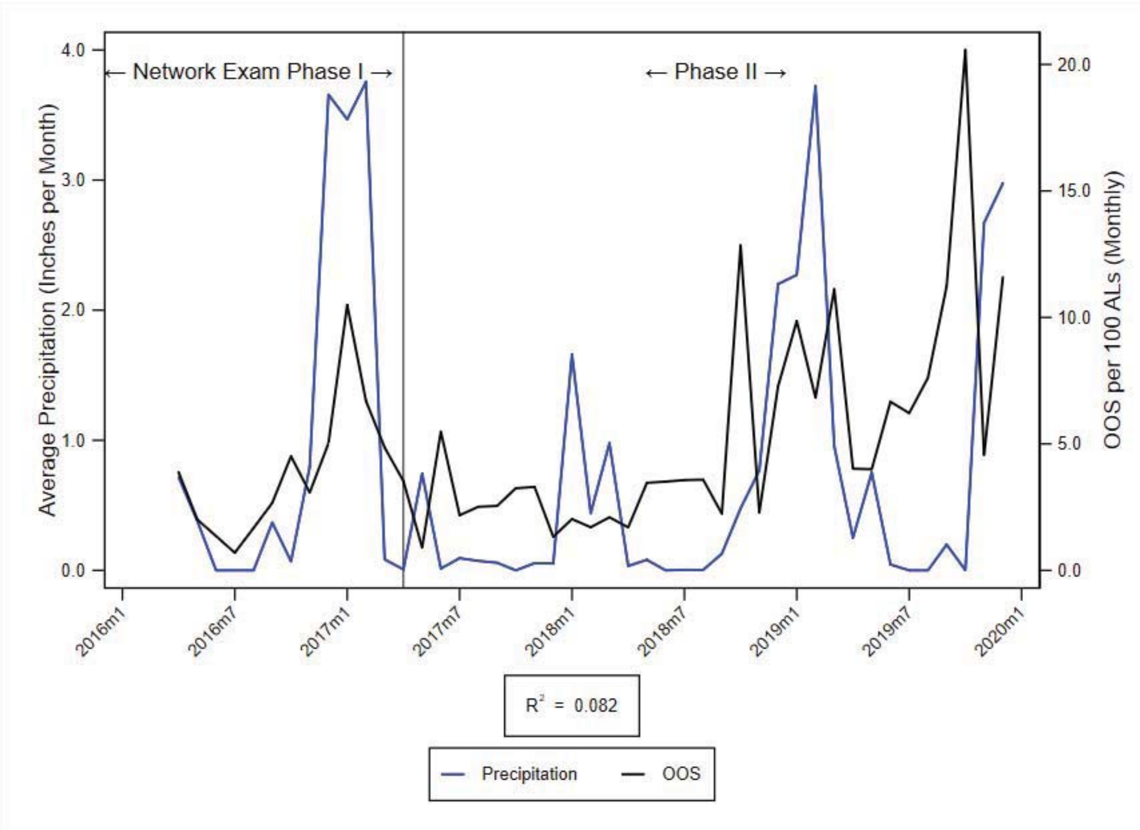
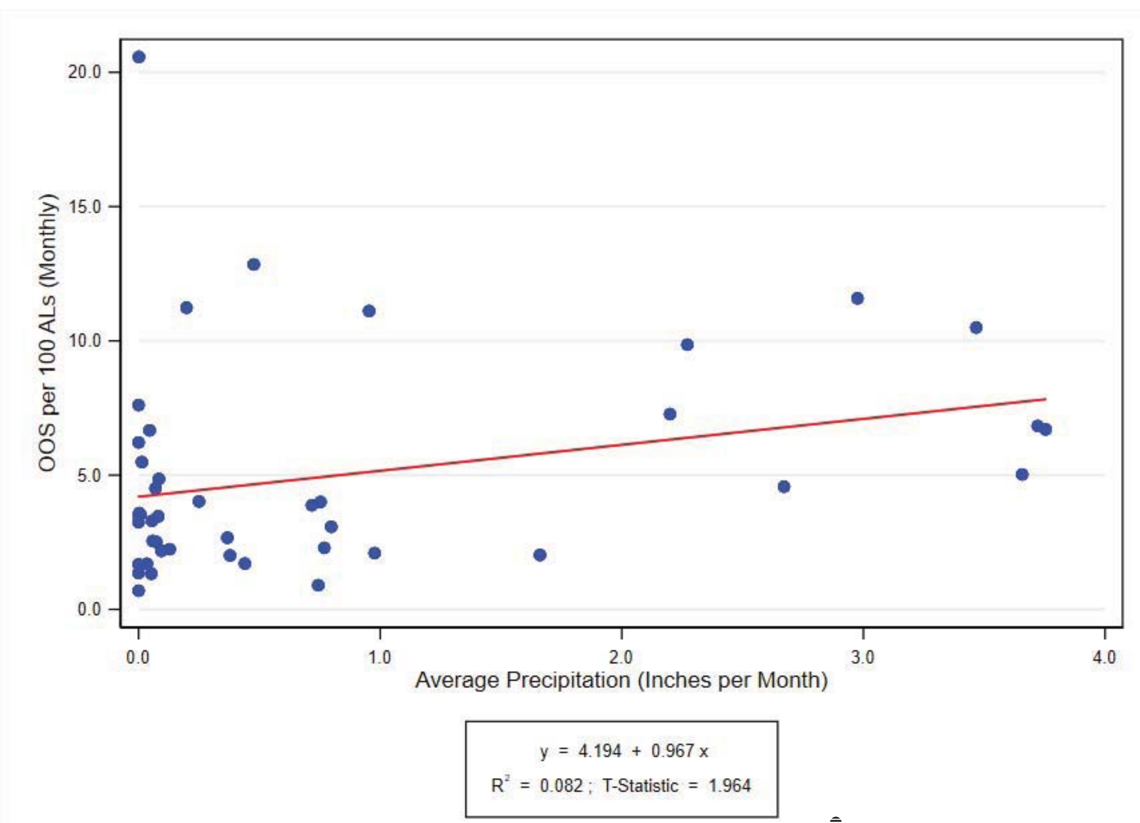


Figure 13.21. REGION 10 SAN DIEGO-IMPERIAL (FTR)





Effects of major wildfires on out-of-service incidents

The massive wildfires that have plagued California in recent years have prompted the Communications Division to include, within the scope of Phase 2 of the Network Examination, the following areas of additional inquiry:

(a) Was service quality worse overall in areas that are prone to wildfires and in areas that had major wildfires during the time period of 2010- 2019?

(b) Has service quality improved or deteriorated in areas that suffered severe wildfire damage?

(c) Analysis of Investment and infrastructure technology in high risk fire areas (both rebuild and existing).

In order to analyze the relationship between major wildfire incidents and OOS incidents, we collected and analyzed wildfire statistics maintained by the California Department of Forestry and Fire Protection (CALFIRE). The CALFIRE data includes dates and locations of major wildfire incidents from 2013 to 2020, as well as the number of acres burned in each incident. Initially, we directed our examination to the same ten Census Regions that we had utilized in examining the effects of precipitation on service outages. To calculate the monthly number of wildfire incidents by Census Region, we identified the county (or counties) in which each major fire occurred, then aggregated the number of incidents in each county within each of the ten California Census Regions. We performed a similar aggregation for the monthly number of acres burned for each Census Region. Unlike the strong relationship identified in our precipitation analysis, the correlation between wildfire incidents or wildfire acres burned and OOS per 100 Access Lines proved to be extremely weak, as summarized in Tables 13.4 and 13.5 below.

We prepared two graphs for each Census Region for each of the two ILECs. Each of the graphs tracks the wildfire metric (incidents or acres burned) against the same service quality metric that we had used in the precipitation analysis above. Each set of graphs provides the wildfire metric vs. OOS per 100 Access Lines for Incidents and for Acres Burned. Figures 13.22 through 13.31 provide graphs for AT&T California covering the period 2013 (the year that CALFIRE began compiling this data) through 2019. Figures 13.32 through 13.41 provide corresponding graphs for Frontier California for the 2016-2019 period.

☞ Overall, we observed little correlation between the incidence of major wild fires and ILEC service quality. Wildfires occur mainly during hot summer and fall months when rainfall is minimal, whereas OOS incidents arise during the periods of heaviest precipitation, which occurs during late fall and winter months.

Table 13.4

AT&T CALIFORNIA
RELATIONSHIP BETWEEN WILDFIRE EVENTS
AND OUT-OF-SERVICE INCIDENTS
2013-2019

Census Region	No. of Wire Centers	Total Inci-dents	Total Acres Burned	Figures	Inci-dents R^2	Acres Burned R^2
1 Superior California	107	408	2,023,686	13.22	.106	.020
2 North Coast	58	144	1,321,172	13.23	.071	.002
3 San Francisco Bay Area	99	114	76,487	13.24	.066	.003
4 No. San Joaquin Valley	53	154	599,885	13.25	.154	.027
5 Central Coast	54	169	697,306	13.26	.041	.021
6 So. San Joaquin Valley	65	157	490,002	13.27	.093	.008
7 Inland Empire	13	183	172,143	13.28	.065	.010
8 Los Angeles County	69	40	188,407	13.29	.047	.008
9 Orange County	32	10	36,764	13.30	.017	.006
10 San Diego – Imperial	60	83	48,915	13.31	.041	.020

Source: CALFIRE data; ETI analysis of AT&T California Out-of-Service incidents 2013-2019

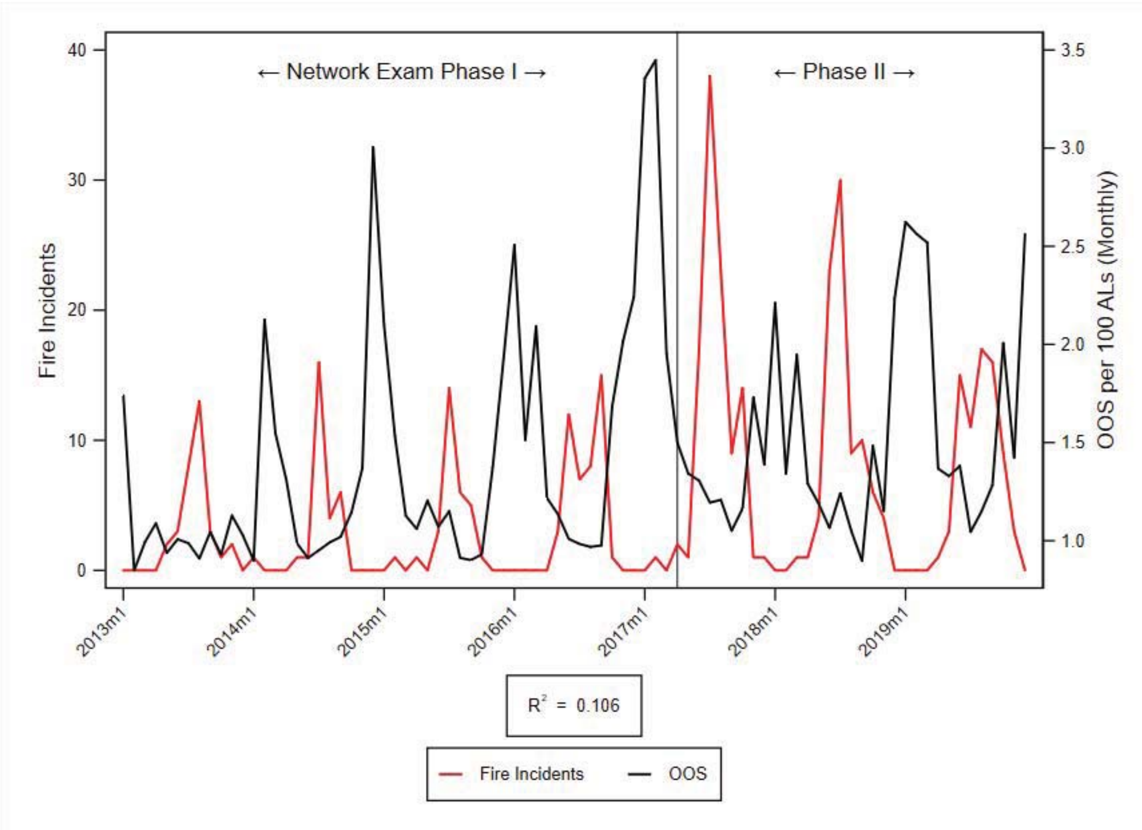
Table 13.5

FRONTIER CALIFORNIA
RELATIONSHIP BETWEEN WILDFIRE EVENTS
AND OUT-OF-SERVICE INCIDENTS
2016-2019

Census Region	No. of Wire Centers	Total Inci-dents	Total Acres Burned	Figures	Inci-dents R^2	Acres Burned R^2
1 Superior California	4	408	2,023,686	13.32	.197	.069
2 North Coast	17	144	1,321,172	13.33	.149	.036
3 San Francisco Bay Area	4	114	76,487	13.34	.141	.020
4 No. San Joaquin Valley	13	154	599,885	13.35	.086	.018
5 Central Coast	20	169	697,306	13.36	.150	.089
6 So. San Joaquin Valley	38	157	490,002	13.37	.188	.104
7 Inland Empire	53	183	172,143	13.38	.086	.034
8 Los Angeles County	37	40	188,407	13.39	.123	.004
9 Orange County	4	10	36,764	13.40	.069	.006
10 San Diego – Imperial	2	83	48,915	13.41	.000	.074

Source: CALFIRE data; ETI analysis of Frontier California Out-of-Service incidents 2016-2019

Figure 13.22. REGION 1 SUPERIOR CALIFORNIA (AT&T)



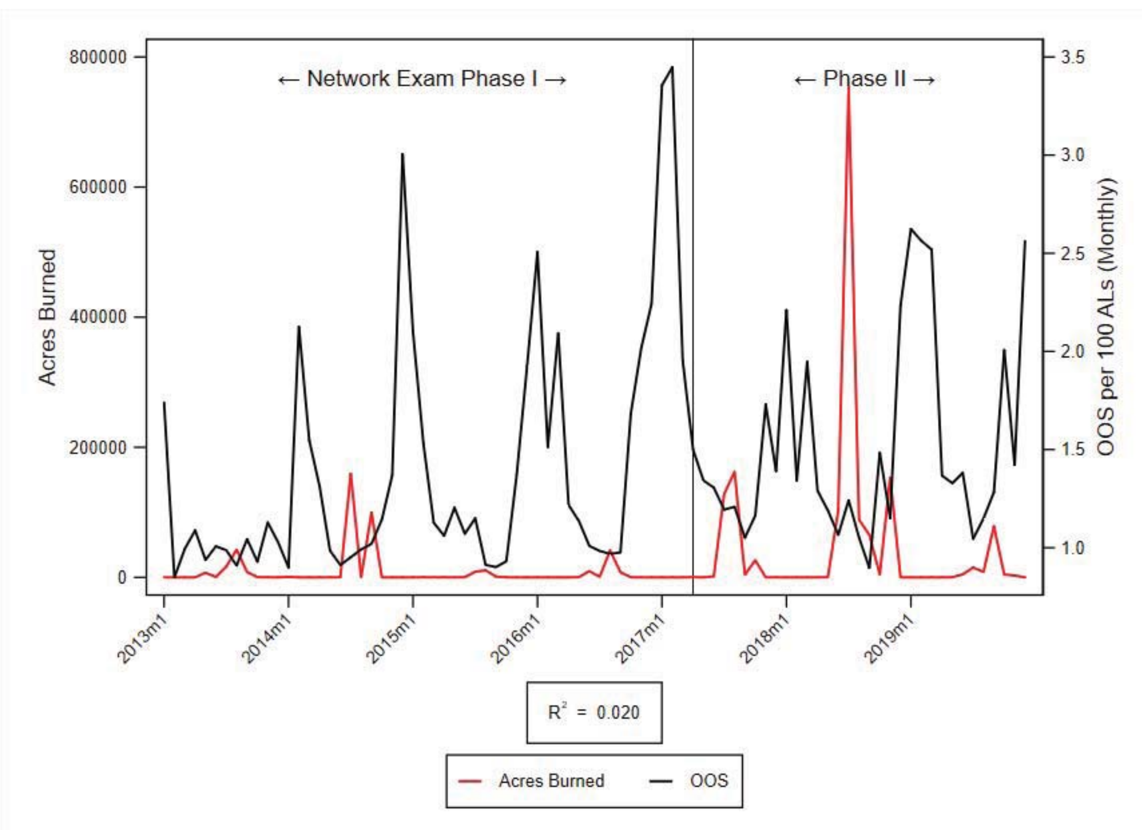
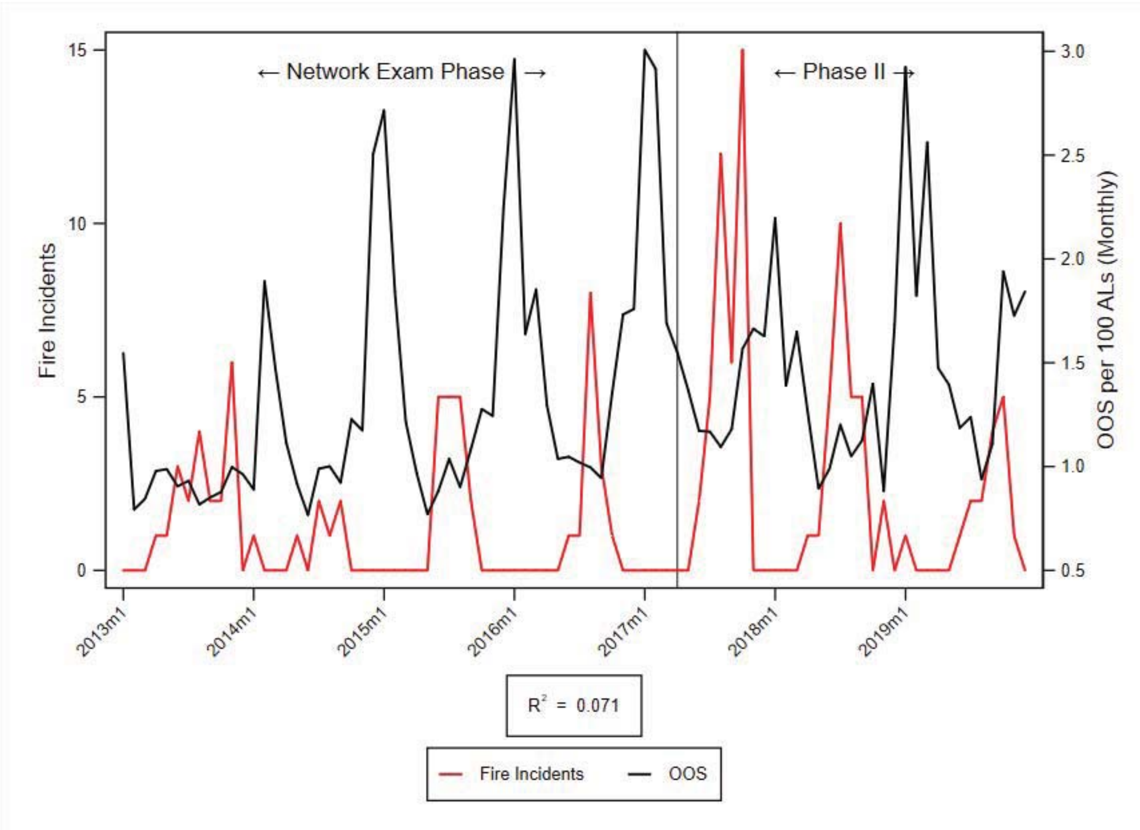


Figure 13.23. REGION 2 NORTH COAST (AT&T)



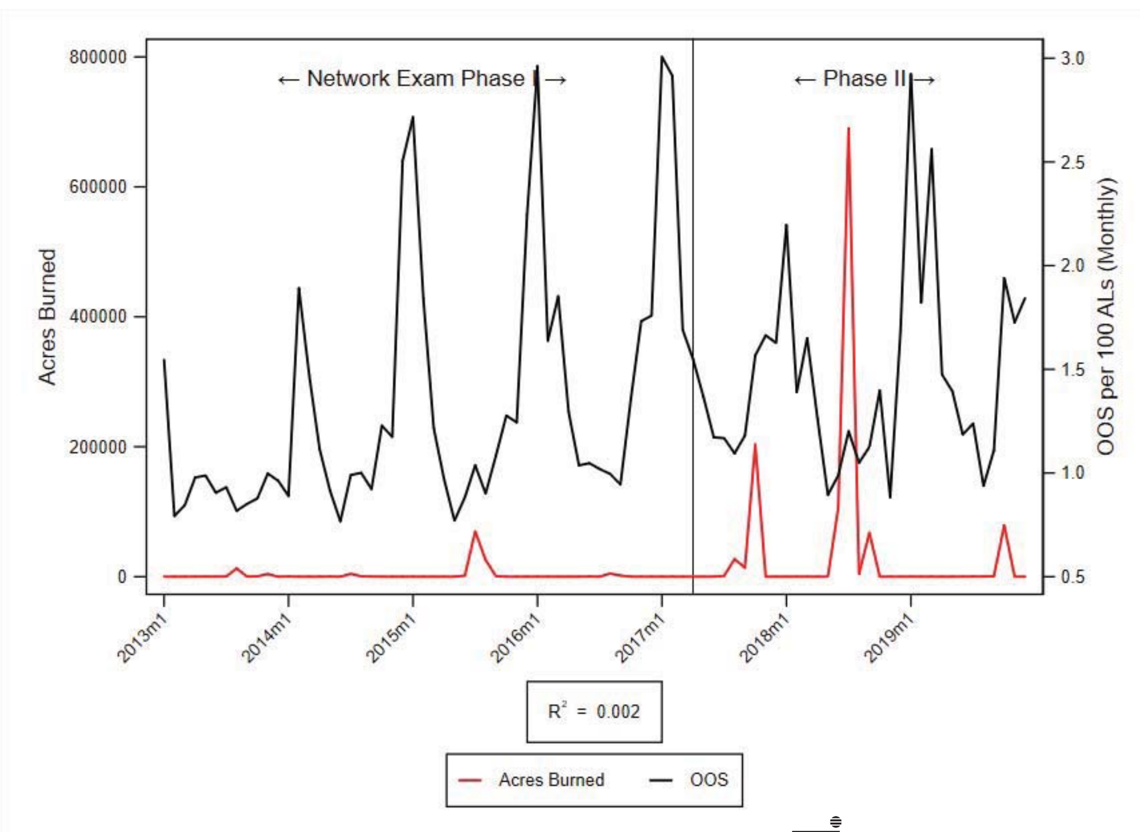


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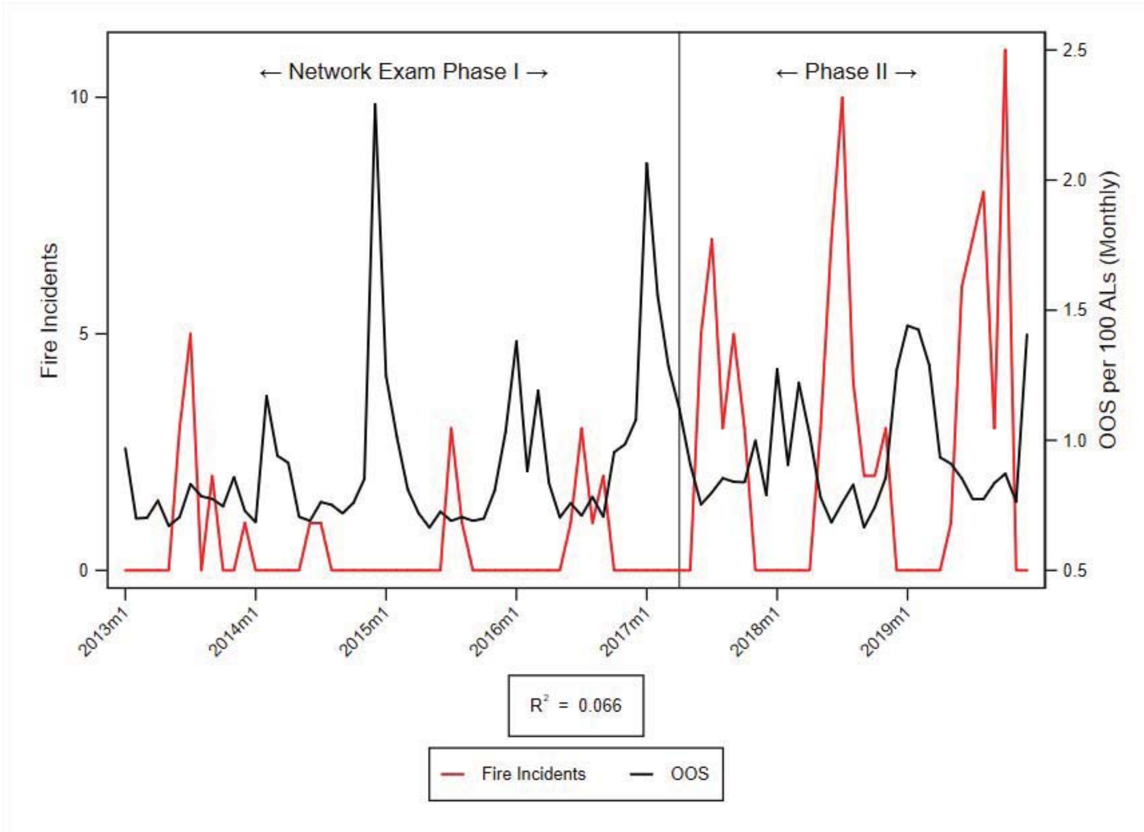
Figure 13.24. REGION 3 SAN FRANCISCO BAY AREA (AT&T)



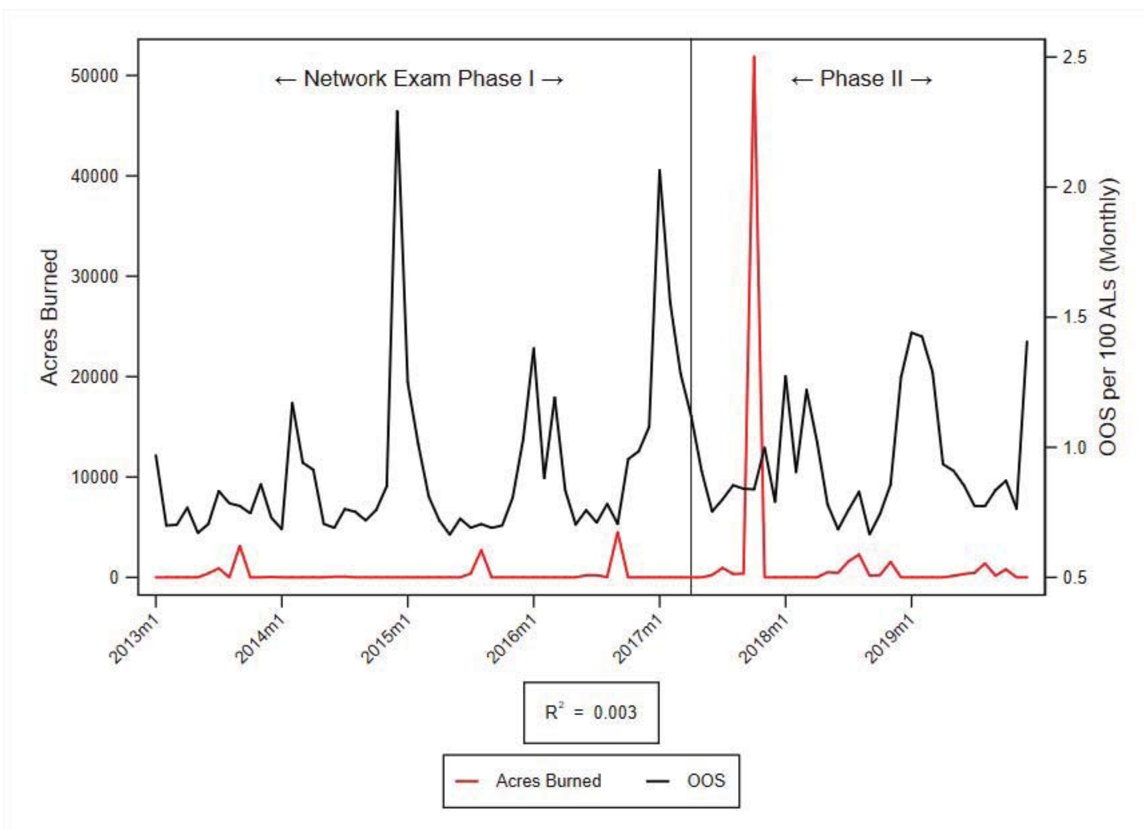
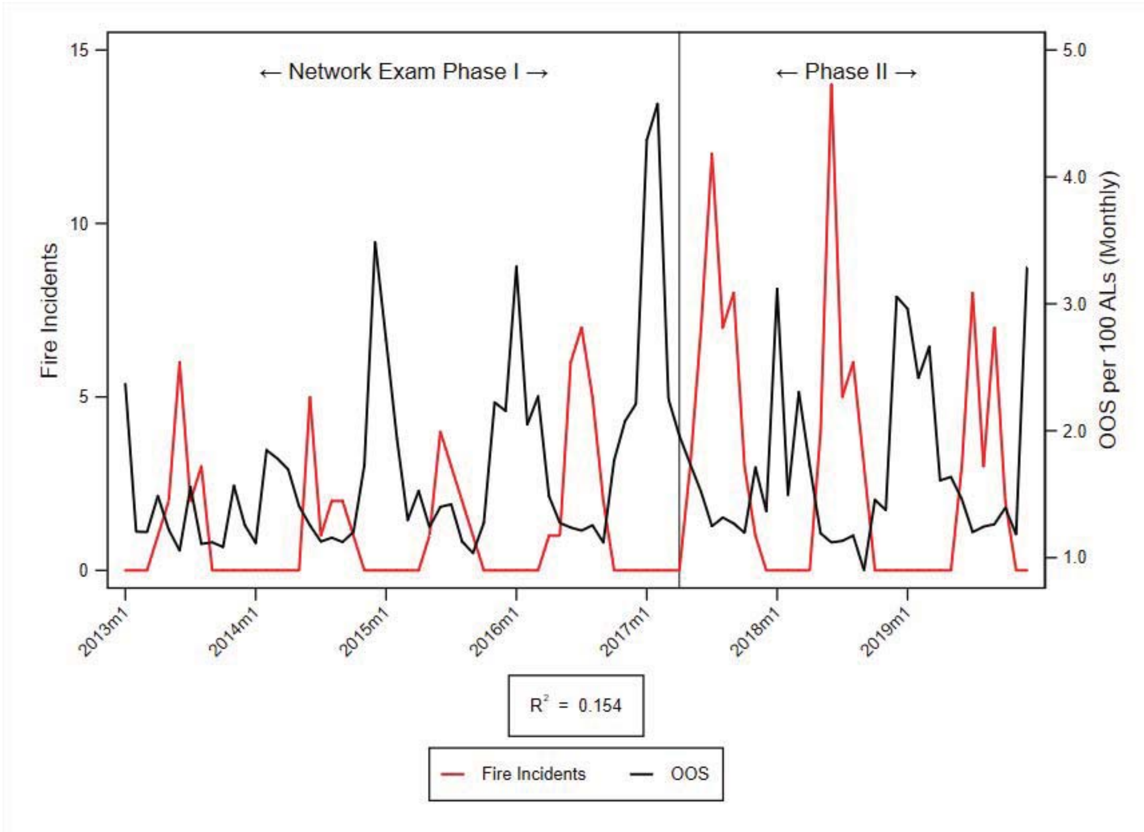


Figure 13.25. REGION 4 NORTHERN SAN JOAQUIN VALLEY (AT&T)



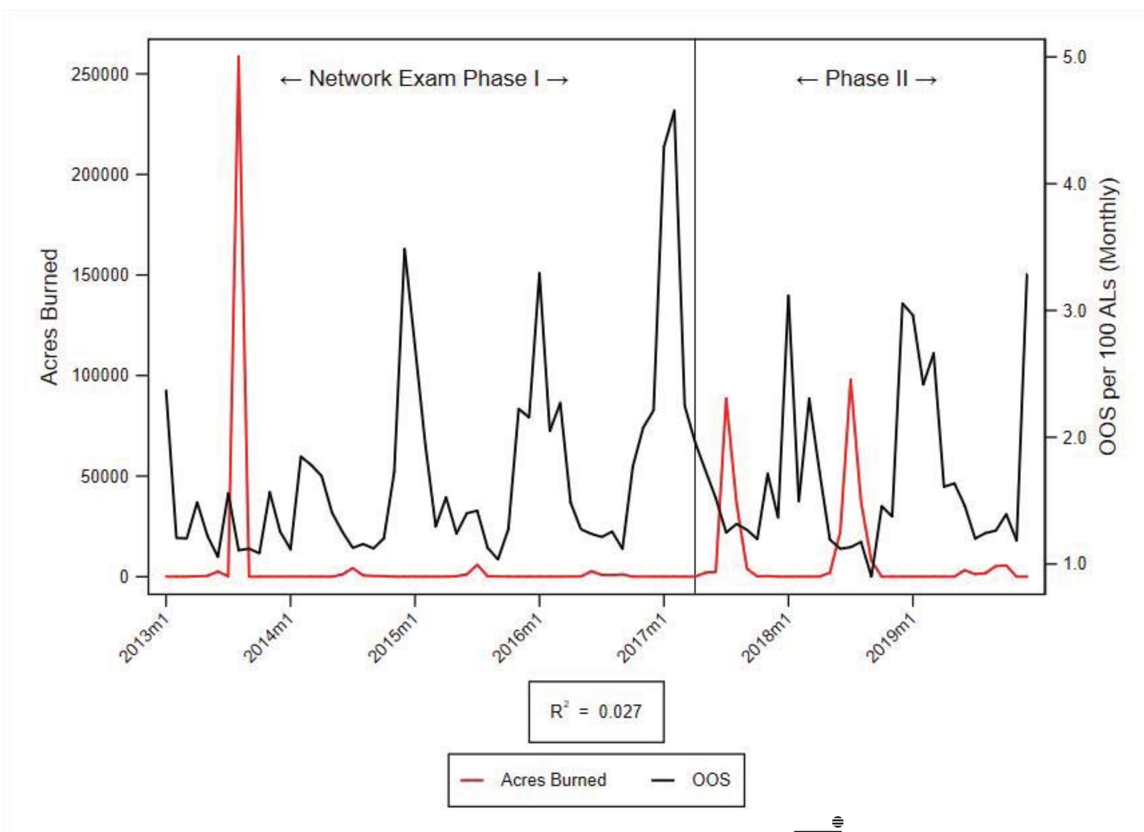
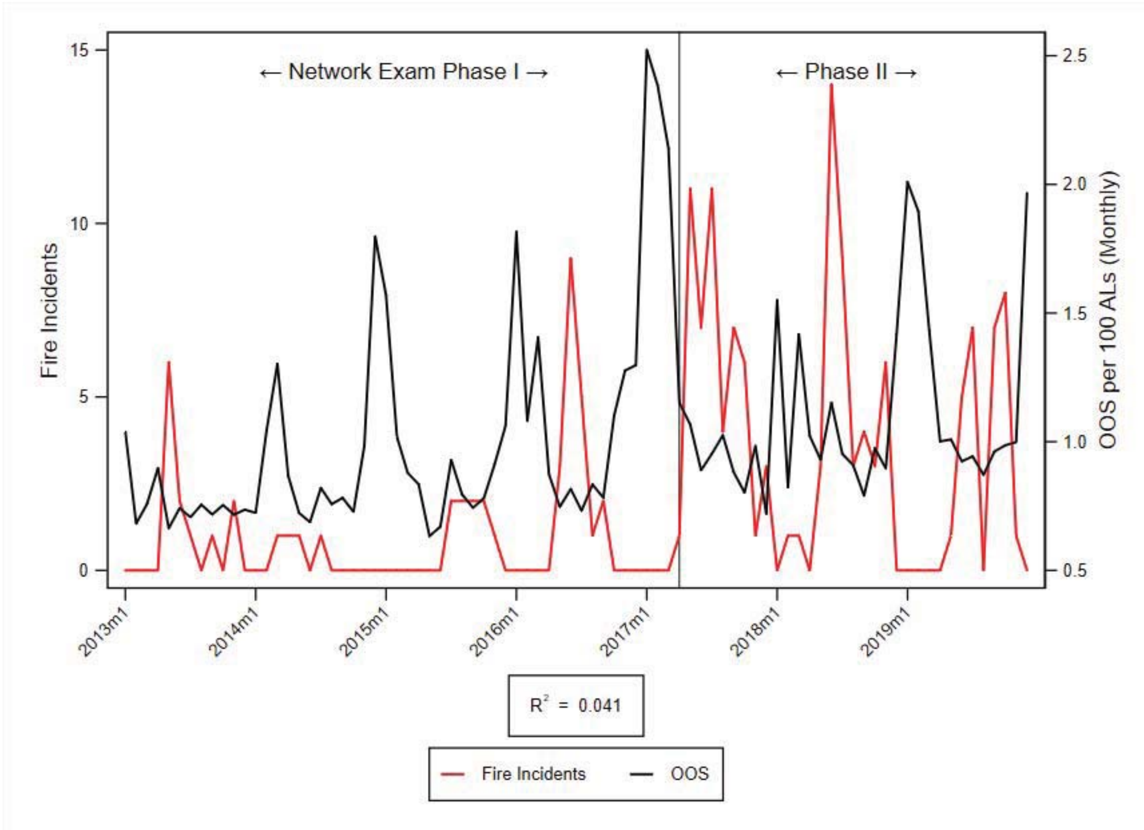


Figure 13.26. REGION 5 CENTRAL COAST (AT&T)



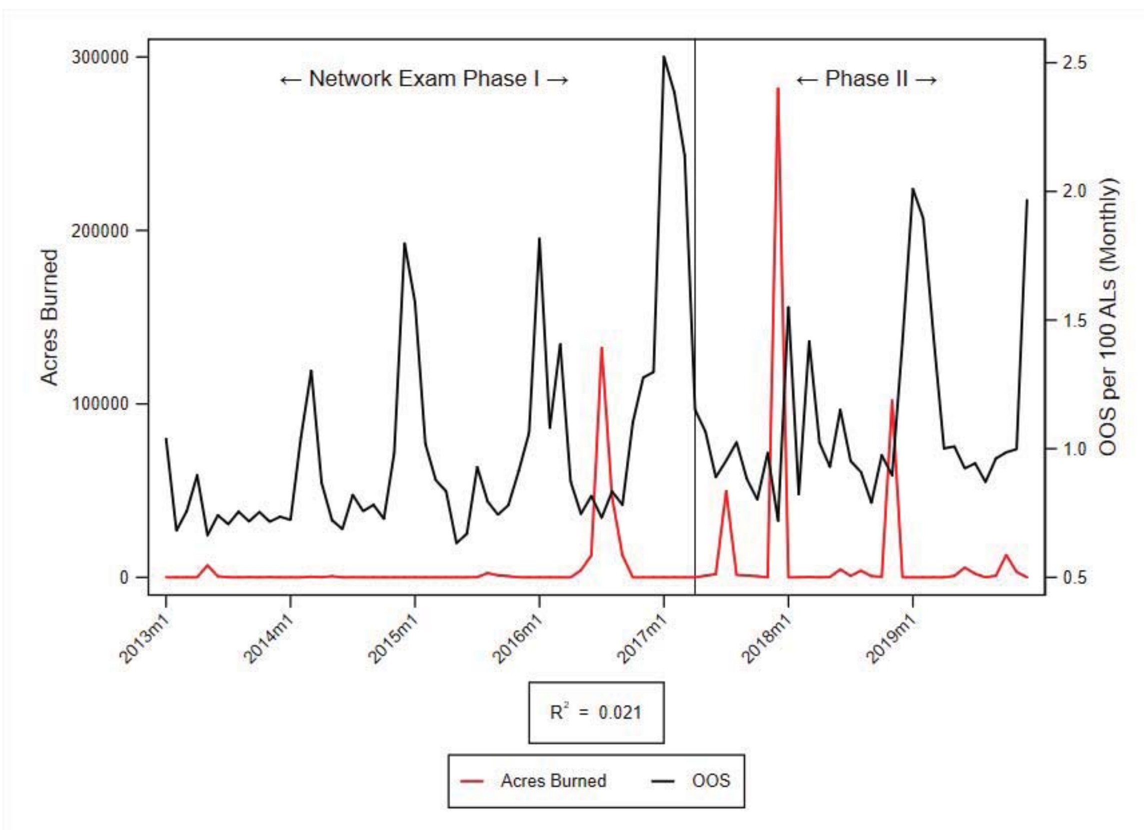
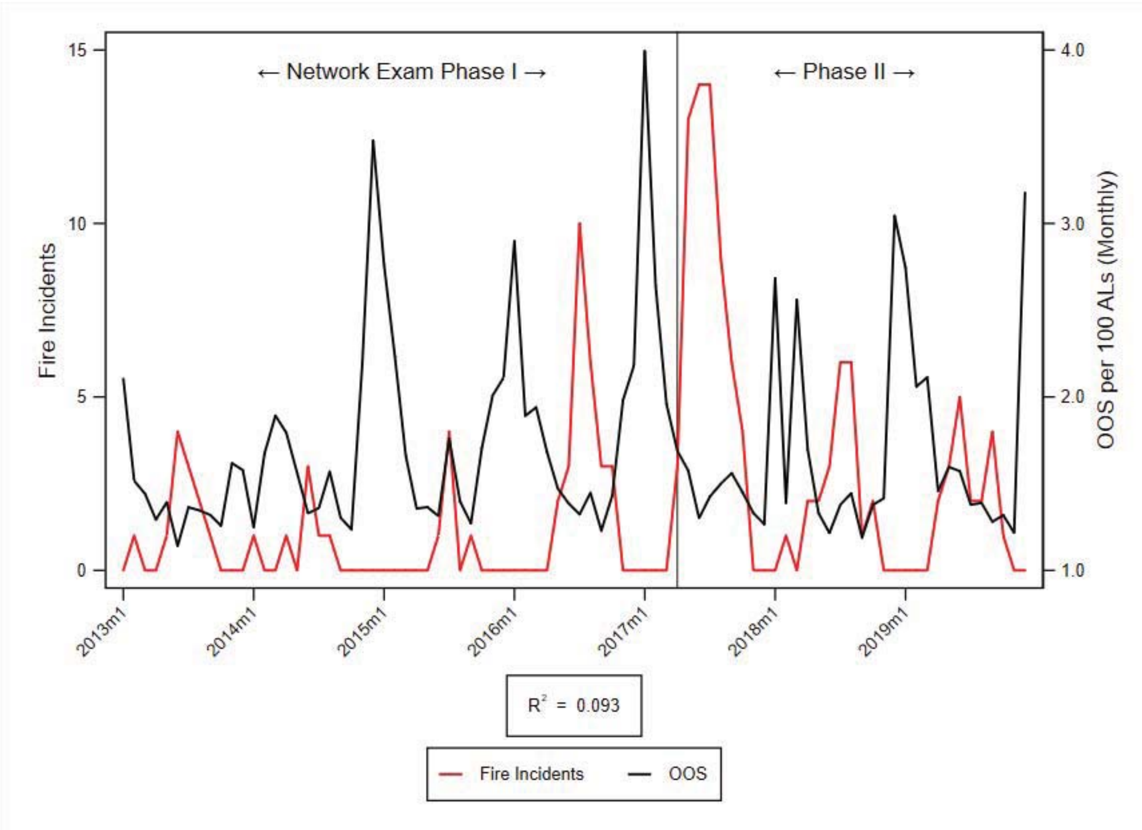


Figure 13.27. REGION 6 SOUTHERN SAN JOAQUIN VALLEY (AT&T)



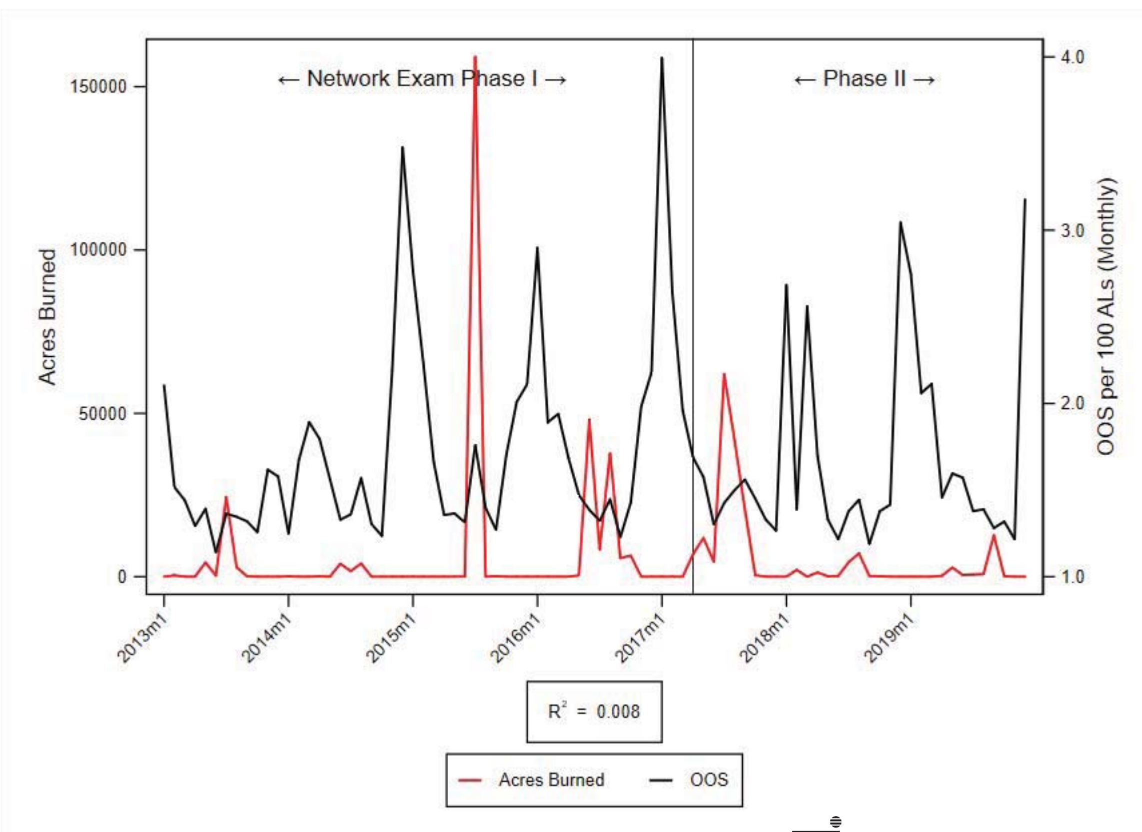
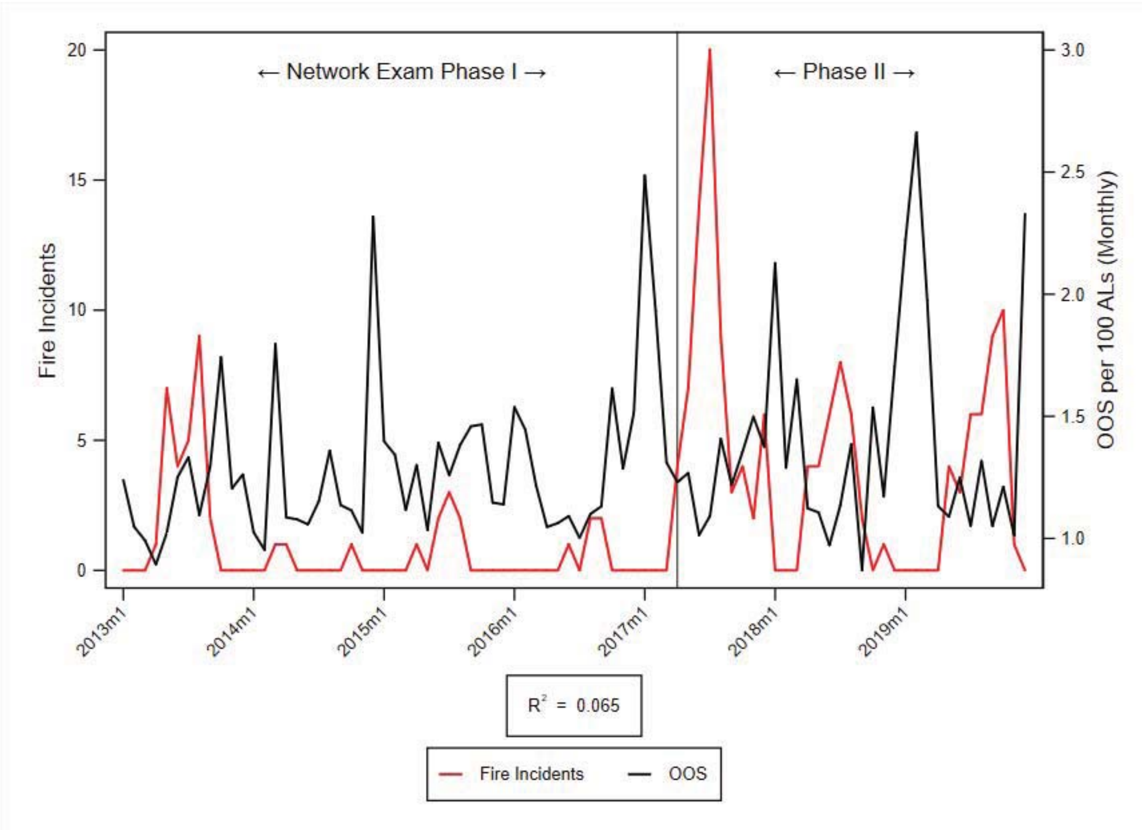


Figure 13.28. REGION 7 INLAND EMPIRE (AT&T)



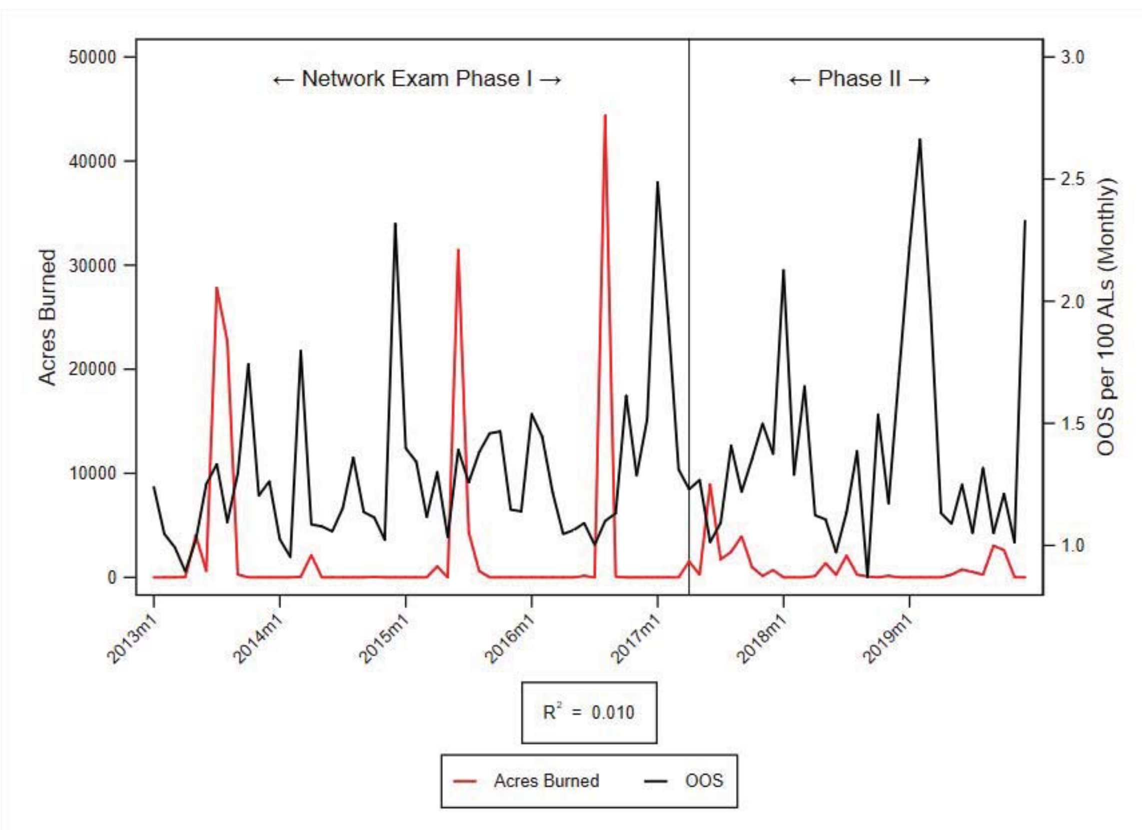
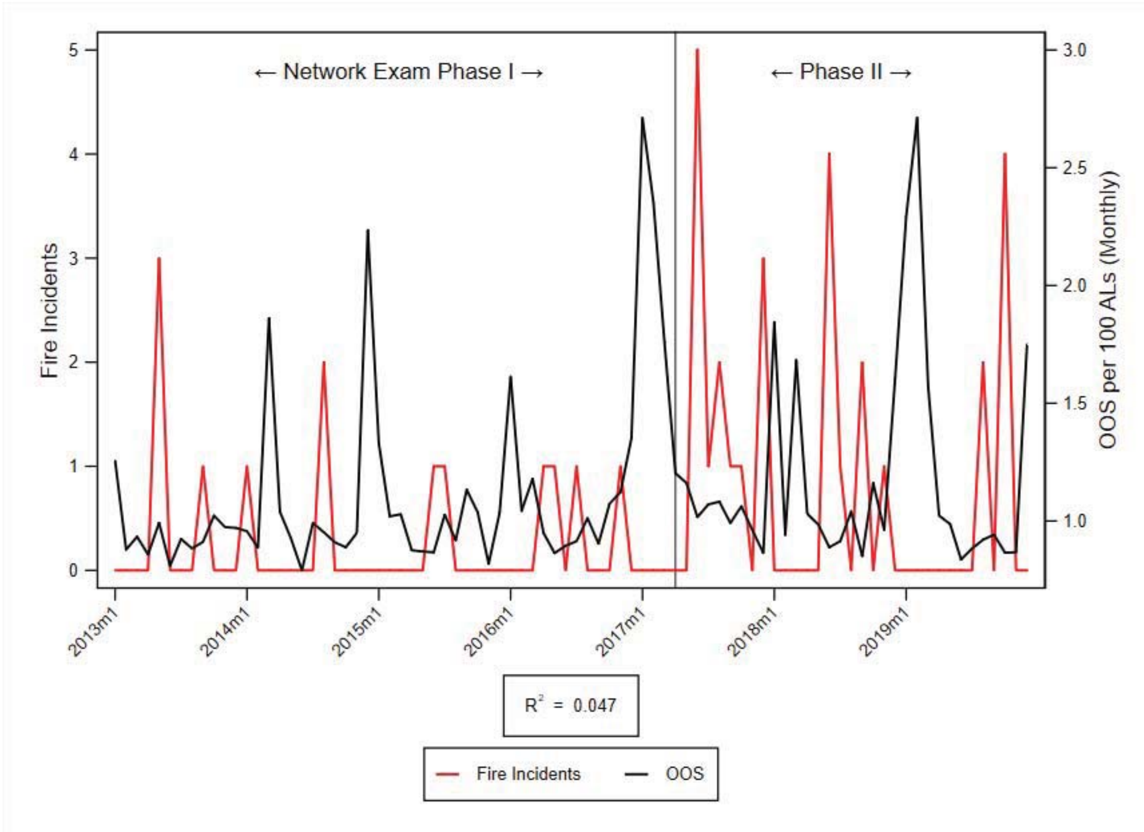


Figure 13.29. REGION 8 LOS ANGELES (AT&T)



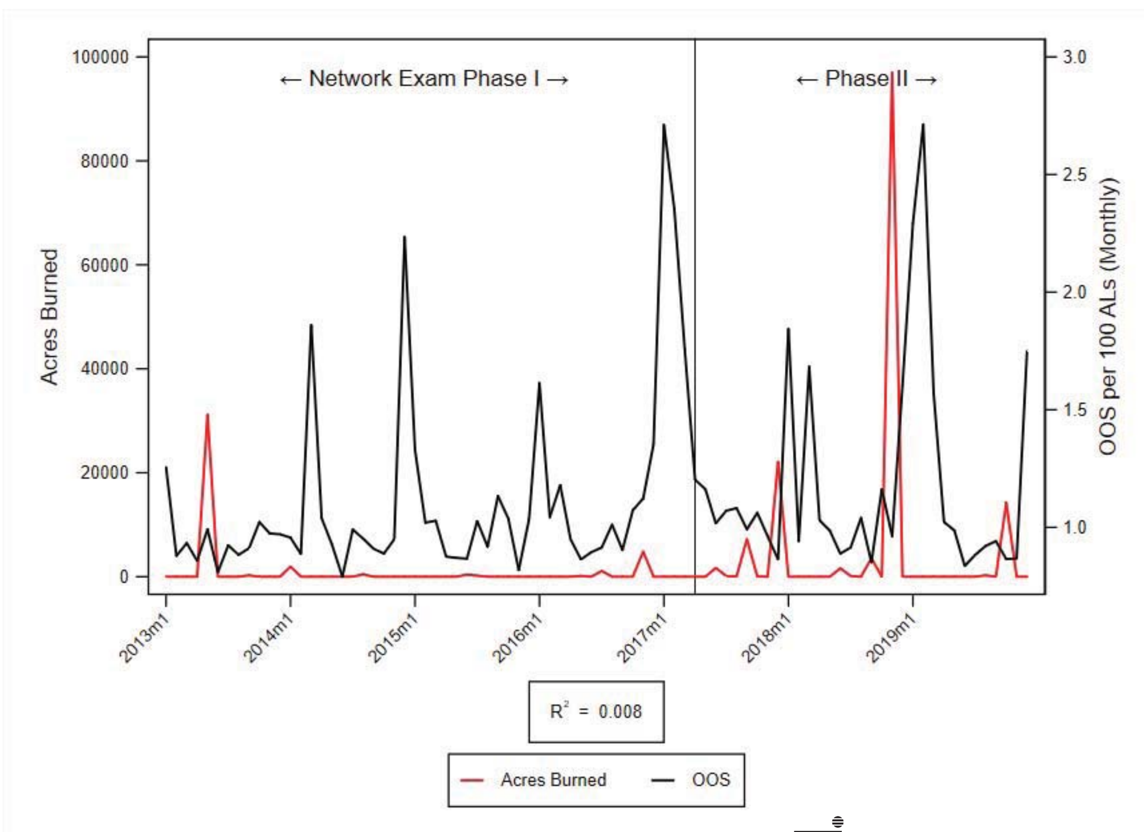
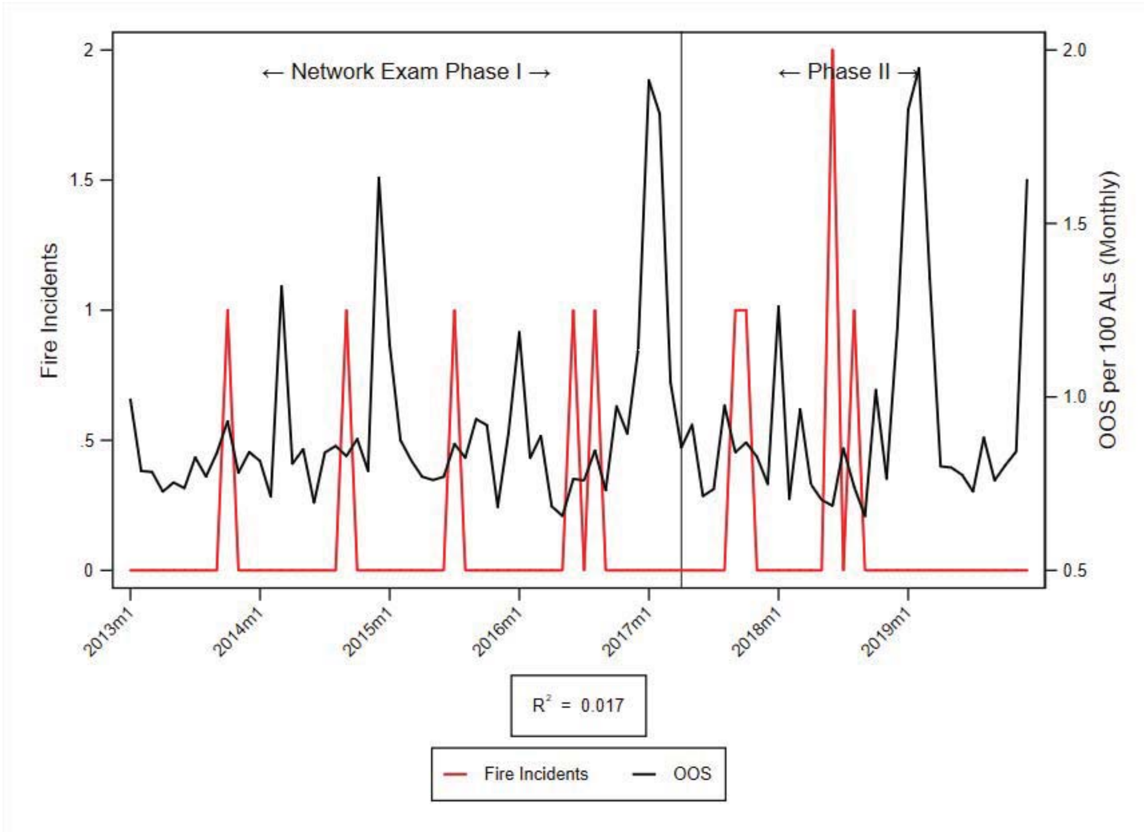


Figure 13.30. REGION 9 ORANGE (AT&T)



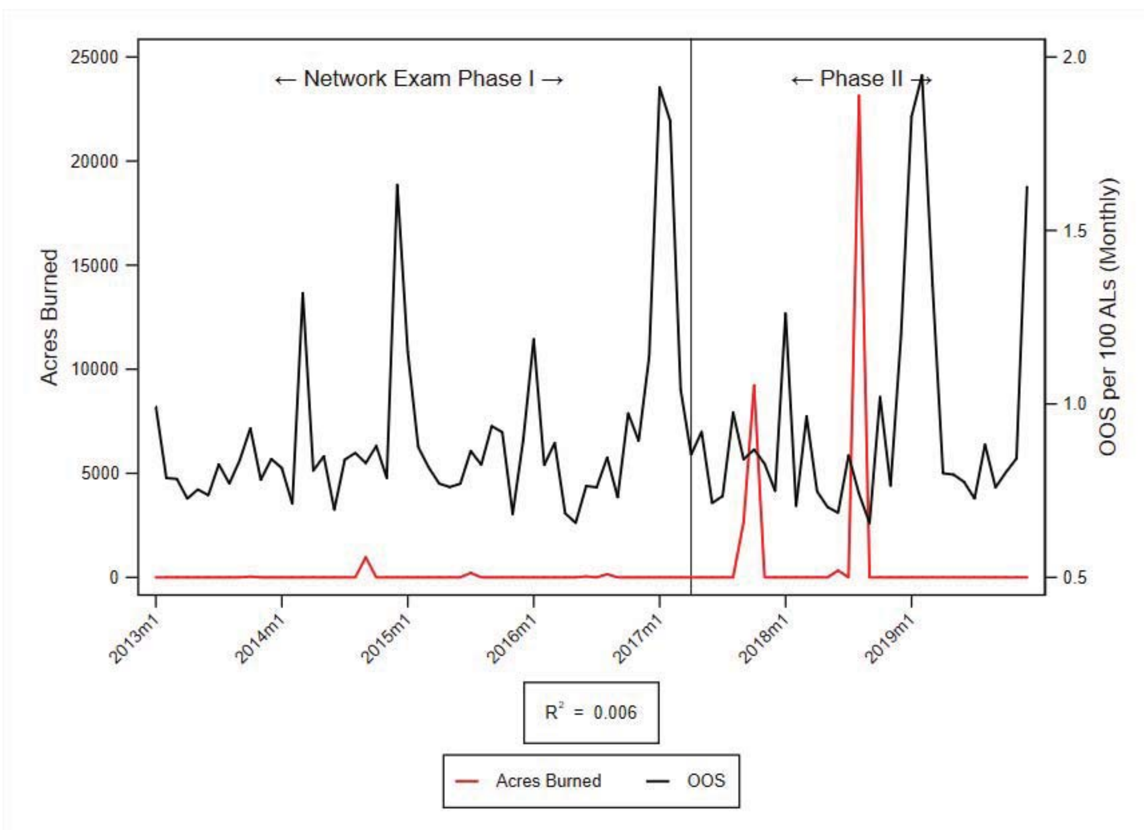
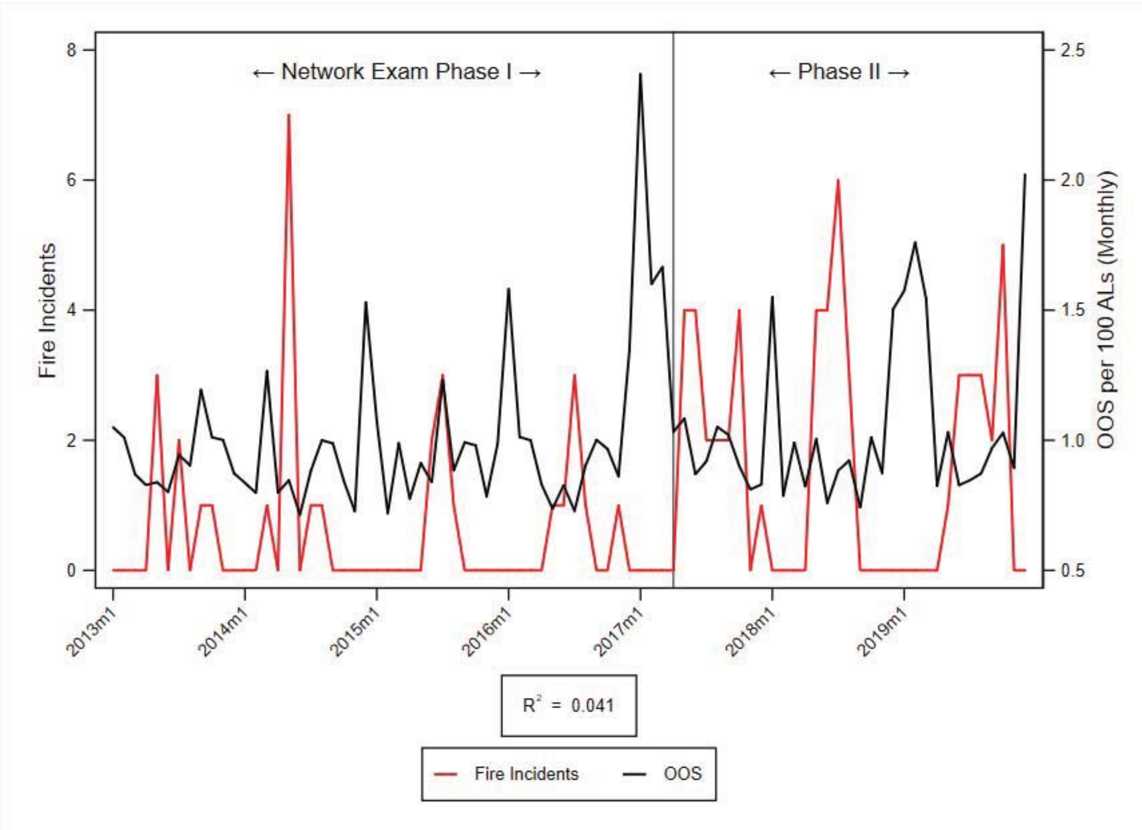


Figure 13.31. REGION 10 SAN DIEGO-IMPERIAL (AT&T)



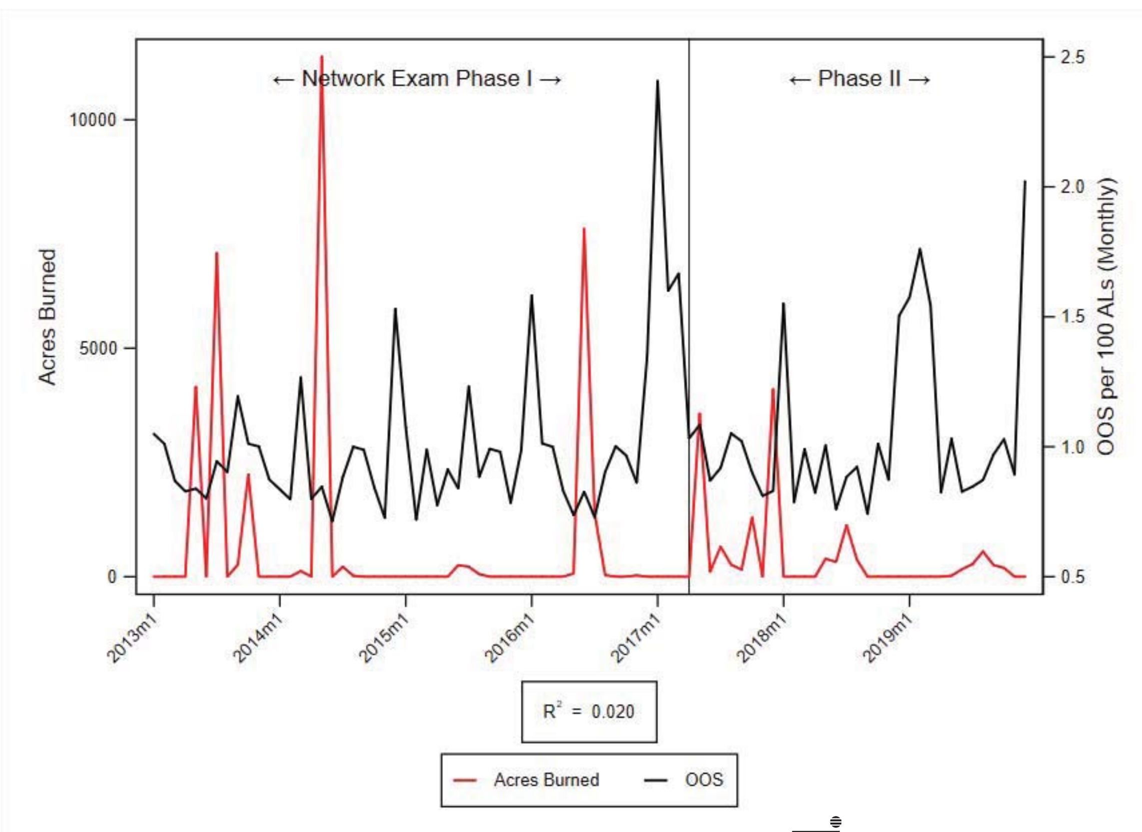
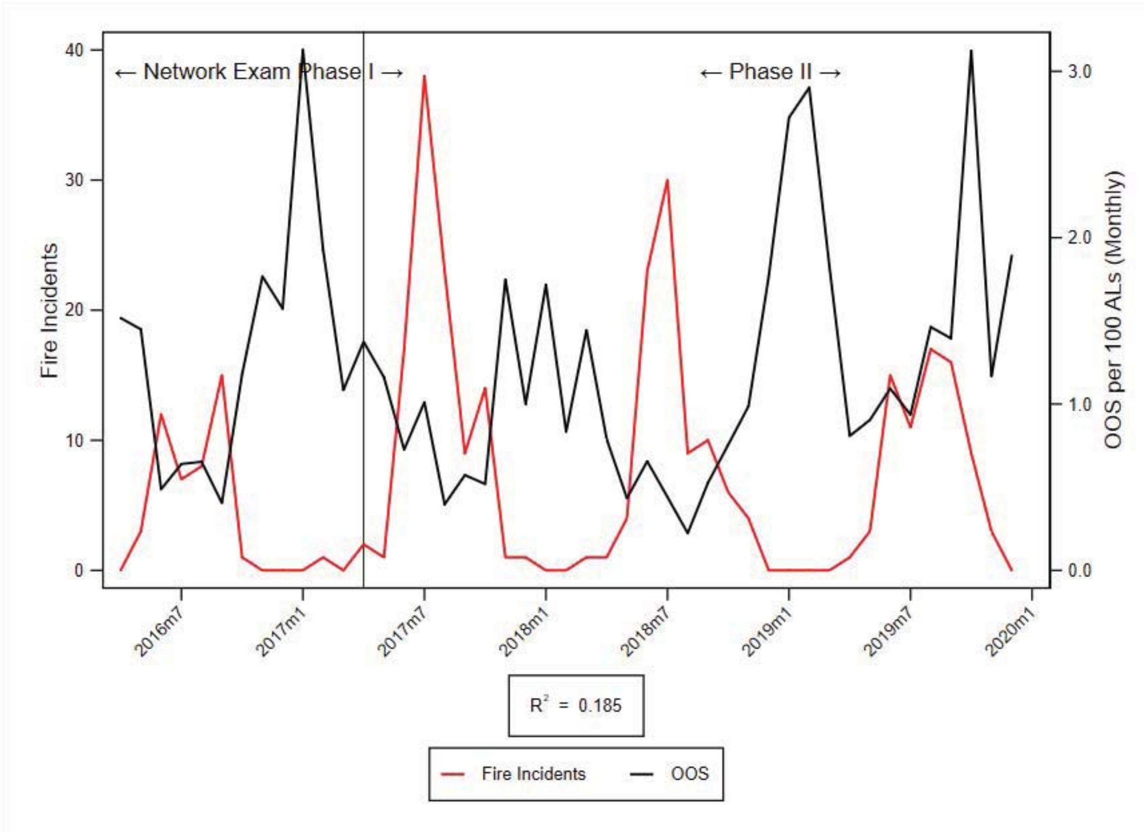


Figure 13.32. REGION 1 SUPERIOR CALIFORNIA (FTR)



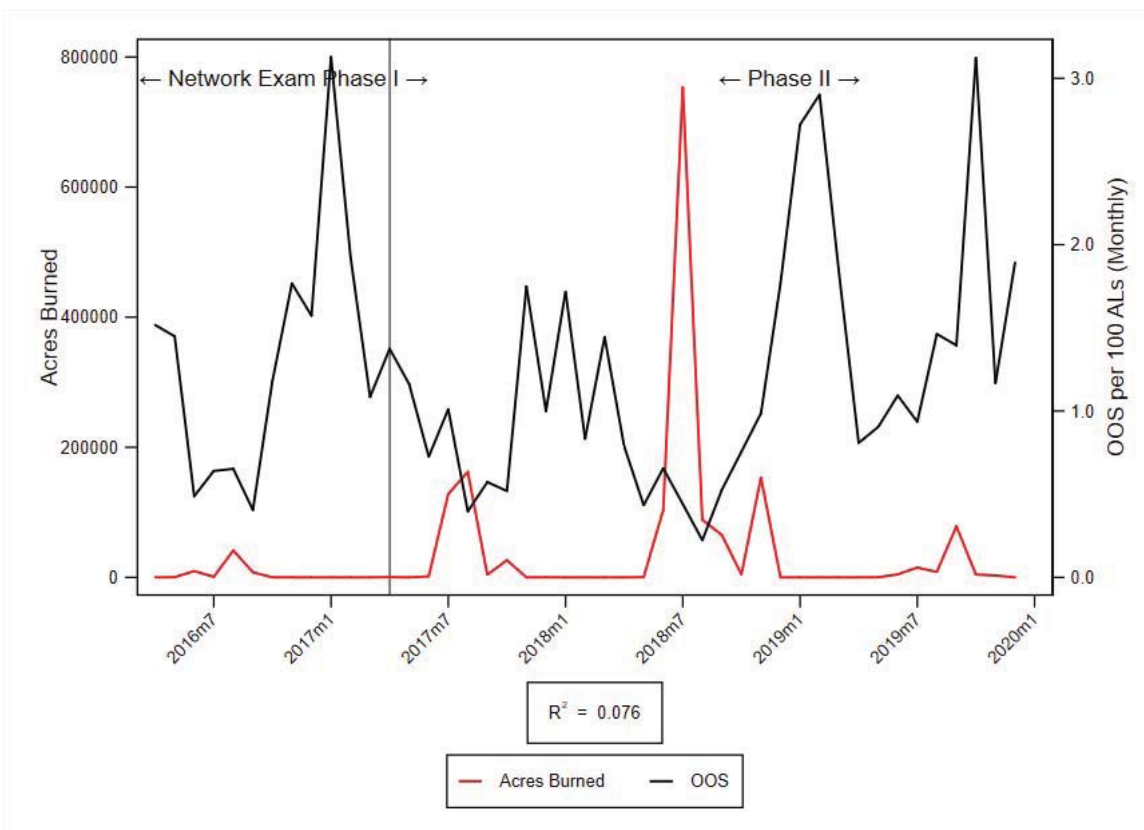
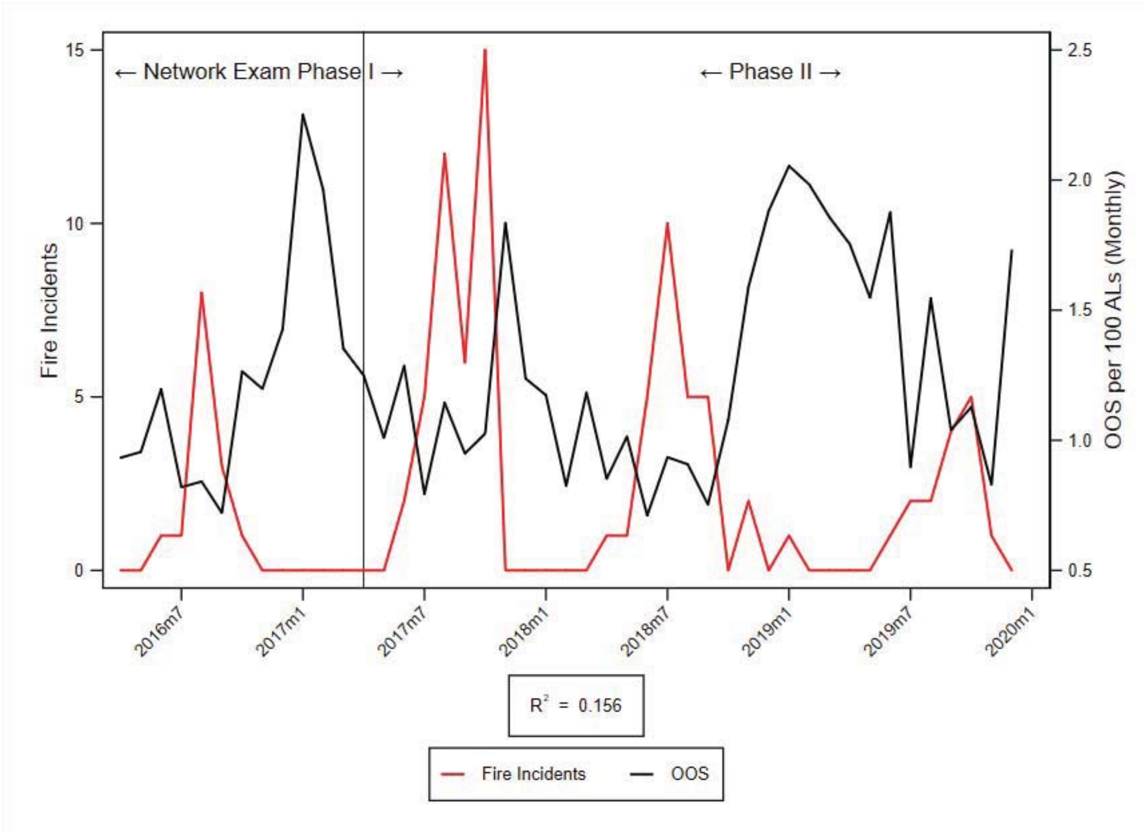


Figure 13.33. REGION 2 NORTH COAST (FTR)



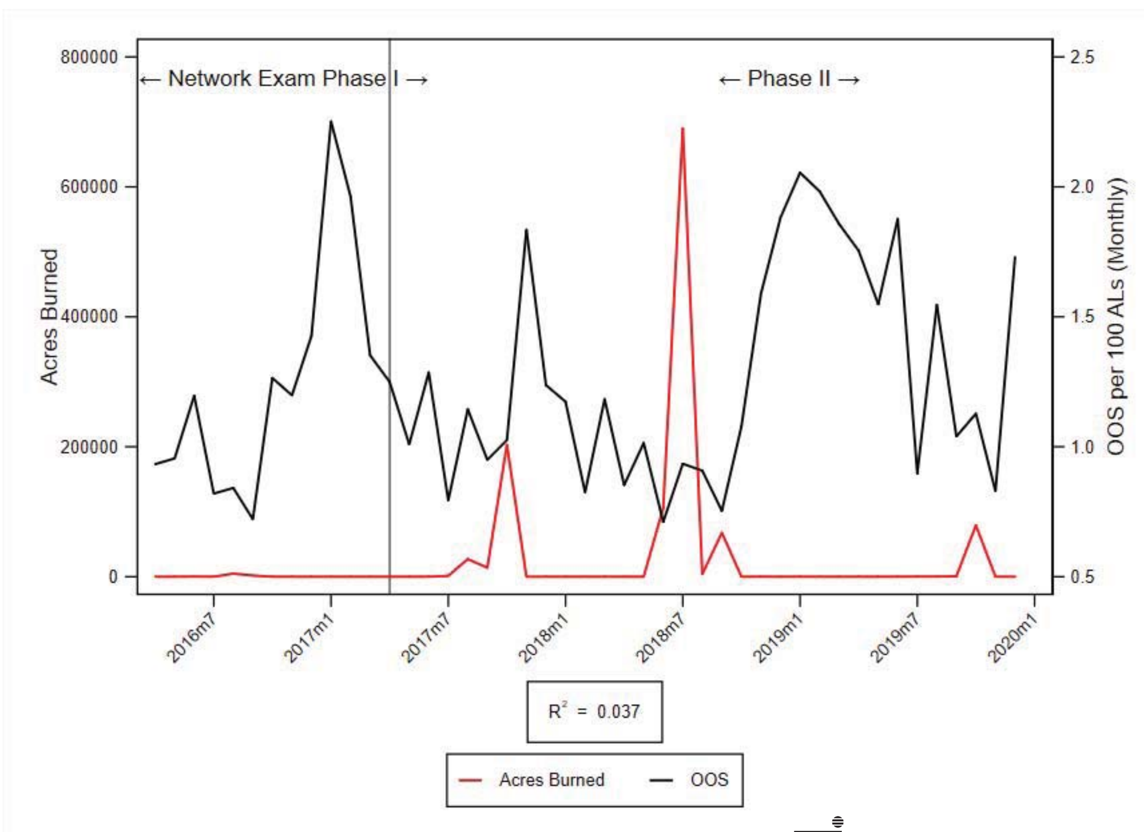
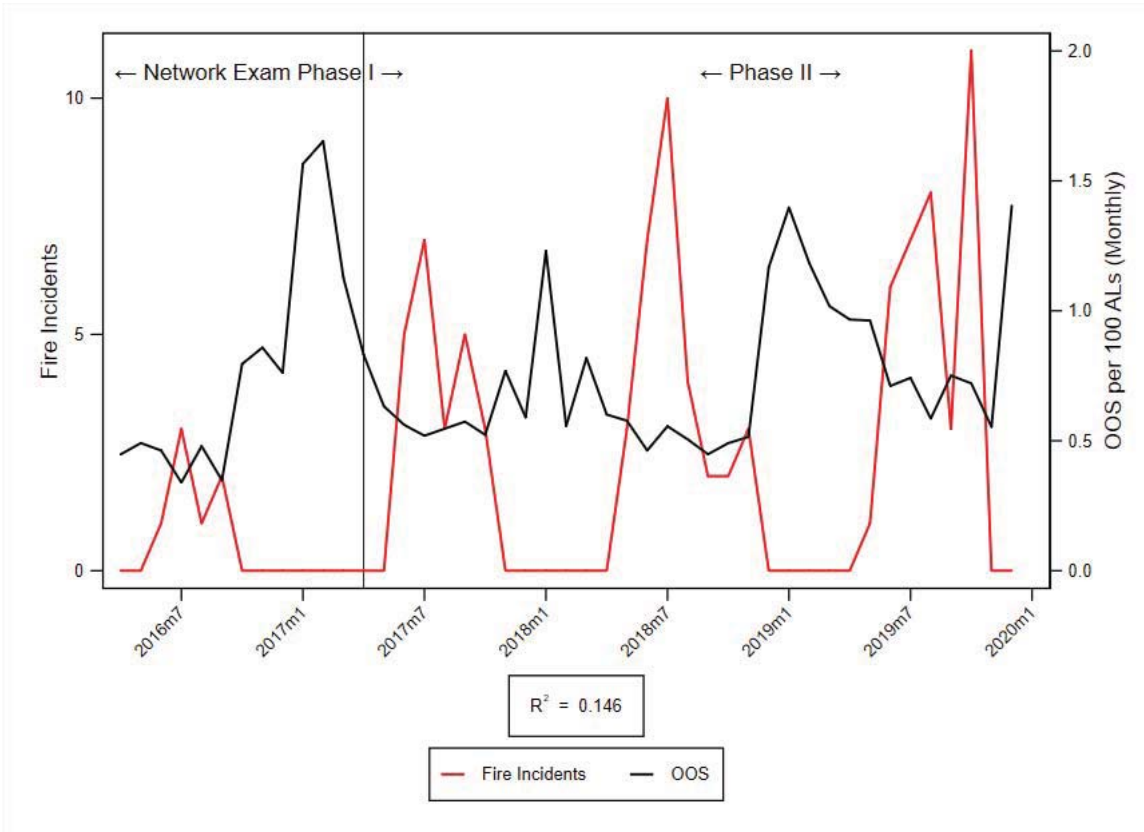


Figure 13.34. REGION 3 SAN FRANCISCO BAY AREA (FTR)



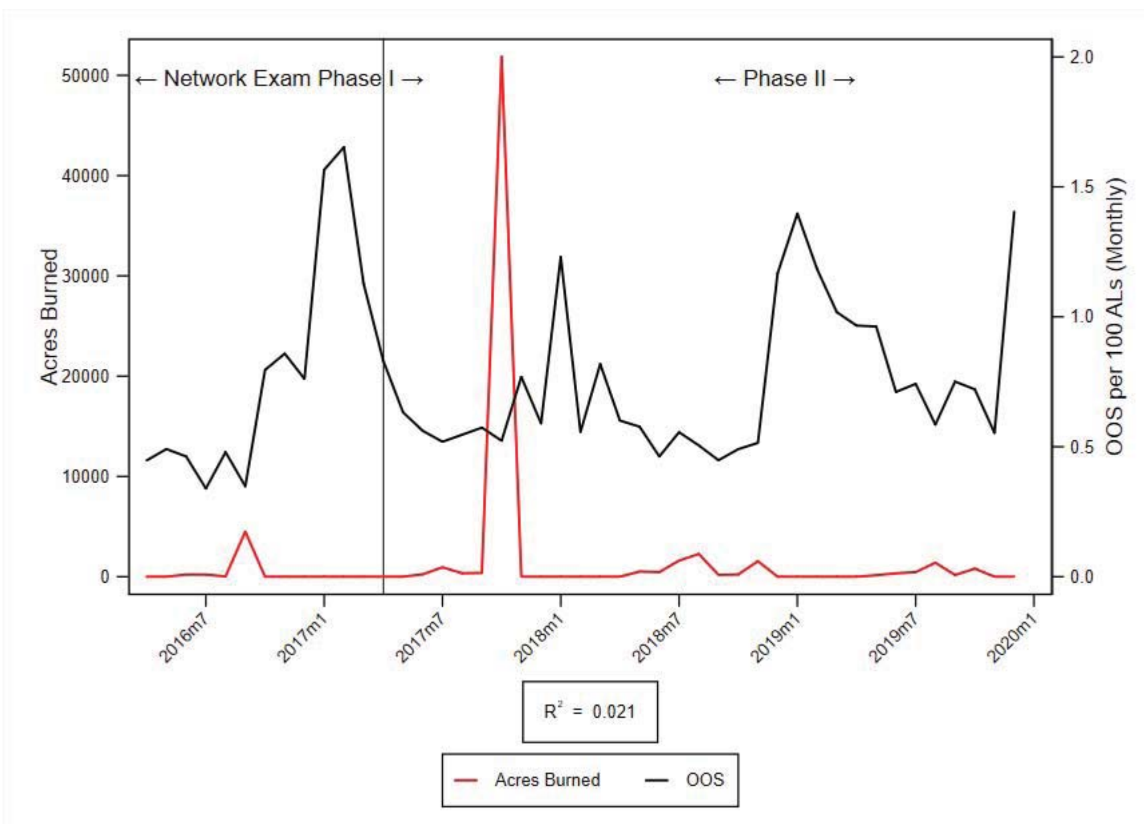
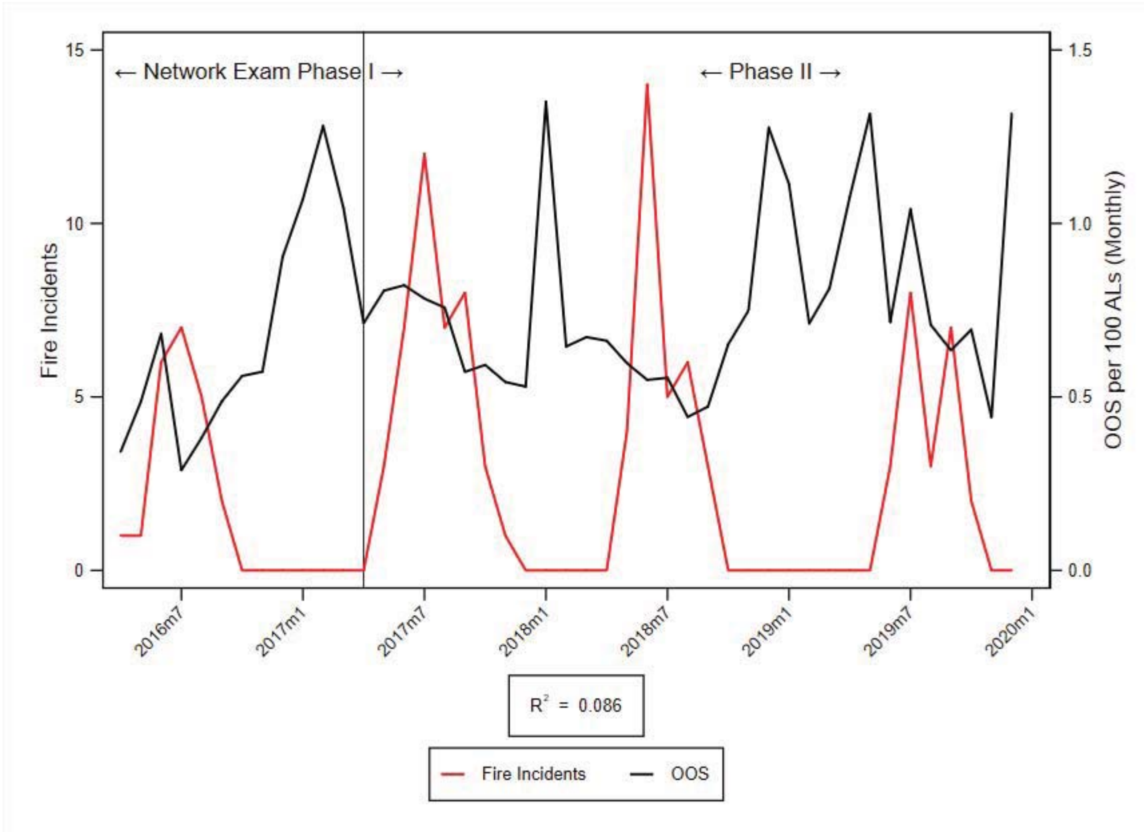


Figure 13.35. REGION 4 NORTHERN SAN JOAQUIN VALLEY (FTR)



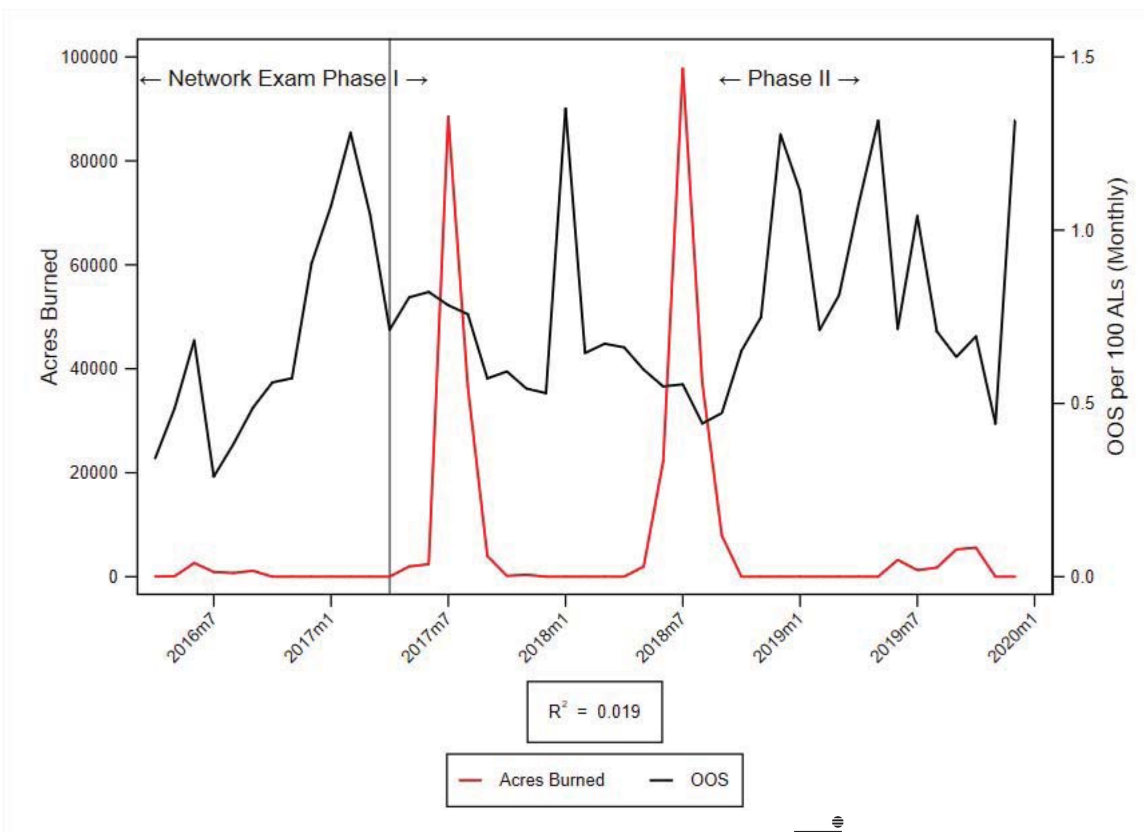
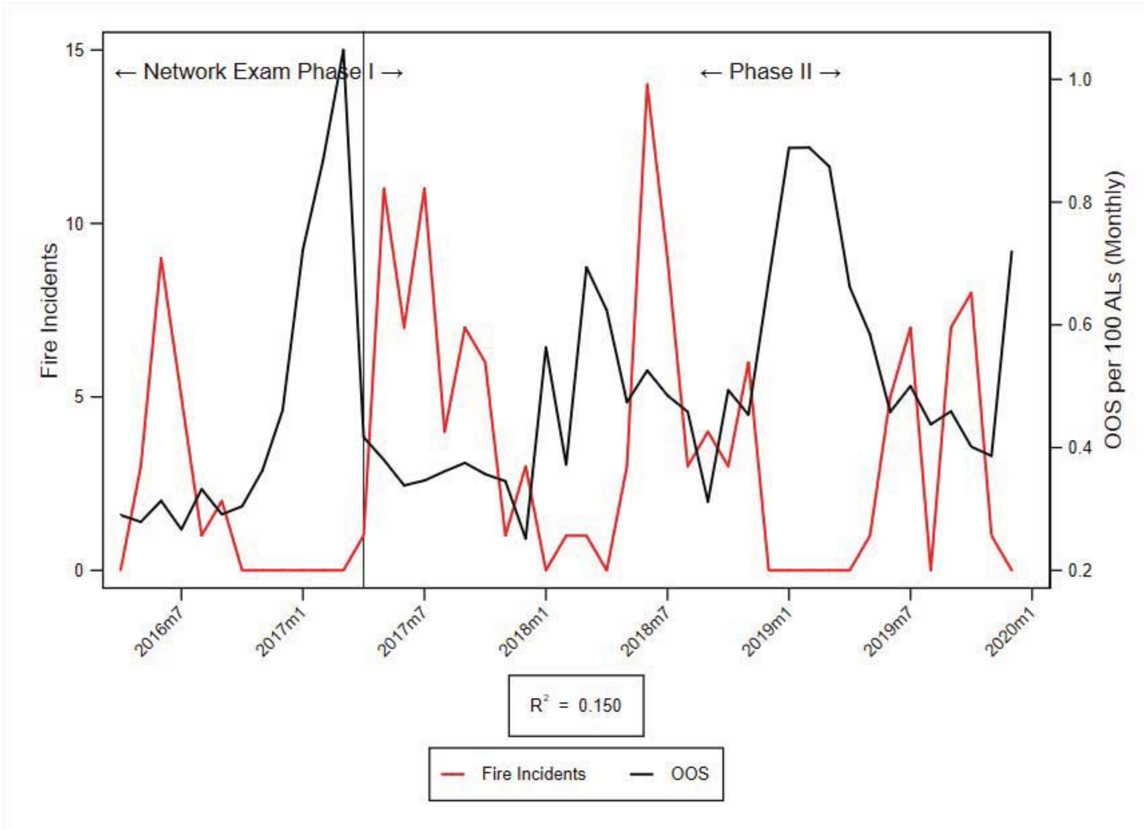


Figure 13.36.   REGION 5 CENTRAL COAST (FTR)



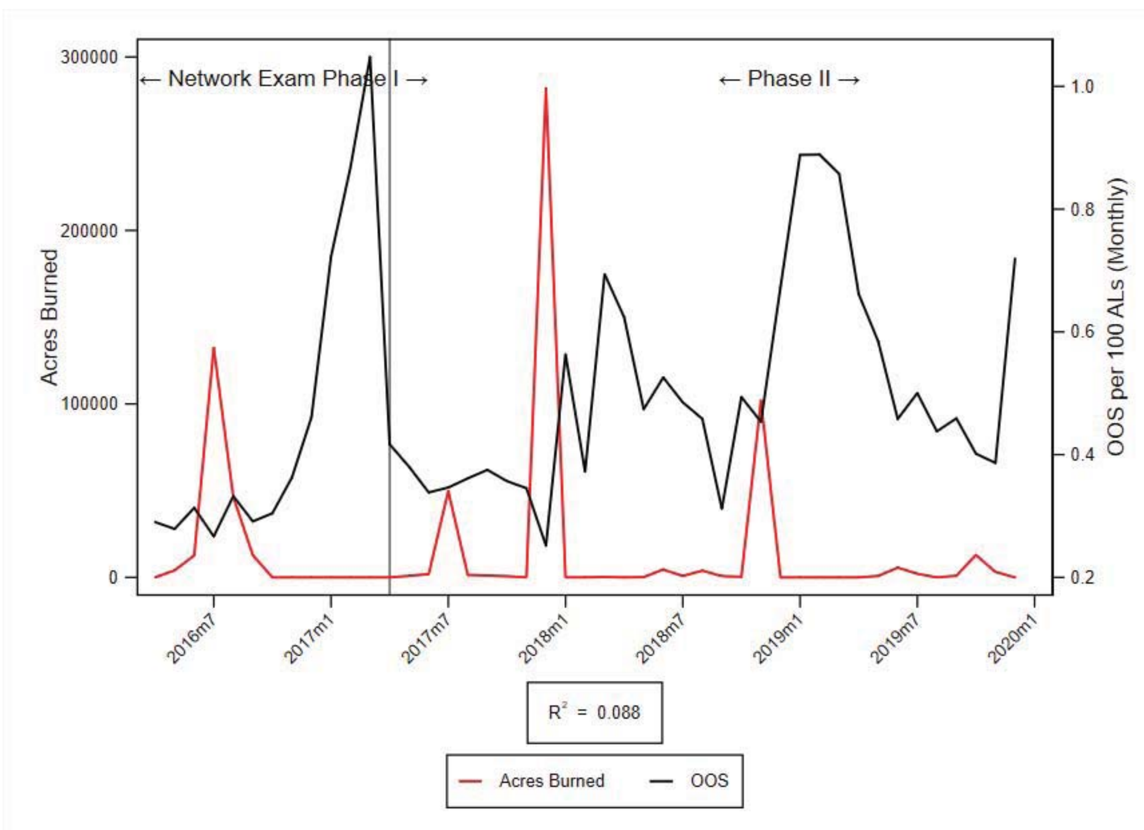
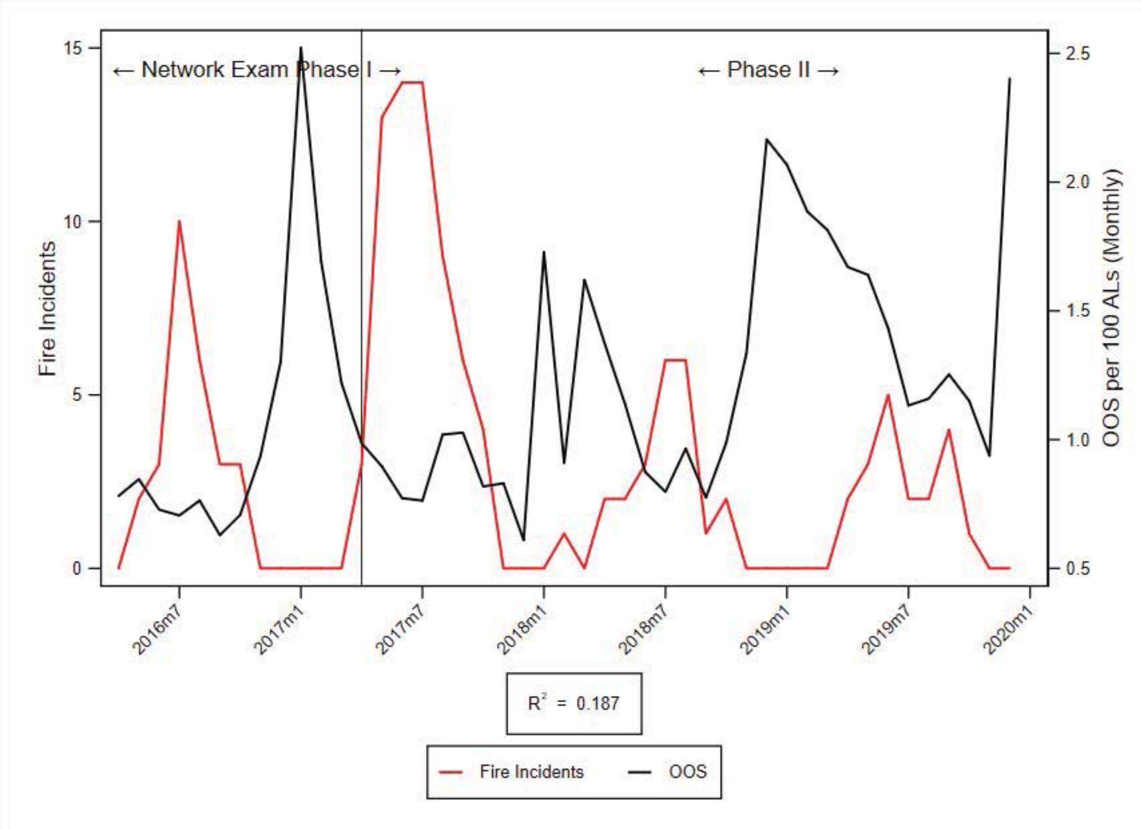


Figure 13.37. REGION 6 SOUTHERN SAN JOAQUIN VALLEY (FTR)



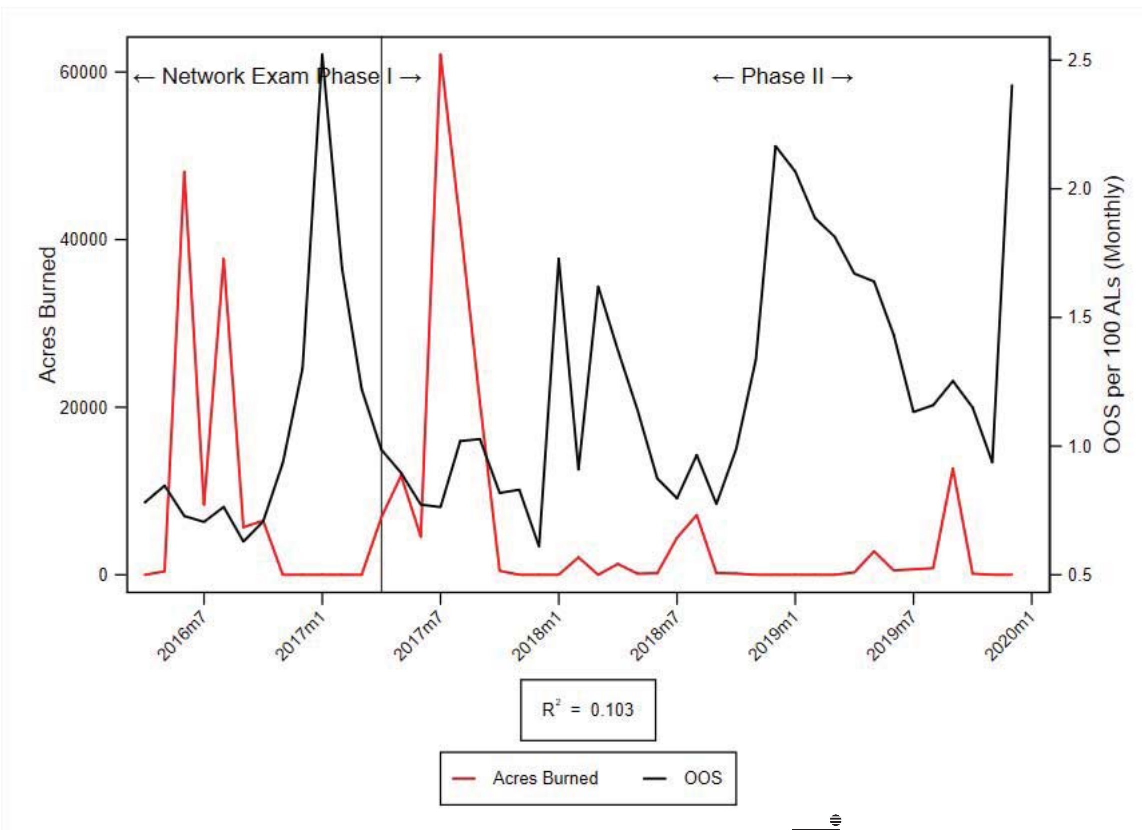


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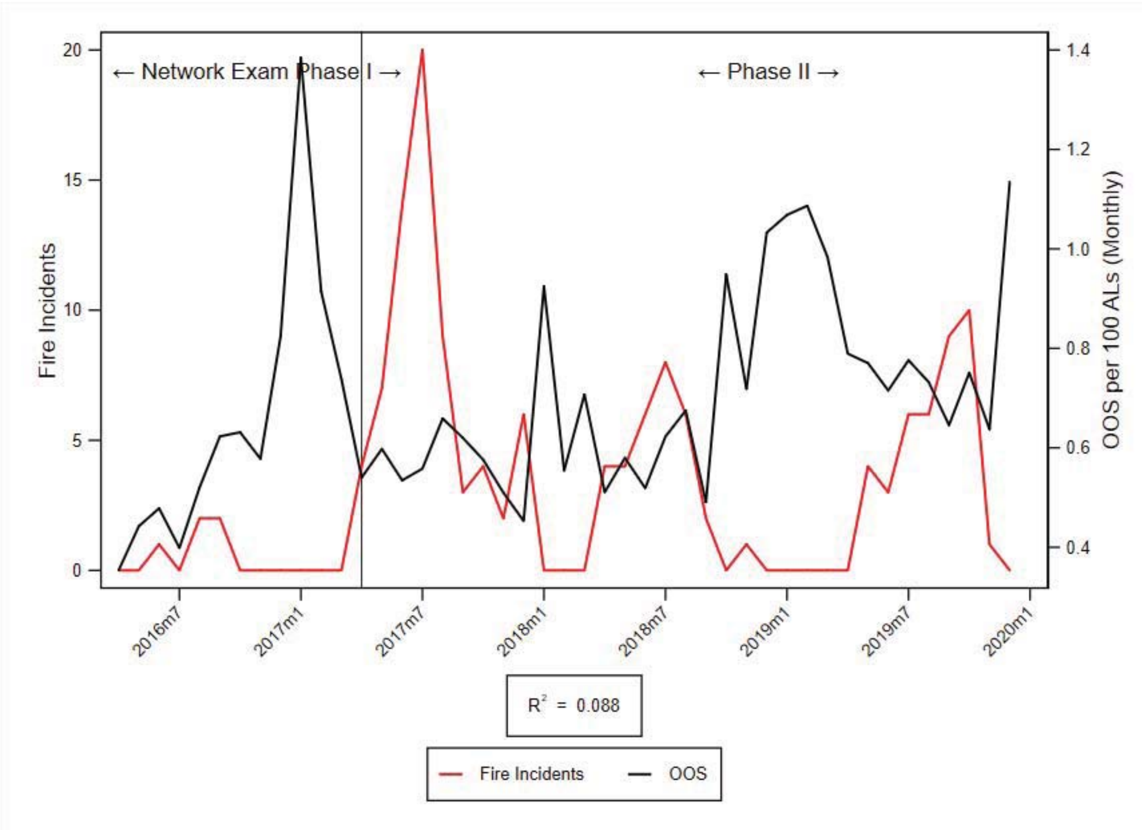
Figure 13.38. REGION 7 INLAND EMPIRE (FTR)



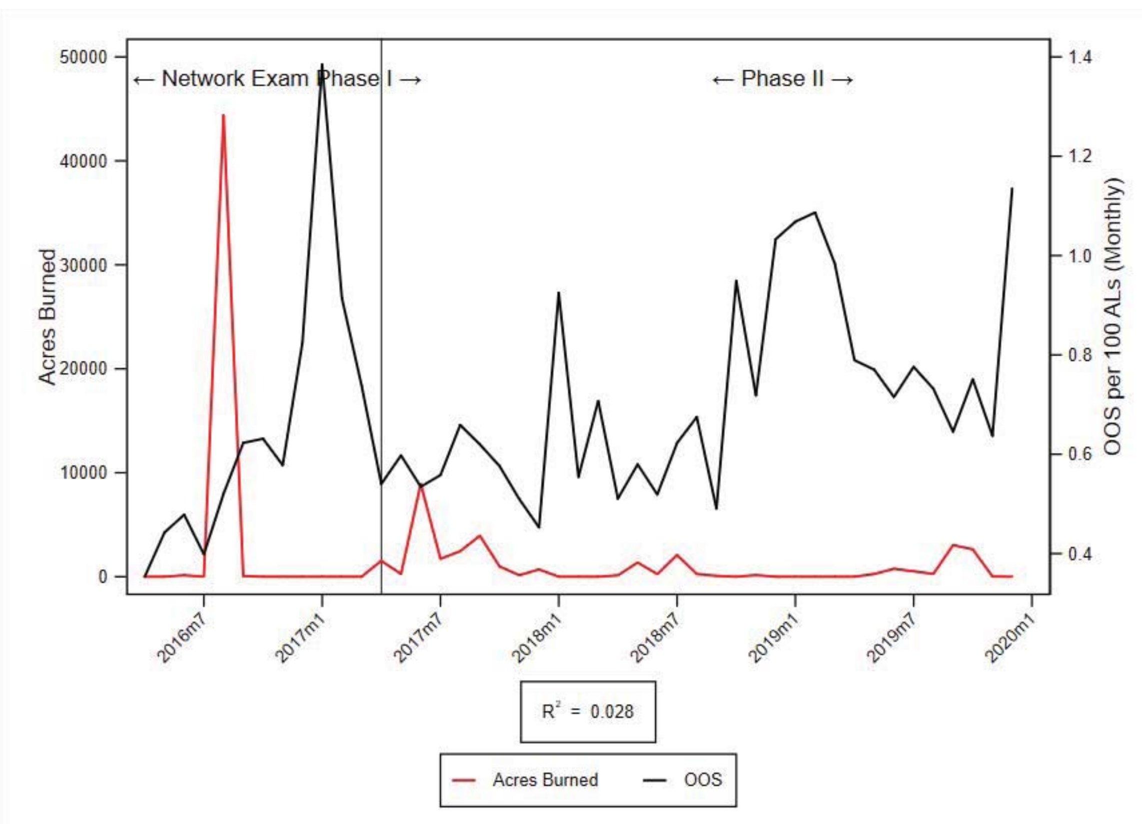
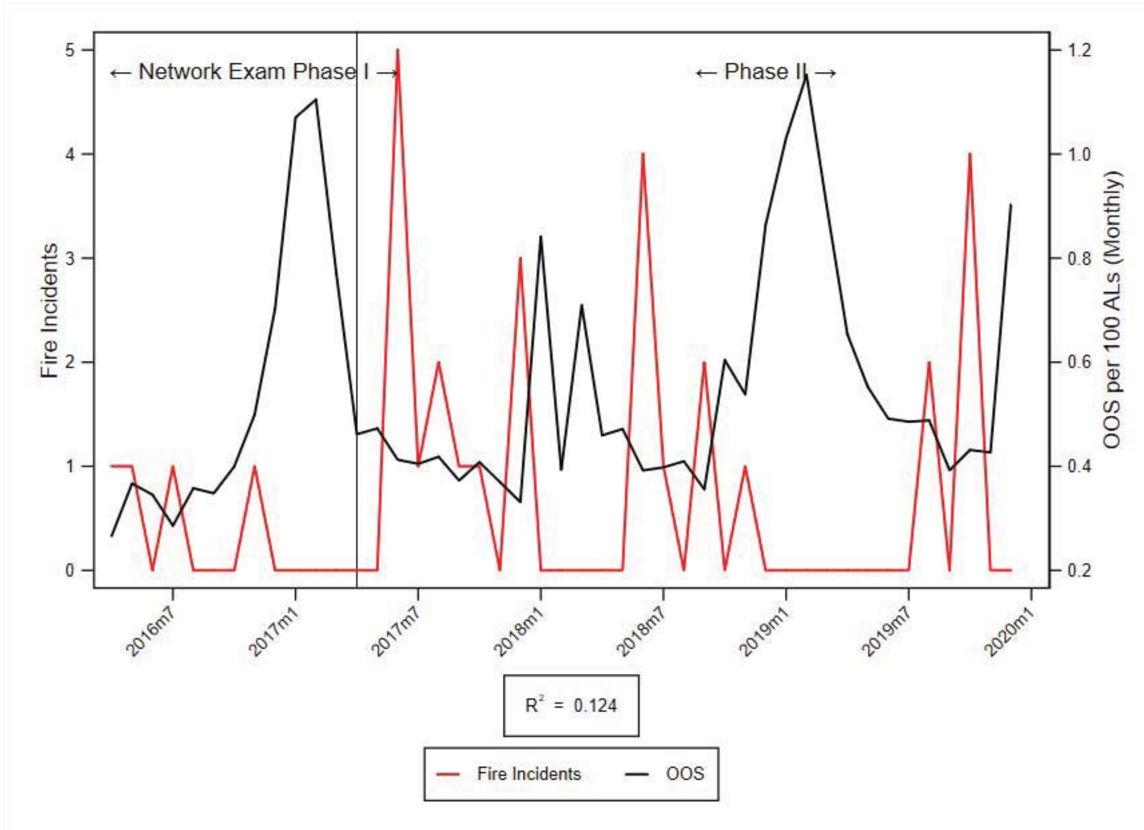


Figure 13.39. REGION 8 LOS ANGELES (FTR)



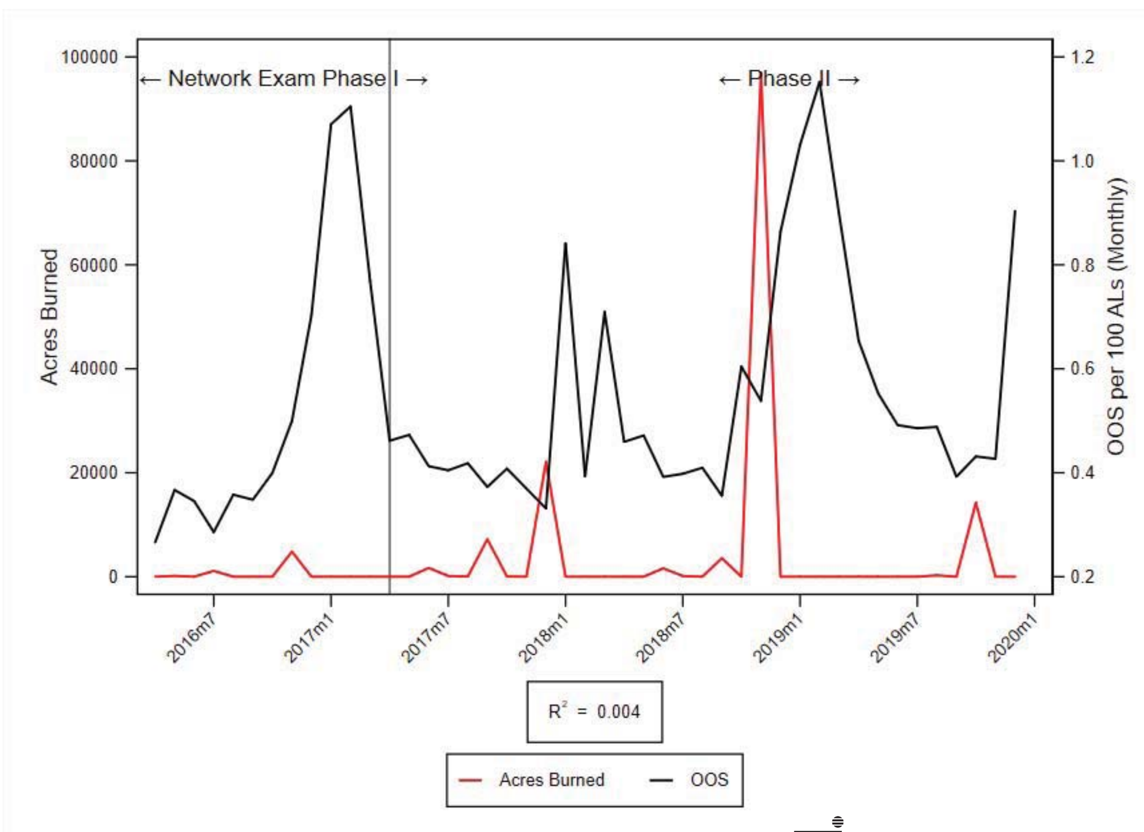
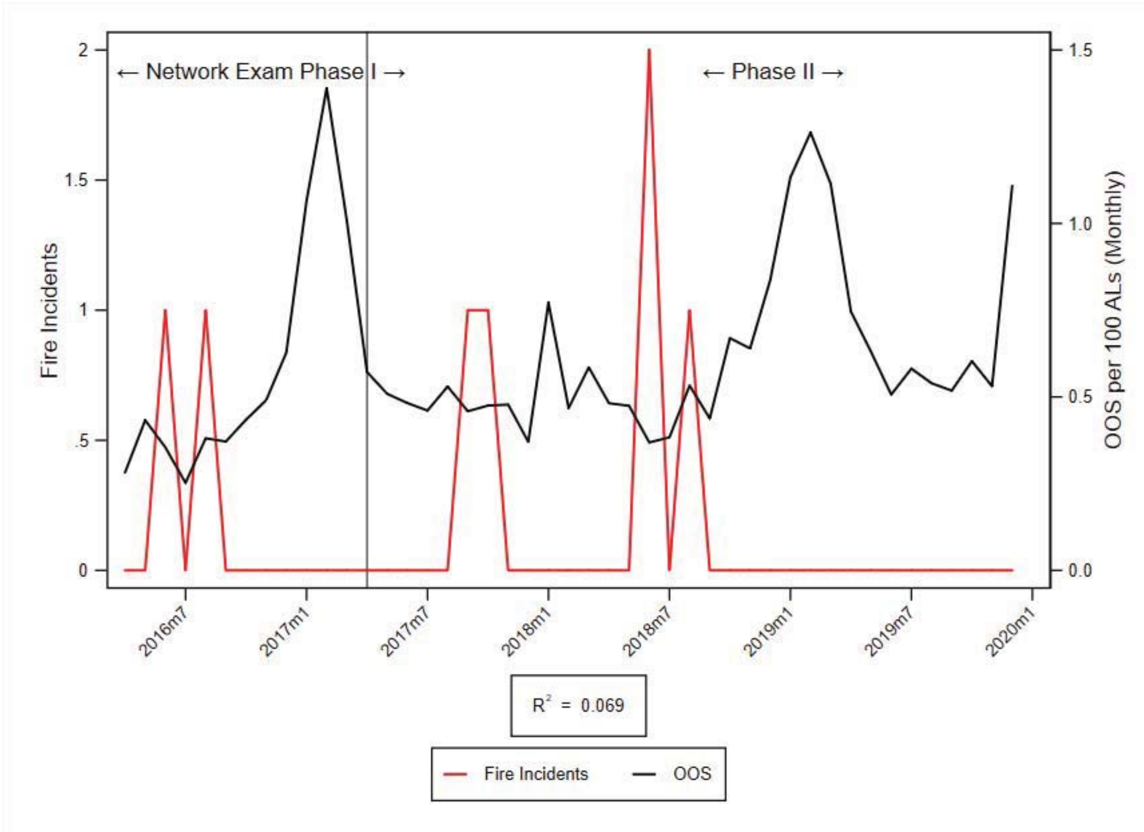


Figure 13.40. REGION 9 ORANGE (FTR)



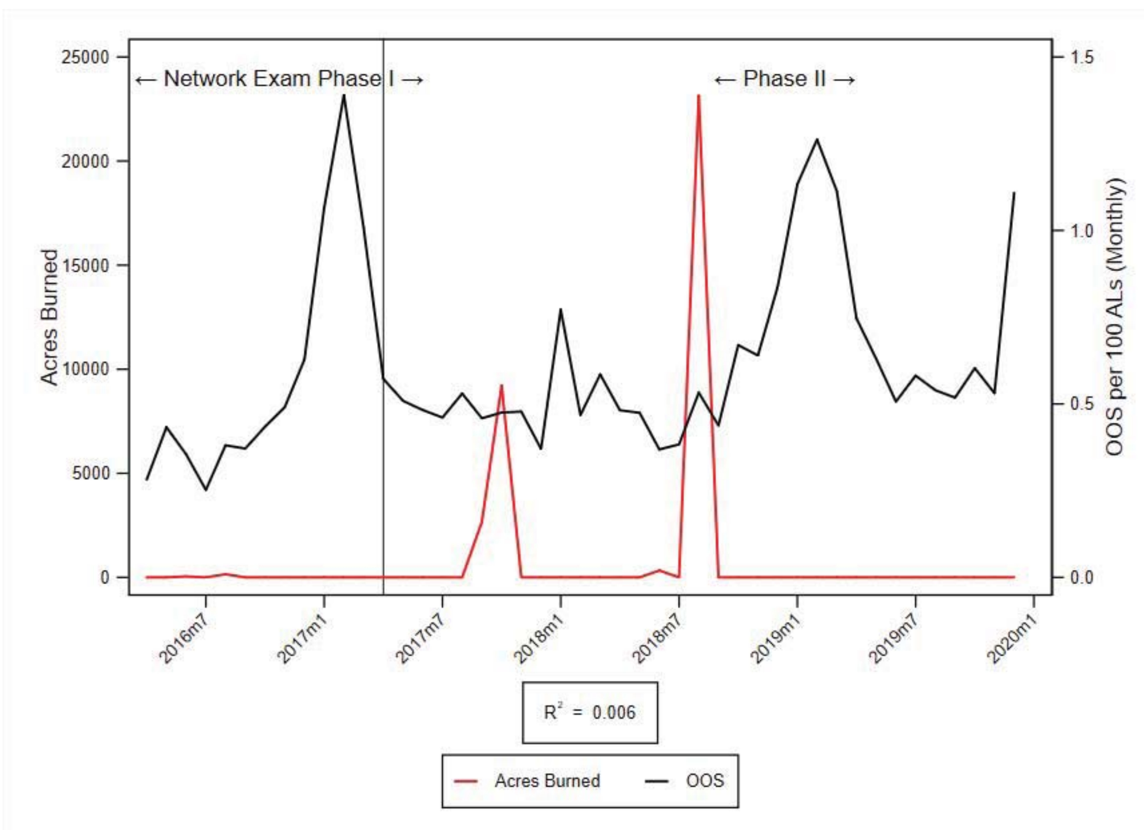
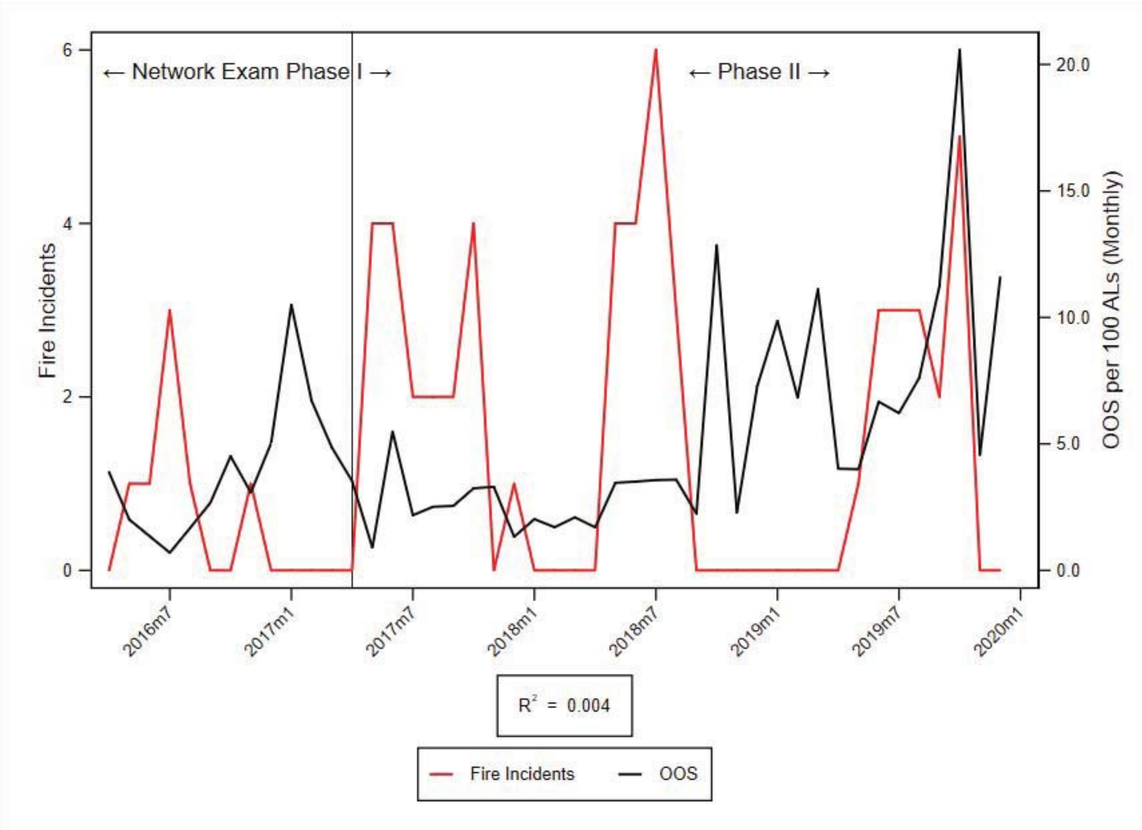
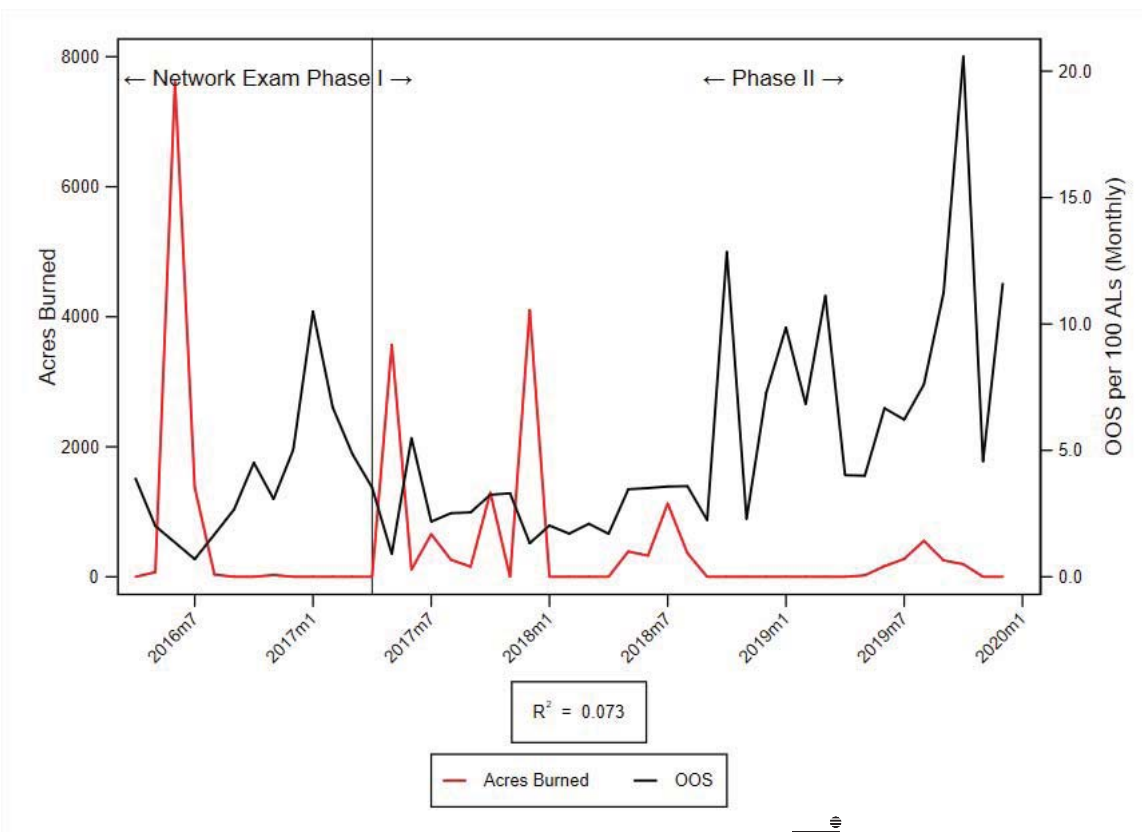


Figure 13.41. REGION 10 SAN DIEGO-IMPERIAL (FTR)





The overall absence of correlation can be observed by an inspection of these graphs. Notably, for a number of them, the peak wildfire incidents and OOS incidents appear to arise around six months apart. Wildfires appear to peak mainly during summer months, while OOS incidents appear to peak in the late fall and early winter. The high correlation between precipitation and OOS incidents suggests at least one plausible explanation for this: Wildfires occur mainly during hot summer months when rainfall is minimal, whereas OOS incidents arise during the periods of heaviest precipitation, which occurs during late fall and winter months. We considered running a regression model in which the wildfire data was lagged by six months, but to have any validity such a model would need to be premised upon some observable *causal* relationship that would, for example, account for service outages arising six months after a major wildfire. We do not believe that any such causal relationship exists, and thus did not pursue this approach.

While the R^2s that were calculated at the Census Region level for wildfire incidents vs. OOS incidents are considerably lower than those associated with precipitation, we noted that at least some are sufficiently high (i.e., in the 0.10 to 0.18 range) – particularly in areas that have been heavily impacted by destructive wildfires – that some additional examination might be warranted. On the possibility that the geographic extent of entire Census Regions might overshadow the more localized impact of individual wildfire incidents, we prepared a similar set of regression analyses at the individual county level. We did this for each of the 51 counties in which AT&T California provides service, and for each of the 26 counties where Frontier California operates. We surmised that, by studying the interactions between wildfires and service outages across smaller geographic units, it might be possible to identify correlations that would be masked at the full Census Region level. However, we did not observe any greater correlation at the individual county level than at the full Census Region level. Tables 13.6 and 13.7 provide the correlations between wildfire incidents or wildfire acres burned and OOS per 100 Access Lines at the individual county level for each of the two ILECs. Appendices 13-1 and 13-2 provide the results of these county-level studies for the AT&T California and Frontier California service areas, respectively.

The lack of any increase in observable correlation when examined across the geographically smaller areas covered within individual counties serves to corroborate our initial finding that wildfires are not a specific source of individual telephone service outages. This is, of course, not to suggest that such events do not wreak extensive damage to the telecommunications infrastructure in the affected areas. But the destruction of infrastructure likely corresponds to the broader destruction of homes and businesses that result from wildfires, and from the available data it does not appear that the restoration of telephone service lags behind the broader reconstruction of the affected communities.

Table 13.6

AT&T CALIFORNIA
COUNTY-LEVEL RELATIONSHIPS BETWEEN WILDFIRE EVENTS AND OUT-OF-SERVICE INCIDENTS
2013-2019

County	Census Region	No. of Wire Centers	Total Inci-dents	Total Acres Burned	Inci-dents R^2	Acres Burned R^2
ALAMEDA	SAN FRANCISCO BAY AREA	19	27	5,597	0.042	0.020
AMADOR	NORTH SAN JOAQUIN VLY	4	11	5,911	0.046	0.009
BUTTE	SUPERIOR CALIFORNIA	9	59	189,061	0.094	0.015
CALAVERAS	NORTH SAN JOAQUIN VLY	8	21	2,565	0.022	0.010
COLUSA	SUPERIOR CALIFORNIA	1	6	459,316	0.021	0.020
CONTRA COSTA	SANFRANCISCOBAYAREA	20	27	6,884	0.009	0.009
EL DORADO	SUPERIOR CALIFORNIA	9	34	114,326	0.046	0.005
FRESNO	SOUTH SAN JOAQUIN VLY	21	53	214,075	0.083	0.001
GLENN	SUPERIOR CALIFORNIA	5	6	2,772	0.015	0.002
HUMBOLDT	NORTH COAST	13	22	17,987	0.037	0.007
IMPERIAL	SANDIEGO-IMPERIAL	9	0	0		
KERN	SOUTH SAN JOAQUIN VLY	21	56	118,540	0.053	0.008
KINGS	SOUTH SAN JOAQUIN VLY	5	5	54,377	0.006	0.000
LAKE	NORTH COAST	8	44	578,038	0.059	0.003
LOS ANGELES	LOS ANGELES	69	40	188,407	0.047	0.008
MADERA	NORTH SAN JOAQUIN VLY	3	32	30,072	0.066	0.006
MARIN	SAN FRANCISCO BAY AREA	12	5	304	0.008	0.006
MARIPOSA	NORTH SAN JOAQUIN VLY	4	25	205,665	0.011	0.004
MENDOCINO	NORTH COAST	11	21	40,346	0.052	0.000
MERCED	NORTH SAN JOAQUIN VLY	6	12	10,546	0.025	0.017
MONTEREY	CENTRAL COAST	20	42	150,596	0.033	0.008
NAPA	NORTH COAST	6	22	243,788	0.012	0.005
NEVADA	SUPERIOR CALIFORNIA	7	17	4,201	0.051	0.001
ORANGE	ORANGE	32	10	36,764	0.017	0.006
PLACER	SUPERIOR CALIFORNIA	12	12	30,979	0.028	0.009
PLUMAS	SUPERIOR CALIFORNIA	4	11	63,817	0.000	0.039
RIVERSIDE	INLAND EMPIRE	5	131	81,311	0.063	0.001
SACRAMENTO	SUPERIOR CALIFORNIA	19	9	1,712	0.030	0.010
SAN BENITO	CENTRAL COAST	4	18	4,022	0.006	0.002
SAN BERNARDINO	INLAND EMPIRE	8	52	90,832	0.057	0.014
SAN DIEGO	SANDIEGO-IMPERIAL	51	83	48,915	0.036	0.019
SAN FRANCISCO	SAN FRANCISCO BAY AREA	8	0	0		
SAN JOAQUIN	NORTH SAN JOAQUIN VLY	9	7	13,229	0.023	0.006
SAN LUIS OBISPO	CENTRAL COAST	13	60	91,149	0.010	0.003
SAN MATEO	SAN FRANCISCO BAY AREA	14	3	153	0.004	0.003
SANTA CLARA	SAN FRANCISCO BAY AREA	19	34	6,982	0.047	0.013
SANTA CRUZ	CENTRAL COAST	8	4	428	0.012	0.007
SHASTA	SUPERIOR CALIFORNIA	6	61	448,461	0.076	0.008

Table 13.6 (continued)

AT&T CALIFORNIA
COUNTY-LEVEL RELATIONSHIPS BETWEEN WILDFIRE EVENTS AND OUT-OF-SERVICE INCIDENTS
2013-2019

County	Census Region	No. of Wire Centers	Total Inci-dents	Total Acres Burned	Inci-dents R^2	Acres Burned R^2
SIERRA	SUPERIOR CALIFORNIA	4	2	915	0.254	0.161
SISKIYOU	SUPERIOR CALIFORNIA	8	50	285,123	0.018	0.002
SOLANO	SAN FRANCISCO BAY AREA	7	18	56,567	0.053	0.007
SONOMA	NORTH COAST	19	14	102,428	0.001	0.037
STANISLAUS	NORTH SAN JOAQUIN VLY	14	17	11,006	0.039	0.010
SUTTER	SUPERIOR CALIFORNIA	5	3	2,850	0.001	0.002
TEHAMA	SUPERIOR CALIFORNIA	7	49	51,889	0.035	0.018
TRINITY	NORTH COAST	1	17	338,048	0.028	0.015
TULARE	SOUTH SAN JOAQUIN VLY	18	33	78,191	0.035	0.009
TUOLUMNE	NORTH SAN JOAQUIN VLY	5	22	299,132	0.094	0.010
VENTURA	CENTRAL COAST	9	19	121,360	0.007	0.000
YOLO	SUPERIOR CALIFORNIA	5	12	108,681	0.024	0.008
YUBA	SUPERIOR CALIFORNIA	6	14	11,910	0.001	0.087

Source: CALFIRE data; ETI analysis of AT&T California Out-of-Service incidents 2013-2019

Table 13.7

FRONTIER CALIFORNIA
COUNTY-LEVEL RELATIONSHIPS BETWEEN WILDFIRE EVENTS AND OUT-OF-SERVICE INCIDENTS
2016-2019

County	Census Region	No. of Wire Centers	Total Inci-dents	Total Acres Burned	Inci-dents R^2	Acres Burned R^2
FRESNO	SOUTH SAN JOAQUIN VLY	9	53	214,075	0.219	0.094
HUMBOLDT	NORTH COAST	6	22	17,987	0.000	0.020
IMPERIAL	SAN DIEGO-IMPERIAL	2				
INYO	SOUTH SAN JOAQUIN VLY	6	10	24,819	0.008	0.008
KERN	SOUTH SAN JOAQUIN VLY	16	56	118,540	0.106	0.039
KINGS	SOUTH SAN JOAQUIN VLY	1	5	54,377	0.003	0.012
LOS ANGELES	LOS ANGELES	37	40	188,407	0.123	0.004
MARIN	SAN FRANCISCO BAY AREA	1	5	304	0.042	0.014
MENDOCINO	NORTH COAST	4	21	40,346	0.139	0.002
MERCED	NORTH SAN JOAQUIN VLY	2	12	10,546	0.007	0.002
MONO	NORTH SAN JOAQUIN VLY	6	5	21,759	0.004	0.015
MONTEREY	CENTRAL COAST	2	42	150,596	0.003	0.017
ORANGE	ORANGE	4	10	36,764	0.069	0.006
PLACER	SUPERIOR CALIFORNIA	2	12	30,979	0.029	0.046
RIVERSIDE	INLAND EMPIRE	19	131	81,311	0.061	0.022
SAN BERNARDINO	INLAND EMPIRE	33	52	90,832	0.074	0.016
SAN JOAQUIN	NORTH SAN JOAQUIN VLY	4	7	13,229	0.004	0.008
SANTA BARBARA	CENTRAL COAST	9	26	329,751	0.071	0.039
SANTA CLARA	SAN FRANCISCO BAY AREA	3	34	6,982	0.108	0.051
SONOMA	NORTH COAST	4	14	102,428	0.007	0.007
STANISLAUS	NORTH SAN JOAQUIN VLY	1	17	11,006	0.040	0.026
SUTTER	SUPERIOR CALIFORNIA	1	3	2,850	0.029	0.013
TRINITY	NORTH COAST	3	17	338,048	0.028	0.039
TULARE	SOUTH SAN JOAQUIN VLY	7	33	78,191	0.036	0.004
VENTURA	CENTRAL COAST	9	19	121,360	0.017	0.001
YOLO	SUPERIOR CALIFORNIA	1	12	108,681	0.084	0.006

Source: CALFIRE data; ETI analysis of Frontier California Out-of-Service incidents 2016-2019

Investment and infrastructure in high risk fire areas

We examined relationships between total acres burned over the 2013-2020 period based upon CALFIRE data and infrastructure investments made by each of the two ILECs. By hypothesis, if ILECs were responding to areas of high wildfire risk with large scale infrastructure investment, we would expect to see some relationship between the extent of wildfire activity and the level of investment being made in a given area. Using county-level wildfire and Gross Plant

Additions investment data, we compared Total Acres Burned with two ILEC investment indicia – TotalGross Plant additions and Gross Plant Additions per Access Line. Because infrastructure reliability and investment would be expected to lag behind the actual wildfire damage, we utilized 2018-2019 Gross Plant Additions data for this analysis.

Tables 13.8 and 13.9 summarize this data for AT&T California and Frontier California, respectively. Because we utilized county-level data for this analysis, we would not expect a perfect match between the wildfire and investment data for each ILEC because, with very few exceptions, wildfires do not affect an entire county and ILECs do not generally serve an entire county. Additionally, because California counties vary in population by a factor of around 1000-to-1 and population has, if anything, an inverse relationship with the total number of acres burned, we utilized two alternate indicia of investment activity:

- Total 2018-2019 Gross Plant Additions for each county
- County-level Gross Plant Additions per Switched Access Line (as of January 2019) for each county

All else equal, ILEC investment in any given area is driven largely by the number of customers in that area, so we would expect larger investments to be made in the more populous counties. To control for this, we also examined *unit gross plant investment* per access line in service, using the January 2019 midpoint of the 2018-2019 Phase 2 study period. We also calculated the percentage of total wildfire acres burned for each of the counties served by each ILEC, as well as the percentage of that ILEC's total Gross Plant Additions for each of the counties it serves. A visual examination of the data in Tables 13.8 and 13.9 suggests little correlation between Total Acres Burned and either Total Gross Plant Additions or Gross Plant Additions per Access Line.

In order to examine the extent of any such correlation quantitatively, we have calculated a statistic known as the Spearman Rank Correlation[94] both as between Total Acres Burned and Total Gross Plant Additions, as well as between Total Acres Burned and Gross Plant Additions per Access Line. Both Acres and Burned and Gross Plant Additions vary by orders-of-magnitude on a county-by county basis, diminishing the usefulness of traditional linear correlation analysis. Rank correlation avoids this problem. It is calculated by first ranking the individual observations for each of the two variables to be examined, in this instance, from highest (assigned the rank of "1") to lowest (assigned the rank of 51 (for AT&T) or 28 (for Frontier). These rankings are also shown on Tables 13.8 and 13.9. Table 13.10 summarizes the two Rank Correlation calculations for each of the two ILECs:

94. Yamane, Taro, *Statistics: An Introductory Analysis* (New York: Harper & Row, 1964), at 435-438.

Table 13.8

AT&T CALIFORNIA
INFRASTRUCTURE INVESTMENT IN HIGH-RISK WILDFIRE AREAS
(sorted by Total Acres Burned - highest to lowest)

Table 13.8: INFRASTRUCTURE INVESTMENT IN HIGH-RISK WILDFIRE AREAS (continued)

County	Wildfire Incidents 2013-2020	Total Acres Burned	Pct of Tot Acres Burned	No. of Wire Centers	Access Lines Jan 2019	2018-29 Gross Plant Additions	Pct of total 2018-29 GPA	GPA per ALs-Jan 2019	Acres Burned Rank	GPA Investment rank	GPA per AL Rank
LAKE	44	578,038	11.49%	8	7,679	5,611,885	0.28%	731	1	36	37
COLUSA	6	459,316	9.13%	1	138	35,973	0.00%	261	2	51	50
SHASTA	61	448,461	8.92%	6	11,840	34,794,138	1.75%	2,939	3	15	2
TRINITY	17	338,048	6.72%	1	508	514,098	0.03%	1,012	4	49	22
TUOLUMNE	22	299,132	5.95%	5	10,048	5,069,941	0.25%	505	5	38	47
SISKIYOU	50	285,123	5.67%	8	4,673	4,323,702	0.22%	925	6	40	29
NAPA	22	243,788	4.85%	6	12,701	12,043,604	0.61%	948	7	28	27
FRESNO	53	214,075	4.26%	21	42,153	34,258,390	1.72%	813	8	16	34
MARIPOSA	25	205,665	4.09%	4	1,758	3,167,291	0.16%	1,802	9	46	4
BUTTE	59	189,061	3.76%	9	18,842	37,990,193	1.91%	2,016	10	14	3
LOS ANGELES	40	188,407	3.75%	69	451,446	391,828,147	19.70%	868	11	1	31
MONTEREY	42	150,596	2.99%	20	30,843	26,252,051	1.32%	851	12	21	33
VENTURA	19	121,360	2.41%	9	22,576	23,449,202	1.18%	1,039	13	22	19
KERN	56	118,540	2.36%	21	34,148	42,158,617	2.12%	1,235	14	12	10
EL DORADO	34	114,326	2.27%	9	18,933	10,816,698	0.54%	571	15	30	44
YOLO	12	108,681	2.16%	5	9,662	10,740,656	0.54%	1,112	16	31	15
SONOMA	14	102,428	2.04%	19	38,850	43,900,406	2.21%	1,130	17	11	13
SAN LUIS OBISPO	60	91,149	1.81%	13	22,565	21,369,125	1.07%	947	18	24	28
SAN BERNARDINO	52	90,832	1.81%	8	15,561	27,359,437	1.38%	1,758	19	20	5
RIVERSIDE	131	81,311	1.62%	5	29,666	40,269,557	2.02%	1,357	20	13	7
TULARE	33	78,191	1.55%	18	26,281	27,533,006	1.38%	1,048	21	19	18
PLUMAS	11	63,817	1.27%	4	4,267	698,836	0.04%	164	22	48	51
SOLANO	18	56,567	1.12%	7	21,545	18,635,144	0.94%	865	23	26	32
KINGS	5	54,377	1.08%	5	5,554	5,687,790	0.29%	1,024	24	35	21
TEHAMA	49	51,889	1.03%	7	7,769	4,197,767	0.21%	540	25	41	45
SAN DIEGO	83	48,915	0.97%	51	145,740	159,693,753	8.03%	1,096	26	3	16
MENDOCINO	21	40,346	0.80%	11	15,026	7,432,464	0.37%	495	27	33	49
ORANGE	10	36,764	0.73%	32	144,937	143,966,352	7.24%	993	28	5	25
PLACER	12	30,979	0.62%	12	19,591	20,132,322	1.01%	1,028	29	25	20
MADERA	32	30,072	0.60%	3	5,319	5,241,661	0.26%	985	30	37	26
HUMBOLDT	22	17,987	0.36%	13	10,594	10,648,626	0.54%	1,005	31	32	24
SAN JOAQUIN	7	13,229	0.26%	9	29,199	29,508,463	1.48%	1,011	32	17	23
YUBA	14	11,910	0.24%	6	5,819	3,617,512	0.18%	622	33	44	40
STANISLAUS	17	11,006	0.22%	14	28,242	22,623,727	1.14%	801	34	23	36
MERCED	12	10,546	0.21%	6	10,264	17,651,102	0.89%	1,720	35	27	6
SANTA CLARA	34	6,982	0.14%	19	121,579	158,426,693	7.97%	1,303	36	4	8
CONTRA COSTA	27	6,884	0.14%	20	67,041	71,948,594	3.62%	1,073	37	9	17
AMADOR	11	5,911	0.12%	4	4,550	3,653,909	0.18%	803	38	42	35
ALAMEDA	27	5,597	0.11%	19	118,102	107,718,143	5.42%	912	39	6	30

Table 13.8: INFRASTRUCTURE INVESTMENT IN HIGH-RISK WILDFIRE AREAS (continued)

County	Wildfire Incidents 2013-2020	Total Acres Burned	Pct of Tot Acres Burned	No. of Wire Centers	Access Lines Jan 2019	2018-29 Gross Plant Additions	Pct of total 2018-29 GPA	GPA per ALs- Jan 2019	Acres Burned Rank	GPA Investment rank	GPA per AL Rank
NEVADA	17	4,201	0.08%	7	18,967	10,987,185	0.55%	579	40	29	42
SAN BENITO	18	4,022	0.08%	4	3,967	4,833,940	0.24%	1,219	41	39	11
SUTTER	3	2,850	0.06%	5	6,042	3,635,319	0.18%	602	42	43	41
GLENN	6	2,772	0.06%	5	2,743	1,588,480	0.08%	579	43	47	43
CALAVERAS	21	2,565	0.05%	8	6,920	3,578,075	0.18%	517	44	45	46
SACRAMENTO	9	1,712	0.03%	19	71,854	84,192,259	4.23%	1,172	45	7	12
SIERRA	2	915	0.02%	4	878	434,367	0.02%	495	46	50	48
SANTA CRUZ	4	428	0.01%	8	25,695	28,861,224	1.45%	1,123	47	18	14
MARIN	5	304	0.01%	12	25,042	174,673,021	8.78%	6,975	48	2	1
SAN MATEO	3	153	0.00%	14	64,370	80,943,675	4.07%	1,257	49	8	9
IMPERIAL				9	8,996	6,269,993	0.32%	697	50	34	38
SAN FRANCISCO				8	98,235	61,524,552	3.09%	626	51	10	39
TOTALS	1,352	5,030,228	100.00%	593	1,802,487	1,988,696,520	100.00%				

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Table 13.9

FRONTIER CALIFORNIA
INFRASTRUCTURE INVESTMENT IN HIGH-RISK WILDFIRE AREAS
(sorted by Total Acres Burned - highest to lowest)

County	Wildfire Incidents 2013-2020	Total Acres Burned	Pct of Tot Acres Burned	No. of Wire Centers	Access Lines Jan 2019	2018-29 Gross Plant Additions	Pct of total 2018-29 GPA	GPA per ALs- Jan 2019	Acres Burned Rank	GPA Investment rank	GPA per AL Rank
TRINITY	17	338,048		3	2,325	3,419,237	0.63%	1,470	1	12	4
SANTA BARBARA	26	329,751		13	38,859	20,939,279	3.89%	539	2	4	21
FRESNO	53	214,075		12	7,007	9,515,871	1.77%	1,358	3	7	5
LOS ANGELES	40	188,407		49	259,444	206,868,260	38.39%	797	4	1	13
MONTEREY	42	150,596		2	518	1,924,831	0.36%	3,718	5	17	1
VENTURA	19	121,360		9	40,429	10,268,917	1.91%	254	6	6	26
KERN	56	118,540		20	10,656	7,183,092	1.33%	674	7	9	18
YOLO	12	108,681		2	134	92,114	0.02%	687	8	25	17
SONOMA	14	102,428		4	1,648	1,148,564	0.21%	697	9	19	16
SAN BERNARDINO	52	90,832		44	109,474	124,884,097	23.17%	1,141	10	2	8
RIVERSIDE	131	81,311		36	107,773	99,286,754	18.42%	921	11	3	10
TULARE	33	78,191		8	4,204	3,414,297	0.63%	812	12	13	11
KINGS	5	54,377		1	760	418,516	0.08%	551	13	23	20
MENDOCINO	21	40,346		4	1,302	1,488,284	0.28%	1,143	14	18	7
ORANGE	10	36,764		6	40,652	19,654,531	3.65%	483	15	5	23
PLACER	12	30,979		2	1,102	738,427	0.14%	670	16	21	19
INYO	10	24,819		5	2,768	2,215,386	0.41%	800	17	16	12
MONO	5	21,759		6	3,126	2,260,006	0.42%	723	18	15	15
HUMBOLDT	22	17,987		5	2,476	6,533,275	1.21%	2,638	19	10	3
SAN JOAQUIN	7	13,229		5	7,891	2,392,896	0.44%	303	20	14	25
STANISLAUS	17	11,006		1	148	110,340	0.02%	744	21	24	14
MERCED	12	10,546		2	914	990,161	0.18%	1,084	22	20	9
SANTA CLARA	34	6,982		3	17,108	8,524,949	1.58%	498	23	8	22
SUTTER	3	2,850		1	74	26,990	0.01%	365	24	26	24
MARIN	5	304		1	3,335	3,926,776	0.73%	1,177	25	11	6
IMPERIAL	0	-		2	216	654,919	0.12%	3,038	26	22	2
MODOC	0	-		1	-	2,479	0.00%	-	27	27	27
SACRAMENTO	0	-		1	-	-	0.00%	-	28	28	28
TOTALS	658	2,194,168	0.00%	248	664,343	538,883,246	100.00%				

Table 13.10

RANK CORRELATIONS BETWEEN TOTAL WILDFIRE ACRES BURNED (2013-2020) AND ILEC GROSS PLANT INVESTMENTS (2018-2019)

Rank Correlation between	AT&T California	Frontier California
Total Acres Burned and Gross Plant Additions	–0.113846154	0.551724138
Total Acres Burned and Gross Plant Additions per Access Line	0.045248869	0.241926656

Notably, the results of these calculations are decidedly different for AT&T and Frontier. In the case of AT&T, the Rank Correlation between Total Acres Burned and Total Gross Plant Additions is *negative* 0.1138, suggesting an inverse relationship between these two variables. When we look at investment on a per-access line basis, the correlation is slightly positive, but quite low at only 0.0452. The clear conclusion here is that, for AT&T, there is no obvious relationship between its investment priorities and areas of high fire risk.

For Frontier, the rank correlation between Total Acres Burned and Total Gross Plant Additions is a *positive* 0.5517, suggesting a relatively strong positive correlation. Even when viewed on a per access line basis, we still see a rank correlation of 0.2419. Of course, these calculations do not reveal any *causal* link between Frontier's investment activities and the incidence of wildfires, although the particularly high rank correlatiion between Acres Burned and Total Gross Plant Additons, which does *not* control for the volume of customers, could be interpreted as inferring at least some causal link in this case.

Conclusion

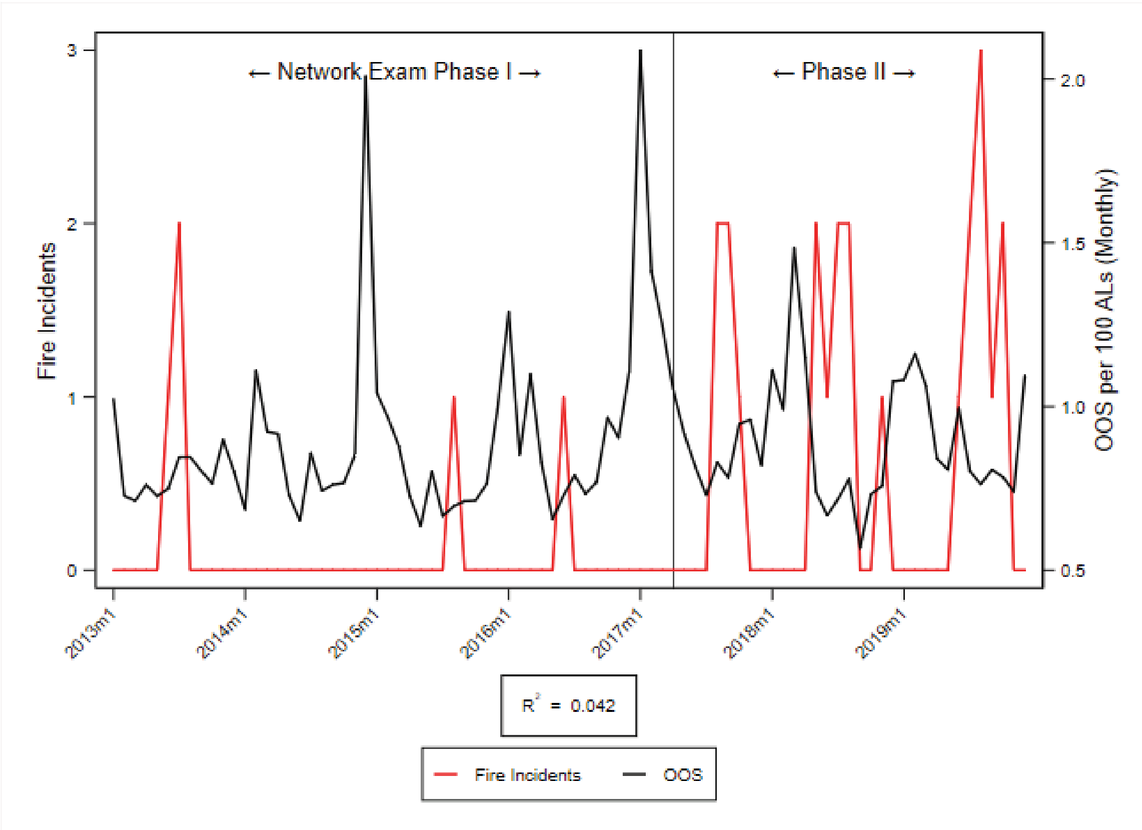
Our analysis of the effect of exogenous environmental conditions upon service quality of legacy circuit-switched telephone service has identified a strong correlation between precipitation and out-of-service incidents, but no discernable relationship between wildfires and service quality. The massive wildfires that have become all too common in California certainly destroy infrastructure as well as homes and other buildings on a grand scale, and undoubtedly have an impact upon the ability of the ILEC to furnish service in the affected area. However, if a home is destroyed along with the owner's telephone service, dealing with that type of service outage is likely a fairly low priority for the property owner, and as such does not result in a simply out-of-service trouble ticket on an individual customer basis. Frontier's plant investments, which in recent years have focused heavily upon outside plant, do appear to have some positive relationship with the extent of wildfires in a given county, but our analysis does not firmly establish a direct causal link between fires and investment overall.

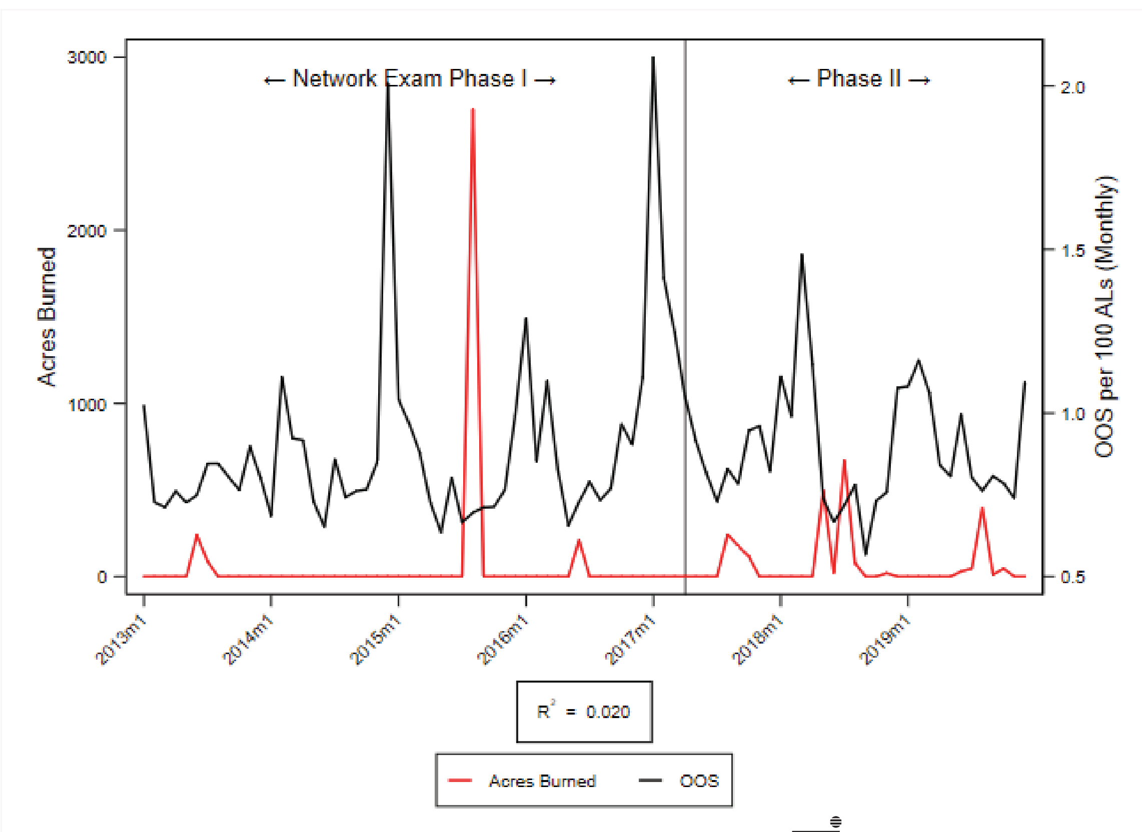
Appendix 13-1

AT&T California

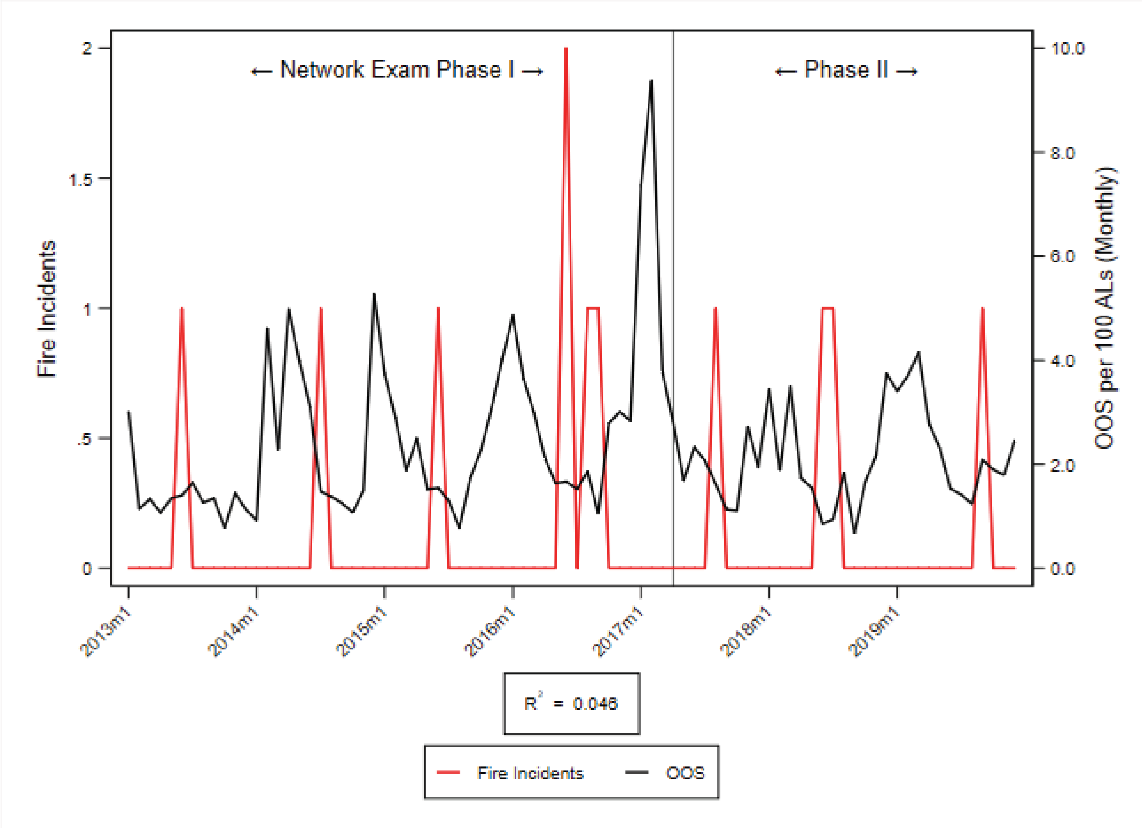
County-level Regression Analyses
Wildfires vs. Telephone Service Outages

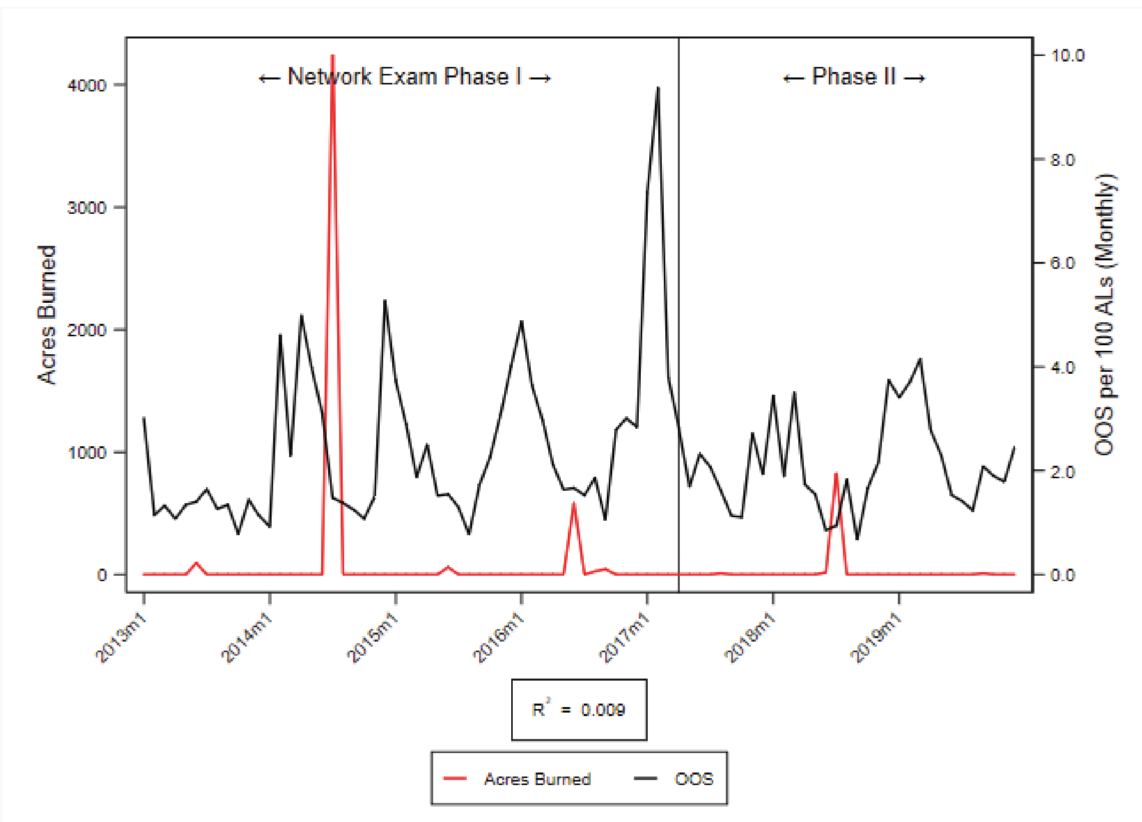
COUNTY-REGION   ALAMEDA - SAN FRANCISCO BAY AREA (AT&T)



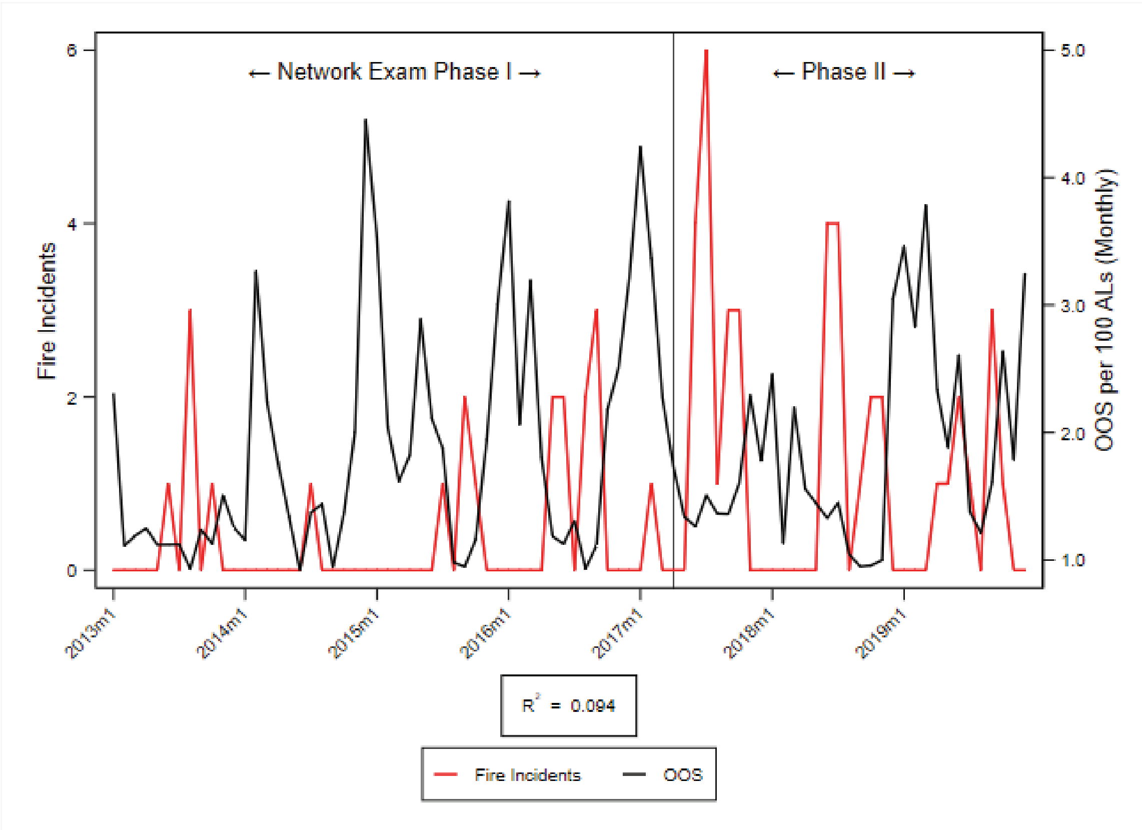


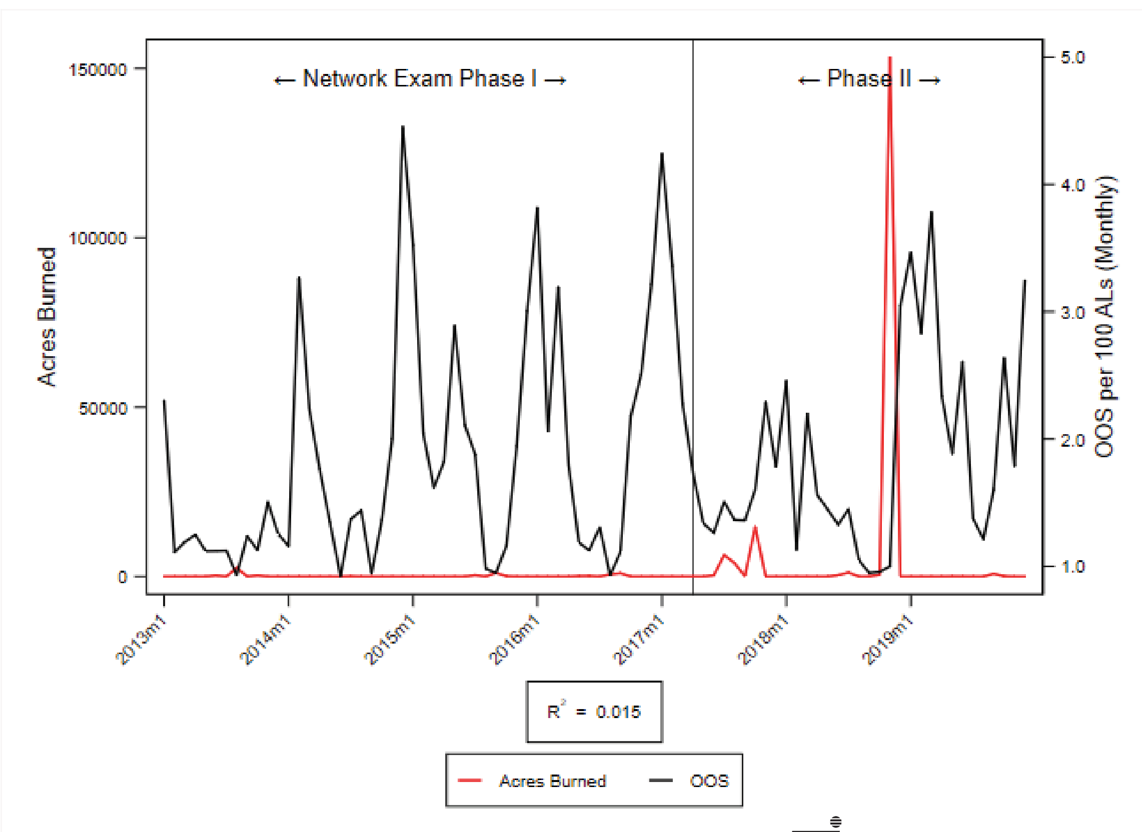
COUNTY-REGION AMADOR - NORTHERN SAN JOAQUIN VALLEY (AT&T)





COUNTY-REGION BUTTE - SUPERIOR CALIFORNIA (AT&T)





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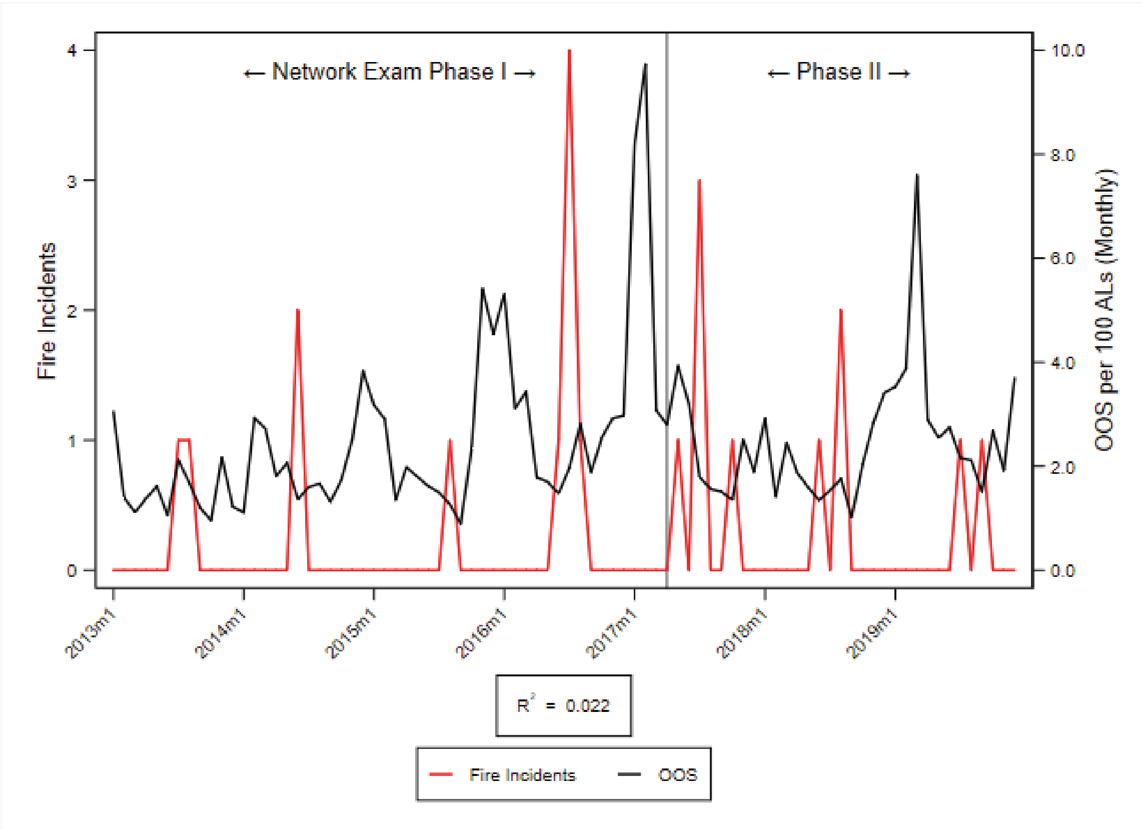
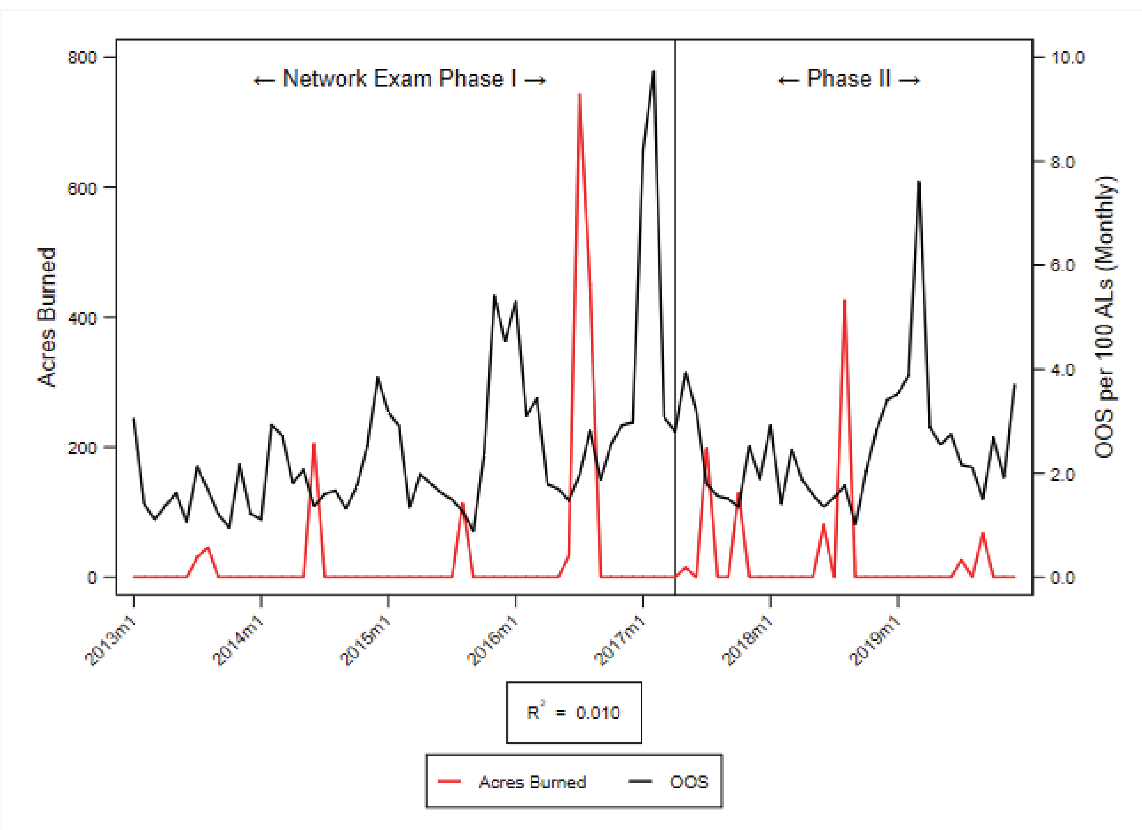
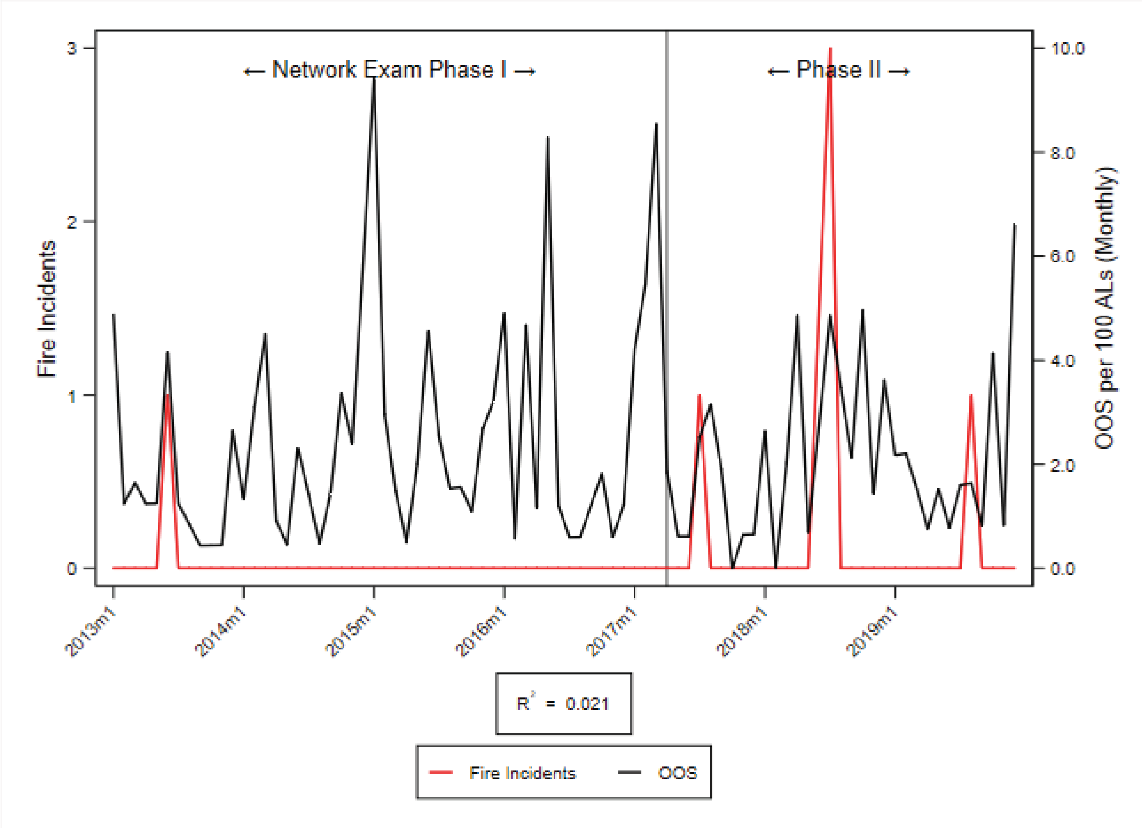
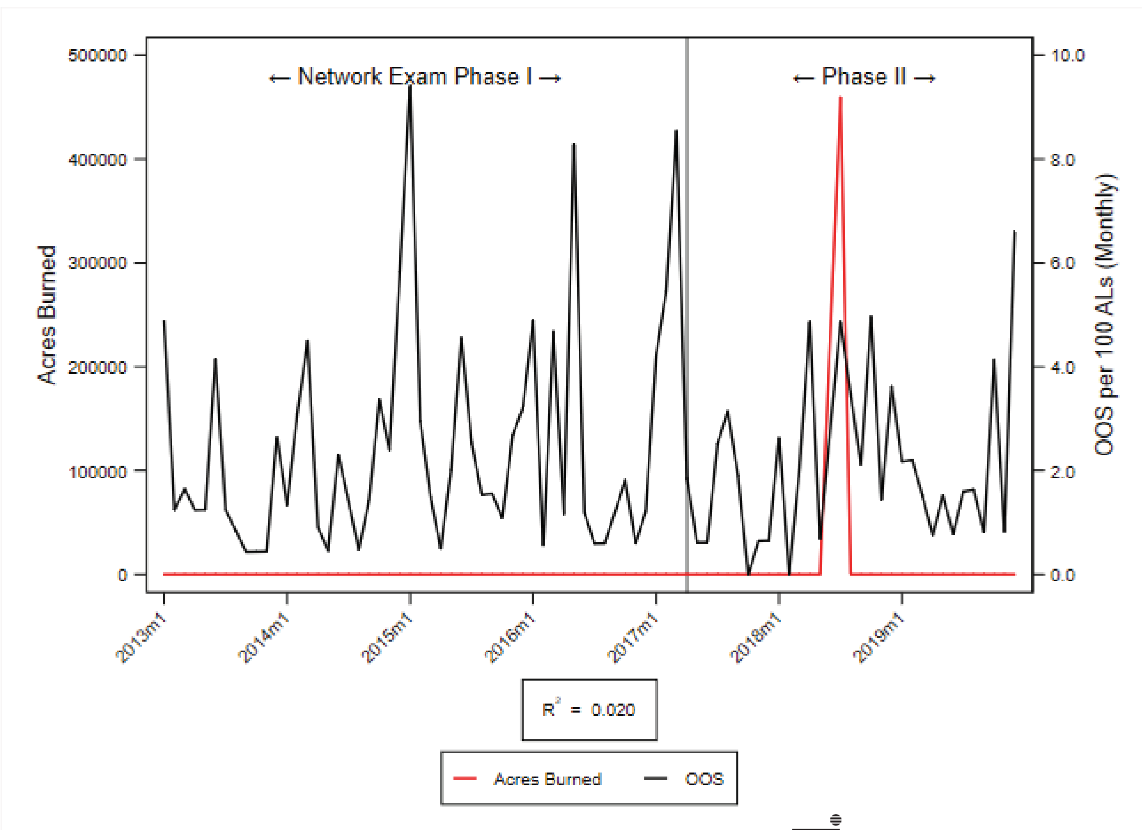
COUNTY-REGION   CALAVERAS - NORTHERN SAN JOAQUIN VALLEY (AT&T)





COUNTY-REGION COLUSA - SUPERIOR CALIFORNIA (AT&T)





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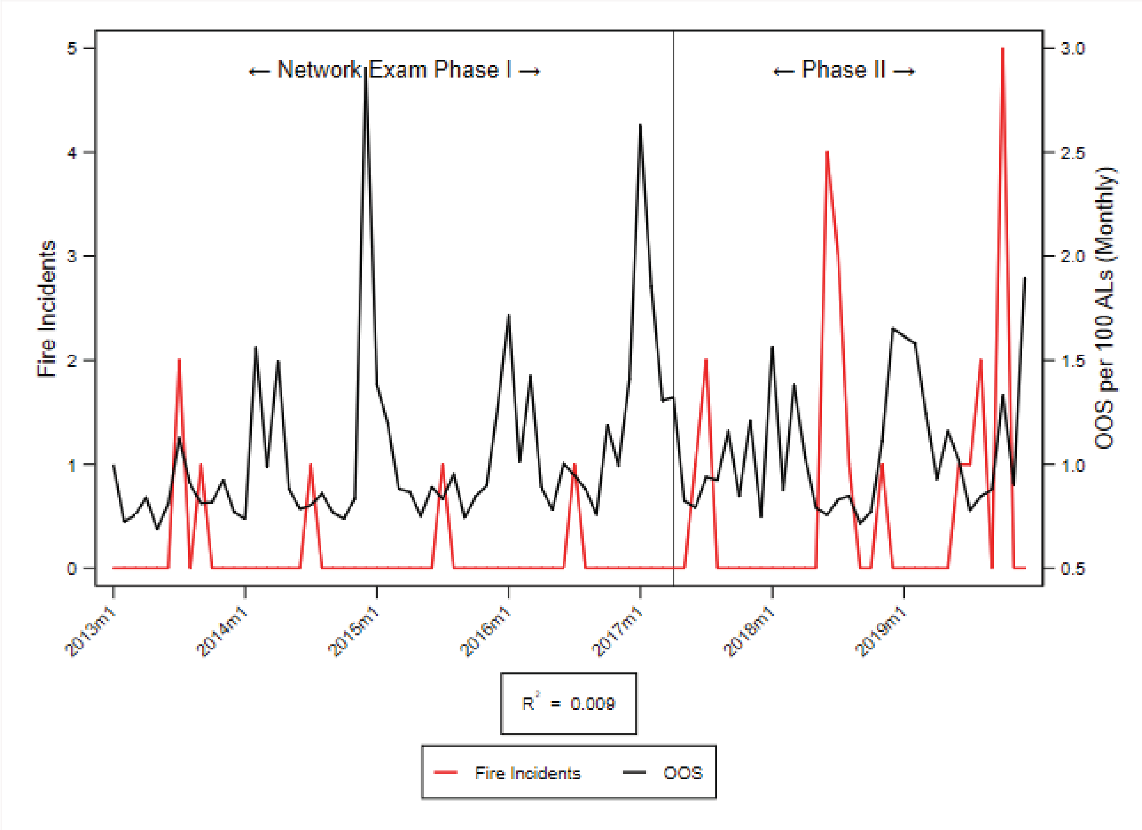
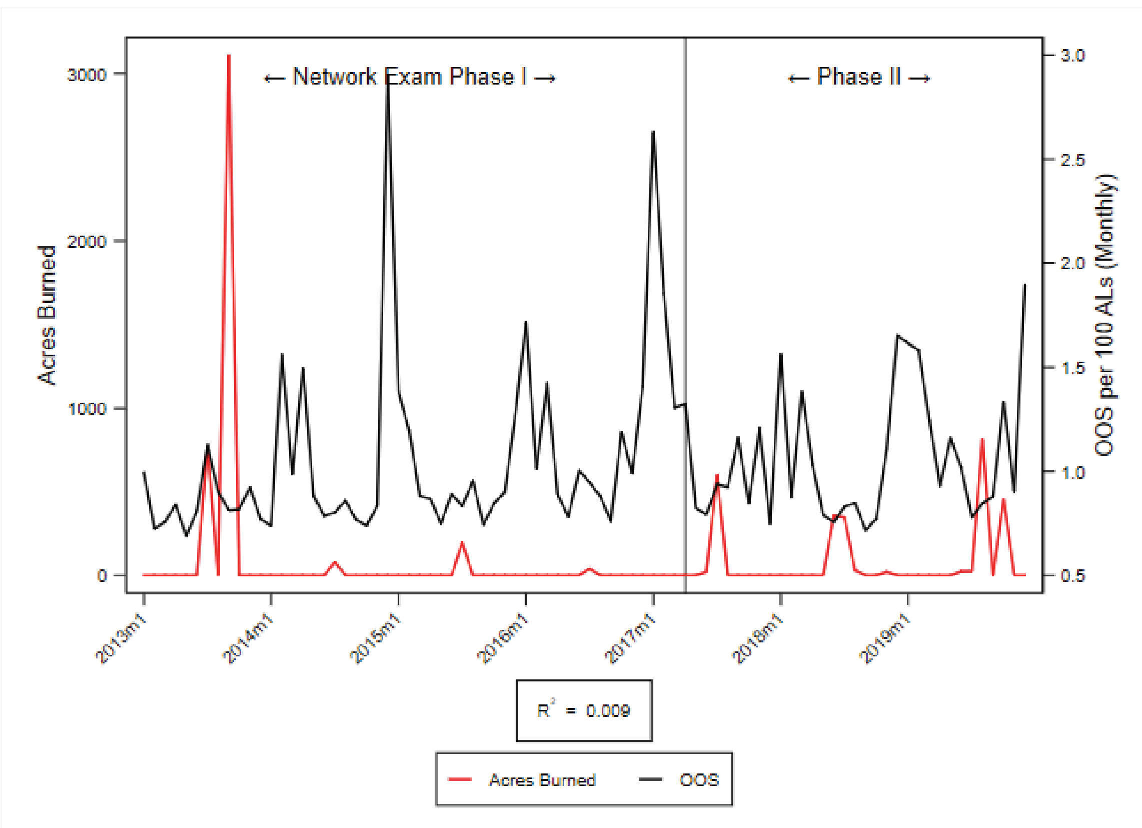
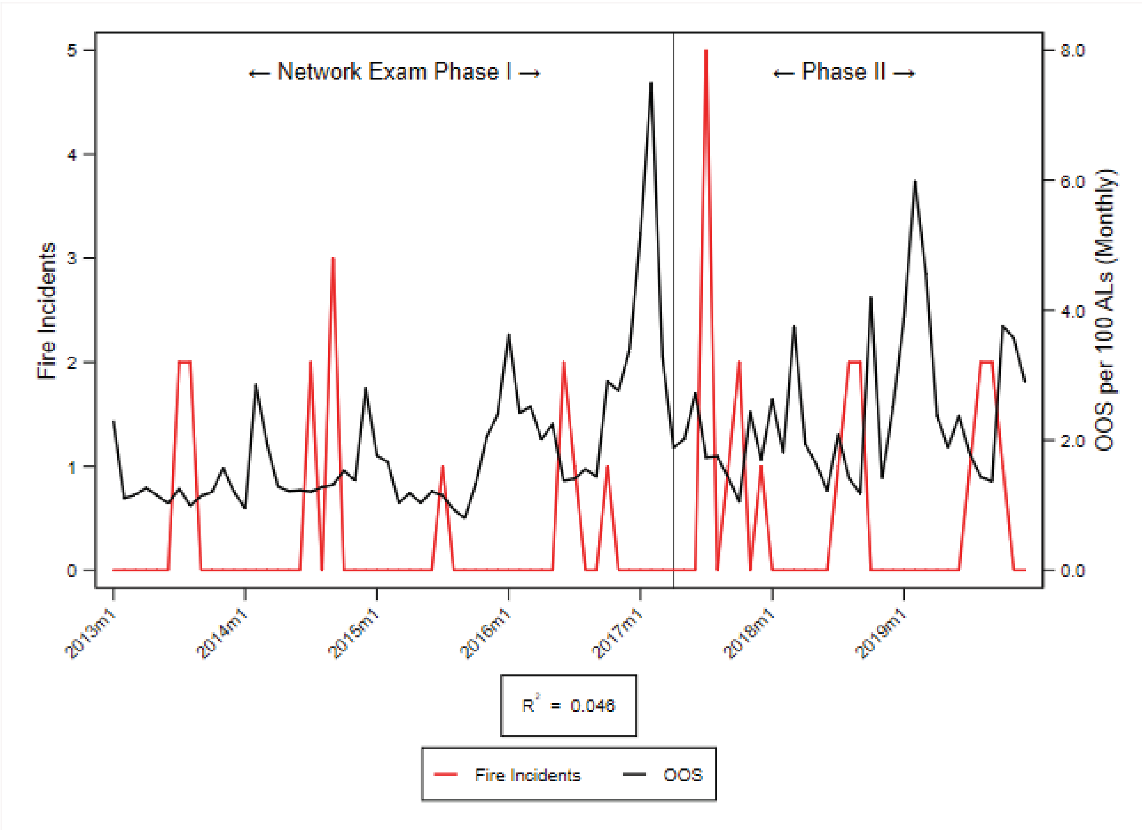
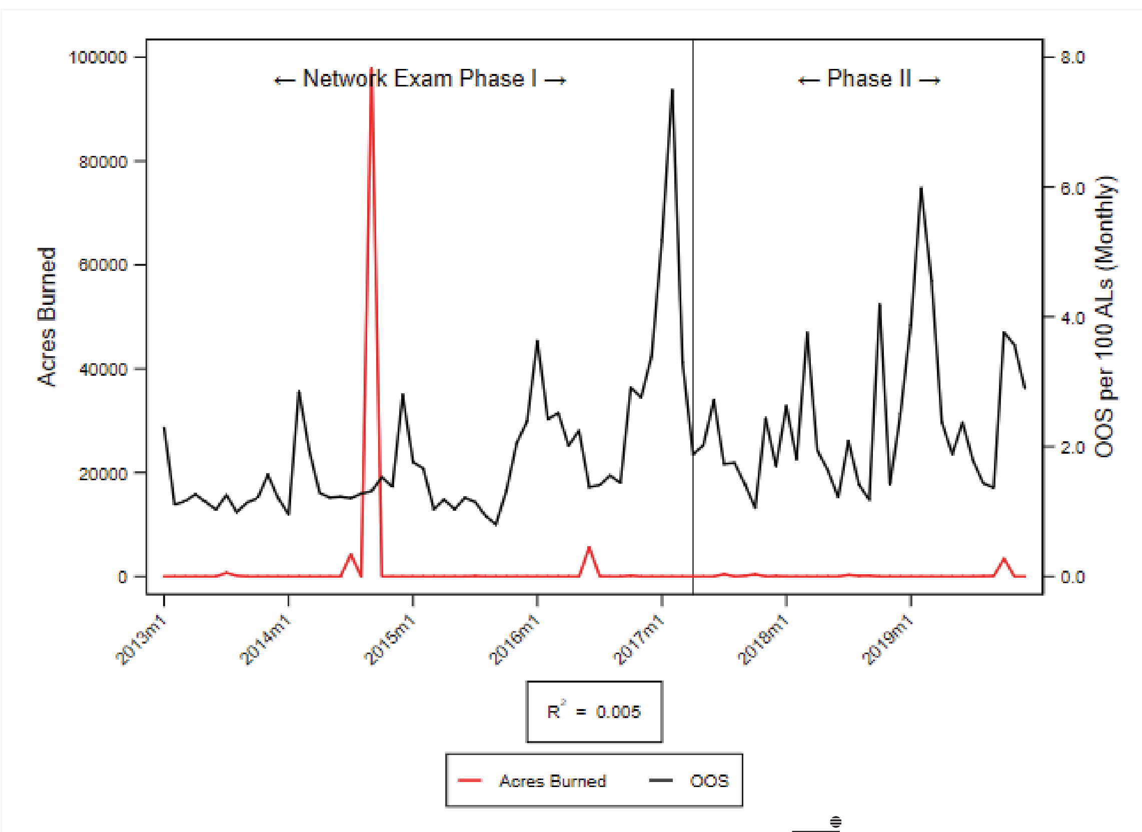
COUNTY-REGION CONTRA COSTA - SAN FRANCISCO BAY AREA (AT&T)



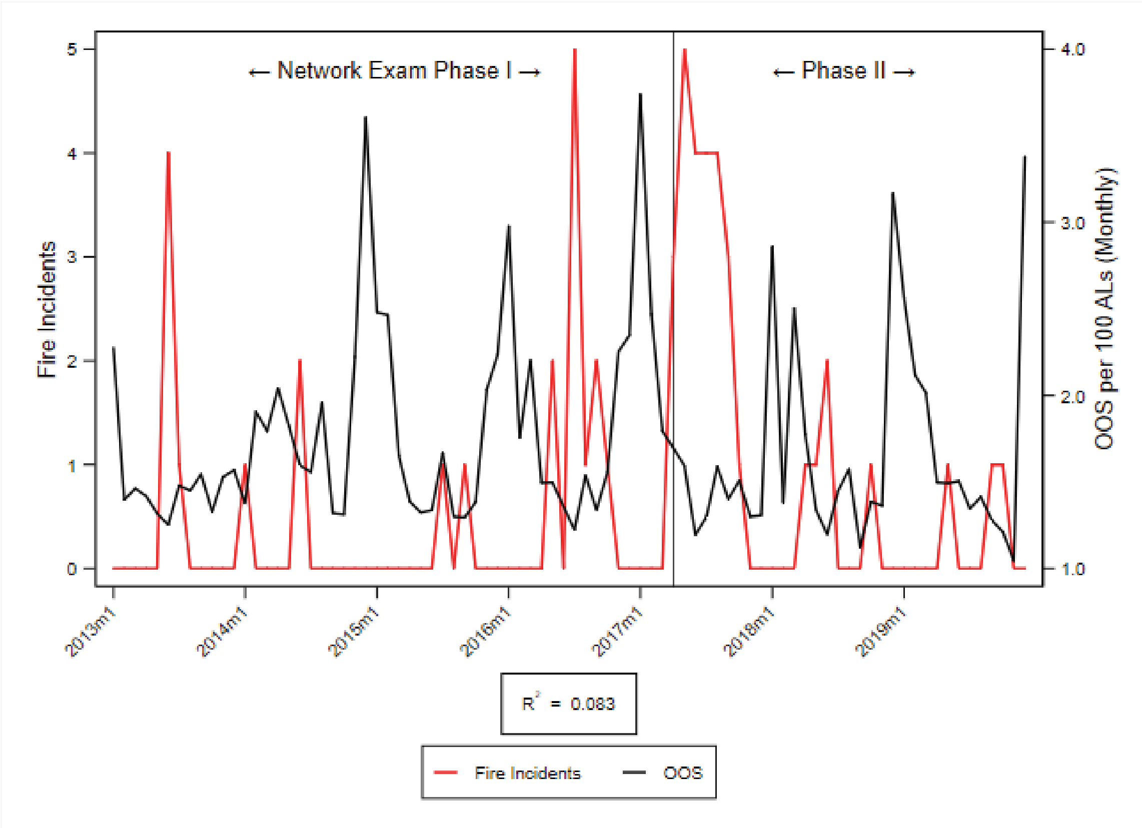


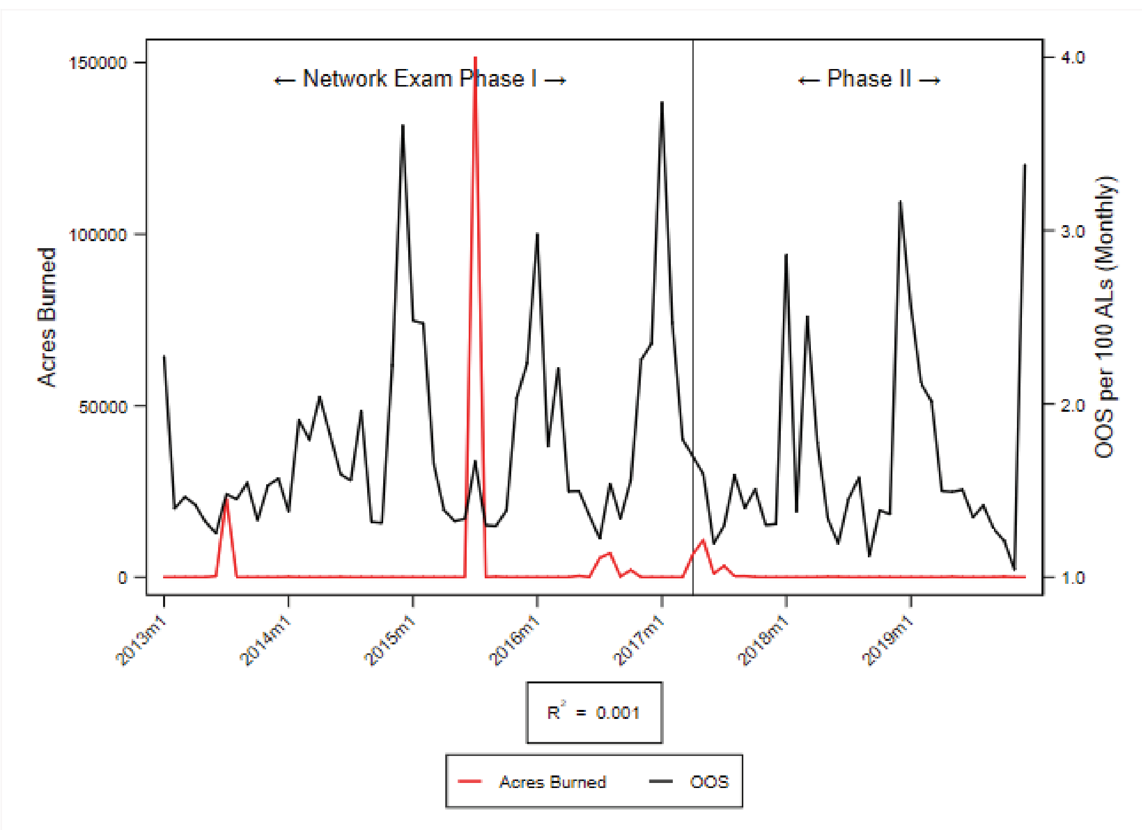
COUNTY-REGION   EL DORADO - SUPERIOR CALIFORNIA (AT&T)



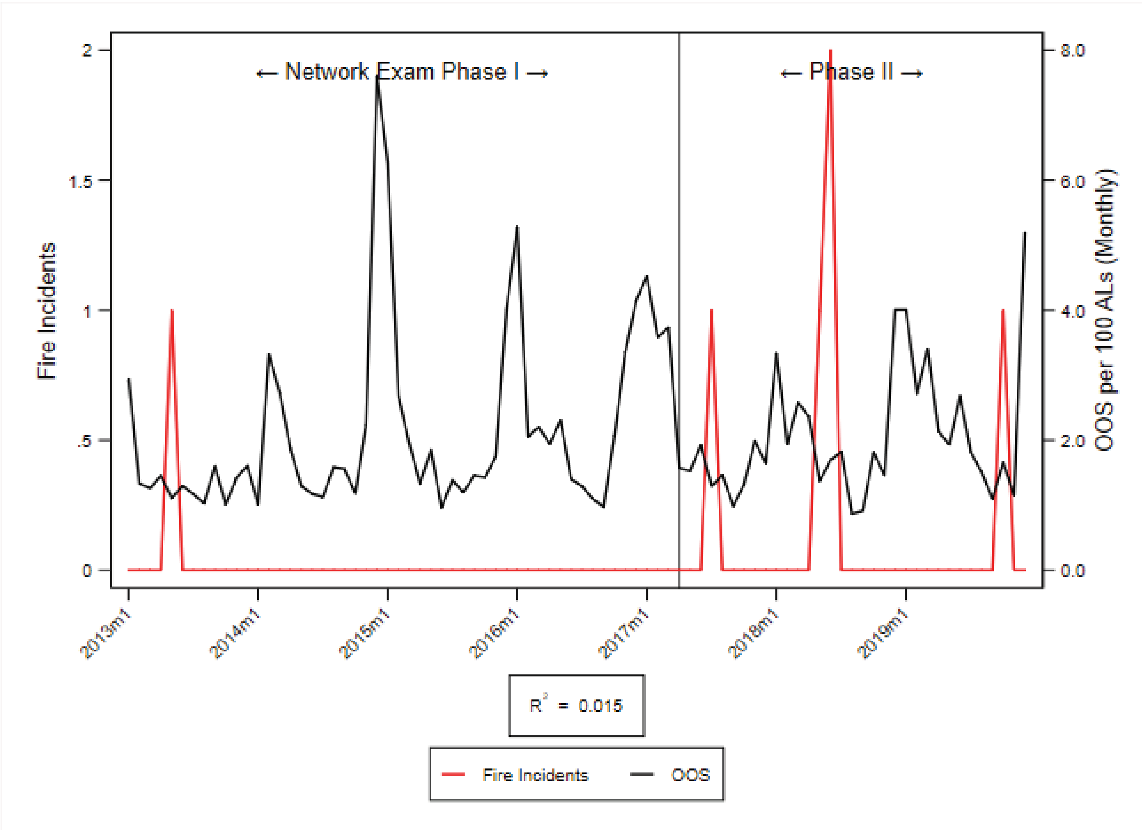


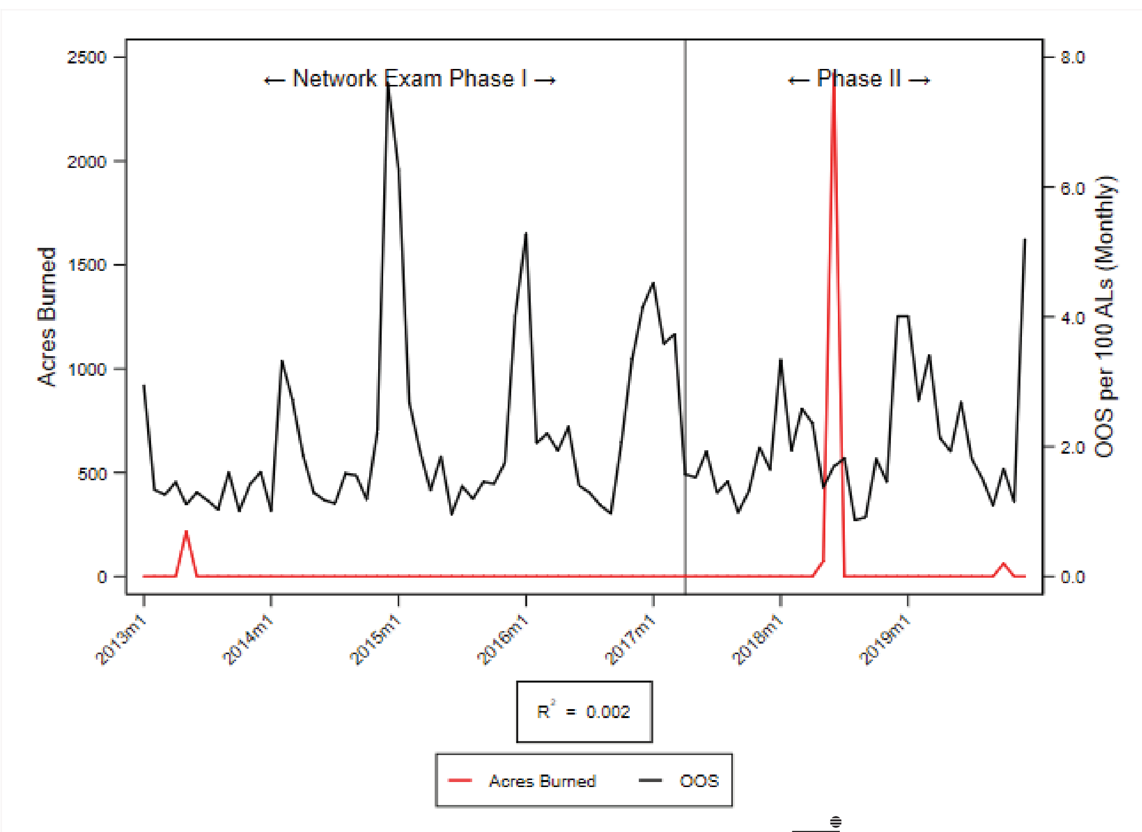
COUNTY-REGION FRESNO - SOUTHERN SAN JOAQUIN VALLEY (AT&T)





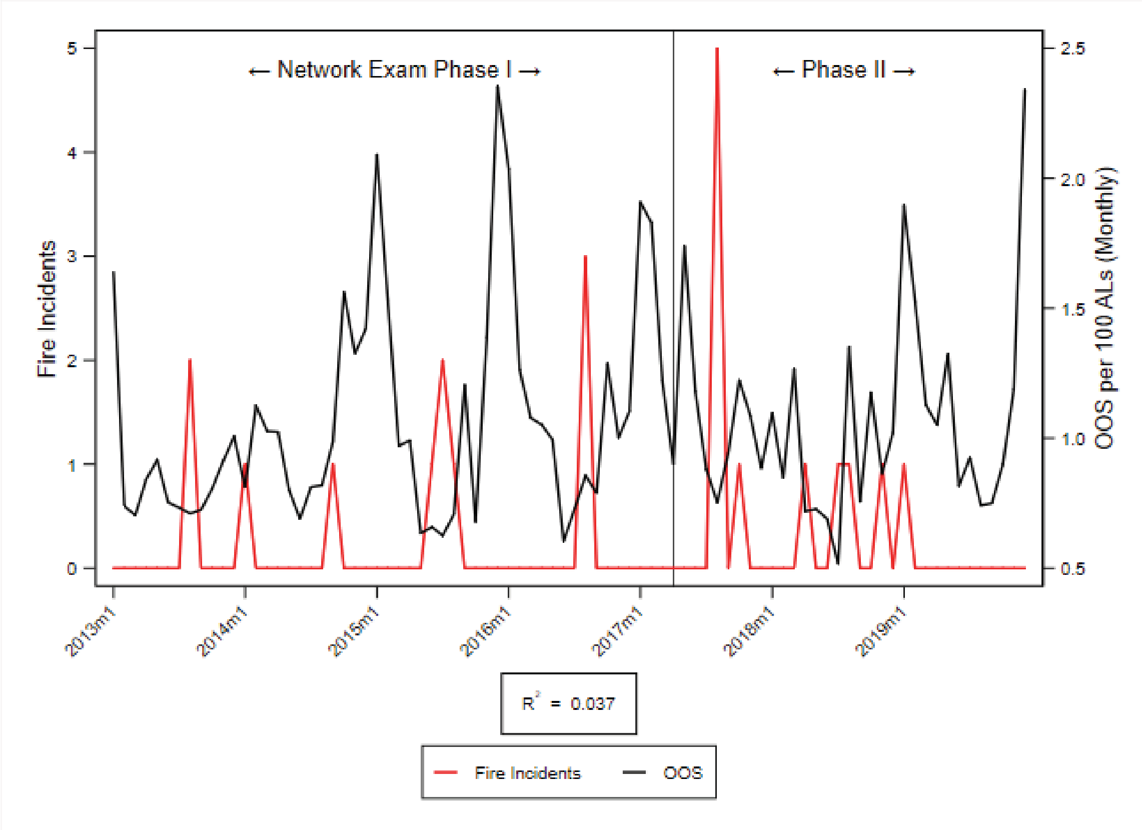
COUNTY-REGION GLENN - SUPERIOR CALIFORNIA (AT&T)

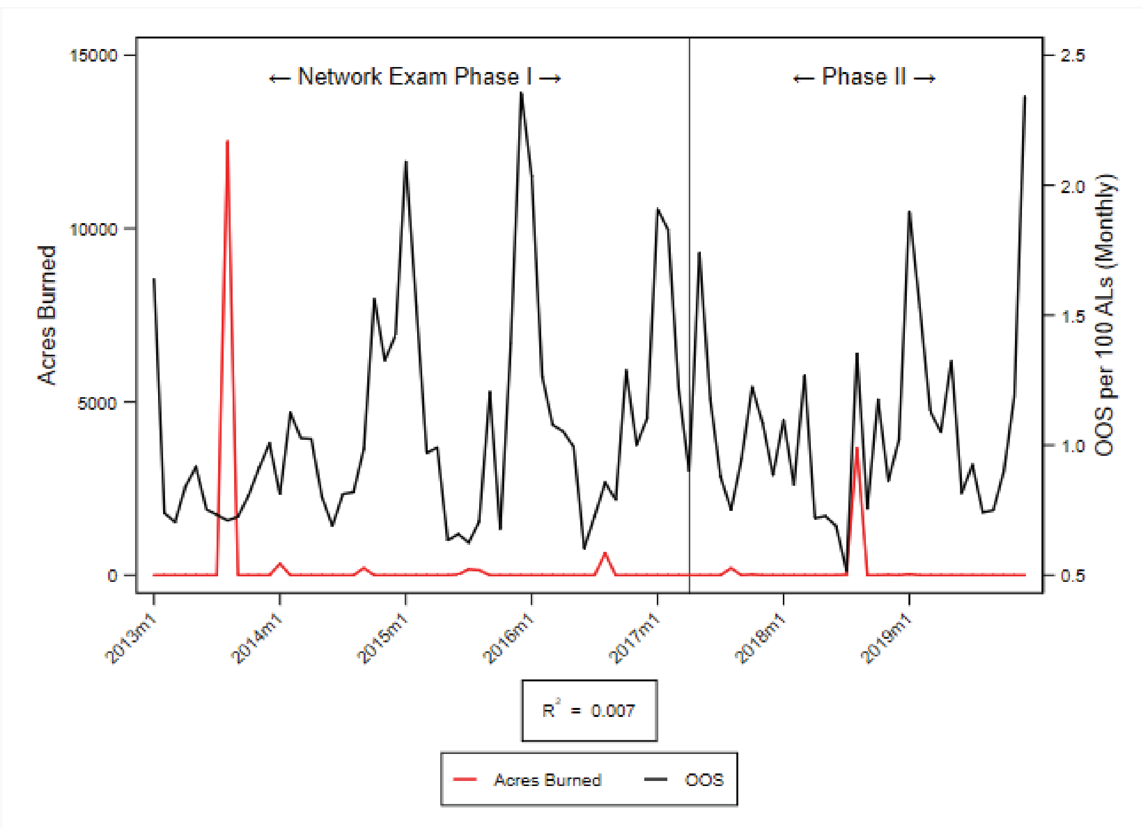




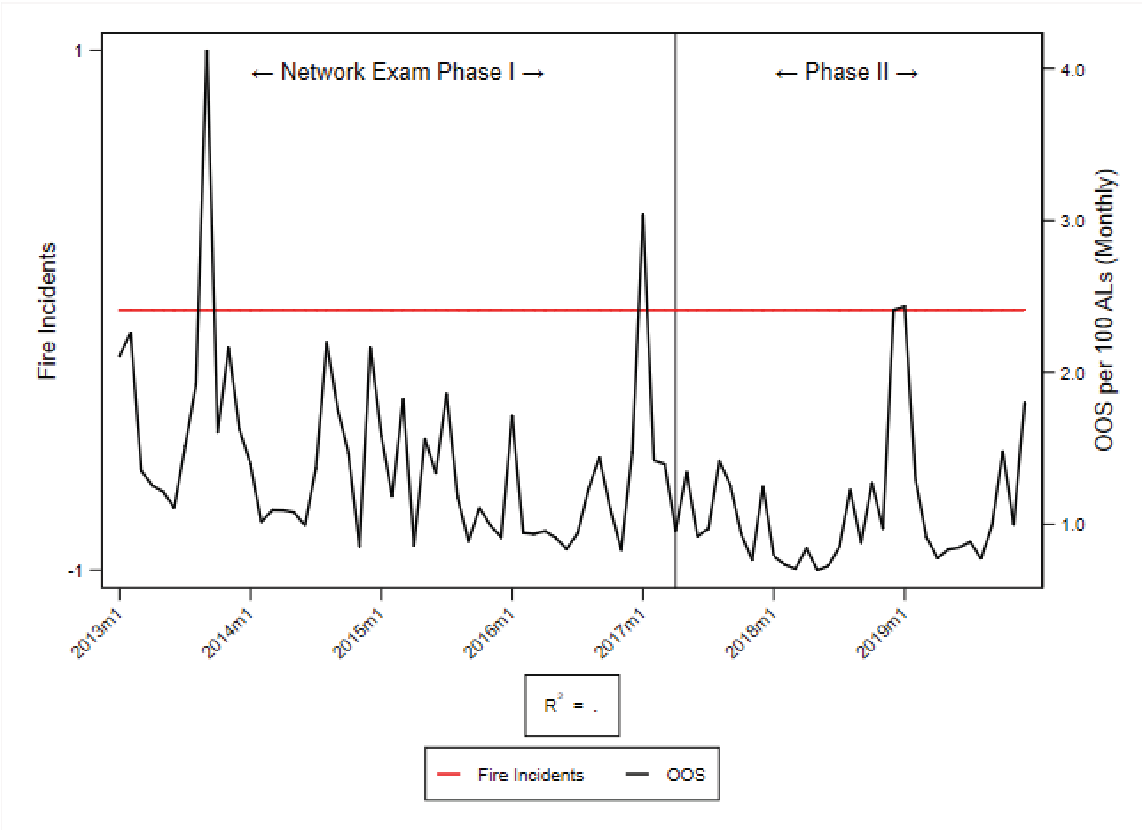
ECONOMICS AND TECHNOLOGY, INC.

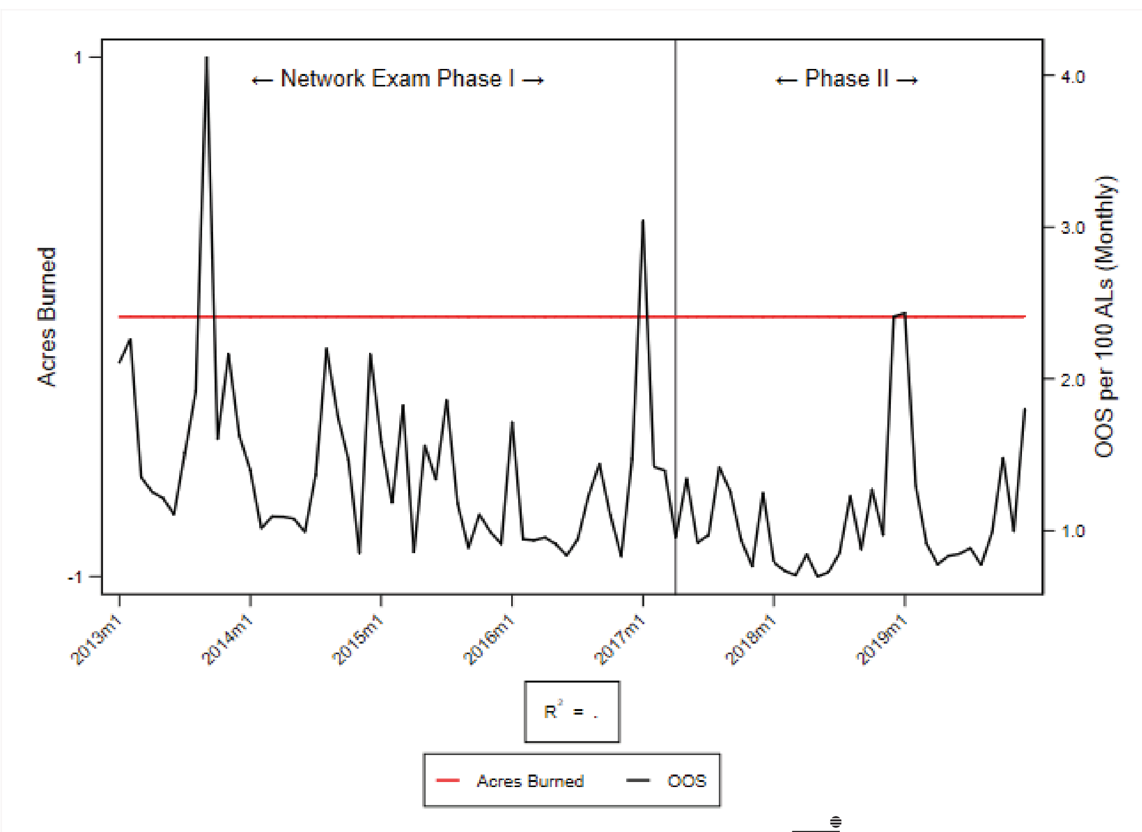
COUNTY-REGION HUMBOLDT - NORTH COAST (AT&T)



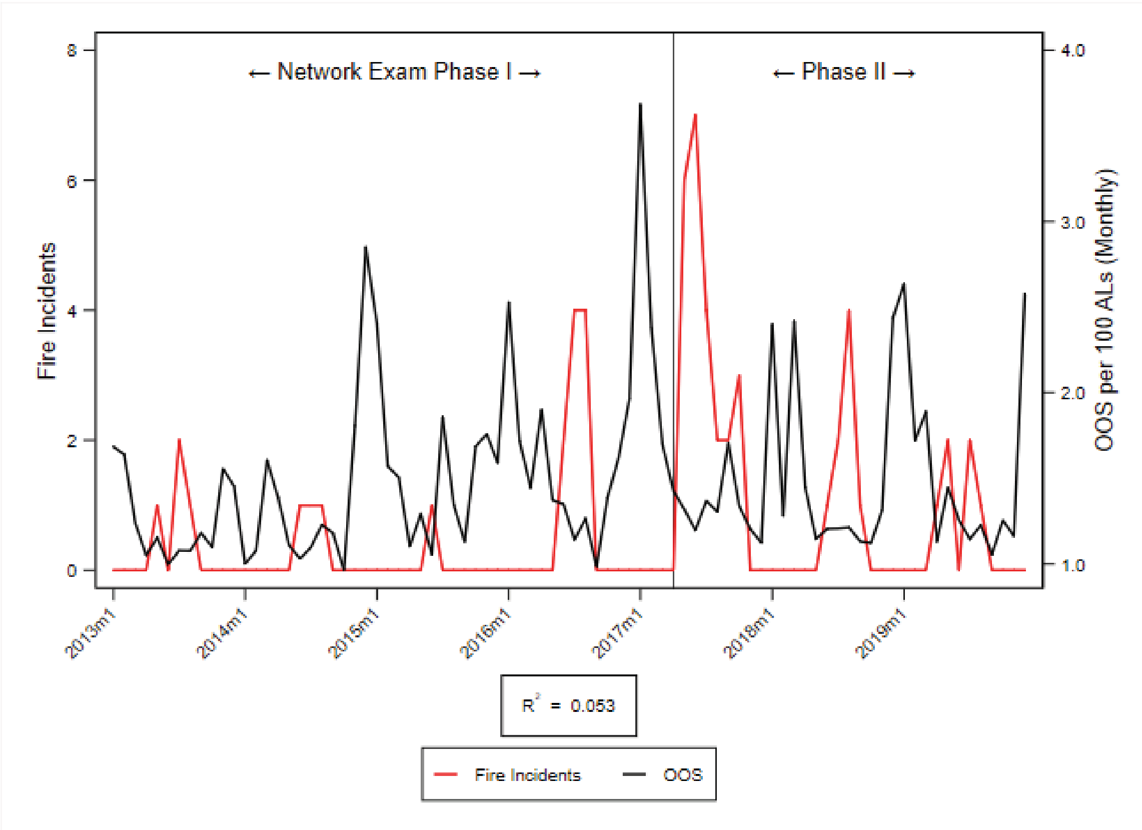


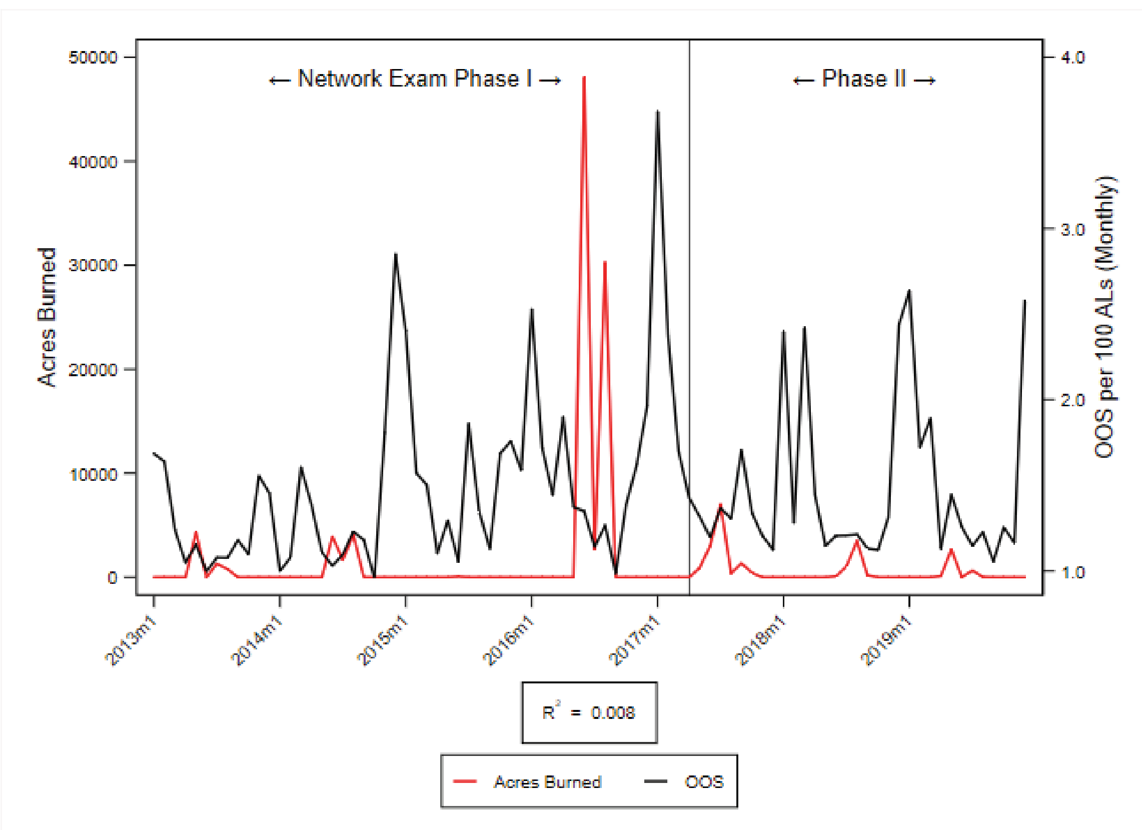
COUNTY-REGION IMPERIAL - SAN DIEGO-IMPERIAL (AT&T)



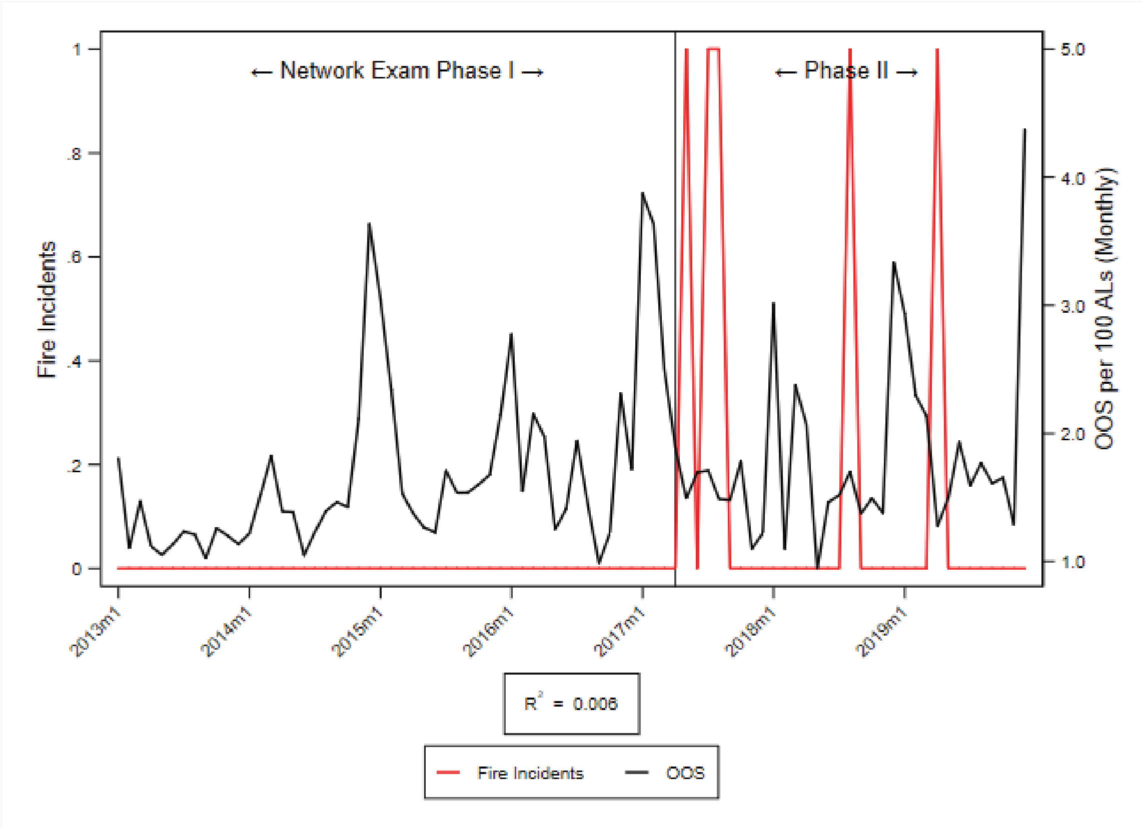


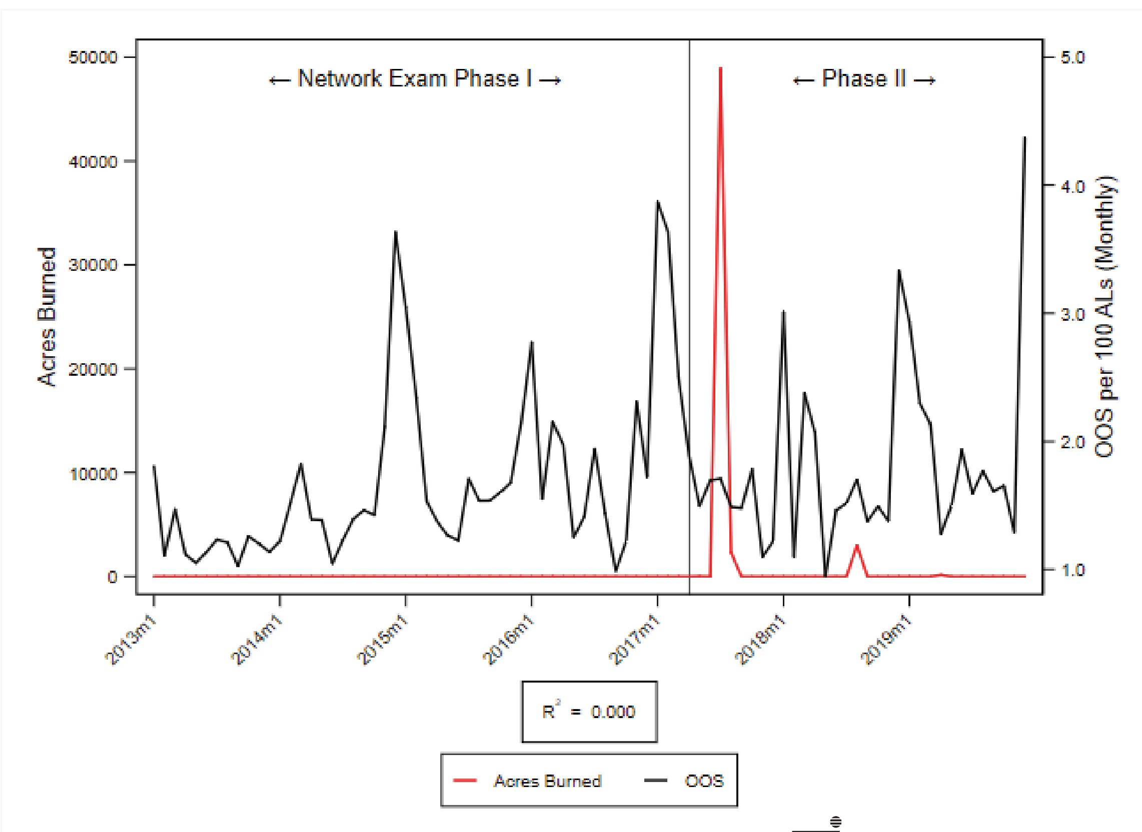
COUNTY-REGION KERN - SOUTHERN SAN JOAQUIN VALLEY (AT&T)





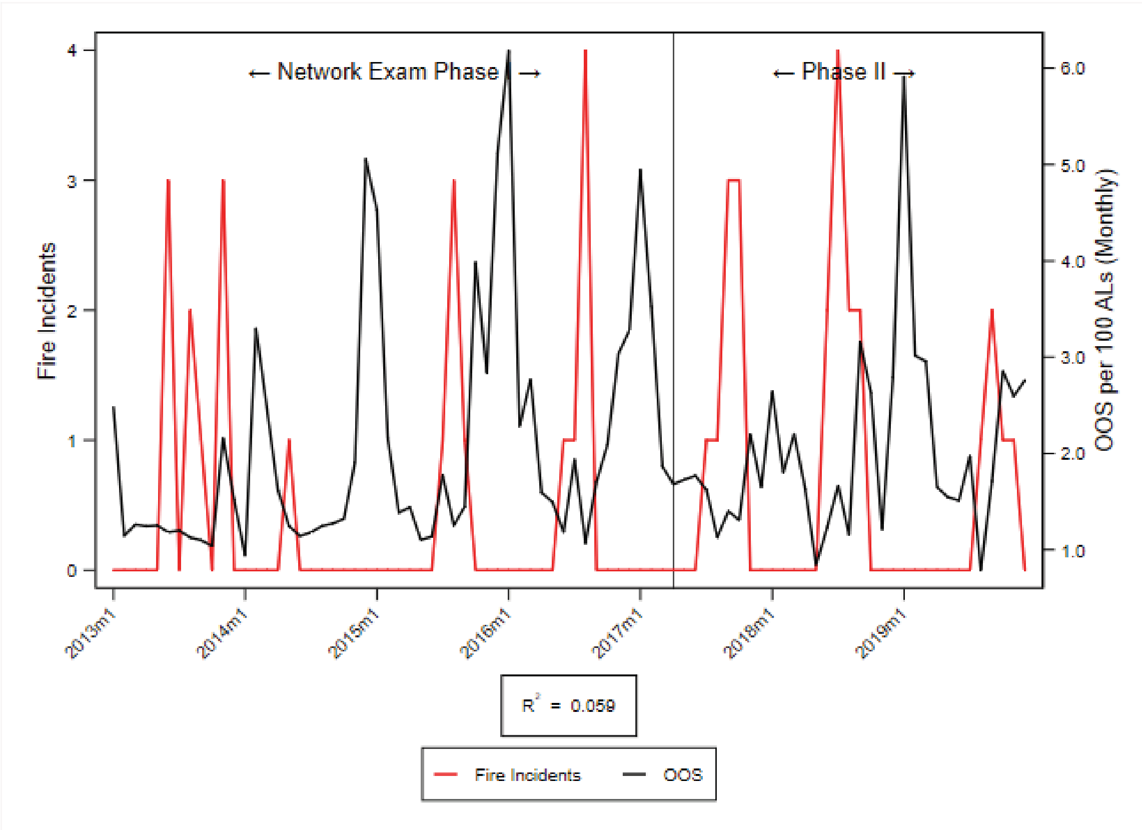
COUNTY-REGION KINGS - SOUTHERN SAN JOAQUIN VALLEY (AT&T)

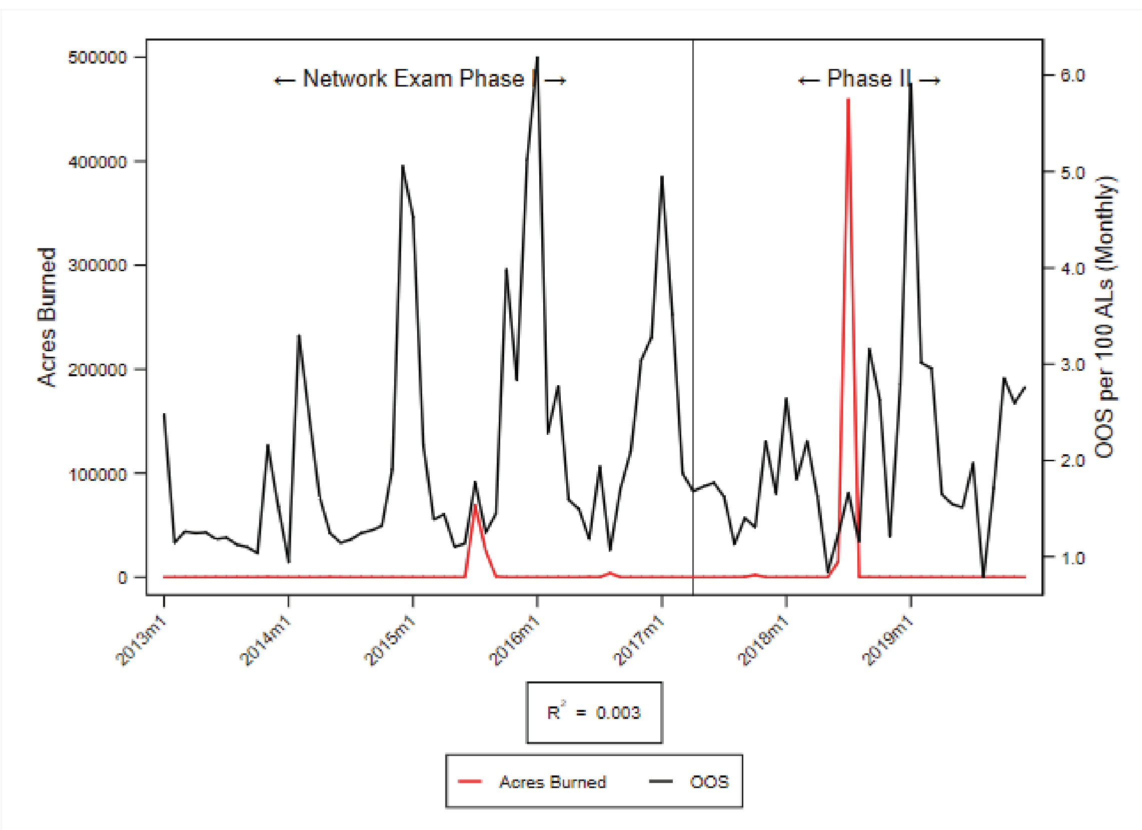




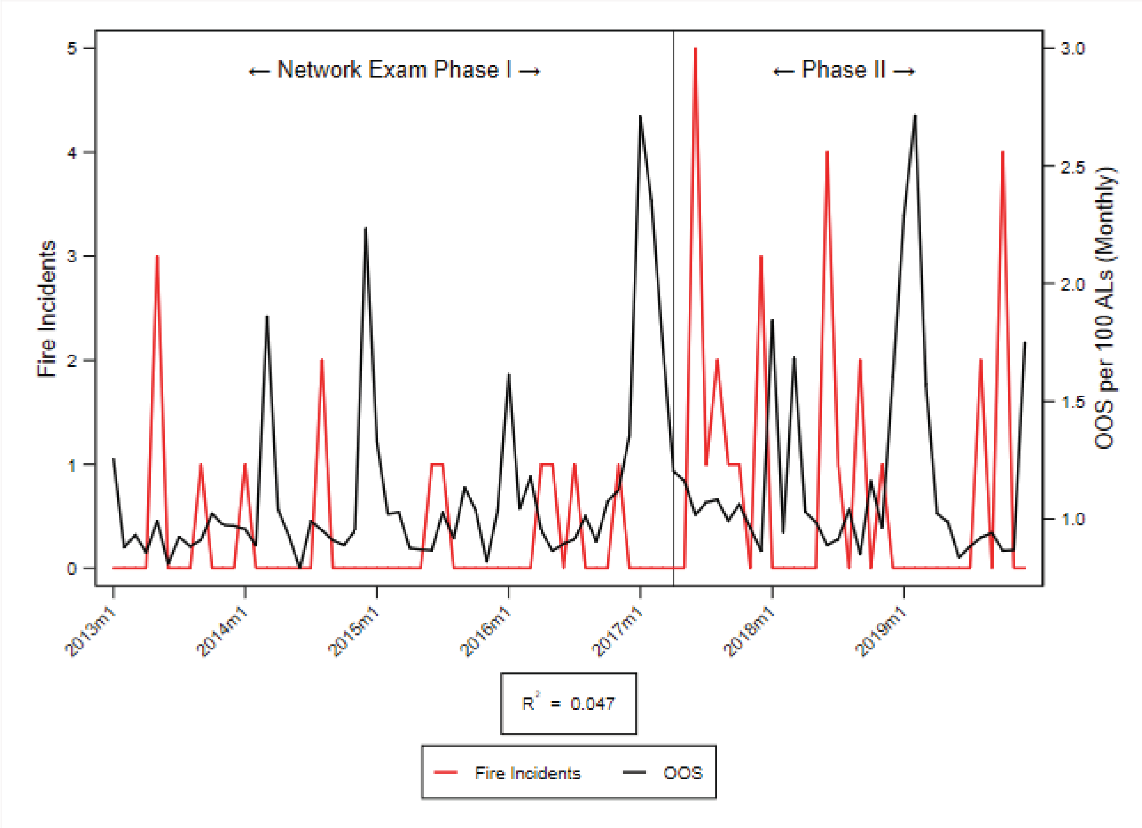
ECONOMICS AND TECHNOLOGY, INC.

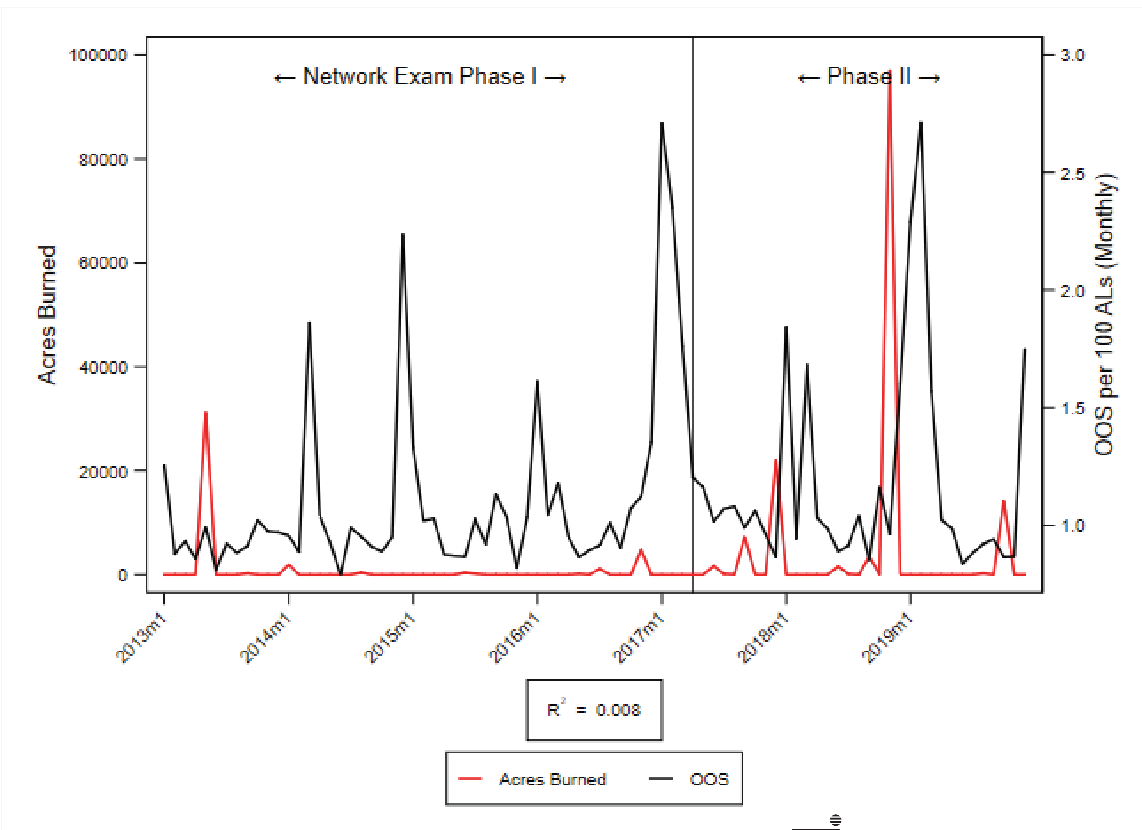
COUNTY-REGION   LAKE - NORTH COAST (AT&T)





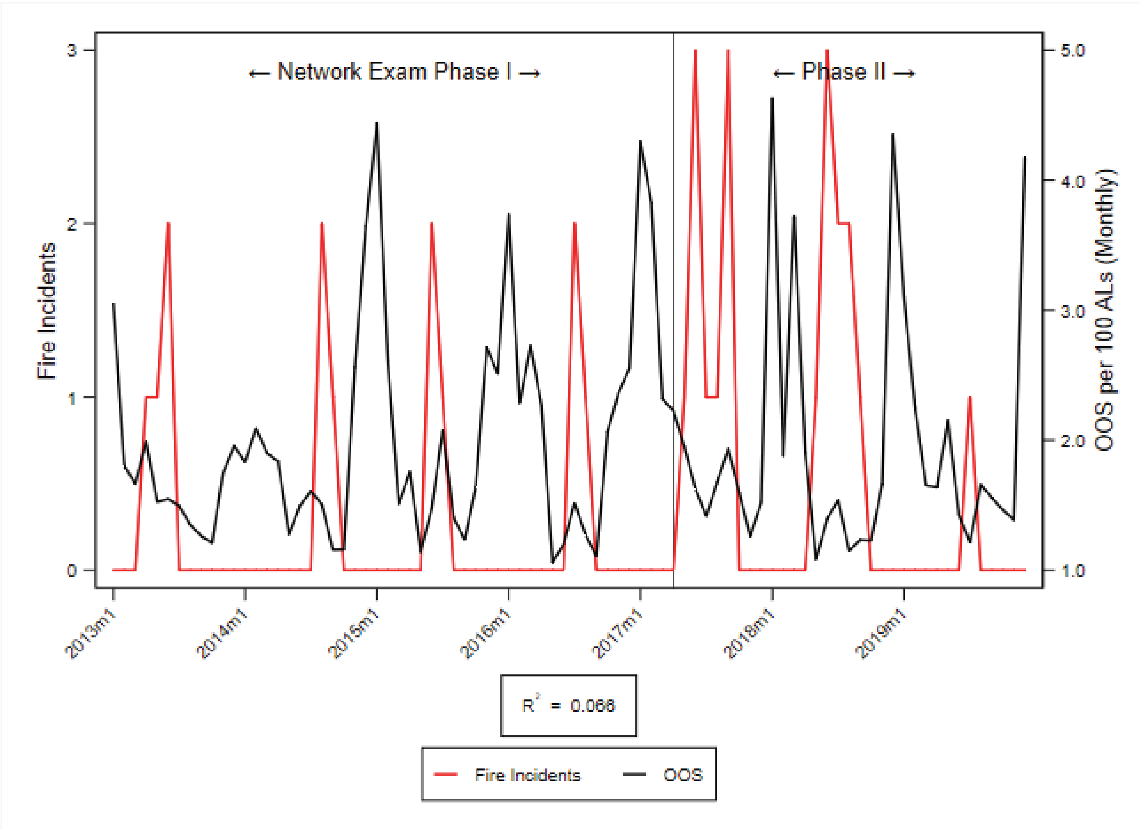
COUNTY-REGION   LOS ANGELES - LOS ANGELES (AT&T)

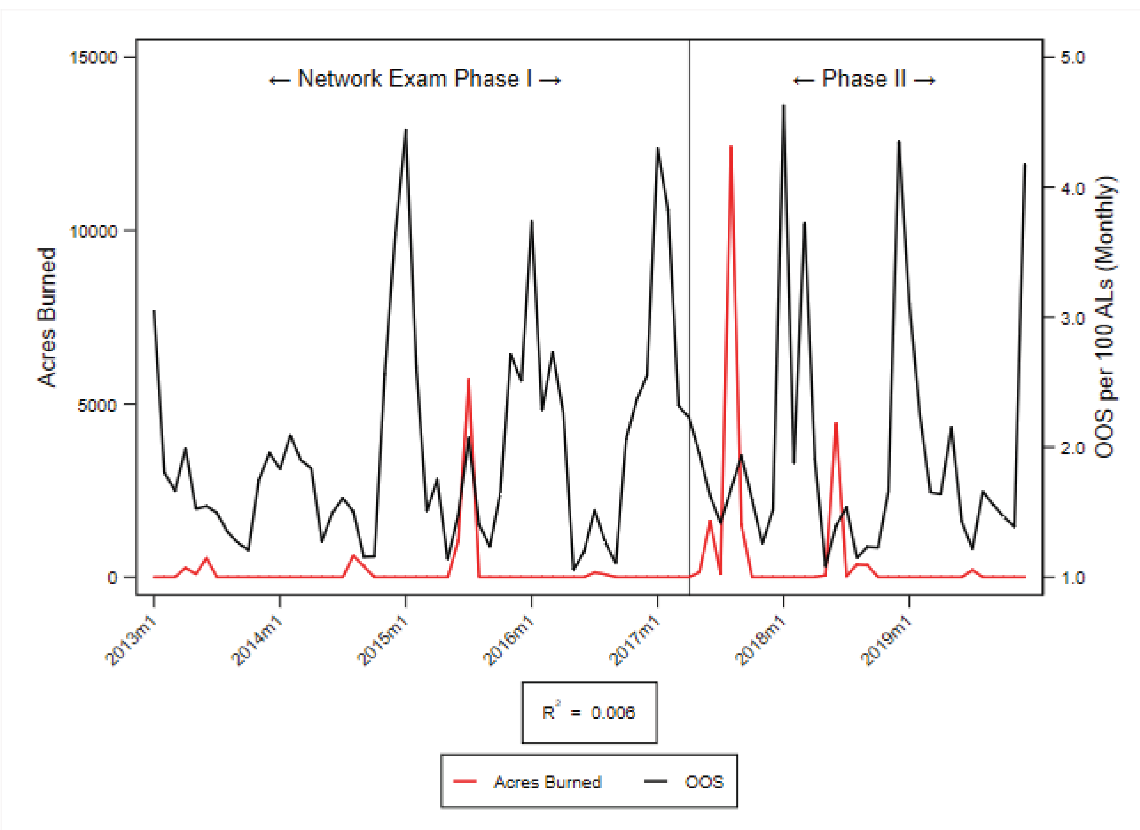




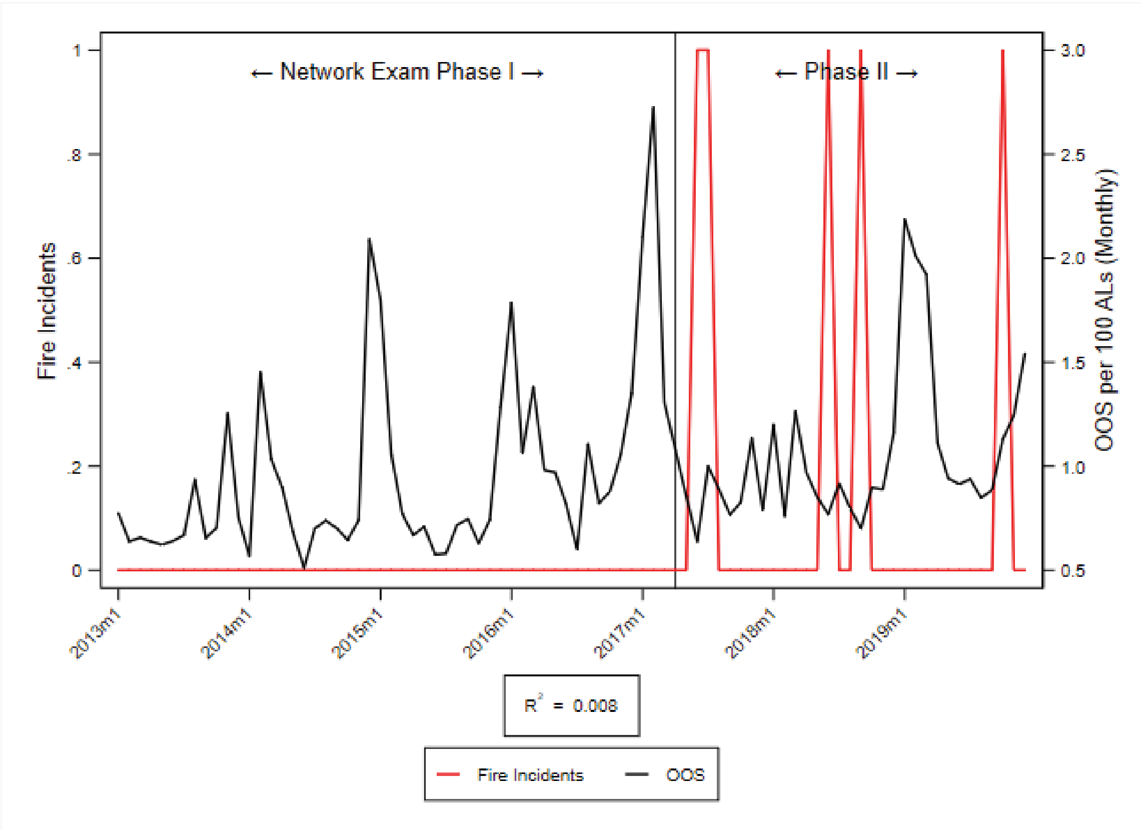
ECONOMICS AND TECHNOLOGY, INC.

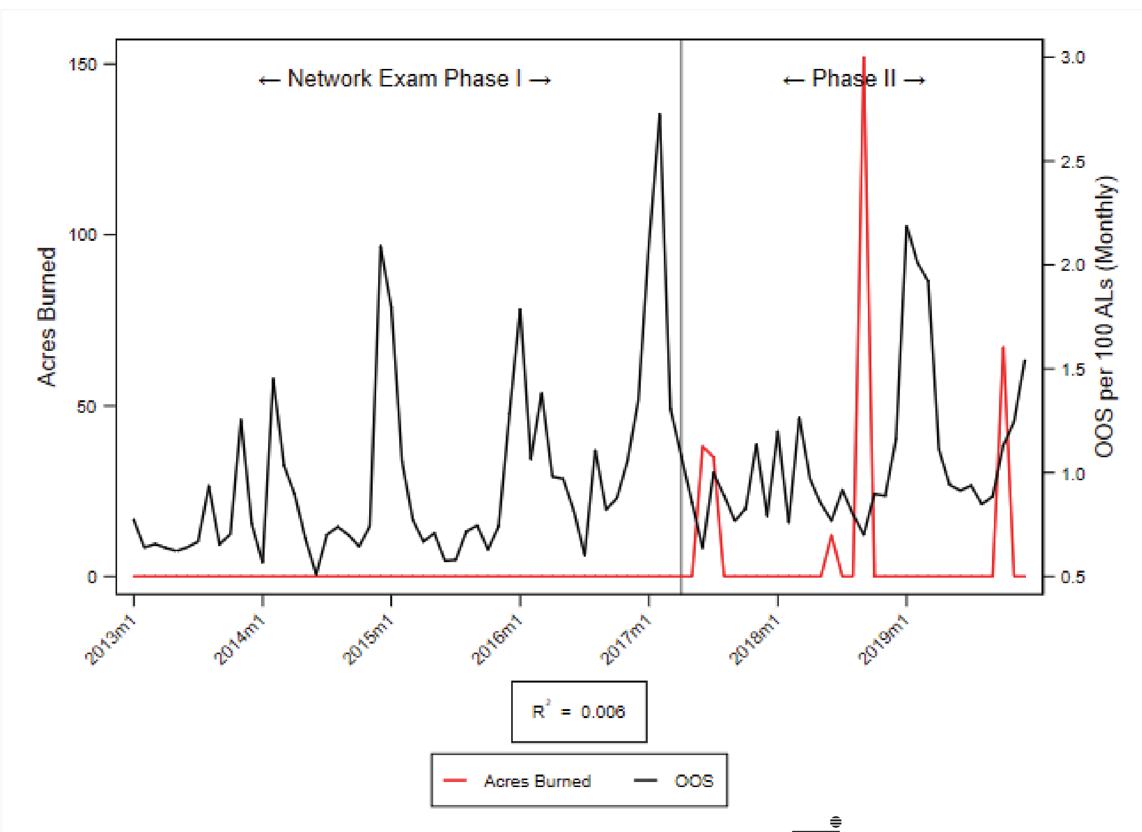
COUNTY-REGION MADERA - NORTHERN SAN JOAQUIN VALLEY (AT&T)





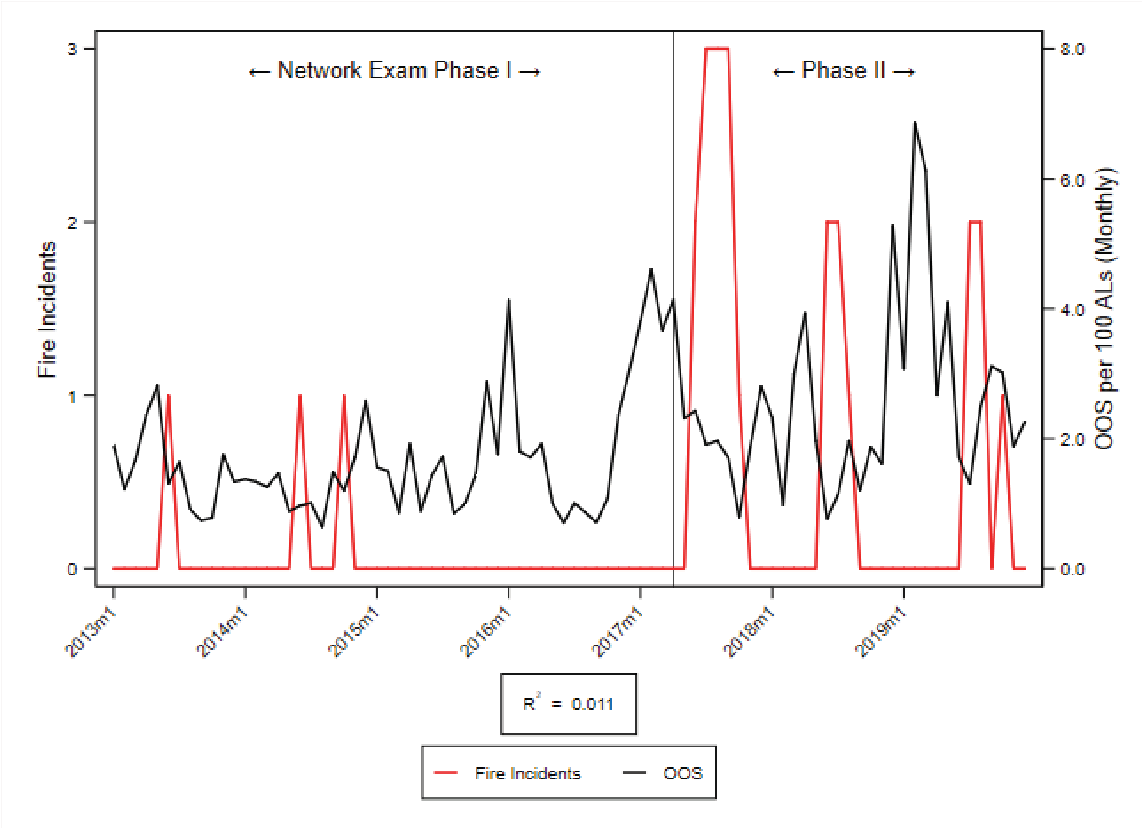
COUNTY-REGION   MARIN - SAN FRANCISCO BAY AREA (AT&T)

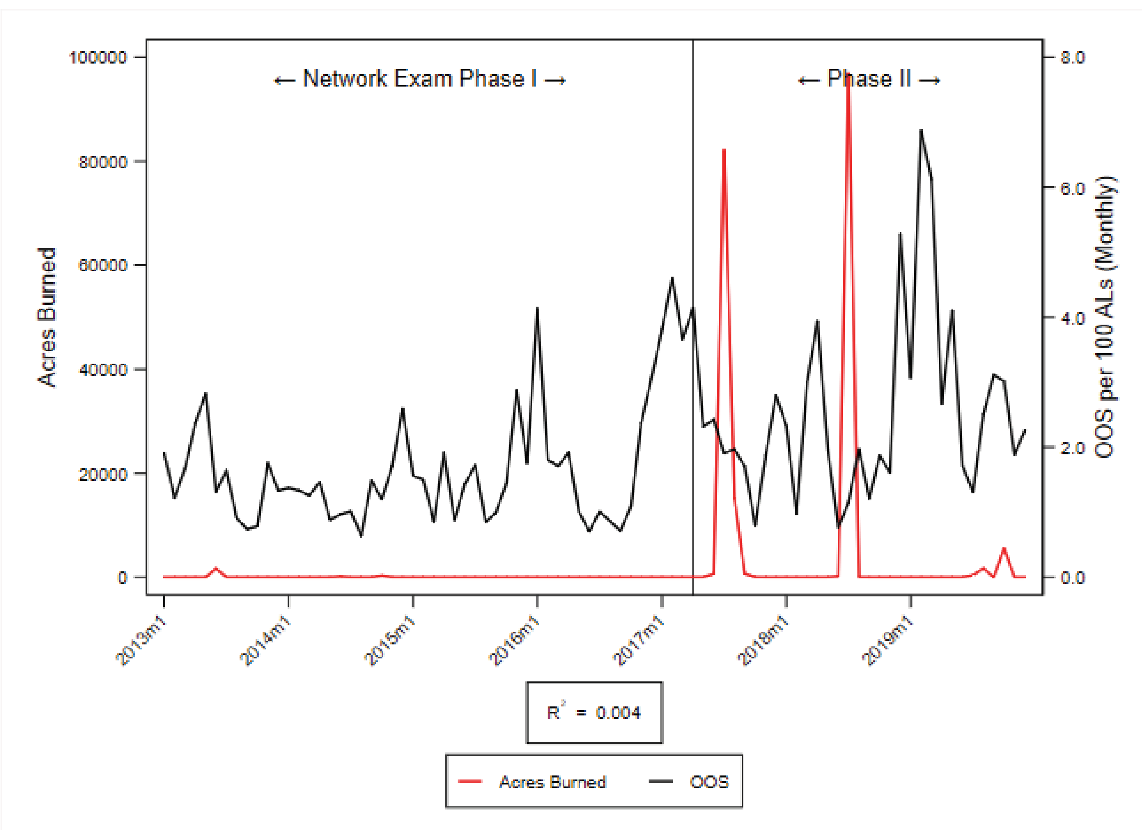




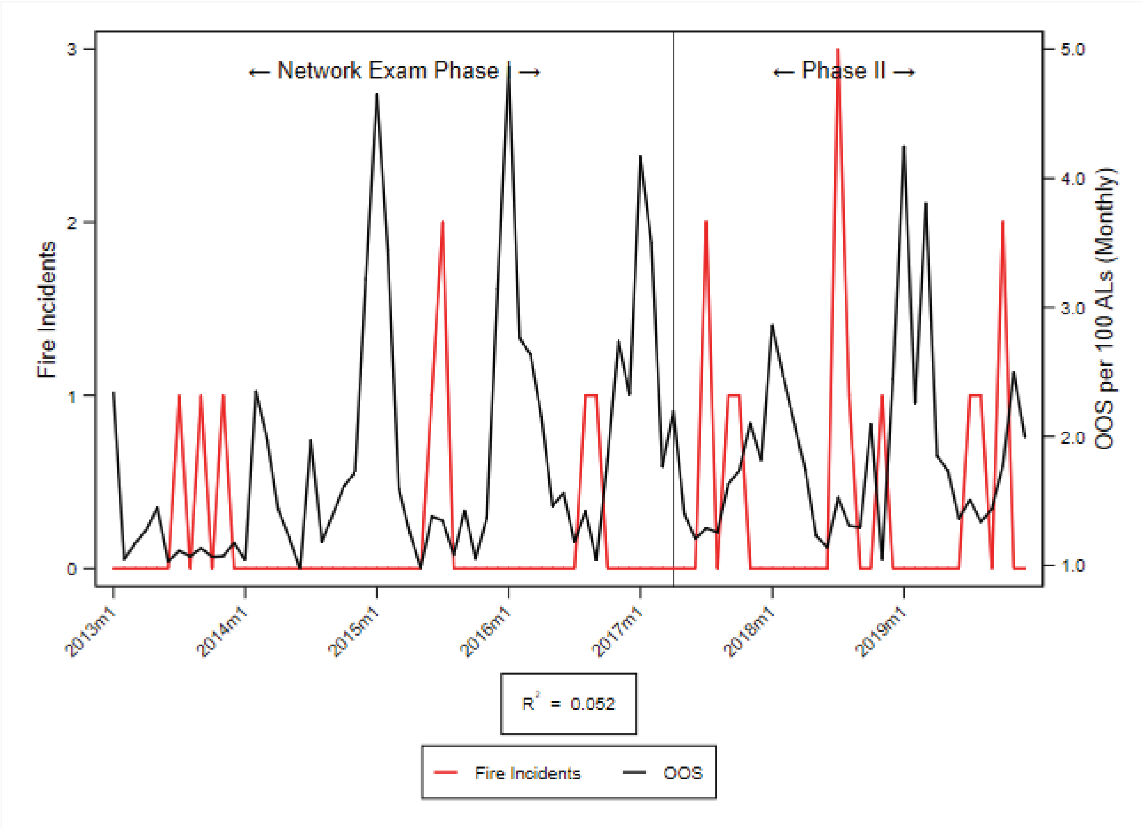
ECONOMICS AND TECHNOLOGY, INC.

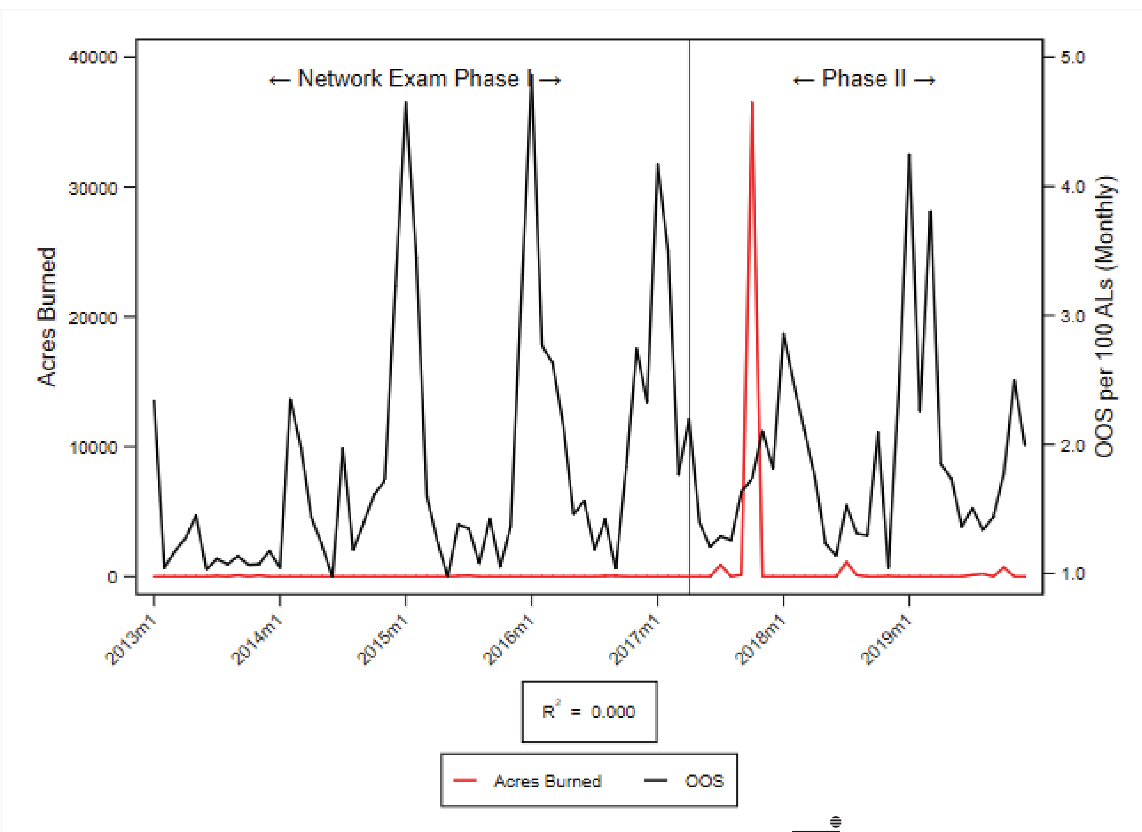
COUNTY-REGION MARIPOSA - NORTHERN SAN JOAQUIN VALLEY (AT&T)





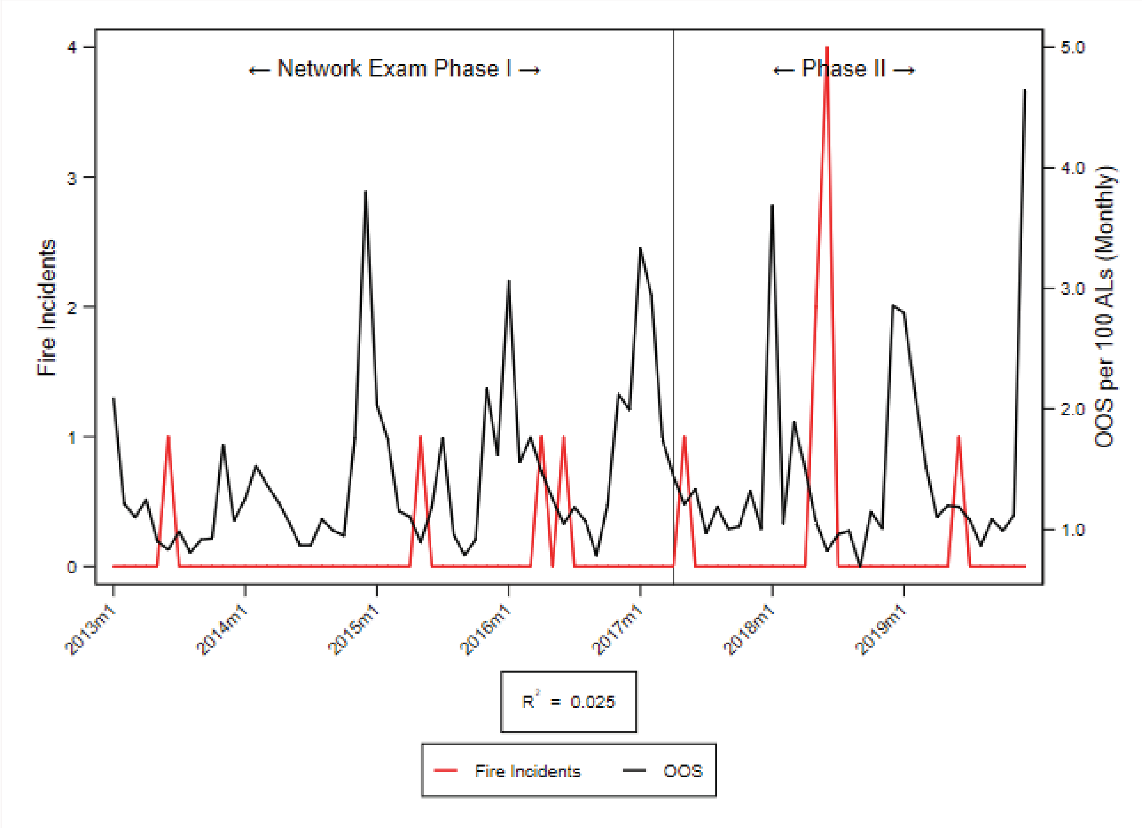
COUNTY-REGION MENDOCINO - NORTH COAST (AT&T)

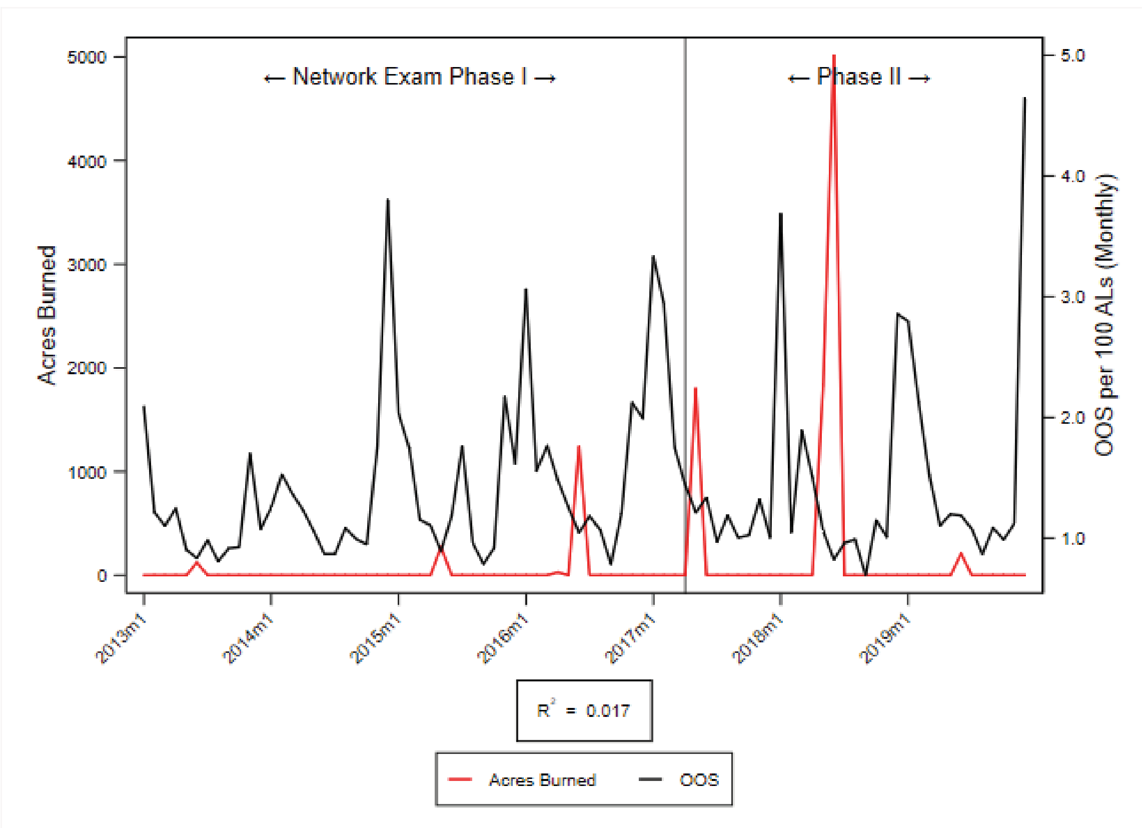




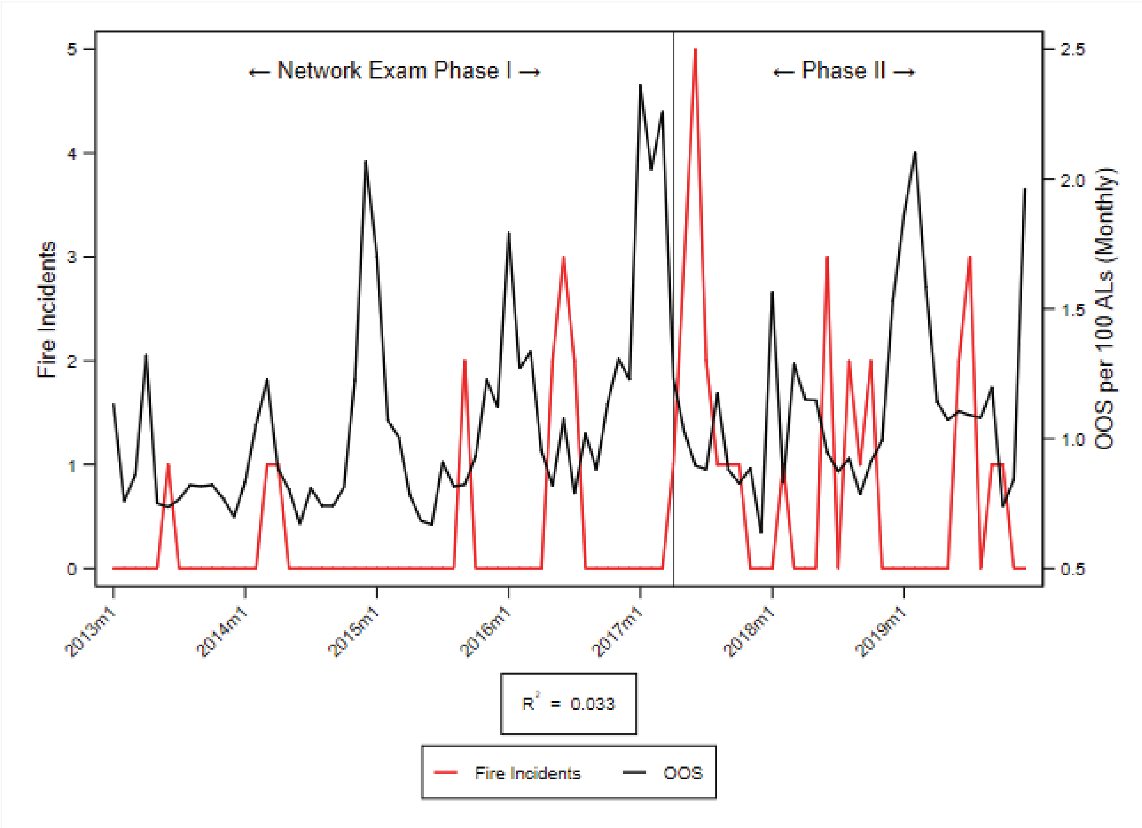
ECONOMICS AND TECHNOLOGY, INC.

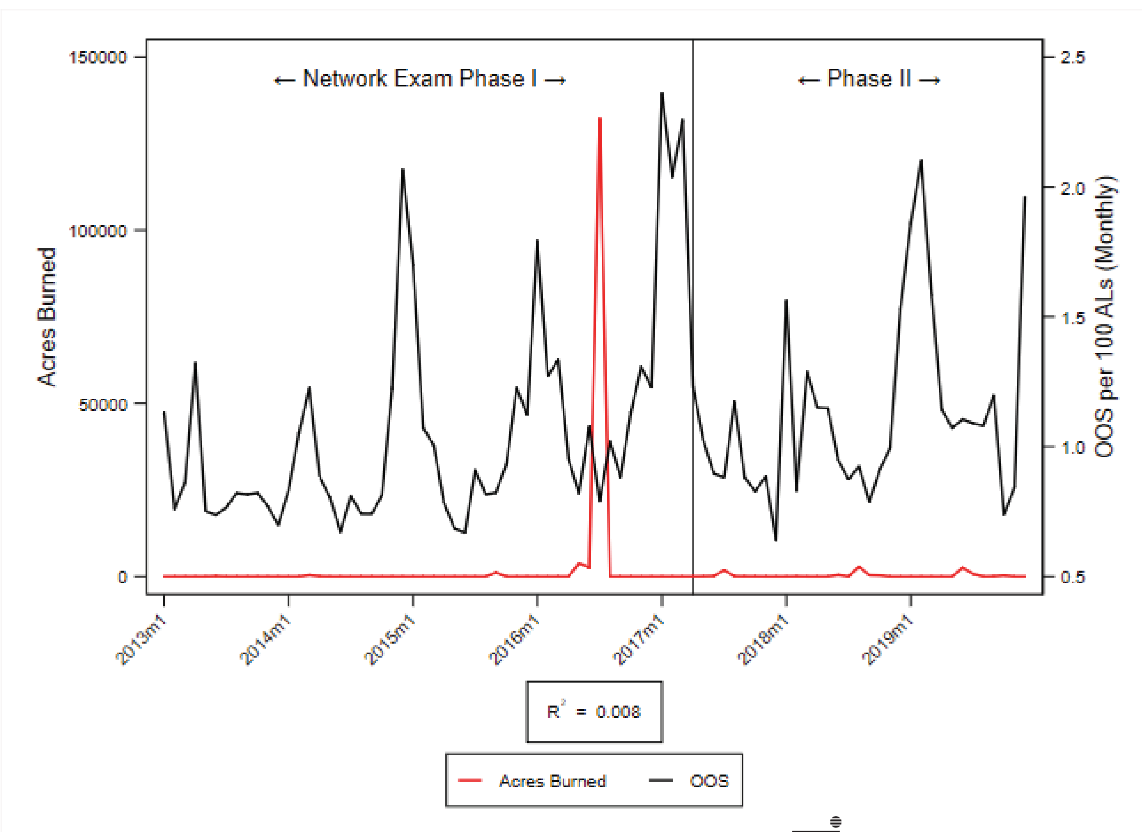
COUNTY-REGION MERCED - NORTHERN SAN JOAQUIN VALLEY (AT&T)





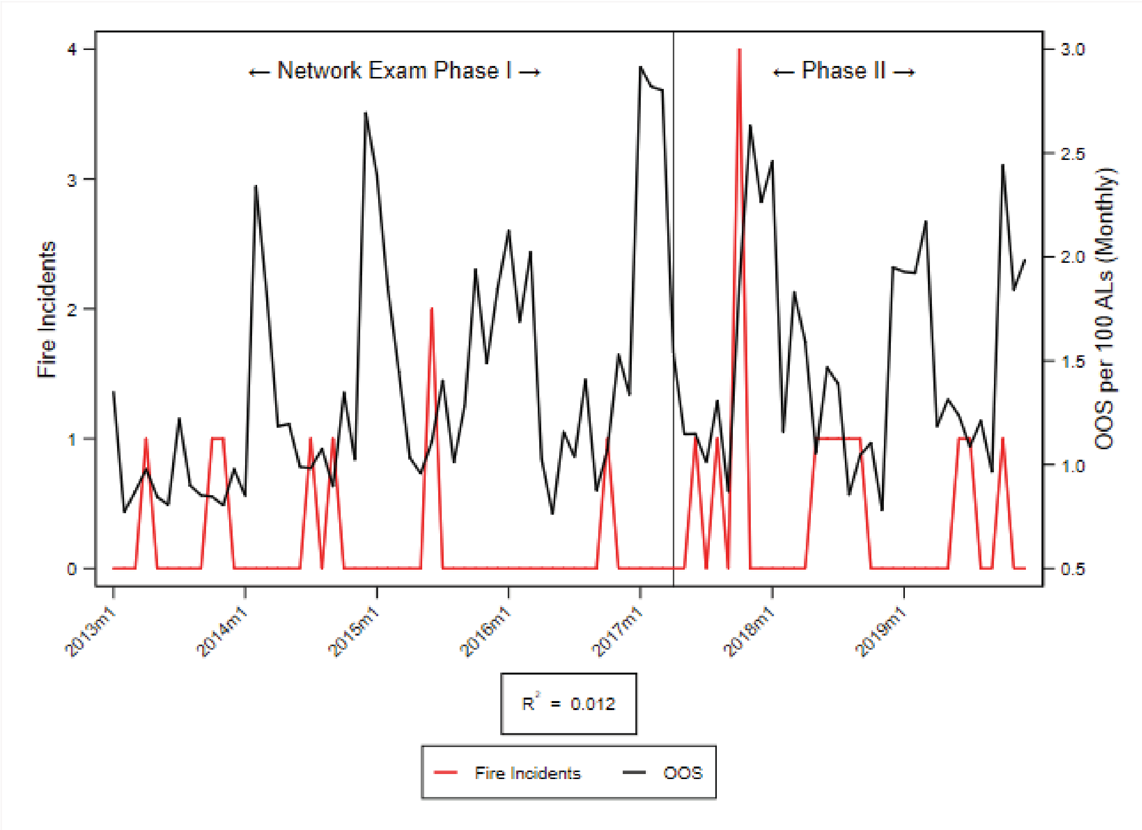
COUNTY-REGION MONTEREY - CENTRAL COAST (AT&T)

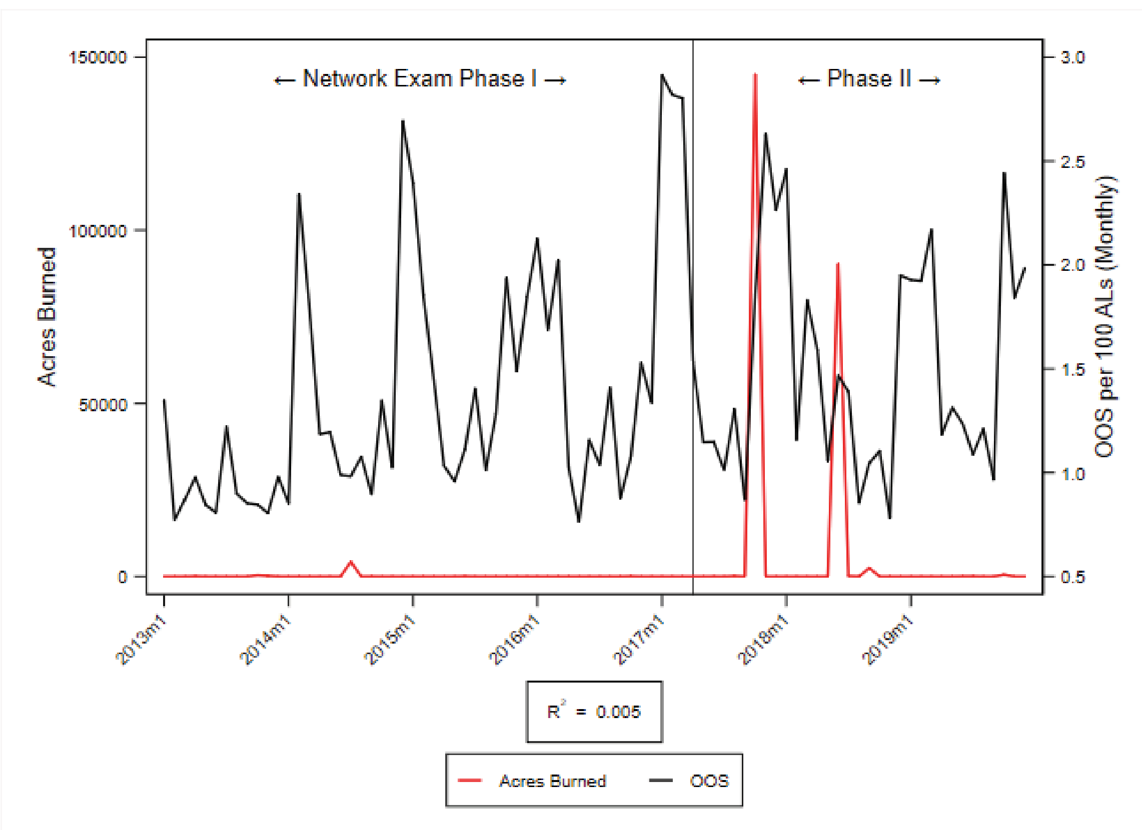




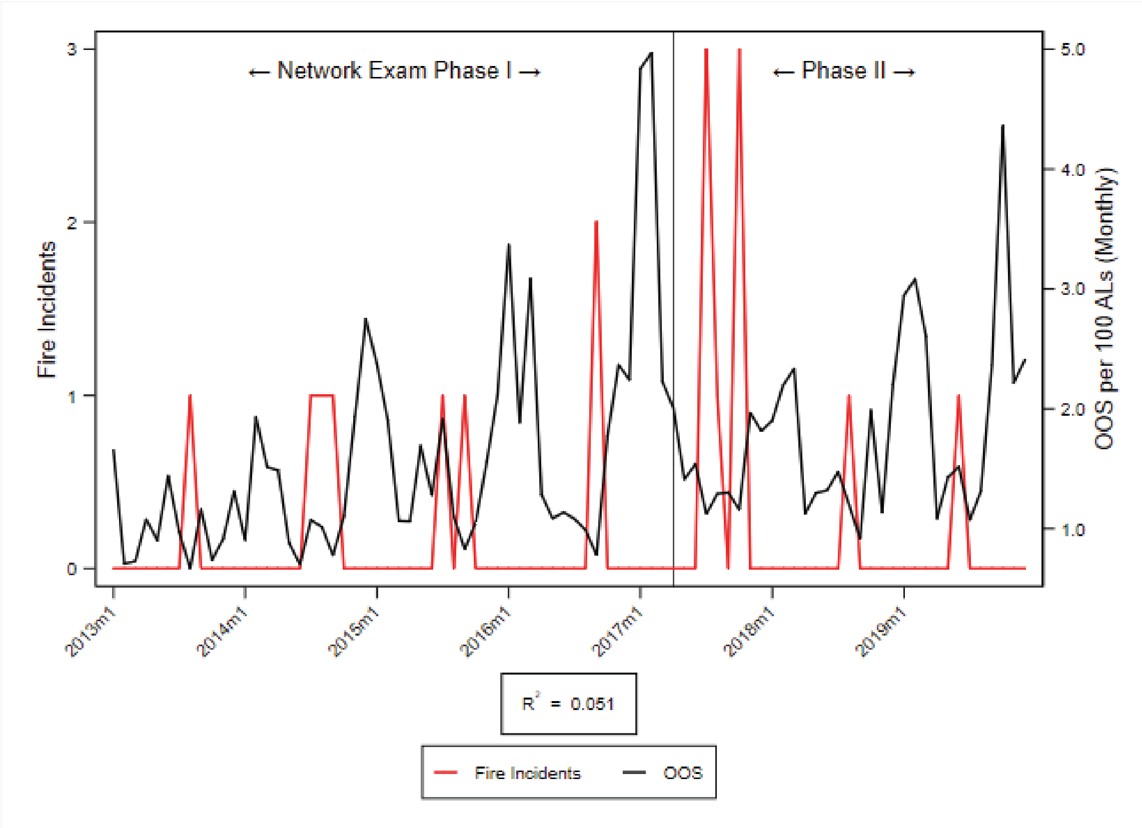
ECONOMICS AND TECHNOLOGY, INC.

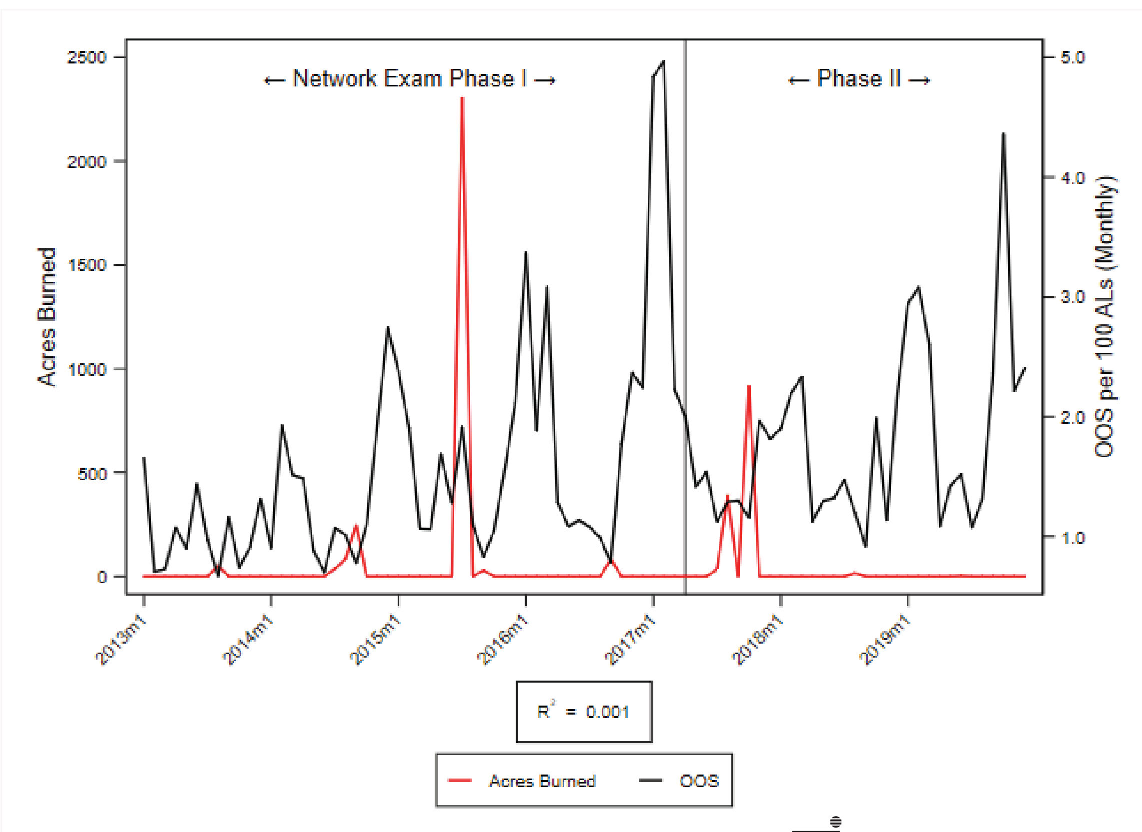
COUNTY-REGION NAPA - NORTH COAST (AT&T)





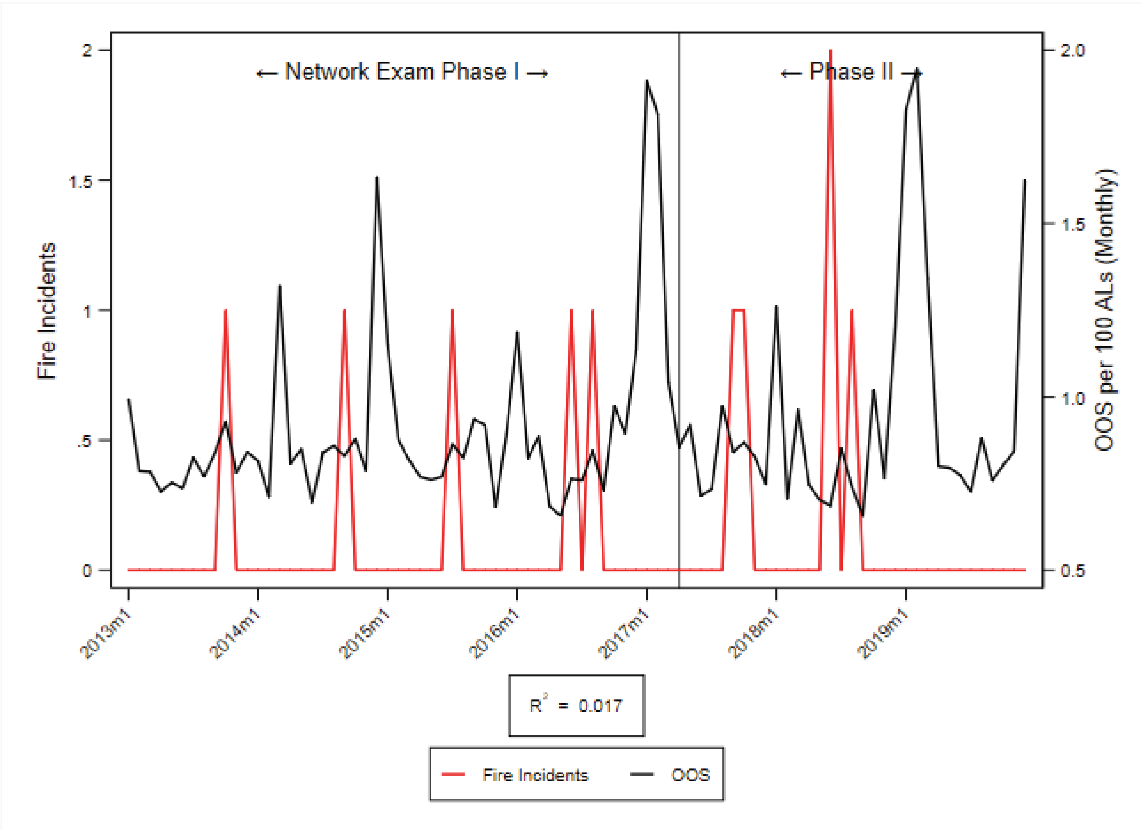
COUNTY-REGION NEVADA - SUPERIOR CALIFORNIA (AT&T)

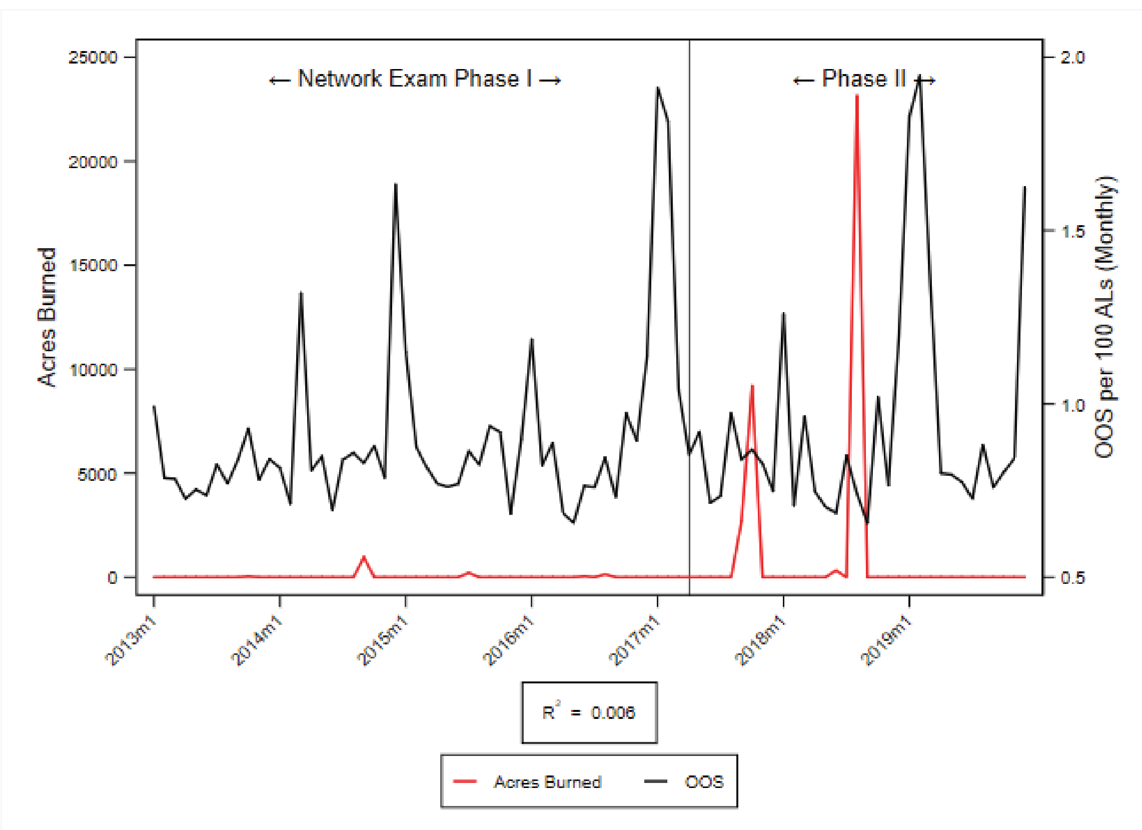




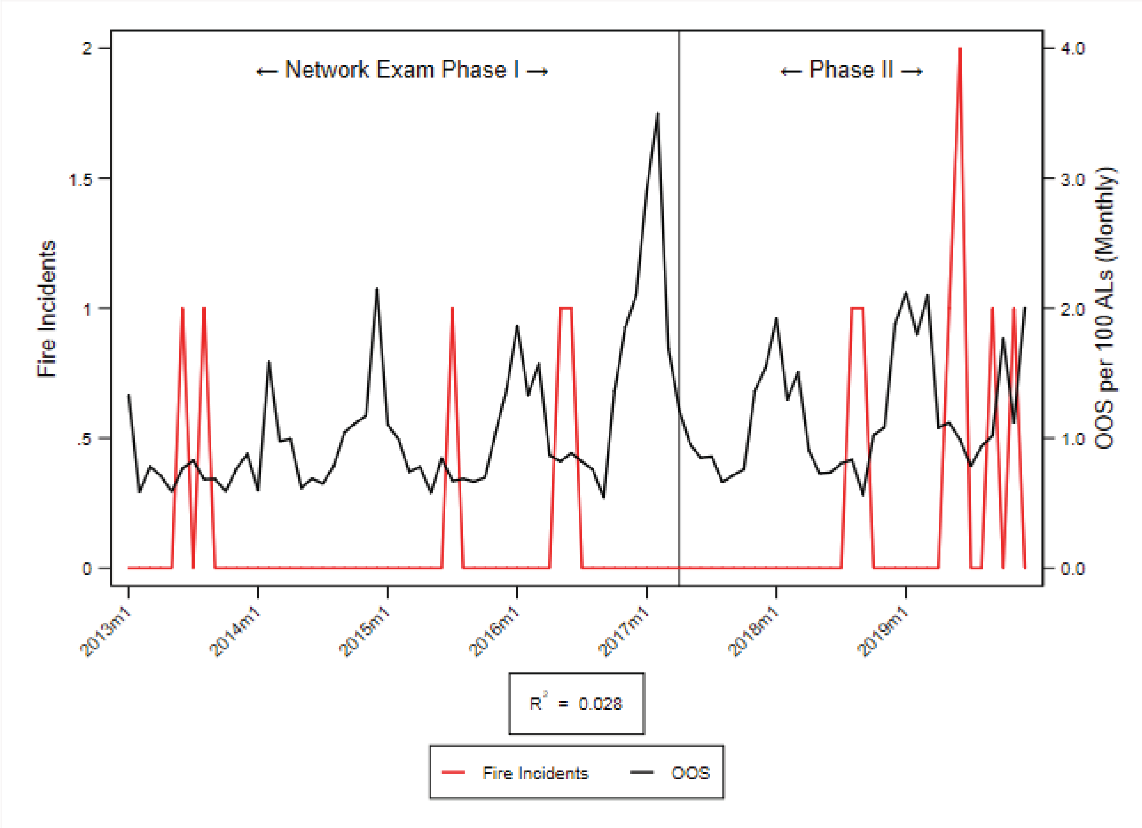
ECONOMICS AND TECHNOLOGY, INC.

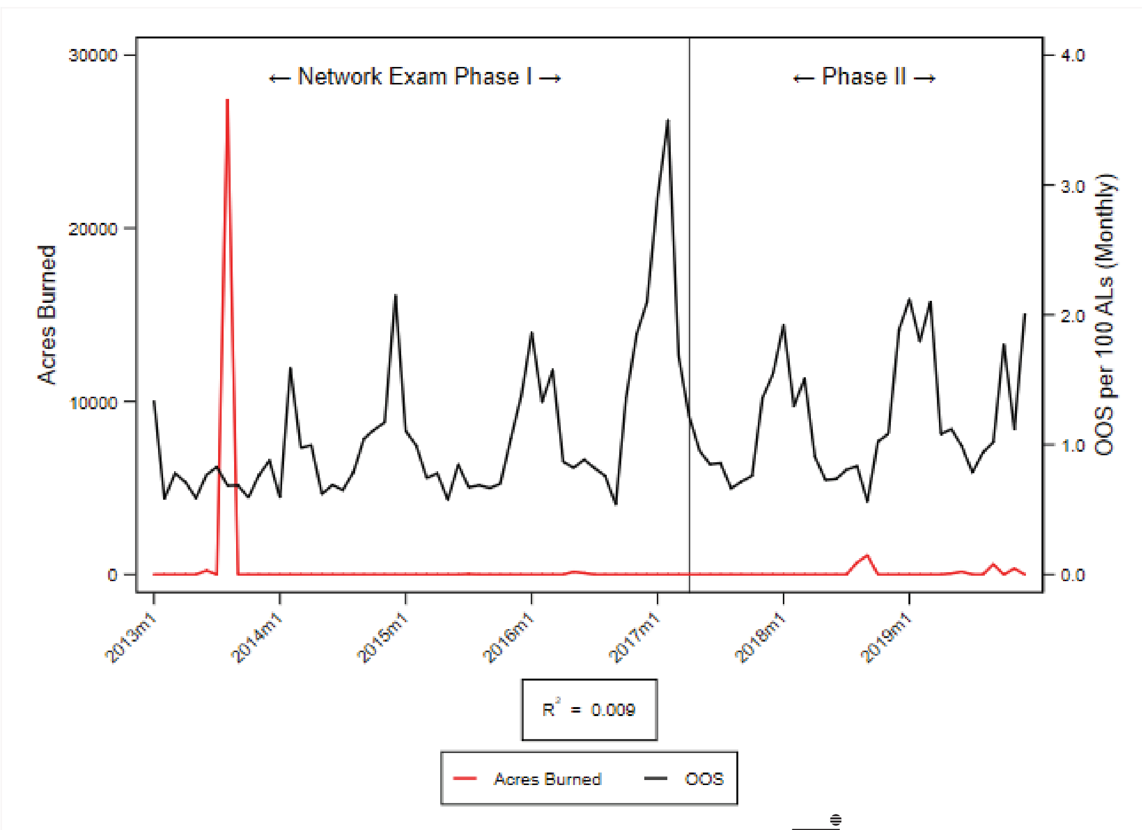
COUNTY-REGION ORANGE - ORANGE (AT&T)





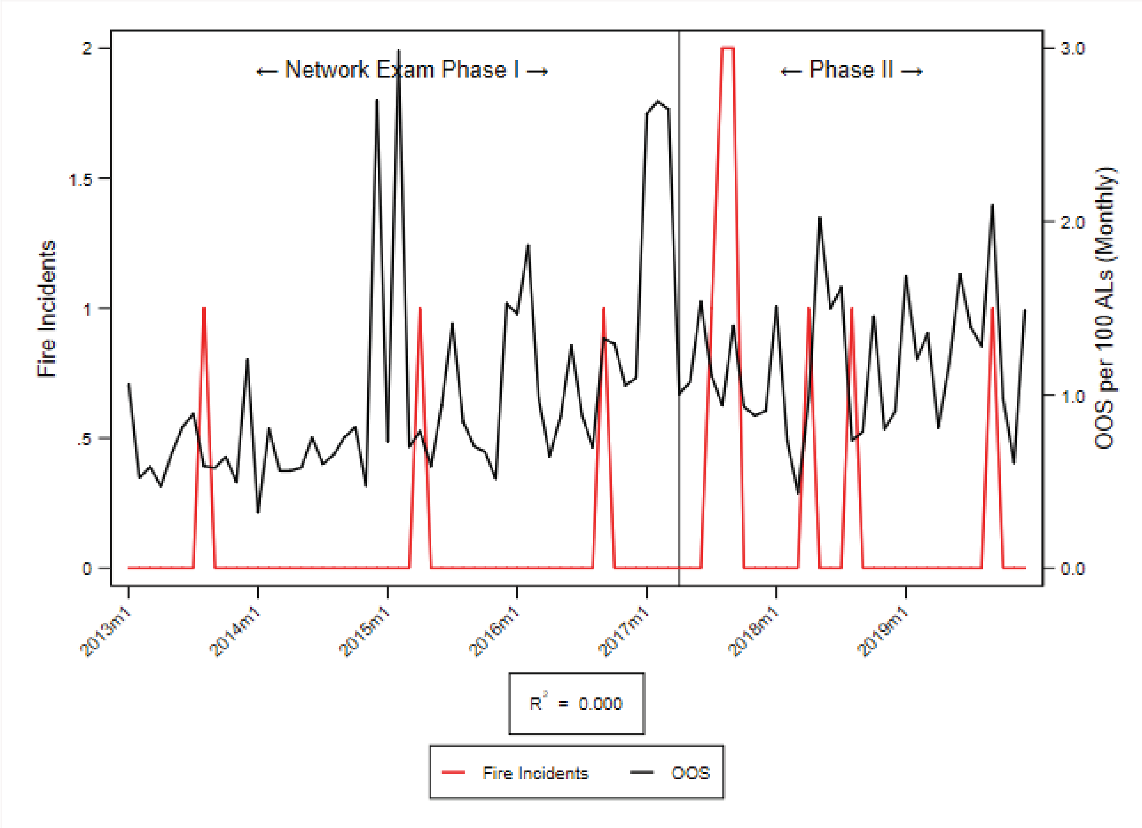
COUNTY-REGION PLACER - SUPERIOR CALIFORNIA (AT&T)

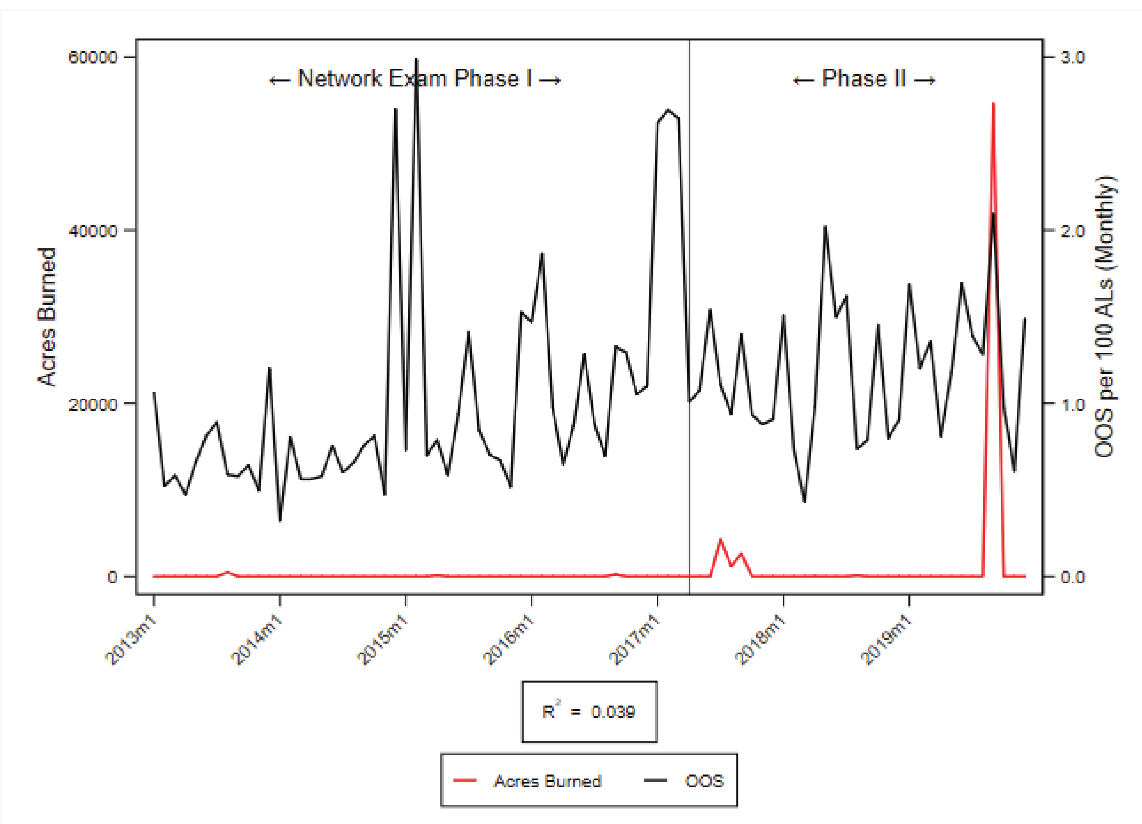




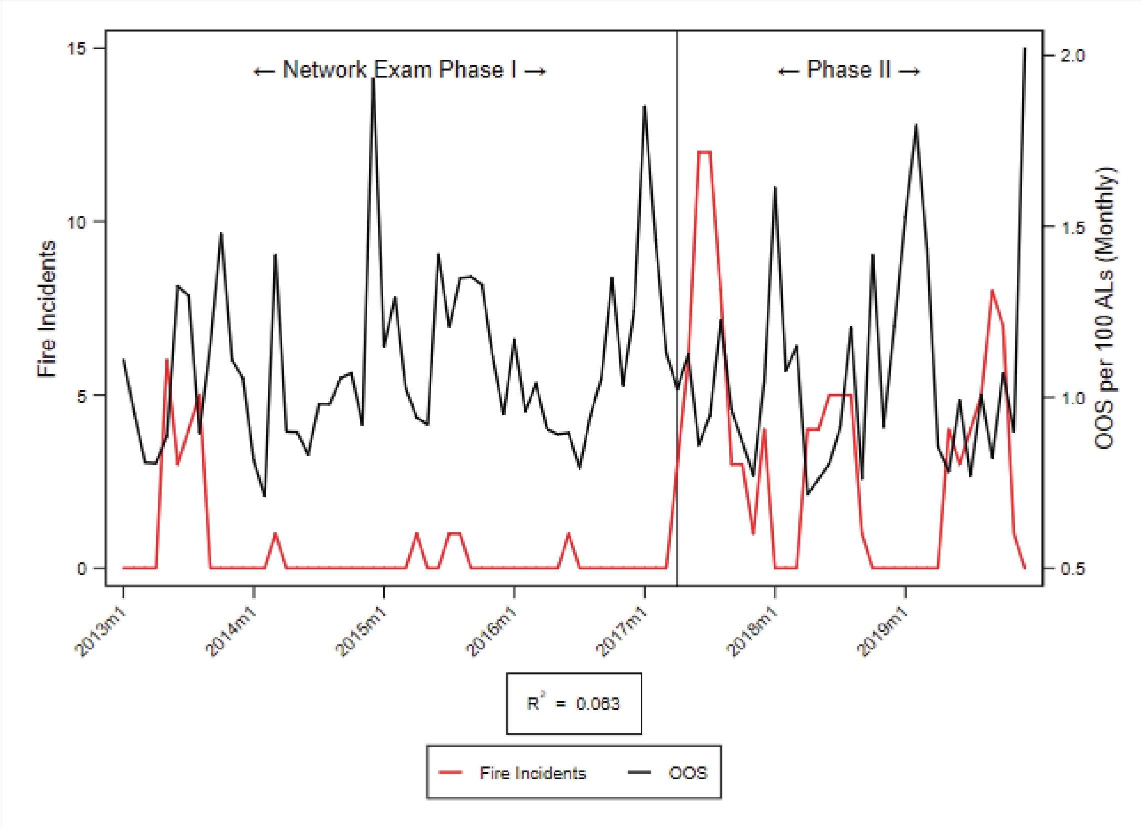
ECONOMICS AND TECHNOLOGY, INC.

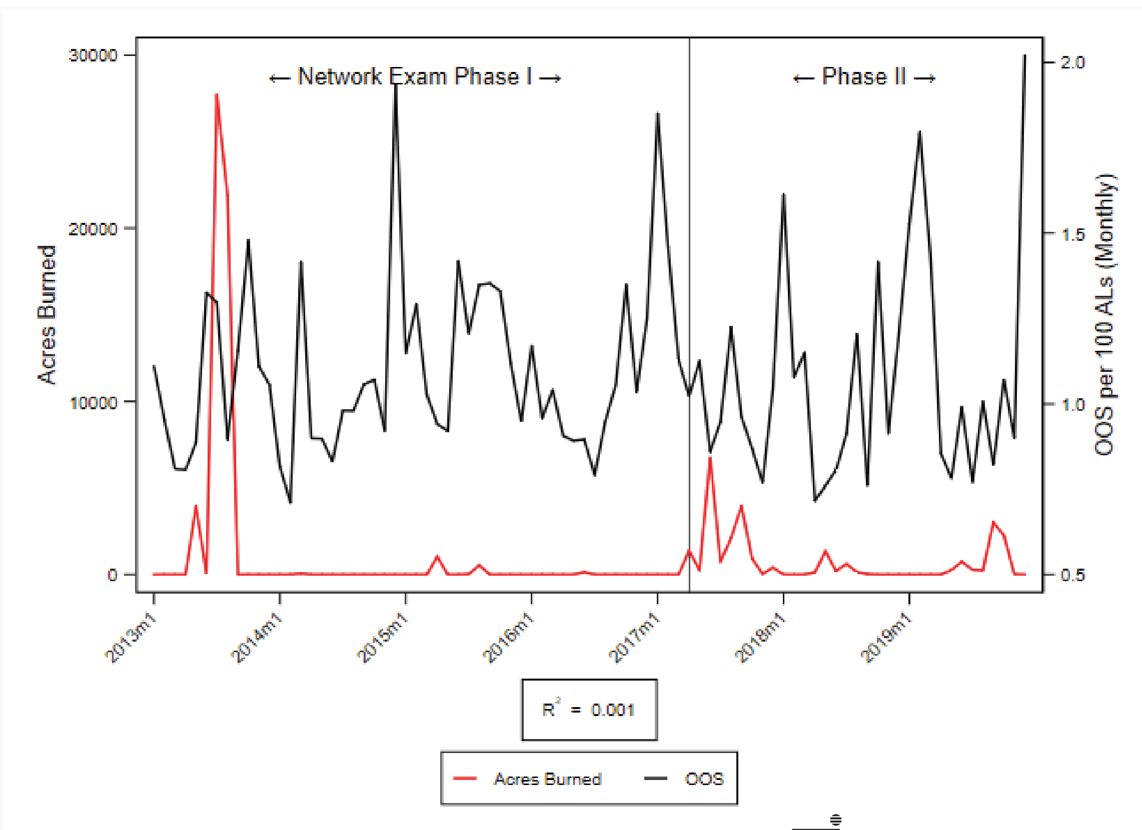
COUNTY-REGION PLUMAS - SUPERIOR CALIFORNIA (AT&T)





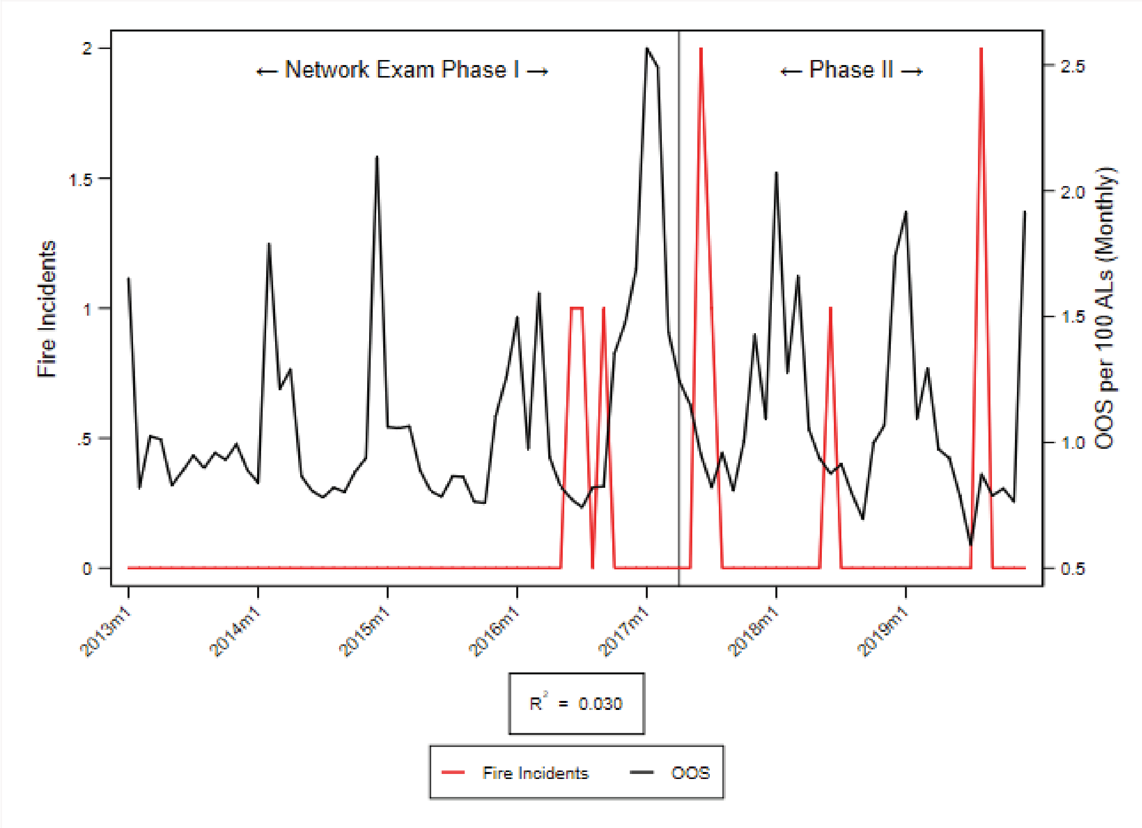
COUNTY-REGION   RIVERSIDE - INLAND EMPIRE (AT&T)

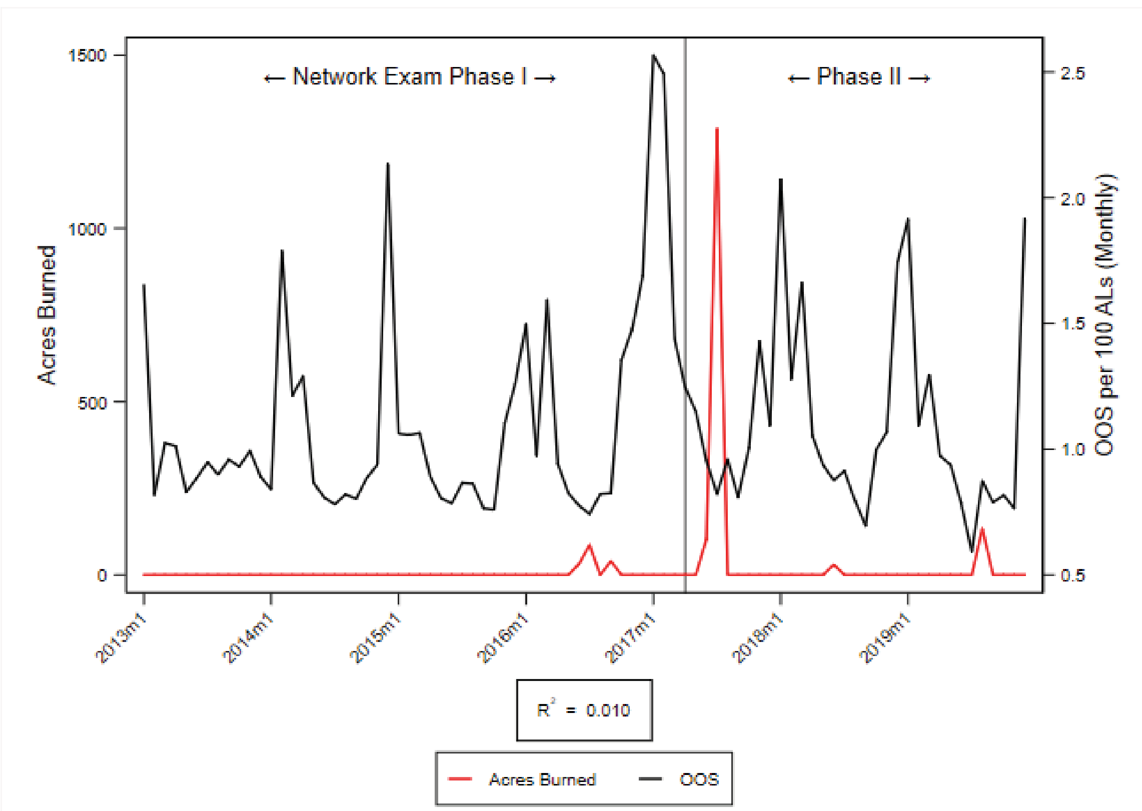




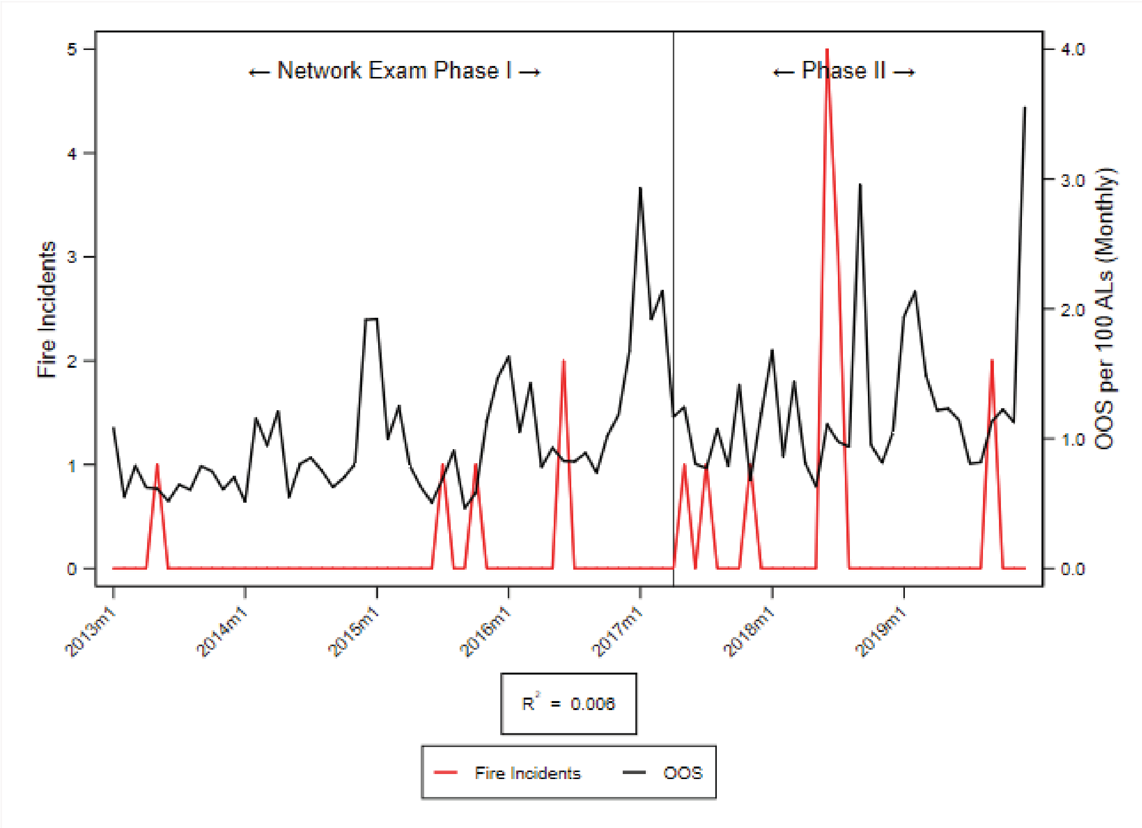
ECONOMICS AND TECHNOLOGY, INC.

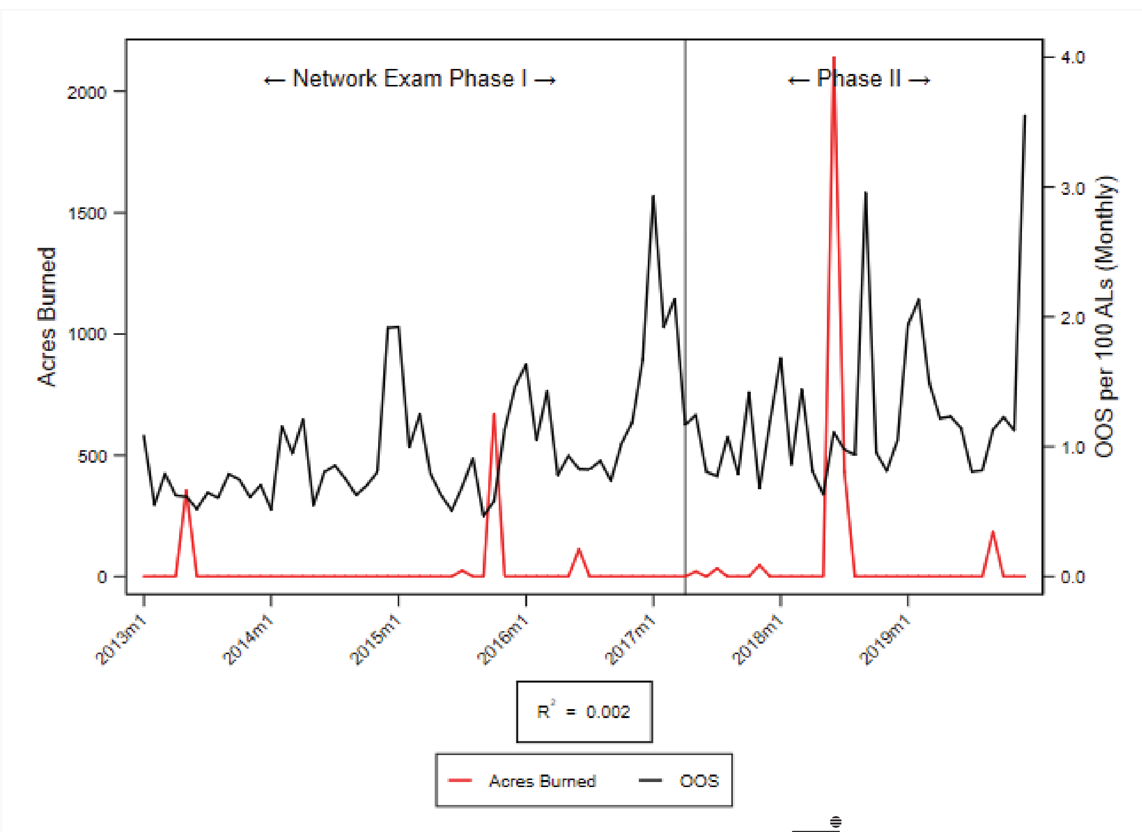
COUNTY-REGION SACRAMENTO - SUPERIOR CALIFORNIA (AT&T)





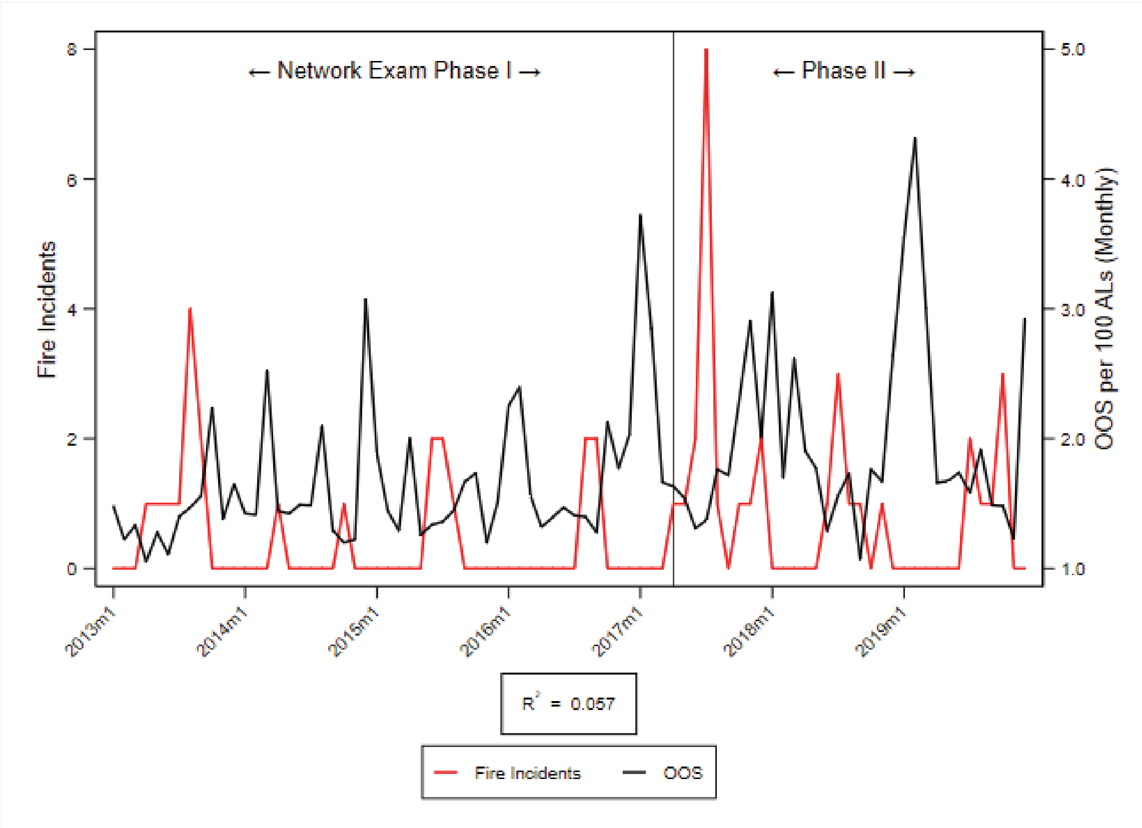
COUNTY-REGION SAN BENITO - CENTRAL COAST (AT&T)

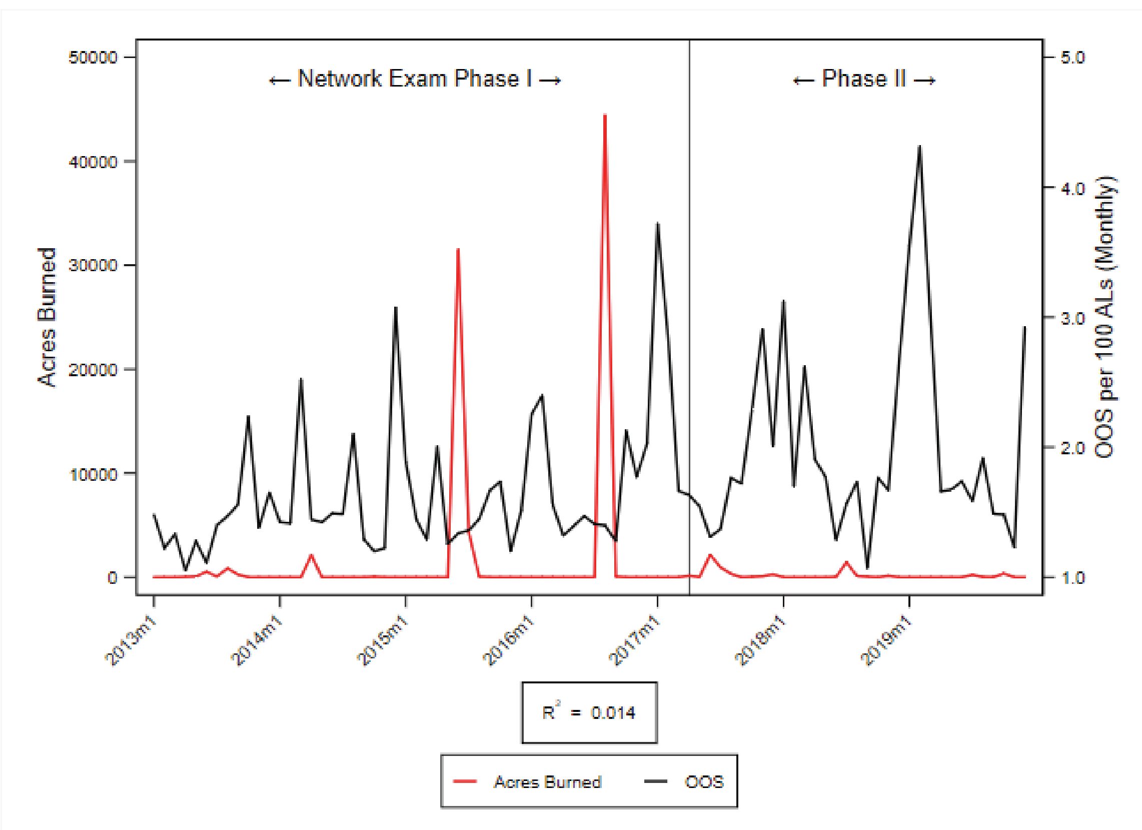




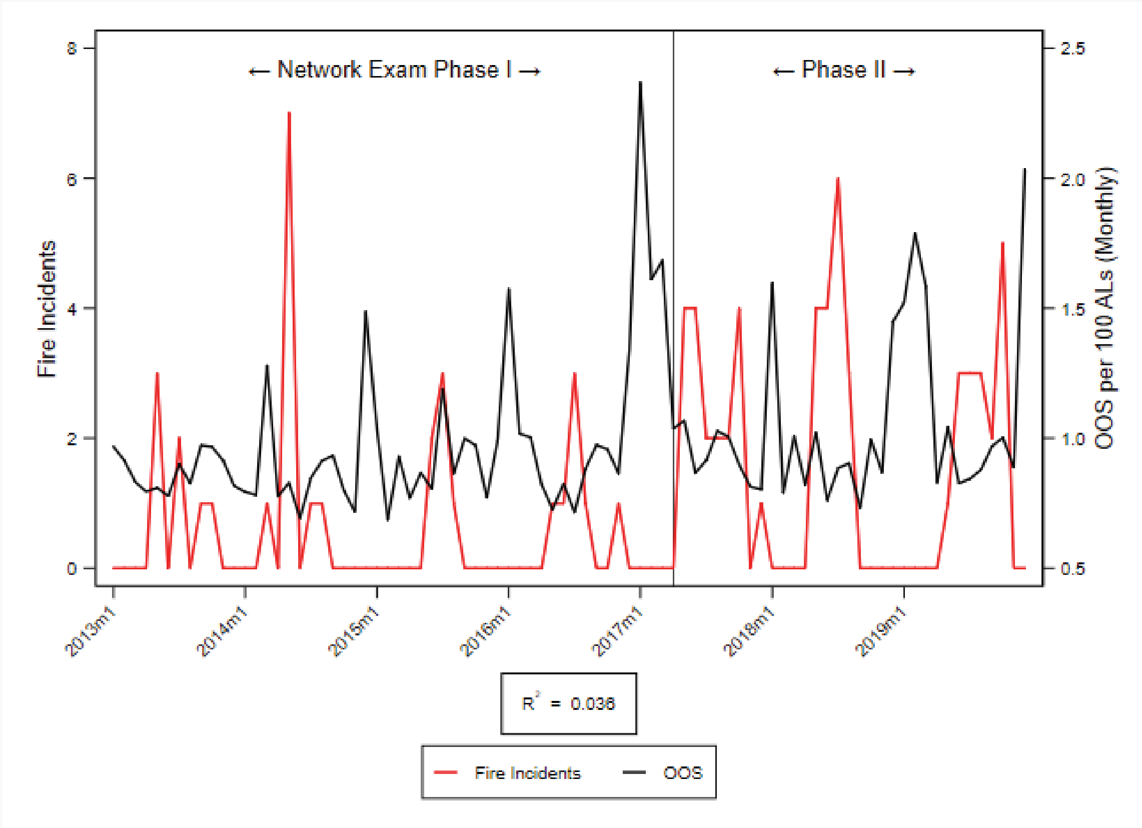
ECONOMICS AND TECHNOLOGY, INC.

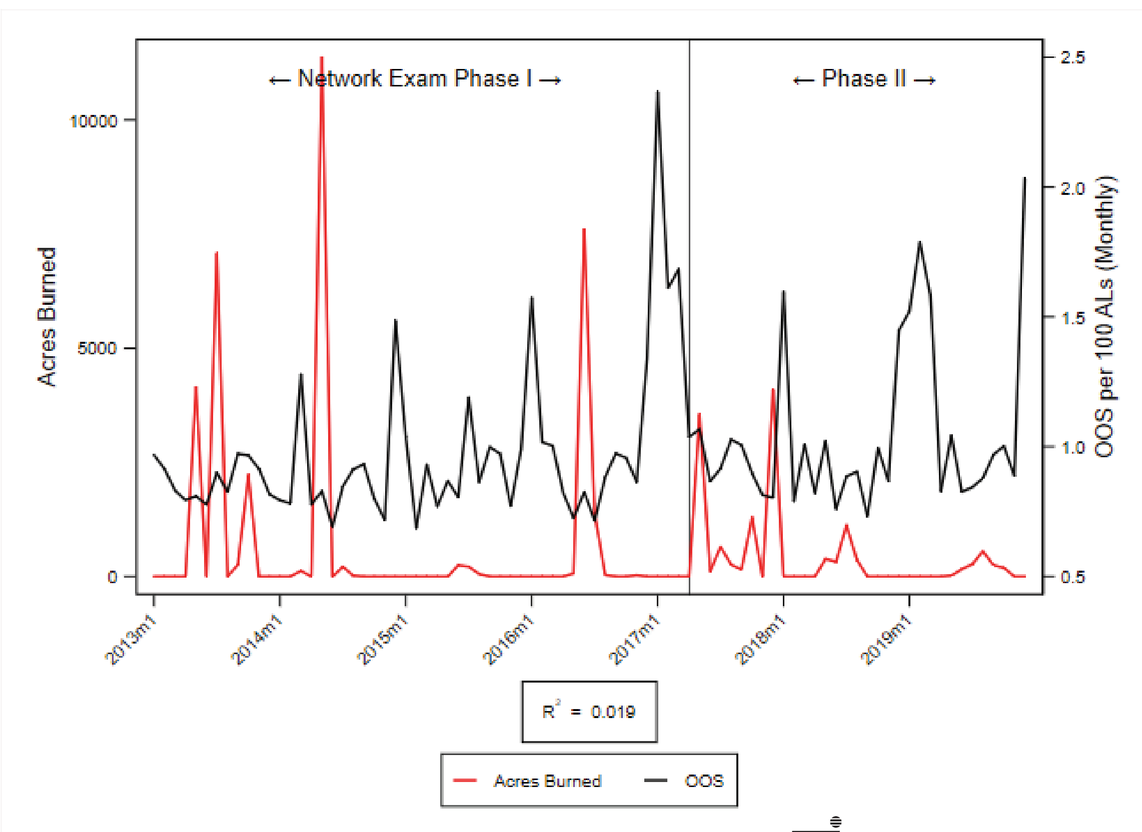
COUNTY-REGION   SAN BERNARDINO - INLAND EMPIRE (AT&T)





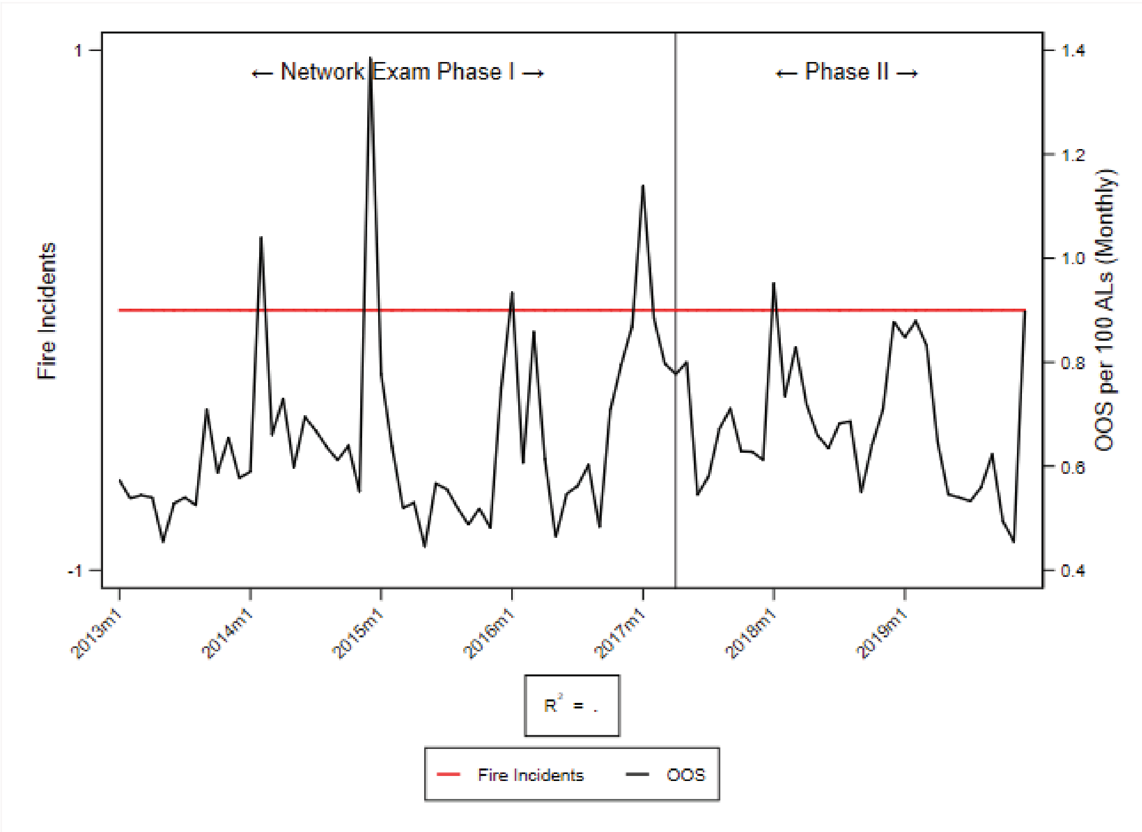
COUNTY-REGION SAN DIEGO - SAN DIEGO-IMPERIAL (AT&T)

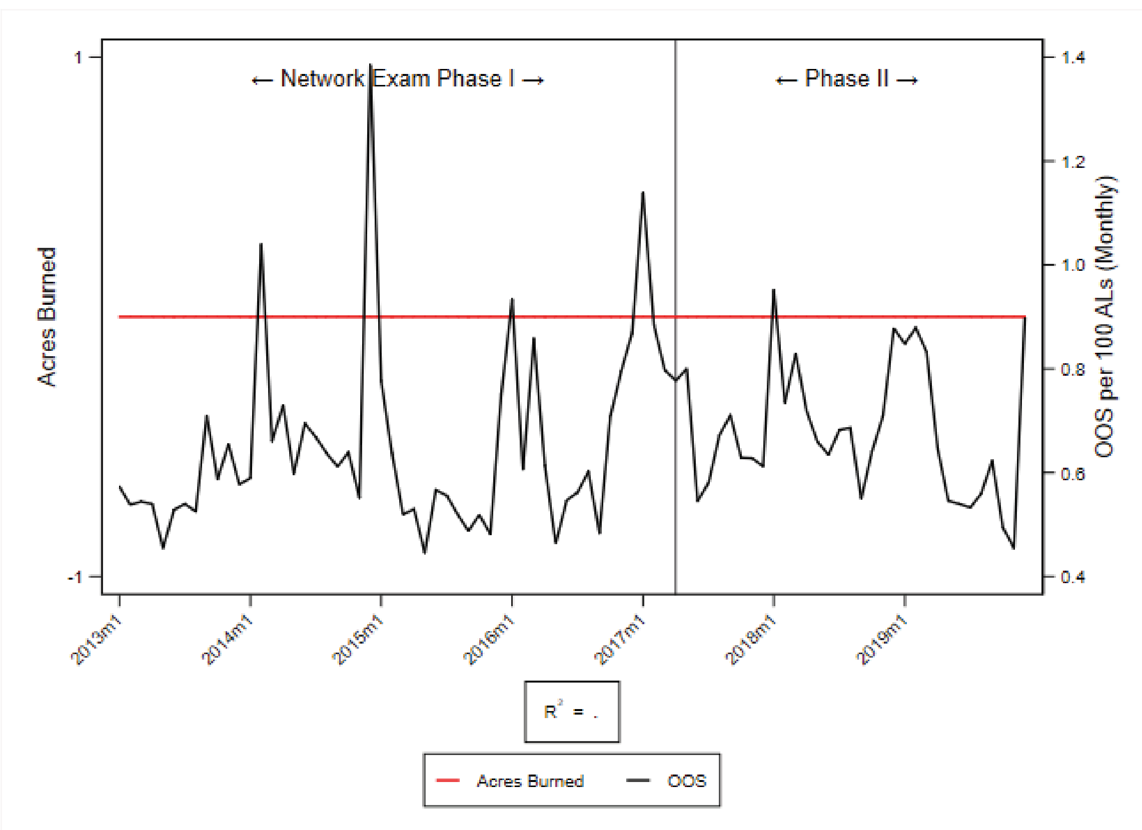




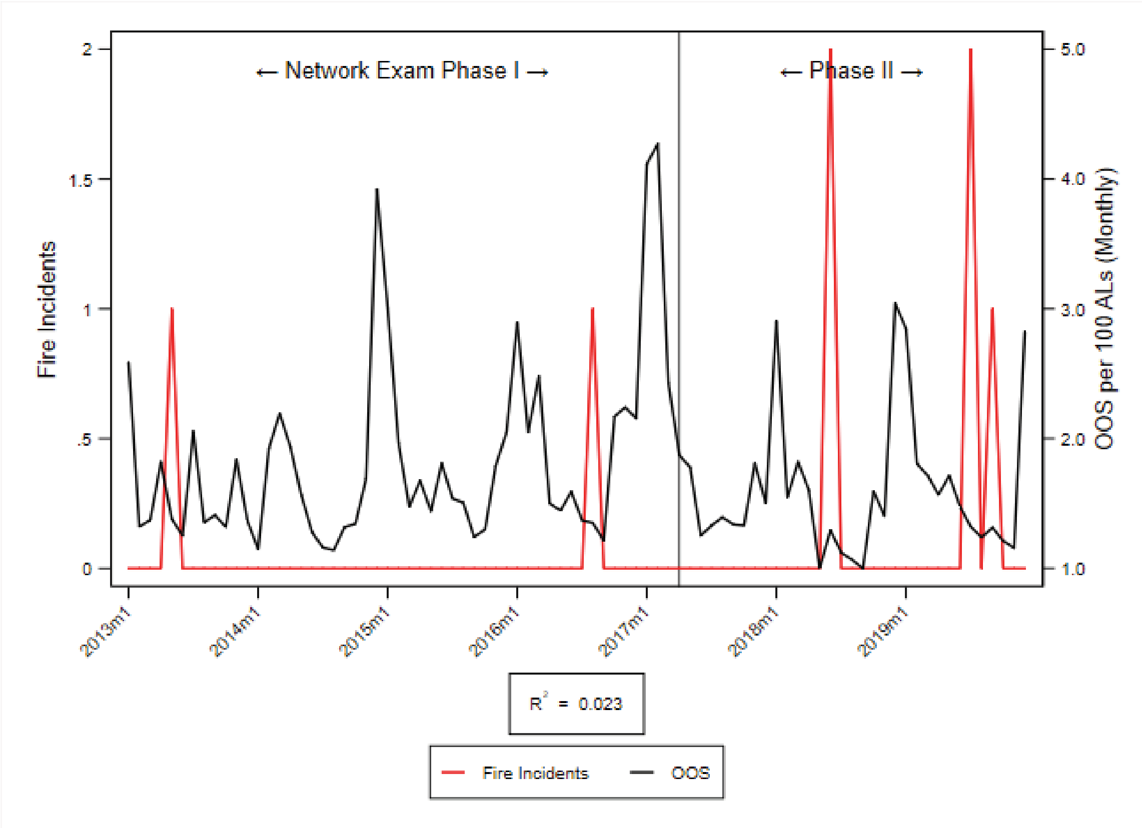
ECONOMICS AND TECHNOLOGY, INC.

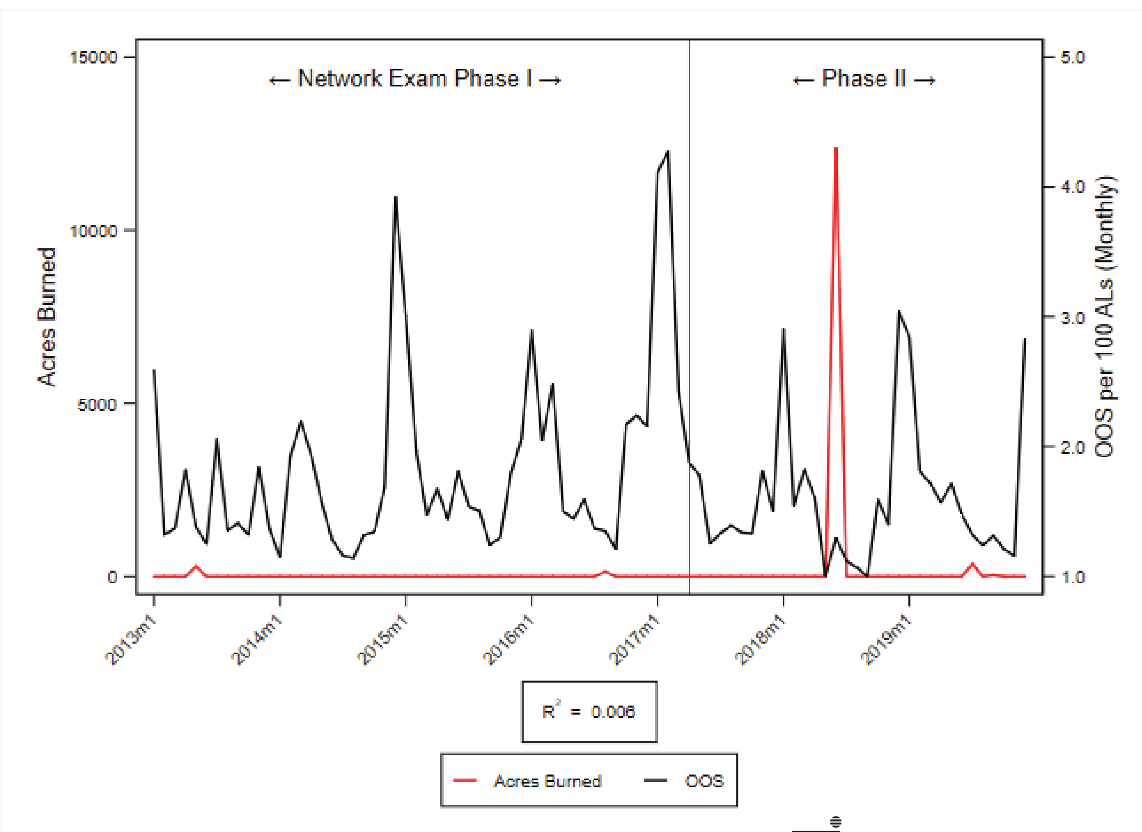
COUNTY-REGION SAN FRANCISCO - SAN FRANCISCO BAY AREA (AT&T)





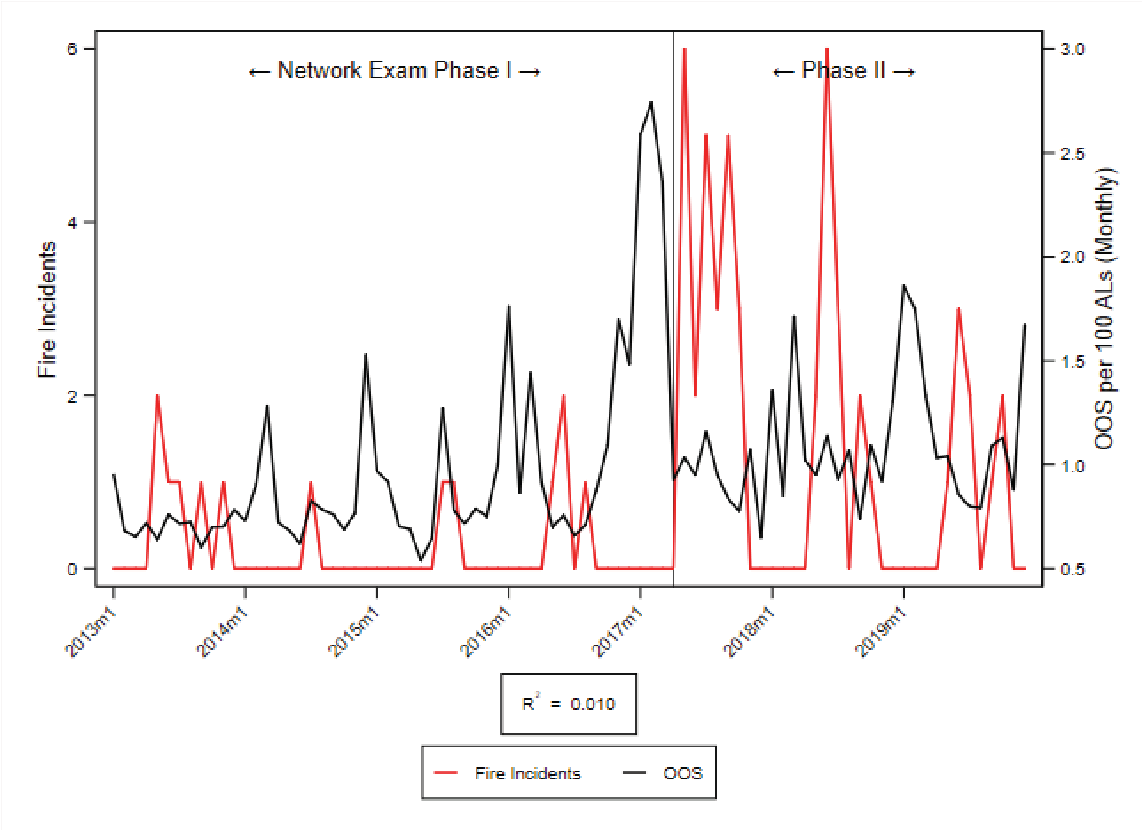
COUNTY-REGION SAN JOAQUIN - NORTHERN SAN JOAQUIN VALLEY (AT&T)

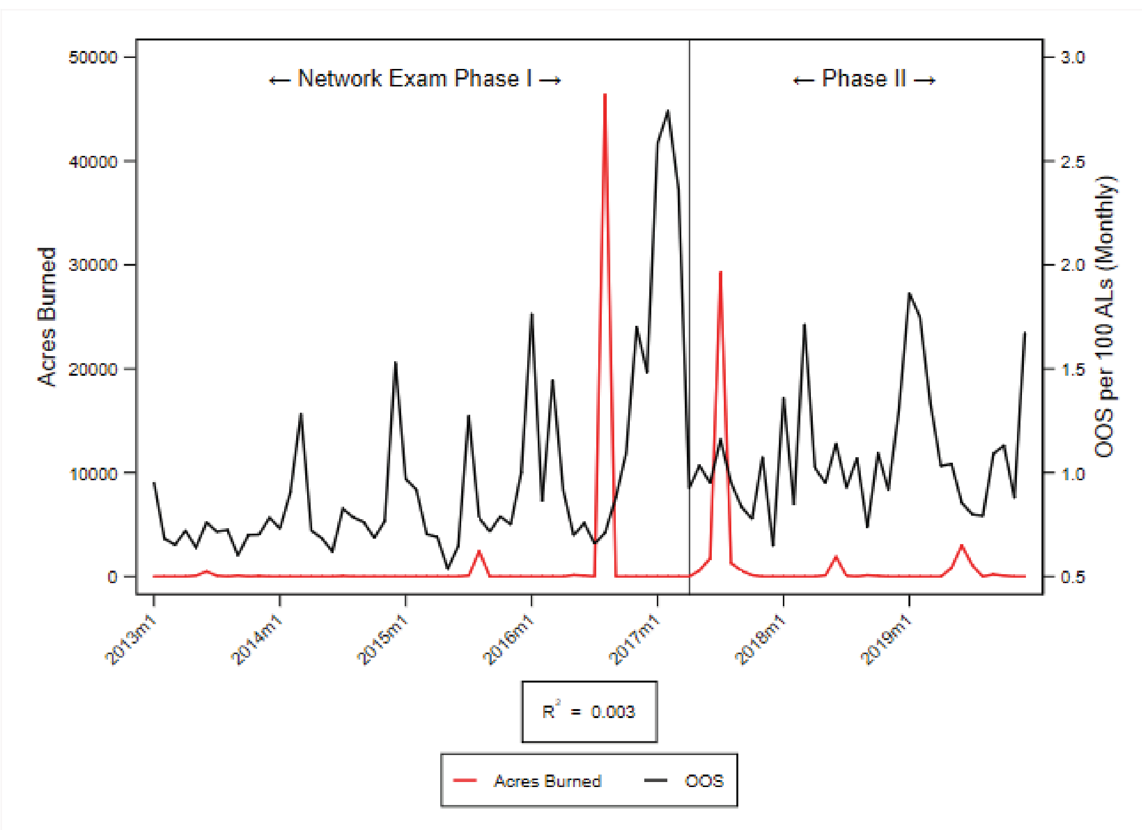




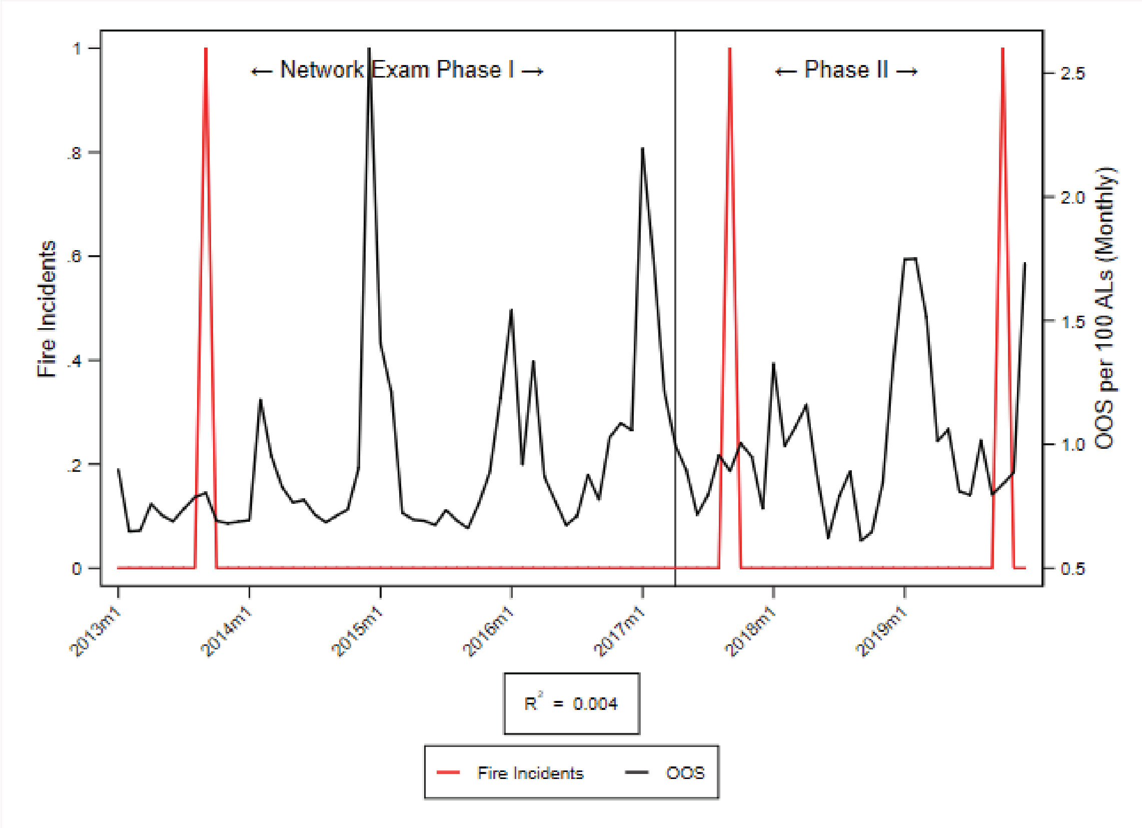
ECONOMICS AND TECHNOLOGY, INC.

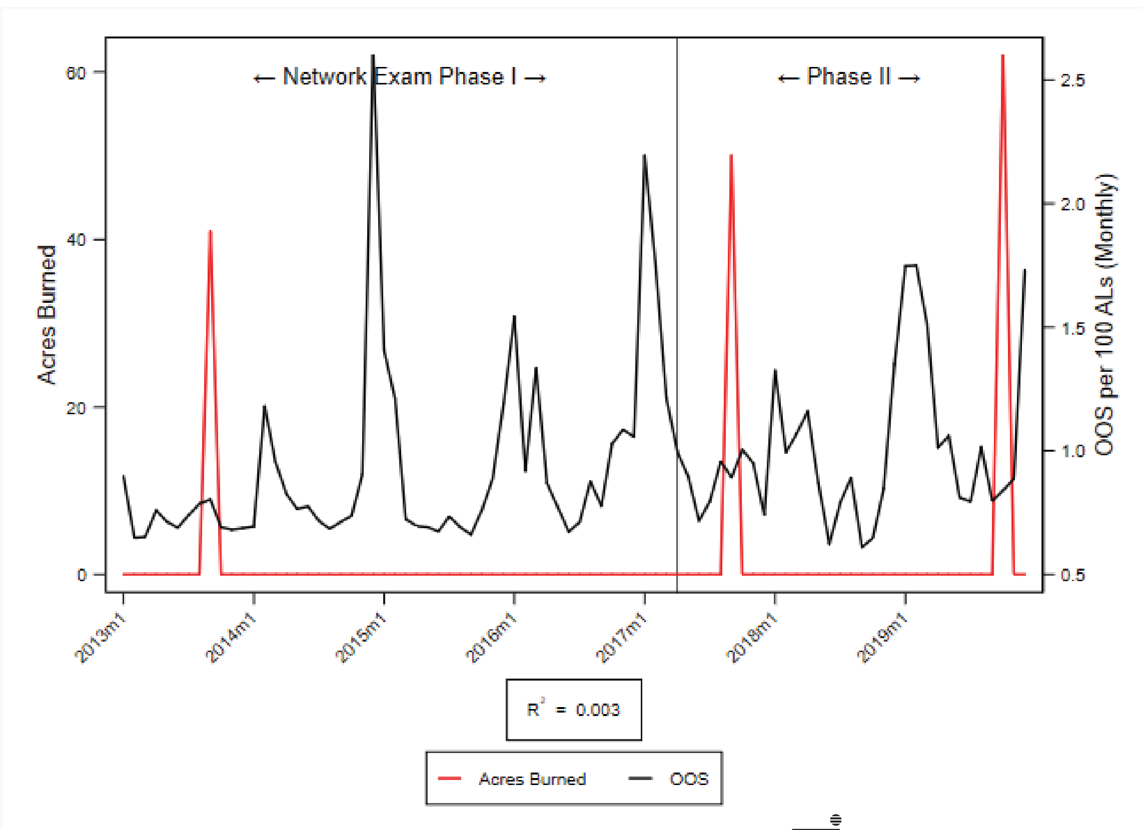
COUNTY-REGION SAN LUIS OBISPO - CENTRAL COAST (AT&T)





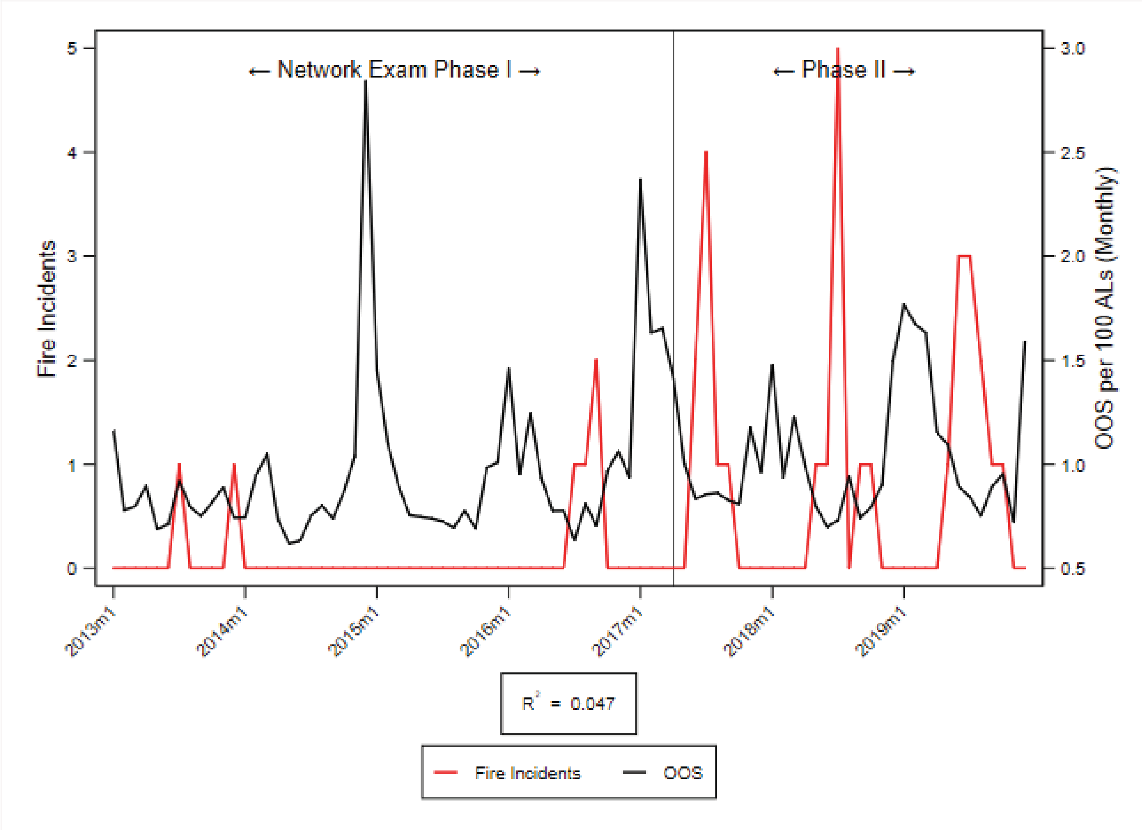
COUNTY-REGION   SAN MATEO - SAN FRANCISCO BAY AREA (AT&T)

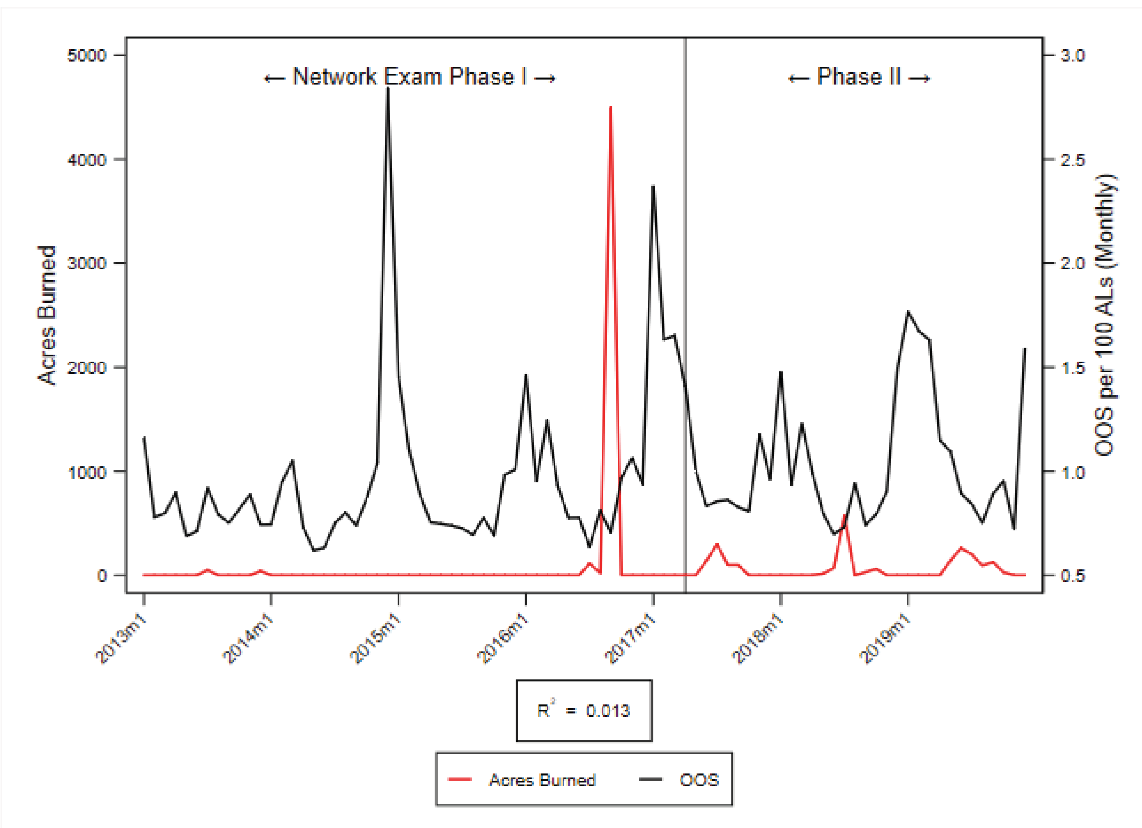




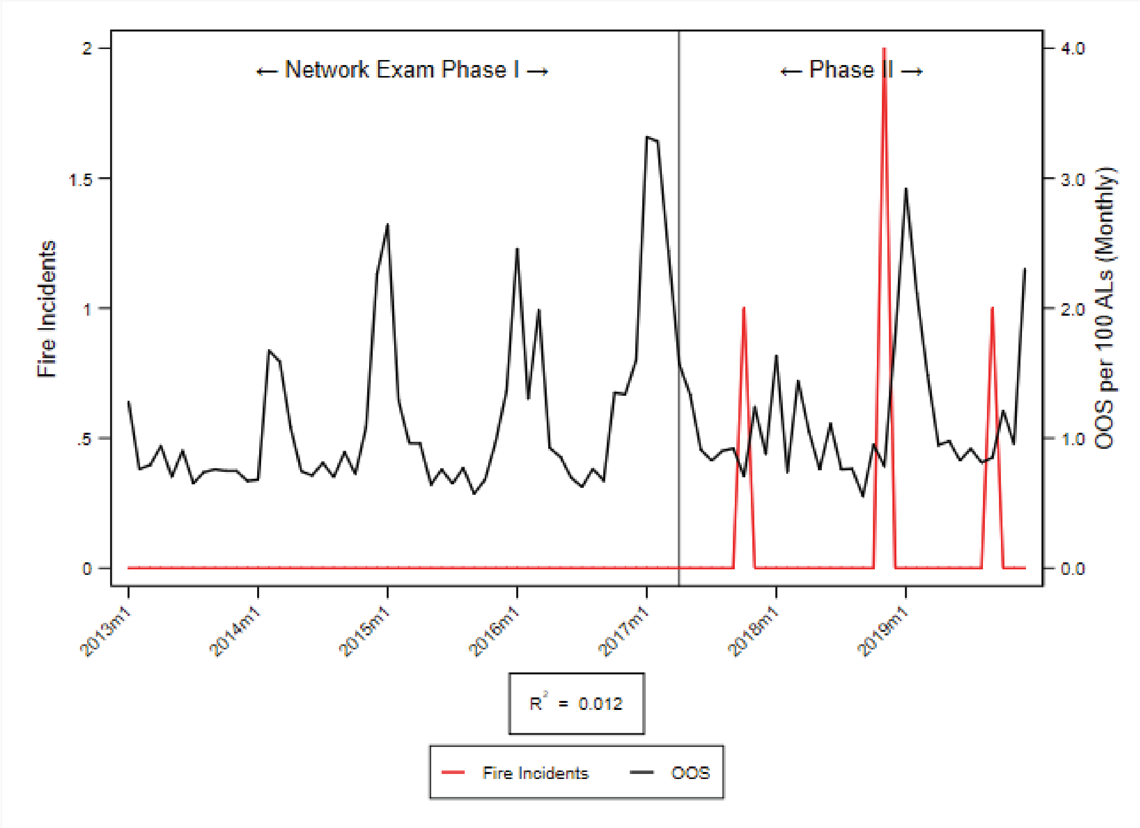
ECONOMICS AND TECHNOLOGY, INC.

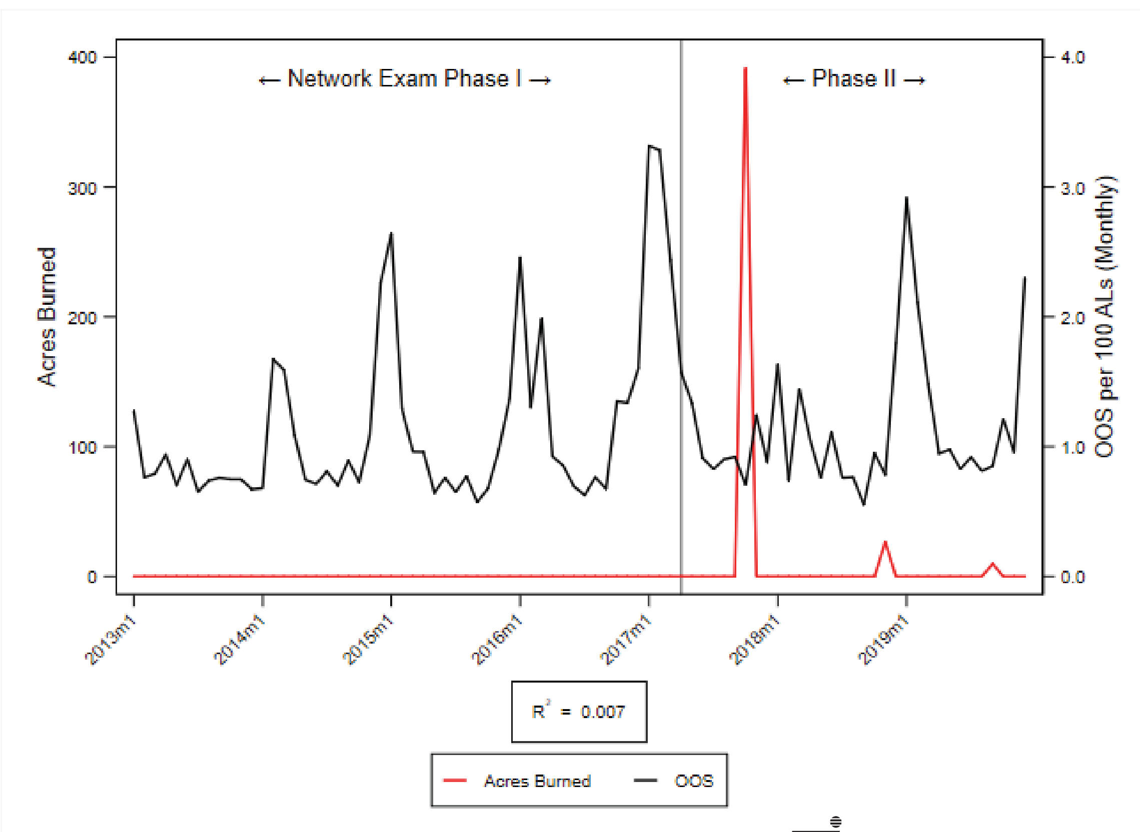
COUNTY-REGION SANTA CLARA - SAN FRANCISCO BAY AREA (AT&T)





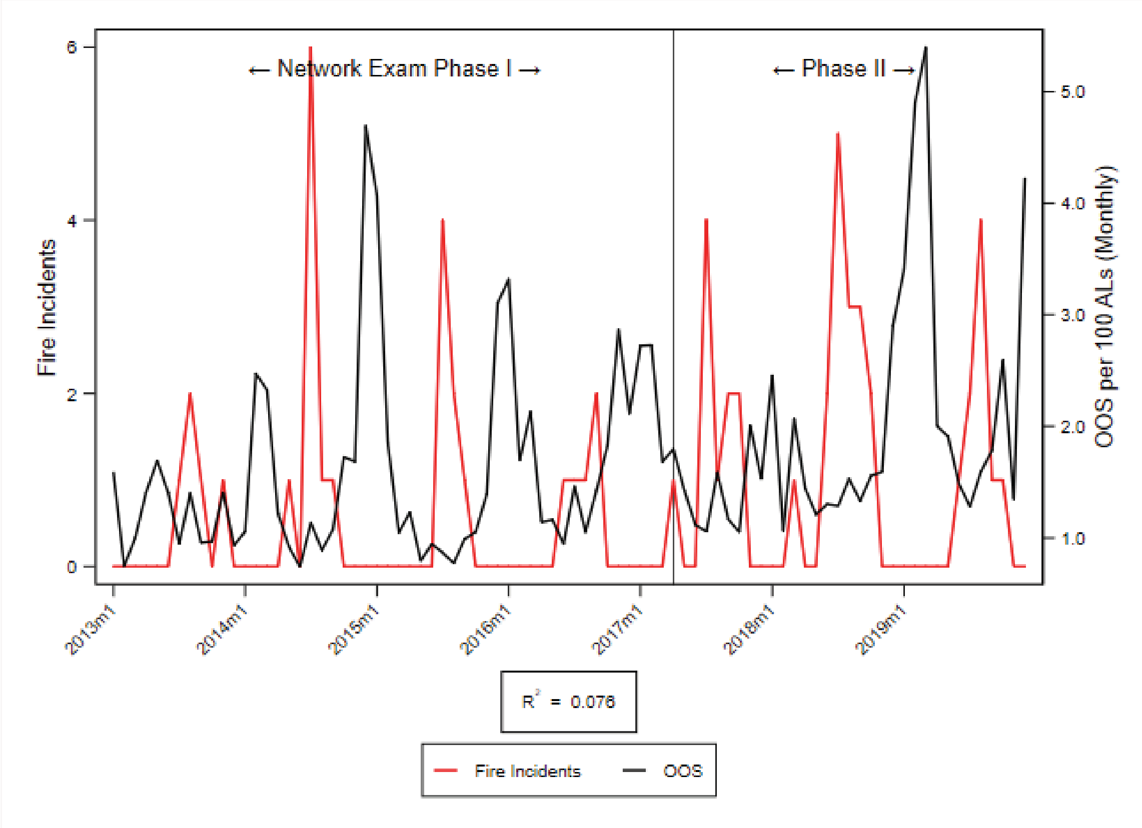
COUNTY-REGION SANTA CRUZ - CENTRAL COAST (AT&T)

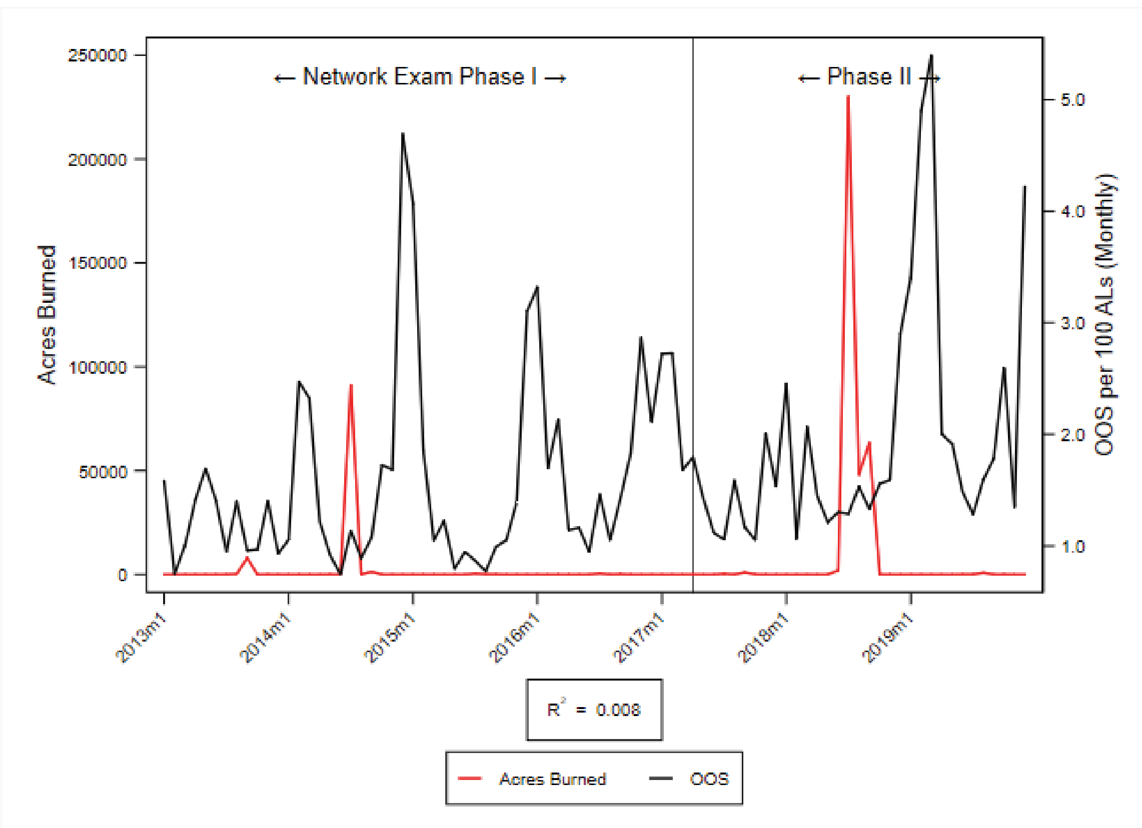




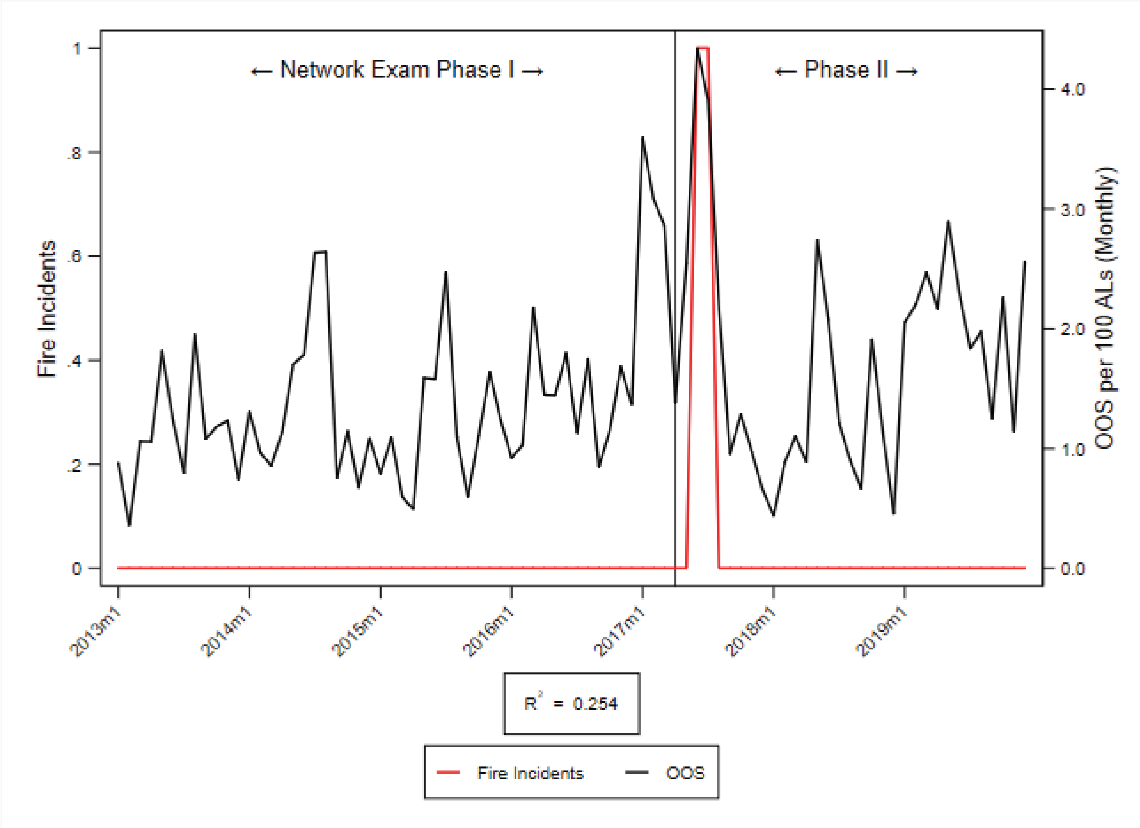
ECONOMICS AND TECHNOLOGY, INC.

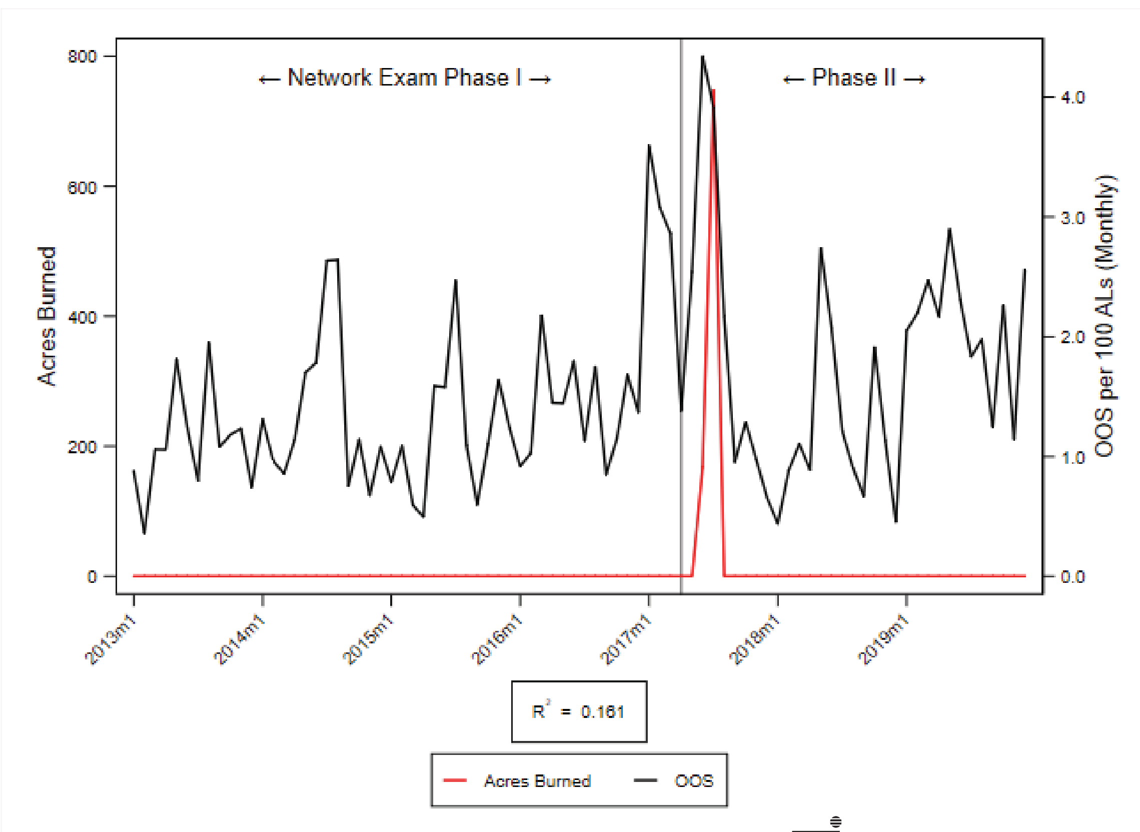
COUNTY-REGION SHASTA - SUPERIOR CALIFORNIA (AT&T)



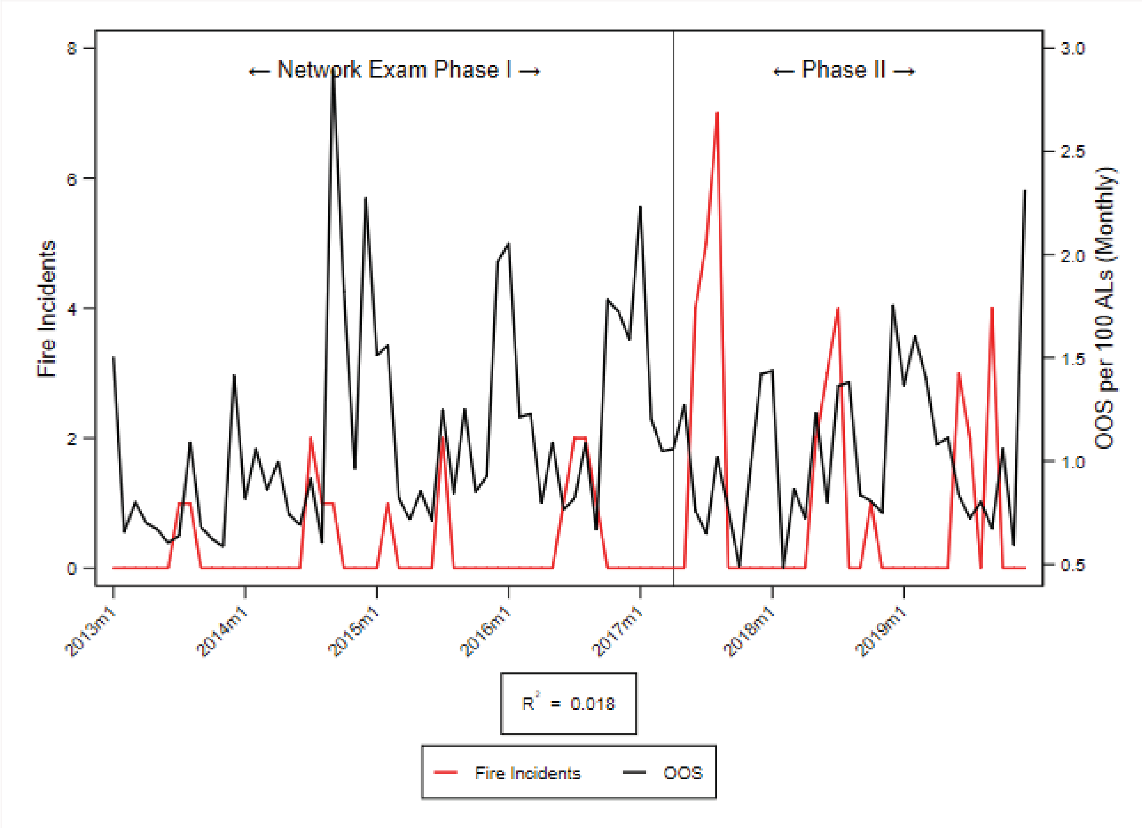


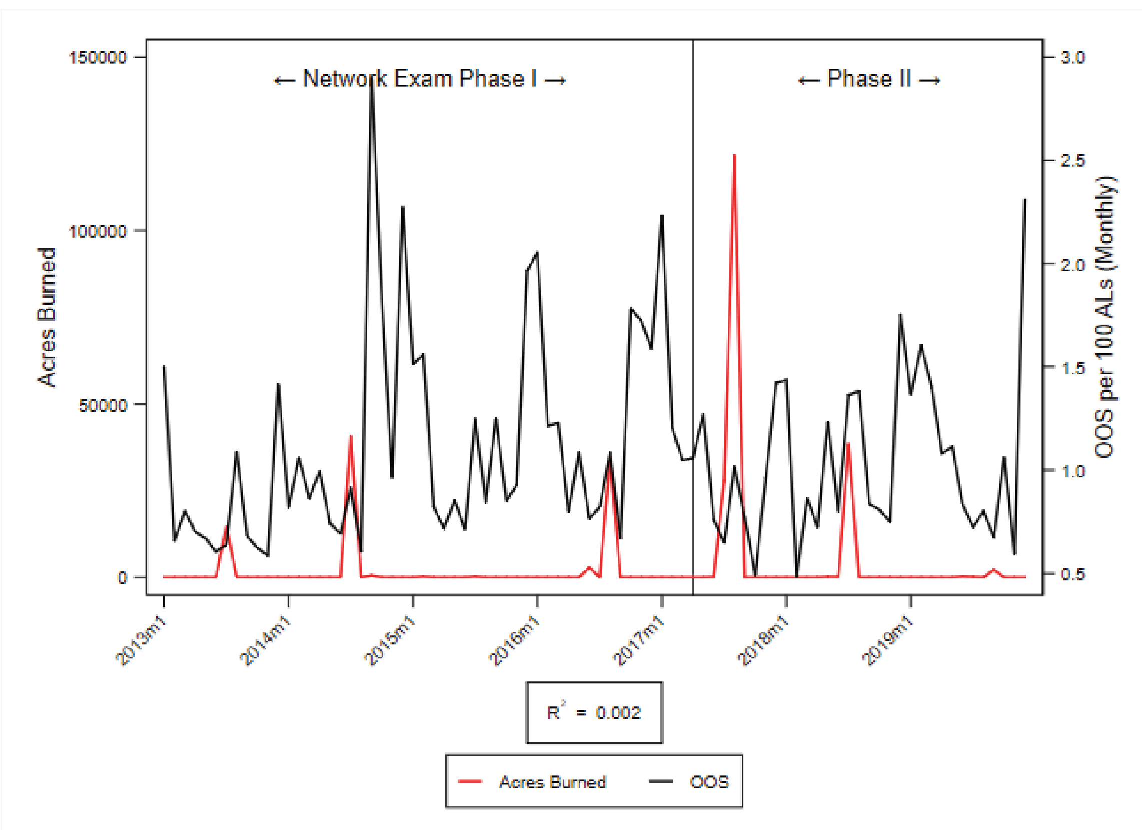
COUNTY-REGION SIERRA - SUPERIOR CALIFORNIA (AT&T)



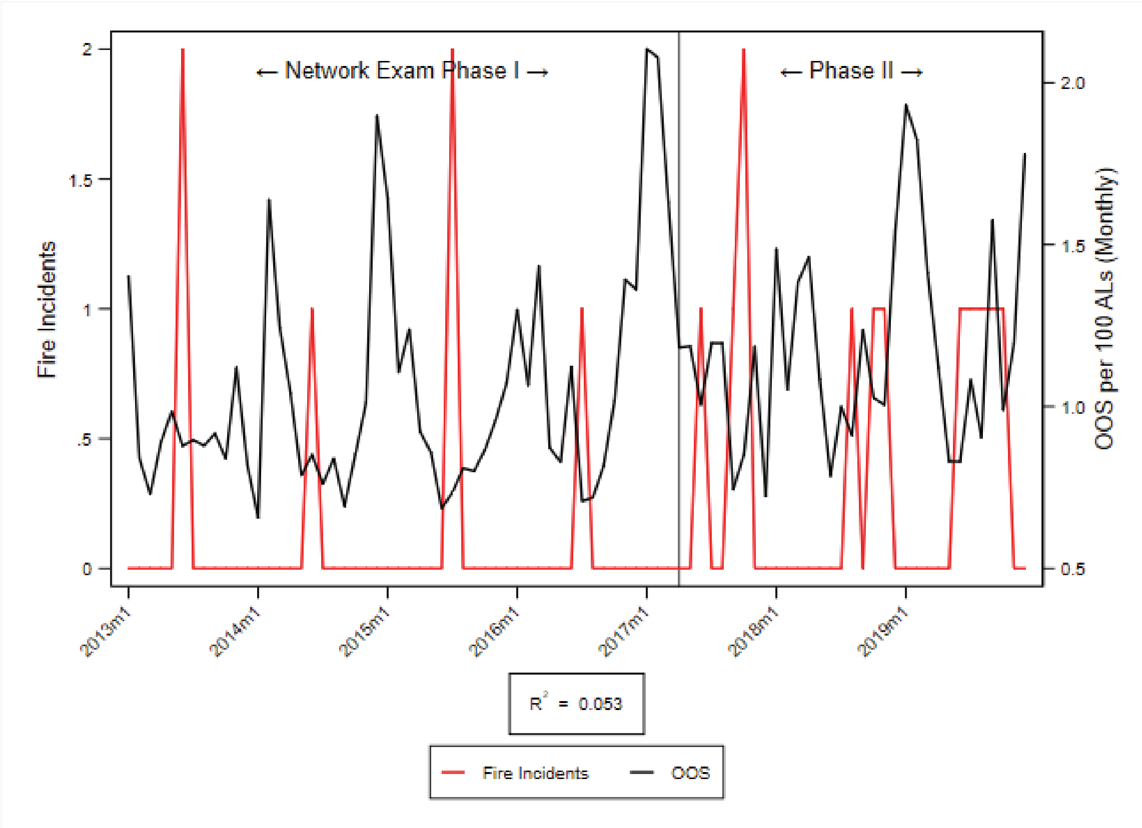


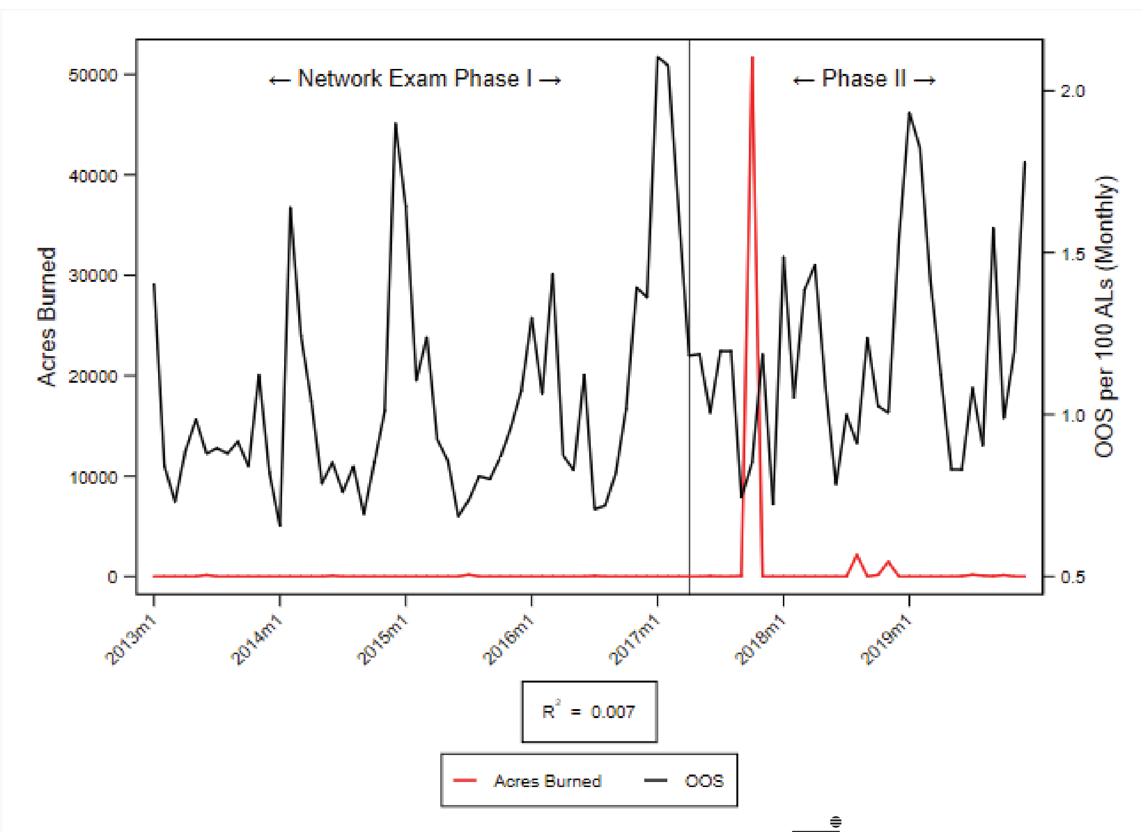
COUNTY-REGION SISKIYOU - SUPERIOR CALIFORNIA (AT&T)





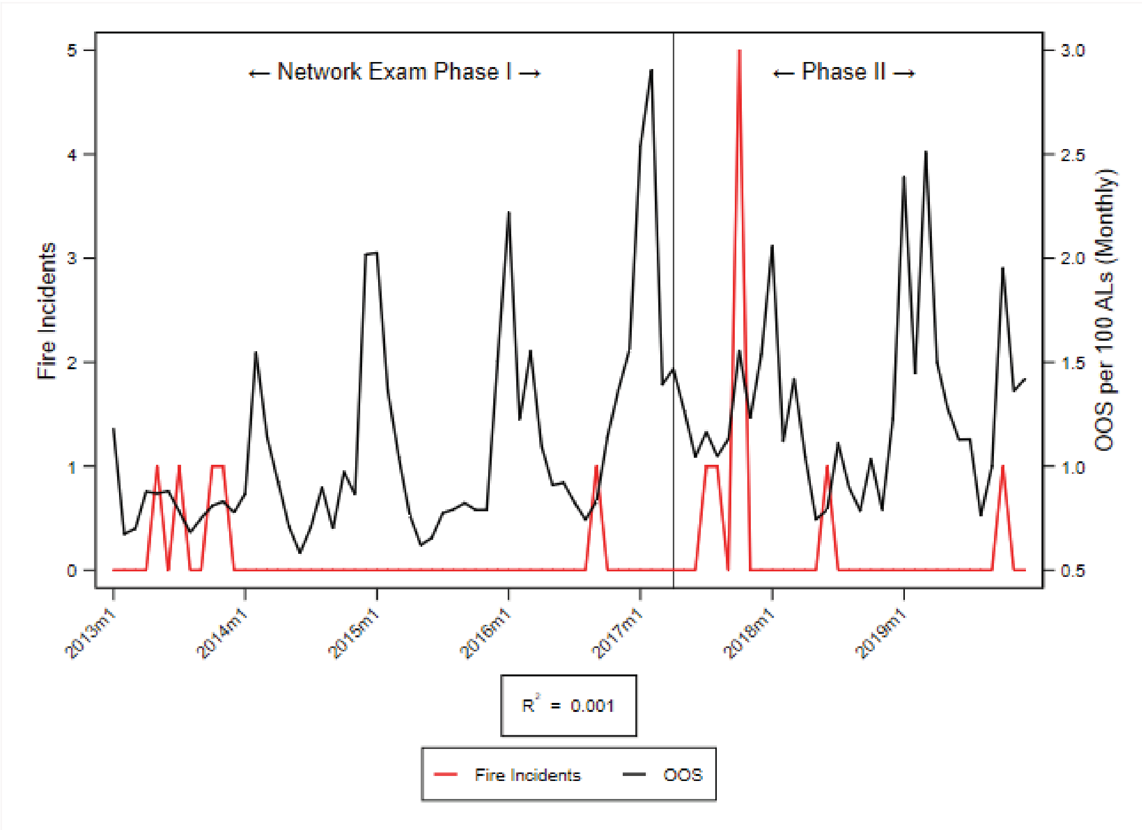
COUNTY-REGION   SOLANO - SAN FRANCISCO BAY AREA (AT&T)

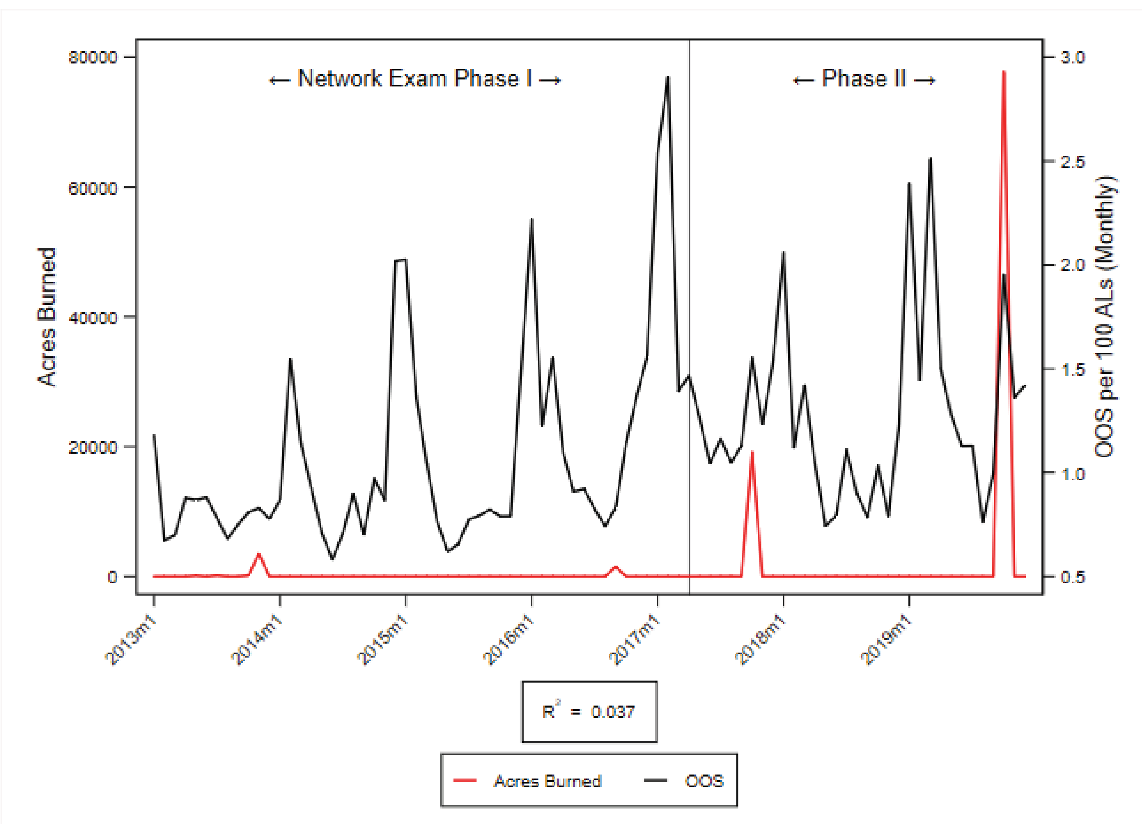




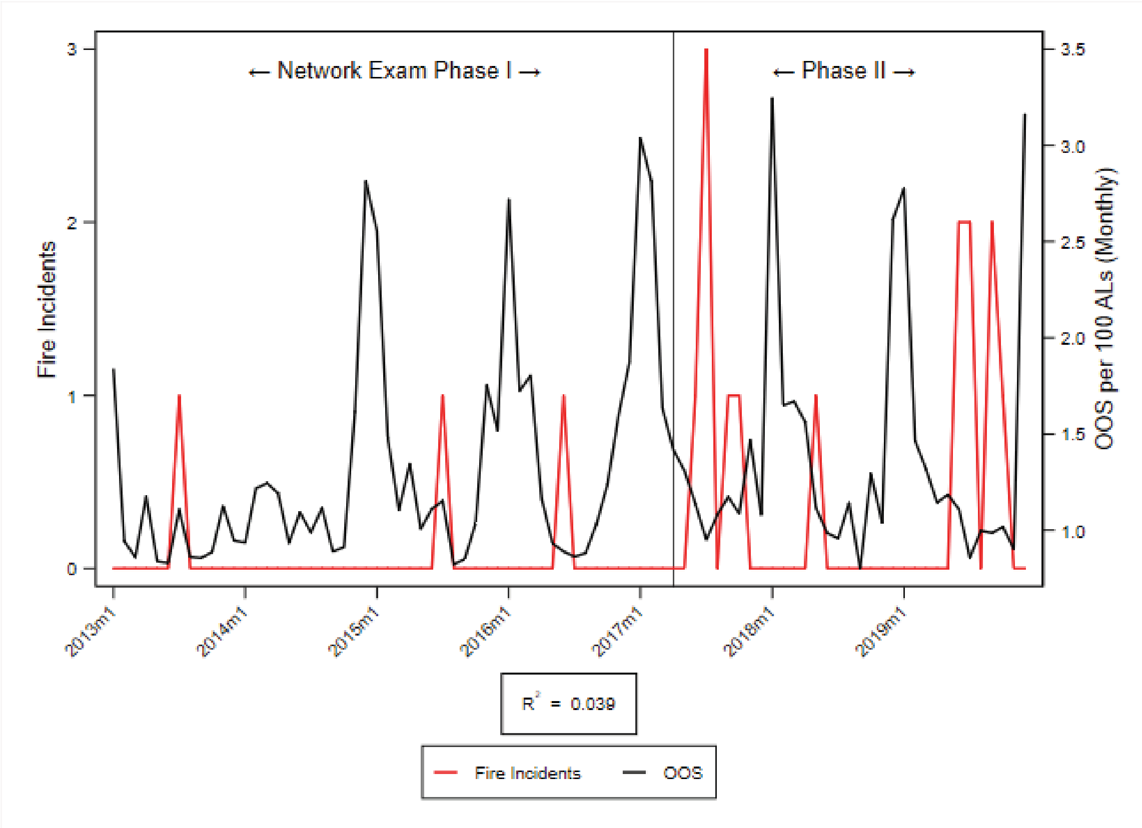
ECONOMICS AND TECHNOLOGY, INC.

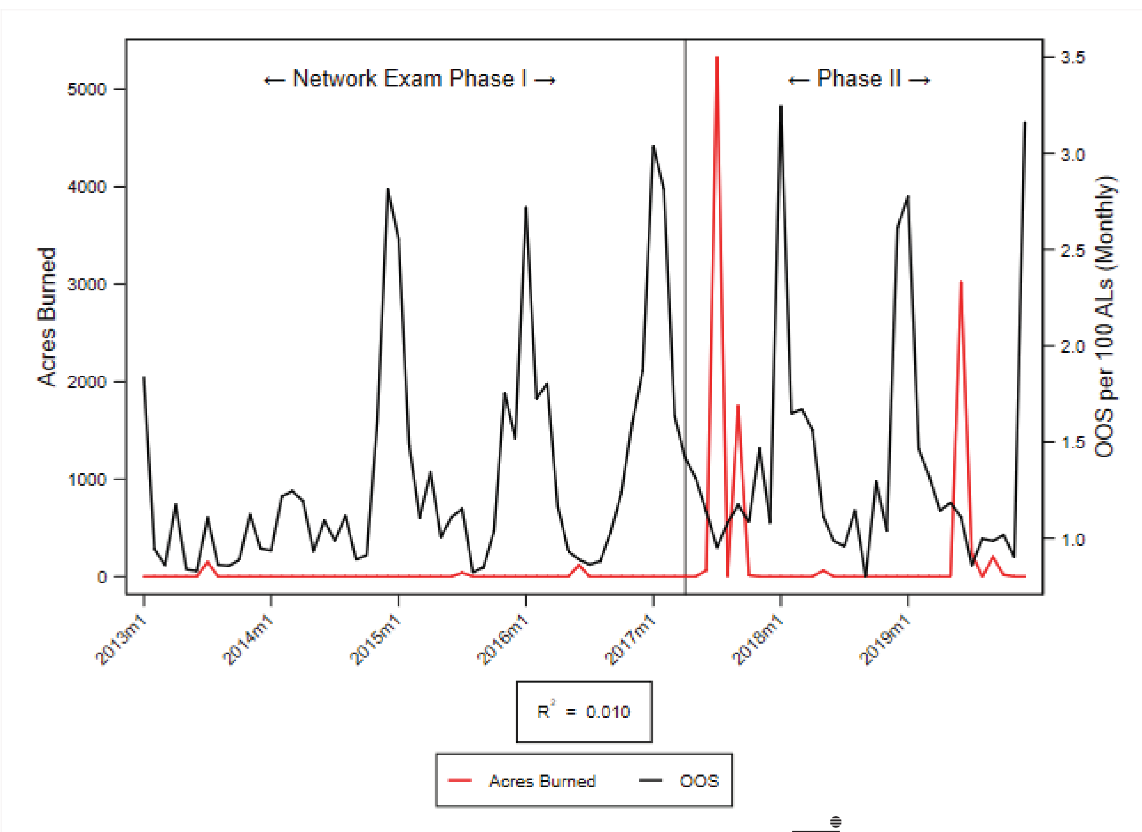
COUNTY-REGION SONOMA - NORTH COAST (AT&T)





COUNTY-REGION   STANISLAUS - NORTHERN SAN JOAQUIN VALLEY (AT&T)

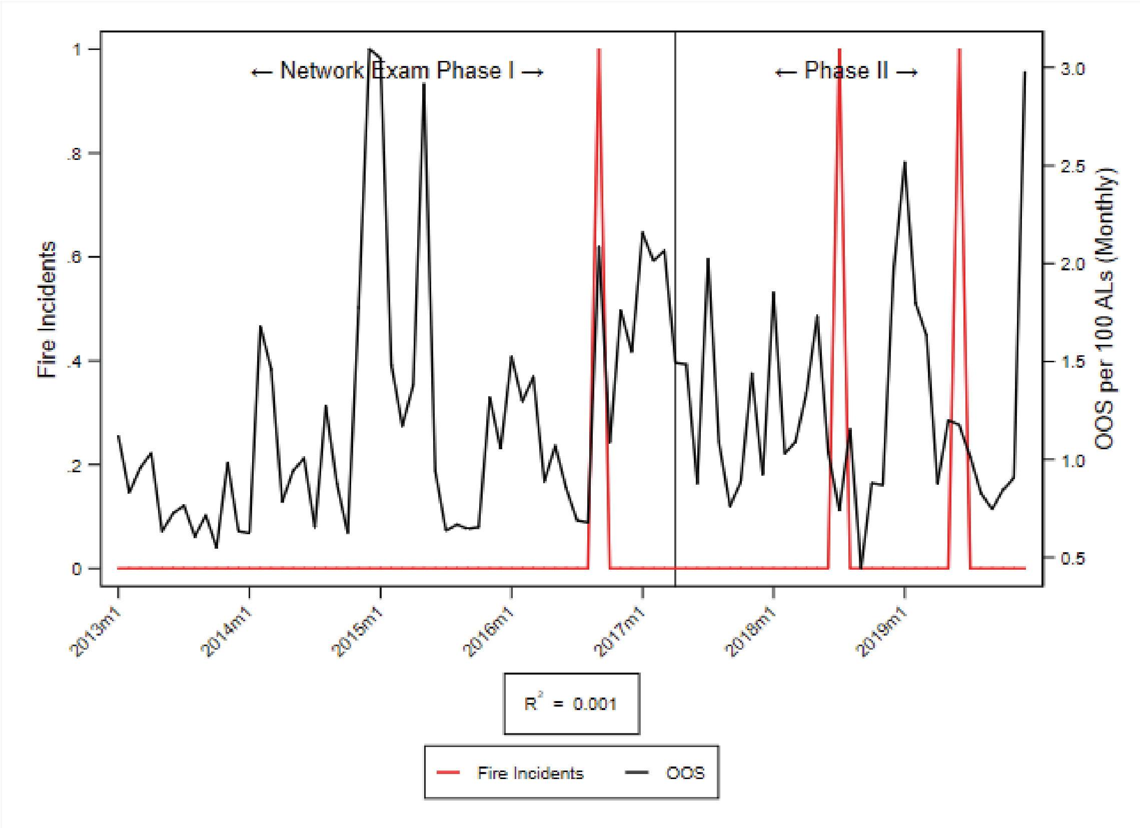


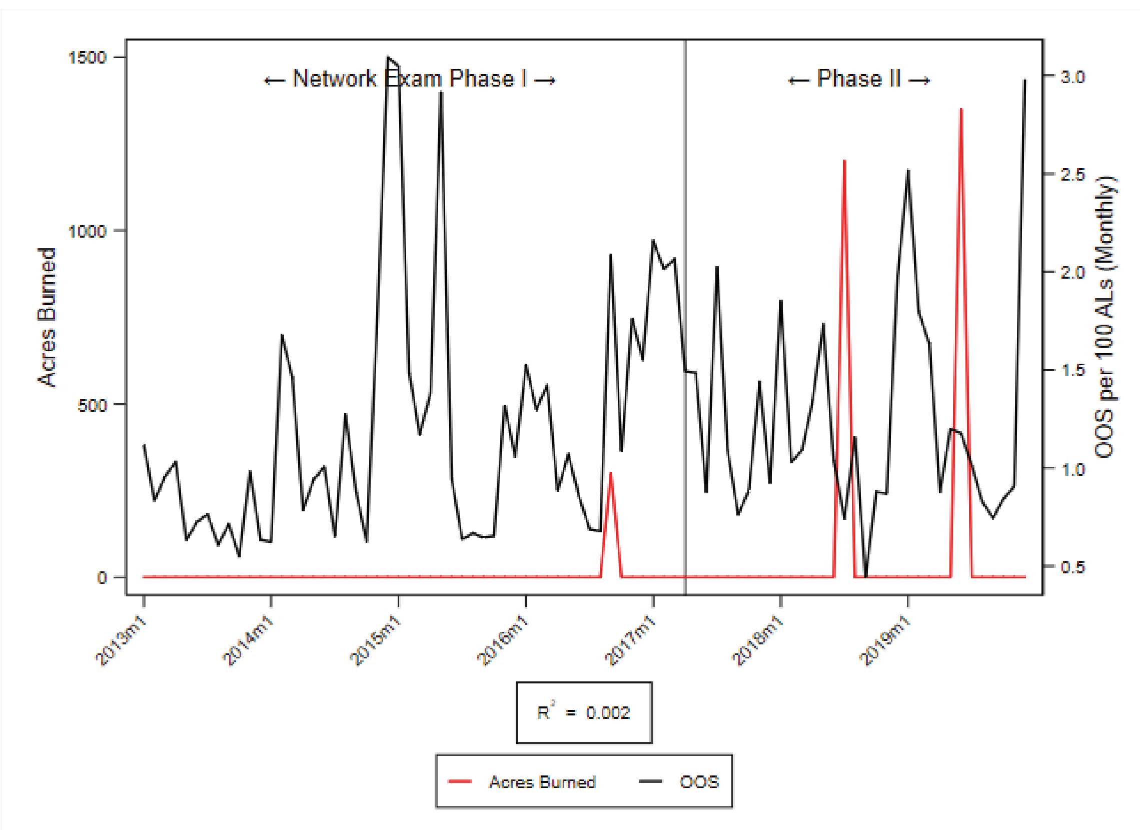


ECONOMICS AND TECHNOLOGY, INC.

CONFIDENTIAL AND PROPRIETARY PER P.U. CODE § 583, GENERAL ORDER 66-D, & D.16-08-024

COUNTY-REGION SUTTER - SUPERIOR CALIFORNIA (AT&T)





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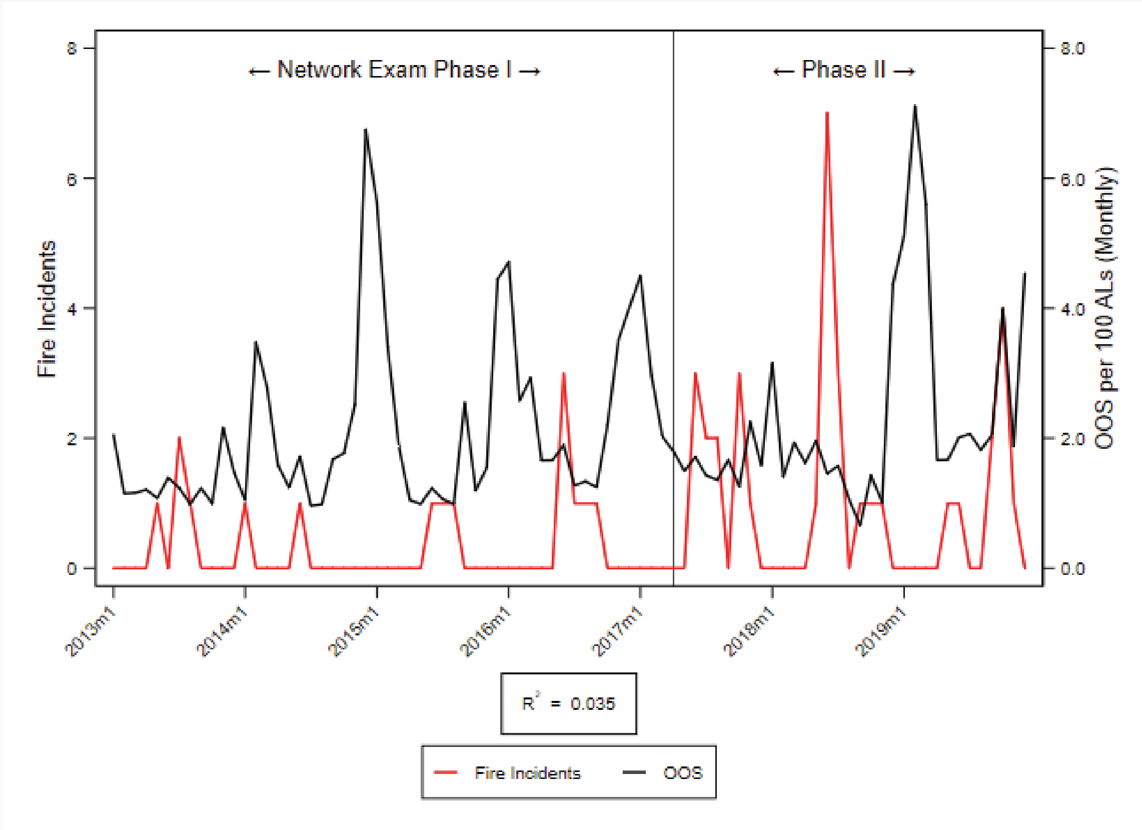

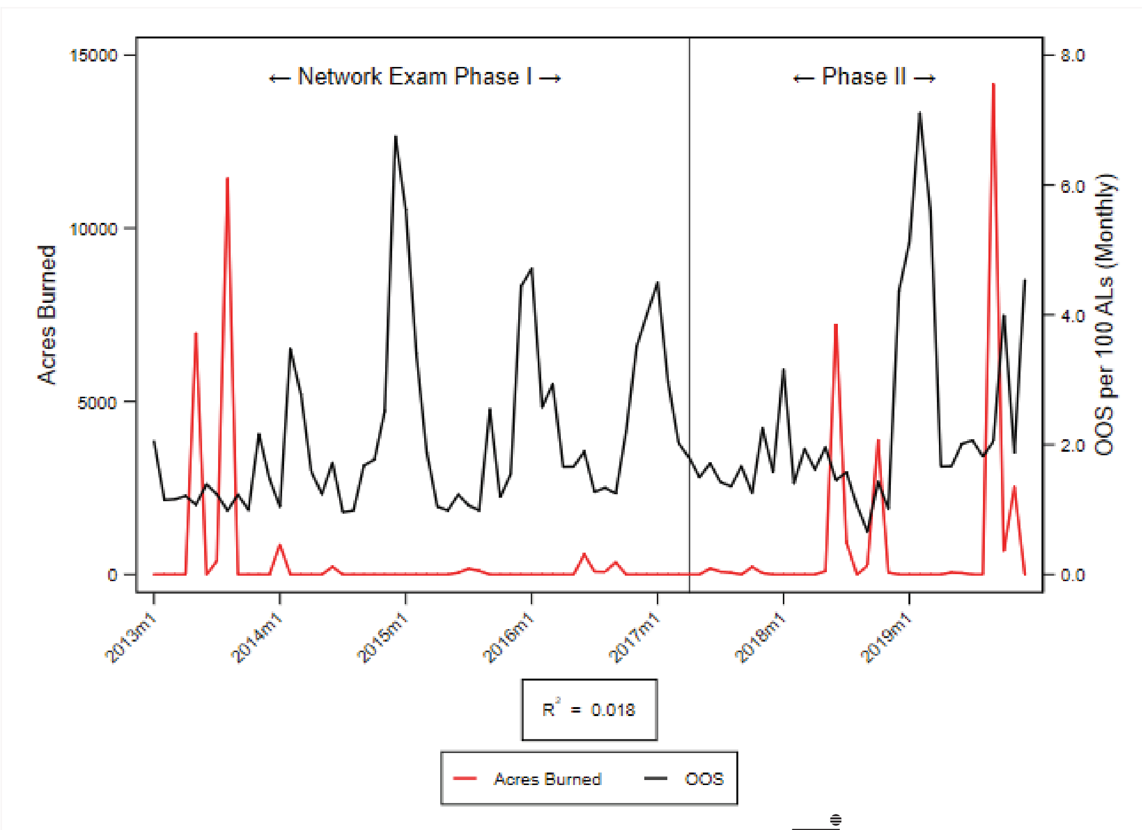

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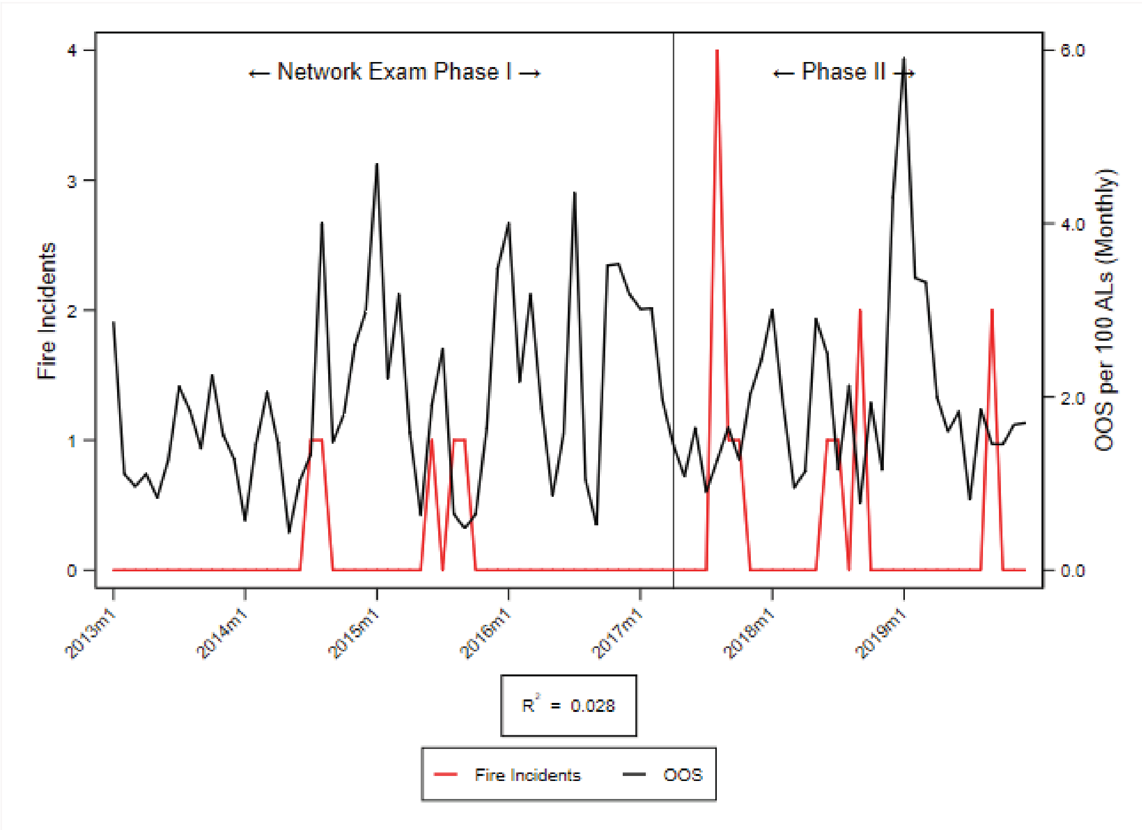
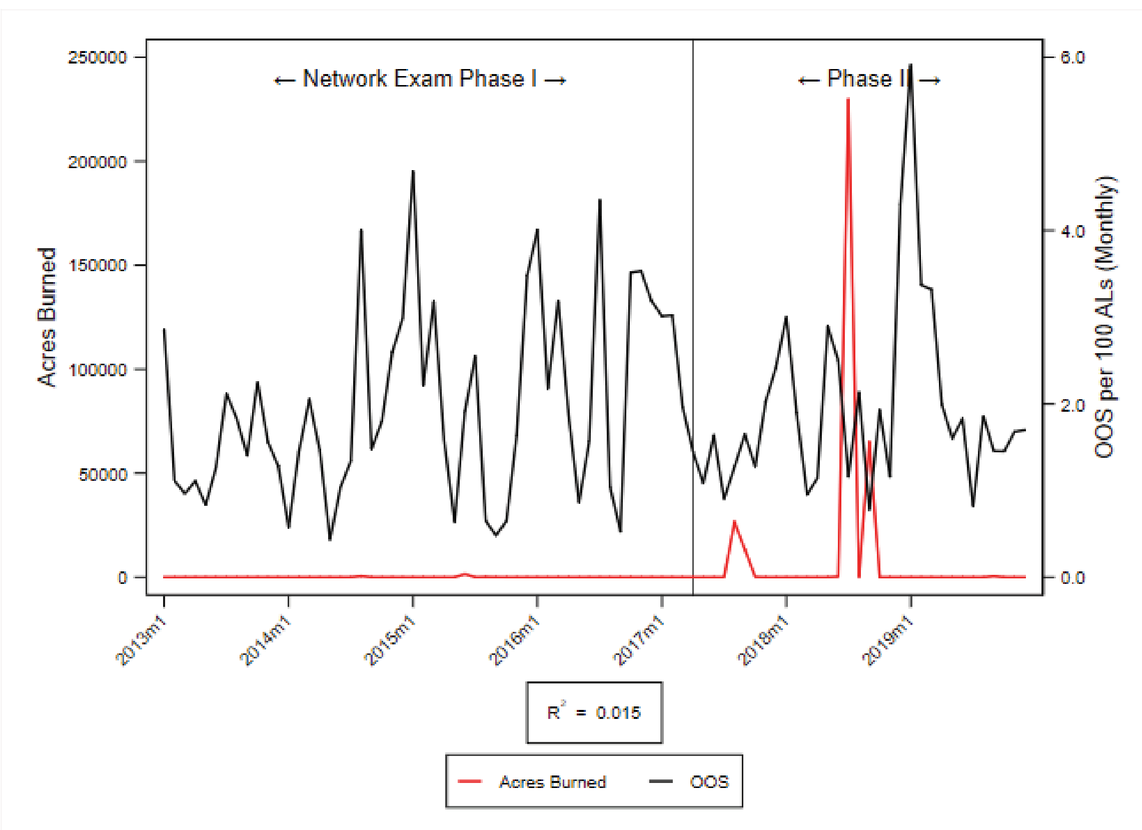
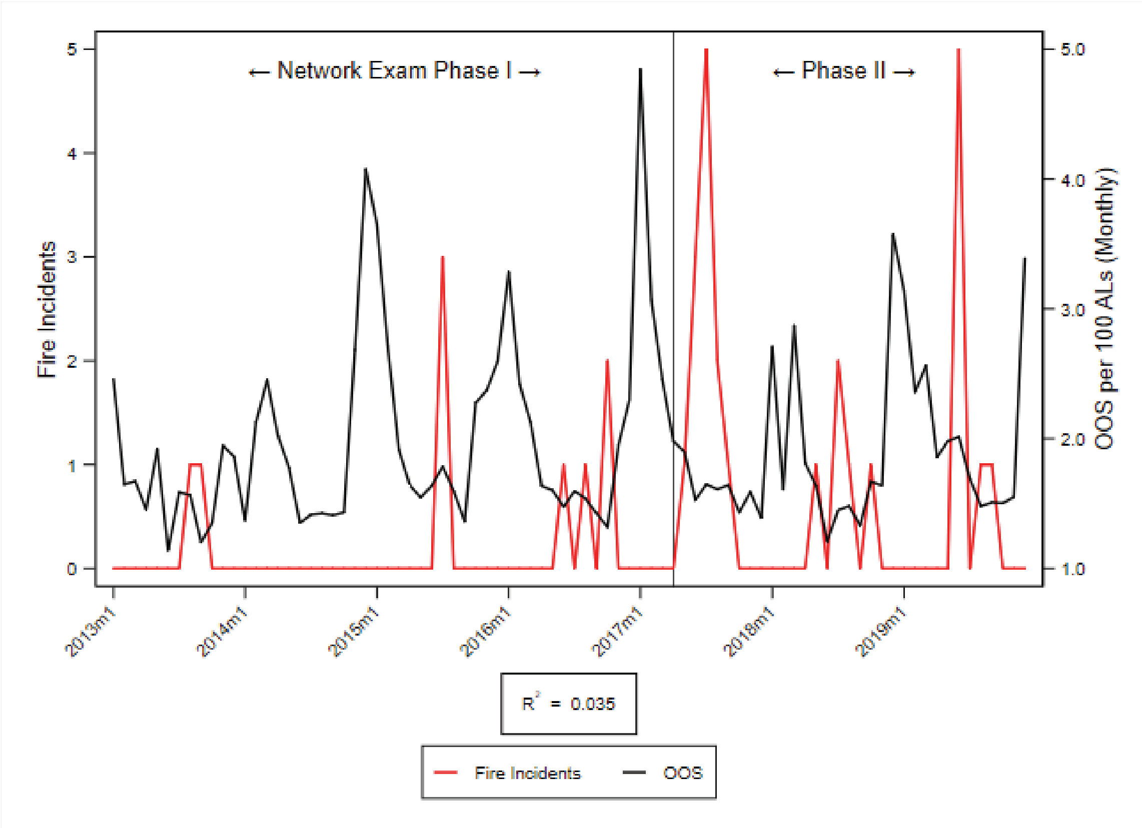
COUNTY-REGION TRINITY - NORTH COAST (AT&T)

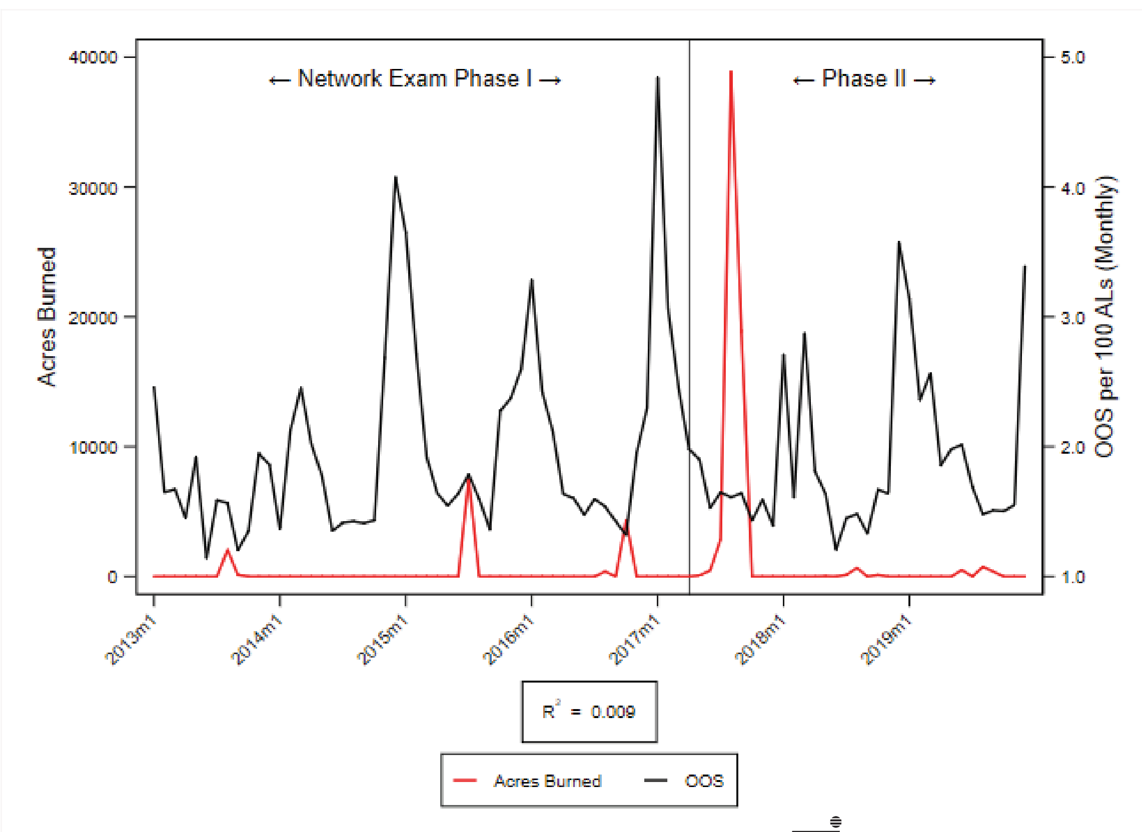




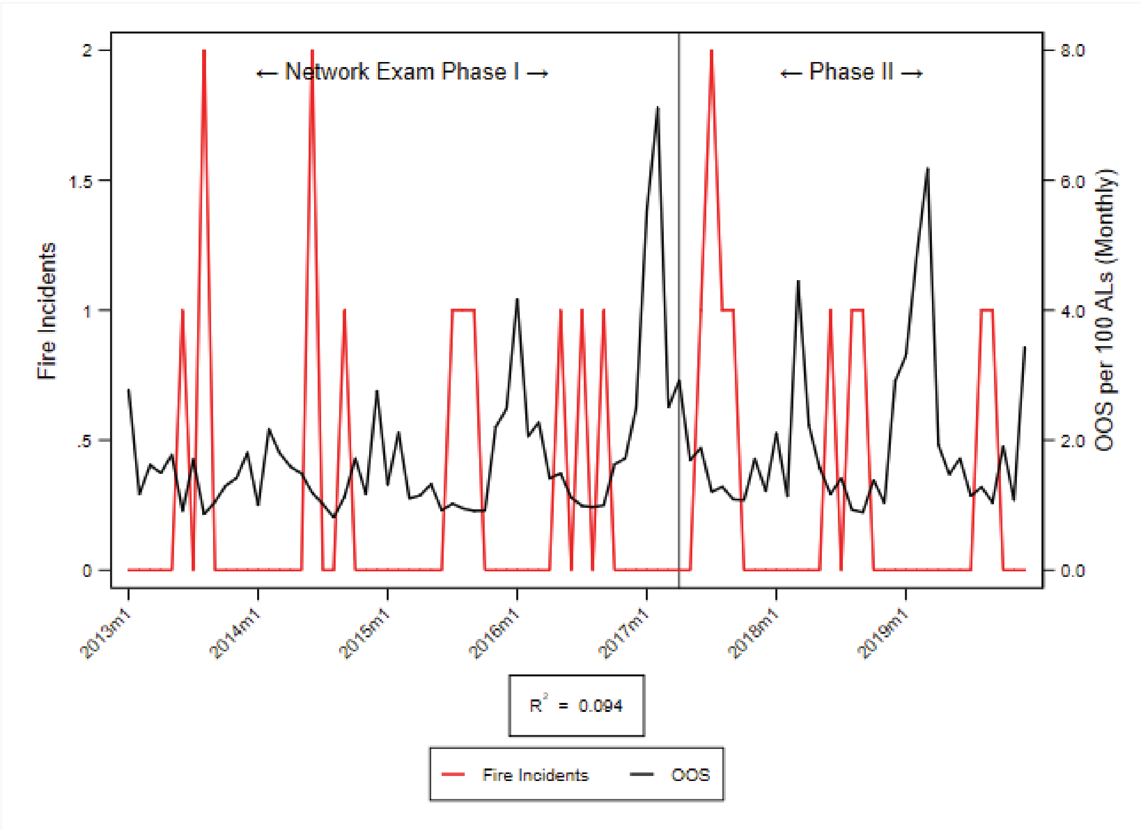
ECONOMICS AND TECHNOLOGY, INC.

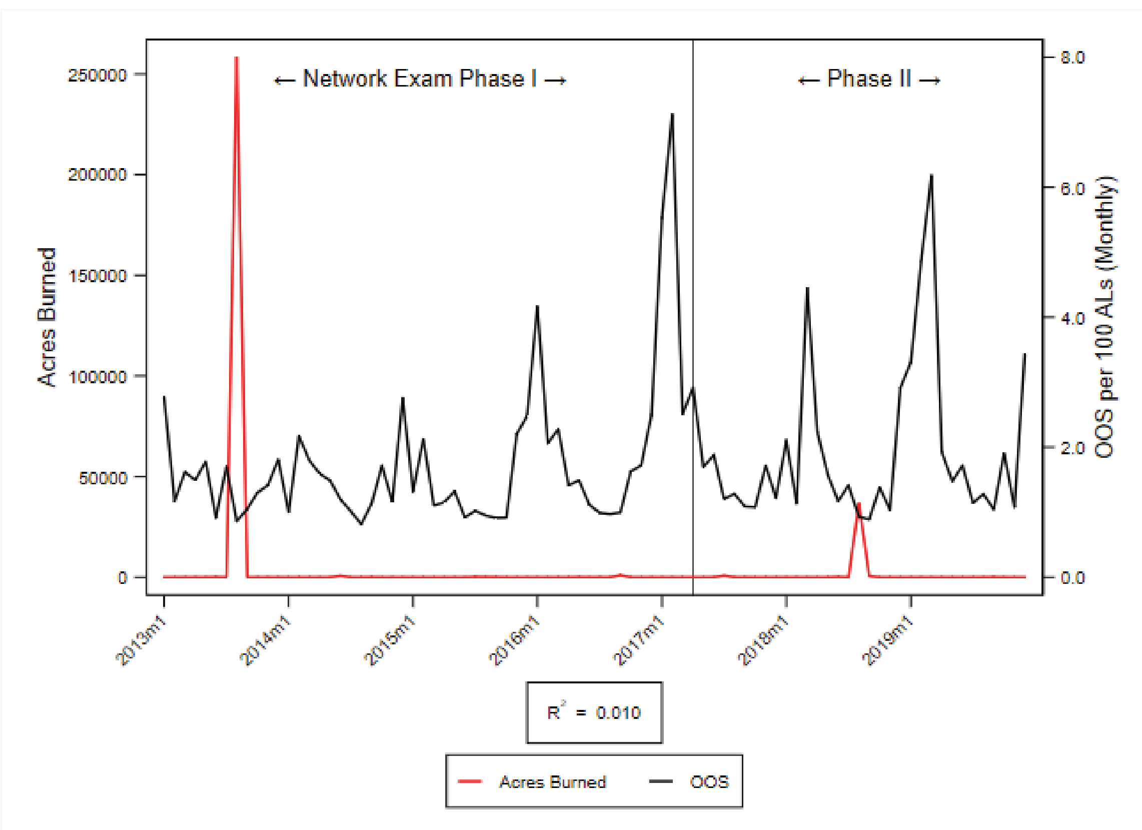
COUNTY-REGION TULARE - SOUTHERN SAN JOAQUIN VALLEY (AT&T)



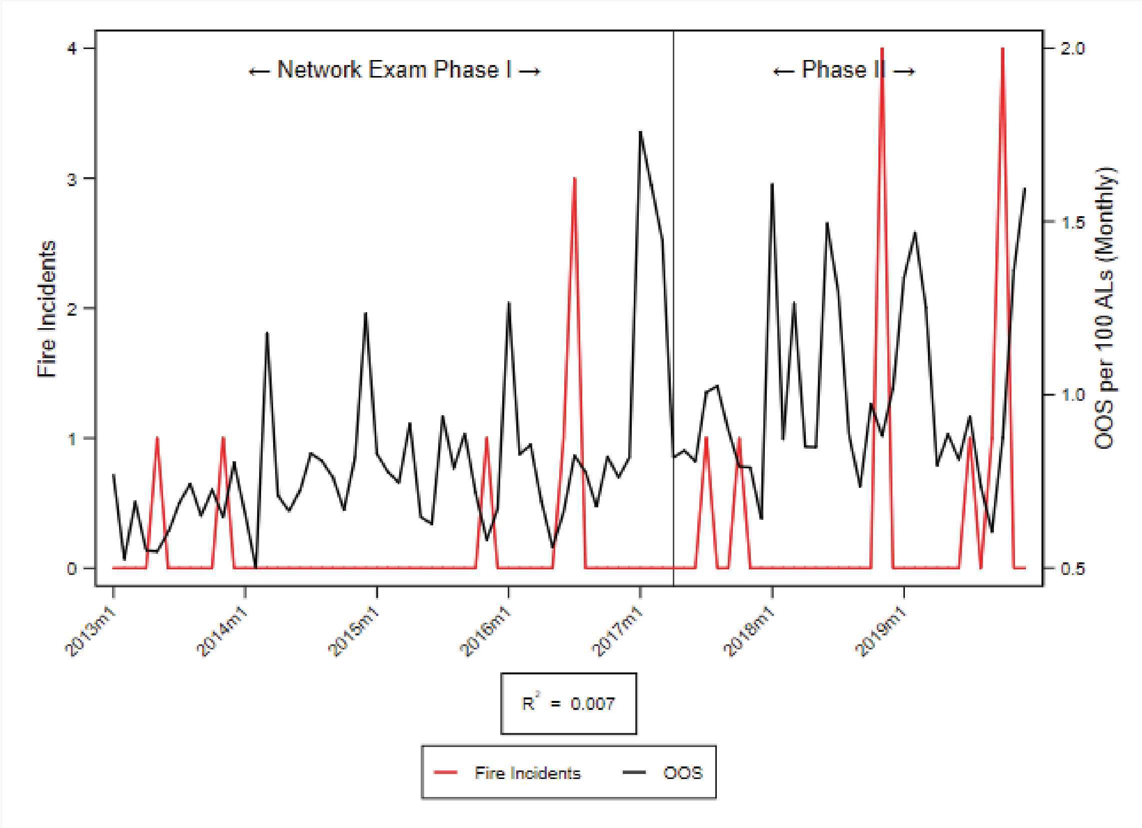


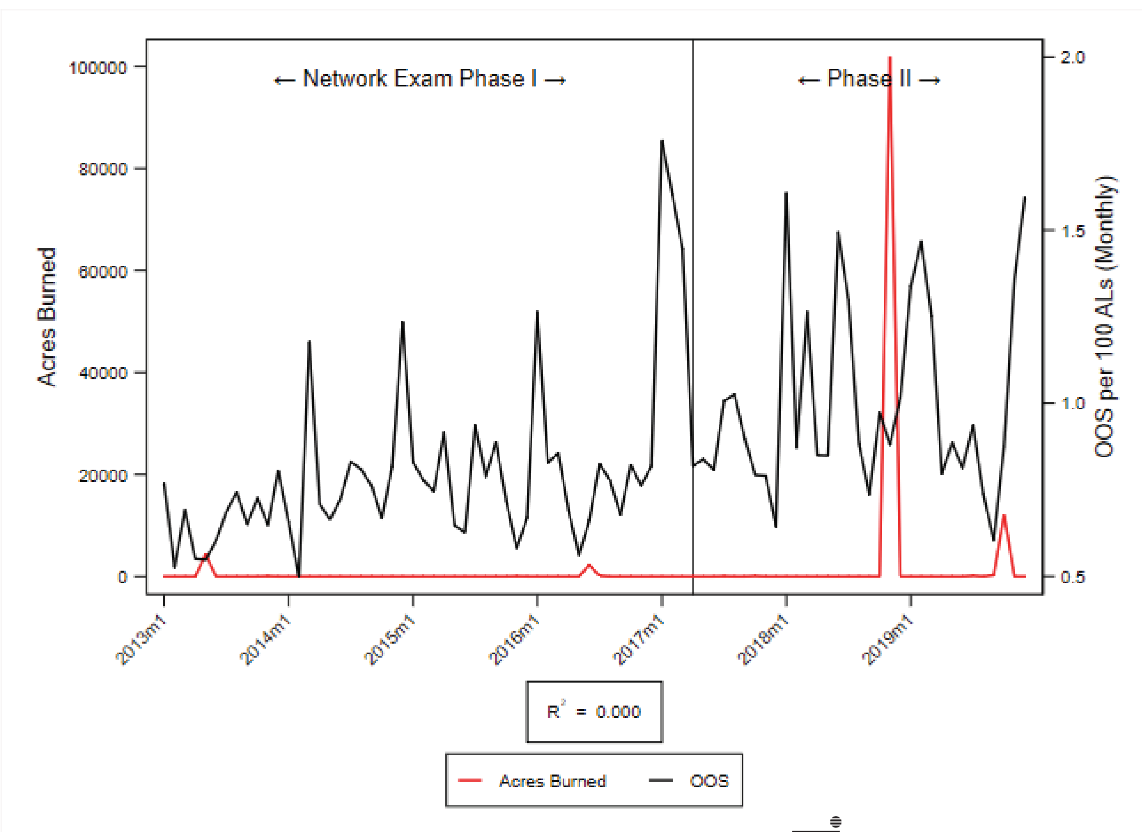
COUNTY-REGION TUOLUMNE - NORTHERN SAN JOAQUIN VALLEY (AT&T)





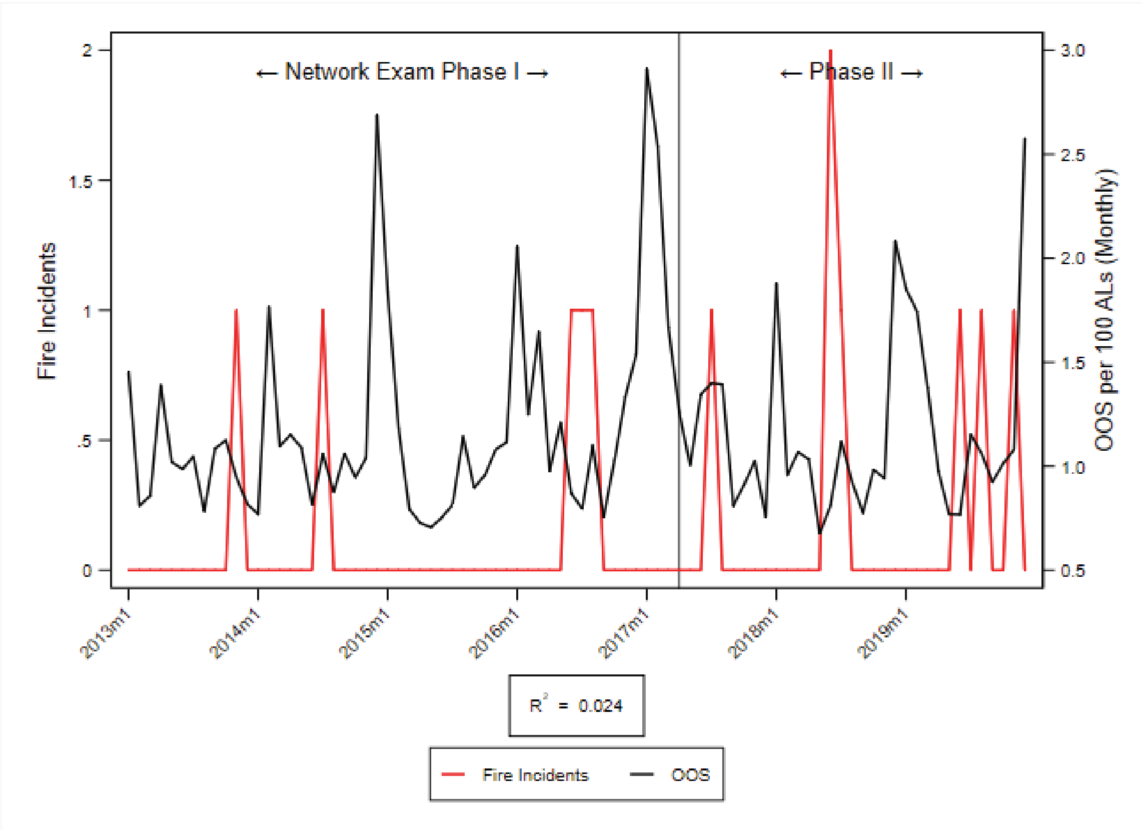
COUNTY-REGION VENTURA - CENTRAL COAST (AT&T)

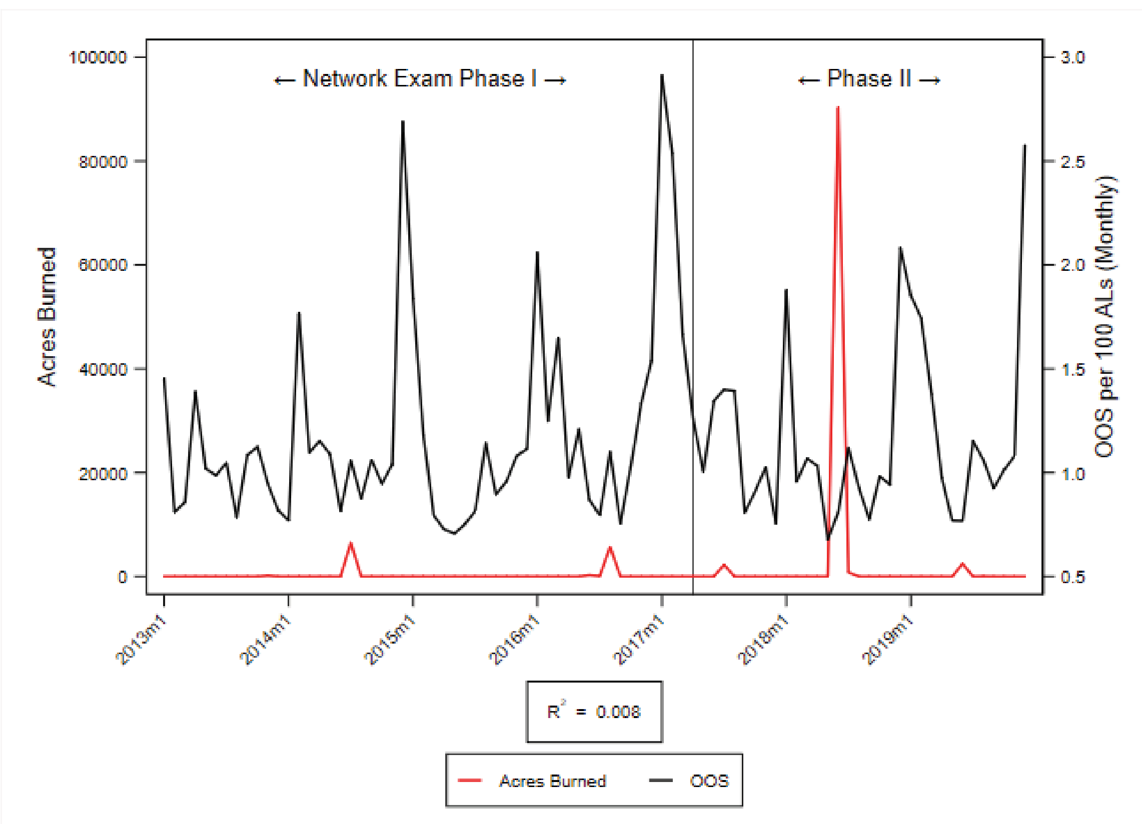




ECONOMICS AND TECHNOLOGY, INC.

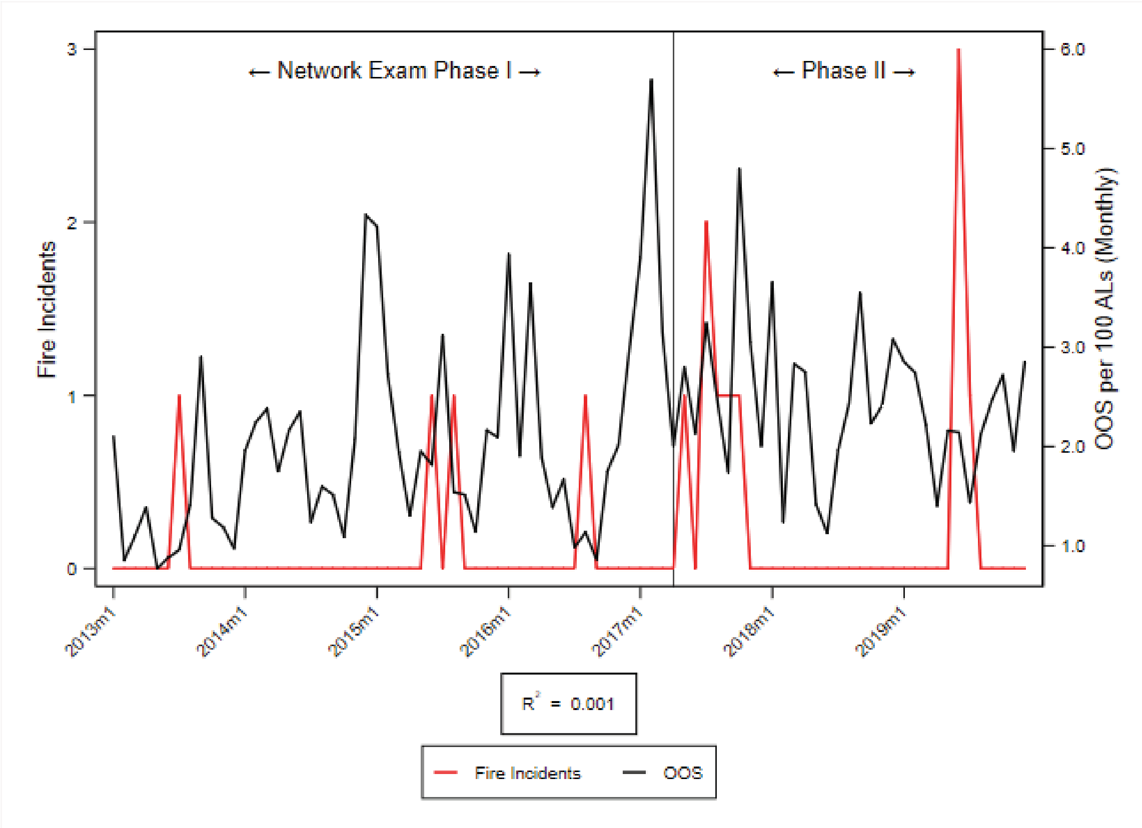
COUNTY-REGION YOLO - SUPERIOR CALIFORNIA (AT&T)

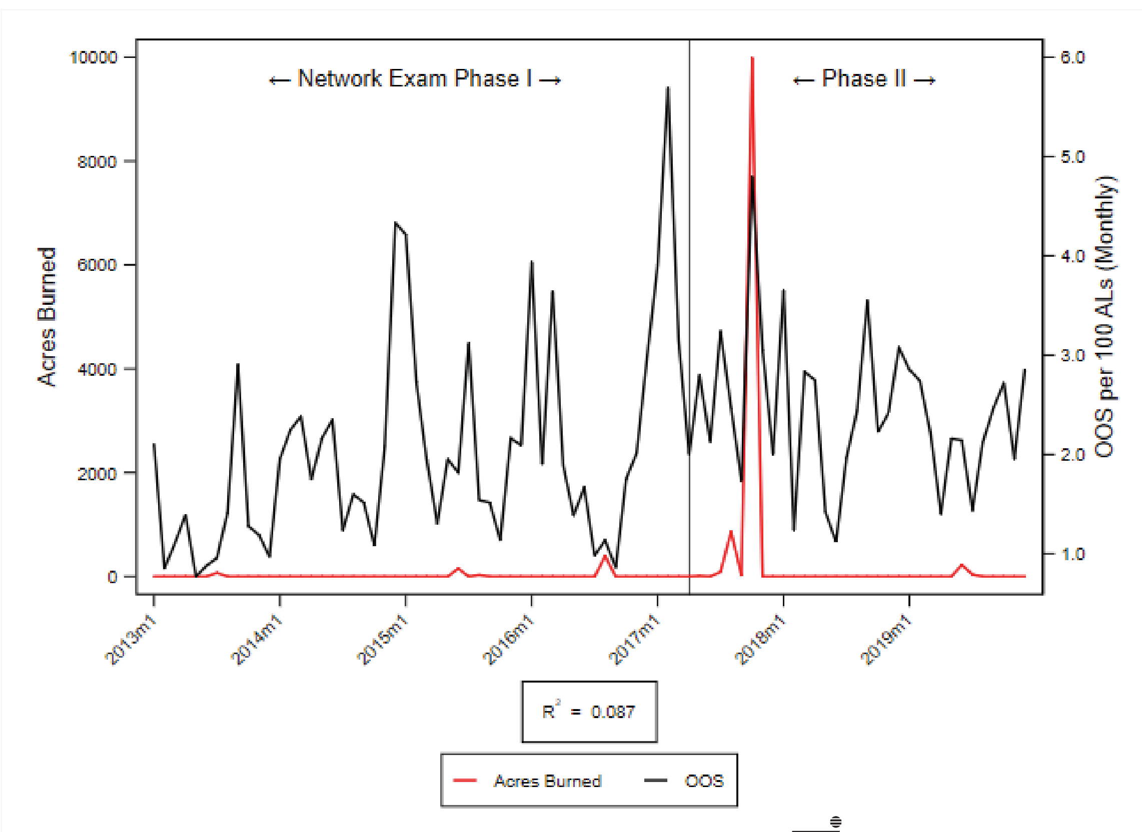




ECONOMICS AND TECHNOLOGY, INC.

COUNTY-REGION YUBA - SUPERIOR CALIFORNIA (AT&T)





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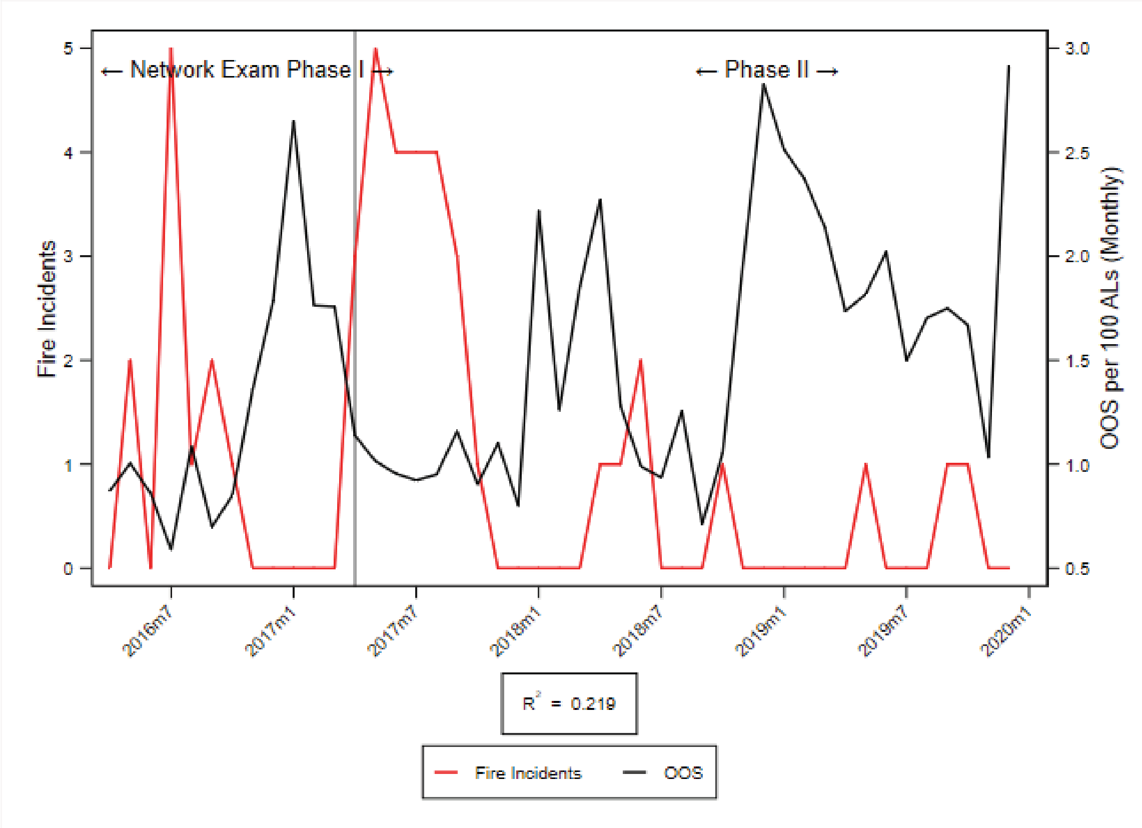
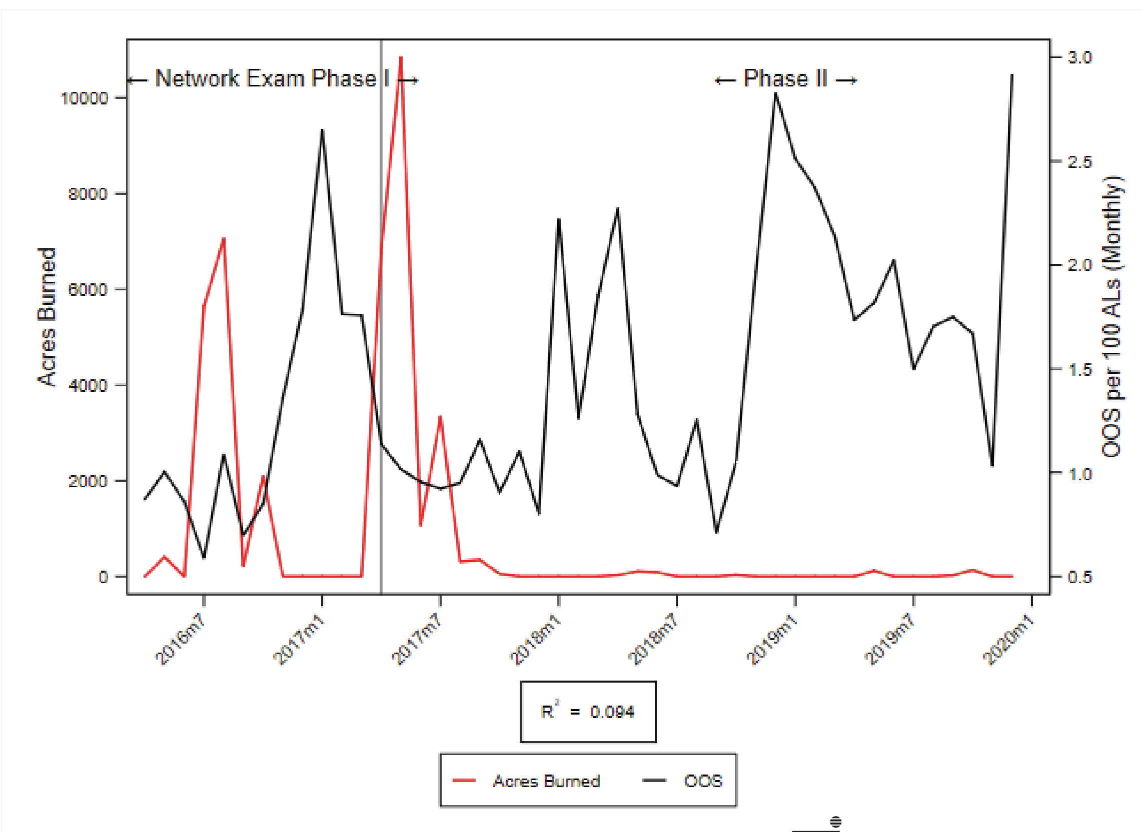
Appendix 13-2

Frontier California

County-level Regression Analyses
Wildfires vs. Telephone Service Outages

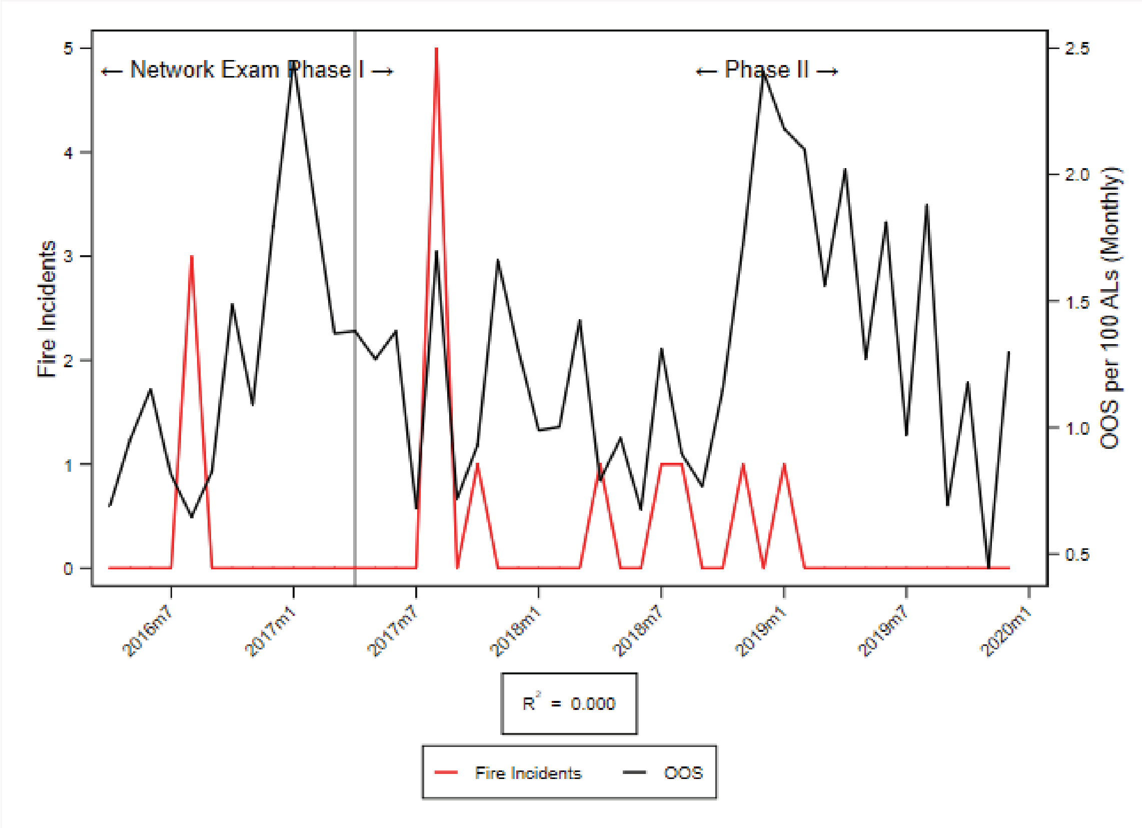
COUNTY-REGION FRESNO - SOUTHERN SAN JOAQUIN VALLEY (FTR)

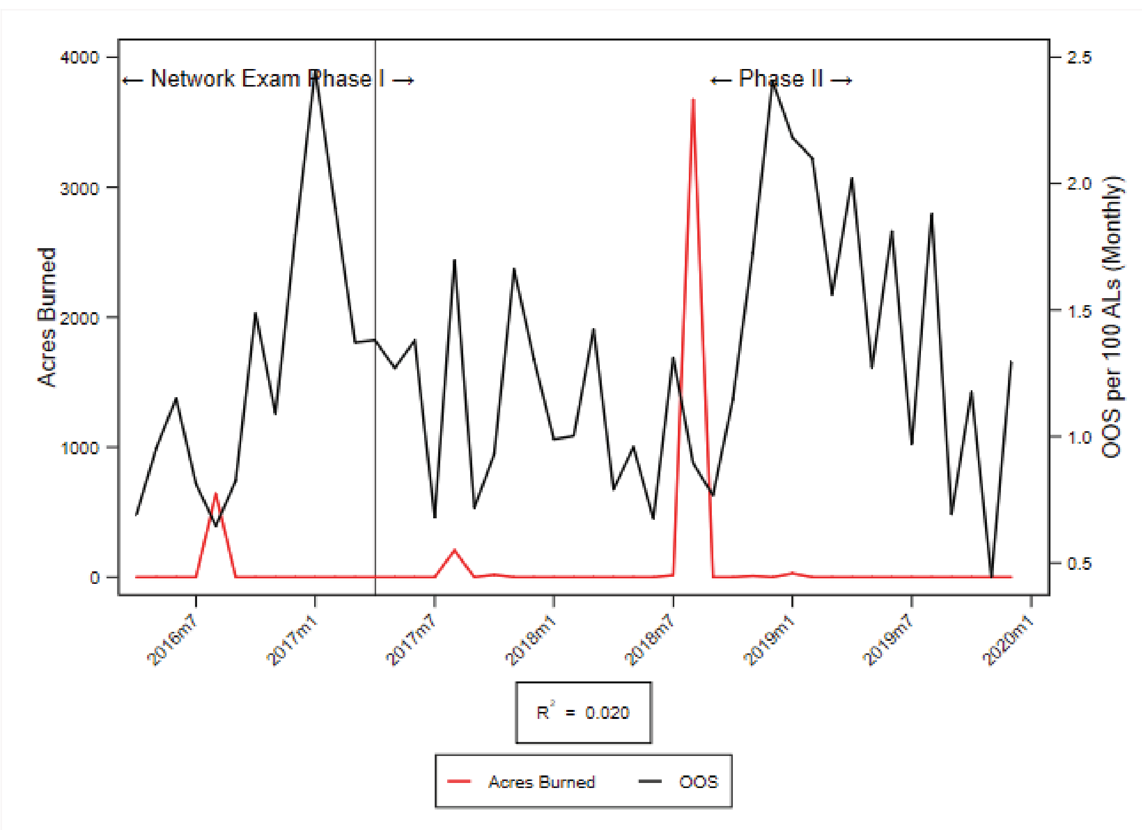




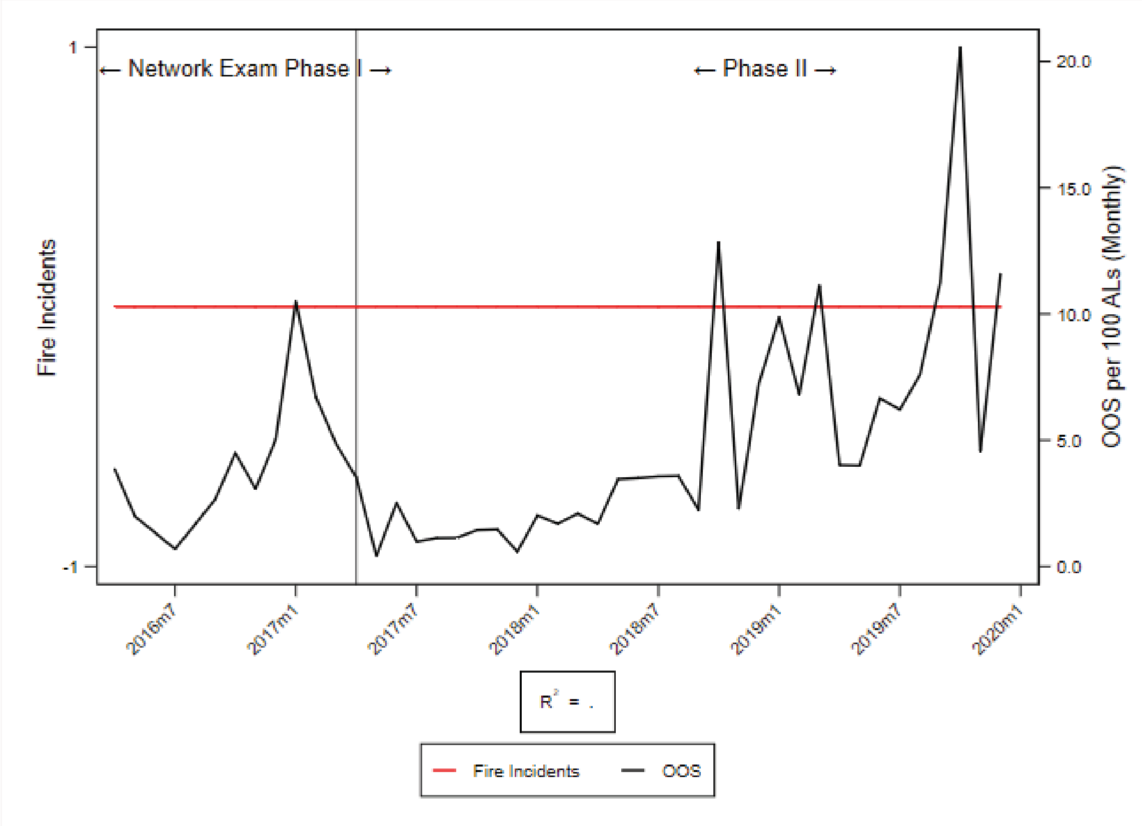
ECONOMICS AND TECHNOLOGY, INC.

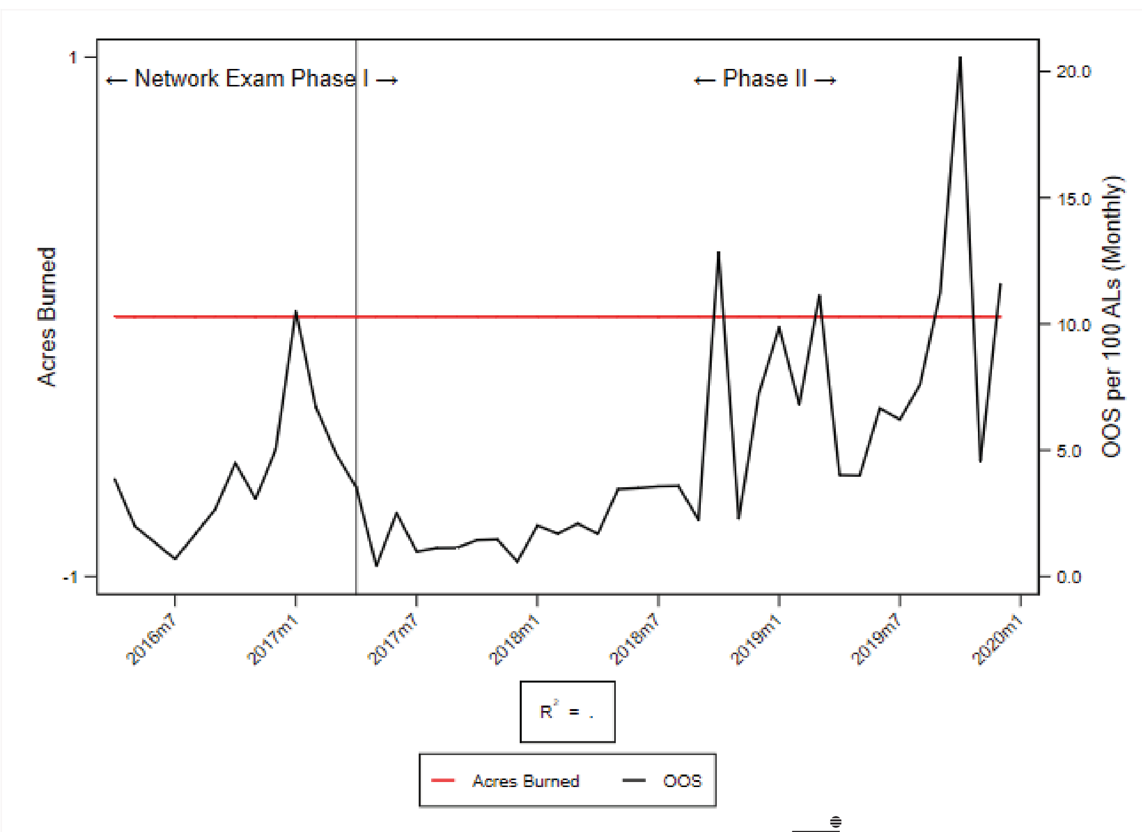
COUNTY-REGION HUMBOLDT - NORTH COAST (FTR)



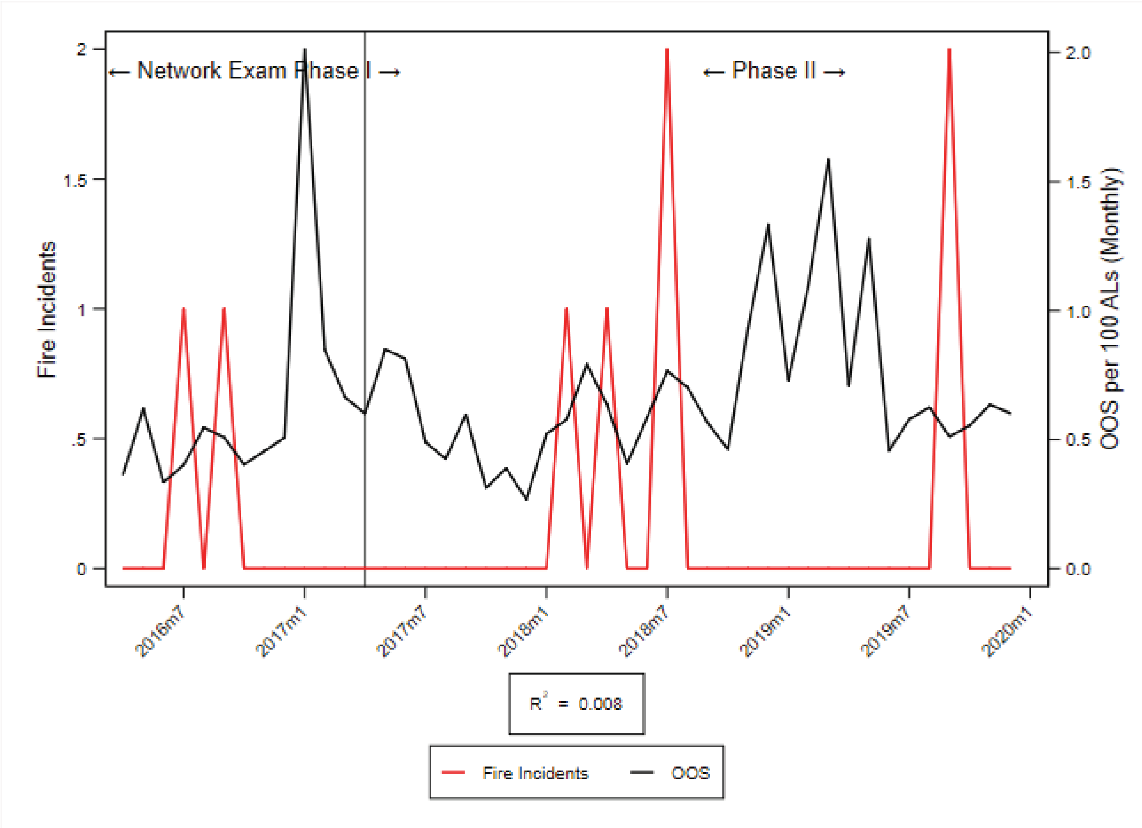


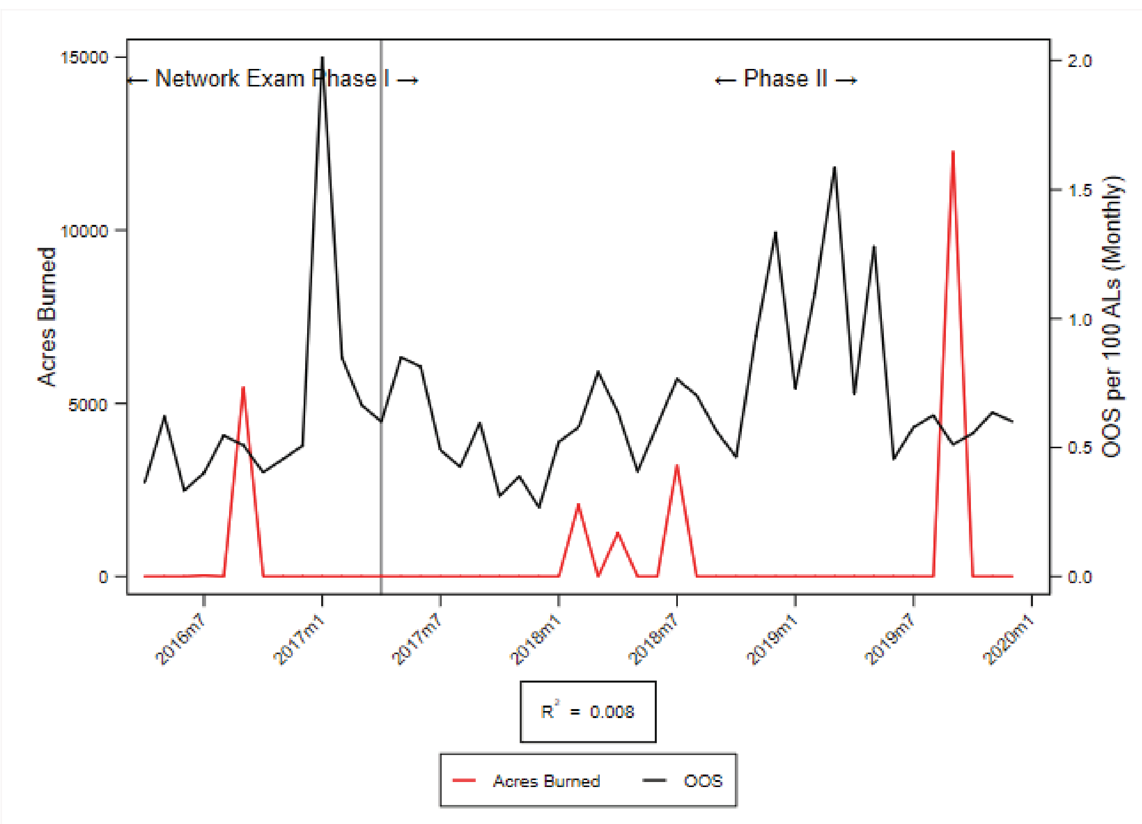
COUNTY-REGION IMPERIAL - SAN DIEGO-IMPERIAL (FTR)



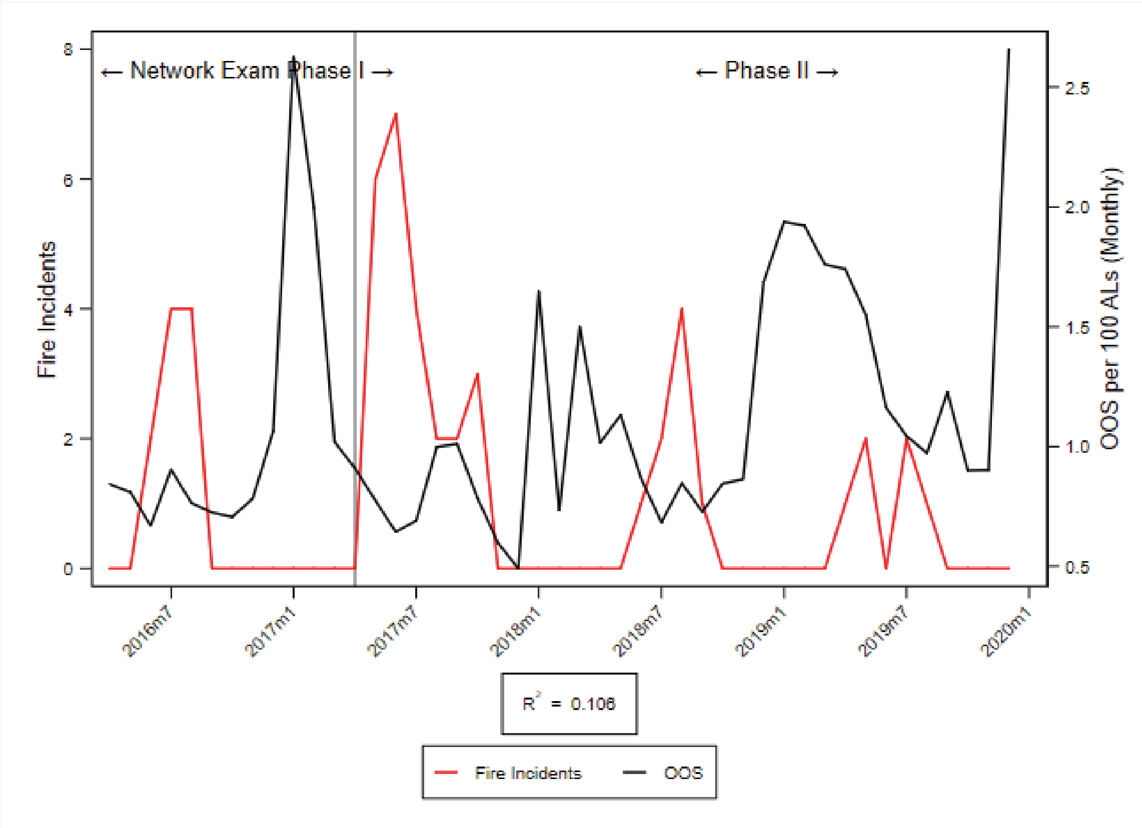


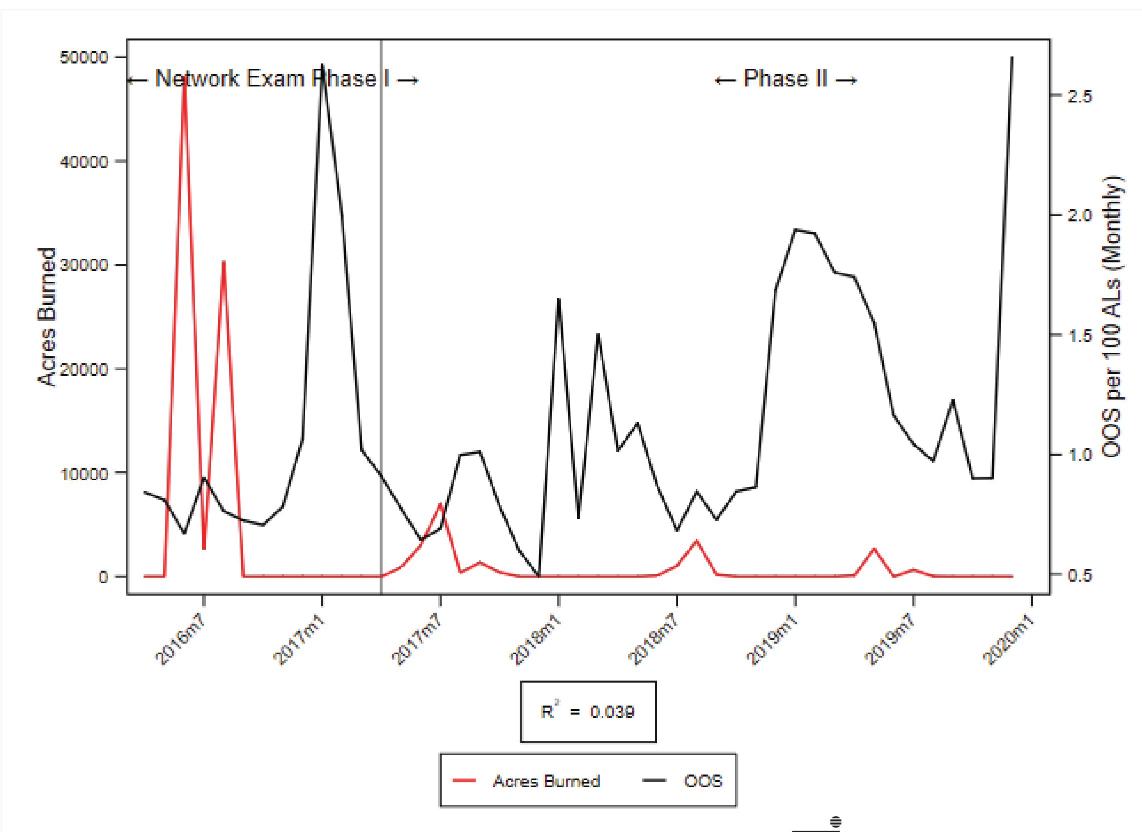
COUNTY-REGION INYO - SOUTHERN SAN JOAQUIN VALLEY (FTR)





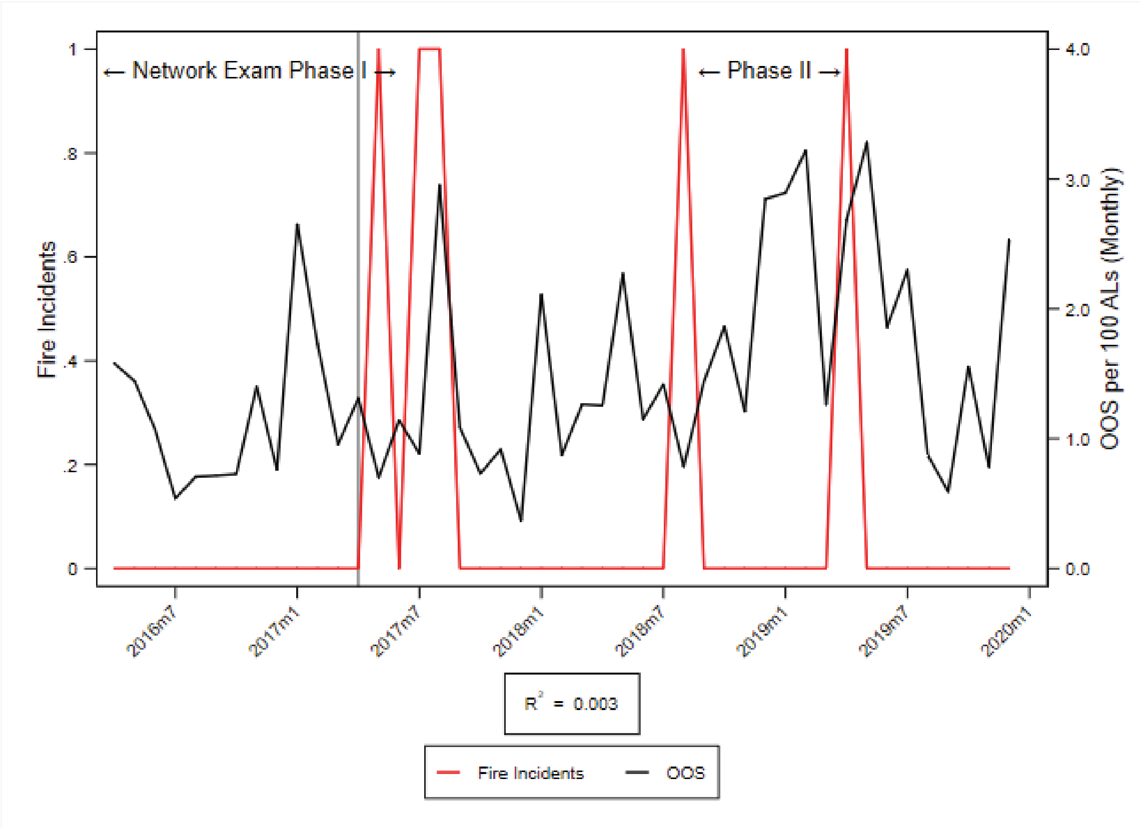
COUNTY-REGION KERN - SOUTHERN SAN JOAQUIN VALLEY (FTR)

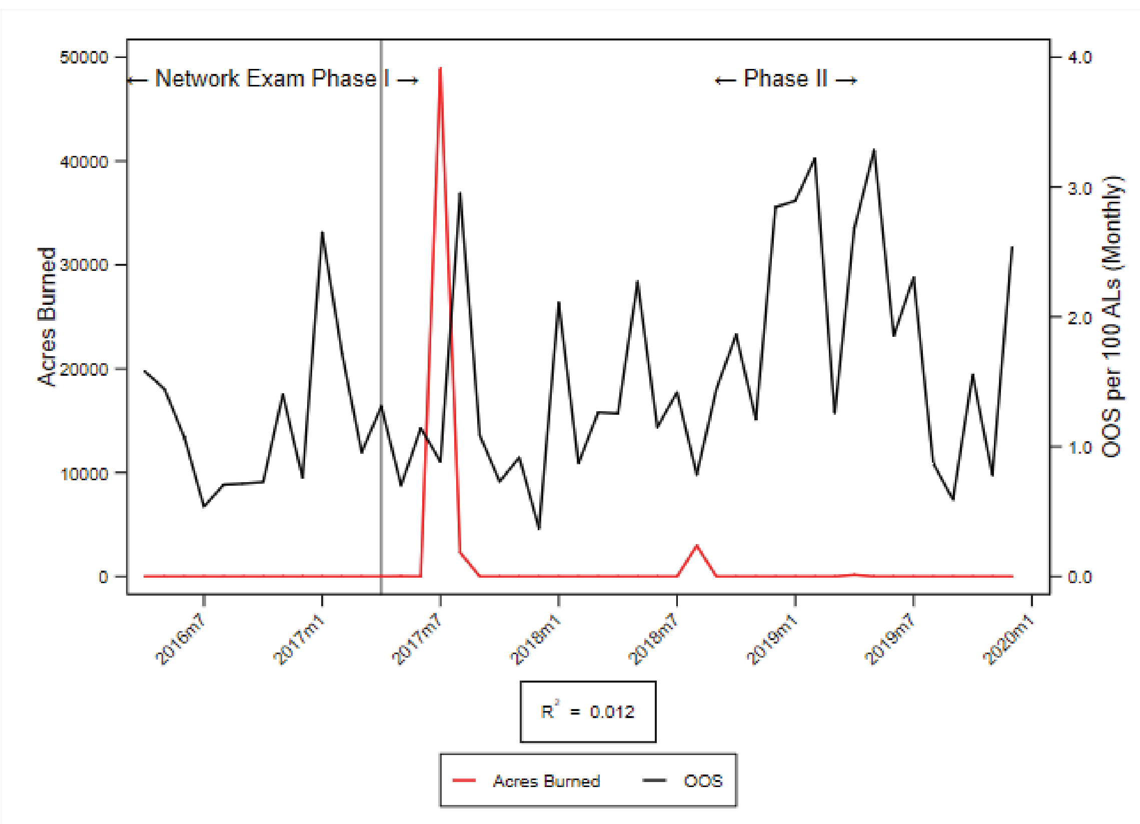




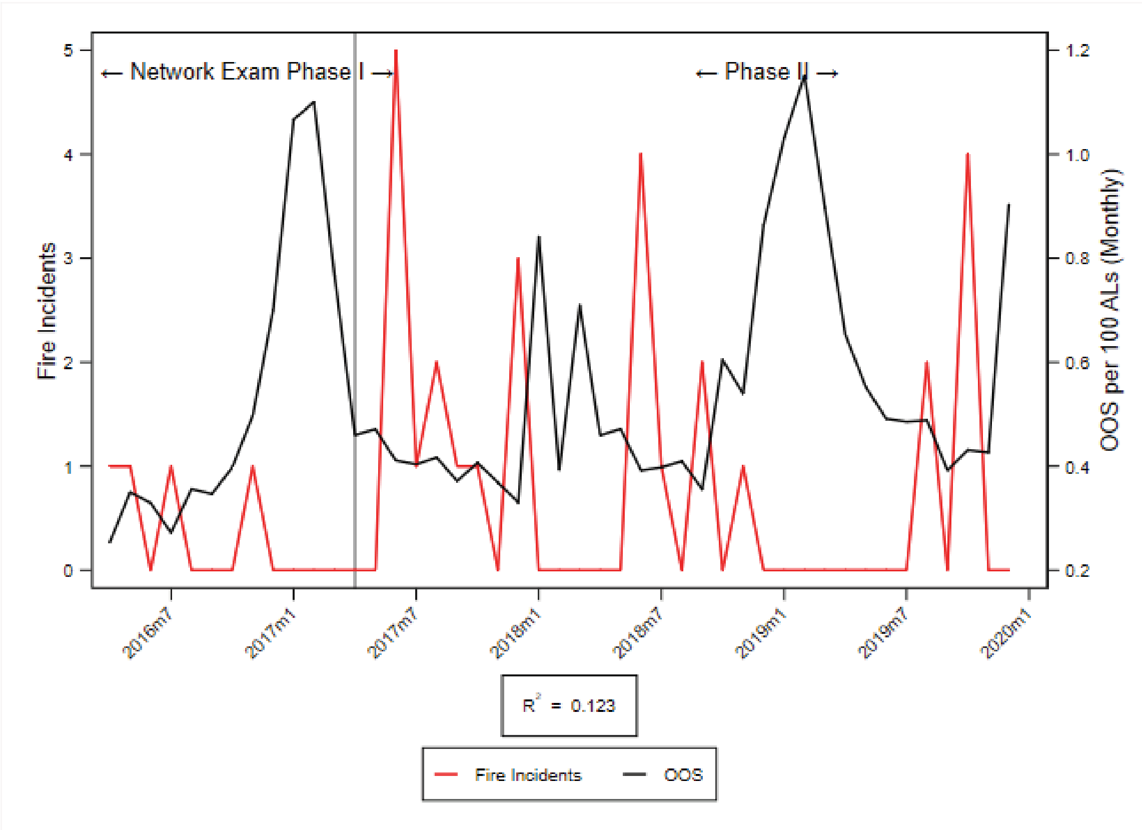
ECONOMICS AND TECHNOLOGY, INC.

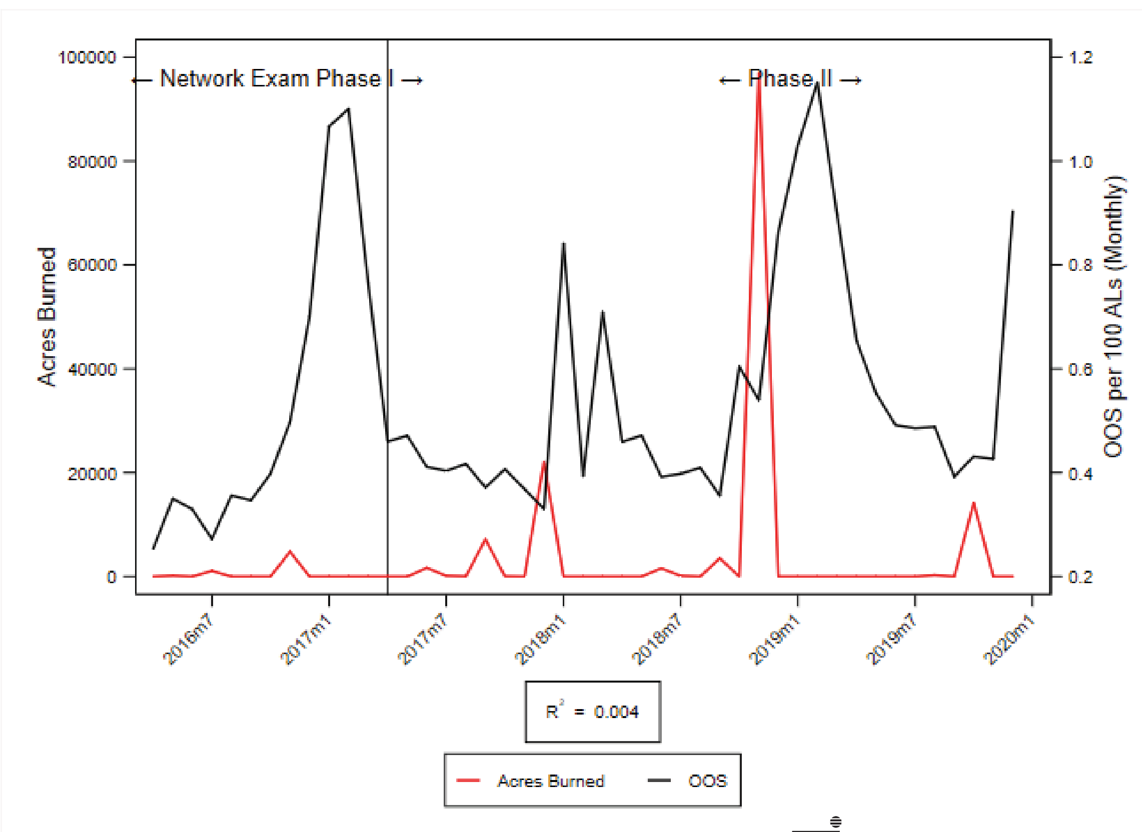
COUNTY-REGION KINGS - SOUTHERN SAN JOAQUIN VALLEY (FTR)



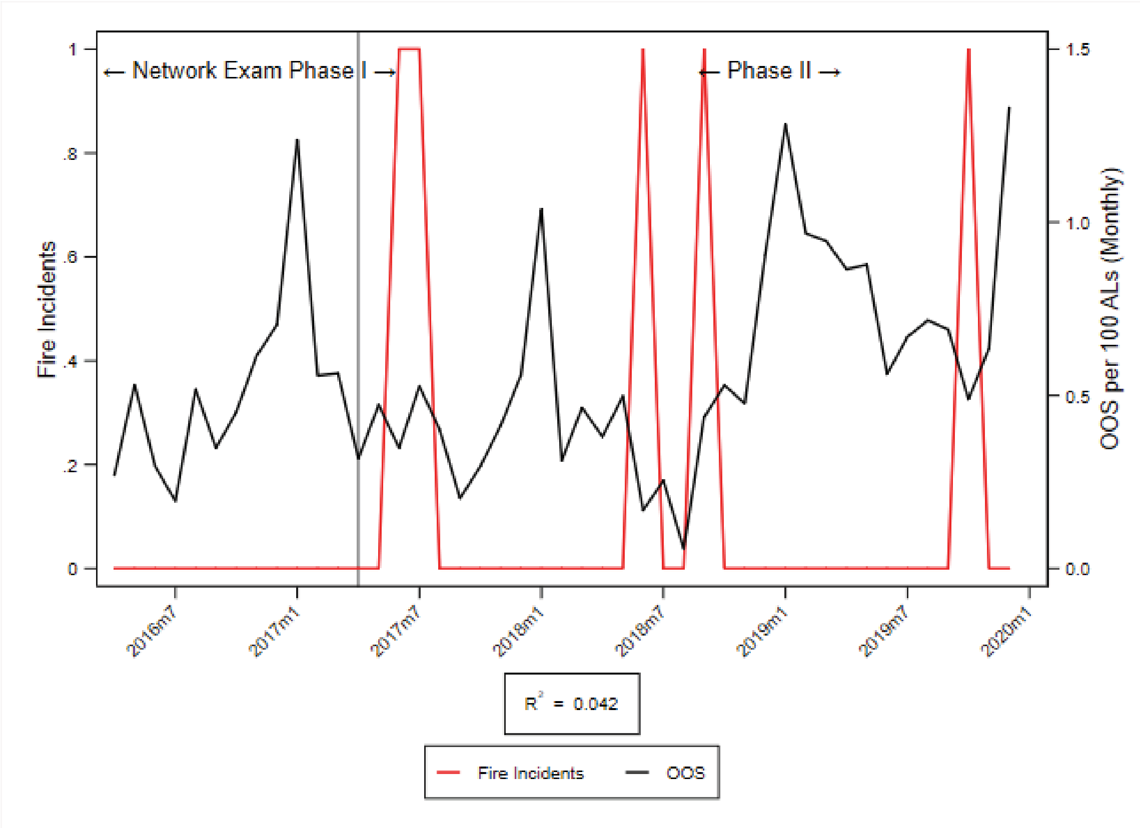


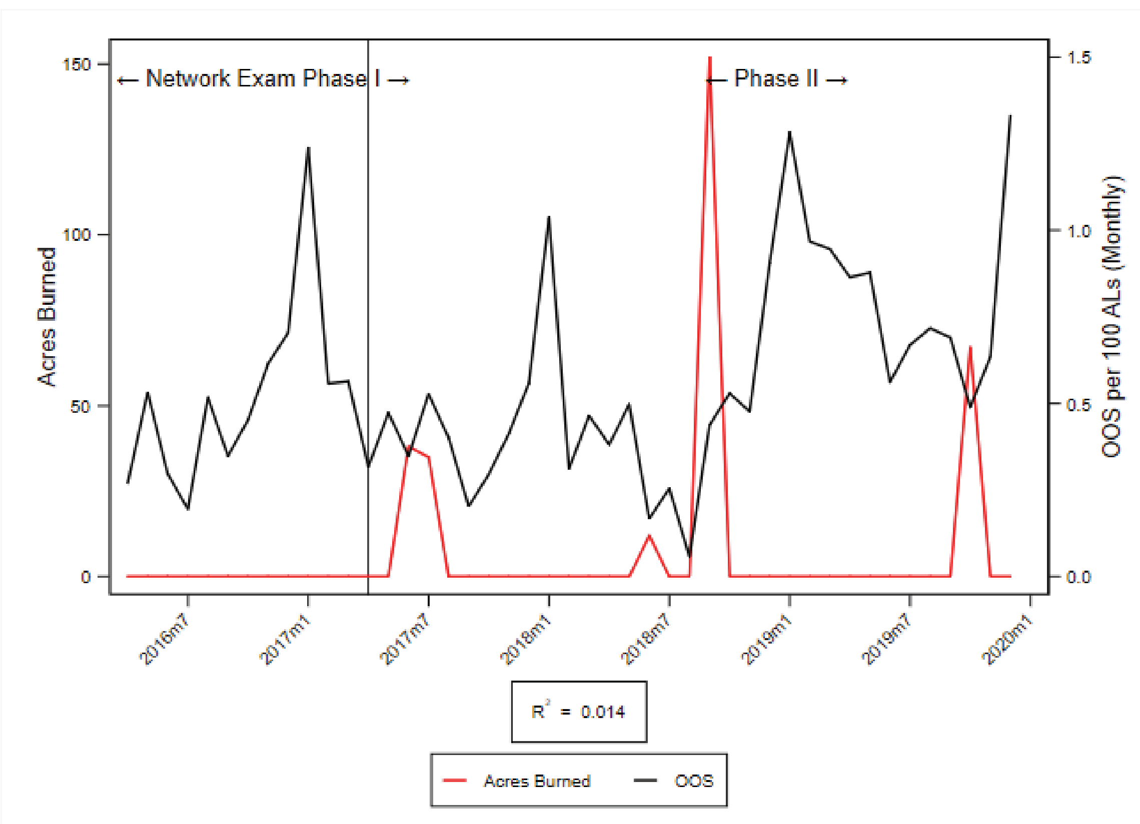
COUNTY-REGION   LOS ANGELES - LOS ANGELES (FTR)



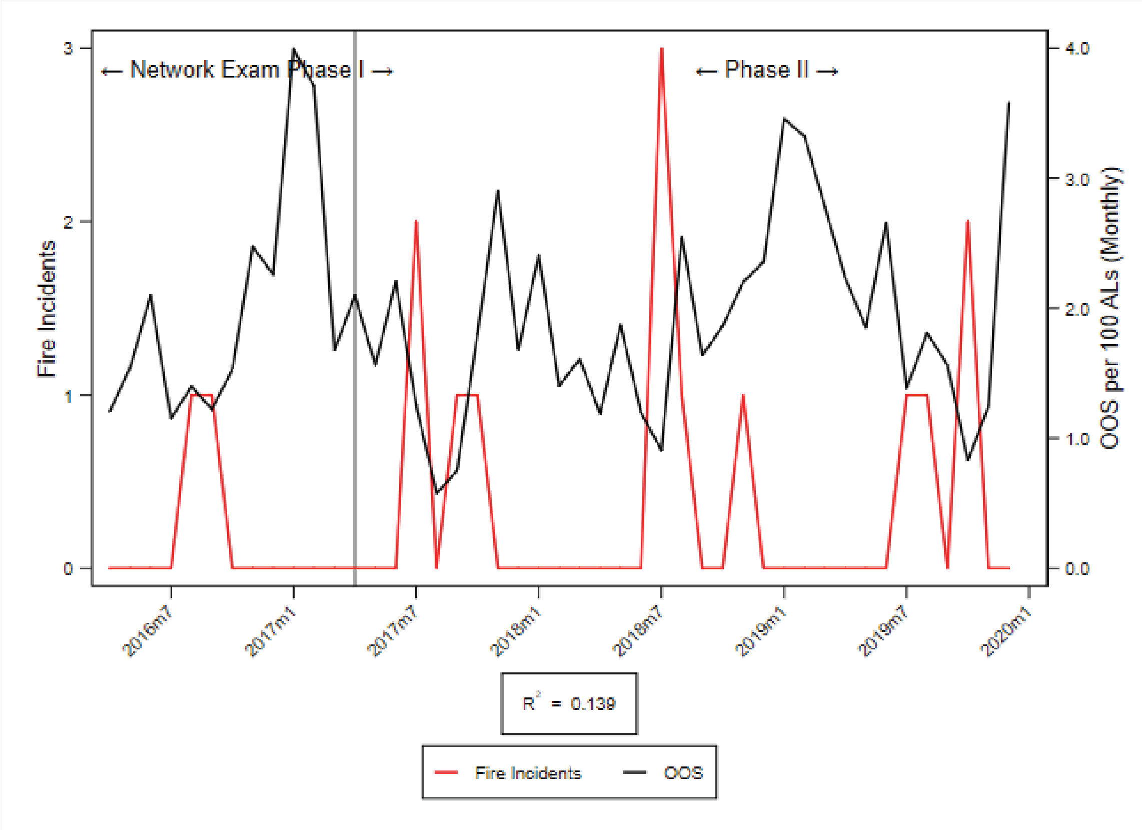


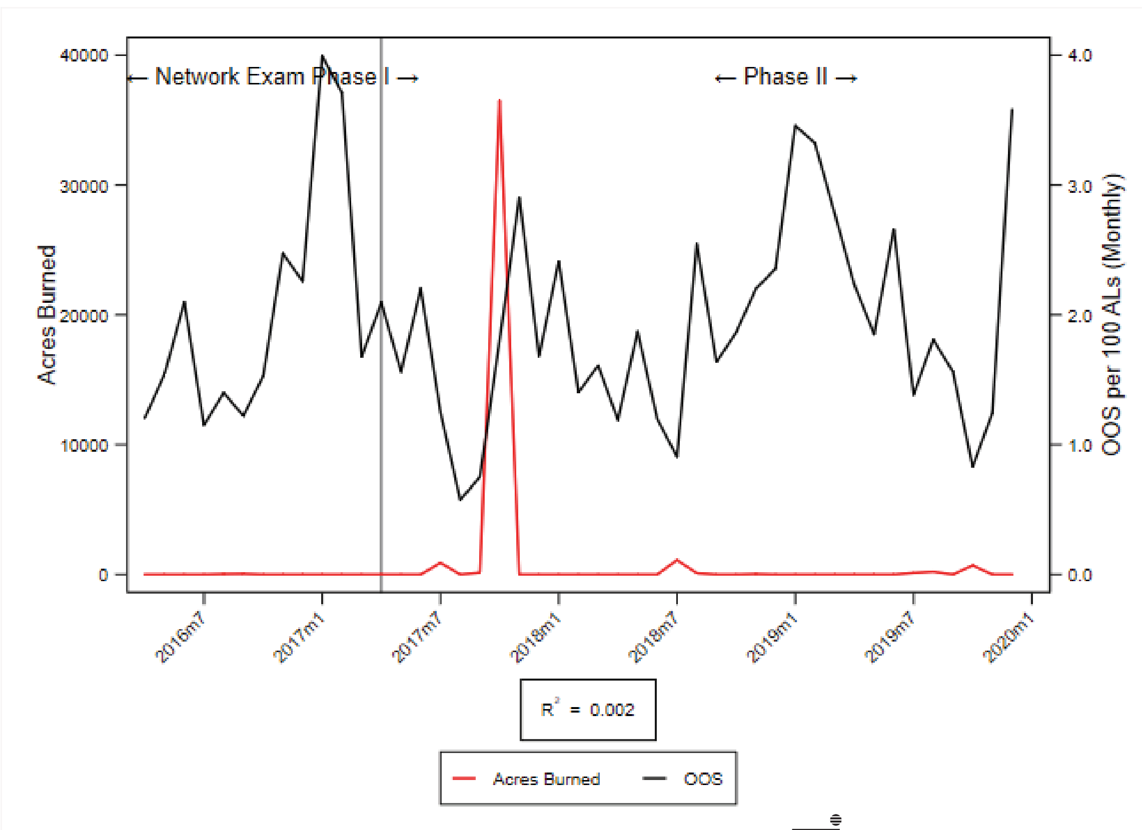
COUNTY-REGION MARIN - SAN FRANCISCO BAY AREA (FTR)



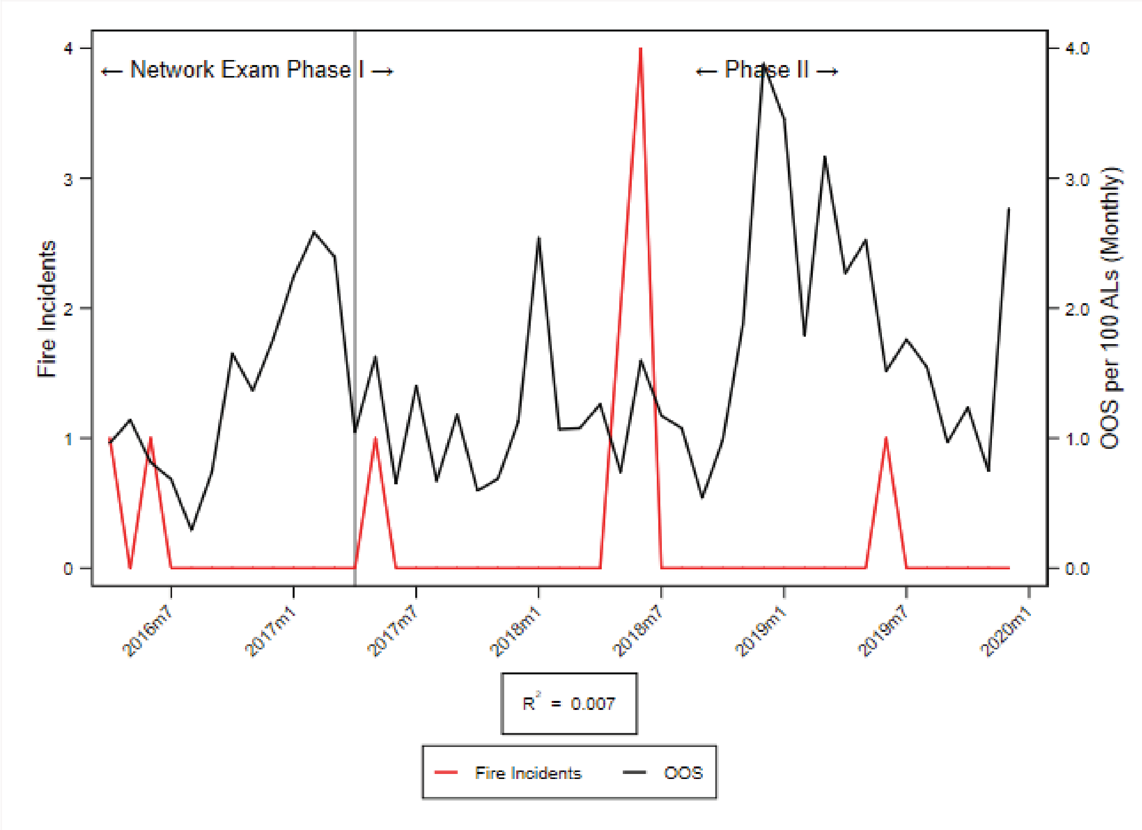


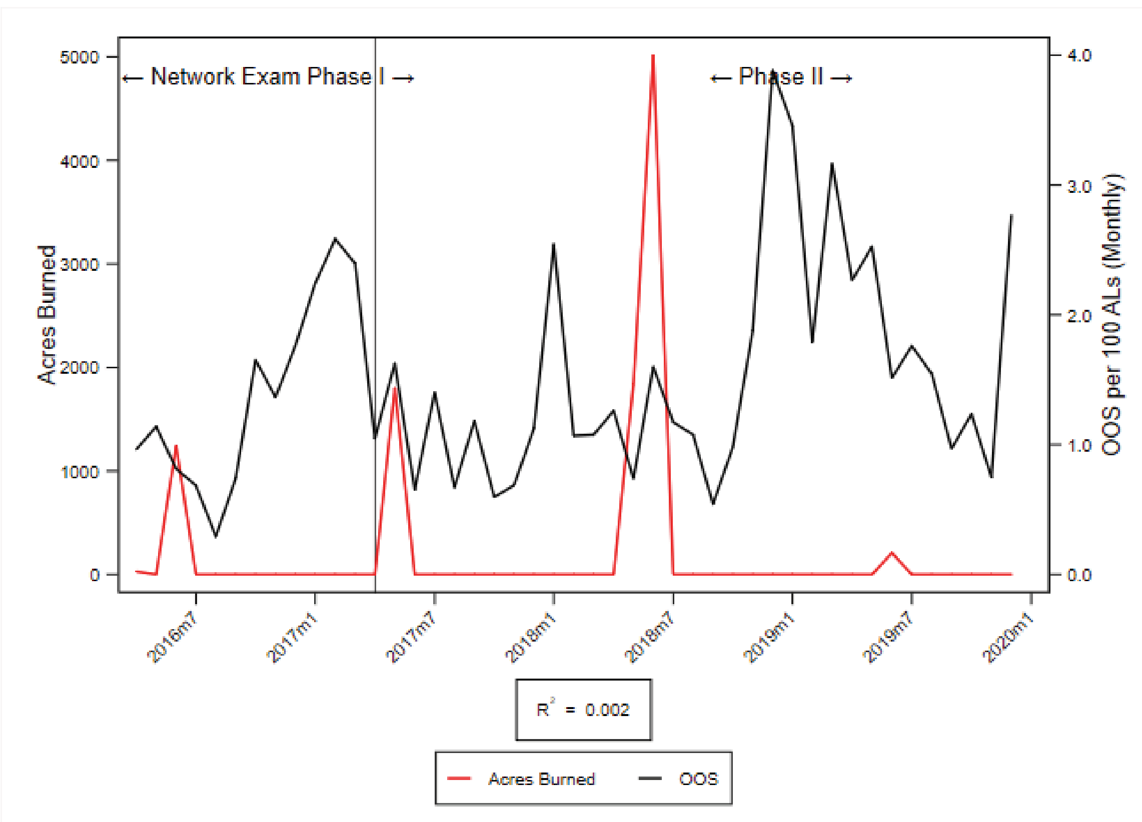
COUNTY-REGION MENDOCINO - NORTH COAST (FTR)



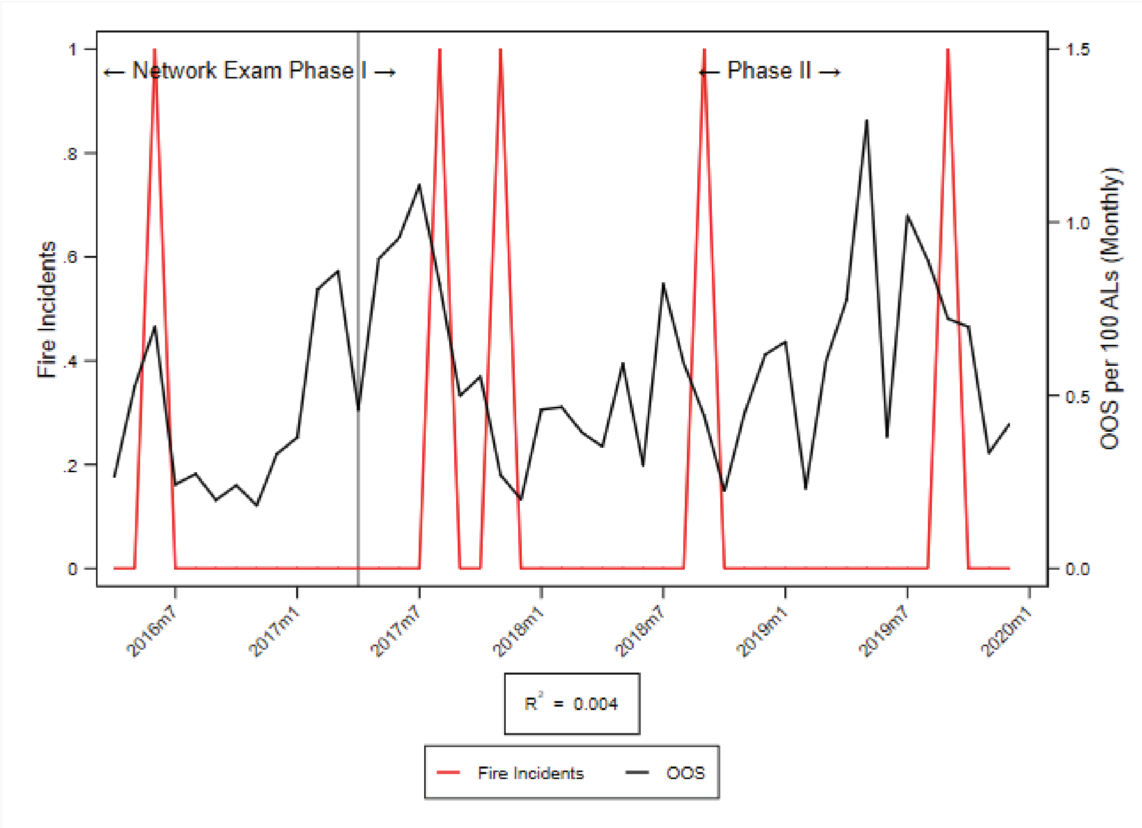


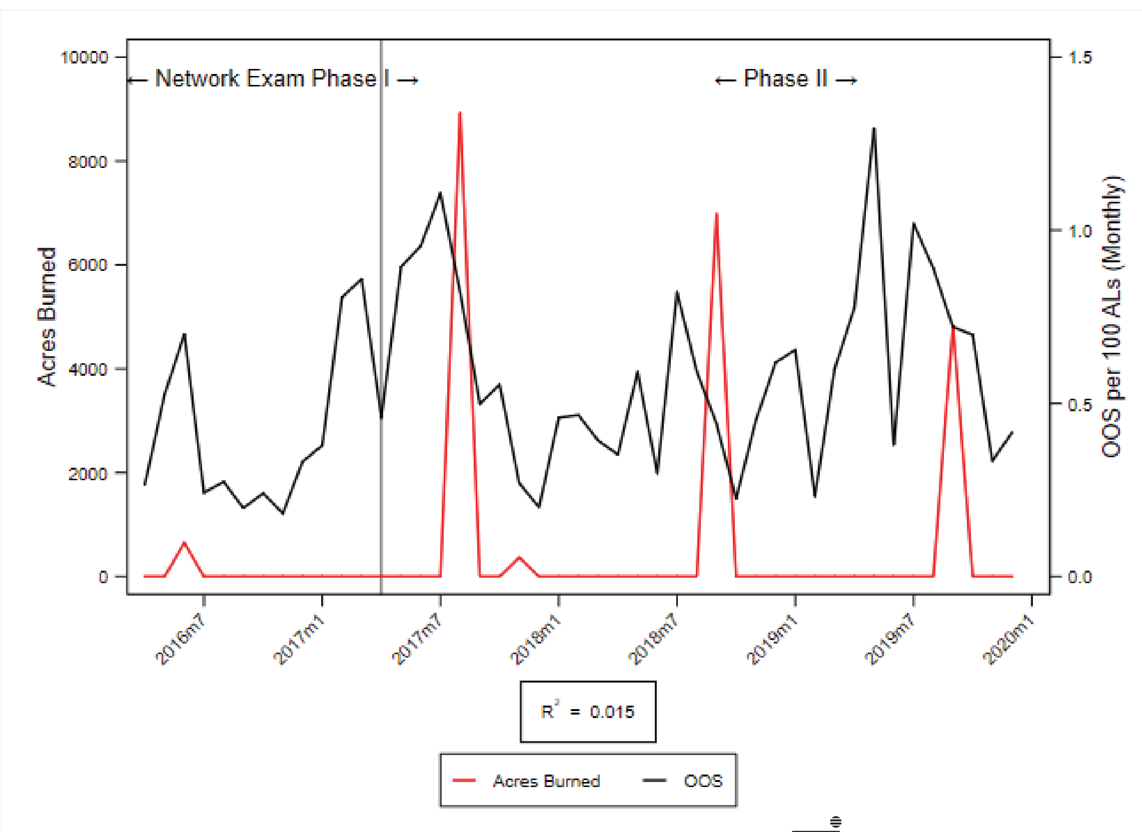
COUNTY-REGION MERCED - NORTHERN SAN JOAQUIN VALLEY (FTR)





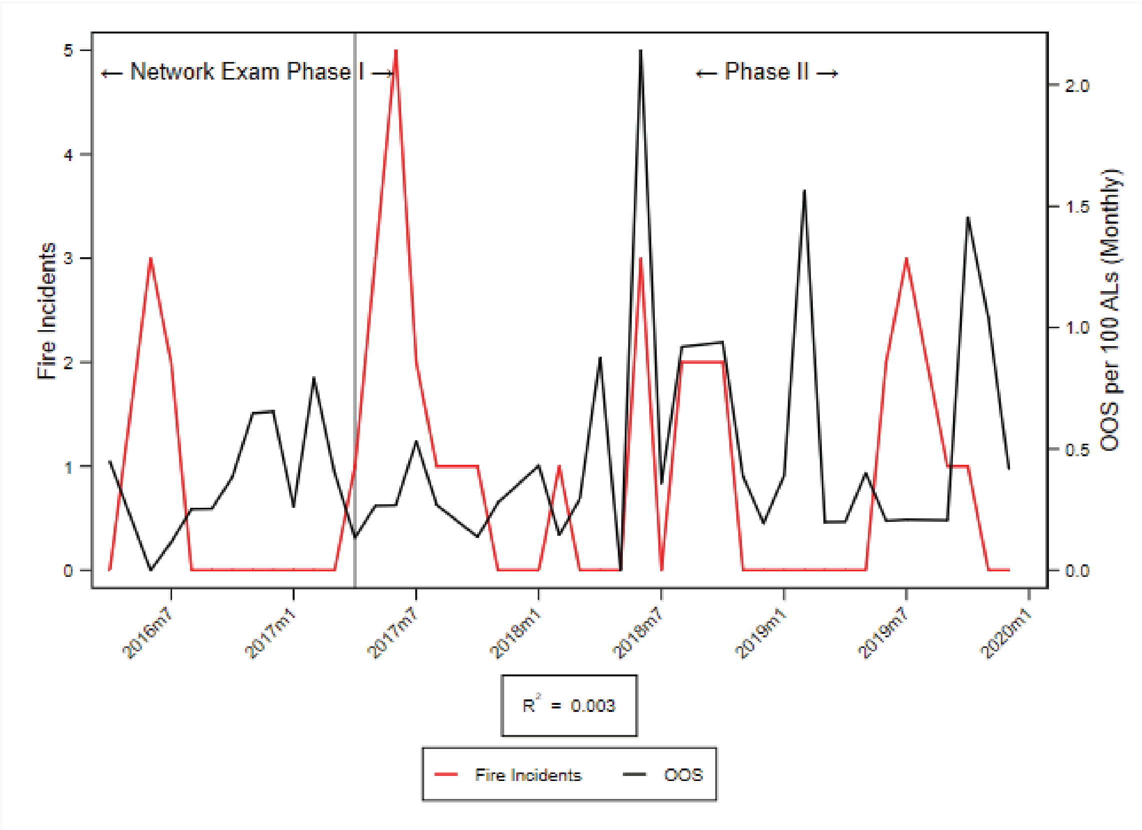
COUNTY-REGION   MONO - NORTHERN SAN JOAQUIN VALLEY (FTR)

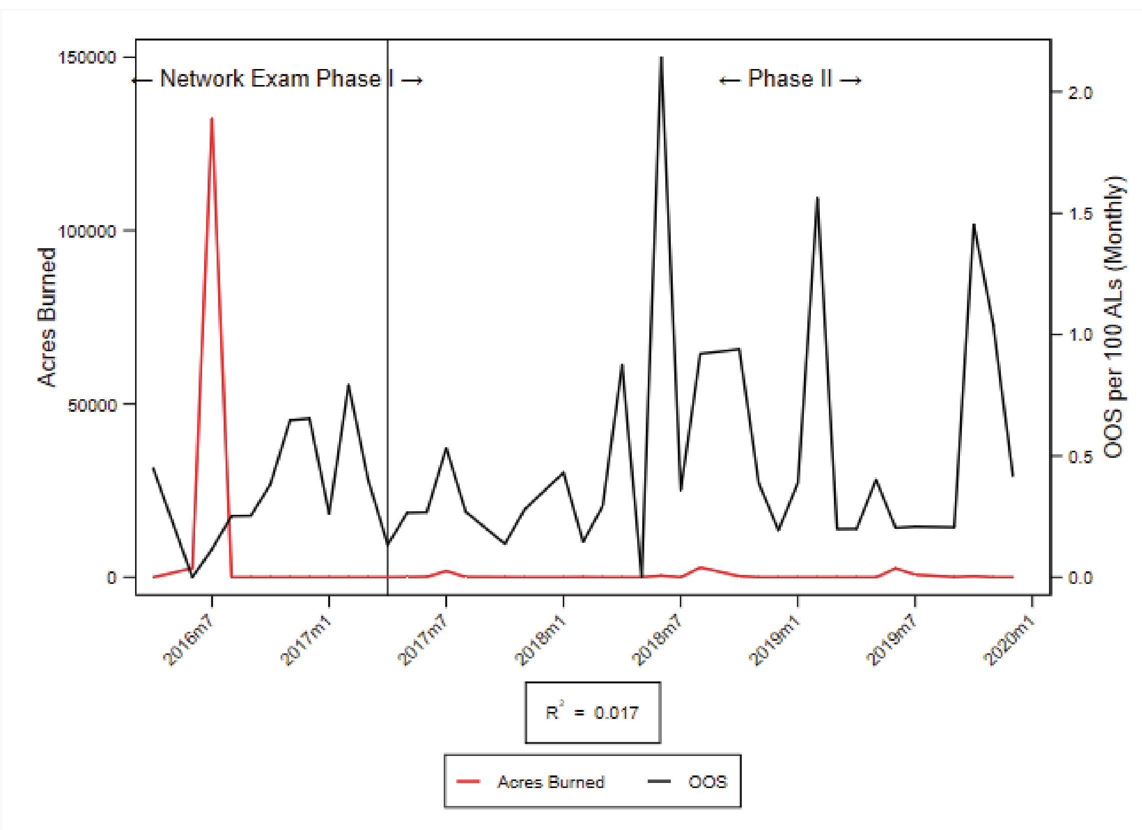




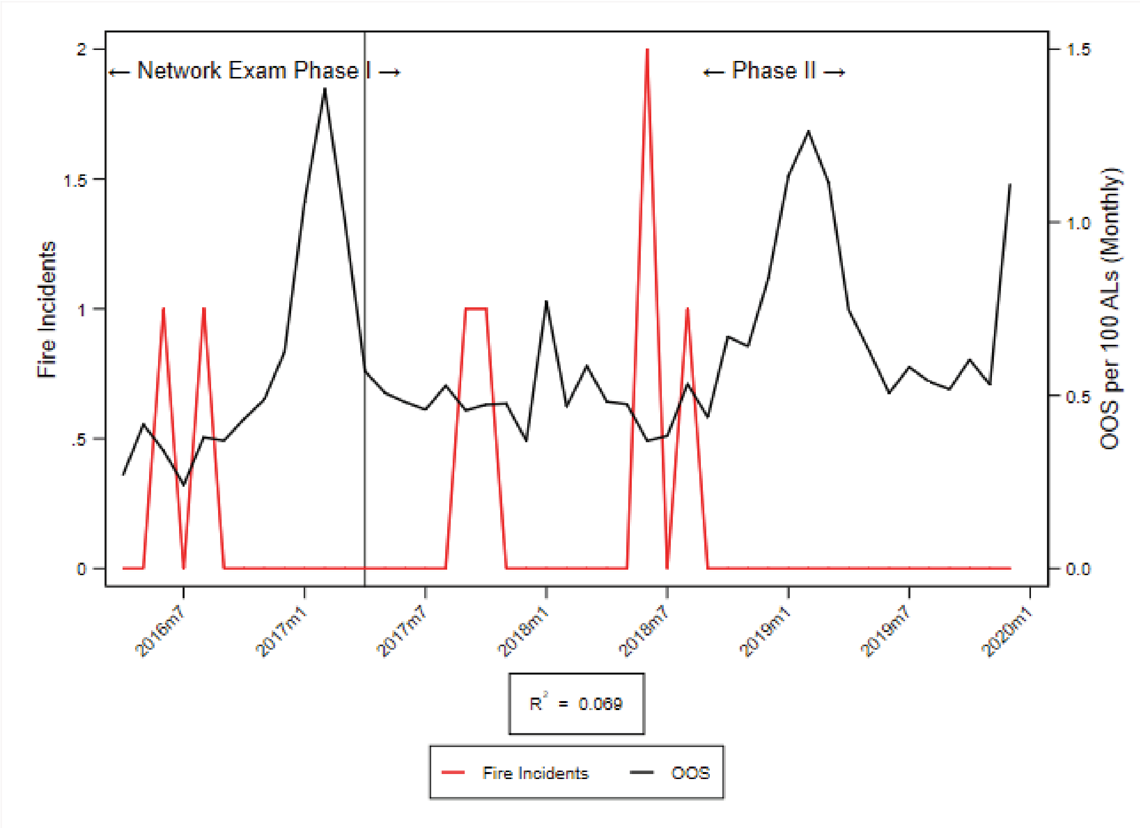
ECONOMICS AND TECHNOLOGY, INC.

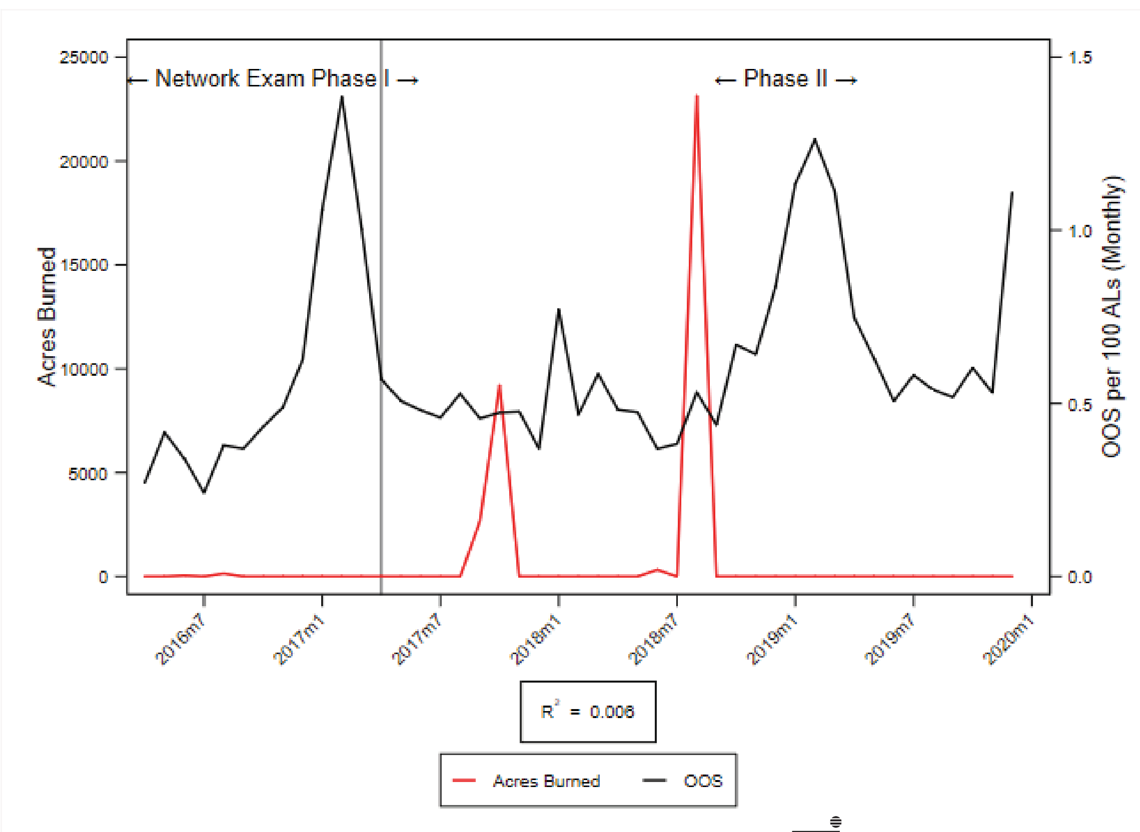
COUNTY-REGION MONTEREY - CENTRAL COAST (FTR)



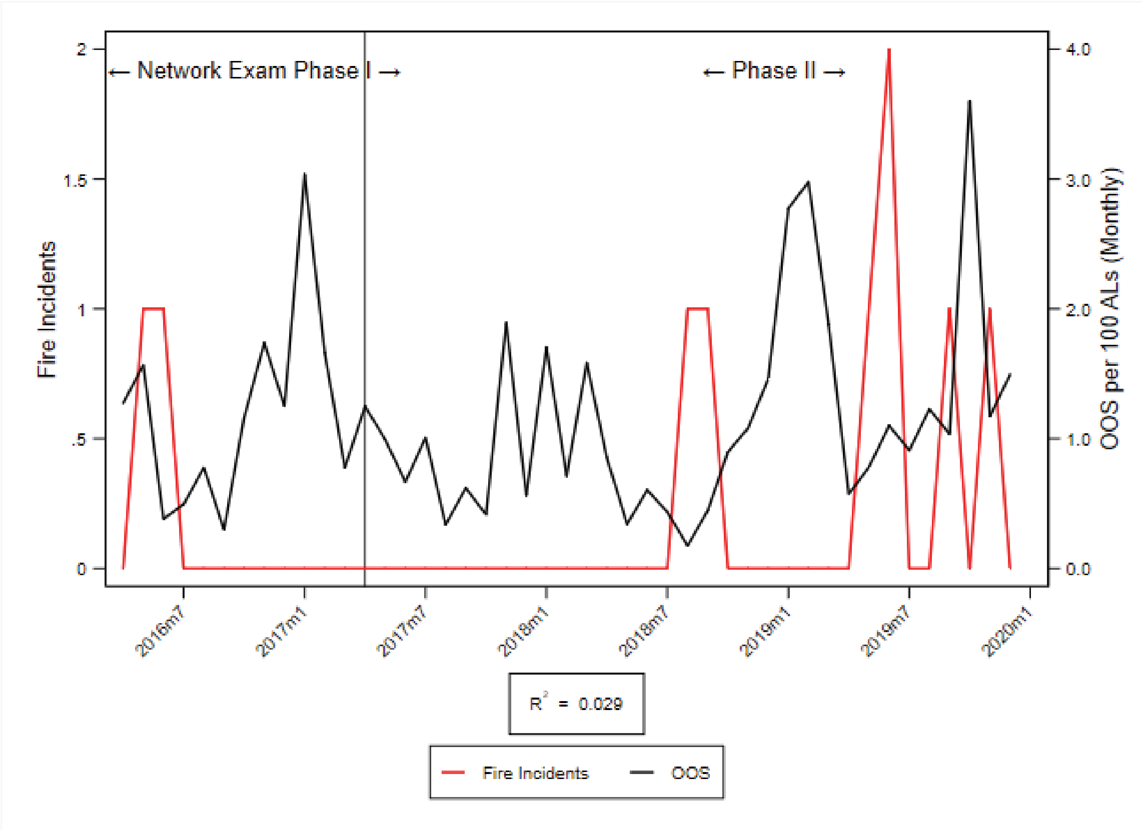


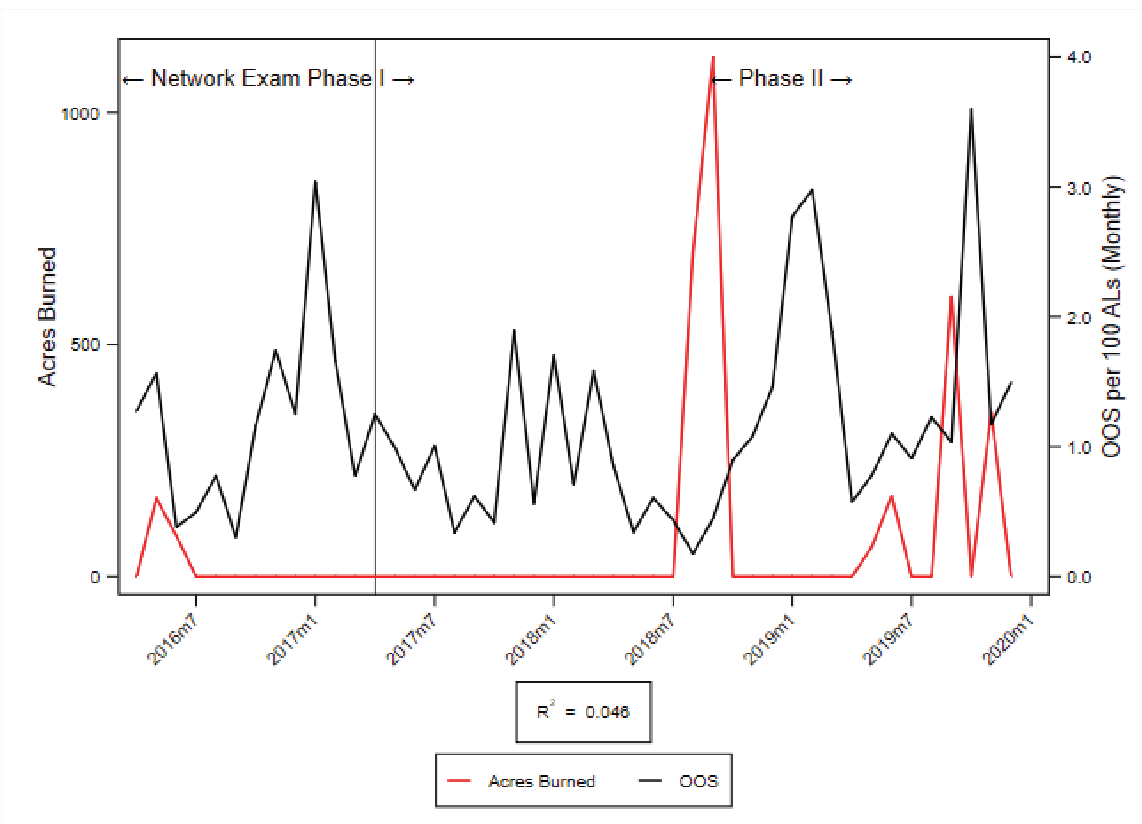
COUNTY-REGION ORANGE - ORANGE (FTR)



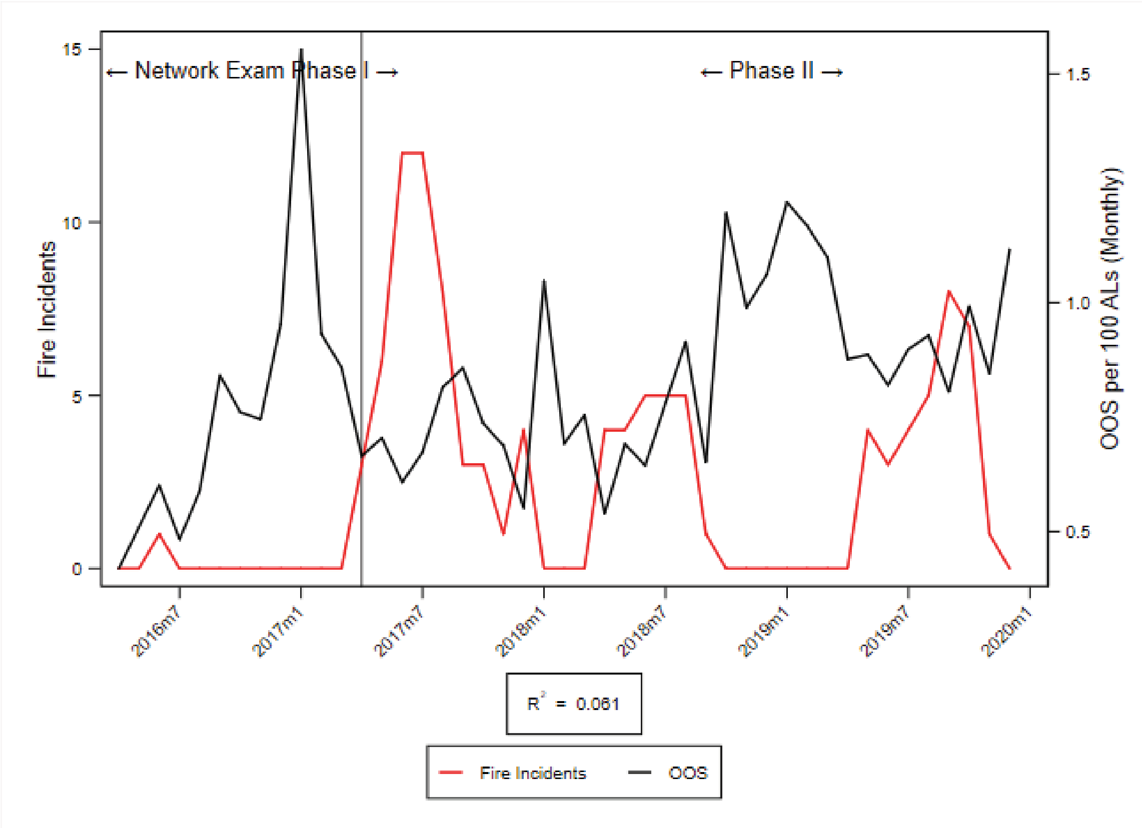


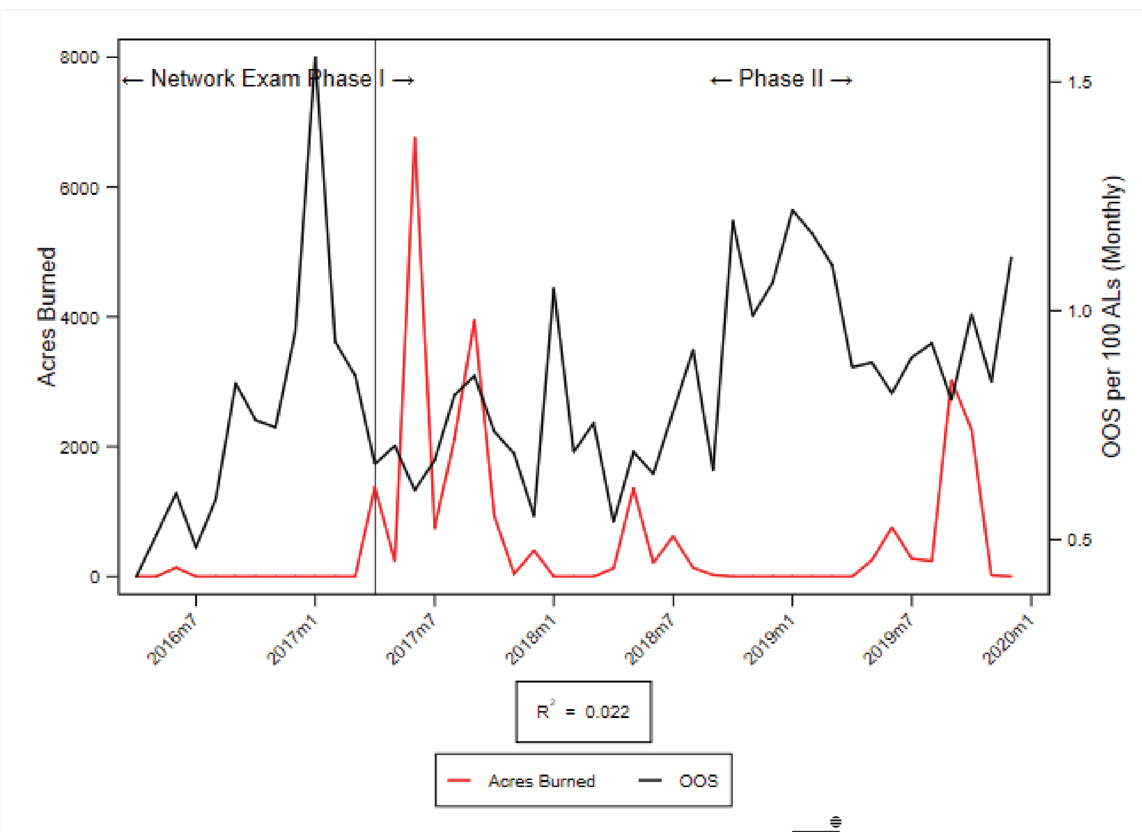
COUNTY-REGION PLACER - SUPERIOR CALIFORNIA (FTR)





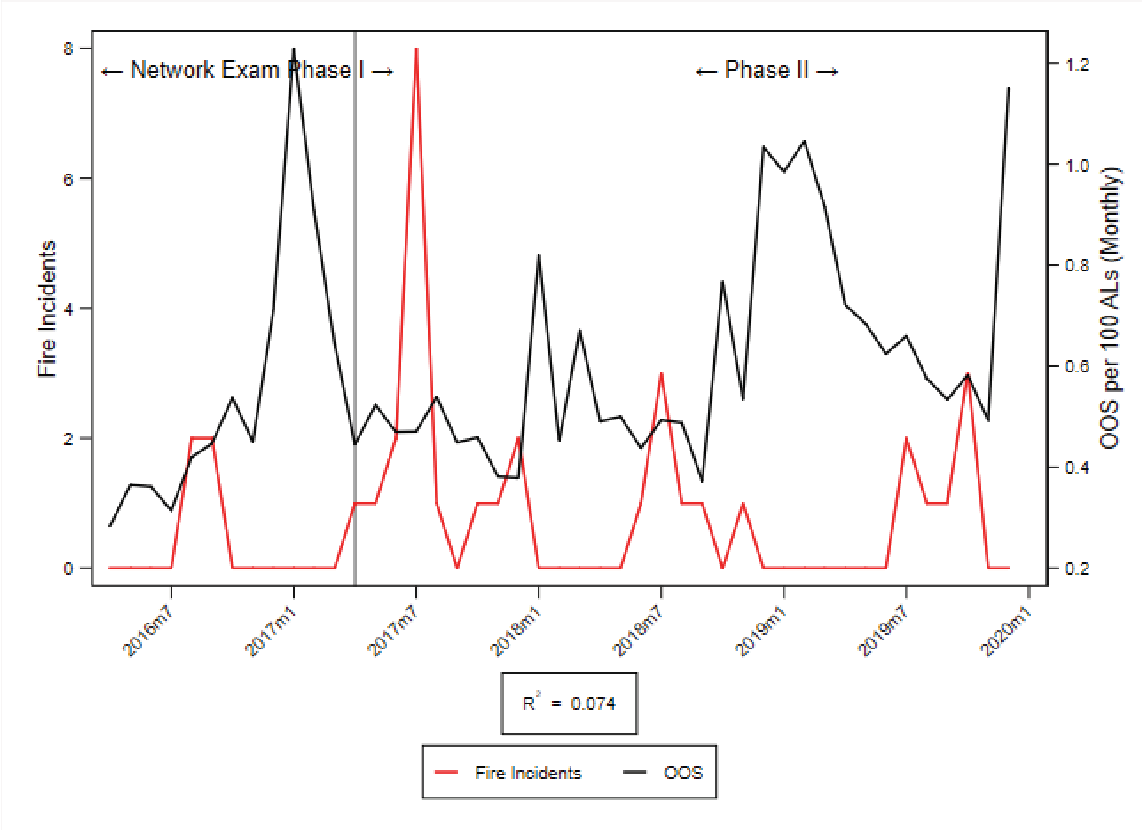
COUNTY-REGION   RIVERSIDE - INLAND EMPIRE (FTR)

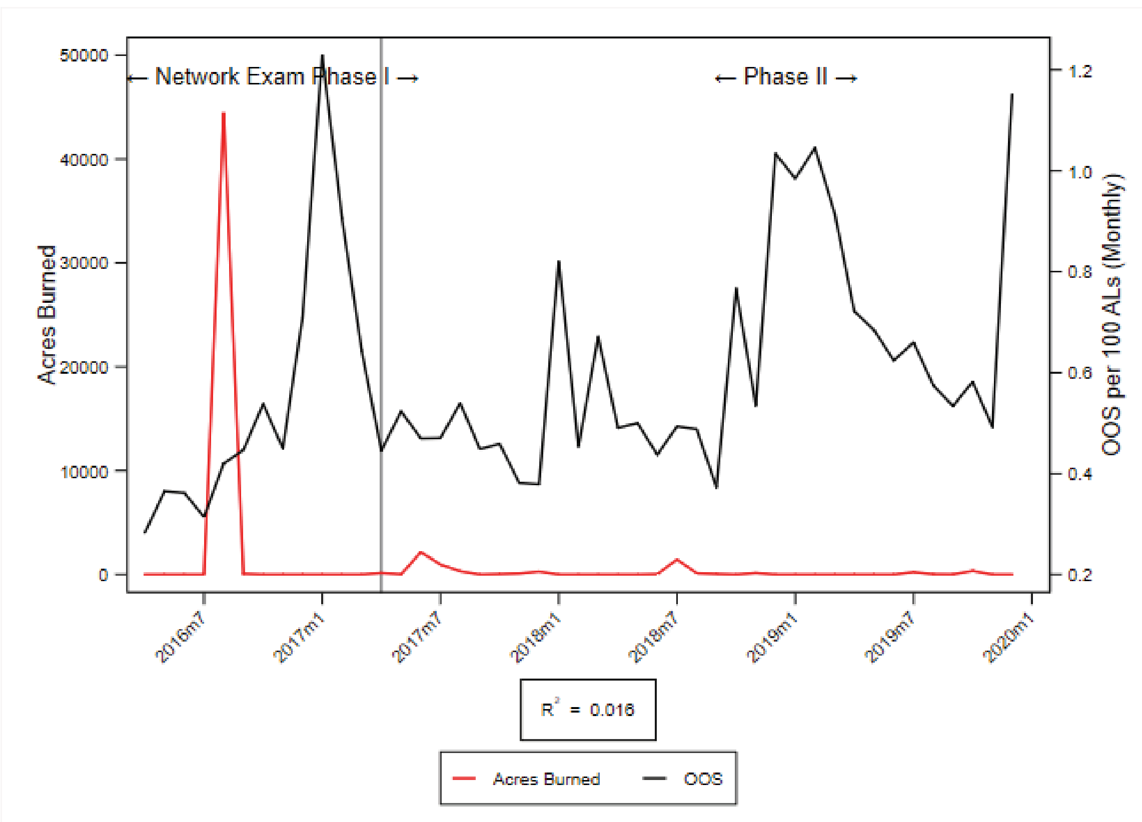




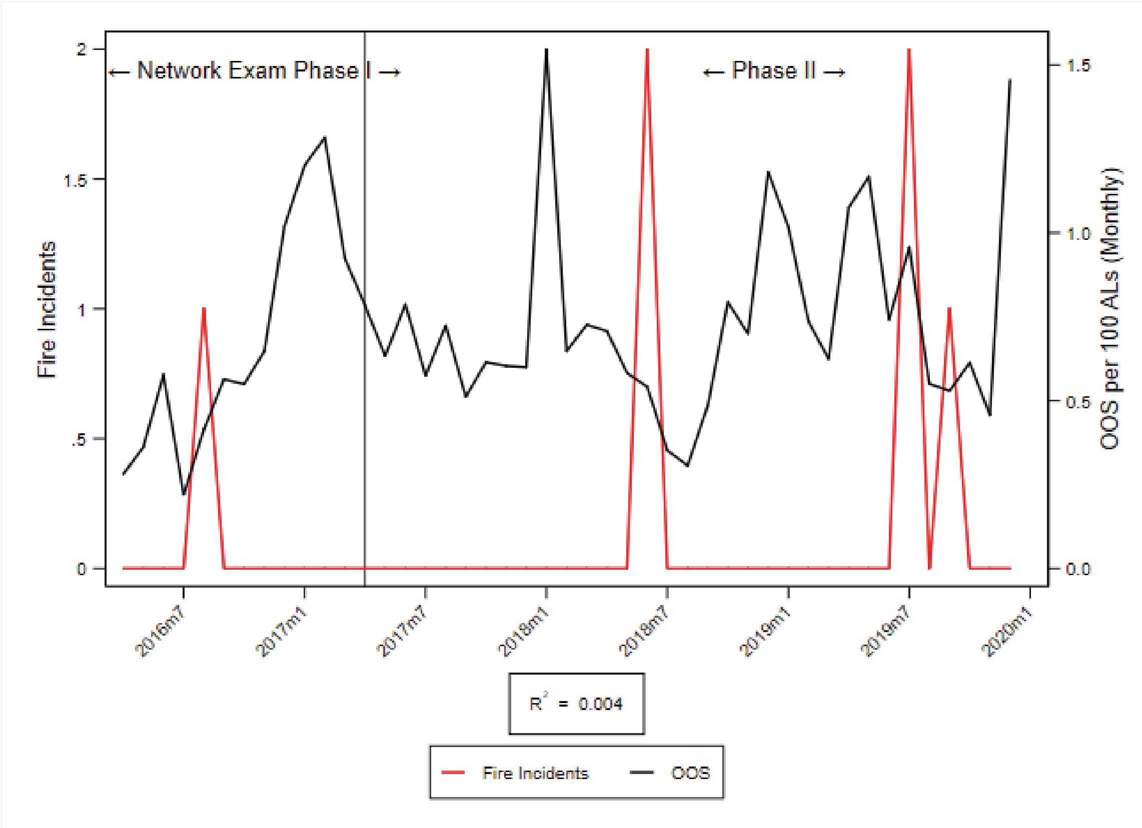
ECONOMICS AND TECHNOLOGY, INC.

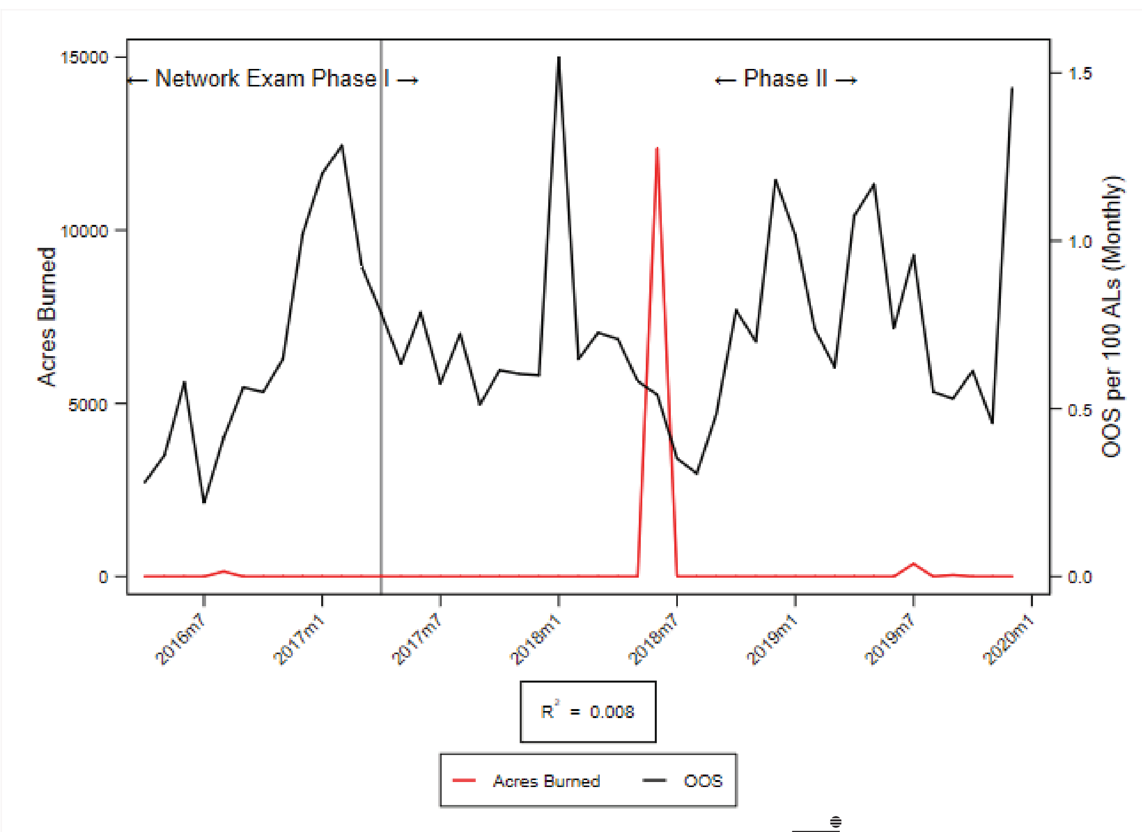
COUNTY-REGION SAN BERNARDINO - INLAND EMPIRE (FTR)





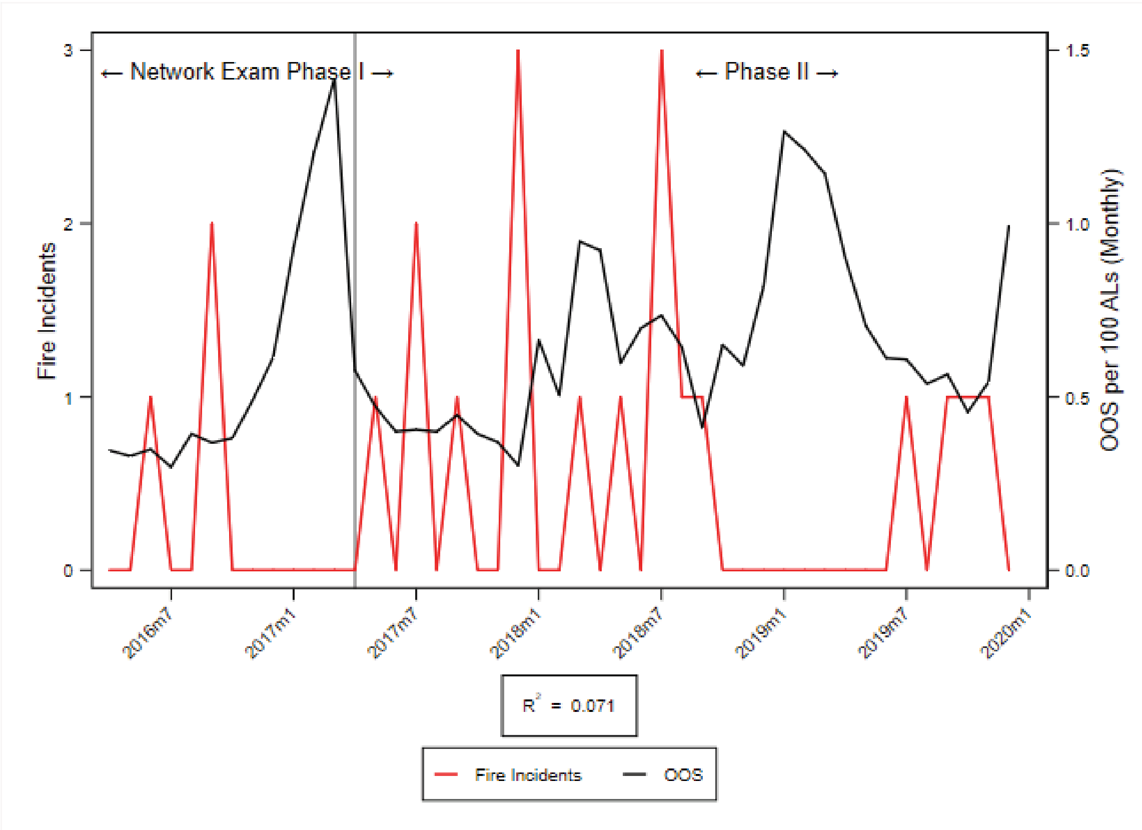
COUNTY-REGION SAN JOAQUIN - NORTHERN SAN JOAQUIN VALLEY (FTR)

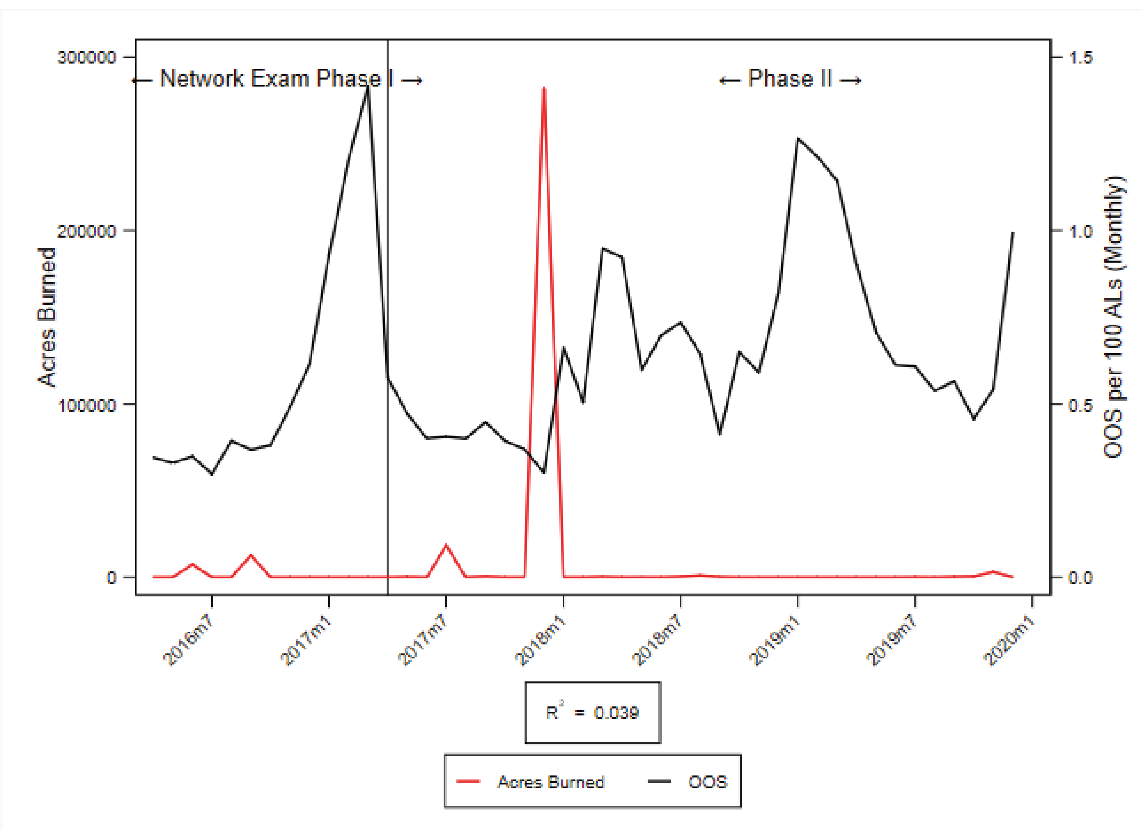




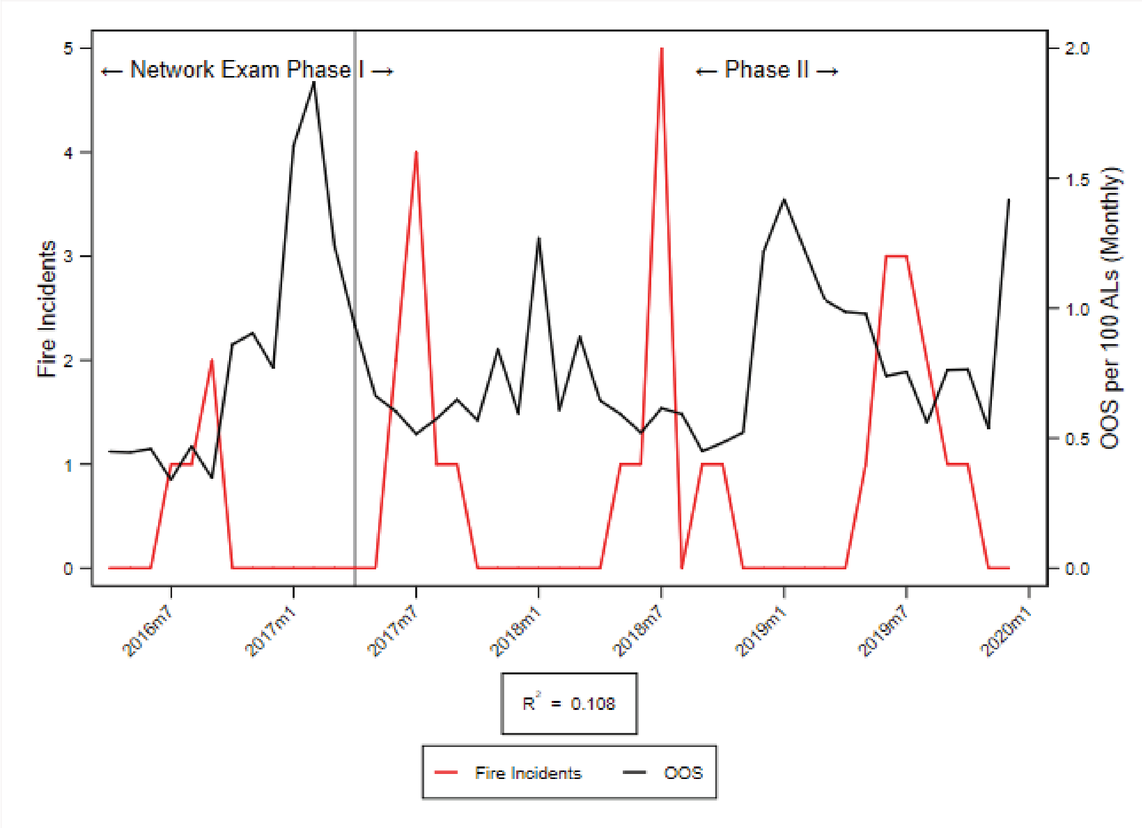
ECONOMICS AND TECHNOLOGY, INC.

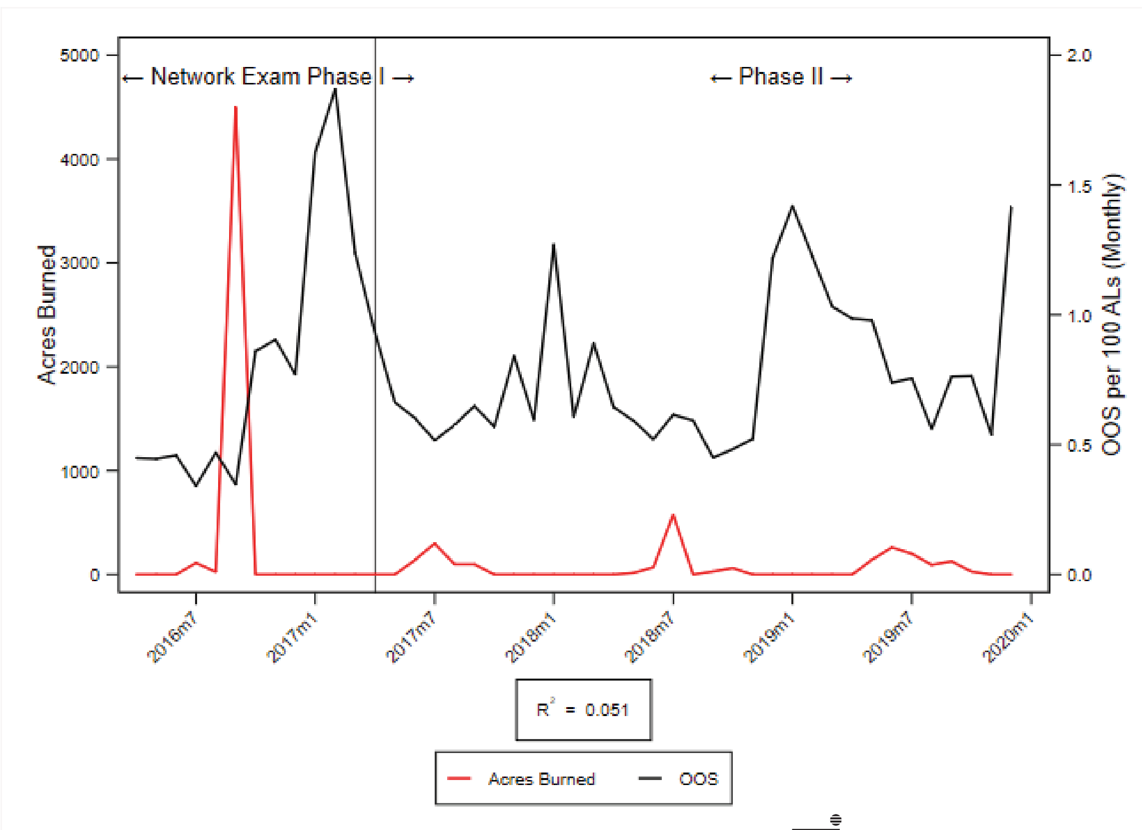
COUNTY-REGION SANTA BARBARA - CENTRAL COAST (FTR)





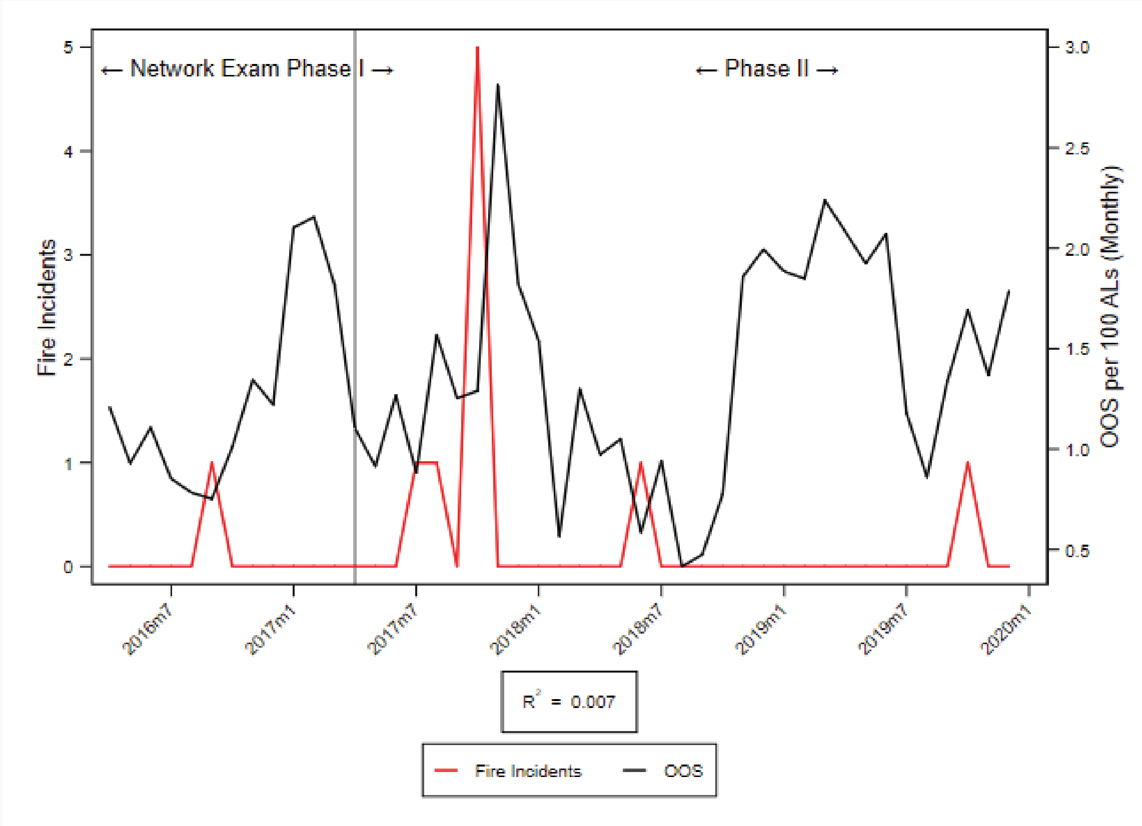
COUNTY-REGION SANTA CLARA - SAN FRANCISCO BAY AREA (FTR)

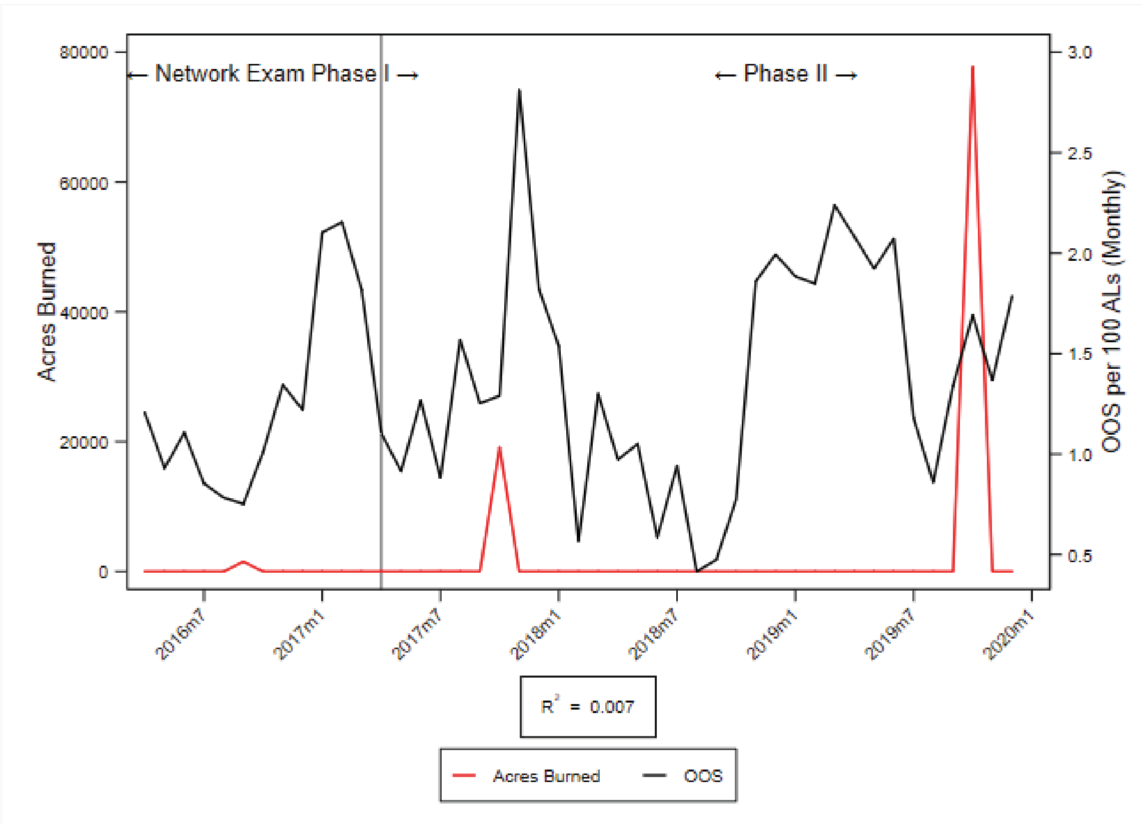




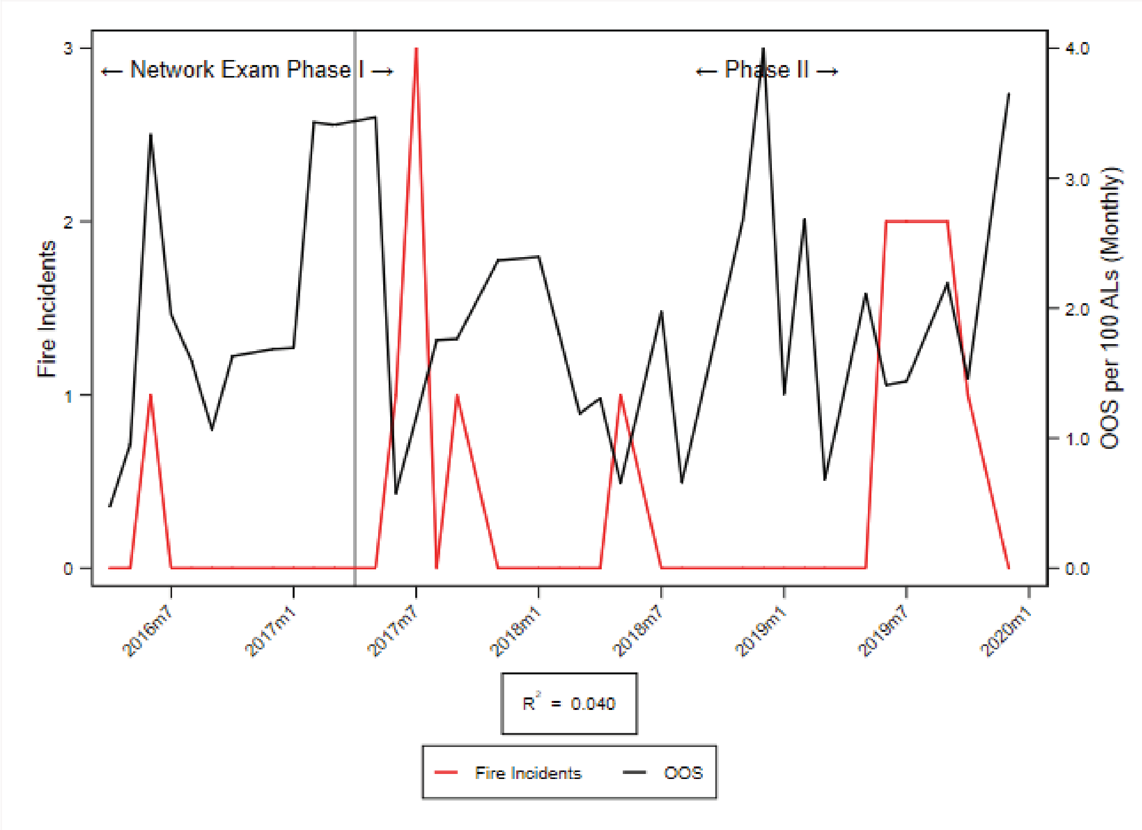
ECONOMICS AND TECHNOLOGY, INC.

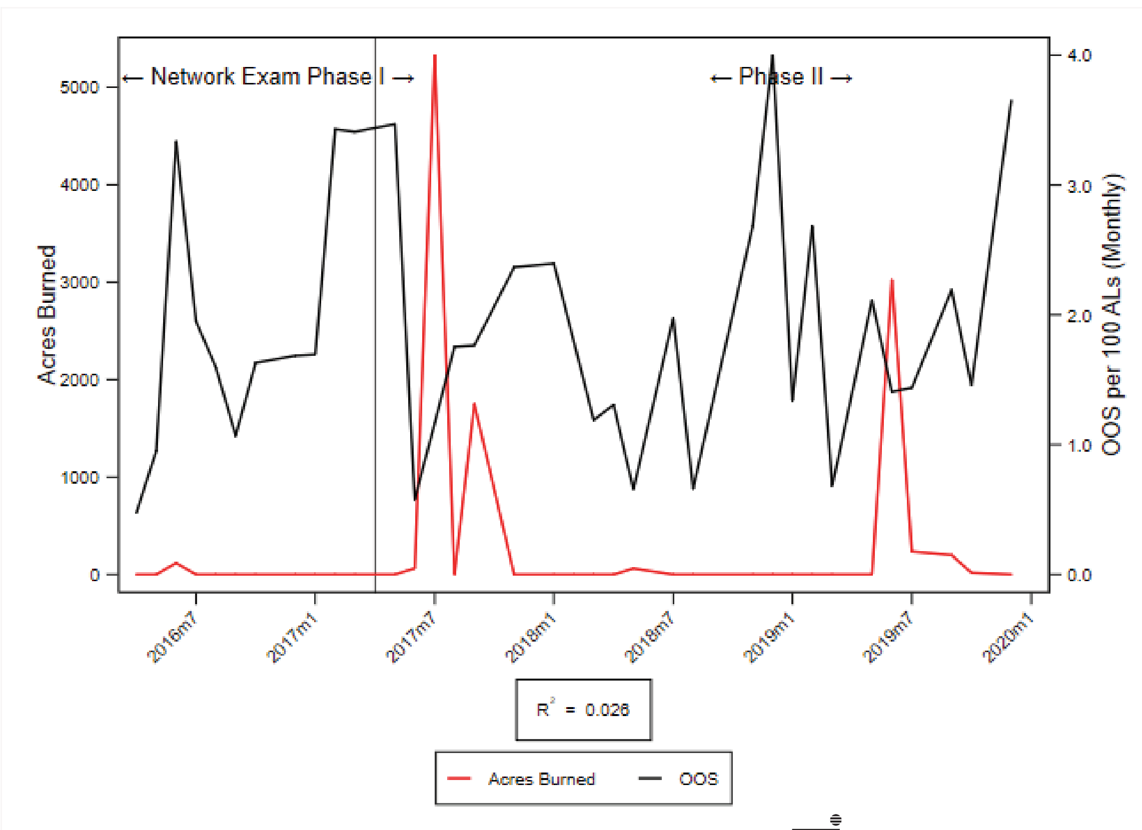
COUNTY-REGION SONOMA - NORTH COAST (FTR)





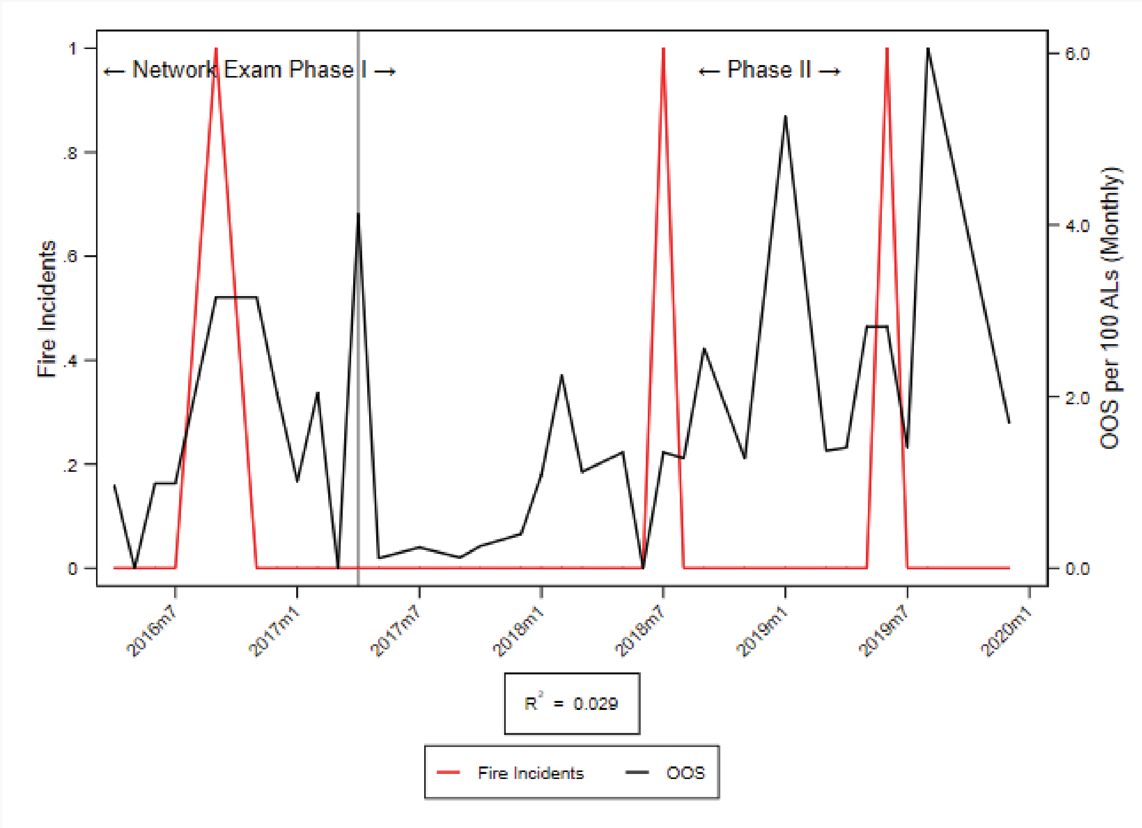
COUNTY-REGION STANISLAUS - NORTHERN SAN JOAQUIN VALLEY (FTR)

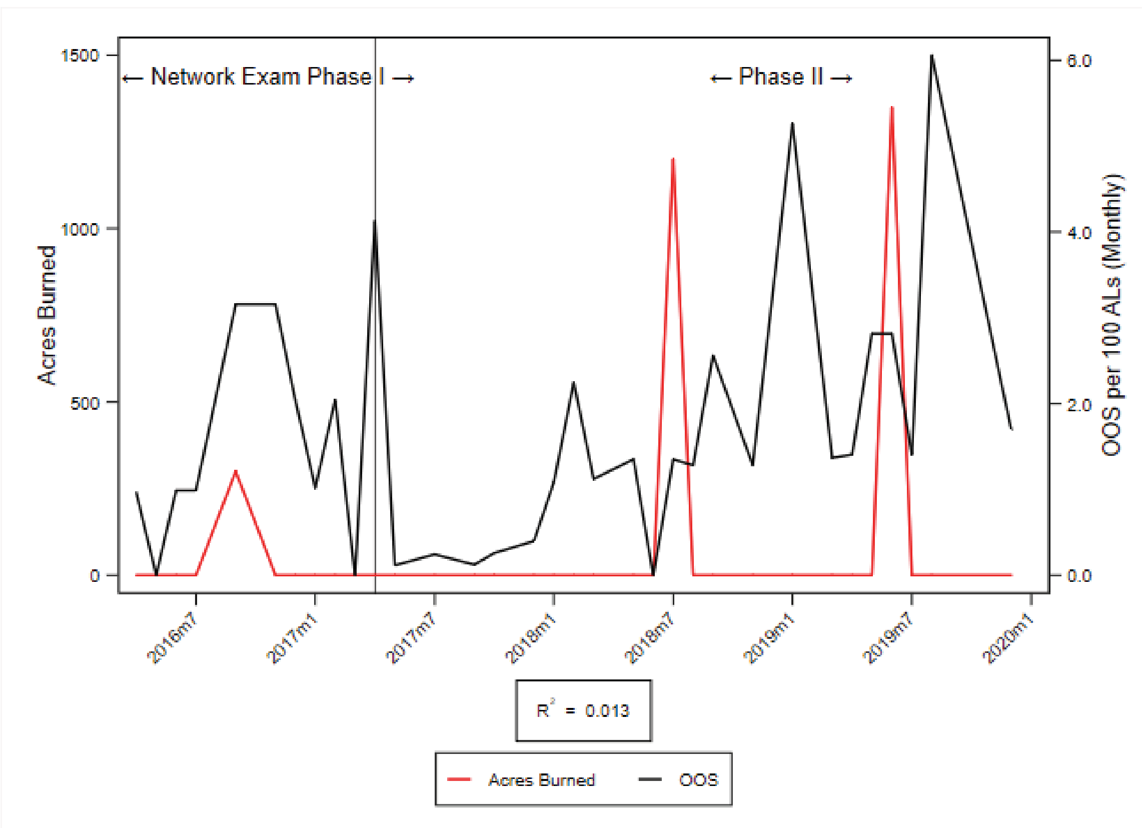




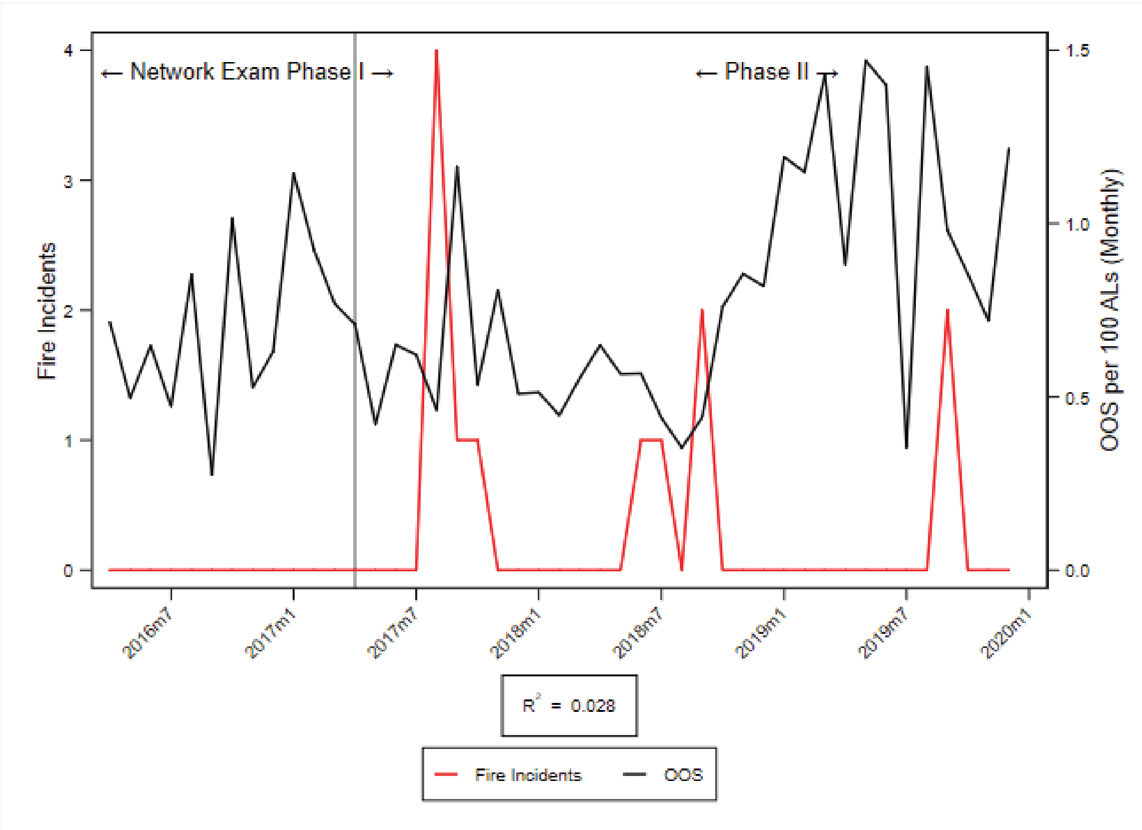
ECONOMICS AND TECHNOLOGY, INC.

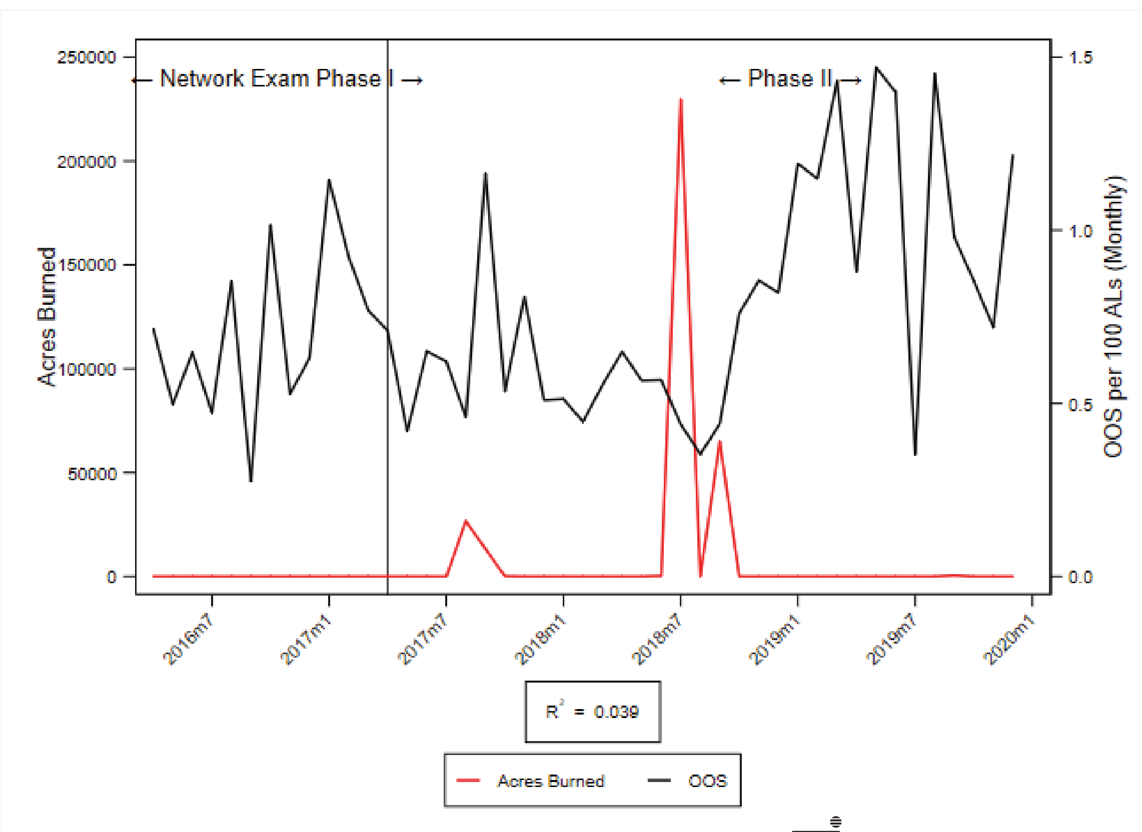
COUNTY-REGION SUTTER - SUPERIOR CALIFORNIA (FTR)





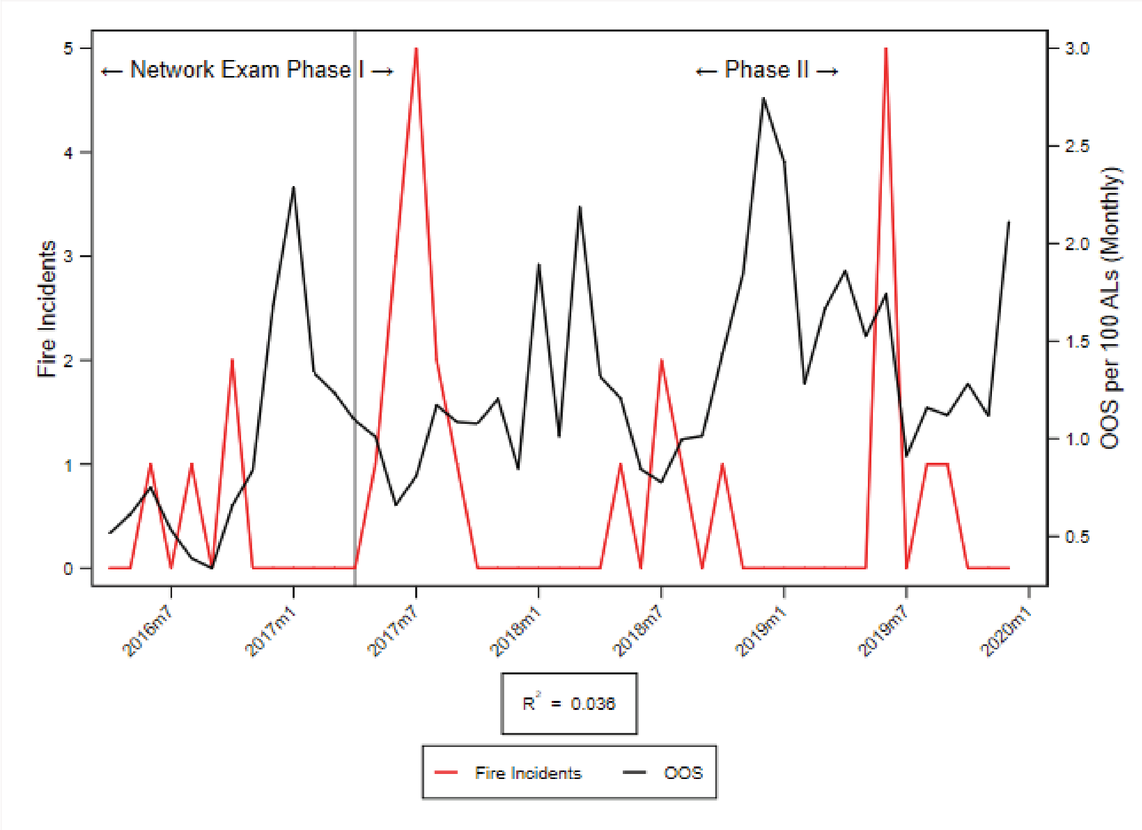
COUNTY-REGION TRINITY - NORTH COAST (FTR)

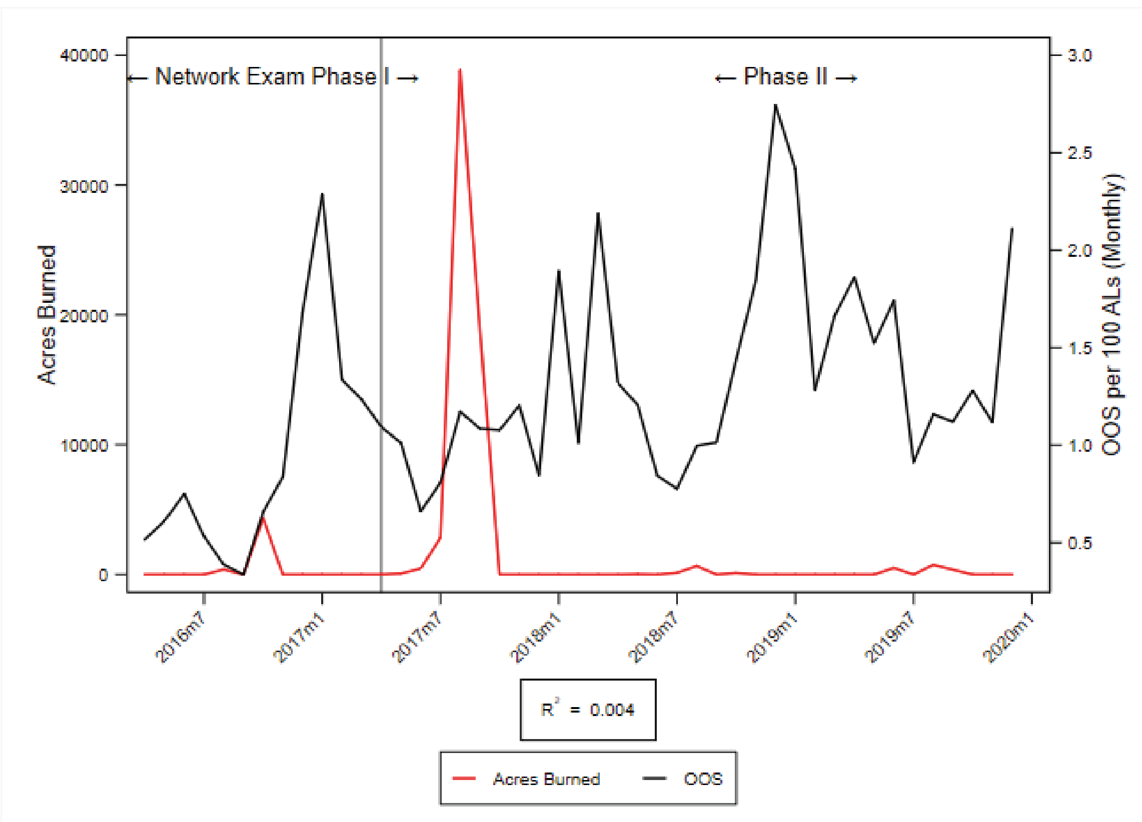




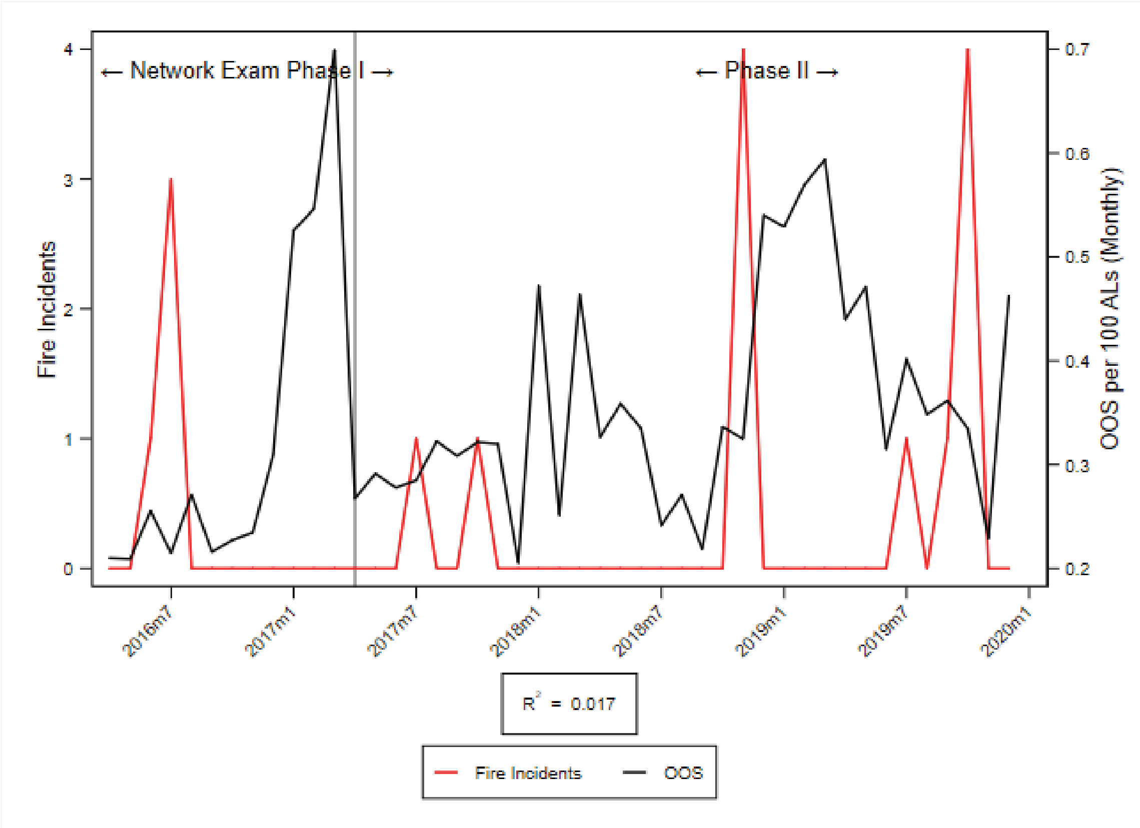
ECONOMICS AND TECHNOLOGY, INC.

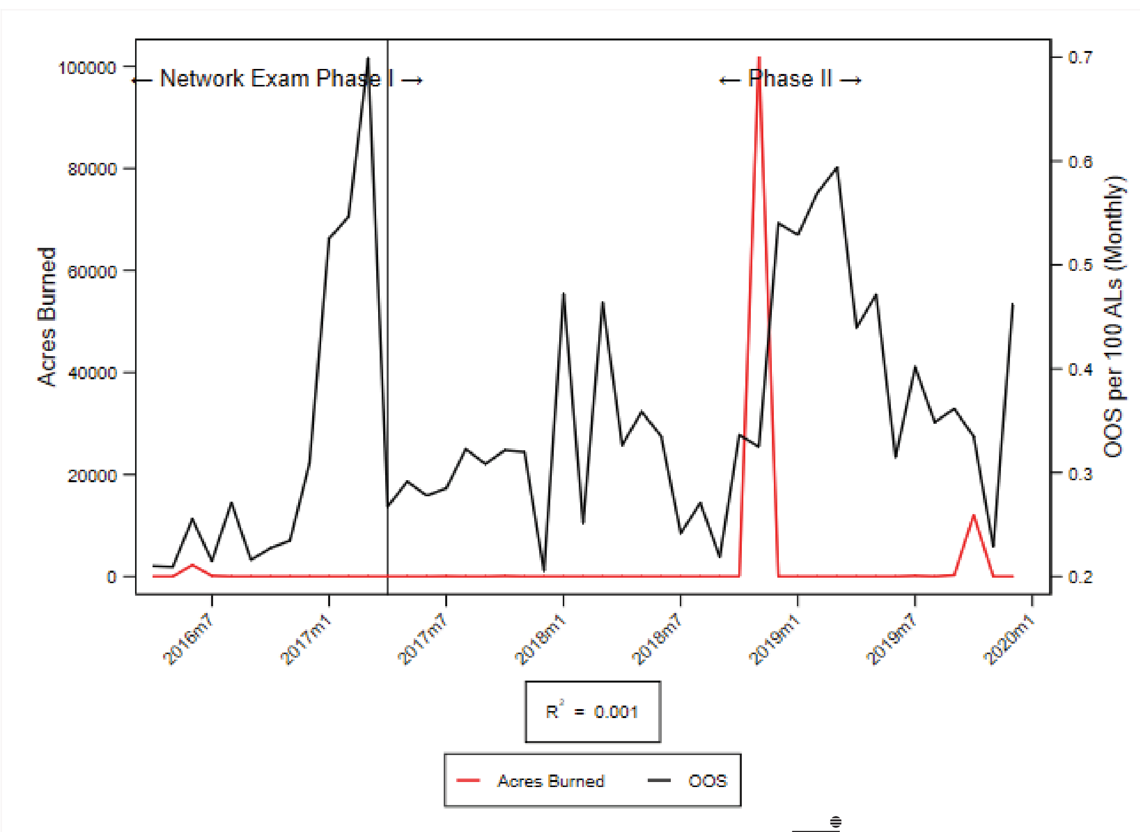
COUNTY-REGION TULARE - SOUTHERN SAN JOAQUIN VALLEY (FTR)





COUNTY-REGION VENTURA - CENTRAL COAST (FTR)





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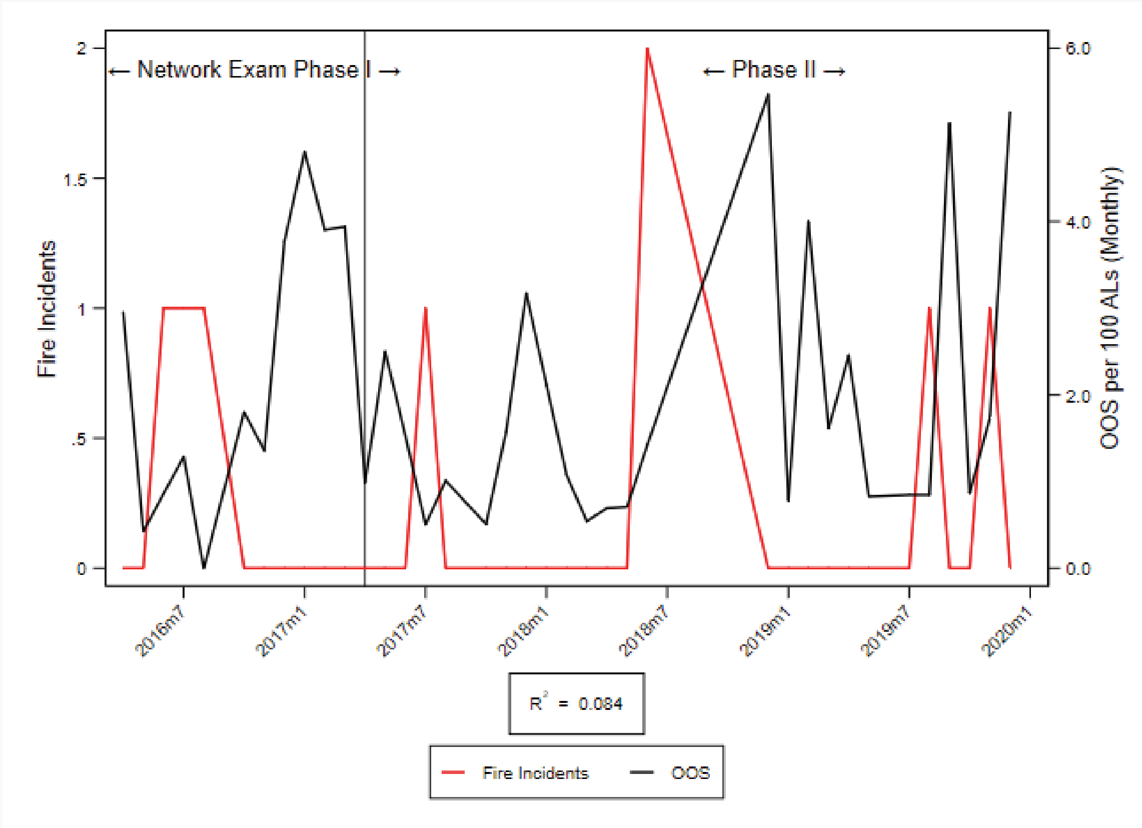
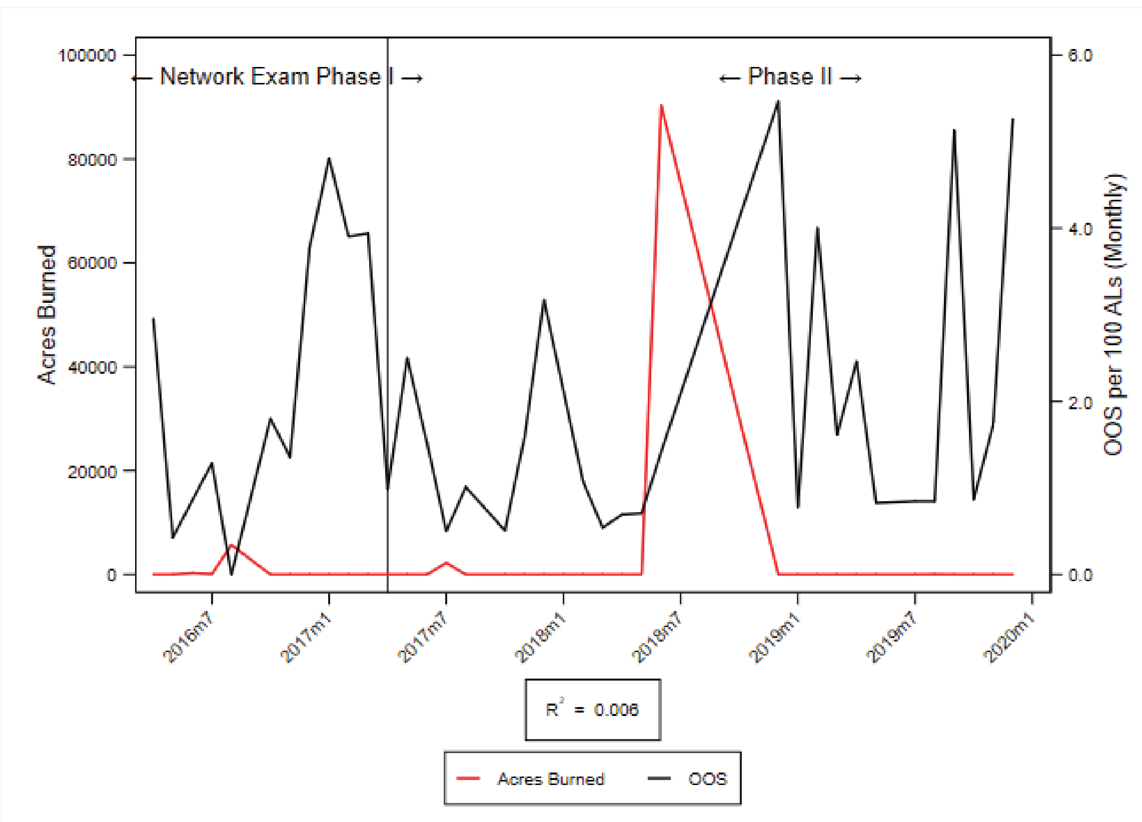
COUNTY-REGION YOLO - SUPERIOR CALIFORNIA (FTR)





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