

**THE EFFECT OF THE LOMA PRIETA EARTHQUAKE
ON CALIFORNIA MIGRATION**

**State of California
Pete Wilson, Governor**

**Department of Finance
Russell S. Gould, Director**



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**Demographic Research Unit
915 L Street
Sacramento, CA 95814
(916) 322-4651**

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When I was asked to give a paper on a disaster in California at Population Association of America for a session on the demography of disaster there was no shortage of disasters from which to pick. California has experienced fire, drought, flood, landslide, pestilence and earthquake in the past few years. An earthquake seemed to be an appropriate choice of study. An earthquake is easy to define, it is very dramatic, it occurs over a very short time span, it is noteworthy and it is also typical of California.

DEFINING THE STUDY

California's history of severe earthquakes has caused disruption and damage, but in spite of this the State has experienced a high rate of migration. However it is quite possible, but difficult to determine, that if California did not have earthquakes its long term growth due to migration would be even higher. But perhaps there is a short term effect that can be discerned. To see if this short term "earthquake effect" could be found it was decided to examine California's migration the year prior to a severe earthquake and the year after to see if a decrease in in-migration and an increase in out-migration occurred.

LOMA PRIETA EARTHQUAKE

The Loma Prieta earthquake that struck the San Francisco Bay Area in California on October 17, 1989 was an appropriate candidate for testing the hypothesis of lower in-migration and higher out-migration immediately after an earthquake. The earthquake was 7.1 magnitude on the Richter scale and was classified as a major earthquake by seismologists. According to the State of California Office of Emergency Services and the Association of Bay Area Governments the death toll was 62 persons, 5,000 housing units were destroyed and the estimate of total property damage was \$5.6 billion. There was extensive damage in five Bay Area Counties: Alameda, San Francisco, San Mateo, Santa Clara and Santa Cruz.

The bad news of the earthquake was the main media story for several days all over the United States with extensive and constant coverage. Again and again television programs displayed the collapsed apartment building in San Francisco, the pancaked elevated freeway in Alameda County and the rustic mountain cabins sliding down the redwood tree covered canyons in Santa Cruz County. All terrifying events, however, although 5,000 housing units were destroyed in these hard hit counties, the units destroyed were only 0.3 percent of the total housing stock of 1.7 million units. This loss would not be enough to cause a change in migration due to a housing shortage in the area.

Because of the media coverage of the Loma Prieta earthquake anybody considering moving to California from another state after October 1989 would be aware a severe earthquake had recently occurred. They would be an informed consumer concerning migration and the decision to move or not to move to California would certainly include an evaluation of living in a state known for earthquakes. And of course anyone living in California in October 1989 would be aware of the quake and would make the decision to either remain in California or decide "I am out of here" and move to a state where they didn't expect to experience earthquakes. According to a State of California Office of Emergency Services poll conducted in 1994, several years after the Loma Prieta earthquake and nine months after the Northridge quake, Californians have quite a cavalier attitude towards earthquakes. 60 percent of the respondents were "not that worried" about earthquakes. 31 percent said it was "useless to prepare for an earthquake" and 30 percent said they would like to prepare but were too busy. Of the 70 percent who said they had lived through a major quake only those who had sustained \$1,000 in damages said they were significantly worried. An interesting poll, but perhaps people that did have a serious fear of earthquakes had left the state or had not moved into California. I especially like the question that resulted in the finding that it was those that got hit in the pocket book that were the most worried about earthquakes.

In 1989 the state was in a steady growth period and the Loma Prieta earthquake was the only disaster during 1989 and 1990. The seven year drought that just ended early this year (replaced by flooding and land slides!) was beginning but it wasn't until several subsequent years of low rainfall had occurred that a drought was declared. The State of California Department of Water Resources declared the drought officially over in February of 1995.

Although the drought was not a confounding factor affecting migration after the earthquake the recent recession may have been. The National Bureau of Economic Research (NBER) dates the US recession from July 1990 nine months after the quake. Since the primary reason people move is for jobs and the recession was being experienced all over the US simultaneously the effect of the recession would be diminished as a reason for persons to move in or out of California. The NBER dates the end of the US recession at March 1991, but in California, the Department of Finance indicates that non-farm employment did not reach a trough until April 1993. Both dates after the time span of this study.

METHODOLOGY

It was decided that the analyses of short term migration would be limited to a monthly comparison of domestic (state to state) migration between California and other US states for 24 months, 12 months prior to the October 17, 1989 earthquake and 12 months after. For analyses purposes the month the earthquake occurred (October 1989) is included as the final month in the 12 months prior to the earthquake.

An analyses would be done for the state total, each of the five counties in the Bay Area most effected by the quake, and the total of these effected Bay Area counties. Sacramento county,

located approximately 100 miles east of the Bay Area is also analyzed for comparison with a county not experiencing damage from the quake.

The measurement instrument for analyzing migration between California and other states is the California Drivers' License Address Change (DLAC) file. A monthly DLAC file is produced by the California Department of Motor Vehicles (DMV). Monthly reports on drivers' license changes between California and other states can be abstracted from the files. The data include all persons age 17+ holding drivers' licenses who make an interstate move. In California 87 percent of the population over age 17+ holds a drivers' license. This figure is probably higher in California than the rest of the US. Although we don't have drivers' license data for the US for comparison we do have data from the 1990 census on the number of vehicles in California compared to the US. There are slightly more vehicles per occupied housing unit in California, 1.8 compared to 1.7 for the US.

The DLAC data are generally reported the month following the month of application for a driver license by the interstate migrant. The numbers are large, in 1989 DMV reported 752,000 DLAC interstate moves (INS plus OUTS), and in 1990 there were 738,000. The county with the smallest population in the study is Santa Cruz which had a total of 5,600 DLAC's in the year prior to the quake and 6,000 after.

POTENTIAL PROBLEMS WITH DLAC

There are problems with the DLAC files. A driver license holder may not apply for a change of address for their license after moving into or out of California in a timely manner or may never apply. However there are several conditions that encourage an interstate mover to change their driver license; it is against the law to drive an automobile in your state of residence without a driver license from that state or to have more than one license. A driver will not be required to take a written or behind the wheel driving test in their new state of residence if they turn in a valid license from another state. Since a driver license is frequently used for identification purposes it is suspect if the current address is not imprinted on the license. When an interstate migrant registers their automobile in a new state they are also required to apply for a driver license if they have not already done so.

Some times "backlogs" of processing DLAC's occur when a state DMV does not process all of the DLAC's the same month they are received and then catches up in a subsequent month. (Occasionally a state will create up to a years backlog). To adjust for the potential irregular reporting and processing problems the data are presented in this report are lagged two months and a three month moving average is used.

In spite of these DLAC shortcomings the file is useful for comparing monthly data over time. There is no evidence that there was a change in the pattern of applying for a new license after moving interstate or in states diligence in processing the applications between 1989 and 1990, before and after the Loma Prieta earthquake.

RESULTS

The DLAC data are cyclical, people tend to move in greater numbers in the summer months than any other time of year. Therefore to be able to determine if there is an immediate short time effect in the monthly data the DLAC are compared for the same months before and after the quake starting in November 1988, and ending October 1990, (the Loma Prieta earthquake occurred October 17, 1989).

CALIFORNIA STATE TOTAL

California DLAC data are displayed in Table 1. Comparing the year before the quake with the year after, there was a decrease of -8.0 percent (430,000 before and 395,000 after) DLAC INS. The OUTS increased 6 percent from, 322,000 before to 343,000 after the quake. The percentage increase in the OUTS was less than the decrease in the INS. The net INS dropped -43 percent, from 108,000 to 52,000. Statewide the earthquake effect hypothesis is supported, fewer DLAC IN and more DLAC OUT in the year following the earthquake.

The October 1989 earthquake was analyzed by month and by January 1990, three months after the quake, the monthly DLAC INS were lower than the month of January 1989 nine months prior to the quake, and continued lower through October 1990, the final month of our study. The INS after the quake took an extra big dip in May, seven months after the quake. It is difficult to conclude from the data what effect, if any, the recession which started in July 1990, had on the magnitude of the DLAC INS. The noticeable divergence in the decrease in INS began in April of 1990, well before the accepted beginning of the recession in California.

The DLAC OUTS did not show as consistent an earthquake effect as the INS. The outs were higher for most of the months but were lower for three dispersed months; early, mid-year and at the end of 1990. However the general pattern was an increase in OUTS. There was no noticeable recession effect after July 1990, in fact the number of DLAC OUTS decreased.

After January 1990 there is a marked earthquake effect for all months, except for the month of June. The strongest monthly effects were experienced January through May of 1990.

The monthly difference for before and after the earthquake for the total State DLAC INS, OUTS, and Net were all significant at the 0.05 level.

BAY AREA COUNTIES EFFECTED BY THE LOMA PRIETA EARTHQUAKE

The total Bay Area Counties that were the locus in California of the earthquake show the same pattern as the total State of more DLAC INS and fewer OUTS before the earthquake with the opposite pattern after the quake--fewer DLAC INS and an increase in OUTS. The

TABLE 1

Monthly Drivers' License Address Changes for the State of California
Before and After the October 1989 Loma Prieta Earthquake

MONTH	DLAC INS				DLAC OUTS				DLAC NET			
	YR	BEFORE EQ	YR	AFTER EQ	YR	BEFORE EQ	YR	AFTER EQ	YR	BEFORE EQ	YR	AFTER EQ
NOV	88	32,161	89	32,529	88	25,133	89	26,066	88	7,028	89	6,463
DEC	88	33,950	89	34,504	88	25,663	89	24,050	88	8,287	89	10,454
JAN	89	33,480	90	32,890	89	24,130	90	24,397	89	9,350	90	8,493
FEB	89	35,089	90	33,883	89	22,836	90	26,748	89	12,253	90	7,135
MAR	89	35,165	90	33,369	89	22,226	90	29,582	89	12,939	90	3,787
APR	89	36,072	90	34,590	89	26,080	90	29,712	89	9,992	90	4,878
MAY	89	39,760	90	27,584	89	27,109	90	30,307	89	12,651	90	-2,723
JUN	89	41,299	90	37,843	89	32,192	90	29,162	89	91,07	90	8,681
JUL	89	40,716	90	37,801	89	28,925	90	32,952	89	11,791	90	4,849
AUG	89	36,487	90	33,107	89	30,259	90	32,694	89	6,228	90	413
SET	89	32,928	90	28,805	89	29,070	90	29,755	89	3,858	90	-950
OCT	89	33,085	90	27,675	89	28,729	90	27,315	89	4,356	90	360
TOTAL		430,192		394,580		322,352		342,740		107,840		51,840

TABLE 2

Monthly Drivers' License Address Changes for Bay Area Counties
Before and After the October 1989 Loma Prieta Earthquake

MONTH	DLAC INS				DLAC OUTS				DLAC NET			
	YR	BEFORE EQ	YR	AFTER EQ	YR	BEFORE EQ	YR	AFTER EQ	YR	BEFORE EQ	YR	AFTER EQ
NOV	88	5,046	89	5,124	88	3,429	89	3,784	88	1,617	89	1,340
DEC	88	5,350	89	5,308	88	3,342	89	3,370	88	2,008	89	1,938
JAN	89	5,160	90	4,998	89	3,232	90	3,437	89	1,928	90	1,561
FEB	89	5,313	90	5,165	89	3,291	90	3,881	89	2,022	90	1,284
MAR	89	5,363	90	5,286	89	3,246	90	4,231	89	2,117	90	1,055
APR	89	5,746	90	5,712	89	3,539	90	4,327	89	2,207	90	1,385
MAY	89	6,680	90	6,496	89	3,590	90	4,327	89	3,090	90	2,169
JUN	89	7,162	90	6,833	89	4,527	90	4,364	89	2,635	90	2,469
JUL	89	6,779	90	6,771	89	4,310	90	4,613	89	2,469	90	2,158
AUG	89	5,801	90	5,868	89	4,506	90	4,769	89	1,295	90	1,099
SET	89	5,064	90	4,922	89	4,289	90	4,218	89	775	90	704
OCT	89	5,269	90	3,697	89	4,151	90	2,660	89	1,118	90	1,037
TOTAL		68,733		66,180		45,452		47,981		23,281		18,199

data are displayed in Table 2. Comparing the year before the quake and the year after the DLAC INS decreased 4 percent (69,000 to 66,000) and the OUTS increased 6 percent (45,000 to 48,000), and the Net INS decreased 22 percent (from 23,000 to 18,000). All three measurements indicating an "earthquake effect" as hypothesized.

Comparing the Bay Area to the State the State had a larger percentage decrease in DLAC INS, -8 percent compared to the Bay Areas -6 percent. The increase in OUTS was the same at 6 percent and the net change was greater for the State than for the Bay Area, -43 percent versus -22 percent. The finding that the effect was stronger statewide than in the Bay Area is surprising, you would expect that the earthquake effect would be stronger in the immediate vicinity of the earthquake rather than Statewide.

For the Bay Area Counties, the DLAC INS were lower for most of the months after the quake compared to before. However the difference was not large and was not significant. The OUTS show an increase for a portion of the comparison time, the five month time period January through May but like the INS there was not a significant difference for the 12 month time period. When the DLAC INS and OUTS are combined for a NET change the earthquake effect is apparent for all months, especially January to June and the data for the net comparison are significant.

Comparing the post recession months for the Bay Area counties after July 1990, the accepted beginning of the recession in California, with the same months in 1989 the DLAC INS are down, the DLAC OUTS are down more months than up and the NET is down, similar to the total State pattern. It is not possible in this research to identify what portion of this trend might be due to recession and/or the earthquake effect.

The finding that the earthquake effect was stronger state wide than in the Bay Area was surprising, one would expect that the effect would be stronger in the immediate vicinity of the quake.

INDIVIDUAL BAY AREA COUNTIES EFFECTED BY THE LOMA PRIETA EARTHQUAKE

Of the five Bay Area Counties most effected by the earthquake three, Alameda, Santa Clara and Santa Cruz were consistent with the findings of an earthquake effect for the total State and Bay Area for all of the DLAC variables, INS, OUTS, and NET. The NET for Alameda, Santa Clara and Santa Cruz after the earthquake was lower than prior. Alameda county, where the freeway collapsed, during the earthquake, shows a fairly consistent monthly divergence after December 1989. Santa Clara counties largest effect came four months after the quake and by nine months after there was little effect, although the NET continued lower. Santa Cruz county is the most dramatic of the counties with the biggest effect showing up for a six month period starting four months after the quake and lasting six months. The tests of

significance for the monthly INS, OUTS and NET DLAC data for Alameda, Santa Clara and Santa Cruz counties were all significant at the 0.05 level.

Two Bay Area counties did not display a consistent earthquake effect San Mateo, showed no discernible pattern. This was true for all three measurements, DLAC INS, OUTS, and NET. The other county not fitting the hypothesis was San Francisco, and was very unusual, the DLAC INS were much stronger after the quake than before, the OUTS tended to be somewhat higher after the quake but were also lower for four of the months. The resulting DLAC NET, was lower after the earthquake for eight months and then showed the opposite trend for the last four months of 1990 with a net higher than the previous year.

For each of these Bay Area counties the strongest diverging months before and after the quake tended to start in January or February and end May through July.

One more county was considered; Sacramento county, which is 100 miles east of the Bay Area, and has not experienced earthquakes. The DLAC data for Sacramento county was similar to the results for the other areas. An earthquake effect was observed for the DLAC OUTS and NET. The months showing the most divergence before and after the quake are February 1990 through April 1990.

SIX MONTH COMPARISON

In the analyses of the data and figures for the 12 month earthquake period there appeared there might be a more concentrated 6 month effect from January 1990, through June 1990, from three months after the quake, to nine months after. Tests of significance for this six month before and after the quake time period were calculated and compare to the 12 month tests. It was found that five areas that did not test significant at the 0.05 level for the 12 month period showed a significant result when tested for the six month time period.

In five cases out the possible 24 combinations of DLAC INS, OUTS, and NET by area for the same areas the six month time period tests are significant and the 12 month time period are not (Bay Area INS and OUTS, San Francisco NET, San Mateo INS and OUTS). In two cases the 12 month time period is significant and the six month is not (State Total DLAC INS and OUTS). And in 15 cases both the 12 month and six month are significant at the 0.05 level. This left two cases, (San Francisco County INS and Sacramento County INS) where neither time period tested significant.

We found an additional five cases involving three areas, that showed a significant difference when we limited the time period to six months instead of 12. There is no obvious exclamation of why some areas appear to show the earthquake effect in a six month time period rather than the 12 month.. It might be expected that the wider area, the state, would take longer to show the effect, which it did, however some counties that suffered damage from the quake also showed the 12 month effect rather than the six month.

CONCLUSIONS

In most cases the areas in California showed a short term decrease in DLAC INS and an increase in DLAC OUTS in the year after the Loma Prieta earthquake compared to the year before. However there were some important exceptions, for example the county of San Francisco had more DLAC INS after the quake than before. A pattern emerged of the months of January through June showing the effect in some areas that did not demonstrate the longer 12 month effect after the Loma Prieta earthquake.

If there is an earthquake effect it appears to be statewide and not just in the immediate geographic area of the quake.

We could not identify a recession effect.

Although we found a DLAC migration effect we have no direct evidence that the earthquake caused the change in migration into and out of California in the year following the quake. Further research would need to be done to establish a cause and effect relationship between the Loma Prieta earthquake and migration.

It would be interesting to do further research using the DLAC data by analyzing the effect by age and look at intra-State DLAC.

In conclusion I would like to warn you that it has been 75 years since California experienced a volcanic eruption-----we are long overdue!