Population Research and Policy Review (2024) 43:59
https://doi.org/10.1007/s11113-024-09904-4

RESEARCH BRIEFS

Population Change in Wildfire-Affected Areas in the United States: Evidence from U.S. Postal Service Residential Address Data

Jack DeWaard[1,2] · Alexander M. Din[3] · Kathryn McConnell[4,5] · Elizabeth Fussell[4]

Received: 4 September 2023 / Accepted: 10 July 2024

Abstract
We examine the utility of data on active and vacant residential addresses to inform local and timely monitoring and assessments of how areas impacted by wildfires and extreme weather events more broadly lose (or not) and subsequently recover (or not) their populations. Provided by the U.S. Postal Service to the U.S. Department of Housing and Urban Development and other users, these data are an underutilized and potentially valuable tool to study population change in disaster-affected areas for at least three reasons. First, as they are aggregated to the ZIP+4 level, they permit highly local portraits of residential and, indirectly, of population change. Second, they are tabulated on a quarterly basis starting in 2010 through the most recent quarter, thereby allowing for timely assessments than other data sources. Third, one mechanism of population change—namely, underlying changes in residential occupancies and vacancies—is explicit in the data. Our findings show that these data are sufficient for detecting signals of residential and, indirectly, of population change during and after particularly damaging wildfires; however, there is also noticeable variation across cases that requires further investigations into, for example, the guidance the U.S. Postal Services provides its postal offices and carriers to classify addresses as vacant.

Keywords Disaster · Wildfire · Housing · Vacancy · Population change

Introduction and Background

The U.S. Postal Service (USPS, 2005) maintains a detailed list of U.S. residences that actively receive mail and, thus, of residential occupancies and vacancies. USPS provides these data on a quarterly basis and at the ZIP code+4 (ZIP+4) level to private firms who use them for many purposes, including to track and understand housing

Extended author information available on the last page of the article

Published online: 29 July 2024

and related phenomena (e.g., population change) in local areas and at a finer temporal scale than is afforded by, for example, annual population estimates provided by the U.S. Census Bureau's Population Estimates Program.[1] USPS also provides these data to public institutions, including the U.S. Department of Housing and Urban Development (HUD), for their use and dissemination.[2]

One of the primary uses of the USPS data in research is to facilitate crosswalks between ZIP codes and other geographies such as Core Based Statistical Areas and counties (Din & Wilson 2020; Wilson & Din 2018). Another related use of these data, and one that is not exactly surprising given their contents, is in research on housing, and on the causes, characteristics, and consequences of residential vacancies in particular. For example, in the paper, "Dawn of the dead city: An exploratory analysis of vacant addresses in Buffalo, NY 2008-10," Silverman et al. (2012) used the USPS data to show that short-term residential vacancies at the census tract level are positively associated with rates of poverty, rental assistance, and long-term vacancy. In two nation-wide analyses, Immergluck (2016) documented an association between rates of poverty and long-term vacancy, with Molloy (2016) showing that long-term vacancies tend to be clustered in specific neighborhoods characterized by housing market distress due to overbuilding and weak housing demand. And, more recently, Berland (2022) suggested that residential vacancies in the USPS data are a potentially good proxy for physical blight when more detailed blight data are unavailable.

In addition to being used to answer substantive and methodological questions of the sort described above, several studies have used information on residential vacancies in the USPS data as a proxy to study population change in disaster-affected areas after extreme weather events, focusing primarily on tropical cyclones such as Hurricane Katrina in 2005 (Finch et al., 2010; Plyer et al., 2009; Schumann III 2018; Weil et al., 2018). This is an important use of these data because, in many disaster settings, conventional sources of data on population change suffer from at least one of three problems that undermine their utility (DeWaard et al., 2020, 2023; McConnell et al., 2021). The first problem is the coarse spatial scales for which data on population change are typically available (e.g., counties). The second problem is the temporal intervals for which data are usually available (e.g., annually), which are too wide to assess population change in a timely fashion in order to understand phenomena such as time lags between extreme weather events and population recovery in disaster-affected areas. Third, and finally, data on population change (e.g., from the U.S. Census Bureau's Population Estimates Program) are often silent with respect to the exact mechanism(s) involved. These three problems impede knowledge and understanding of population change in disaster-affected areas, as well as the ability of key actors (e.g., local governments, officials, and practitioners) to respond in timely and data-informed ways. Perhaps not surprisingly, then, the availability, quality, and comparability of data, including from non-traditional sources such as the USPS, is an important consideration in research on population change disaster-affected settings (Gardere et al., 2020; Rivera, 2020).

[1] See https://www.census.gov/programs-surveys/popest.html.

[2] See https://www.huduser.gov/portal/datasets/usps.html.

Building on the above studies of population change in disaster-affected areas after extreme weather events, the first aim of this paper is descriptive and is to document the utility of the USPS data for resolving, or at least coming closer to resolving the three problems discussed above. Regarding mechanism(s), residential occupancies and vacancies are an important part of understanding population change in disaster-affected areas. Residential occupancies and vacancies might and often do reflect housing damage and loss (Fussell, 2015), which is a key input in calculations of the price tag extreme weather events, including so-called "billon-dollar weather and climate disasters" (NCEI, 2022; Smith & Matthews, 2015). Residential occupancies and vacancies might also reflect other related phenomena such as ex ante decisions and behaviors before a given extreme weather event or after an extreme weather event in anticipation of future such events (Quiñones et al., 2022).

Regarding the spatial and temporal granularity of the USPS data, the fact that these data are aggregated to the ZIP+4 level permits zeroing in on residences that we can be reasonably confident were actually impacted by an extreme weather event in question, which is a significant improvement over the use of other geographies such as counties. Additionally, consistent with the idea that people, populations, and places are differentially vulnerable to the hazards associated with extreme weather events, these data afford the opportunity to assess differences (e.g., across neighborhoods) within disaster-affected areas. Finally, the fact that these data are tabulated on a quarterly basis permits more rapid monitoring and assessments of population change during and after extreme weather events.

In addition to demonstrating how the USPS data address the three problems discussed above, the second aim of this paper is to demonstrate their potential use in studies of population change in response to extreme weather events other than tropical cyclones, which, relative to other extreme weather events such as tornadoes and wildfires (Raker, 2020; St. Denis et al., 2023), tend to have larger spatial footprints (Touma et al., 2019). Informed by a growing consensus that signals of population change are most pronounced for more (versus less) damaging and destructive extreme weather events (McConnell et al., 2021), we focus in this Research Brief on a selection of the most destructive U.S. wildfires where, importantly, one would expect to see such a signal should there be one to be detected. We seek to show that the USPS data are well-suited for picking up indirect signals of population change through residential occupancies and vacancies associated with wildfires, particularly wildfires that resulted in extensive damage or loss to residential structures.

Approach and Results

The data for this paper were sourced from the USPS' Address Management System (AMS) and provided to HUD at the ZIP+4 level on a quarterly basis. Residential vacancies are defined with respect to mail having been delivered, but not having been retrieved for at least 90 days and are of two types: short-term vacancies are less than six months since retrieval, and long-term vacancies are greater than six months from retrieval. These data also include a Not-a-statistic ("No-stat") category. Addresses are designated as No-stat for a variety of reasons. In addition to mail not having been

retrieved for at least 90 days, No-stat addresses can include addresses that are under construction, have been demolished, or have merged with another address. HUD (2018) also notes that USPS' 2011 program Move to Competitive (MTC) Addressing for PO Boxes, which allows USPS customers to register PO Boxes as street addresses to receive deliveries from private carries, has had the effect of inflating the number of No-Stat addresses in the AMS. Finally, occupied, or active, residences are those that do not fit into one of the three categories (short-term vacant, long-term vacant, or No-Stat) above.

With respect to case selection, informed and guided by the idea that it is typically the most destructive wildfires and extreme weather events more broadly that produce detectable population shifts (McConnell et al., 2021), we focus on five of the most destructive wildfires in U.S. history. Beyond the fact that wildfire-population relationships are highly heterogeneous and not generalizable, or, as Gray and Wise (2016:555) put it, not "monolithic and unidirectional," we selected these wildfires based on information on the number of residential structures destroyed from a new dataset created by St. Denis et al. (2023), with the spatial footprint of each wildfire determined using data from the Monitoring Trends in Burn Severity (MTBS) database (Eidenshink et al., 2007).[3] These include the following five wildfires:

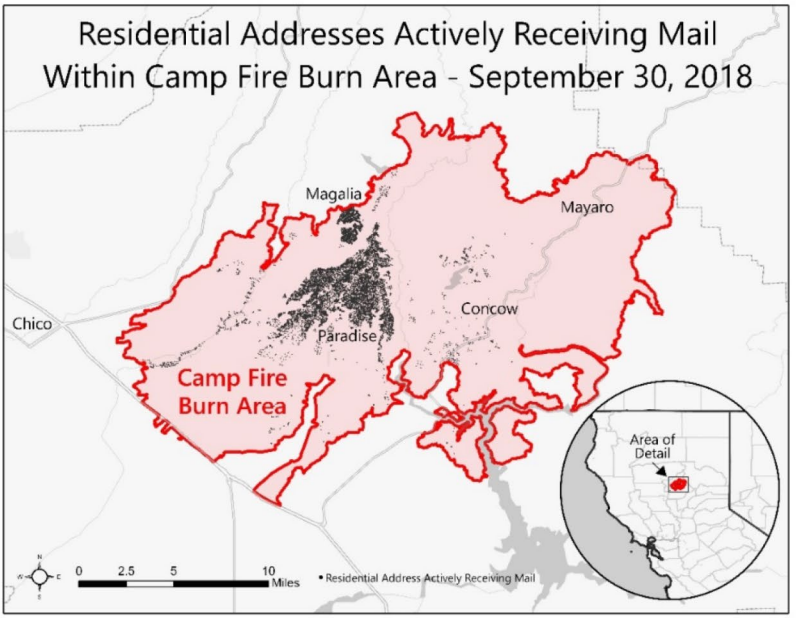
- Camp Fire, which destroyed 13,983 residential structures in northern California in 2018.
- Chimney Tops 2 Fire, which destroyed 2,013 residential structures in eastern Tennessee in 2016.
- Valley Fire, which destroyed 1,307 residential structures in northern California in 2015.
- Woolsey Fire, which destroyed 1,195 residential structures in southern California in 2018.
- Carr Fire, which destroyed 1,079 residential structures in northern California in 2018.

To provide an initial and visual portrait of what the USPS data consist of and how they can be used, in Fig. 1, we display two maps of the burn area and corresponding number of active residential addresses before and after the Camp Fire. Consistent with prior research on population change before and after the Camp Fire (McConnell & Braneon, 2024; McConnell et al., 2021), the number of active residential addresses clearly and sharply decreased after the Camp Fire, falling from approximately 16,000 active residential addresses to less than 5,000 addresses.[4]

[3] See https://www.mtbs.gov/.

[4] While it is not the aim of, and we do not have sufficient space in, this Research Brief to also focus on comparing the USPS data to data residential occupancies and vacancies from other sources, researchers at HUD recently developed and launched a new online tool that can be used for this purpose. See www.huduser.gov/apps/public/usps/login?previous=https://www.huduser.gov/apps/public/usps/mappingtool. For the sake of only one quick comparison here focusing on the Camp Fire and the four central census tracts that were burned during this fire, in 2018, the USPS data underestimate the number of active residential housing units compared to occupied housing units in the decennial census by about 1.1%. And, in

Panel A. Before Camp Fire



Panel B. After Camp Fire

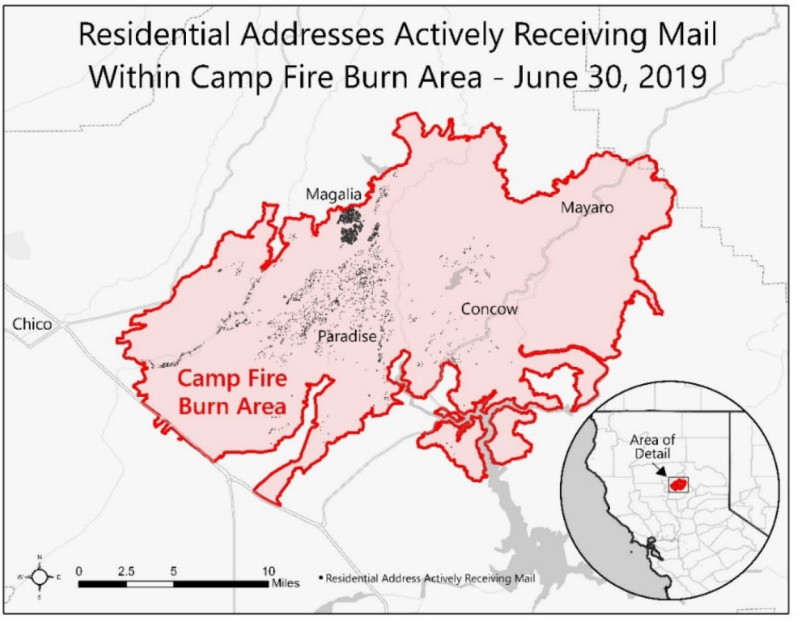


Fig. 1 Residential addresses in camp fire burn area. *Source* Authors' construction using data from Monitoring Trends in Burn Severity (MTBS) and U.S. Postal Service (USPS)

To further examine these and other changes over the entire series for which the USPS data are available, in Fig. 2, we display quarterly estimates of the number of active, short-term vacant, long-term vacant, and No-Stat residential addresses in the Camp Fire burn area, as well as two vacancy rates calculated with and without No-Stat addresses in the denominators. Before the Camp Fire, the area within the burn perimeter had a steady, but slightly increasing number of active residential addresses, peaking at 16,569 in 2018-Q3. The number of short-term vacant, long-term vacant, and No-Stat residential addresses were also quite consistent. The close of 2018-Q4, when the Camp Fire occurred, had similar numbers of active, long-term vacant, and No-Stat residential addresses; however, the number of short-term vacant residential addresses increased significantly to 771 from only 90 in 2018-Q3. We also observe a large decline in active residential addresses to 5,944 in 2019-Q1. The large volume of short-term vacant residential addresses in 2019-Q1 changed to being categorized as No-Stat in 2019-Q2, which peaked that quarter at 17,569. Active residential addresses bottomed out during 2019-Q2 at 4,855. Through the rest of the time series, short-term and long-term vacancies remained small and stable. Active residential addresses then increased, which might signify post-disaster recovery, by an average of 158 per quarter, reaching 7,381, and No-Stat addresses decreased by 157 per quarter, falling to 15,050 by 2023-Q2.

Residential vacancy rates also increased considerably after the Camp Fire, with levels and the persistence of these increases depending significantly on whether No-Stat is included in the denominator. The vacancy rate without No-Stat peaked in 2019-Q1 at 52.3%, followed by declining to pre-Camp Fire levels at 4.9% in 2019-Q2. The vacancy rate that includes No-Stat peaked in 2019-Q2 at 79.4% and gradually decreased by 0.4%, on average, to 68.9% by 2023-Q2.

To provide a sense of the relative magnitudes of these increases and change over time more broadly, in Fig. 3, we display corresponding z-scores calculated using the

2020, the USPS data overestimate the number of active residential housing units compared to occupied housing units in the decennial census by about 4.6%.

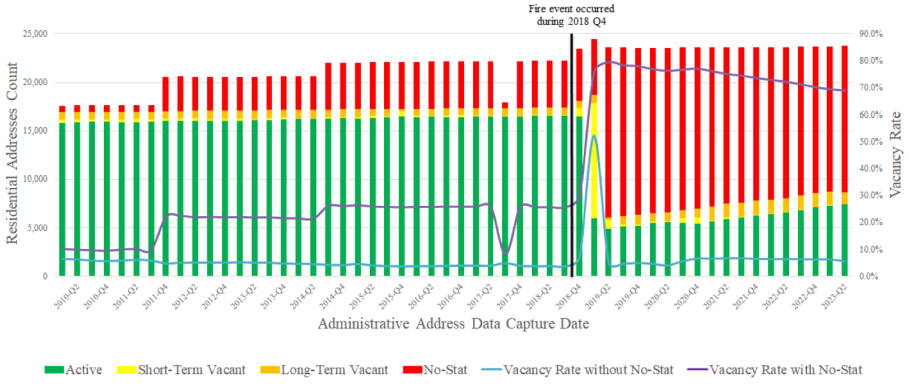


Fig. 2 Residential addresses and vacancy rates in camp fire burn area by quarter: 2010–2023. *Source* Authors' construction using data from Monitoring Trends in Burn Severity (MTBS) and U.S. Postal Service (USPS)

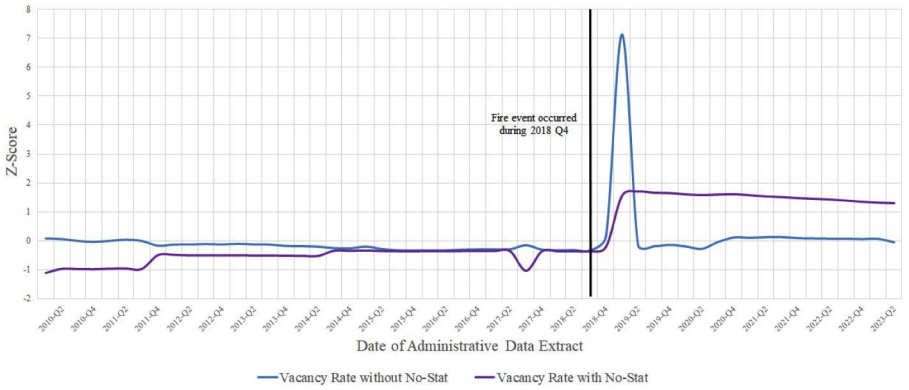


Fig. 3 Deviations of vacancy rates in Camp Fire burn area by quarter: 2010–2023. *Source* Authors' construction using data from Monitoring Trends in Burn Severity (MTBS) and U.S. Postal Service (USPS)

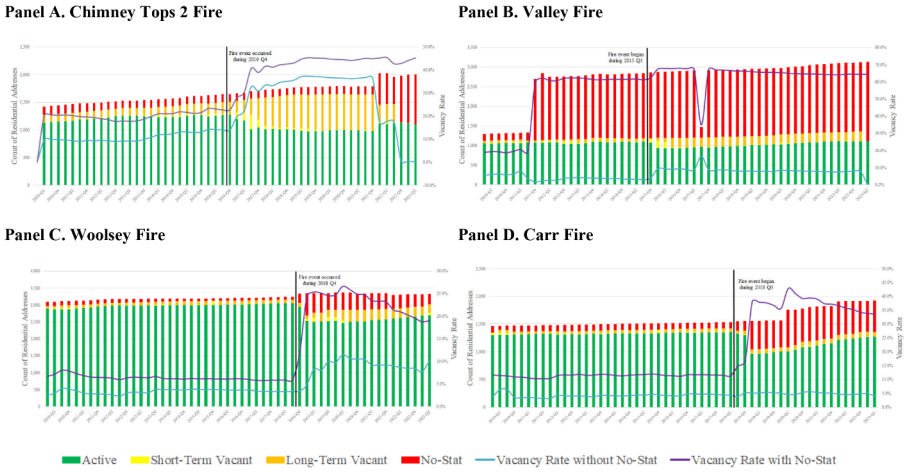


Fig. 4 Residential addresses and vacancy rates in remaining burn areas by quarter: 2010–2023. *Source* Authors' construction using data from Monitoring Trends in Burn Severity (MTBS) and U.S. Postal Service (USPS)

entire series of each vacancy rate. While we present descriptive results, it seems clear enough from these results that one signal of the Camp Fire was the sharp increase the rate of residential vacancies, many of which were on probably on account of damaged or destroyed structures, in the burn area (McConnell & Braneon, 2024; McConnell et al., 2021).

In Figs. 4 and 5, we replicate our work in Figs. 2 and 3 for the other four wildfires. Like the Camp Fire, the number of active residential addresses declined to varying extents after each of these fires, and, with the exception of the vacancy rate with No-Stat included in the denominator for the Valley Fire, vacancy rates increased. How-

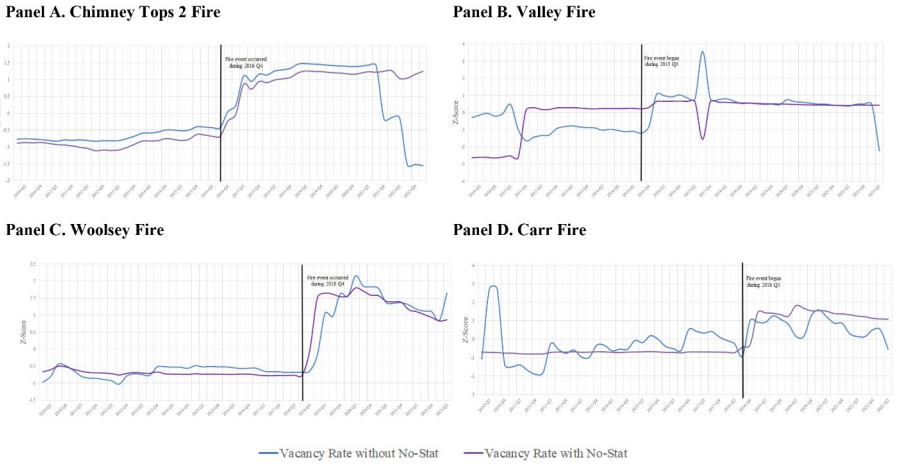


Fig. 5 Deviations of residential vacancy rates in remaining burn areas by quarter: 2010–2023. *Source* Authors' construction using data from Monitoring Trends in Burn Severity (MTBS) and U.S. Postal Service (USPS)

ever, these findings aside, the results presented in Figs. 4 and 5 raise some additional questions about the USPS data that we discuss in the concluding section below.

Discussion and Conclusion

In this paper, we sought to demonstrate the utility of USPS data on residential occupancies and vacancies provided to HUD by USPS for local and timely monitoring and assessments of population change in areas impacted by highly destructive wildfires and extreme weather events more broadly in the United States. In addition to their fine spatial and temporal resolution, a key advantage of these data relative to other data sources on population change is that part of the mechanism of population change—namely, underlying changes in residential occupancies and vacancies—is explicit in the data. Given these benefits, these data should potentially be incorporated into the toolkits of disaster researchers and others studying neighborhood change.

Despite these advantages, our results also raise several questions about the USPS data that warrant further investigation. Among these, perhaps the most urgent, and one that we foreshadowed at the end of the previous section regarding one of the vacancy rates for the Valley Fire, is whether the USPS' guidance to postal offices and carriers about how to make determinations about vacant and No-Stat residential addresses, particularly in cases of wildfires and extreme weather events more broadly, produces consistent estimates across geographic areas. Current guidance from the USPS (2005:28) contains only the following instructions: "Natural Disasters – When the long-term effects of a natural disaster (such as beach erosion, landslides, sinkholes, etc.) render the territory incapable of development the previous addresses occupying the territory may be deleted." It is also important to understand

whether and to what extent any such guidance by the USPS is followed in practice, something that may and probably does vary across postal offices and carriers.

In this vein, digging into additional guidance to postal offices and carries by the USPS (2013), Din and Han (2022) highlighted the need to distinguish rural and urban postal routes to shed light on the use and prevalence of, for example, designating addresses as vacant in some areas relative to as No-stat in others. Limited guidance has existed for quite some time from the USPS to HUD and others regarding the fact that addresses listed as No-Stat along rural postal carrier routes are likely vacant or removed (e.g., demolished), and are not residences under construction. In pursuing this line of work, it should also be noted that USPS-defined rural and urban postal routes are not geographic descriptions, but, instead, are descriptions of postal carrier pay structures and therefore may not necessarily align with conventional definitions of rural and urban. Relatedly, and as we pointed out earlier but lack the space to do so in this Research Brief, future research might also compare active residential addresses for rural and urban areas in the USPS data to data on, for example, occupied housing units from the U.S. Census Bureau.

Taken together, our work in this paper in only a starting point and highlights the promise of the USPS data for policy relevant research on many topics, including, as argued here, population change in response to extreme weather events. We also identified the need for more work to be done on and with the USPS data in further assessments of their utility for this purpose. For our part, we have demonstrated their potential use and indicated the need for clearer guidance and training to produce more consistent coding of occupancy and vacancy statuses in both urban and rural postal routes. And our work also lays the groundwork for other, related lines of research on, for example, post-disaster recovery of active residential addresses.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11113-024-09904-4.

Acknowledgements Suppressed for blind review.

References

Berland, A. (2022). Are housing vacancy rates a good proxy for physical blight? *Cityscape*, *24*, 53–68.

DeWaard, J., Fussell, E., Curtis, K. J., Whitaker, S. D., McConnell, K., Price, K., Soto, M., & Anampa Castro, C. (2023). Migration as a vector of economic losses from disaster-affected areas in the United States. *Demography*, *60*, 173–199.

DeWaard, J., Johnson, J. E., & Whitaker, S. D. (2020). Out-migration from and return migration to Puerto rico after Hurricane Maria: Evidence from the consumer credit panel. *Population and Environment*, *42*, 28–42.

Din, A., & Han, P. (2022). Does the inclusion of residential no-stat addresses along rural postal carrier routes improve vacancy rate estimates. *Measuring Blight*, *24*(2), 69–90. https://www.jstor.org/stable/48680617

Din, A., & Wilson, R. (2020). Crosswalking zip codes to census geographies. *Housing Tenure and Financial Security*, *22*(1), 293–314. https://www.jstor.org/stable/26915499

Eidenshink, J., Schwind, B., Brewer, K., Zhu, Z-L., Quayle, B., & Howard, S. (2007). A project for monitoring trends in burn severity. *Fire Ecology*, *3*, 3–21.

Finch, C., Emrich, C. T., & Cutter, S. L. (2010). Disaster disparities and differential recovery in New Orleans. *Population and Environment*, *31*, 179–202.
Fussell, E. (2015). The long-term recovery of New Orleans' population after Hurricane Katrina. *American Behavioral Scientist*, *59*, 1231–1245.
Gardere, L., Plyer, A., & Ross, D. (2020). How data became part of New Orleans' DNA during the Katrina recovery. *New England Journal of Public Policy*, *32*, 1–11.
Gray, C., & Wise, E. (2016). Country-specific effects of climate variability on human migration. *Climatic Change*, *135*, 555–568.
HUD (2018). https://www.huduser.gov/portal/sites/default/files/pdf/2018-USPS-FAQ.pdf
Immergluck, D. (2016). Examining changes in long-term neighborhood housing vacancy during the 2011 to 2014 US national recovery. *Journal of Urban Affairs*, *38*, 607–622.
McConnell, K., & Braneon, C. V. (2024). Post-wildfire neighborhood change: Evidence from the 2018 camp fire. *Landscape and Urban Planning*, *247*, 04997.
McConnell, K., Whitaker, S. D., Fussell, E., DeWaard, J., Curtis, K. J., Price, K., St. Denis, L., & Balch, J. (2021). Effects of wildfire destruction on migration, consumer credit, and financial distress. Working Paper 21–29, Federal Reserve Bank of Cleveland.
Molloy, R. (2016). Long-term vacancy in the United States. *Regional Science and Urban Economics*, *59*, 118–129.
NCEI. (2022). *Billion-dollar Weather and Climate disasters*. National Centers for Environmental Information, National Oceanic and Atmospheric Administration.
Plyer, A., Bonaguru, J., & Hodges, K. (2009). Using administrative data to estimate population displacement and resettlement following a catastrophic U.S. disaster. *Population and Environment*, *31*, 150–175.
Quiñones, E., Nobles, J., Riosmena, F., & Nawrotzki, R. (2022). Anticipatory migration and local labor responses to rural climate shocks. Working paper, Center for Demography and Ecology, University of Wisconsin-Madison.
Raker, E. (2020). Natural hazards, disasters, and demographic change: The case of severe tornadoes in the United Sates, 1980–2010. *Demography*, *57*, 653–674.
Rivera, F. I. (2020). Puerto Rico's population before and after Hurricane Maria. *Population and Environment*, *42*, 1–3.
Schumann, I. I. I. R. (2018). Ground truthing spatial disaster recovery metrics with participatory mapping in post-katrina Mississippi. *Applied Geography*, *99*, 63–76.
Silverman, R. M. (2012). Dawn of the dead city: An exploratory analysis of vacant addresses in Buffalo, NY 2008–2010. *Journal of Urban Affairs*, *35*, 131–152.
Smith, A. B., & Matthews, J. L. (2015). Quantifying uncertainty and variable sensitivity within the US billion-dollar weather and climate disaster cost estimates. *Natural Hazards*, *77*, 1829–1851.
St. Denis, L. A., Short, K. C., McConnell, K., Cook, M. C., Mietkiewicz, N. P., Buckland, M., & Balch, J. K. (2023). All-hazards dataset mined from the US National incident management system 1999–2020. *Scientific Data*, *10*, 1–23.
Touma, D., Stevenson, S., Camargo, S. J., Horton, D. E., & Diffenbaugh, N. S. (2019). Variations in the intensity and spatial extent of tropical cyclone precipitation. *Geophysical Research Letters*, *46*, 13992–14002.
USPS. (2005). *Edit Book Training*. Post Rate Commission, U.S. Postal Service.
USPS. (2013). *Maintaining the rural carrier route listing report*. PS Form 6558-C, U.S. Postal Service.
Weil, F. D., Rackin, H. M., & Maddox, D. (2018). Collective resources in the repopulation of New Orleans after Hurricane Katrina. *Natural Hazards*, *94*, 927–952.
Wilson, R., & Din, A. (2018). Understanding and enhancing the U.S. department of housing and urban development's zip code crosswalk files. *The Housing-Health Connection*, *20*(2), 277–294. https://www.jstor.org/stable/26472179

Authors and Affiliations

Jack DeWaard[1,2] · Alexander M. Din[3] · Kathryn McConnell[4,5] · Elizabeth Fussell[4]

✉ Jack DeWaard
jdewaard@popcouncil.org

[1] Social and Behavioral Science Research, Population Council. One Dag Hammarskjold Plaza, New York, NY 10017, USA

[2] Center for Studies in Demography and Ecology, University of Washington, 206 Raitt Hall, 1901 Chelan Lane, Seattle, WA 98195, USA

[3] Department of Housing and Urban Development, Program Monitoring and Research, 451 7th St SW, Washington, DC 20410, USA

[4] Population Studies and Training Center, Brown University, 68 Waterman Street, Box 1836, Providence, RI 02912, USA

[5] Department of Sociology, University of British Columbia, 6303 NW Marine Dr, Vancouver BC V6T 1Z1, Canada