Evaluating tenant relocation outcomes from flood-related voluntary property
buyouts in the United States

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Abstract

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In the United States (U.S.) flooding is a persistent and costly natural disaster. Flood hazards can

be mitigated through voluntary property buyouts, where property owners voluntarily agree to sell

their property to the government and the property is maintained as open space. Little is known

about where people relocate after a buyout and whether their flood risk is mitigated through this

program. In particular, there is limited research evaluating the impact on tenants of buyout

properties, who do not benefit monetarily from buyouts, as homeowners do. This paper evaluated

rental property buyouts conducted through the U.S. Federal Emergency Management Agency's

(FEMA's) Hazard Mitigation Grant Program (HMGP) between 2006 and 2017, tracking a total

of 245 tenant households that were displaced from the buyout to their next location. Relocation

trends were evaluated in terms of distance of the move and how flood exposure changed from the

buyout address to the relocation address. Most tenant households relocated short distances and

more than 70% reduced their exposure to flood hazards. However, nearly 10% of tenants remain in flood-prone areas after relocating, suggesting that the buyout may not eliminate flood risk for all impacted populations. Some individual household characteristics were also evaluated with regards to relocation trends. Most tenant households experienced the flood which triggered the buyout, but this experience did not appear to influence relocation trends when compared to households who did not experience the flooding. Households with children were more likely to reduce their flood hazard than households without children. These findings suggest that relocation decisions are more complex than just experience with environmental disasters and family structure. This analysis provides preliminary information regarding buyout outcomes of tenants but is limited to analysis of secondary information. Future research may consider interviewing residents who are impacted by buyouts to better understand their experiences with buyouts and what factors are driving their relocation decisions.

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1. INTRODUCTION

In the United States (U.S.), 90% of natural disasters involve flooding (United States Department of Homeland Security [US DHS], 2022). Between 2018 and 2022, flooding events in the U.S. have resulted in 71 presidentially declared disasters (Federal Emergency Management Agency [FEMA], n.d.) and 27 billion-dollar weather disasters (NOAA National Centers for Environmental Information, 2023). Currently, annual flood losses are an estimated $32 billion (Wing et al., 2022). With climate change, this could increase to over $40 billion by 2050 (Wing et al., 2022).

One form of mitigating flood hazards is through managed retreat. Managed retreat is a risk mitigation tool where people, structures, and assets are physically moved away from an area at risk. It can be used to address environmental hazards, such as flooding or wildfire. Hino et al. (2017) define two elements of managed retreat: 1) a deliberate action that aims to manage a natural hazard at risk that 2) involves the abandonment of land or relocation of assets. In the U.S., managed retreat to address flood hazards has been largely implemented via voluntary property buyouts (Siders, 2019), where the government purchases hazard-prone properties from the owner. In the U.S. property buyouts are administered through federal government agencies, including FEMA, the Department of Housing and Urban Development (HUD) and the Small Business Administration (SBA). FEMA's Hazard Mitigation Grant Program (HMGP) is the largest and longest-running program that funds property buyouts (Mach et al., 2019). Buyouts conducted through FEMA's HMGP are all voluntary, in which the property owners voluntarily agree to sell their property to the government. For flood-related buyouts, the government must then remove any

structures and the land must be maintained as open space in perpetuity (Greer & Brokopp Binder, 2017).

There is a growing body of literature on FEMA's implementation of buyouts as a tool for managed retreat. This literature mainly describes how buyouts have occurred in specific locations or after specific events, providing insight into a particular aspect of buyouts, such as cost effectiveness of buyouts in avoiding future flooding (Tate et al., 2016) and the experience of homeowner participants in buyouts (Binder & Greer, 2016). Additionally, three studies have evaluated implementation of FEMA HMGP property buyouts at the national level. The first study, conducted by Mach et al. (2019), evaluated which counties received FEMA funding for property buyouts and, once counties received funding, in what areas were these funds disbursed. In 2020, Elliot et al. published research evaluating the influence of white racial privilege on whether counties receive FEMA funding and where counties implement buyouts. Finally, Nelson & Molloy (2021) recently performed a temporal analysis of address-level FEMA data to investigate how implementation of HMGP has changed over time. The findings of all three studies conducted at the national level point to inequities in who participates in property buyouts and where property buyouts occur.

While it is important to evaluate implementation of programs like voluntary property buyouts, it is equally important to understand whether the programs are achieving their intended goal. According to FEMA's website, acquisition of hazard-prone homes funded through the HMGP "enable owners to relocate to safer areas" (FEMA, 2022). However, there are no requirements to provide relocation assistance nor track where people relocate. As a result, there is a lack of information on where people relocate post-buyout and whether they actually relocate to safer areas (Tate et al., 2016; Siders, 2019).

There is a vast body of literature studying where people move and what influences those migration decisions, both at an international level and internal to individual countries. These theories of migration aim to explain patterns of migration flows (i.e., origin, destination, volume of migrants) as well as motivations for migration. One of the first theories of migration, established by Ernst Ravenstein, stated that most migrants only move a short distance (Ravenstein, 1889). This continues to hold true; in the United States, approximately 65% of moves between 2017 and 2018 were short distance, defined as within the same county (Frost, 2020).

Drivers of migration can act as push factors, leading people to leave places, or as pull factors, attracting people to certain areas (Hunter & Simon, 2022). Black et al.'s (2011) conceptual framework identified five main drivers of migration: economic, political, demographic, social and environmental. In this framework, environmental change can be a direct driver of migration or indirectly influence other drivers of migration. Importantly, migration is often the result of several interacting drivers, with the environment being one of many factors influencing the decision to migrate and destination choice.

An important distinction in the movement of people is agency. Migrations may be seen as voluntary or forced. In the case of voluntary property buyouts, the decision of homeowners to participate in a buyout affords them mobility, whereas tenants experience displacement. Displacement often corresponds with a push that forces people to leave a place, which can include forcing people to move out of a home. In situations of displacement, the choice to move is made for the people based on external factors. On the other hand, mobility is a form of migration that is "a proactive move to improve livelihoods and opportunities" (Black et al., 2011, p. S6). Homeowners who voluntarily accept a buyout have agency in both the decision to move and where to move to next.

While the buyout itself is the impetus for moving, the destination is still dependent on a variety of factors that are specific to the individual or household. Direct experience with the flooding event triggering the buyout may influence where the household chooses to relocate. Research in the United Kingdom (Burningham et al. 2008), Calgary (Haney, 2019), and Virginia (Knocke & Kolivras, 2007) revealed that residents who experienced flooding were more aware of flood risks than those with no flood experience. However, increased perception of flood risks does not always lead residents to move to safer areas. Economic considerations such as proximity to jobs or other employment opportunities can be an important in addition to flood risk to residents, regardless of homeownership status (Correll et al., 2021). Additionally, place attachment or feelings of satisfaction about other aspects of their community can deter people from leaving, even if residents are concerned about flood risk. A study of residents who experienced repeated flooding revealed some were reluctant to leave their community due to place attachment (Kick et al., 2011).

Social ties to the local community may also impact relocation decisions, especially as these ties can contribute to an individual's or household's social capital. Examples of social capital resulting from local social ties include providing help in an emergency and financial or emotional support (Kan, 2007). According to a study in the United Kingdom, relocating five miles or less has little impact on friendship ties (Belot & Ermisch, 2009). Additionally, households with children are more likely to rely on local social capital, making inter-county moves more difficult than intra-county moves (Kan, 2007). Remaining within the same neighborhood can also be important for households where children have strong local friendships (Dawkins, 2006). Finally, residential stability can also impact childhood health and education (Jelleyman & Spencer, 2008; Been et al., 2011). In summary, relocation decisions are highly complex and involve a variety of drivers that influence individuals and households differently.

To better understand how residents of buyout properties relocate, there have been two studies which evaluated where homeowners move after choosing to participate in a buyout. One study examined homeowner movement from flood-related buyouts in Houston, Texas between 2000-2017 and found that over 90% of homeowners stayed within the Houston metropolitan area, moving a median distance of less than 10 miles (Loughran & Elliott, 2019). While the study did not explicitly evaluate whether the relocation resulted in reduced hazard exposure, the authors suggest that environmental risks such as flooding did not appear to drive relocation decisions of homeowners. A second study analyzed the relocation of homeowners who participated in buyouts in Staten Island, New York after Hurricane Sandy (McGhee et al., 2020). In addition to mapping relocation trends, the study also evaluated the change in exposure to flood hazards for households. The authors found that while over 75% of homeowners relocated within the same county, a majority of the homeowners relocated to an area that was not exposed to a flood hazard. Subsequent studies about the buyouts conducted from Hurricane Sandy suggest that flood hazard was an important driver for homeowners who decided to participate in the buyout (Binder et al., 2019).

However, homeowners are not the only population that are impacted by buyouts. There were 2,004 properties acquired by the FEMA HMGP buyout program from 1989 to 2017 which were listed as rental units (4.9% of buyouts). An additional 908 properties (2.2%) were listed as multi-family homes, suggesting that even if they are owner-occupied units, other people are renting the remaining units. While federal guidelines require that property buyouts are voluntary, this only pertains to the voluntary consent of the homeowner. Participation in buyouts is not necessarily voluntary for those who do not own the land on which they live. When the property owner chooses to participate in a buyout, tenants may be effectively evicted (Kraan et al., 2021). Additionally,

between 1989 and 2017, there were 1,226 manufactured home properties that participated in FEMA's HMGP (regardless of rental status). With manufactured homes, one may own the home itself but may not be the property owner; the owner of the pad on which the manufactured home sits is considered the property owner (FEMA, 2015). Therefore, owners of manufactured homes who are renting the pad are in the same position as home renters when the property owner decides to participate in a buyout.

As noted above, current research efforts have focused on evaluating the outcome of property buyouts for homeowners only. There is limited research specifically addressing how buyouts affect tenants of bought out properties; notably, both papers evaluating homeowner relocation trends call out the need to specifically examine the impact of property buyouts on renter populations. The lack of studies focused on renters is concerning for several reasons. According to studies conducted by Brookings and the Pew Research Center, renter populations in the U.S. tend to have lower incomes, be more racially and ethnically diverse, and younger than homeowners (DeSilver, 2021; Crump & Schuetz, 2021). Additionally, renter status has been linked to increased vulnerability to floods (Rufat, 2015). For example, renters often lack the resources to adequately prepare for, respond to, and recover from a disaster, as compared with homeowners (Dundon & Camp, 2021; Lee & Van Zandt, 2019). Considering that a goal of property buyouts (and managed retreat) is to reduce vulnerability of property and people to disasters, it is important to understand how property buyouts impact a population that may be more vulnerable to natural hazards as well as displacement.

To address this gap in the literature, this research specifically evaluated how tenants relocated after a buyout across the U.S. and was not limited to only one city or disaster event, like the previous studies on homeowner movement after a buyout. This study aimed to understand

tenant movements after a property buyout in the U.S. and whether these buyouts actually mitigated the risk of flooding for the tenants. Additionally, this research examined specific subgroups of tenants to determine if their relocation patterns are different. The study investigated the following research questions:

1) Where do tenants relocate after the property owner chooses to participate in a buyout? How far away do they relocate?

   Hypothesis 1: Based on migration literature, tenants do not relocate very far. According to research of past relocation trends in the U.S. (including buyouts-related and not buyouts-related), they are likely to remain in the same state and county.

2) Did the relocation reduce the risk of flooding for tenants?

   Hypothesis 2: The goal of the buyout program as a hazard mitigation strategy is to reduce long-term flood risk for people and property from future disasters. As such, people who were living at buyout properties should have their flood risk reduced because of the buyout. However, the literature regarding how environmental factors, such as flood risk, influence migration decisions is inconclusive.

3) Do relocation trends differ between subgroups of tenants? Specifically, do people who experienced the flooding which triggered the buyout relocate differently than those who did not? Did households with children relocate differently due to buyouts compared to households without children?

   Hypothesis 3: Households who likely experienced the flooding have increased perceptions of flood risk, which will lead them to relocate to safer areas.

Hypothesis 4: Households with children will remain closer to buyout properties because maintaining local social capital and minimizing disruptions to education for children are important in relocation decisions.

2. METHODS

2.1. SCOPE OF ANALYSIS

This study sought to identify where tenants relocated after a property buyout conducted through FEMA's HMGP. All buyouts conducted by FEMA where address-level data were available were included in this study, regardless of which state these buyouts occurred. The unit of analysis for this study is households. Households are defined in the homeowner movement database (described below), and each household is given a unique 12-digit household identifier. This study includes data from 2006-2020, which is the time span in which there is overlap between various data sets utilized in this research.

2.2. DEFINING STUDY SAMPLE

The sample for this study consisted of tenants of properties that participated in a buyout. The address-level FEMA HMGP property buyout records from 1989-2017 were made available through a Freedom of Information Act (FOIA) request (Benincasa, 2019). This data contained the address of the bought-out property (street number, city, state, and zip), the name of the owner, the type of structure, whether the property was owner-occupied or rented, the fiscal year in which the federal funding was allocated for the buyout, and the disaster that was associated with the buyout. For this study, the FEMA HMGP address-level data was subset to include only properties that were listed as "Rental" units or structures that were listed as "Manufactured Home," "2-4 Family,"

or "Multifamily Dwelling – 5 or More Units." Additionally, as this study focused on flooding hazards, only properties bought back in response to disasters associated with floods, storms, or hurricanes were included.

Because buyouts often take several years to complete after funding is allocated (Mach et al., 2019), additional information available online through OpenFEMA[1] was used to identify when the buyouts were closed. Tenants of rental properties may change frequently, so having both the year of the disaster and the closeout year of the buyout provided temporal boundaries for identifying which household in a rental unit was forced to relocate due to the buyout. The steps taken to obtain these temporal bounds are shown in **Figure 1** and described below.

To identify the year when buyouts closed, the disaster associated with each buyout funding was first identified using FEMA's "Disaster Declarations Summaries" data set,[2] and then the buyout close date was identified using one of two data sets: FEMA's "Hazard Mitigation Grant Program Property Acquisitions" data set[3] or FEMA's "Hazard Mitigation Assistance Mitigated Properties" data set.[4] For disasters that were declared more recently, buyout properties may have been approved but not closed out yet at the time these data were accessed. If the buyout close date was unidentified or unavailable based on these two additional data sets, the buyout was dropped from the study sample.

Finally, given the temporal constraints of the household movement database, only buyout properties where the disaster occurred in 2006 or later and the buyout was closed in 2019 or earlier

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[1] https://www.fema.gov/about/openfema/data-sets
[2] https://www.fema.gov/openfema-data-page/disaster-declarations-summaries-v2, downloaded July 5, 2022
[3] https://www.fema.gov/openfema-data-page/hazard-mitigation-grant-program-property-acquisitions-0, downloaded June 30, 2022 [note: this data set no longer exists or is not accessible on OpenFEMA]
[4] https://www.fema.gov/openfema-data-page/hazard-mitigation-assistance-mitigated-properties-v2, downloaded October 20, 2022 [note: version 3 of this data set is available on OpenFEMA; however it does not include status, approved date, or closed date, which is critical for this analysis]

were considered. In total, this resulted in 1,504 unique buyout properties for the study sample. The

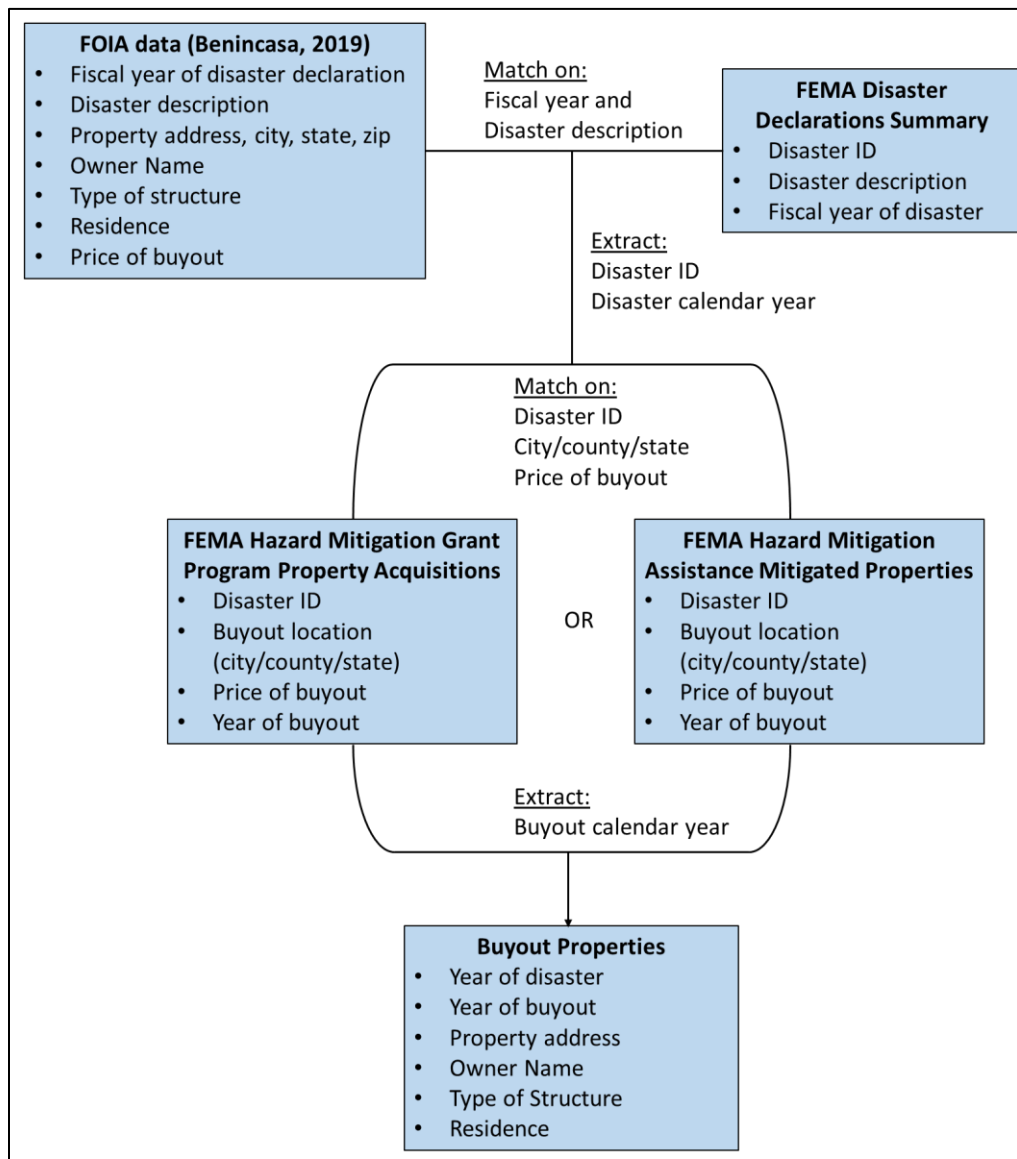addresses of these buyout properties are henceforth referred to as buyout or origin addresses.

Figure 1. Data sets used to compile complete buyout properties data.

2.3. IDENTIFYING AND RELOCATING HOUSEHOLDS

Household Movement Data

The Data Axle (formerly InfoGroup) Historical Consumer data set was used to identify households and track their movements across years. This is a proprietary commercial data set built from over 100 contributing sources, such as real estate, tax assessments, voter registrations, utility connections, and public records. This data set contained information about households living at specific addresses for each year from 2006-2020. As mentioned earlier, each household is assigned a unique 12-digit household identifier, and multiple households may be present at one address. Additionally, the data set included estimated length of residence of each household at the address identified, whether children are present in the household, geographic data including coordinates and census county, and names of household residents.[5]

Identifying Households at Buyout Addresses

Buyout origin addresses were matched with addresses in the Data Axle Historical Consumer data set to identify the households living at each origin address. Because buyout properties were vacated at some point between when the disaster occurred and when the buyout was "closed" administratively by FEMA, all origin addresses were searched and matched chronologically from the year of the disaster through the year when buyouts were closed. Based on this, the most recent household identified at the origin address was considered the household that was ultimately impacted by the buyout decision. Because some origin properties may be owner-occupied multi-family units or manufactured homes, any identified households that matched the listed owner of the buyout property were removed, as this study focused on tenants

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[5] Names of residents were used to verify ownership of property but were not extracted from the database or used in any further analysis in this study.

only.[6] Using the above criteria resulted in a study population of 935 tenant household living at buyout properties.

Identifying Post-Buyout Addresses and Evaluating Trends

Relocation or post-buyout addresses were defined as the next location that tenants moved to after a property was bought out. A household's next location was identified by conducting a chronological search through the Data Axle Historical Consumer data set starting from the buyout year (last year household was identified at the buyout address). Relocation addresses were identified by matching the unique household identifier at the buyout address (identified in the step above) to a different address in a future year. Once a household was identified at a new address, the household was removed from searches in subsequent years. A total of 245 households were successfully identified at a new address after the buyout. A significant portion of households were not identified at a new address because their unique household identifier was not found in subsequent years of the Data Axle Historical Consumer data set. This is further addressed in the "Data Loss Bias Analysis" and "Limitations" sections of this paper. Relocation trends of tenants affected by property buyouts were evaluated by comparing origin and relocation pairs, including state and county, as well as calculating distances of relocations.

2.4. FLOOD EXPOSURE

Exposure to Flood Data

Flood hazard information for each buyout and relocation was obtained using FEMA's effective flood maps, which are available online via FEMA's Flood Map Service Center.[7] FEMA flood maps are

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[6] The FEMA HMGP property buyout data set included the names of owners who were paid from the buyout. These names were compared with the household resident names in the Data Axle Historical Consumer data set to determine if the identified household was the owner.
[7] https://msc.fema.gov/portal/home

the most common source of flood hazard in the U.S. and therefore are used in this study to evaluate flood exposure for tenants. FEMA flood maps were created in support of the National Flood Insurance Program (NFIP) for floodplain management, mitigation, and insurance purposes. Because of this, flood hazards are delineated into three different flood zones:

1) 1% annual chance of flooding, which are high-risk flood zones;

2) 0.20% annual chance of flooding, which are moderate-risk flood zones; and

3) Areas outside of the 0.20% annual chance of flooding, which are considered areas of minimal flood hazard or low-risk flood zones.

The relevant flood maps were accessed by downloading a geodatabase file for each state. It is important to note that FEMA flood maps are not a comprehensive measure of exposure to flooding, and they may not capture all types of flooding events such as heavy rainfalls (United States Government Accountability Office [US GAO], 2021b). Additionally, the three levels of flood hazards described above indicate the chance of a flood occuring but do not provide any indication of the severity of flooding that might occur. Limitations such as these are discussed further in the Limitations section.

Change in Exposure to Flood Hazard

To evaluate the change in flood exposure, the risk at origin and relocation addresses were identified by geolocating each location within the FEMA flood maps. Because this research aimed to understand whether residents at buyout properties reduced their exposure to flood hazard at the time of their relocation, flood exposure was first evaluated based on the flood maps available at the time of the relocation. However, if flood maps for the area were not available at the time of relocation, this was noted, and flood exposure was evaluated based on the next available flood map. For each origin and relocation pair, the change in exposure was evaluated according to **Table 1**.

Table 1. Change in Flood Exposure Criteria.

Exposure has…	Scenarios	
	Origin	Relocation
Increased	0.20%	1%
	Minimal	0.20%
	Minimal	1%
Not Changed	1%	1%
	0.20%	0.20%
	Minimal	Minimal
Decreased	1%	0.20%
	1%	Minimal
	0.20%	Minimal
Notes: "1%" refers to the 1% annual chance flood zone "0.20%" refers to the 0.20% annual chance flood zone "Minimal" refers to areas outside of the 0.20% annual chance flood zone which have minimal flood risk		

2.5. DATA LOSS BIAS ANALYSIS

There was data loss in nearly every step of the analysis of this study. To understand if any bias was introduced due to this data loss, an analysis was conducted comparing the full FEMA tenant buyout locations data set with the subset of buyout locations where households were successfully relocated. **Figure 2** shows which states were represented in the original FEMA rental buyout dataset and how many of these buyouts were successfully relocated. There was no state that had more than 75% data retention. Buyouts in several states were entirely lost in the household identification and relocation steps, resulting in no tenant relocation data (e.g., Oregon, California). Further discussion on this data loss is in the Limitations section.
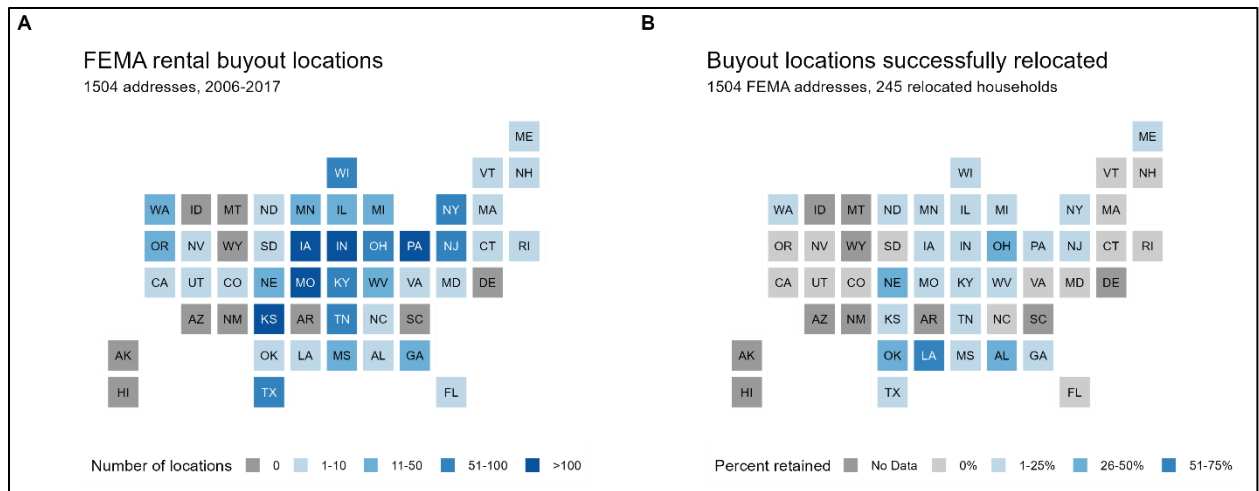
Figure 2. Initial FEMA rental buyout locations (A) and retention rate of successful relocations (B).

Identification of households and their subsequent relocation in the household movement data set was more successful for households living in single family homes compared with manufactured homes (**Table 2**). Relocation trends observed in this study may be biased towards tenants who rented single family homes and may not be representative of tenants residing in manufactured homes. In terms of flood hazard at the buyout location, whether households likely experienced the flooding that triggered buyout, and whether households had children, the data loss did not appear to significantly bias the final results (**Table 3**).

Table 2. Data loss bias analysis based on residential structure.

Residential Structure	FEMA rental buyouts (n=1504)	Households Identified (n=935)	Households Relocated (n=245)
Single Family	725 (48.2%)	500 (53.5%)	159 (64.9%)
Manufactured Home	419 (27.9%)	159 (17.0%)	27 (11.0%)
Multi-family (2+)	351 (23.3%)	271 (29.0%)	59 (24.1%)
Other	9 (0.6%)	5 (0.5%)	0 (0.0%)

Table 3. Data loss bias analysis of additional parameters.

Parameter	Households Identified (n=935)	Households Relocated (n=245)
Flood Hazard at Buyout		
Minimal	166 (17.6%)	44 (18.0%)
0.20% Flood Zone	65 (7.0%)	16 (6.5%)
1% Flood Zone	680 (72.7%)	185 (75.5%)
No Data	25 (2.7%)	0 (0.0%)
Likely Experienced Flooding		
Yes	639 (68.3%)	184 (75.1%)
No	296 (31.7%)	61 (24.9%)
Households with Children		
Yes	113 (14.2%)	28 (11.4%)
No	802 (85.5%)	217 (88.6%)

3. RESULTS

3.1. HOUSEHOLDS RELOCATED

Of the 935 households identified at buyout properties, 245 households were identified at a new address between 2007-2020. These 245 households represent FEMA property buyouts associated with 59 different flooding disasters between 2006-2016. Most of the households were relocated within one year after the buyout occurred (n=215), with 29 households identified between two to six years after the buyout occurred. One household was identified in a new location 12 years after the buyout occurred.

3.2. MOVEMENT TRENDS

The 245 households identified and relocated represented 27 different states at the origin addresses and 28 states at the relocation addresses. **Table 4** shows the distribution of origin and relocation addresses in each state.

Table 4. Number of FEMA property buyout locations (origins) and relocations by state, between 2006-2020.

State	Origin	Relocation	State	Origin	Relocation
Iowa	47	43	Louisiana	3	3
Missouri	27	26	Georgia	2	3
Kansas	23	22	Maine	2	2
Ohio	21	20	Minnesota	2	2
Pennsylvania	21	21	North Dakota	2	1
New Jersey	20	19	Alabama	1	1
Indiana	14	14	Michigan	1	2
Kentucky	11	10	Mississippi	1	1
New York	10	10	Oklahoma	1	1
Illinois	9	10	Washington	1	1
Texas	9	14	West Virginia	1	1
Wisconsin	7	8	Arkansas	0	1
Tennessee	5	4	Colorado	0	1
Nebraska	4	3	North Carolina	0	1

Of the 245 households identified and relocated, 94% relocated within the same state (n=231), with 84% of those also staying within the same county (n=194). The average relocation distance for moves within the same state was 8.30 miles, with a median relocation distance of 2.57 miles.[8] Three of the 231 households that remained within the same state relocated across the state, resulting in a relocation distance of more than 100 miles. Fourteen households relocated to different states, 12 of which relocated more than 100 miles away. The remaining two households relocated from one side of a state border to the other, resulting in a move that was less than 10 miles from the origin address. A comparison of these relocation trends with homeowners is addressed in the "Discussion" section.

Nearly 94% of households stayed within 100 miles of the origin address (n=230), with 63% of households staying within 5 miles of the origin address (n=155). **Table 5** and **Table 6** provide a summary of statistics for relocation distances, based on whether the relocation occurred within

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[8] Distances calculated as straight-line distance from origin to relocation address.

the same state or county, respectively. **Figure 3** provides additional details on distance of relocations and whether these were within the same state or to a different state.

Table 5. Relocation distances, for all moves (n=245).

Relocation State (vs. Origin)	Count	Distance (miles)		
		Mean	Median	Max
Same	231	8.30	2.57	354
Different	14	600	653	1,449

Table 6. Relocation distances, for moves within the same state (n=231).

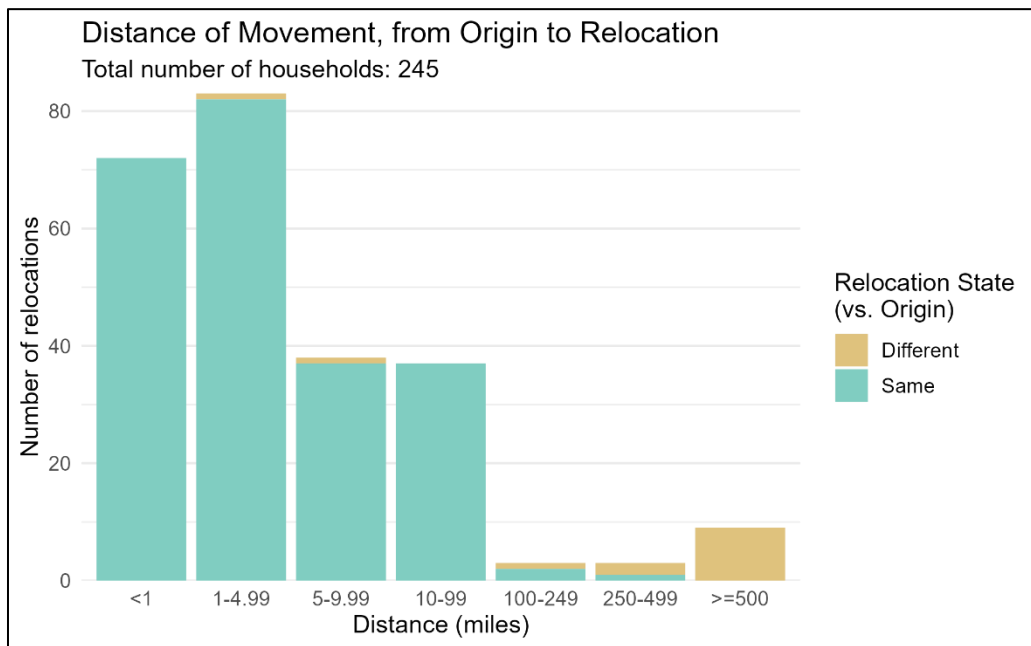| Relocation County (vs. Origin)	Count	Distance (miles)		
		Mean	Median	Max
Same	194	3.14	1.63	22.1
Different	37	35.3	18.1	354

Figure 3. Distribution of relocation distances and whether household remains in the same state.

3.3. CHANGES IN EXPOSURE TO FLOOD HAZARD

All origin (buyout) and relocation (post-buyout) addresses were successfully mapped to an associated FEMA flood map with flood hazard information. Most households in this study (n=185) lived in buyout properties that were located in the 1% annual chance flood zone. Of the remaining households, 16 lived in buyout properties located in the 0.20% annual chance flood zone and 44 buyout properties were located in areas designated as minimal flood zones. While a majority of households (n=221) relocated to an area of minimal flooding, 23 households still remain inside a designated flood zone (20 households in the 1% annual chance and 3 households in the 0.20% annual chance). One household relocated to an address where the flood hazard was "undetermined but possible" according to FEMA flood maps.

The change in exposure to flood hazard score was assessed for all movements, except for the household that had an "undetermined" flood hazard at the post-buyout location. Of the remaining 244 households, 181 households decreased their flood exposure after relocating. Exposure to flood hazard remained the same for 63 households and increased for one household that moved from a minimal flood hazard zone to a 1% annual chance flood zone. **Figure 4** illustrates the change in exposure to flood hazard for all 245 households.
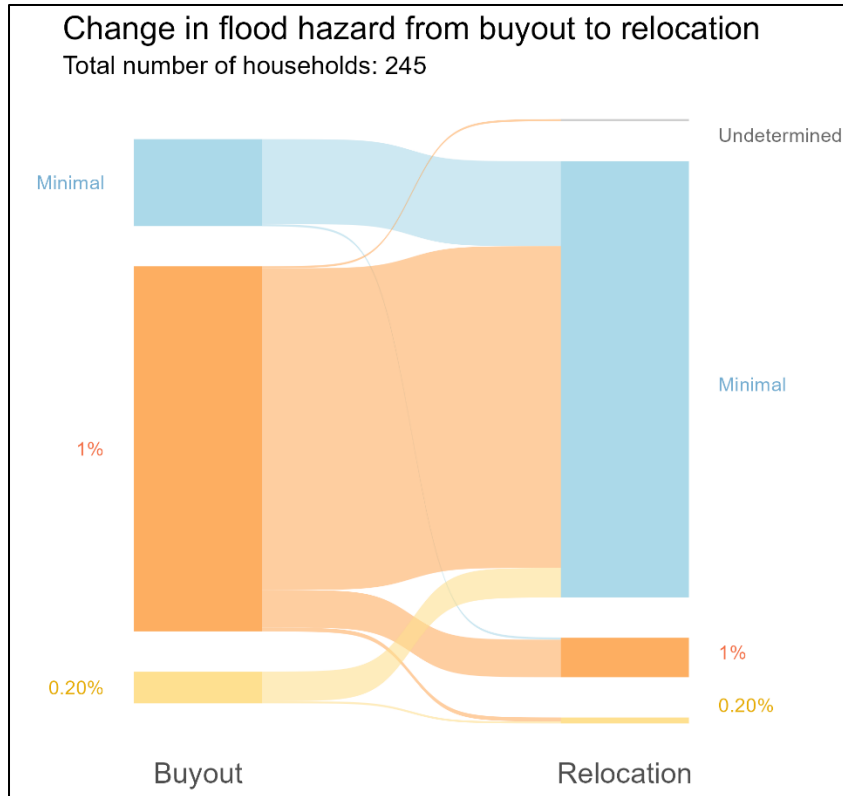
Figure 4. Diagram depicting buyout and post-buyout flood hazard and the change in exposure to flood between locations.

The remainder of the results section analyzes changes in flood hazard exposure for different groups and will focus on the groups where exposure to flood hazard either decreased or remained the same (n=243).[9] Welch two sample t-tests were conducted to determine if there was any association between distance of relocation and change in flood hazard exposure. There was no significant difference in how far households relocated on average and whether their exposure to flood hazard decreased or remained the same. This holds true for all households (n=243, p=0.27), relocations within the same state (n=229, p=0.35), and relocations within the same county (n=194, p=0.45).

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[9] The two households that were removed include the household whose flood hazard at the post-buyout location was "undetermined" and the household where exposure to flood hazard increased.

3.4. HOUSEHOLDS THAT LIKELY EXPERIENCED FLOODING TRIGGERING BUYOUT

Almost 75% of households (n=182) were living at the buyout address in the year that the flooding occurred, based on the length of residence reported in the Data Axle Historical Consumer Data. **Table 7** shows a comparison of relocation distances between subgroups of households who likely experienced the flooding and those who did not. There is no significant difference in how far each subgroup relocated, using a difference in means test (Welch two sample t-test). This remains true even when comparing subsets of relocations within the same state and relocations within the same county. **Table 8** compares the change in exposure to flood hazard between households who likely did and did not experience the flooding that triggered the buyout. There is no significant difference between how each subgroup relocated in terms of reducing their exposure to flood hazards, based on a difference in proportions test with Yates' continuity correction.

Table 7. Comparison of relocation distances between households that likely did or did not experience flooding (n=243).

Experienced Flooding	Count	Distance (miles)		
		Mean	Median	Max
Yes	182	35.9	2.78	1,449
No	61	61.4	2.70	965
Notes:				

No statistical significance between groups:
  All relocations (n=243): p=0.98
  Same state relocations (n=229): p=0.54
  Same county relocations (n=194): p=0.48				

Table 8. Comparison of flood exposure change between households that likely did or did not experience flooding (n=243).

Experienced Flooding	Count	Change in Flood Exposure (% of total)	
		Decreased	**Same**
Yes	182	135 (74.2%)	47 (25.8%)
No	61	46 (75.4%)	15 (24.6%)
Notes:			
No statistical significance between groups: All relocations (n=243): p=0.98			

3.5. HOUSEHOLDS WITH CHILDREN

Households with children are an important subset of the relocated households, because they may have additional factors to consider specific to children when choosing where to relocate, such as proximity to schools. There were 33 households identified and relocated which had children (13.5% of all relocations). All households with children relocated within the same state, with 27 remaining in the same county and 6 moving to a different county. **Table 9** shows in which states these 33 households were residing. Because all households with children relocated within the same state, a comparison between same-state relocations is the most appropriate. **Table 10** shows a comparison of relocation distances between households with children and without children. A difference in means test (Welch two sample t-test) revealed no difference in relocation distance between households with children and households without children who relocated within the same state. **Table 11** shows the relocation distances of these subgroups, based on whether households remained in the same county. A comparison of relocations within the same and different counties also revealed no significant difference between these subgroups. **Table 12** shows how each subgroup relocated in terms of change in flood hazard exposure. Households with children are

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more likely to decrease their flood hazard in their post-buyout location than households without

children, based on a simulated difference in proportions test.

Table 9. Number of households with children living in FEMA bought-out properties, by state.

State	Households
Iowa	7
Kentucky	5
Pennsylvania	5
Ohio	4
Missouri	3
Kansas	2
Indiana	2
New Jersey	1
Texas	1
Wisconsin	1
West Virginia	1
New York	1

Table 10. Comparison of relocation distances for households with and without children, for moves within the same state (n=229).

Household with Children	Count	Distance (miles)		
		Mean	Median	Max
Yes	33	6.36	3.85	27.7
No	196	8.57	2.13	354
Notes: No statistical significance between groups: Same state relocations (n=229): p=0.39				

Table 11. Comparison of relocation distances for households with and without children by county of relocation, for moves within the same state (n=229).

Relocation County (vs. Origin)	Household with Children	Count	Distance (miles)		
			Mean	Median	Max
Same	Yes	27	3.36	3.42	8.02
	No	167	3.11	1.60	22.1
Different	Yes	6	19.8	20.8	27.7
	No	29	40.0	18.1	354
Notes: No statistical significance between groups: Same county relocations (n=194): p=0.68 Different county relocations (n=35): p=0.16					

Table 12. Comparison of flood exposure change between households with and without children, for moves within the same state (n=229).

Household with Children	Count	Change in Flood Exposure (% of total)	
		Decreased	Same
Yes	33	29 (87.9%)	4 (12.1%)
No	196	142 (72.4%)	54 (27.6%)
Notes:			
Difference between groups statistically significant: All relocations (n=229): p=0.078 (*)			
Significance levels indicated by stars: 1% (***), 5% (**), and 10% (*)			

4. DISCUSSION

4.1. GENERAL TRENDS

Relocation trends indicate that tenants do not relocate far once displaced. This finding supports Hypothesis 1 and generally agrees with the empirical relocation studies specific to homeowners and voluntary property buyouts in the U.S. In terms of distances moved, 94% of tenants relocated within 100 miles of the origin address, and 63% relocated less than five miles away. This corresponds to homeowner relocation trends, where over 90% of homeowners in Houston stayed within 100 miles of the origin address (Loughran & Elliott, 2019), and, after Hurricane Sandy, 60% of homeowners who participated in a buyout stayed within five miles of the origin address (McGhee et al., 2020). Additionally, this study found that 84% of tenants remained within the same county after relocating. This is a higher percentage than observed in homeowner relocation studies, where only 79% of Houston homeowners remained in the same county and 75% of homeowners in New York relocated within the same county. While this study did not examine the motivations of tenants in making these relocation decisions, one possible

explanation for these local moves is that remaining within five miles of the origin is less likely to negatively impact friendship networks and social capital (Belot & Ermisch, 2009).

This study found that most households reduced their exposure to flood hazards by relocating, agreeing with findings of homeowner relocation trends in New York (McGhee et al., 2020). However, 9.4% of households (n=23) remain in high- or moderate-risk flood zones. According to FEMA officials, one key benefit of property buyouts is the permanent removal of people from flood-prone areas (US GAO, 2022). Buyouts are often described as opportunities to move people to safer locations, but this may not be the outcome for all impacted people. Results from this study as well as other buyout relocation studies (Loughran & Elliott, 2019; McGhee et al., 2020) show that some residents relocate into other flood-prone areas after a buyout, regardless of homeownership status. Future implementation of buyouts may want to consider educating or assisting residents of buyout properties regarding relocation options that are consistent with program goals of relocating people out of flood-prone areas.

4.2. HOUSEHOLDS THAT LIKELY EXPERIENCED FLOODING TRIGGERING BUYOUT

Households that likely experienced the flooding which triggered the buyout did not relocate differently compared to households that likely did not experience the flooding, in terms of both distance moved and change in exposure to flood hazards. While this suggests that experience with flooding may not strongly influence how tenants relocate, most tenants still relocated to areas with lower exposure to flood hazards, regardless of flood experience. This finding also indicates that there were likely other factors contributing to relocation decisions of tenants besides just experience with the flooding. In this study, experience with flooding was treated as a binary, only indicating whether households did or did not experience the flooding. In reality, severity of flooding events can differ, and the same flooding event can be experienced differently between

individuals. Therefore, even within the subgroup of households who likely experienced the flooding, relocation outcomes can be different for individual households based on the level of flooding they experienced and other household factors. As migration theory posits, environmental drivers are only one of many drivers that can influence relocation decisions. Where to relocate can also depend on individual and community level factors.

Additionally, there is evidence that the impact of experiencing a flood event decreases over time (Albright & Crow, 2019). The FEMA HMGP buyout process can take an average of 5.7 years from when the flooding occurred to when the buyout is closed (Mach et al., 2019). In this study, the average time between when the flooding occurred to when the tenants relocated was 2.4 years. While experience with the flooding event may have increased concern over flood risks, the influence of this concern on where people moved next may have weakened as more time passed between the flood and moving. Because buyouts did not occur immediately after the flooding event, exposure to flood hazards may not have been the driving factor in relocation decisions of tenants.

4.3. HOUSEHOLDS WITH CHILDREN

Households with children generally remained in the same area after the buyout, with a maximum relocation distance of less than 30 miles. There were 27 households with children who relocated within the same county, moving on average less than five miles. This is not surprising, as literature suggests that short distance relocations allow movers to maintain social capital (Belot & Ermisch, 2009). This is especially important for households with children, who might rely on local social capital for help (Kan, 2007) or whose children have important local friendships that, if severed because of a move, could cause trauma (Dawkins, 2006). For the other six households

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with children who moved to a different county, different factors may have driven those relocation decisions, such as familial ties or economic opportunities.

This study also found that households with children were significantly more likely to decrease their flood hazard than households without children. This agrees with literature regarding residential stability and children. Residential instability or frequent moves can have negative impacts on children, including on health and education (Hatch, 2021; Desmond et al., 2015; Jelleyman & Spencer, 2008; Been et al., 2011). By relocating to areas of lower flood risk, households with children reduced the probability that they would need to relocate again due to flooding.

4.4. LIMITATIONS

This research contributed to current literature by providing the first nationwide analysis of tenant relocations resulting from homeowner voluntary property buyouts in the U.S. A novel methodology was employed combining publicly available FEMA data sets and commercially available household-level data to track where tenants relocated after a buyout occurred. However, there are limitations associated with the use of these data sets. First, due to data availability, only buyouts conducted between 2006 and 2017 were analyzed in this study. The Data Axle Historical Consumer data was not available prior to 2006, and the address-level FEMA buyout data was not available after 2017. Second, the continuity of data within the Data Axle Historical Consumer data set limited the successful relocation of a significant number of households. This is discussed in the "Data Loss Bias Analysis" section and presents a limitation of this research. Based on email correspondence with Data Axle, the Historical Consumer data set is updated using a variety of different sources of data, which confirm a household's current address. Households are reassigned to new addresses if they appear in the National Change of Address database. Households are

removed from the data set if their information is not updated after 24 months (B. Kunes, personal communication, January 24, 2023). In this process, households and their unique household identifier may not persist through the different years of the data set.

There are also limitations associated with the data source for flood risks. FEMA flood maps are developed to provide information about flood hazards, but the Association of State Floodplain Managers (ASFM) estimates that as of January 2020, these maps only cover about one-third of the U.S. (ASFM, 2020). Additionally, FEMA flood maps are not updated frequently (US DHS, 2017; ASFM, 2020). To this point, FEMA has testified to Congress that over 40% of flood insurance claims between 2017-2019 were made for properties in areas either unmapped by FEMA or outside of FEMA-designated flood hazard zones (US GAO, 2021a). While these maps are the most well-known source of flood hazards, they do not provide flood hazard information to many areas of the country, and it has been shown that FEMA flood maps likely underestimate the population of the U.S. that is exposed to flood hazard, because not all potential sources of flooding are represented in these flood zone designations (Wing et al., 2018). Currently, there are other sources of flood data that are more comprehensive and could be used to evaluate exposure to flood hazards, such as First Street Foundation. However, as this study sought to understand whether buyouts reduced tenant exposures to flood hazards at their next location, it was important to use the information that would be available to tenants at the time of their relocation decision, which would be FEMA flood maps. While flood hazards were identified for all 245 households at buyout and relocation addresses in this study, only 96 post-buyout addresses had maps available ***at the time of relocation***. Therefore, this study may not accurately capture how tenants understood flood risks and how flood hazard information factored into their relocation decisions.

4.5. FUTURE WORK

This study provided the first nationwide analysis of relocation outcomes of tenants as a result of voluntary property buyouts. At the time of writing this paper, only homeowner relocation outcomes in specific locations (Houston, Texas, and Staten Island, New York) were published and available. A nationwide assessment of homeowner relocation patterns would be a more appropriate comparison for the results of this study. This could allow for evaluation of any differences in relocation outcomes for buyouts in specific states or after specific disasters.

The analysis presented in this study utilized secondary data sources to evaluate relocation outcomes from historical buyouts. However, the outcomes observed could be further explained by directly surveying displaced tenants. Collecting demographic data of tenants and interviewing or surveying tenants to understand their experience with buyouts, their perceived flood risks (if any) and what factors affected their relocation decisions could better contextualize movements and help inform how voluntary property buyouts affect tenants. For example, anecdotal experiences of renters relocating after Hurricane Sandy touched on concerns about leaving social networks, flooding, and affordability of rental units outside of the floodplain (Morris, 2021). Additionally, buyouts may have a similar effect on tenants as evictions. Buyouts can result in a forced relocation for tenants, as the unit is no longer available to the tenant (either legally or physically), and the tenant has no choice other than to relocate (Hatch, 2021; Desmond et al., 2015). Although buyouts are a planned project, it is unclear whether tenants are aware that their landlord is pursuing a buyout and how much advance notice a tenant is given to find new housing. Further research focusing on tenant experience with the buyout and relocation decisions could help improve voluntary property buyout policies and reinforce recommendations in the literature to provide relocation assistance in

conjunction with property buyouts (Kraan et al., 2021; Dundon & Camp, 2021; McGhee et al., 2020; Binder & Greer, 2016).

This study contributed to research on property buyouts and whether they are achieving their intended goal of reducing risk to people and property, including tenants. However, this study was limited to only analyzing where people move to immediately after a buyout. Existing literature suggests that once people move, they are more likely to move again in the future (DaVanzo, 1983). In light of this, a longitudinal study tracking tenant households several years after the buyout can determine whether subsequent moves are conducted. Such a study can allow for evaluation of the longer-term outcomes of buyouts, including where people move in terms of flood risk and ultimately, whether the goal of removing people from flood-prone areas is achieved.

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