The complex role of local governance in facilitating property buyouts and managed retreat in response to climate hazards

Short title: The complex role of local governance in managed retreat

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Abstract

Managed retreat is an increasingly important management option for responding to the localized impacts of climate change and poses a complex governance challenge. Floodplain property buyouts represent the largest form of managed retreat currently underway in the U.S. and have been broadly studied as disaster response policy using large national datasets. Research on the local governance dimensions of property buyouts remains limited but critically needed to inform ongoing buyout programs and the design of future retreat efforts. This paper contributes new knowledge of the local governance dimensions of property buyouts and managed retreat by studying forty towns in Vermont that completed property buyouts along streams and rivers following catastrophic flooding in 2011. Using statewide and town-level datasets, measures of the watershed context of each buyout, and qualitative interviews this research seeks to understand the social, institutional, and environmental variables that led some towns to implement many buyouts while other similarly flood-impacted towns implemented far fewer. Results indicate that lower income towns implemented more buyouts and fluvial erosion had an outsized role in driving flood losses on buyout sites. Measures of town governance capacity and local governance paradigm are found to influence the occurrence of property buyouts in complex and unexpected ways. Findings depict how property buyouts are a highly localized process that requires cross-scale governance and hinges upon pre-existing social and institutional networks, local leaders, and trust. Buyouts and retreat processes emerge as a stage for opposing notions over the role of government, landowner rights, and economic development to be contested at the floodplain parcel scale. Findings also demonstrate the limitations of property buyouts in geographically constrained landscapes that are perceived as being bound to risk. Federal buyout programs tend to be unresponsive to local nuance and risk perpetuating systemic inequities

where buyout and retreat governance processes cannot be reconciled with local context. These findings can inform the design and administration of buyout and retreat programs to better empower frontline communities to respond to changing environments.

1. Introduction

Global flood losses have increased over the past century despite growing public investments in flood control and mitigation [1–3]. Extreme precipitation events, changing hydrogeomorphic conditions, and intensifying floodplain development are expected to continue increasing the exposure of people and infrastructure to flood-related hazards in coming decades [4–6]. Where the risk of flooding becomes untenable, communities may wish to consider relocating away from high-risk areas to prevent future flood losses and to restore natural landscape processes that regulate flood risk. Described as the coordinated relocation of people and assets away from high-risk places, managed retreat will become an increasingly important management alternative where natural hazards such as floods, wildfire, or sea level rise threaten the future of communities [7–9]. Despite its developing appeal, managed retreat poses a complex governance challenge involving high levels of uncertainty, overlapping authorities, and numerous forms of expertise that generate "institutional ambiguity" [10]. Long-standing institutions and policies responsible for creating existing distributions of risk and cycles of repetitive loss will be inadequate for meeting this challenge [11]. Retreat strategies must move people and communities, and they must also transform the institutions and systems of governance responsible for creating and upholding inequitable patterns of vulnerability and environmental degradation in society today. To be successful, these efforts must understand and center the role of local governments in designing and implementing retreat programs [12].

Managed retreat has been framed as a coordinated governance response to the growing exposure of populations to global environmental change [10]. Research examining the theoretical and empirical dimensions of managed retreat is limited but growing in scope [13,14]. Existing

empirical work has largely focused on the relocation of coastal communities in anticipation of sea level rise and coastal hazards [15–18]. Less empirical attention has been paid to retreat within inland watersheds [13] or small or rural communities [19], and the governance dimensions of managed retreat remains underexplored [10]. The limited scope of existing research reflects the limited number of formal programs facilitating managed retreat in practice today. Managed retreat in the US has been facilitated through voluntary floodplain property buyouts in communities with high flood risk [20]. More than 40,000 homes have been relocated from floodplains since 1989 in response to severe flooding through the Federal Emergency Management Agency's (FEMA) floodplain property buyout program. Property buyouts are administered by federal agencies in coordination with state and regional governments and are offered on a case-by-case basis to property owners that have experienced substantial flood damage (typically damage equivalent to greater than 50% the value of the structure). A buyout project involves the voluntary sale of damaged property to a local government sponsor at a pre-disaster market value, and subsequent demolition and permanent conversion of the land to open space supportive of natural floodplain functions [21]. Property buyouts offer a piecemeal approach to achieving managed retreat goals, but pose their own set of challenges to local governments and homeowners [22]. A homeowner's decisions to accept a buyout is personally and financially challenging and is complicated by high levels of uncertainty imposed by buyout procedures that, on average, take five years to complete following flood loss [23]. Buyouts are administratively burdensome for local governments to implement, especially where governments face limited availability of financial and staff resources amid larger disaster recovery efforts [24]. Research on floodplain property buyouts tends to focus on homeowner experiences [25], and evaluating the outcomes of buyout programs along cost-effectiveness, avoided flood damage, or

social vulnerability and equity metrics [21,26–29]. Most research to date uses large national datasets to examine high-level trends in the distribution of buyouts, and very little work has gone beyond county-level analyses to understand how property buyouts and managed retreat occur locally. County and local governments are responsible for deciding how to implement buyouts, and who to offer them to, and they likely exhibit a variety of approaches to doing so [30].

The geographic distribution of buyouts broadly reflects the distribution of flood hazards and disaster declarations across the U.S., although states with the greatest reported flood losses are not necessarily those with the greatest utilization of buyouts [20]. Mach et al. (2019) report that buyouts tend to occur in wealthier counties nationally but within less-wealthy communities within those counties. This is attributed to the assumed higher governance capacity of wealthy county governments that are better equipped to navigate the buyout process following flood loss. Federal buyout programs have historically relied on cost-benefit ratios to determine which structures are eligible for buyout following flood loss, and this approach has shown to disproportionately designate lower-value structures as substantially damaged and eligible for buyout [26,28]. These outcomes have various social-equity implications with material impacts on communities and families. Whereas public disaster recovery funding should be available to the most impacted and vulnerable populations, it can lead to the disproportionate targeting of low-income and minority communities for buyout while wealthier communities remain intact and rebuild. Buyout programs risk ignoring and perpetuating the racialized history of housing and disaster policy in the U.S. where minority and underrepresented perspectives remain excluded from decision making [29]. These challenges depict a central tension within the federal buyout programs – that financial benefits of property buyouts are realized across scales while the costs are concentrated on homeowners and the communities being dissolved. While the decision

111 to accept a property buyout is ultimately up to an individual homeowner, U.S. federal buyout
112 programs require a local government or organization to sponsor and administer the buyout
113 process. The process local governments use to decide which communities and homes to offer
114 buyouts to often lacks transparency and generates public distrust, especially where buyout
115 programs are influenced by political motivations [28,31]. The factors influencing homeowner
116 acceptance of buyout offers has been examined within policy literature [32], but little research
117 has examined why local governments choose to implement buyouts instead of rebuilding in
118 place.

119 Research addressing the utilization of property buyouts has generally occurred at national
120 levels with federally derived data [20,33]. There is a dearth of literature examining the property
121 buyouts at more granular, local scales or that combine large buyout datasets with qualitative data
122 from policy actors and local flood managers [34] or integrate geomorphic parameters to
123 contextualize the geospatial elements of floodplain buyouts. This paper contributes a study of
124 locally driven retreat from flood hazard areas along streams and rivers in Vermont (a state
125 significantly affected by Tropical Storm Irene in 2011) using floodplain property buyouts, and
126 seeks to understand the social, institutional, and watershed variables that influence the
127 occurrence of property buyouts. By setting the unit of analysis at the town level in a state without
128 strong county governments, this study contributes a local perspective of property buyout and
129 retreat governance that has yet to be examined in retreat literature. An analytical framework
130 informed by institutional theory and socio-technical systems is used to answer two research
131 questions. First, how does the distribution of buyouts across Vermont in response to a 2011
132 tropical storm compare to national buyout trends? Second, why do some local governments

implement numerous floodplain property buyouts, while other similarly flood-impacted communities do not?

These questions are examined through a comparative study of flood response and recovery strategies exhibited by towns across Vermont, U.S.A. following catastrophic flooding in 2011. More than 150 voluntary property buyouts were completed in 40 municipalities across Vermont in the decade following severe flood losses. Some towns implemented many buyouts while other similarly flood-impacted towns implemented very few. Towns exhibit different patterns in the use of buyouts; some towns completed batches of buyouts that opened large tracts of contiguous floodplain area, while other towns completed buyouts in a patchy, seemingly piecemeal approach. This study leverages differential outcomes in the use of buyouts across towns to derive causal inferences about town-specific drivers of floodplain retreat and associated governance strategies. By studying why, and how communities implement floodplain buyouts this paper develops new knowledge of the local governance dimensions of retreat and gains insights to the local policy interventions needed to empower frontline communities to respond to changing environments.

1.1 Property buyouts facilitate floodplain retreat

To operationalize and examine these research questions requires contextualizing floodplain property buyouts within the U.S. flood governance system. Floodplain retreat reflects a departure from longstanding paradigms of natural hazard governance in the United States. Flood governance is carried out through a multilevel structure that coordinates federal, state, regional, and local governments to administer pre-disaster and post-disaster strategies and policy programs. Pre-disaster strategies involve constructing flood control infrastructure and stream

channel engineering projects, administering flood mitigation standards to guide development within high hazard areas, and using flood risk communication tools, such as flood maps, to inform land use decisions. Post-disaster strategies involve emergency response services and the distribution of recovery funding through public assistance grants to local and state governments and flood insurance payouts to individual homeowners to support recovery and rebuilding [35]. This governance structure assigns high levels of independence to local and regional governments to enact and enforce their own floodplain standards and bylaws, although communities must meet minimum requirements for floodplain development standards to maintain enrollment in the national flood insurance program and receive disaster assistance.

Floodplain property buyouts offer a post-disaster policy tool to permanently remove severely damaged homes from floodplains in lieu of rebuilding in place, providing a pathway for homeowners and communities to escape future flood losses [22]. Buyouts are challenging to implement, however, and use of the floodplain buyout program has declined in recent decades relative to the increasing frequency and magnitude of large flood events impacting U.S. communities each year [36–38]. The U.S. flood governance system relies on a mixed-bag of policies that distort public perceptions of flood risk and generate perverse incentives for local governments to prioritize economic development of floodplains over investment in flood mitigation [39–41]. Federal agencies build and maintain complex networks of flood control infrastructure that mute small and moderate sized floods, provide non-risk-based flood insurance rates to homeowners, and ensure disaster relief following flood losses that act together to encourage building, and rebuilding, in risky places [13,42,43]. Widespread floodplain development occurred throughout the 20th century as a result, setting the stage for cycles of

repetitive flood loss currently documented in communities along waterways and coastlines throughout the U.S. [44,45].

The voluntary floodplain property buyout program was designed to address the challenge of repetitive flood loss by giving substantially flood-impacted homeowners an opportunity to sell damaged homes instead of rebuilding them. Even with the prospect of reduced future flood losses, however, the decision to pursue floodplain buyouts is complex, politically charged, and in competition with deeper system dynamics that reinforce status quo procedures that lead local governments to rebuild in floodplains [11,43]. Communities that ultimately elect to administer floodplain buyouts have begun to overcome these powerful systemic forces to proactively escape cycles of repetitive flood loss.

1.2 Framework for studying buyouts in local flood governance systems

This study analyzes the social, institutional, and environmental dimensions of local-level flood governance systems that influence the use of property buyouts to retreat from flood hazard areas. An analytical framework integrating concepts from institutional economics and socio-technical systems was developed to assess and compare local flood governance systems. A socio-technical system framing is useful for operationalizing flood governance as a subject of study, and depicts how numerous heterogenous elements (technology, infrastructure, institutions, organizations, resources, behaviors, etc.) align and operate together to carry out governance functions [46]. Socio-technical systems are directed and maintained by networks of actors, formal and informal relationships, specific forms of expertise, and knowledge that impose a collective logic directing the development and incremental change of system elements through

time [47]. Socio-technical systems exhibit self-reinforcing dynamics and are subject to path-dependence, becoming highly stable and resistant to change [48,49]. These dynamics narrow the range of pathways that a system may respond to complex problems and must be overcome to permit system changes [50].

Flood governance systems are composed of complimentary arrangements of institutions (e.g. floodplain management), infrastructure (e.g. levees), rules (e.g. floodplain development standards), cultural values (e.g. 'we will rebuild stronger'), and expertise (e.g. engineering) that together guide how people live with flood risk and respond to flood loss (Fig 1). These arrangements produce increasing returns and high transaction costs that generate strong path-dependencies [43]. Where flood governance arrangements are institutionalized by formal regulations (e.g. development standards in flood hazard areas), organizational commitments (e.g. flood insurance policies), vested interests (e.g. homes in floodplains), and sunk costs (e.g. infrastructure networks) they gain powerful inertia that opposes redirection or change [47]. Operating together, flood governance systems project flood safety onto flood-prone landscapes but at the cost of reliance on an inflexible system [50]. These institutional arrangements and path-dependent processes have created flood governance systems that are highly resistant to change even where they perpetuate suboptimal outcomes for people and watershed landscapes, for instance, repetitive flood losses and degraded floodplain environments [51–53].

Fig 1. The U.S. flood governance system modeled as a socio-technical system.

Flood governance is enacted through complimentary arrangements of expertise, infrastructure, policy and management paradigms, community development patterns, and public expectations that are self-reinforcing and resistant to change. Floodplain buyouts disrupt this system but are challenging to implement.

This study treats floodplain property buyouts as an intervention in status-quo flood governance that seeks to move people away from flood hazard areas and break cycles of repetitive flood loss. Communities that successfully implement property buyouts are those that disrupt the inertia of socio-technical system dynamics to implement new policy, practices, or alterations to infrastructure. These shifts can be made during windows of opportunity for change, for instance, following impactful flood events that call into question status-quo governance arrangements [46,47]. Systemic change may take the form of latent societal shifts in values, attitudes, dominant discourses, or logics that underpin existing practices and laws. Active forms of change may include adjustments to power constellations among actors and interest groups, changes in the external landscape, or market-driven shifts that adjust cost-benefit ratios of existing system elements [54]. These pressures accumulate and eventually disrupt dominant system dynamics to allow new ideas, practices, or actors to take hold [46,55]. These models of socio-technical system change are used to direct this analysis of the potential environmental, social, and institutional pressures that drive local governments to use floodplain property buyouts. Those pressures may include internal community factors such as a history of persistent flood loss, growing public and private costs of flooding, lowered public confidence in standard policies and practices, shifting public discourses that rationalize building in flood hazard areas, and local or government actors advocating for change [51]. External pressures may include highly salient flood events, environmental stressors such as stream erosion and water quality impairment, organizations advocating for new policy, or changes in higher levels of government [11].

For this study, floodplain property buyouts were hypothesized to occur at greater rates in wealthier towns with a history of repetitive flooding and greater exposure to flood hazards [20].

Local governance capacity is known to be an important mediator of flood mitigation efforts and is a product of human capital, knowledge, expertise, competency, and a town's financial resources [56]. Buyouts are expected to occur in greater numbers in towns with high measures of local governance capacity, and in the presence of supportive local leaders that are influential and well-connected across governance networks [57]. The community attributes, institutional arrangements, and environmental variables that influence if, and how, local governments implement property buyouts and enact floodplain retreat remain unexplored in prior research.

1.3 Study setting

Vermont is a small state in the Northeastern United States delineated by the Green Mountains along the west and the Connecticut River valley along the east. Vermont has over 37,000 kilometers of streams and rivers with a long history of stream modification by dams and channel engineering to support commerce, agriculture, and flood mitigation. Vermont has a low population density (26 people/km^2), the largest city of Burlington has a population of less than 50,000 and most Vermont towns have fewer than 5,000 residents. Vermont has a history of regular flooding with 17 disaster declaration flood events since 1964 and the flood of record occurring in 1927 [58]. In 2011 Tropical Storm Irene brought five to eleven inches of rain in under twenty-four hours to much of the state, a record-setting amount of precipitation that caused catastrophic flooding and more than $800 million in losses to communities and public infrastructure. Vermont's topography of hills and narrow valleys turned streams into raging torrents with enormous erosive force that destroyed transportation networks and left many towns stranded for days. In total more than 800 kilometers of state road, 200 bridges, and 1000 culverts were destroyed, 3,500 homes were damaged, and 312 houses and 500 mobile homes were majorly impacted or destroyed. Of the impacted homes, 10% were low-income households and

only 2.5% were enrolled in flood insurance. Vermont communities filed $63 million in flood insurance claims from Irene flooding alone, whereas fewer than $8 million in flood insurance claims were made cumulatively statewide between 1978 and 2010 [59]. Flood impacts were primarily attributed to fluvial erosion damage caused by the lateral movement of confined stream channels into roads, bridges, and buildings [60].

Irene served to usher along changes in watershed and flood governance in Vermont. The state's Rivers Program, situated in Vermont's Agency of Natural Resources, manages streams, floodplains, and riparian lands using fluvial-geomorphic informed principles that seek to conserve and restore natural stream equilibrium conditions within Vermont's rivers. The Rivers Program has worked to undo historic river management paradigms centered on channel engineering and structural control, and to move modern river management towards passive paradigms that "give rivers the room to move" [61]. The River Program and State agencies have developed resources and guidance to encourage local governments to adopt river corridor protections that regulate land use along waterways at the "river corridor" level, instead of the regulatory floodway, or "100-year floodplain", used to communicate flood risk by the Federal Emergency Management Agency (FEMA). The river corridor is a unit of land defined by the space needed to accommodate natural processes and meander patterns of a stream in its equilibrium condition – and is generally much wider than the typical 100-year floodplain (VT ANR). Regulating land development at the river corridor unit is challenging where towns and structures already exist within the river corridor area and reflects a key tension within river and floodplain management in the state, especially where river corridor protections are perceived as opposing economic development opportunity. River corridors provide a regulatory tool for towns

to guide safe development in flood-prone areas, and also work to educate and shape public perceptions of how rivers function, move, and flood naturally.

Voluntary floodplain property buyouts have been an important component of flood recovery efforts in the decade following Irene, and buyouts may have served as a tool for reorienting local governance towards the river corridor unit in some towns. In Vermont, local governments enjoy high levels of self-determination to enact and enforce river corridor and floodplain management as they choose. Local governing bodies, such as select boards and town councils, have high degrees of influence over watershed management and local planning decisions, state and federal agencies are left with very few, mostly incentive-based, tools to encourage local governments to enact preferred standards or regulations [62]. Vermont towns reflect a patchwork of differing development standards and flood mitigation and preparedness planning as a result. The status of local river corridor protections, hazard planning, and priority flood mitigation actions can serve as useful indicators of a town's approach to flood governance and dominant paradigms of river management (e.g. engineered stream channel control, or room for the river). County governments hold relatively little authority in Vermont's governance landscape compared to other States, and institutional gaps left between state and municipal governments are filled by boundary organizations, such as regional planning commissions and watershed partnerships, that provide expertise and guidance to assist towns with planning [63]. The built and natural environment are intimately bound across the Vermont landscape and communities tend to espouse strong support for persevering the historic and rural character of their towns and shared spaces [64]. A powerful sense of place-attachment rooted in local heritage can yield resistance to environmental change in Vermont towns, even under the auspices of restoration [65].

2. Materials and Methods

This study employs a mixed-methods research design that draws on multiple disciplines and sources of data. The research is carried out through two parts; a statewide analysis of all property buyouts, and a comparative analysis of fourteen towns that demonstrate high and low utilization of floodplain buyouts using a method of causal inference to identify potential drivers of differential buyout outcomes. By setting this analysis more than a decade following Tropical Storm Irene in 2011, this study gains a longitudinal perspective that adds greater certainty in differentiating short-lived policy and planning responses from fundamental governance transitions. This study takes a novel approach to incorporating geomorphic parameters that provide a watershed context of where buyouts occurred.

2.1 Statewide analysis of buyout distribution

A statewide analysis of the distribution of 150 property buyouts across 40 municipalities was carried out to understand how Vermont's use of floodplain buyouts compares to national trends, and to test for patterns in buyout occurrence across several sets of social, institutional, and environmental variables. The location of all floodplain property buyouts were obtained, mapped, and stratified by town and assessed across the following sets of variables to test hypotheses and uncover trends.

1) Social variables include household demographic data and datasets that convey a town's relative exposure and experience with flood hazards. Relative household income, percent of town structures in flood hazard areas, and the number of historical flood insurance claims were collected for all towns. Relative household income was measured as a town's median household income divided by the statewide median household income. All data were obtained from public U.S. census and FEMA databases.

2) Institutional variables characterize the robustness of a town's hazard planning and recovery efforts and approach to governance. Datasets include the total recovery funding received from FEMA for disaster recovery, the condition of local hazard mitigation plans, floodplain and river corridor protections, and enrollment in state-sponsored cost-sharing programs for infrastructure repair. These data were obtained from public databases hosted by FEMA and Vermont state agencies.
3) The watershed context of each property buyout location was evaluated using multiple metrics that characterize flood generating and channel adjustment processes. Those measures include drainage area, elevation, river mile, and valley bottom confinement ratio. These variables were measured using the U.S. Geological Survey's StreamStats [66] watershed delineation and measurement tools. Valley bottom confinement ratios were measured in the methods described by [67] to generate a relative measure of reach scale pressures driving lateral channel adjustments, and thus exposure to fluvial erosion hazards at each buyout location.

2.2 Comparative analysis of buyouts and governance outcomes

A comparative analysis of fourteen specific municipalities was carried out to generate a more granular understanding of the community attributes and institutional factors that led to different outcomes in floodplain buyouts across towns. This analysis leveraged a semi-natural experimental setup using a subset of towns that were selected through an iterative process informed by the statewide analysis and semi-structured interviews with key informants. Two sets of towns were selected; one set of towns that completed the greatest number of buyouts or demonstrated the most strategic use of buyouts. A second set of towns was selected that also experienced high levels of flood loss but demonstrated little or no use of floodplain buyouts.

These communities serve as counterfactuals to isolate variables predicted to have explanatory power in generating observed differences in floodplain buyouts and governance outcomes. Counterfactual towns were selected to meet three criteria, 1) they experienced heavy impacts from flooding during Tropical Storm Irene, 2) they could have implemented floodplain buyouts during flood recovery efforts, and 3) they implemented none, or far fewer buyouts than they could have. Fourteen towns were selected in total, seven buyout towns and seven counterfactual towns. This semi-natural experimental setup examines how all towns responded differently to Tropical Storm Irene in 2011, and assumes that towns are situated within a common regulatory context and face common institutional incentives and barriers to floodplain property buyouts. Towns may differ, however, in the condition of certain socio-technical variables (e.g. percent structures in floodplain, local governance capacity, hazard planning, etc.) or landscape pressures (e.g. type of flood hazard) that are unique to that town. Two categorical variables were developed to measure the condition of each town's local governance capacity, and flood mitigation strategies, using a composite of several quantitative and qualitative metrics (Table 1). Towns were evaluated and scaled across both variables using best available information and feedback from regional floodplain managers.

Variable	Description	Evaluation Data	Scale
Local Governance Capacity	The capacity for local governments to implement and enforce policies,	Town government staff positions, leaders, annual town budget, hazard mitigation plans, enrollment in state	Low, Moderate, High

	respond to complex challenges.	and federal cost sharing programs, interviews.	
Flood Mitigation Strategies	The mix of regulatory, structural, and non-structural actions taken to mitigate flood loss and guide safe development in flood hazard areas.	Minimum floodplain development standards, priority flood mitigation actions, river corridor protections, hazard mapping, interviews.	Low, Moderate, Strong

Towns were evaluated using data gathered from each town's hazard mitigation plan, major flood history, current floodplain management standards, policies, and priority mitigation projects, in addition to FEMA, U.S. census, and Vermont state agency datasets. Twenty interviews were completed in 2022-'23 with key-informants from federal, state, regional, and municipal governments, local watershed organizations, and actors involved with flood governance. Interviews lasted one to two hours each and were structured using questions to prompt discussion of actor roles, experiences, perspectives, and vision for flood governance, and interview transcripts were coded thematically for analysis in the qualitative analysis program Atlas.ti. All these data were taken together to characterize each town's flood governance system and the factors influencing property buyout outcomes.

3.0 Results

3.1 Lower income towns completed more buyouts

Floodplain buyouts were completed in 49 towns situated in eighteen distinct watersheds across Vermont. Towns completed from one to eighteen buyouts, and 99% of buyouts occurred in low population density towns (median population density of 43 people/mile^2). Most buyouts were completed in lower income towns (68%), defined as towns with median household income below the state level (Fig 2A). Town buyout counts are slightly positively associated with two variables - the percent of town structures in flood hazard areas (Fig. 2B) and the number of flood insurance claims submitted historically (Fig. 2C). The relative distribution of FEMA post-disaster funding was also examined and indicates that lower income towns completed larger buyout projects and generally received more FEMA funds (Fig 3). Overall, lower income towns show a greater proportion of town structures in FEMA-mapped flood hazard areas, greater numbers of historic flood insurance claims, and received more FEMA recovery funding in the years following Tropical Storm Irene. These findings indicate that lower income towns tend to have greater exposure to flood hazards (as delineated by FEMA flood maps) and have experienced more flood loss in the past, and presumably, had more floodplain properties eligible for buyout. No trends in county-level data were found.

Fig 2. The number of buyouts completed plotted by town income, flood hazard area, and historic losses.

Town level data was plotted to explore how the number of buyouts completed relates to several other town metrics. (A) A negative relationship is found between relative median household income and the number of buyouts completed. Relative household income is a ratio of median town household income to median state household income, towns below 1.0 are considered lower income. (B) A slightly positive relationship is found between the percent of town structures in flood hazard areas and the number of buyouts, and

similarly for (C) the number of historic flood insurance claims made in a town and the number of buyouts completed.

Fig 3. Lower income towns completed larger buyout projects and received more FEMA post-disaster funding.

A plot depicting the interacting effects of household income and post-disaster FEMA funding received at the town level on the number of buyouts completed. Relative measures of household income and FEMA funding reflect a ratio of town level data to state level data. Lower income towns are considered those with less than 1.0 relative median household income.

3.2 Buyout locations reflect both fluvial erosion and inundation flood hazards

Property buyouts occurred across Vermont's varying watershed landscapes, and 77% of buyouts occurred within five major river basins. Buyouts occurred across wide elevation and river-mile gradients and most (63%) occurred on stream locations with less than 55 square miles of contributing drainage area (Fig 4). Most buyouts occurred on tributaries to Vermont's larger major river basins at mid and higher elevations, as is reflected in the elevation difference between many buyouts and the longitudinal profiles of the river basins they're situated in, depicted in Figure 4. These findings reflect the dual drivers of flood hazard in Vermont's landscape - inundation flooding that occurs along larger, low-elevation, meandering channels often at the confluence of two streams, and fluvial erosion hazards within valley-confined stream segments, often in mid and higher elevation headwater streams.

Fig 4. Buyouts are widely distributed across the longitudinal profiles of Vermont river basins, but primarily situated in mid and upper reaches.

77% of buyouts occurred in the five major river basins plotted, and 63% occurred in the mid and upper reaches of watersheds with less than 55 square miles of contributing drainage area. Higher elevation sites tend to reflect higher rates of fluvial-erosion driven flood hazards, whereas flatter, lower elevation sites face inundation driven flood hazards.

3.3 Buyout towns have higher measures of local governance capacity and leadership

Fourteen towns were selected and compared closely (Table 2), seven towns that implemented the greatest number of buyouts ("buyout towns", towns A-G) and seven towns that served as counterfactual study units ("counterfactual towns", towns H-N). Buyout and counterfactual towns reflect similar measures of population, household income, percent of town structures in flood hazard areas, and historic flood insurance claims. Both groups received high amounts of flood recovery funding from FEMA in the aftermath of Irene, although buyout towns received more on average ($3.99 million per town) than did counterfactual towns ($2.67 million per town), and this difference is assumed to be attributed to the extra funding received to complete property buyout transactions. Towns in both study groups face risk from inundation and fluvial erosion flood hazards, although erosion hazards are the dominant source of risk among buyout towns (5 out of 7 towns).

453 **Table 2. Comparative analysis of buyout towns and counterfactual towns.**

	Town	Population	Relative Household Income	% SFHA	Historic Claims	Flood Hazard Type	Buyouts	Local Gov Capacity	Mitigation Standards
Buyout	A	5,918	0.92	5	47	Fluvial	18	Moderate	Moderate
	B	10,686	1.02	1	26	Inundation	9	High	Strong
	C	8,491	0.74	11	217	Inundation	7	High	Strong
	D	4,129	0.82	12	16	Fluvial	13	Moderate	Strong
	E	718	0.96	8	23	Fluvial	19	Low	Low
	F	504	1.28	5	5	Fluvial	8	Moderate	Moderate
	G	12,184	0.78	5	61	Fluvial / Inundation	22	High	Strong
Counterfactual	H	5,331	0.94	22	64	Inundation	0	High	Strong
	I	15,333	0.80	1	1	Fluvial	3	High	Moderate
	J	1,844	0.91	2	27	Fluvial	0	Moderate	Moderate
	K	2,255	1.06	4	49	Inundation	2	Moderate	Low
	L	2,129	1.03	8	17	Inundation	0	Low	Low
	M	739	0.95	2	5	Fluvial	0	Low	Strong
	N	5,491	0.78	5	117	Inundation	0	Low	Strong
Mean	Buyout	6,090	0.93	6.71429	56.4286				
	Counterfactual	4,732	0.92	6.28571	40				

454

Buyout towns were found to have higher measures of local governance capacity as evaluated across measures of financial and human resources. Buyout towns have average annual town budgets that are 92% larger than counterfactual towns when normalized by population. Five buyout towns have a town planning office with one or more full-time planning staff working to implement and enforce flood hazard mitigation plans, floodplain development standards, and carry out the complex and administratively burdensome property buyout process. Many small New England towns have a limited number of paid staff positions that hold numerous overlapping roles in town administration, as was found for two buyout towns (E, F) and four counterfactual towns (K, L, M, N) that have only a single zoning administrator and a volunteer-based planning commission. Adequate financial and human resources and expertise are required to implement complex policies and buyout programs, and buyout towns generally have more of those resources. As described by one informant – "*There is a huge disparity among towns in funding and capacity, and the towns might be right next to each other. We all pay taxes, but we don't all get the same amount back. If you have a professional planner you can do much more, like moving [vulnerable homes] and getting buildings out of the floodway working with FEMA, and then restoring floodplain properties, we just completed one that will reduce flood level by 5 feet*." (Int#11 Nov 2022).

3.4 Buyout success depends on strong working relationships and local 'champions'

A town's capacity to complete buyouts is determined by the degree of trust between residents and town officials, and the efficiency of working relationships between town officials and higher levels of government. Irene inflicted immense emotional trauma to many Vermonters

and town residents looked to town administrators for guidance, information, and support in the wake of flood loss. Interviews characterize the importance of having a familiar and trusted person involved in difficult decisions to rebuild a home or accept an offer for buyout. All instances of successful buyouts studied here benefited from strong relationships among homeowners, towns officials, boundary organizations, and state agencies. Completing the buyout process hinged upon the groundwork of competent local administrators (e.g. town clerk) who had preexisting relationships with homeowners and could work effectively with boundary organizations as conduits of communication and coordination to keep the buyout process moving administratively. As a state floodplain manager described, people are central to the success of buyout projects; "*People being involved is the core of this, are there people in town who are willing to do the work? Especially for buyouts, they require so much work at the local level…from the state level I can't do the paperwork and make all the local work happen. It really needs the community push, staff support, and local funding*." (Int#7 Feb 2023).

Several examples of town officials serving a leadership role in buyout procedures were documented. In those cases, a town official served more like a project manager in championing property buyouts from start to finish in coordination with regional planning commissions. These "buyout champions" were highly engaged town planners or administrators with pre-existing knowledge of FEMA's post-disaster policy tools, including floodplain property buyouts. Buyout champions were uncovered in towns A, D, and G through interviews, and documented as well-known actors often referenced by first name across local, regional, and state government networks. They possessed local knowledge of their town's hazard landscape and could identify homes eligible for buyout amid the fray of recovery efforts. They also had personal relationships with homeowners and were willing to "*sit down with families at the table and talk about the*

option of buyouts, someone that people trust and can get the ball rolling" (Int#1 Dec 2022). Buyout champions served as trusted members of their community with the organizational skills, diligence, and working relationships necessary to complete the complex buyout application process and work across governance scales. A state agency actor noted the importance of buyout champions that could work across scales to pursue funding to support buyouts, "*the biggest challenge with getting money into the state [for buyouts] requires local actors to champion grants, those who have expertise and capacity to move grants along. But those aren't common, so regional planners work with towns to help where local leaders are missing"* (Int#13, Aug 2022). Champions also generated public and political support for buyouts through advocacy with town selectboards, and made the case for projects being in the best interest of a town. As one of those champions observed at a public meeting, "*there was enough general community support and acknowledgement that it was the right thing to do. Homeowners who wanted to be bought out came to the meetings and told their story and everyone agreed we needed to do them. You got the sense in the community that people were generally wanting to see it happen on interest of the homeowners"* (Int#9, Dec 2022).

Boundary organizations were critical to engaging with towns across the state to identify opportunities for buyouts, distribute funding, and drive the buyout process in coordination with town officials and the state government. In some cases, local champions emerged that could take on a leadership role in directing and advocating for buyouts, and these champions were described as having pivotal roles in buyout success in four towns. Where local champions did not emerge, regional actors filled gaps in local capacity by working directly with town administrators, as was documented in two towns (towns E, F). This boundary work produced one of the largest buyout projects in a town with otherwise weak predictors of buyout success (Town E).

3.5 Counterfactual towns have mixed levels of capacity and lack willingness to lead buyouts

Only two counterfactual towns demonstrated high levels of local governance capacity with dedicated town planning resources and staff (Towns H, I). Both towns are enrolled in the FEMA community rating system (CRS), a designation earned by communities that achieve high levels of flood mitigation and preparedness and awards reduced flood insurance rates for all community homeowners. Town I experienced extensive losses to fluvial erosion during Tropical Storm Irene and implemented three buyouts and a floodplain restoration project in response. These projects were initiated and led by state agencies because the town was only "*half committed to these new approaches, they never championed them, so the state held their hand the whole way*" (Int#12, Feb 2023). Without local leadership Town I was unable to advance further floodplain buyout or restoration projects, despite having numerous opportunities to do so. Similarly, town H experienced high levels of flood loss, has a well-resourced planning office, and demonstrates robust flood hazard planning but did not complete any property buyouts. Closer analysis reveals that town H made a thorough attempt to implement a dozen or more floodplain property buyouts within a single neighborhood but was consistently stalled by administrative barriers in permitting and funding with FEMA. Interviews indicate that town H even had a local champion leading the buyout effort and securing local homeowner willingness, but ultimately those buyouts applications were denied by FEMA because administrative requirements could not be met. Flood recovery efforts were instead redirected towards flood mitigation strategies focused on elevating structures in-place and enacting higher elevation building standards for inundation flooding.

Other counterfactual towns have moderate or low governance capacity and lacked the local champions needed to advance buyout projects. Town K experienced the greatest extent of infrastructure damage from Tropical Storm Irene in the state but only implemented two buyouts. Flood losses were focused in the town's business district and one buyout was completed on a business property, the other was completed for a house that was swept off its foundations and lost downstream. Numerous other buyouts could have been initiated but local administrators found low interest from property owners and speculate that businesses were more likely to be sold to new owners instead of accept buyout offers. New business owners opposed buyouts within the town's business district, and this was attributed to Town K being located near the southern border of Vermont and having a more transient community with shorter local memory of historic flood loss. In another example, town M has faced growing fluvial erosion risk from a meandering stream channel that caused large flood losses in 2008. Property owners denied repeated offers for buyout from the state government and the town has instead requested state agencies construct channel stabilization projects to halt channel migration processes and protect town structures. These instances detail the challenge of initiating the buyout process without a trusted local champion laying the groundwork for them, even if there are strong opportunities to do so. As discussed by an emergency management actor, "*Landowner readiness and engagement with buyouts is super slow. Town readiness is also limited and challenging, buyouts are really complex grants and programs to administer, not all towns are able to do it*" (Int#15, Dec 2022).

Two counterfactual towns with moderate governance capacity demonstrate active opposition to property buyouts and flood mitigation activities that restrict land use or development opportunities (Town L, N). Town L has some of the lowest flood mitigation standards and a town government that "*intentionally avoids regulations for the sake of*

maintaining autonomy…and refuses to interfere with private landowners" (Int#12, Feb 2023). The town government refused to consider property buyouts even when residents expressed interest in them and instead moved to redevelop floodplain parcels that have been repetitively flooded historically. A resident of town L described, "*I tried to get my community to buy a 4 acre floodway property that had lost access because of erosion, so it could become recreation and river access, and it wouldn't cost the town a dime. The selectboard saw no value in the property and refused to even appraise the property for free, public amenities and avoided future flood damage were not something of value to them, despite getting support from local organizations and state agencies*" (Int#11, Nov 2022). Town N historically enacted strong flood mitigation standards and hazard mapping, but interviews describe how the town's standards have been rolled back as influential local landowners have opposed restrictive floodplain development standards and buyouts. Where town planning roles are carried out through volunteer positions, as in Town N, they have less capacity to support mitigation objectives through consistent outreach and consensus building.

The strength of flood mitigation standards and river corridor protections varies widely across both town groups and did not serve as a good predictor of buyout occurrence. Six towns in total, three in both comparison groups, have some level of river corridor protection bylaws in place. Interviews with regional and state planners indicate that a mix of strong, moderate, and weak mitigation standards are exhibited in both buyout and counterfactual groups, with the weakest standards enforced by towns E, K, and L. Numerous instances of town governments working to weaken flood mitigation standards, or undo previously enacted protections, were documented in both buyout and counterfactual towns (towns A, G, I, N). One town administrator described how the strength of a town's flood mitigation standards "*all depends on the politics of*

the town, who's in charge and who has the largest voice" (Int#9, Dec 2022). These narratives demonstrate how local mitigation standards and flood resilience efforts are subject to abrupt change in response to shifting town politics. Even in towns that implemented many buyouts in the past (e.g. town A), changes in town leadership resulted in weakening of flood mitigation regulations in recent years.

3.6 Buyout towns prioritize non-structural mitigation actions

Buyout towns with well-funded and staffed planning offices, unsurprisingly, have more robust hazard mitigation plans, demonstrated records of completed and planned flood mitigation projects, and prioritize both structural and non-structural strategies for reducing future flood loss. Six of seven buyout towns describe property buyouts, river corridor easements, and floodplain restoration as priority flood mitigation actions, in addition to upgrading culverts and protecting infrastructure that cannot be relocated. Five towns identify specific buyout projects slated for future completion and three buyout towns have implemented river corridor protections to conserve floodplains and reduce future flood losses (towns A, D, F) and two others articulate river corridor protections as aspirational but as administratively or political challenging to implement. Overall, hazard mitigation planning documents from buyout towns indicate a prioritization of both structural and non-structural approaches to reducing future flood loss, for instance, moving structures through buyouts or guiding future development away from hazard areas using river corridor protections. These plans indicate a recognition of the dynamic nature of fluvial processes within river corridors and a concern for reducing conflict between people and fluvial processes where possible through corridor protections and easements, buyouts, and restoration.

Counterfactual towns tend to prioritize structural mitigation projects. Only one town's hazard mitigation plan mentions floodplain property buyouts as a useful mitigation action (town I) but falls short of ranking buyouts as priority actions or articulating specific buyout goals. Six town plans assign highest priority to actions involving the retrofitting, or "floodproofing", of structures in floodplains, upgrading undersized infrastructure (e.g. culverts), and enhancing emergency response services and infrastructure repairs after floods. Three counterfactual towns have enacted some level of river corridor protection (towns I, J, N) and one identifies a specific floodplain restoration project goal (town J). Four towns do not discuss river corridor protections or restoration at all, and one describes river corridor protections as politically infeasible. Hazard mitigation plans from counterfactual towns indicate a general acknowledgement that flood hazards pose the greatest risk to communities, but also a commitment to remaining in place by resisting and controlling fluvial processes through infrastructure upgrades, floodproofed homes, stream channel engineering, and supporting minimal restrictions to land use on flood prone lands.

3.7 Resistance to buyouts and river corridor protections

Local efforts to implement property buyouts face different challenges in different towns. In buyout towns, challenges to completing buyouts were most often cited at the homeowner and administrative level and include retaining homeowner engagement, securing buyout funding, and completing the complex buyout application process. The property buyout process often takes multiple years to complete and can impart hardship to impacted families and make it difficult to maintain homeowner support throughout, especially where buyouts involve primary residences or vulnerable populations - "*Even giving someone the whole value of their home isn't always enough to relocate, especially where they don't own the land, are already underwater on their*

mortgage, or lack family support" (Int#12, Feb 2023). Even where finding success in completing buyouts, some town officials lamented how buyouts can only achieve so much amid the face of ongoing floodplain development, "*it's really depressing to complete a buyout when downstream someone is building in the same risky place*" (Int#15, Jan 2023).

Resistance to buyouts in counterfactual towns tended to be concentrated at the town government level and driven by fundamental differences in governing values and principles. Put simply, "*the assumed costs of doing a buyout outweighs the perceived benefits for many towns*" (Int#16 Feb 2023). Active opposition to buyouts was uncovered in three towns (L, M, N) for numerous concerns including loss of town tax base, reduced future development opportunities, place attachment, and aversion to higher government involvement in local affairs or landowner decisions. Numerous examples of opposition to buyouts were uncovered at the town administration level, even in the face of landowner interest in buyouts. Towns expressed concern that buyouts would undermine future development opportunities, erode grand lists and impart significant local economic consequences. A development-focused mindset was cited as the largest barrier to buyouts and river corridor protections in numerous towns, "*filling the floodplain and flooding other people doesn't bother [some towns] if they get good business out of it*" (Int#14, Feb 2023). In other examples, local leaders disagreed with the fundamental premise that governments should be involved in private landowner affairs, whether regulating land use in river corridors or administering property buyouts. In such cases town officials opposed property buyouts on principle because, "*Some communities perceive buyouts as a form of social welfare and as inappropriate*" (int 11, Nov 2022).

4.0 Discussion

Property buyouts were widely used across Vermont towns in response to catastrophic flooding in 2011. Most property buyouts were completed using FEMA's hazard mitigation program, and all were administered through a multilevel governance structure that coordinated federal and state agencies with regional planning commissions to engage with town governments and homeowners. Results depict how the buyout process was highly localized and shaped by unique landscape, social, and institutional factors. Buyouts primarily occurred in the mid and upper reaches of the state's major watersheds in steeper, more valley confined stream landscapes. Buyout sites reflect both inundation and fluvial-erosion driven flood hazards, but most buyouts were likely a result of fluvial-erosion damage to homes. Counter to what was expected, most buyouts occurred in lower income towns. Those towns tended to have greater numbers of structures in flood hazard areas and greater rates of historic flood loss, as measured by past insurance claims. Two variables distinguish towns that completed many buyouts from those that underutilized them – local governance capacity and local governance paradigm. These two variables are interrelated in complex ways and yield insights to how managed retreat is governed at the local level.

4.1 The complex role of local governance capacity in floodplain retreat

The role of local governance capacity in driving floodplain retreat in Vermont is more complicated than predicted. In many cases, towns that implemented more buyouts show higher measures of local governance capacity. In two cases, towns that implemented the greatest number of floodplain buyouts have low to moderate measures of local governance capacity. Regional boundary organizations formed close working relationships with these towns to

680 facilitate many successful buyouts. The importance of trust and coordination among local,
681 regional, and state governments is apparent in each buyout case studied, especially where local
682 capacity to lead is limited. These findings suggests that towns with low governance capacity are
683 not prevented from completing buyouts where higher levels of government are available to fill
684 local gaps, local administrators can work across governance scales, and where local governing
685 principles support direct involvement in property buyouts. A lack of local governing capacity
686 may even ease the way for boundary actors to facilitate strategic retreat outcomes, as suggested
687 by some results.

688 Local governance capacity was evaluated by a town's staff positions, hazard mitigation
689 planning, annual budget, and engagement with state and federal programs. These metrics
690 together reflect how much staff labor, expertise, and resources a town has available for hazard
691 preparedness and response planning. It may also serve as an indirect measure of the property
692 value captured in a town's grand list, and presumably suggests that wealthier towns may have
693 higher capacity to implement floodplain buyouts. Findings indicate the alternative, that more
694 buyouts were implemented in towns with lower relative household income. Whether this is
695 because lower income towns have greater vulnerability to flood hazards and thus more homes
696 that qualify for buyout, or because lower income towns were more successful at implementing
697 buyouts, remains unclear. However, the tendency for high flood risk places to be
698 disproportionately occupied by lower income homeowners has been confirmed broadly in the
699 U.S. [5]. These results from Vermont demonstrate the need for policy responses that are
700 equitable in addressing the complex intersections of risk and social vulnerability. From a social
701 vulnerability-oriented perspective, households with the greatest exposure to flood hazards and
702 with lower capacity to cope with, or recover from, flood losses should be prioritized by retreat

703 policies [26]. Importantly, an equity and justice perspective reminds us that prioritizing the most
704 vulnerable households for retreat may lead to the disproportionate dissolution of frontline,
705 underserved, and minority communities while leaving privileged communities intact [28].
706 Retreat programs must be tailored to local needs through participatory approaches that cultivate
707 trust and integrate local knowledge and histories into long-range planning and visions for retreat
708 outcomes. These processes will require adequate local governance capacity, strong personal and
709 institutional networks, and scaled governance processes.

710 Local governance capacity alone does not predict the occurrence of buyouts. Towns with
711 stronger flood mitigation standards that prioritize a mix of structural and non-structural actions
712 tended to complete greater numbers of buyouts. Implementing and enforcing stronger mitigation
713 standards is administratively costly and was expected to occur only within towns with higher
714 governance capacity, but this was not found in every case. Differences in the strength and
715 preferred form of flood mitigation across towns reflects differences in flood governance
716 paradigms, and likely influences the occurrence of buyouts. Towns were plotted along axes of
717 both governance capacity and flood mitigation standard to illustrate how the variables interact
718 (Fig 5). The resulting quadrant is useful for understanding the various paradigms of flood
719 governance uncovered across towns and how they influence the occurrence of floodplain
720 buyouts. Most buyouts occur under strong mitigation standards and high governance capacity,
721 these towns demonstrate a paradigm reflecting the ‘make room for the river’ approach
722 encouraged by state government agencies in recent years. In these cases, buyouts were locally
723 supported and often benefitted from the leadership of local champions that worked directly with
724 homeowners and advocated for buyouts in town government. Flood governance paradigms in
725 these towns acknowledge the tension between fluvial processes and development activities

within river corridors, generally aiming to relieve or avoid that tension where possible. Two counterfactual towns have strong mitigation standards despite having limited governance capacity (towns M, N), depicting a 'respect the river' paradigm that values local self-determination amid strong protections for river corridors. Most buyouts were completed between these two quadrants where community support for them was strong.

Fig 5. Local governance capacity and flood mitigation strategies have interacting effects on the occurrence of buyouts, and four distinct governance paradigms emerge.

Towns are plotted across graded axes for governance capacity and strength of flood mitigation strategies, and bubble size is scaled to reflect the number of buyouts completed, from 0 to 22. Four quadrants emerge that depict unique paradigms of flood governance, reflecting varying levels of support for government interventions in private land decisions and flood preparedness.

Towns in the bottom quadrants of Figure 3 demonstrate weaker mitigation standards and less local support for floodplain buyouts with varying levels of governance capacity. Towns depicting a 'hands off' approach to governing flood risk had low governance capacity and minimal mitigation standards, and buyouts only occurred within this paradigm (town E) under the leadership of boundary organizations. No towns studied here show high governance capacity and weak mitigation standards, but these communities likely do exist and demonstrate a paradigm that prioritizes private landowner rights with minimal restrictions on land use for flood mitigation. Towns in these two quadrants exhibit a general lack of willingness to become involved in decisions over private property, or to accept assistance from higher levels of government needed to complete buyouts. Interviews reveal how some administrators in these

749 towns perceive the use of public funds to relocate private homes as an inappropriate use of flood
750 recovery funding and they oppose such measures on political principle. Local opposition to
751 buyouts was of two mindsets, where local officials opposed using public funds to 'bail-out'
752 individual homeowners by purchasing their damaged homes. Or, town officials opposed using
753 buyouts because they transformed private property into public goods and were perceived as
754 posing an economic loss to the town. This sentiment was especially pronounced in towns
755 described as being more dependent on tourism or seasonal industries (e.g. ski towns).

756 These findings point out that local governance capacity must not be conflated with the
757 political orientation or willingness of a town to implement floodplain retreat, or to become
758 involved in decisions over private property. Governing floodplains and river corridors as public
759 goods to provide flood mitigation benefits requires limiting private land use actions and these
760 approaches require strong local support to be successful [68]. Local apprehension towards taking
761 on management responsibilities for bought-out floodplain parcels has been reported elsewhere
762 [34], but opposition documented here goes beyond concern for affording maintenance of buyout
763 parcels and reflects concern for affording the loss of developable land, even if that land is
764 attached to risk. Many Vermont towns exist in landscapes confined by valleys and streams and
765 buyouts present a fundamental loss of town space that some towns may perceive as an existential
766 threat.

767 This study contributes new knowledge of the governance of property buyouts, and by
768 extension, managed floodplain retreat. Local governments must have the capacity to work with
769 homeowners to initiate and shepherd the buyout process, and they must see it as an appropriate
770 responsibility of their government to do so. High levels of local governance capacity will benefit
771 communities that own the political willingness to retreat from hazard areas and develop long-

term strategies for reducing vulnerability to future hazards. But strong governance capacity may also pose as resistance to those same actions in communities that oppose retreat-oriented policy interventions, even where local landowners support them. This reveals a potential conflict of interest between town officials and individual homeowners. Vulnerable households may remain excluded from opportunities to retreat where it is contingent upon the formal support of town leadership, as is the case with FEMA's property buyout program that requires a local sponsor. The capture of willing homeowners by unwilling towns poses a significant challenge to retreat governance and could generate inequitable and unjust outcomes. These findings emphasize the need for a plurality of policy tools for facilitating retreat at the community level, and at the individual household level. Those policy tools must also be responsive to the nuance of multiple dimensions of local governance. The Vermont state government has endeavored to address this challenge through the new Flood Resilient Communities Fund that enables state government agencies to engage directly with homeowners to complete property buyouts without the constraints of FEMA-sponsored buyouts, such as requiring a local sponsor, residing in a FEMA floodplain, or meeting strict cost-benefit ratios.

4.2 Applying a "thin icing of buyouts across a layer cake of flood prone places"

This study frames floodplain property buyouts as a parcel-by-parcel approach to the managed retreat of communities from risky places. Results document how buyouts provide a means to retreat from localized flood hazards, in this case along fluvially dynamic streams and flood prone valleys. Several towns demonstrated a coordinated approach to implementing numerous buyouts to relocate entire neighborhoods, but this approach was rare and challenging to complete.

Vermont's geography drove flood loss from both inundation and fluvial erosions hazards, and the most successful use of buyouts occurred in towns primarily facing fluvial erosion hazards. This finding is significant because fluvial erosion hazards are not delineated in FEMA flood risk maps, and erosion-driven losses have been inconsistently treated in flood policy historically [61]. In several cases, fluvial erosion led to the complete loss of homes and underlying property ground due to stream channel migration. Few options other than buyout were available to homeowners recovering from such losses, and this contributes to the higher rates of buyout success in towns facing erosion hazards. Interviews also suggest that towns facing fluvial-erosion hazards have a greater understanding of the tension between fluvial processes and the built environment, simply by proximity to them. First-hand knowledge of the linkages between human and fluvial-geomorphic systems is likely to shape the perceptions and decisions of town officials and homeowners and prime them towards a greater willingness to seek or accept buyout offers [69].

Interviews uncovered a common concern for the limitations of what buyouts can achieve in a landscape defined by dynamic risk. Vermont towns are "*bound to a geography that is flood vulnerable*" (Int#15, Dec 2022) and towns have little space to retreat to. Many Vermont communities sit at, or even below, base flood elevation along rivers that frequently adjust and migrate. River corridor protections and planning are designed to integrate fluvial knowledge into community practices but cannot be retroactively applied to guide development in towns that were built centuries ago. Numerous state government actors and some town officials acknowledged the inadequacy of property buyouts in achieving meaningful flood reduction outcomes in the most vulnerable towns, for instance suggesting, "*all we're ever going to be able to do is apply a thin icing of buyouts across a layer cake of flood prone places in Vermont*"

(Int#15, Dec 2022). This sentiment is accentuated when discussed in the context of state governance principles that assign primacy to local control, and the wicked problem that emerges where towns endeavor to continue building and persisting in high hazard places, even as it perpetuates cycles of repetitive loss and recovery. Similar challenges likely exist among risk-bound communities all over the U.S. and elsewhere. While property buyouts have provided a policy mechanism to facilitate the most significant form of managed retreat currently underway in the U.S., property buyouts will be inadequate for realizing the entire scope of managed retreat outcomes that will be needed in some contexts.

4.3 Retreat requires cross-scale governance that is responsive to local context

Facilitating retreat from risky spaces, whether through property buyouts or other programs, must first be a local process. The federal floodplain property buyout program is a blunt policy tool that is generally unresponsive to local nuance and the complexity of risk, loss, and retreat. The property buyouts studied here were administered in response to a federally declared disaster, and structured by contracts among federal, state, and regional governments that directed buyout procedures with local governments and individual homeowners. This structure gives state and regional governments complete control over the buyout process and the flow of knowledge and resources to local governments. As a result, only properties that met federally defined eligibility requirements, and resided in towns able and willing to engage across governance scales were able to complete a buyout. Local nuance within town governance, community values, and the social and environmental drivers of risk become illegible to high levels of government where standards are applied uniformly across contexts [70]. For instance, defining buyout eligibility

using federal cost-benefit ratios, and using flood hazard maps that delineate inundation flood risk but not fluvial erosion hazards, will continue to generate inefficient and inequitable outcomes for buyout programs. The current approach to floodplain property buyouts overlooks the informal and socially-embedded elements that give life to the buyout process, such as relationships, trust, lived experiences, leadership, and power [71]. Implementing property buyouts and managed retreat at equitable and meaningful scales will require multi-level institutions that hold a granular understanding of local conditions, and a receptivity to the underlying socially-embedded institutions that hold communities together. A robust body of work examining institutional design and performance indicates that a 'one size fits all', or uniformly top-down approach is unlikely to be successful in governing unique local conditions [72,73]. The institutions needed to facilitate managed retreat must work across scales and be adaptive to preexisting local governing arrangements, networks, practices, and cultural values. Those institutions are likely to emerge through incremental evolution, or institutional bricolage, that reconciles formal institutional design with the adaptive and ad hoc nature of local processes and relationships [71]. Numerous examples of these emergent local buyout processes were documented and shaped by unique stories of loss, relationships built on trust and care among neighbors, and the trial-and-error efforts of people navigating complex networks of disaster recovery bureaucracy.

This study has several limitations that must be acknowledged. Research was conducted many years after Tropical Storm Irene and this posed a challenge to identifying actors with first-hand accounts of buyout processes. Information on town flood losses, disaster response and recovery funding, and sequences of events are subject to being estimated, and efforts to corroborate these data were taken wherever possible. Vermont offers a useful empirical setting for studying local governance in small and medium sized communities, some findings are likely

to be limited in their extension to more urban contexts. More research is needed to understand the evolution of local governance that leads towns to move away from repetitive flood loss cycles and towards retreat-oriented governance paradigms.

5.0 Conclusion

This study sought out to understand the local governance dimensions of property buyouts and managed retreat. The theoretical framing and research methods used here are designed to interrogate the systemic social and institutional factors that influence local responses to flood loss, and how those intersect with local physical geography. Conducting research in a state that assigns high levels of authority to town governments and setting the unit of analysis at the town level, this research leverages a semi-natural experimental setup to examine variations in buyout outcomes across forty towns. Results indicate that lower income towns implemented more buyouts and fluvial erosion had an outsized role in driving flood losses on buyout sites, a hazard that tends to be overlooked in national flood risk maps. These results differ from national trends which report a greater occurrence of property buyouts under the administration of wealthier county governments. A focused comparative analysis of fourteen flood-impacted towns was carried out to further interrogate these findings and depicts how property buyouts are administered through a multilevel governance structure, but hinge upon the actions of local governments and locally embedded social networks, leaders, and shared perspectives on the role of government. Towns demonstrating the greatest use of buyouts showed higher measures of local governance capacity in some, but not all cases. Findings support discussion of the important but complicated role of local government in administering buyouts. Regional boundary organizations were critical to filling gaps in local governance to complete large buyout projects

884 in towns where local administrators could work across scales, and where local politics supported
885 direct involvement in private property decisions. Findings indicate the importance of trust and
886 coordination among local, regional, and state governments in each buyout case studied,
887 especially where local capacity to lead is limited. Measures of local governance capacity and
888 local flood mitigation are integrated in a novel way to illustrate four paradigms of flood
889 governance uncovered in this study, and how they relate to broader retreat efforts applicable to
890 other contexts. This paper demonstrates how buyouts and retreat processes emerge as a stage for
891 opposing notions of the role of government, landowner rights, and economic development to be
892 contested at the floodplain parcel scale. Findings also demonstrate the limitations of property
893 buyouts in geographically constrained landscapes that are perceived as being bound to risk.
894 Federal buyout programs tend to be unresponsive to local nuance and risk perpetuating systemic
895 inequities where multilevel governance processes cannot be reconciled with local context, and
896 this emphasizes the need for a plurality of policy tools that can engage communities across
897 governance scales while being responsive to local needs. This study has important insights for
898 the design and administration of ongoing and future buyout and retreat programs designed to
899 help frontline communities respond to changing local environments due to climate change.

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905

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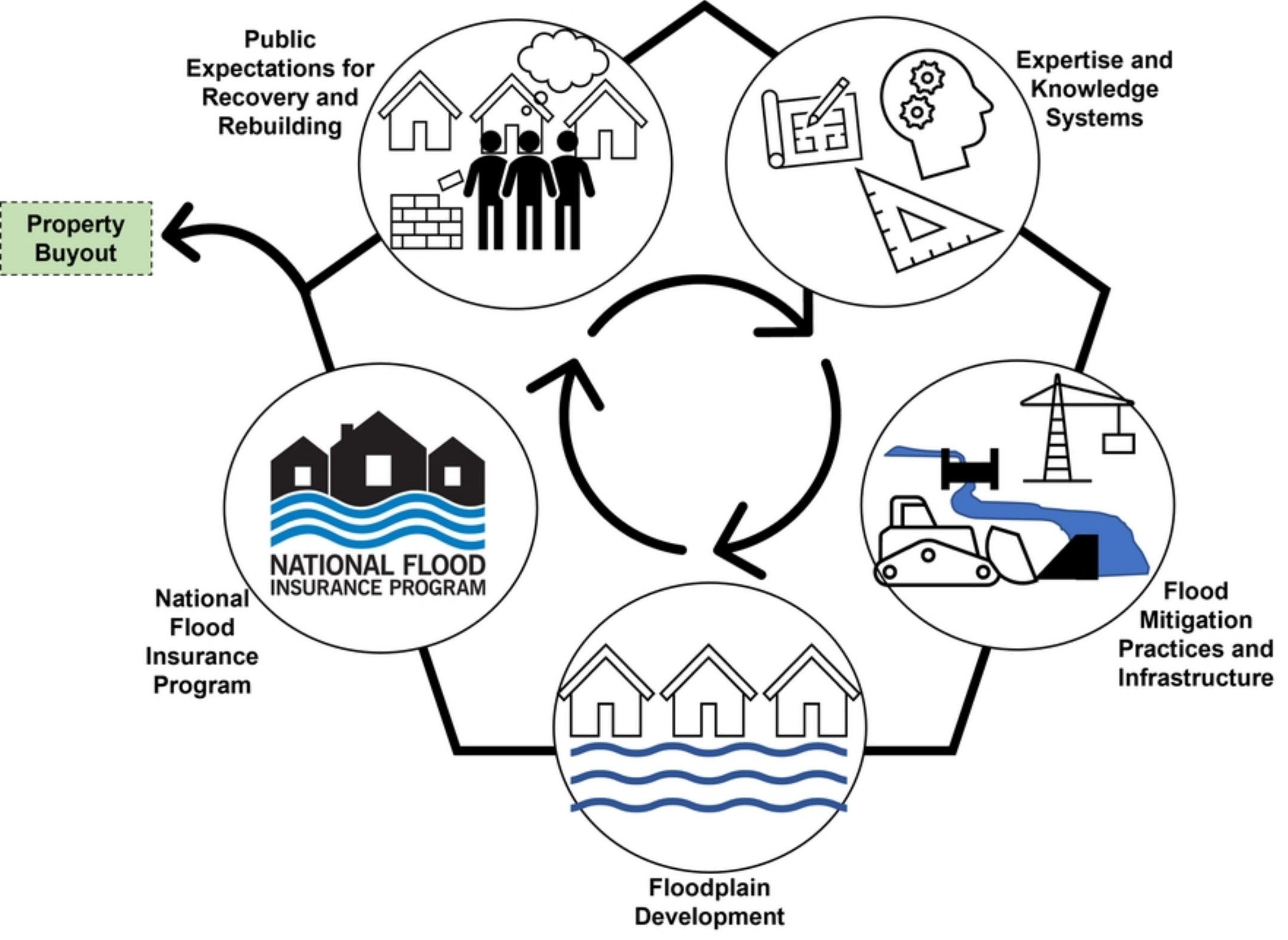
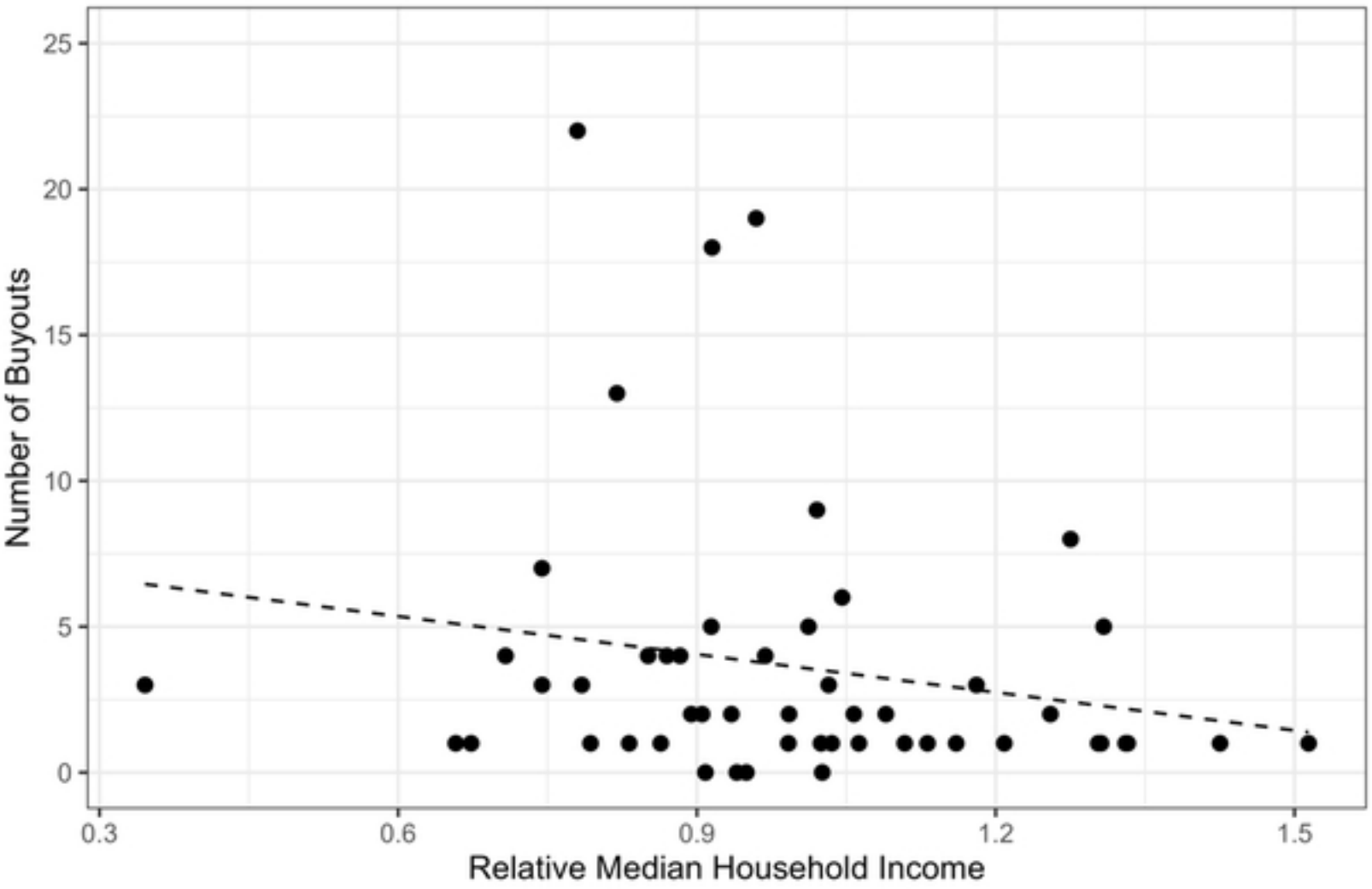
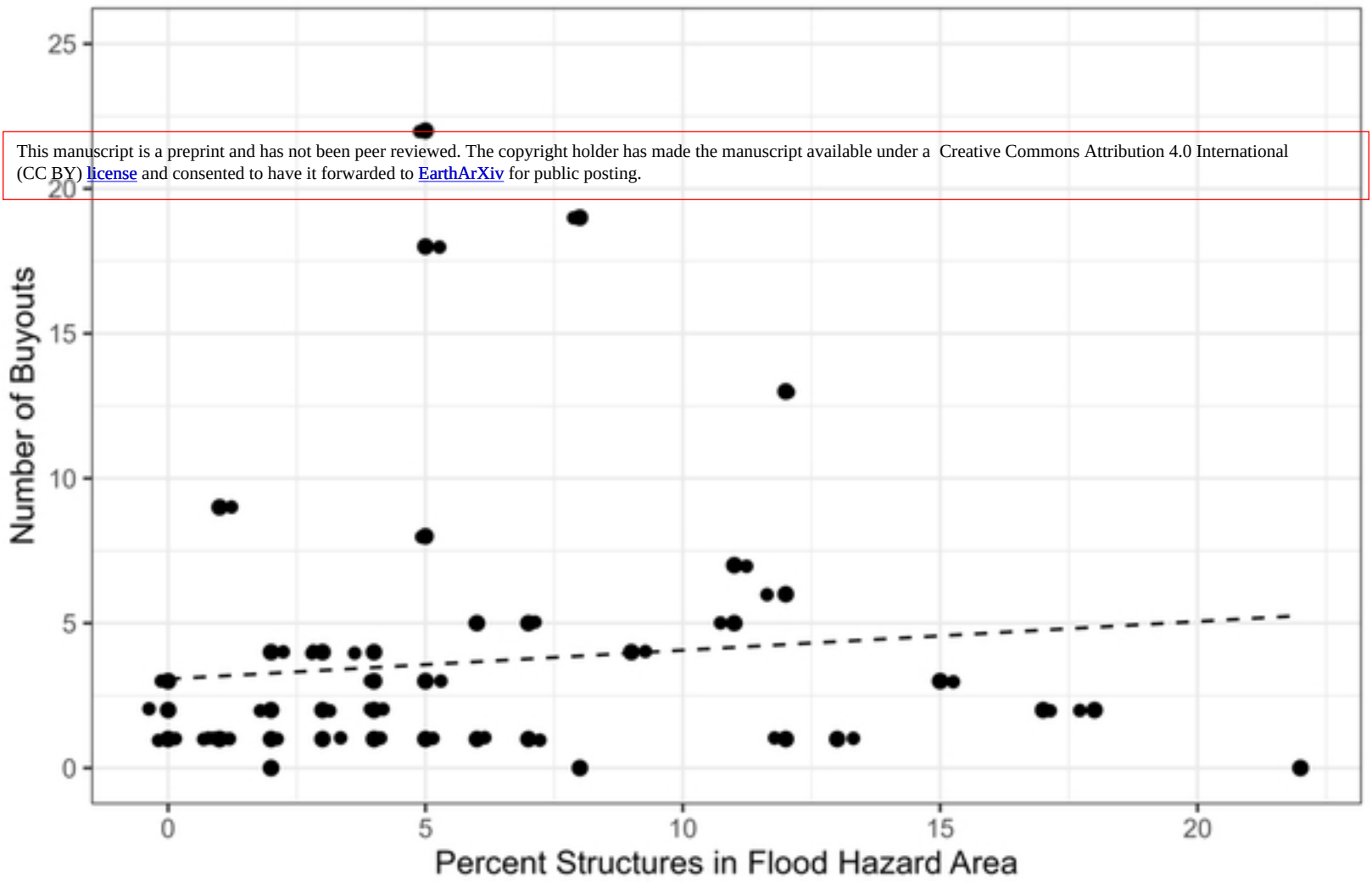

Public Expectations for Recovery and Rebuilding
Expertise and Knowledge Systems
Property Buyout
NATIONAL FLOOD INSURANCE PROGRAM
National Flood Insurance Program
Flood Mitigation Practices and Infrastructure
Floodplain Development

Figure1





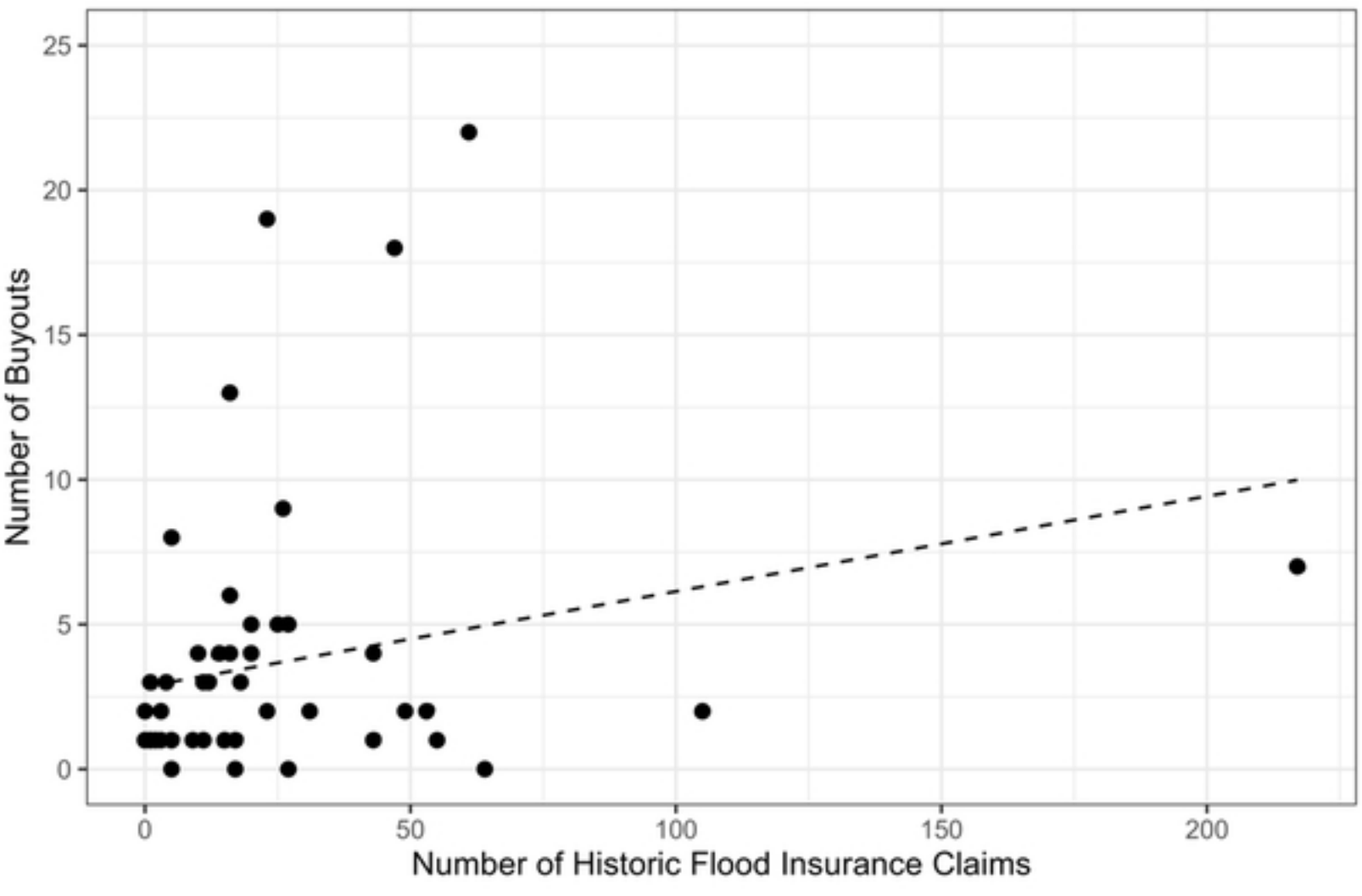


Figure2

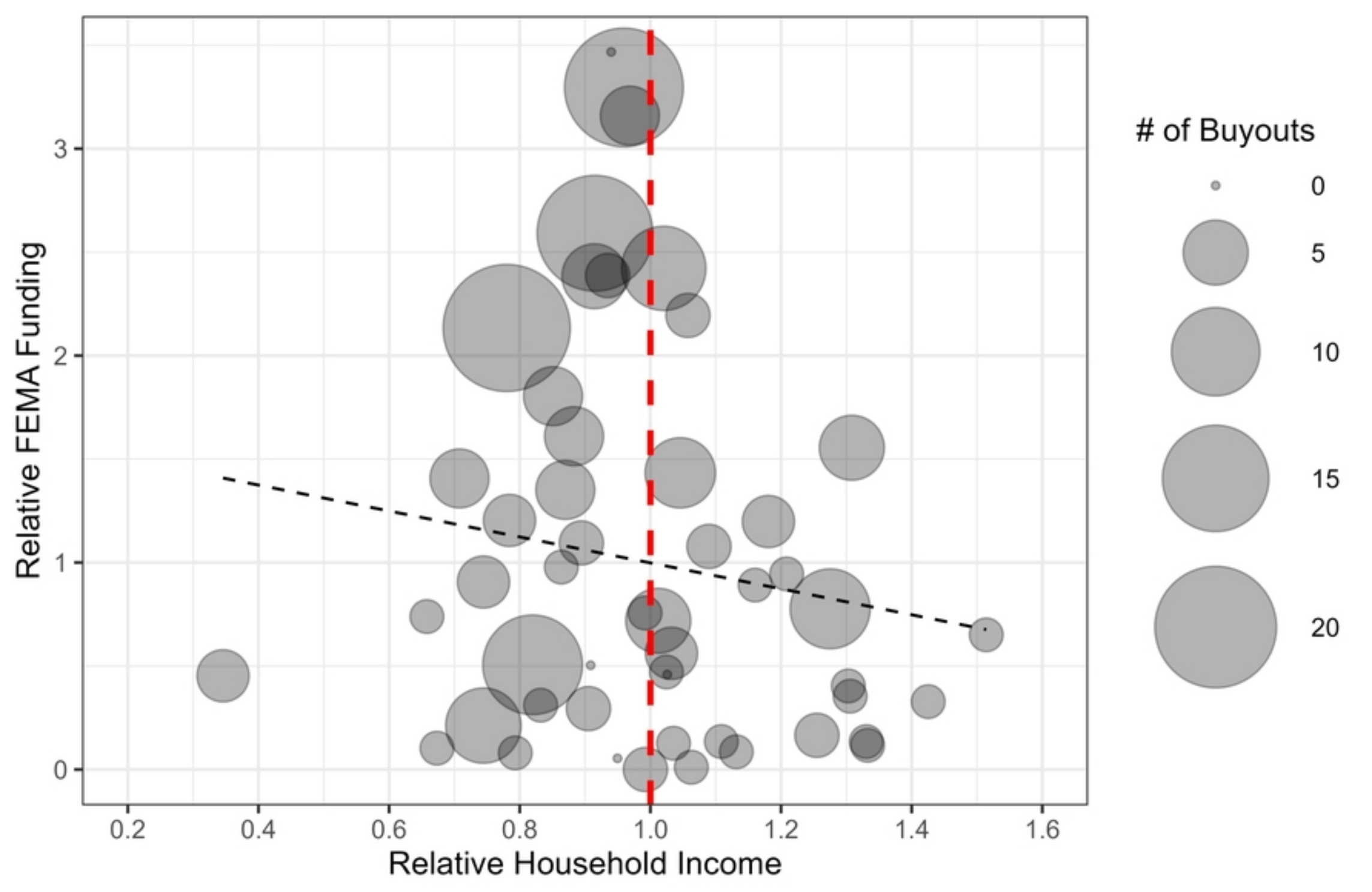

Relative FEMA Funding
3
2
1
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Relative Household Income
# of Buyouts
0
5
10
15
20

Figure3

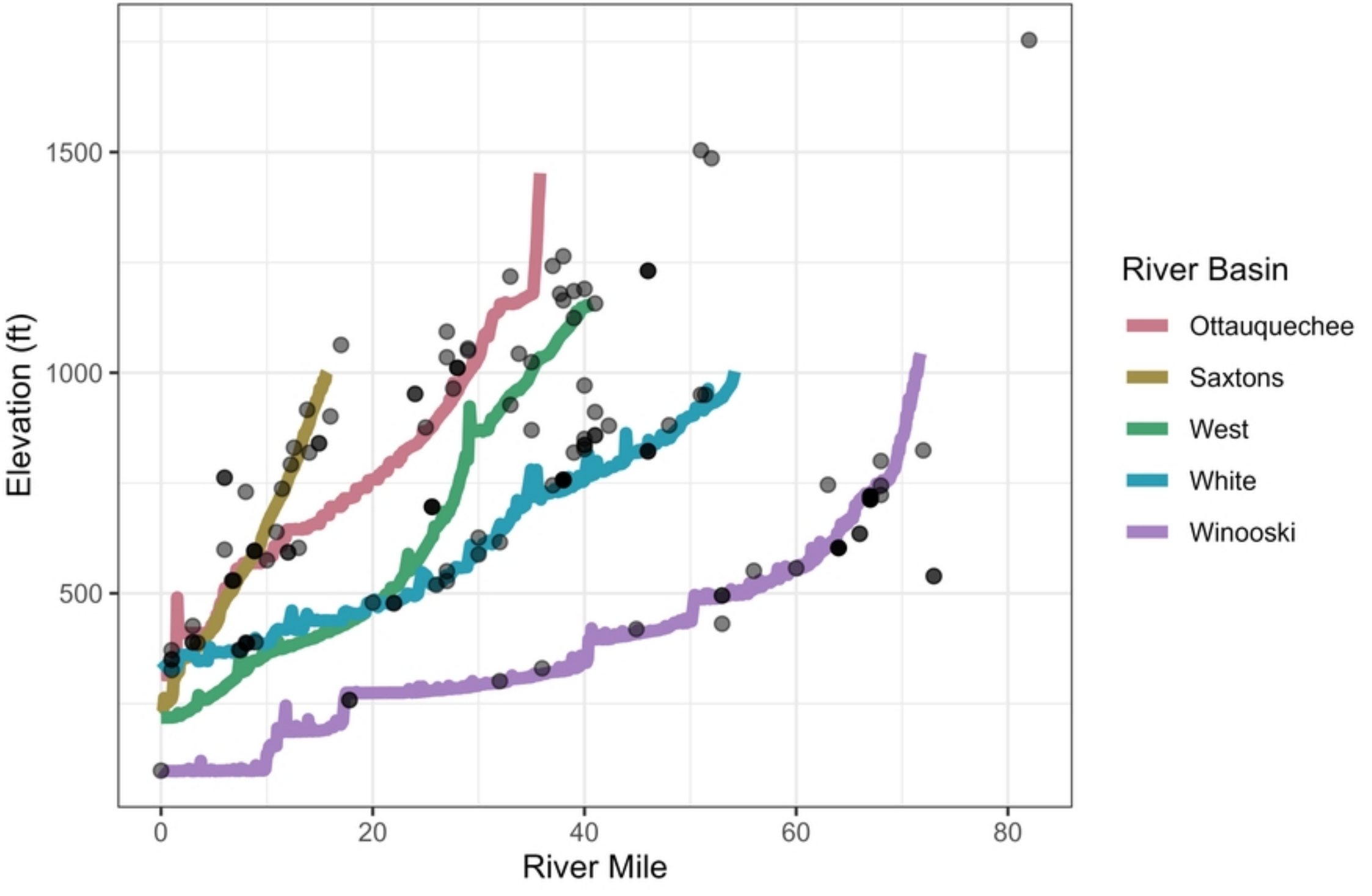

1500
1000
500
Elevation (ft)
0
20
40
60
80
River Mile
River Basin
Ottauquechee
Saxtons
West
White
Winooski

Figure4

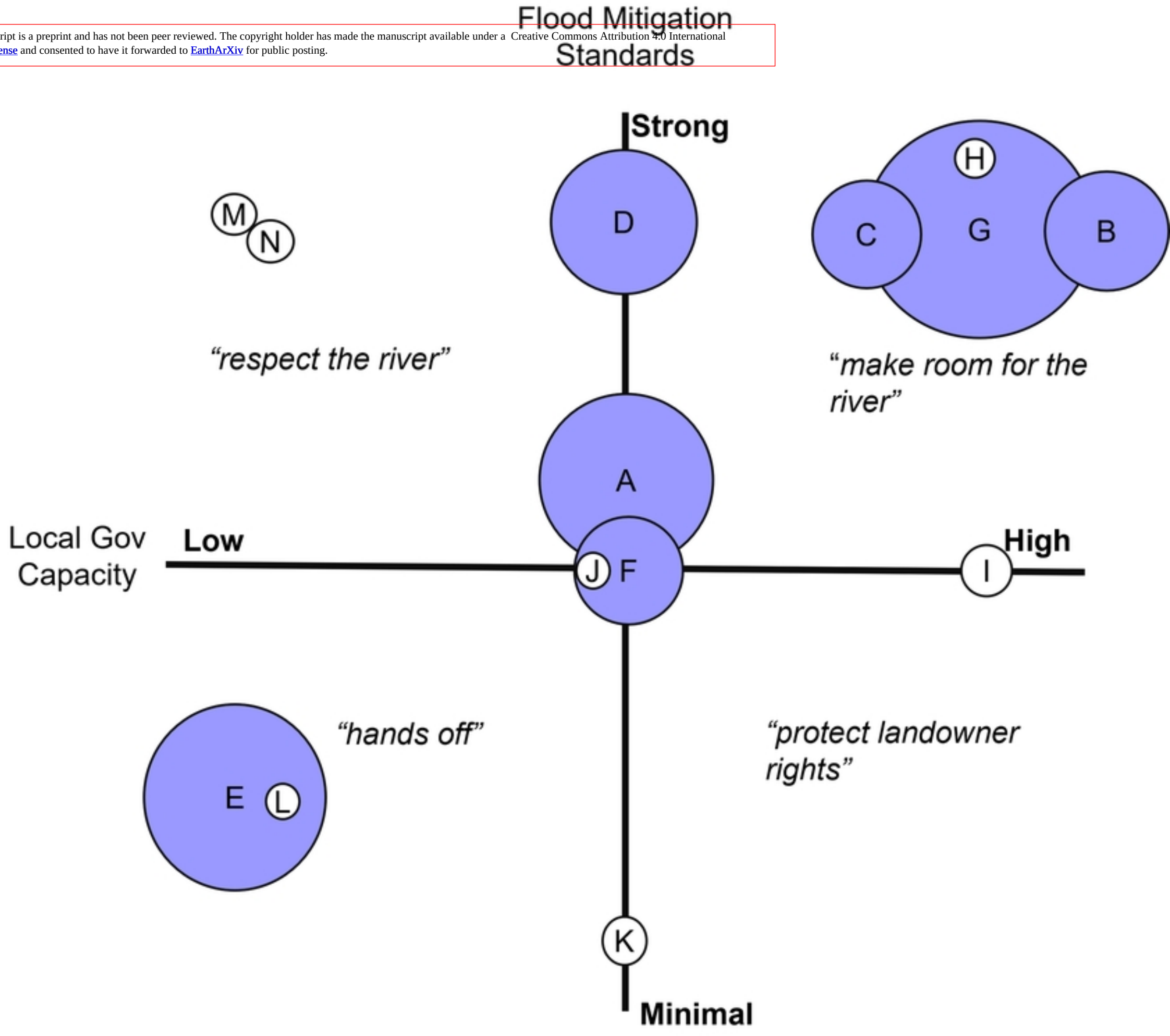


Figure5