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September 2020 - Working Paper 2020-3

Forthcoming in Land Economics, 2021

The Willingness to Pay for Flood Insurance

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Abstract

Flooding is the natural disaster that causes the most damage. Post-flood, many families are not insured and do not have sufficient savings for rebuilding and governmental aid can be limited. We undertake, using a stated preference survey, the first willingness-to-pay (WTP) elicitation for flood insurance in the U.S. WTP increases with modeled flood risk and flood risk perceptions. WTP for residents in our study area's 100-year floodplain is 47% to 59% of the median flood insurance premium, which suggests the need for financial assistance for families that are at risk of flood damage and are unable to afford risk-based premiums.

Forthcoming *Land Economics* (accepted August 7, 2020; anticipated publication date November 2021).

Acknowledgements
Support for this research comes from the Bernard Goldhammer Grant for Research on Economics and Natural Resources, Reed College; the Stendal Fund for Economics, Reed College; the Miller and Mintz Funds for Economics, Reed College; the Travelers-Wharton Risk Management and Leadership project and the Wharton Risk Management and Decision Processes Center. We are grateful to Jacob Sherman, Marie Walkiewicz, Deb Meihoff, Gary Wolff, Daniel Newberry, Craig Lauder, Ben Lund, John Edgington, Aimee Sisco, Kathy Wu, Kristin Bott, David Isaac, Joe Marquez, Iliana Alcantar, Thao Dinh, Mike Kozlov, and Melody Harvey for their help with this project. Constructive feedback was received from participants in the 2019 W-4133 Meetings, 2019 AERE Summer Meetings, and from Richard Carson, Trudy Cameron, Kelly McConville and two anonymous referees. Florin Feiner and Ben Thomas provided research assistance.

I. INTRODUCTION

Flooding is the natural disaster that causes the most property damage in the United States. Flood risk is increasing in many places around the country due to climate change and increased development in hazard-prone areas (see, for example: AECOM (2013) and Lin et al. (2016)). In order to recover financially from floods, households need flood insurance. Contrary to many perceptions, federal disaster aid for victims in the U.S. is often limited or delayed, making it an inadequate recovery source.[1] In addition, roughly 44% of Americans do not have $400 of liquid funds for an emergency, and the percentage is even higher (52%) for those with a high school education or less (Board of Governors of the Federal Reserve System 2017). As such, for many families there is no substitute for flood insurance. Despite this, many families at risk of flooding do not have a flood insurance policy and many of the families that need the protection the most are least able to afford it.

Several studies have sought to identify the determinants of flood insurance demand. Unsurprisingly, they generally find take-up rates are higher in areas where the hazard is greater (or risk perceptions greater) and that take-up rates increase with higher levels of education and income, as well as higher home values (Kousky 2011; Landry and Jahan-Parvar 2011; Petrolia, Landry, and Coble 2013; Ajita Atreya, Ferreira, and Michel-Kerjan 2015; Brody et al. 2017). Atreya et al. (2015)

[1] Federal dollars are only provided following large disasters that receive a federal disaster declaration. Localized flooding may fail to receive this assistance. Even if a declaration is issued, most declarations only authorize assistance to local governments. If authorized by the president, qualifying individuals can receive assistance from FEMA's Individual and Household Program (IHP). From 2005 to 2014, however, IHP was authorized in only 35 percent of major disaster declarations. These grants are capped at a bit over $33,000 and for most events only average a few thousand dollars. According to FEMA (2016, 5), "IHP is not a substitute for insurance and cannot compensate for all losses caused by a disaster; it is intended to meet basic needs and supplement disaster recovery efforts." Beyond these grants, the Small Business Administration offers disaster loans to households. These must be repaid and for some families the extra debt is burdensome. Additionally, many families may not qualify. The lowest income families are discouraged from applying and sent to the FEMA Individual Disaster Assistance grants, which may be insufficient.

also find in Georgia that take-up rates increase by roughly 1% for each percentage point increase in the African American population in a county.

There has been growing policy concern that low and middle-income households that need the financial protection of insurance are unable to afford it. Atreya et al. (2015) estimated an income elasticity for flood insurance of 0.39 using enrollment data in the National Flood Insurance Program (NFIP) in Georgia and Kriesel and Landry (2004) estimated an income elasticity of 0.49 using NFIP data for nine coastal counties in six states. Hung (2009) estimated income elasticities of 0.45 and 0.50 in a contingent valuation study of willingness to buy flood insurance in Taiwan. Beyond just looking at income elasticities, a recent study on the cost of flood insurance in New York City found that flood insurance was cost burdensome (which the authors define as contributing to a ratio of mortgage principle, interest, property tax and insurance to income greater than 0.4) for roughly a quarter of owner-occupied residences (Dixon et al. 2017).

Over 90% of residential flood insurance in the United States is provided by the federal government via the National Flood Insurance Program (NFIP). Unlike a typical private good, prices are not set competitively in the market but influenced by political values about the affordability and fairness of coverage. In addition, not being subject to market pressure, the program's pricing is outdated and contains multiple cross-subsidies (Kousky, Lingle, and Shabman 2017). Finally, demand is also difficult to infer from market data since high risk properties with a loan from a federally backed or regulated lender are required to purchase insurance and consumer information about flood risk and insurance is low (Chivers and Flores 2002; Royal and Walls 2019). Thus, using the tools of contingent valuation to elicit homeowners' willingness-to-pay (WTP) for flood insurance could inform policy decisions about this program. To our knowledge, however, no such WTP elicitations have been undertaken in the United States and we identify only three globally.

A WTP study for flood insurance conducted in the Netherlands estimated an income elasticity of 0.17 (Botzen and van den Bergh 2012). However, the context differs from ours in fundamental respects: flood insurance was not available in the Netherlands at the time the study was conducted and the country has not had major flooding since 1953 due to investments in structural flood protection. Hung (2009) used a fuzzy contingent valuation method to value the WTP for flood insurance for two areas in Taiwan. A key finding from this study is that the fuzzy WTP regions are wide, which the author attributes to respondents' preference uncertainty about paying a randomly selected bid amount for a flood insurance policy. Roder et al. (2019) used an open-ended question to determine the WTP for flood insurance in the Veneto region of Italy, which is characterized as not having a well-developed market for private property flood insurance. Model results were not reported due to a lack of "sufficient statistical quality," which the authors attribute to the many respondents who reported zero WTP or did not answer the open-ended WTP question. We build on these three studies by eliciting WTP for flood insurance in a very different context, one where there is already a flood insurance market, but it is not competitive and is instead dominated by a public provider that insures a population with a different level of underlying risk and socio-demographic characteristics.

The current study draws on contingent valuation methods to elicit WTP for flood insurance from a sample of residents in two low- to middle-income neighborhoods of Portland, Oregon at risk of fluvial (river) and pluvial (rainfall) flooding. We administered a survey to residents in 2018 asking about their flood experiences, flood insurance purchases, perceptions of flood risk, and their WTP for flood insurance. We use a payment card elicitation given the nature of our good, which is a currently available flood insurance policy, and examine how WTP varies with income, risk perceptions, objective risk, previous experience with flooding, the length of time residing in one's current home, and respondent demographic characteristics.

Our study contributes to the literature in several ways. First, we report, for the first time, flood insurance income elasticities and annual WTP estimates for a study area in the United States. Second, we present annual WTP models using three different measures of objective risk, including a model that uses state-of-the-art hydrological estimates of predicted flood volume during a 100-year event. Third, the type of flooding that occurs in our study area—shallow flooding of 1-3 feet—is not commonly studied. Fourth, our study area has a high percentage of properties that were built before flood insurance rate maps were produced for the area. As we discuss further below, these properties have historically been paying discounted flood insurance premiums that are now being phased out leading to escalating flood insurance rates. The study area also has a high poverty rate and a high percentage of foreign-born residents and residents that speak a language other than English at home.

The paper is organized as follows. Section II provides an overview of flood insurance in the United States and Section III introduces our study area in Portland, the flood risk, and the survey population. Section IV discusses our survey design and Section V provides an overview of the housing dataset, geospatial variables, and respondent characteristics. Section VI details the distribution of our annual WTP values and discusses our hypotheses. Estimation methods and results are presented in Section VII with a discussion of our findings and policy recommendations in Section VIII.

II. AN OVERVIEW OF FLOOD INSURANCE

The National Flood Insurance Program (NFIP), housed in the Federal Emergency Management Agency (FEMA), has been one of the primary flood management programs of the federal government for the last fifty years.[2] Communities can voluntarily enroll in the NFIP,

[2] For a detailed overview of the NFIP see Kousky (2018).

adopting minimum building codes and land use regulations, and in exchange, all of their residents become eligible to purchase flood insurance. Over 22,000 communities participate in the program, including Portland, Oregon (FEMA 2017).

Households can purchase building coverage for up to $250,000 and contents coverage for up to $100,000. Policy and claim administration are handled largely by private insurance companies in exchange for a fee, but the NFIP bears all of the risk of flood damage and sets premiums. Participation in the early years of the program was low. In response, in 1973, Congress required flood insurance on all federally backed loans or federally regulated mortgages for property located in a 100-year floodplain (i.e. areas where the annual likelihood of floods is greater than or equal to 1 in 100). Today, there are over 5 million policies-in-force nationwide with just under 27,000 in Oregon and roughly 1,800 in Portland.[3]

FEMA also delineates the flood hazard in participating communities via Flood Insurance Rate Maps (FIRMs). These maps were developed in large part to designate the boundary of the 100-year floodplain or Special Flood Hazard Area (SFHA). The SFHA is critical to implementing the NFIP for two reasons. First, in this area lenders must require flood insurance on federally backed or regulated loans. Second, in the SFHA, communities must adopt certain land use and building regulations, which include, for example, that all new construction must be elevated above the estimated base flood elevation. The maps also designate different flood zones, which have historically been used in setting insurance rates. In the SFHA there are V zones and A zones. V zones indicate coastal areas subject to breaking waves, which is not applicable to Portland. There are several different A zones; of relevance for our study area are the two zones AE and AH. AE is the standard 100-year floodplain where FEMA has also estimated the potential height of floodwaters in a 100-year flood event, referred to as the base flood elevation. AH refers to areas of shallow

[3] Data available from FEMA at: https://www.fema.gov/policy-claim-statistics-flood-insurance

flooding of only 1 to 3 feet. Shallow flood areas likely have lower expected damages than areas that can experience deeper flooding, such as properties located in the AE zones in our study area. The area outside the 100-year floodplain is referred to as Zone X.

The FIRMs were designed to implement the requirements of the NFIP and assist in setting insurance premiums. They were not designed to be ideal risk communication products and have been criticized over the years for creating a false binary perception of flood risk (i.e. perceiving there to be minimal risk outside the SFHA and uniform and more substantial risk inside the SFHA), for being out-of-date, and for not reflecting changing risk conditions such as climate change (Joyce 2016; Office of Inspector General 2017; Shaw, Thompson, and Meyer 2013). While FEMA is required to revisit maps every five years, updating maps must be prioritized given the limited budget and the length of time required to produced them.

FEMA is in the process of overhauling its rating structure, referred to as the Risk Rating 2.0 initiative. Historically, and at the time of our study, NFIP premiums were set based on rating tables updated annually (for more detail on this rating process, see Kousky et al. (2017)). Premiums varied by flood zone shown on the FIRM and by differences in housing characteristics, such as presence and type of basement, number of stories, and the amount of coverage purchased.

There have been a few classes of policyholders that have received discounted insurance premiums. The most important of these groups for our study area are referred to as pre-FIRM, which are properties that were constructed before FEMA had mapped the flood hazards in an area. These homes were given discounted premiums early in the program so as to not penalize owners who had built before floodplain regulations were adopted. Legislation passed in 2012 and 2014 began to phase out these discounts. Insurance premiums for pre-FIRM properties are now being increased between 5% and 18% every year until they reach full risk rates. Nationwide, on January 1, 2019, 40.4% of residential policies were pre-FIRM. In the two main zip codes that span our study area the percentage was 75.6% (FEMA 2019b).

To encourage communities to adopt more flood mitigation measures, the NFIP created the Community Rating System (CRS) in 1990. Participating communities can receive points for undertaking various risk management and risk reduction measures. As they accrue points, they move up levels in the program from the lowest (Class 10) to the highest (Class 1). At each new level, residents in the community located in the SFHA get an additional 5% reduction on their insurance premiums. Outside the SFHA, a 5 percent reduction in premiums is given for residents of Class 7–9 communities, and a 10 percent reduction applies for Class 1–6 communities. Portland is currently a Class 6, which gives residents in the SFHA a 20% reduction in premiums while those in X zones receive a 10% discount. The median cost of flood insurance for all single-family residential properties in the two zip codes that cover the majority of the study area was $777 in 2018 (FEMA 2018). Properties in the X zone had a median cost of $348 while those in the A zone had a median cost of $878. These premiums reflect the CRS discount that Portland has obtained.

Because of Portland's participation in the CRS, property owners in our study area's 100-year floodplain receive multiple mailings each year from the city that describe the risk of flooding from living in the floodplain, the need to protect their property from flood damage, and a discussion about flood insurance requirements. Some residents in our study area who live outside the 100-year floodplain also receive mailers from the city about flood risk, e.g., a map showing detour routes when roads are closed due to flooding.

III. STUDY AREA

Our study area is comprised of two adjoining neighborhoods in Southeast Portland, Oregon: Lents and Powellhurst-Gilbert (see Figure 1a). Roughly 4,560 acres in total, these two neighborhoods are prone to flooding from both Johnson Creek, which bisects the bottom part of the Lents neighborhood (Figure 1b), and the ephemeral Holgate Lake (Figure 1d). Just under 8% of our study area is in the 100-year floodplain and 3.7% of the study area is in the 500-year floodplain (Figure 1b). Within the 100-year floodplain, 70% of the area is categorized by FEMA as Zone AH, indicating only shallow floods, with the remaining 30% in the AE zone (Figure 1c). Once Johnson Creek overtops its banks, water flows downhill, so that residents as far away as 1 mile from the creek are still in the mapped 100-year floodplain due to surface-water flooding (Figure 1b). Groundwater flooding affects properties in the Holgate Lake area (Figure 1d).[4]

Figure 1: Study Area and Floodplain Characteristics

Figure 1a: Study Area

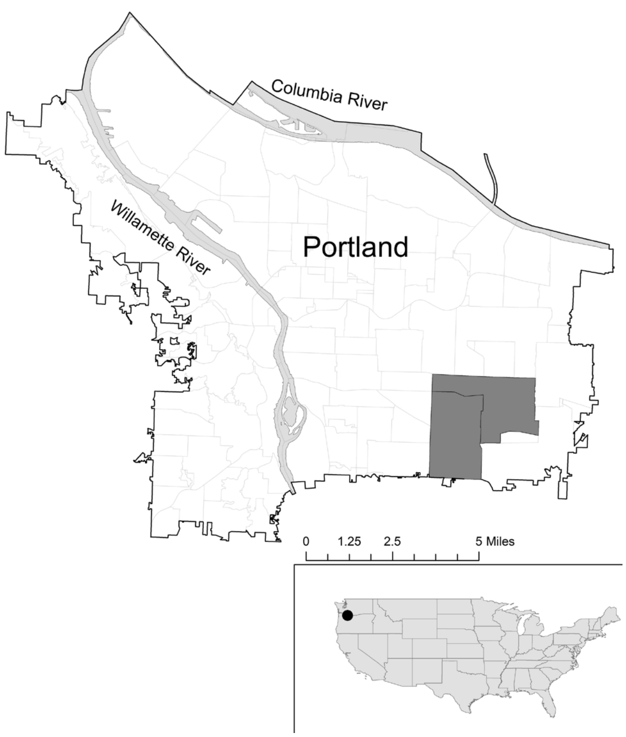
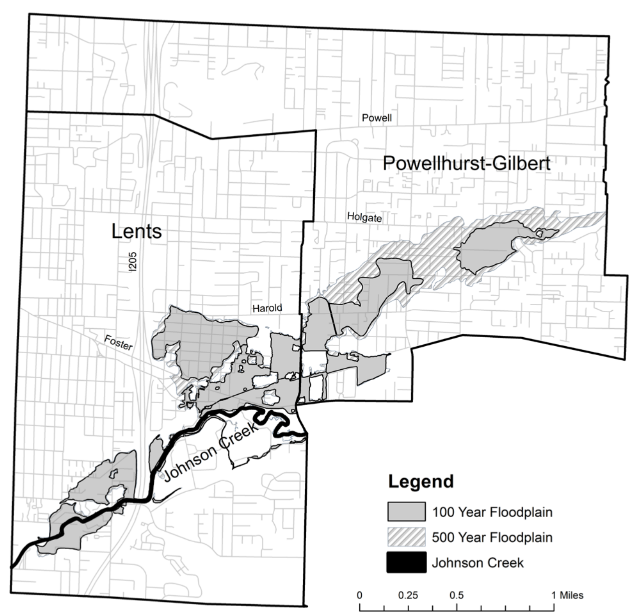


Figure 1b: 100- and 500-year Floodplains



[4] We received too few responses from the Holgate Lake area to estimate the effect on WTP for respondents who are in the Holgate Lake area 100-year floodplain separately from the Johnson Creek 100-year floodplain.

Figure 1c: AE and AH zones

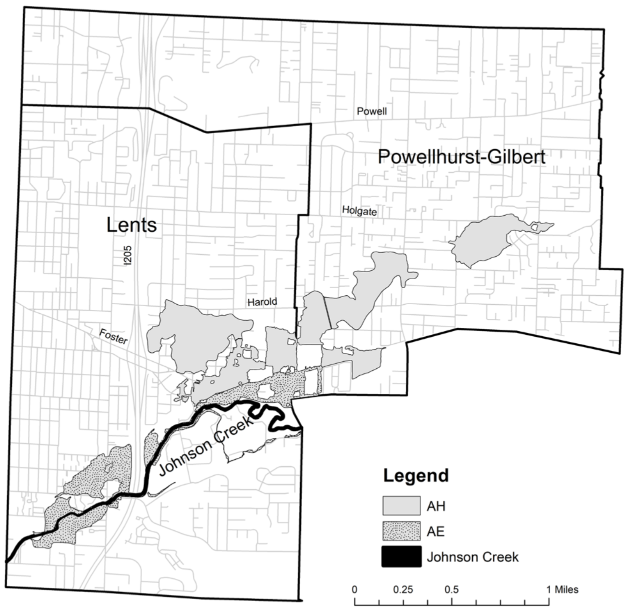
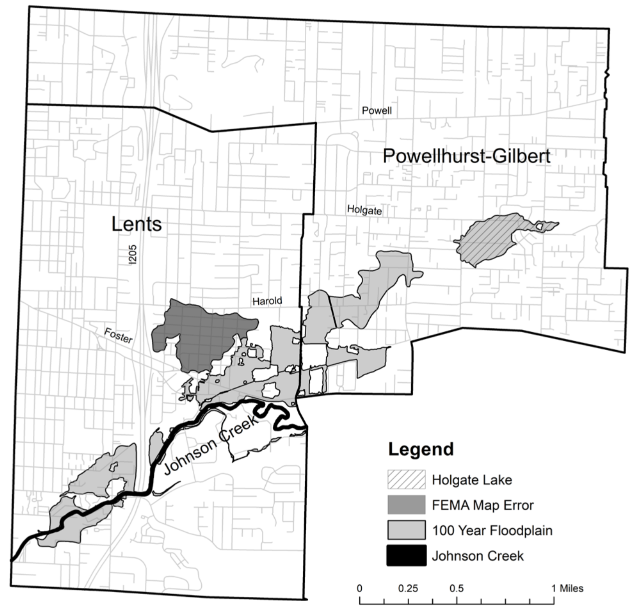


Figure 1d: FEMA Map Error & Holgate Lake



Of the 10,413 single-family residential properties in the study area, 594 have a building footprint that is either fully inside or intersected by the 100-year floodplain and 302 have a building footprint that is either inside or intersected by the 500-year floodplain.[5] We focus on building footprint (rather than tax lot boundary) to determine if a property is "in the floodplain" because properties with a building footprint inside or intersected by the 100-year floodplain with a federally-backed mortgage are required to have flood insurance.[6] Around 90% of the properties in the 100-year floodplain were built before the first FEMA FIRM went into effect in October 1980; the current FIRM is from 2004.

[5] Properties with building footprints in both the 100- and 500-year floodplains are included only in the 100-year floodplain.

[6] Netusil et al. (2019) examined the effect on property sale price from using building footprint, instead of the parcel's tax lot, and found a substantial positive bias when using tax lot to determine floodplain location.

Johnson Creek, which is one of last free-flowing streams in the Portland metropolitan area, has reached flood stage forty times since 1937 (NOAA 2019) with at least eight floods causing major property damage (Federal Emergency Management Agency, Region 10 2016). Surface-water flooding occurs during the winter months as a result of intense precipitation, which is sometimes preceded by saturated soils, snow, or both conditions (Lee and Snyder 2009). Record rainfalls in water years 1996 and 1997 caused an estimated $4.7 million in damages (Federal Emergency Management Agency, Region 10 2016) with flooding along Johnson Creek lasting for several days during these events (Lee and Snyder 2009). Future flooding in the study area may be worse because of predicted increases in stream flows during the rainy winter months due to climate change (Chang, Watson, and Stecker 2017) and because of increased development in the watershed (Jung, Chang, and Moradkhani 2011).

Investments have been made in the study area by FEMA, city, regional and state agencies, nonprofits, and private property owners to restore floodplain functionality and reduce property damage from flooding. Between 1990 and 2014, 104 acres were restored in the study area to reduce flood risk, such as by removing fill, creating side channels, and increasing the size of culverts (Jarrad 2016).

A major floodplain restoration project, the Foster Floodplain Natural area, was completed in 2012 on a 63-acre site in the study area (Bureau of Environmental Services 2019). This project reduced nuisance flooding from once every other year to once every six years, on average, but it did not change the probability of a 100-year event. As part of the Foster Floodplain project, FEMA required a letter of map revision (LOMR) to be submitted. However, an error occurred in how FEMA recorded the LOMR[7] when the floodplain restoration project was complete, which resulted

[7] A letter of map revision is a process to modify a small part of an existing FIRM before remapping is done for a community, usually to reflect a new investment in flood control.

in around 340 single-family residential properties (Figure 1d) being incorrectly removed from the 100-year floodplain (Sherman 2018). This mapping error was discovered by the city after property owners and lenders were incorrectly notified by FEMA that they were no longer in a floodplain and not required to purchase flood insurance if they had a federally-backed mortgage. City officials notified FEMA about the error, but it is unknown if or when FEMA contacted lenders about the mistake. This may lead to a difference in how property owners in the "FEMA map error" part of the 100-year floodplain view the risk of flooding and, in turn, their WTP for flood insurance. For example, it is conceivable that property owners that experienced this error have lower trust in FEMA estimates of risk or in FEMA programs broadly in a way that could influence their WTP.

The study area is one of the most diverse in Portland based on 5-year (2013-2017) American Community Survey data for the census tracts that most closely align with the neighborhood boundaries. 64% of study area residents are White (77% for Portland as a whole), 17.1% are Asian, 5.7% are Black or African American, and 16.4% are Hispanic or Latino (U.S. Census Bureau 2019). Study area residents are almost twice as likely to be foreign-born (27%) as Portland residents (14%) and 39% speak a primary language at home other than English. Poverty rates are higher in our study area (23.3%) than in Portland (15.6%) and only 13% of residents (compared to 35% for Portland) have a bachelor's degree or higher. In addition, slightly fewer residents in the study area are in owner-occupied housing (51% compared to 56% in Portland as a whole).

In 2016, the study area was certified as an Oregon Solutions Project with a focus on preserving existing houses, enhancing industrial lands to promote job growth, and mitigating flood risk from Johnson Creek (Oregon Solutions 2017). Oregon Solutions Projects bring together local, state, and federal agencies with stakeholders to develop innovative strategies to address challenging public policy questions. Outcomes for our study area included a pilot flood insurance savings program for low-income residents in the 100-year floodplain (for an overview of the program see

Sherman and Kousky (2018)) and state-of-the-art hydraulic modeling of predicted flood volume from a 100-year event (Wolff 2018), which we use as one measure of objective risk in our WTP models.

IV. SURVEY DESIGN

The survey design process followed best practices as described in Dillman et al. (2014) and Johnston et al. (2017). Hard copies of the English-language version of our survey were pre-tested with economists having expertise in survey design, government agency staff and nonprofit staff who work in the study area, and with two professionally-moderated focus groups of residents from our study area. Residents were recruited to the focus group via Craigslist and were compensated for their time. Focus group members emphasized the importance of including community members who may not have access to a computer and who may not be native English speakers, so the final version of the survey was available in four languages—English, Spanish, Russian and Vietnamese—and could be completed online or by requesting a hard copy.

Addresses of all single-family residential properties in our study area neighborhoods were obtained using the regional government's tax lot layer (Metro Data Resource Center 2018). This data set was cleaned—for example, to remove properties that were determined to not be single-family residential (such as vacant lots and commercial properties that were zoned single-family residential). All residents of the 1,186 properties with a tax lot inside or intersected by the 100- or 500-year floodplain were invited to take the survey as were 2,841 residents of randomly selected neighborhood properties from outside the floodplains.

Unique alphanumeric access codes were created for each property, which allowed us to link survey responses with individual property information. This identifier also allowed us to have respondents whose building footprint is inside or intersected by the 100-year floodplain answer a different WTP question than respondents outside the 100-year floodplain (more on this below).

Mailings took place between mid-August and mid-September, 2018. The first two mailings used professionally-designed oversized postcards and the final two mailings were signed letters on college stationary. Focus group participants responded positively to including the Portland Housing Bureau as a study co-sponsor because of the bureau's role in implementing a flood insurance savings program in the study area (Sherman and Kousky 2018) and participants' belief that policies to reduce flood risk would require city agencies taking a leadership role.

Survey respondents were offered a 1-in-5 chance to win a $20 gift card to a local grocery store, which was supplemented in the final two mailings with the chance to win a $150 gift card. In addition to the four mailers, the survey was promoted by the local watershed council, by neighborhood residents on NextDoor and Facebook, and through neighborhood association websites, newsletters, and mailing lists. The survey website was closed in mid-October, 2018. After accounting for the 225 undeliverable mailings the overall response rate was 11.1%. Response rates were 17.8% in the 100-year floodplain, 9.9% in the 500-year floodplain, and 9.9% from outside the floodplains. The response rate is in line with prior studies on this topic (Dixon et al. 2017; Brody et al. 2017) and is reasonable given the small financial compensation we provided and because renters, who occupy 49% of properties in our study area, were unlikely to complete the survey.[8]

All respondents answered survey questions about how long they had lived in their current home, their perceived flood risk, their past experience with flooding, their expected future flooding to their current house, whether they had flood insurance, and their insurance literacy; the survey questions for flood risk perception, past flood experience, and expected future flooding are in Appendix A. The WTP elicitation varied, however, by floodplain location. All respondents,

[8] Only twelve of the 395 respondents who answered the property ownership question were renters.

regardless of their location inside or outside the 100-year floodplain, were presented with a scenario where they were asked to select their maximum annual WTP for a specific flood insurance policy from the perspective of a property owner located in the 100-year floodplain in the study area neighborhoods. Those currently in the SFHA were told of this fact and then asked the WTP question while those outside the SFHA were asked to consider their maximum annual WTP as if they were living in a SFHA. The full wording of each WTP elicitation is provided in Appendix B.

For efficient estimation, the WTP elicitation was done using a payment card instead of a dichotomous-choice response format due to the limited number of possible respondents in the 100- and 500-year floodplains (594 and 302, respectively). Payment cards are not incentive compatible (Boyle 2017), but the nature of our marketed good, which is primarily provided by the National Flood Insurance Program, means that respondents cannot change premiums by acting strategically. It is also unlikely, even if a respondent perceives flood risk to be very low, that their maximum annual WTP for flood insurance is $0 and payment cards appear to avoid the $0 spike seen with other response formats (Boyle 2017).

Payment card values were drawn from the known range of National Flood Insurance Policy premiums for single-family residential properties in the two zip codes that overlap our study area. In 2018 these ranged from a first percentile of \$174 to a 99^{th} percentile of \$3,202 with \$348 as the 25^{th} percentile, a median of \$777, and \$1,042 as the 75^{th} percentile (FEMA 2019a). Focus group participants responded favorably to the payment card values, so these were used in the final version of the survey (see Appendix B).

V. HOUSING, GEOSPATIAL DATA AND RESPONDENT CHARACTERISTICS

Survey respondents were asked to self-report demographic information. Using addresses and the unique identifier on each survey allowed us to link respondents to housing data such as the size of each property's tax lot, building square footage, year built, and total assessed value (Metro Data Resource Center 2018). ArcGIS 10.5.1 was used to derive location variables including a property's flood zone based on its building footprint (Metro Data Resource Center 2016b) and Euclidean distance to Johnson Creek (Metro Data Resource Center 2016a). The FEMA map error area was identified in consultation with city staff (Sherman 2018). The estimated volume of flooding from a 100-year event was determined by overlaying building footprints (Metro Data Resource Center 2016b) for the largest structure on each single-family residential property with the projected flood inundation layer (Wolff 2018).

Table 1 shows the summary statistics for the self-reported demographic information of our respondents and their property characteristics as calculated for their residence. Compared to 5-year (2013-2017) American Community Survey data for the census tracts that most closely align with the neighborhood boundaries (U.S. Census Bureau 2019), survey respondents are more likely to be older, White, employed full-time, and to have a bachelor's degree or higher. The average household income, based on the midpoint of the income ranges provided in the survey, was $72,139, which is higher than the study area's average income of $47,647.[9] Compared to non-respondents, survey respondent properties are significantly older, live in homes with smaller building square footage, and are located closer to Johnson Creek.[10] Lot square footage and total assessed value are not statistically different between respondents and non-respondents.[11]

[9] Six respondents selected an income range of "More than $200,000." These respondents were assigned an income of $250,000.
[10] The income and age values are an average of the median values for the study area census tracts.
[11] We are unable to correct our estimates for nonrespondents. Our population of interest is property owners and Portland does not track which properties are rented, so we cannot differentiate between property owners and renters.

Table 1: Survey Respondent and Property Characteristics

Variable	Average	Standard Deviation	Minimum	Maximum	ACS Data
Age (years)	52.08	15.86	22	97	35.19
Household size	2.57	1.39	1	11	2.76
Female	0.5172	0.5004	0	1	0.4949
Bachelor's degree or higher	0.5449	0.4986	0	1	0.1308
White	0.8196	0.3850	0	1	0.6373
Asian	0.0557	0.2297	0	1	0.1714
Black or African American	0.0106	0.1025	0	1	0.0569
American Indian or Alaska Native	0.0133	0.1145	0	1	0.0133
From multiple races	0.0239	0.1528	0	1	0.0548
From other race	0.0106	0.1026	0	1	0.0561
Prefer not to answer	0.0663	0.2491	0	1	-
Hispanic or Latino	0.0476	0.2132	0	1	0.1639
Income (dollars)	72,139	42,686	15,000	250,000	47,647
Employed full time	0.5397	0.4991	0	1	0.2964
Year house built	1958	28.69	1903	2017	-
Lot square footage	8,382	6,527	468	64,051	-
Building square footage	1,370.18	552.41	528	3,548	-
Total assessed value ($)	280,012	72,418	159,190	807,250	-
Euclidean distance to Johnson Creek (feet)	4,078	2,421	304	10,948	-

VI. WTP DISTRIBUTION AND HYPOTHESES

As stated earlier, respondents in the floodplain were asked their maximum annual WTP based on their current home's location and those outside the 100-year floodplain were asked to consider their maximum annual WTP if they were to live in the 100-year floodplain. Respondents selected from eleven dollar amounts ranging from $0 to "More than $3,000" or "I don't know." A respondent with a maximum WTP between two amounts, e.g., $350 and $550 should select the smaller amount (see Appendix B). Since all respondents were asked to report their maximum annual WTP for flood insurance inside the 100-year floodplain, differences in WTP based on where they actually reside could indicate variations in knowledge, understanding, or risk preferences across these groups. Table 2 shows the breakdown of maximum annual WTP values for the survey responses used in our models.

Table 2: Annual Willingness to Pay (N=279)

Annual Willingness to Pay	Count	Percentage
$0	38	13.62%
$100	43	15.41%
$150	24	8.60%
$250	38	13.62%
$350	39	13.98%
$550	46	16.49%
$850	14	5.02%
$1,250	27	9.68%
$2,000	7	2.51%
$3,000	1	0.36%
More than $3,000	2	0.72%

The 50 respondents that selected the "I don't know" WTP option are not included in our models. Of the 38 respondents who selected $0 maximum annual WTP, 82% stated in a follow-up question that they thought flooding and property damage were unlikely to occur, which is consistent with McClelland et al.'s (1993) insurance market experiment that found a bimodal distribution—with many individuals bidding either zero or much more than the expected value—for a low probability event. Flood insurance was not worth it for 18% of responses, 11% stated they couldn't afford to pay for flood insurance, 16% had other more important priorities, and 8% felt that it was unfair to expect them to pay for flood insurance.[12] Botzen and van den Bergh (2012) report a much higher percentage of respondents expressing $0 WTP ranging from 49.2% for a 1-in-400 flood probability to 75.8% for a 1-in-1250 flood probability. Thirty-seven percent of respondents in Roder et al.'s (2019) study failed to answer or wrote in $0 WTP for the flood insurance policy

[12] Respondents could select multiple reasons for why they had $0 WTP, which is why the sum of possible responses exceeds 100%.

described in their survey; in our study the percentage of "I don't know" and $0 WTP responses is only about 27%, perhaps reflecting greater familiarization with this issue among our sample.

The explanatory variables used in our models, and their hypothesized signs, are given in Table 3. Our predictors of WTP are drawn from prior studies, our knowledge of flood insurance demand, and our familiarity with this particular study area. We expect measures of objective risk, such as a property's location in the 100-year floodplain, location in an AE or AH flood zone, and the volume of expected flooding during a 100-year flood event, to have a positive effect on WTP compared to the excluded category of properties located outside a floodplain. We are uncertain about the expected sign for properties with a building footprint in the 500-year floodplain. While these properties are at increased risk of flooding compared to outside the 100-year or 500-year floodplain, homeowners are often unaware that they are at risk because there is no disclosure requirement for these properties. As such, they do not receive as much information from government agencies—federal or local— on flooding and insurance as those in the 100-year floodplain.

Table 3: Summary Statistics for Explanatory Variables (N=279)

Variable	Description and Units	Expected Sign	Average	Standard Deviation	Count when variable=1
Objective Risk Measures					
In 100-year floodplain	=1 building footprint in 100-year floodplain =0 otherwise	+	0.2509	0.4343	70
AE zone	=1 building footprint in AE flood zone =0 otherwise	+	0.0287	0.1672	8
AH zone	=1 building footprint in AH flood zone =0 otherwise	+	0.2222	0.4165	62
In 500-year floodplain	=1 if building footprint in 500-year floodplain =0 otherwise	?	0.0717	0.2584	20
Outside floodplain *(excluded)*	=1 if building footprint is outside a floodplain =0 otherwise	N/A	0.6774	.4683	189
Volume of expected flooding	Volume of expected flooding in primary structure (1,000 cubic feet)	+	0.2371	0.9751	N/A
Subjective Flood Risk & Flood Experience					
Experienced flood damage	=1 if any flood damage reported =0 otherwise	?	0.0932	0.2912	38
Zero expected future flooding *(excluded)*	=1 if expected frequency of basement flooding is 0 =0 otherwise	N/A	0.7168	0.4513	200
1-2 times expected future flooding	=1 if expected frequency of basement flooding is 1-2 times =0 otherwise	+	0.2258	0.4189	63
3 or more times expected future flooding	=1 if expected frequency of basement flooding is 3 or more times =0 otherwise	+	0.0573	0.2329	16
Home's risk much lower than neighborhood	=1 if home's risk is much lower than neighborhood =0 otherwise	?	0.3692	0.4834	102
Home's risk somewhat lower than neighborhood	=1 if home's risk is somewhat lower than neighborhood =0 otherwise	?	0.2366	0.4257	65

Home's risk average for neighborhood	=1 if home's risk is average for neighborhood =0 otherwise	?	0.1935	0.3958	54
Home's risk somewhat higher than neighborhood	=1 if home's risk is somewhat higher than neighborhood =0 otherwise	+	0.0466	0.2111	13
Home's risk much higher than neighborhood	=1 if home's risk is much higher than neighborhood =0 otherwise	+	0.0108	0.1033	3
Don't know home's risk compared to neighborhood *(excluded)*	=1 if respondent selected "don't know" for home's risk =0 otherwise	N/A	0.1434	0.3511	40
Home Characteristics					
Mortgage	=1 if property has a mortgage =0 otherwise	?	0.7849	0.4116	219
Property has a basement and/or crawlspace	=1 if property has a basement and/or crawlspace =0 otherwise	?	0.9534	0.2111	266
Property's total value	Total assessed property value $10,000 (2017)	+	28.2143	6.8772	N/A
In FEMA map error area	=1 if property in FEMA map error area =0 otherwise	-	0.1470	0.3547	41
Distance to Johnson Creek	Euclidean distance to Johnson Creek (feet)	-	4,121	2,458	N/A
Demographics					
Income	Midpoint of income categories (dollars)	+	73,952	43,551	N/A
Education	=1 if bachelor's degree or higher =0 otherwise	+	0.5806	0.4943	162
White *(excluded)*	=1 if White =0 otherwise	N/A	0.8495	0.3582	237
Asian	=1 if Asian =0 otherwise	?	0.0538	0.2260	15
Prefer not to answer	=1 if "prefer not to answer" =0 otherwise	?	0.0430	0.2032	12
Other	=1 if Black or African American, American	?	0.0538	0.2260	15

	Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, Some other race, or from multiple races =0 otherwise				
Age	Years	?	50.76	15.25	N/A
Male *(excluded)*	=1 if male =0 otherwise	N/A	0.4516	0.4985	126
Female	=1 if female =0 otherwise	?	0.5232	0.5004	146
Non-binary or prefer not to answer	=1 if nonbinary or PNTA =0 otherwise	?	0.0251	0.1567	7
Tenancy less than 1 year *(excluded)*	=1 if less than 1 year =0 otherwise	N/A	0.0932	0.2912	26
Tenancy of 1-3 years	=1 if tenancy of 1-3 years =0 otherwise	?	0.2151	0.4116	60
Tenancy of 4-7 years	=1 if tenancy of 4-7 years =0 otherwise	?	0.1792	0.3842	50
Tenancy of 8-15 years	=1 if tenancy of 8-15 years =0 otherwise	?	0.2079	0.4065	58
Tenancy of more than 15 years	=1 if tenancy of more than 15 years =0 otherwise	?	0.3047	0.4611	85

We expect subjective flood risk, captured by the respondent's assessment of their current home's flood risk compared to their neighborhood, to increase WTP for the highest two levels compared to the excluded "I don't know" category (Botzen and van den Bergh 2012; Seifert et al. 2013). We are uncertain about the expected signs for the other risk categories.

Expected future basement or crawlspace flooding, another question about risk perceptions on the survey, should increase a respondent's WTP, but we are uncertain about the sign for respondents who experienced flood damages. The highest crest ever recorded in the study area occurred in December, 2015 (NOAA 2019), so if respondents draw on this recent flood event as a reminder of flood risk (Dixon et al. 2006; Browne and Hoyt 1999), we would expect a positive effect on WTP, but if respondents believe that the chance of a flooding has declined, the so called "gambler's fallacy," then the expected effect on WTP would be negative (Kunreuther and Michel-Kerjan 2015). We list this effect as uncertain in Table 3.

Home characteristics may also influence a respondent's WTP. We are uncertain about sign if a respondent has a basement and/or crawlspace (compared to neither). On the one hand, shallow flooding is more likely to impact homes with basements, potentially increasing the WTP for insurance, but on the other hand, NFIP coverage in basements is much more limited, suggesting a lower WTP for a NFIP policy if only basement inundation is of concern. Botzen and van den Bergh (2012) found that distance from the water body decreased WTP, while Brody et al. (2017) found that proximity to a flood hazard area did not affect the decision to purchase flood insurance. Exploring the relationship between WTP and distance to Johnson Creek is especially interesting in our study area because the majority of the 100-year floodplain is not close to Johnson Creek (Figure 1b). If respondents use distance to the water body as a heuristic for flood risk, then we expect a negative sign for that coefficient.

Demographic factors are included in the model with income being the primary variable of interest. We expect a positive coefficient for the income variable based on other research that explores WTP for flood insurance and income (Botzen and van den Bergh 2012; Ajita Atreya, Ferreira, and Michel-Kerjan 2015; Kriesel and Landry 2004). Previous research has found a positive relationship between the adoption of flood insurance and the participant's level of education (Ajita Atreya, Ferreira, and Michel-Kerjan 2015), so we hypothesize a similar relationship for WTP. There are conflicting findings in the literature about age (Botzen and van den Bergh 2012; Dohmen et al. 2011), so we are uncertain about the expected sign for that variable.

VII. REGRESSION MODELS AND RESULTS

Flood insurance is a marketed good, so it is reasonable to assume that all respondents are willing to pay some amount of money for the flood insurance policy described in our WTP question (Appendix B). This makes our use of CV different from applications in the nonmarket valuation literature where it is reasonable to assume that respondents have a true $0 WTP.

There are several options for estimating determinants of annual WTP to account for censoring of our dependent variable including Interval Tobit using a normal or Weibull distribution (Wooldridge 2019; StataCorp 2019a; 2019b; Carson et al. 1992), a double-hurdle model such as the Cragg (Cragg 1971; Burke 2009), or a Poisson or Negative Binomial Model. We tested all of these models and found the Interval Tobit model (normal distribution) had the best fit to the data. Those results are included in Table 4 with predicted WTP values based on the Interval Tobit (Weibull distribution) model given in Appendix C.[13] The Cragg, Poisson and Negative Binomial models had a much poorer fit than the Interval Tobit models, so we do not report those results.

The Interval Tobit models use the log of the lower and upper bounds of the annual WTP values as the dependent variable. Independent variables, which are listed in Table 3, include objective risk measures, subjective risk and flood experience variables, as well as home and demographic characteristics. Objective risk measures vary by model with Model 1 using a property's location (based on building footprint) in the 100- or 500-year floodplain, Model 2 instead using the AE or AH flood zones, and Model 3 using the projected flood volume (1,000s of cubic feet) inside a building during a 100-year event. Results are presented in Table 4; the estimated coefficients are average marginal effects.

[13] We ran an OLS model using the natural log of the lower bound of the WTP value as the dependent variable. We lose observations (279 to 241) because respondents who selected $0 drop out of the model. Key findings from the Interval Tobit model hold in the OLS model.

Table 4: Interval Tobit Regression Results

	Model 1 *Floodplain*	*Model 2* *AE and AH Zones*	*Model 3* *Volume*
In 100-year floodplain	0.6897*** (0.1975)		
AE zone		1.0792*** (0.3212)	
AH zone		0.5963*** (0.2173)	
In 500-year floodplain	-0.2655 (0.2581)	-0.2623 (0.2579)	
Volume of expected flooding			0.1463*** (0.0386)
Experienced flood damage	-0.1696 (0.2272)	-0.1546 (0.2284)	-0.1351 (0.2289)
1-2 times expected future flooding	0.4426*** (0.1377)	0.4590*** (0.1376)	0.4503*** (0.1412)
3 or more times expected future flooding	0.4300** (0.1804)	0.4355** (0.1809)	0.4082** (0.1825)
Home's risk much lower than neighborhood	0.2195 (0.1915)	0.2306 (0.1910)	0.2773 (0.1906)
Home's risk somewhat lower than neighborhood	0.2953 (0.1894)	0.2947 (0.1879)	0.3065 (0.1930)
Home's risk average for neighborhood	0.3336 (0.2034)	0.3398* (0.2034)	0.3664* (0.1974)
Home's risk somewhat higher than neighborhood	0.3961* (0.2195)	0.4052* (0.2211)	0.4488* (0.2326)
Home's risk much higher than neighborhood	1.2012*** (0.4632)	0.9923** (0.4205)	1.6243*** (0.5588)
Mortgage	0.1745 (0.1704)	0.1779 (0.1701)	0.1756 (0.1685)
Property has a basement and/or crawlspace	-0.0957 (0.2155)	-0.0891 (0.2157)	-0.0592 (0.2255)
Property's total value	-0.0067 (0.0099)	-0.0070 (0.0099)	-0.0090 (0.0107)
In FEMA map error area	-0.4284* (0.2326)	-0.3138 (0.2602)	0.1312 (0.1869)
Log Euclidean distance to Johnson Creek	-0.0455 (0.0743)	-0.0160 (0.0825)	-0.1208* (0.0710)
Natural log of income	0.3087** (0.1203)	0.3107** (0.1206)	0.3519*** (0.1240)

Education	0.0648 (0.1405)	0.0559 (0.1406)	0.0225 (0.1399)
Asian	-0.4576** (0.2157)	-0.4664** (0.2167)	-0.4969** (0.2137)
Race is "prefer not to answer"	-0.5869** (0.2528)	-0.5937** (0.2534)	-0.6078** (0.2607)
Race is "other"	0.0793 (0.3042)	0.0837 (0.3068)	0.0502 (0.3159)
Respondent's age	0.0025 (0.0055)	0.0031 (0.0055)	0.0026 (0.0055)
Female	-0.0769 (0.1229)	-0.0779 (0.1225)	-0.0272 (0.1225)
Gender is non-binary or prefer not to answer	0.3435 (0.4846)	0.3764 (0.4853)	0.2816 (0.5087)
Tenancy of 1-3 years	0.0844 (0.2213)	0.0810 (0.2228)	0.0082 (0.2255)
Tenancy of 4-7 years	-0.1873 (0.2150)	-0.1965 (0.2162)	-0.2408 (0.2206)
Tenancy of 8-15 years	-0.0665 (0.2341)	-0.0654 (0.2348)	-0.1473 (0.2372)
Tenancy of more than 15 years	-0.4664* (0.2490)	-0.4857* (0.2492)	-0.5136** (0.2515)
Constant	2.8613* (1.5133)	2.6140* (1.5511)	2.9759** (1.5106)
Observations	279	279	279
Log Likelihood	-572.21	-571.66	-575.64
AIC	1202.42	1203.32	1207.28
BIC	1307.73	1312.26	1308.96

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Respondents with a property inside or intersected by the 100-year floodplain (Model 1) are estimated to be willing to pay about 69% more for flood insurance than respondents who live outside the 100- or 500-year floodplains. In Model 2, survey respondents who live in an AE or AH flood zone are predicted to have a significantly higher annual WTP — around 108% higher for AE and 60% higher for AH — than respondents who live outside floodplain areas. Given the possibility of deeper flood waters, and thus more significant damage, the magnitude of the coefficient on the AE zone variable exceeds the AH zone variable, as would be expected, although the estimated coefficients are not significantly different from each other (p-value 0.167). This could be due to the low number of respondents in our sample that have properties in the AE zone. In neither Model 1 nor Model 2 is the estimated coefficient on the 500-year floodplain variable significant. This is not surprising since there is no requirement in this area to purchase flood insurance and there is no required disclosure about flood risk when properties in the 500-year floodplain are sold. As such, those in the 500-year floodplain likely have similar information and education as those outside either the 100-year or 500-year floodplains. Model 3, which uses the expected volume of water inside a building during a 100-year event as the objective risk measure, also has a significantly positive WTP with each additional 1,000 cubic feet of water in a building increasing estimated WTP by 14.63%. This measure more accurately captures the potential for damage at a property and we find annual WTP is indeed responsive to the improved measure.

Surprisingly, self-reported prior experiences with flood damage are not statistically significant—perhaps because it had been several years since the last flood (NOAA 2019). We may also fail to find significance if respondents who care less about flooding are more likely to live in riskier areas, that is, those who are most likely to have experienced a flood are also least likely to be concerned about it. In contrast to prior experience, some flood risk perception variables are significant.[14] Respondents who viewed their current home's flood risk as being somewhat higher than their neighborhood had about a 40% higher annual WTP than respondents who selected "I don't know." This increases to 120% for respondents who believe their home's risk of flooding is much higher than their neighborhood. A positive expected frequency of basement or crawlspace

[14] Note, the correlations between our measures of flood risk are never greater than 0.43 and usually substantially lower than this.

flooding in the next 30 years, in comparison to the excluded category of no expected basement or crawlspace flooding, was also significantly positive in influencing WTP in all models, but we fail to reject the hypothesis of equal estimated effects for respondents who expect flooding 1-2 times, or 3 or more times.

Structural characteristics of the house were never statistically significant predictors of WTP.[15] It is perhaps surprising that there was not a positive and significant coefficient on building value because higher valued homes would need to purchase higher levels of coverage for the same financial protection and this would cost more.[16] We did find that being in the FEMA map error location lowered WTP in Model 1. While respondents in the 100-year floodplain are estimated to have a 69% higher annual WTP than respondents outside any floodplain in this model, the annual WTP for respondents in the FEMA map error area is only 26% higher than respondents outside any floodplain.[17] The FEMA map error area variable was not statistically significant in Models 2 or 3. The effect of distance from Johnson Creek is negative in all models, but only significant in Model 3 where a 1% increase in distance from Johnson Creek is estimated to decrease WTP by 0.12%. Although the location of the floodplain can be as far as 1 mile from Johnson Creek (Figure 1), the lack of significance for this variable in Models 1 and 2 may be due to collinearity with the floodplain location variables.

Personal characteristics of the respondent are more predictive. Respondent's income is significantly positive in all models with estimated elasticities of between 0.31 and 0.35 across all three models. Respondents who self-identified as Asian have a roughly 46% - 50% lower WTP than

[15] One possible explanation for why structural characteristics are insignificant is if home values are correlated with subjective flood risk. The correlation between total building value and respondents' assessments of their current home's flood risk compared to their neighborhood, however, is only weakly negative (-0.1073).
[16] Median building coverage in our study area for single-family policies in the 100-year floodplain is $175,500.
[17] Respondents in the FEMA map error area are also in the 100-year floodplain. The estimated effect is the sum of the "In 100-year floodplain" and "In FEMA map error area" coefficients.

White residents. The estimated effect for individuals who selected "prefer not to answer" for the race variable is even larger with a lower willingness to pay of 58.69% (Model 1), 59.37% (Model 2), and 60.78% (Model 3). Surname and location information have been used by some researchers to predict race and ethnicity (Imai and Khanna 2016; Crabtree and Chykina 2018; Shah and Davis 2017; Henninger, Meredith, and Morse 2018). Using the R package 'wru' (Khanna and Imai 2019) we predict that about half of the respondents who selected "prefer not to answer" are non-White.

The effect of tenancy of 15 years or more is significantly negative compared to the excluded category, which is tenancy of less than 1 year. Unfortunately, we are not able to identify the mechanism driving this result, but there are several plausible hypotheses. The first is learning and experience: residents who have lived a long time in the neighborhood, and have not experienced substantial flood-related damage, are willing to pay less for flood insurance because they believe they are at lower risk. Second, there could be a selection effect, in that homeowners that have lived in the neighborhood longer than fifteen years may have reasons they are unable to move elsewhere, such as income constraints, that also translate into a lower ability to pay for flood insurance.

Predicted means and median annual WTP for the three models are reported in Table 5 for all respondents, and then separately for respondents with properties that have building footprints inside or intersected by the 100-year floodplain from those with properties outside the 100-year floodplain.[18] A test of means firmly rejects the hypothesis of equal mean WTP for those respondents inside and outside the 100-year floodplain (p-value = 0.00). A test of means across models found that the mean WTP estimates for respondents inside the 100-year floodplain are not statistically different from each other; we reached the same conclusion for respondents outside the 100-year floodplain.

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[18] WTP estimates using the Interval Tobit (Weibull distribution) are in Table C2. Estimates are comparable to those reported in Table 6, for example, median annual WTP for respondents who live in the 100-year floodplain are $496.69 (Model 1), $505.63 (Model 2), and $454.86 (Model 3).

Respondents inside and outside the 100-year floodplain were presented with the same valuation scenario of a 1-in-4 chance of their home flooding with 1 to 3 feet of water over the life of a 30-year mortgage (Appendix B). The difference in predicted annual WTP for respondents in the 100-year floodplain may be a result of greater knowledge about flood risks for 100-year floodplain residents due to the city's extensive outreach efforts as part of FEMA's Community Rating System.

Another possible explanation for why 100-year floodplain respondents have a higher WTP is that they are anchoring on self-reported flood insurance payments (Ariely, Loewenstein, and Prelec 2003). For example, a respondent with a current flood insurance premium of $1,000, who exhibited an anchoring bias, would state a maximum WTP of $850 based on the possible payment card values (Appendix B). However, of the 50 respondents with self-reported flood insurance premiums, 30% selected a higher value and 44% selected a lower value than what they currently paid for flood insurance. In other words, the vast majority of respondents (74%) did not anchor on their self-reported flood insurance premiums.

Table 5: Summary Statistics for Predicted Annual WTP

	Model 1 *Floodplain*	*Model 2* *AE and AH Zones*	*Model 3* *Volume*
All respondents (N=279)			
Mean	$391.44	$393.35	$385.28
Median	$324.21	$320.35	$327.31
Standard Deviation	$297.19	$313.97	$278.42
Respondents in 100-year floodplain (N=70)			
Mean	$613.48	$620.06	$538.95
Median	$501.91	$513.90	$414.11
Standard Deviation	$461.81	$499.95	$437.90
Respondents outside 100-year floodplain (N=209)			
Mean	$317.07	$317.42	$333.82
Median	$280.61	$277.20	$296.13
Standard Deviation	$158.57	$160.45	$171.42

VIII. CONCLUSIONS AND POLICY IMPLICATIONS

Our study focuses on two highly urbanized neighborhoods in Portland, Oregon that are susceptible to flooding. In many ways, our study area is facing similar flood risk management challenges as other communities around the country. Changes in the frequency, timing, and intensity of storms due to climate change are predicted to cause more flooding in many places. Urban centers face heightened flood risk from intense precipitation events that overwhelm local drainage systems (National Academies of Sciences, Engineering, and Medicine 2019). These changes can be exacerbated by population growth, increased development, and decreases in natural areas that could help mitigate flooding. Given these common threats, our work in Portland has broader implications.

As stated earlier, insurance is a critical recovery tool for these increasing disasters. Our paper presents the first WTP estimates for flood insurance for a study area in the United States. In the U.S., homeowners in the mapped 100-year floodplain are required to purchase flood insurance if they have a loan from a federally backed or regulated lender. In 2011-2015, an estimated 10% of the U.S. population lived in a 100- or 500-year floodplain, with 15% of 100-year floodplain residents classified as living in poverty (Peri, Rosoff, Yager 2017). Estimates for our study area, with a higher poverty rate at 23%, predict a median annual WTP of between $414 and $514.

We find that WTP is higher, as would be expected, with higher objective flood risk and with greater perceptions of flood risk. This is probably a combination of both greater value of insurance in areas of higher risk, but also greater risk awareness and understanding in higher risk areas, particularly SFHAs. Given the insurance and property disclosure requirements in these areas, residents may be more aware of the benefits of flood insurance. It should be noted that the NFIP is currently in the process of modernizing their rating using modern catastrophe models to better reflect property-level flood risk. If this is implemented in 2021 as currently planned, flood insurance premiums will be more tightly linked to objective flood risk.

Flood awareness may vary not just by actual risk, but by other demographic factors. For instance, we find a significantly negative association between WTP and respondents who self-identified as Asian or selected "prefer not to answer;" this could provide additional support for Atreya et al.'s (2015) suggestion that FEMA information campaigns target audiences by demographic factors or to prioritize reaching all communities in outreach and education campaigns.

For many respondents, their stated WTP is well below the actual cost of flood insurance in the 100-year floodplain, highlighting a challenge to improving financial resilience to flood events. The median cost of flood insurance in the zip code that covers the majority of the study area was $878 in 2018 (FEMA 2019a), which already includes a 20% subsidy because Portland has a class 6 rating in the Community Rating System. The median annual WTP for respondents in the 100-year floodplain ranges from roughly 47% to 59% of the cost of flood insurance policies for properties in the 100-year floodplain.[19] The significantly positive income elasticity means that the gap between WTP and actual price may be larger than our estimates because the mean household income of survey respondents was higher than the study area average (U.S. Census Bureau 2019). The gap would also be larger in communities that have not participated in the CRS and taken actions to lower NFIP premiums for residents.

The fact that we find WTP increases with income reflects both the utility received from flood insurance and a respondent's ability-to-pay, or the marginal utility of income. While it is difficult to tease apart these two components of WTP, recognizing them is important for informing the ongoing policy dialogue on flood insurance affordability. Among those that can afford a policy, they may not feel it provides value—that it is not "worth it" —if they fail to understand the role of insurance in their recovery, have challenges in assessing low probability events (Botzen and van den

[19] If we code respondents who selected "I Don't Know" as having $0 WTP, the median annual WTP for respondents in the 100-year floodplain ranges from around 34% to 42% of the cost of flood insurance policies for properties in the 100-year floodplain. Predicted results are in Table C3.

Bergh 2012; Meyer and Kunreuther 2017), or the policy terms do not meet their needs. There is thus a need for providing more transparent information to residents in flood-prone areas on the potential losses they can suffer from future floods and the role that insurance can play in aiding the recovery process.

There are also families, however, who would value flood insurance but do not have enough disposable income to afford the policy. In our case, there is some evidence that the divergence between WTP and the price of an NFIP policy in our study area may be largely reflective of ability-to-pay. First, all respondents were told about the risk of flooding in the WTP question (Appendix B) and the simple act of responding to that question would have made flood risk more salient.[20] The WTP question also reminded participants about what they would receive from the insurance policy and about the limitation of post-disaster aid. Second, while prior work has found risk perceptions may decline as time from a major disaster increases (Atreya, Ferreira, and Kriesel 2013; Bin and Landry 2013; Kousky 2010; Shr and Zipp 2019), our study area faces a different flood risk profile—frequent, shallow flooding—so respondents are continually reminded of the risk. This was verified in a recent hedonic study of our area, which found a consistently lower sales price for homes in the 100-year floodplain over a 25-year period (Netusil, Moeltner, and Jarrad 2019).

Given the documented role of insurance in recovery, many observers have proposed means-tested assistance, such as an insurance voucher, if inability to afford coverage is a true barrier to wider take up (Dixon et al. 2017; Kunreuther 2018; National Research Council 2015). Our societal preferences toward redistribution are often good- or service-specific and there is a growing view among policymakers that in the face of increasingly costly flood events, insurance is a preferred and

[20] Based on answers to questions about expected future flooding (Appendix A), most respondents did not expect basement flooding over the next 30 years. But, on average, respondents assessed risk as higher than would be inferred from FEMA maps. Assuming the annual risk of flooding in the SFHA is roughly 1% or greater, respondents estimate flooding in their basement or crawlspace more times than an average of 1% per year over 30 years. This is also true of respondents in the 500-year floodplain, where the annual risk is 0.2%.

also necessary recovery mechanism. That said, such a federal policy remains elusive. Our results, however, can help inform what magnitude of an insurance voucher would be needed to assist families should Congress decide to act on this recommendation.

In response to a lack of federal policy, a small number of communities around the country have adopted their own flood insurance affordability programs, including Portland. Portland's pilot program helped participating residents in our study neighborhoods lower their insurance costs through elevation certificates and insurance consultations that helped qualify them for reduced premiums through the NFIP: the program achieved an average savings of over $700 (Sherman and Kousky 2018). This was accomplished without the use of direct support, such as through insurance vouchers, which could be a useful complementary policy. This pilot program could be scaled to other communities.

As climate change continues to escalate the risk from a range of natural disasters, financial recovery is going to become an increasingly pressing national concern. Insurance tends to provide more funding and provide that funding faster than other forms of assistance, but its value is often not well communicated and its cost can be prohibitive. To ensure equitable recovery, programs that educate potential victims about the role of flood insurance and also support the purchase of flood insurance among lower income households are needed.

REFERENCES

AECOM. 2013. "The Impact of Climate Change and Population Growth on the National Flood Insurance Program Through 2100, Prepared for Federal Insurance and Mitigation Administration, Federal Emergency Management Agency." Arlington, Virginia. https://www.adaptationclearinghouse.org/resources/the-impact-of-climate-change-and-population-growth-on-the-national-flood-insurance-program-through-2100.html.

Ariely, Dan, George Loewenstein, and Drazen Prelec. 2003. "'Coherent Arbitrariness': Stable Demand Curves Without Stable Preferences." *Quarterly Journal of Economics* 118 (1): 73–106.

Atreya, A., S. Ferreira, and W. Kriesel. 2013. "Forgetting the Flood? An Analysis of the Flood Risk Discount over Time." *Land Economics* 89 (4): 577–96. https://doi.org/10.3368/le.89.4.577.

Atreya, Ajita, Susana Ferreira, and Erwann Michel-Kerjan. 2015. "What Drives Households to Buy Flood Insurance? New Evidence from Georgia." *Ecological Economics* 117 (September): 153–61. https://doi.org/10.1016/j.ecolecon.2015.06.024.

Bin, Okmyung, and Craig E. Landry. 2013. "Changes in Implicit Flood Risk Premiums: Empirical Evidence from the Housing Market." *Journal of Environmental Economics and Management* 65 (3): 361–76. https://doi.org/10.1016/j.jeem.2012.12.002.

Board of Governors of the Federal Reserve System. 2017. "Report on the Economic Well-Being of U.S. Households in 2016."

Botzen, W.J.W., and J.C.J.M. van den Bergh. 2012. "Risk Attitudes to Low-Probability Climate Change Risks: WTP for Flood Insurance." *Journal of Economic Behavior & Organization* 82 (1): 151–66. https://doi.org/10.1016/j.jebo.2012.01.005.

Boyle, Kevin J. 2017. "Contingent Valuation in Practice." In *A Primer on Nonmarket Valuation*, 83–131. The Economics of Non-Market Goods and Resources. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-7104-8_4.

Brody, Samuel D., Wesley E. Highfield, Morgan Wilson, Michael K. Lindell, and Russell Blessing. 2017. "Understanding the Motivations of Coastal Residents to Voluntarily Purchase Federal Flood Insurance." *Journal of Risk Research* 20 (6): 760–75. https://doi.org/10.1080/13669877.2015.1119179.

Browne, Mark J., and Robert E. Hoyt. 1999. "The Demand for Flood Insurance: Empirical Evidence." *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.169448.

Bureau of Environmental Services. 2019. "Foster Floodplain Natural Area." 2019. https://www.portlandoregon.gov/bes/article/286175.

Burke, William J. 2009. "Fitting and Interpreting Cragg's Tobit Alternative Using Stata." *The Stata Journal: Promoting Communications on Statistics and Stata* 9 (4): 584–92. https://doi.org/10.1177/1536867X0900900405.

Carson, Richard T, Robert C Mitchell, W Michael Hanemann, Raymond J Kopp, Presser, Stanley, and Rudd, Paul A. 1992. "A Contingent Valuation Study of Lost Passive Use Values Resulting from the Exxon Valdez Oil Spill." https://mpra.ub.uni-muenchen.de/6984/.

Chang, Heejun, Eric Watson, and Angela Stecker. 2017. "Chapter 8: Climate Change and Stream Temperature in the Willamette River Basin: Implications for Fish Habitat." In *Bridging Science and Policy Implication for Managing Climate Extremes*, 119–32. World Scientific Publishing.

Chivers, James, and Nicholas E. Flores. 2002. "Market Failure in Information: The National Flood Insurance Program." *Land Economics* 78 (4): 515–521.

Crabtree, Charles, and Volha Chykina. 2018. "Last Name Selection in Audit Studies." *Sociological Science* 5: 21–28. https://doi.org/10.15195/v5.a2.

Cragg, John G. 1971. "Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods." *Econometrica* 39 (5): 829–44.

Dillman, Don A., Jolene D. Smyth, and Leah Melani Christian. 2014. *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method.* John Wiley & Sons.
Dixon, Lloyd, Noreen Clancy, Benjamin Miller, Sue Hoegberg, Michael Lewis, Bruce Bender, Samara Ebinger, et al. 2017. *The Cost and Affordability of Flood Insurance in New York City: Economic Impacts of Rising Premiums and Policy Options for One- to Four-Family Homes*. RAND Corporation. https://doi.org/10.7249/RR1776.
Dixon, Lloyd, Noreen Clancy, Seth Seabury, and Adrian Overton. 2006. *The National Flood Insurance Program's Market Penetration Rate: Estimates and Policy Implications*. RAND Corporation. https://doi.org/10.7249/TR300.
Dohmen, Thomas, Armin Falk, David Huffman, Uwe Sunde, Jürgen Schupp, and Gert G. Wagner. 2011. "Individual Risk Attitudes: Measurement, Measurement, Determinants, and Behavioral Consequences." *Journal of the European Economic Association* 9 (3): 522–50. https://doi.org/10.1111/j.1542-4774.2011.01015.x.
Federal Emergency Management Agency, Region 10. 2016. "FEMA Best Practices Disaster Mitigation Working in Oregon: Natural Floodplain Restoration Protects Communities."
FEMA. 2016. "Individuals and Households Program Unified Guidance (IHPUG)." FP 104-009-003. Washington, D.C.
———. 2017. "NFIP Desk Reference Guide for State Insurance Commissioners and Others."
———. 2018. "FIMA NFIP Redacted Policies Data Set." March 2018. https://www.fema.gov/media-library/assets/documents/180376.
———. 2019a. "FIMA NFIP Redacted Claims Data Set." 2019. https://www.fema.gov/media-library/assets/documents/180374.
———. 2019b. "FEMA Publishes NFIP Claims and Policy Data." June 11, 2019. https://www.fema.gov/news-release/2019/06/11/fema-publishes-nfip-claims-and-policy-data.
Henninger, Phoebe, Marc Meredith, and Michael Morse. 2018. "Who Votes Without Identification? Using Affidavits from Michigan to Learn About the Potential Impact of Strict Photo Voter Identification Laws." SSRN Scholarly Paper ID 3205769. Rochester, NY: Social Science Research Network. https://papers.ssrn.com/abstract=3205769.
Hung, Hung-Chih. 2009. "The Attitude towards Flood Insurance Purchase When Respondents' Preferences Are Uncertain: A Fuzzy Approach." *Journal of Risk Research* 12 (2): 239–58. https://doi.org/10.1080/13669870802497702.
Imai, Kosuke, and Kabir Khanna. 2016. "Improving Ecological Inference by Predicting Individual Ethnicity from Voter Registration Records." *Political Analysis* 24 (2): 263–72. https://doi.org/10.1093/pan/mpw001.
Jarrad, Maya. 2016. "Johnson Creek Restoration Sites 1990-2014." Harvard Dataverse, V3. https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/L4DDCR.
Johnston, Robert J., Kevin J. Boyle, Wiktor (Vic) Adamowicz, Jeff Bennett, Roy Brouwer, Trudy Ann Cameron, W. Michael Hanemann, et al. 2017. "Contemporary Guidance for Stated Preference Studies." *Journal of the Association of Environmental and Resource Economists* 4 (2): 319–405. https://doi.org/10.1086/691697.
Joyce, Christopher. 2016. "Outdated FEMA Flood Maps Don't Account For Climate Change." NPR.Org. September 15, 2016. https://www.npr.org/2016/09/15/492260099/outdated-fema-flood-maps-dont-account-for-climate-change.
Jung, I.-W., H. Chang, and H. Moradkhani. 2011. "Quantifying Uncertainty in Urban Flooding Analysis Considering Hydro-Climatic Projection and Urban Development Effects." *Hydrology and Earth System Sciences* 15 (2): 617–33. https://doi.org/10.5194/hess-15-617-2011.

Khanna, Kabir, and Kosuke Imai. 2019. *Wru: Who Are You? Bayesian Prediction of Racial Category Using Surname and Geolocation* (version 0.1-9). https://CRAN.R-project.org/package=wru.
Kousky, Carolyn. 2010. "Learning from Extreme Events: Risk Perceptions after the Flood." *Land Economics* 86 (3): 395–422.
———. 2011. "Understanding the Demand for Flood Insurance." *Natural Hazards Review* 12 (2): 96–110. https://doi.org/10.1061/(ASCE)NH.1527-6996.0000025.
———. 2018. "Financing Flood Losses: A Discussion of the National Flood Insurance Program." *Risk Management and Insurance Review* 21 (1): 11–32. https://doi.org/10.1111/rmir.12090.
Kousky, Carolyn, Brett Lingle, and Leonard Shabman. 2017. "The Pricing of Flood Insurance." *Journal of Extreme Events* 04 (02): 1750001. https://doi.org/10.1142/S2345737617500014.
Kriesel, Warren, and Craig Landry. 2004. "Participation in the National Flood Insurance Program: An Empirical Analysis for Coastal Properties." *Journal of Risk and Insurance* 71 (3): 405–20. https://doi.org/10.1111/j.0022-4367.2004.00096.x.
Kunreuther, Howard. 2018. "Improving the National Flood Insurance Program." *Behavioural Public Policy*, July, 1–15. https://doi.org/10.1017/bpp.2018.26.
Kunreuther, Howard, and Erwann Michel-Kerjan. 2015. "Demand for Fixed-Price Multi-Year Contracts: Experimental Evidence from Insurance Decisions." *Journal of Risk and Uncertainty* 51 (2): 171–94. https://doi.org/10.1007/s11166-015-9225-4.
Landry, Craig E., and Mohammad R. Jahan-Parvar. 2011. "Flood Insurance Coverage in the Coastal Zone: Flood Insurance Coverage in the Coastal Zone." *Journal of Risk and Insurance* 78 (2): 361–88. https://doi.org/10.1111/j.1539-6975.2010.01380.x.
Lee, Karl K., and Daniel T. Snyder. 2009. *Hydrology of the Johnson Creek Basin, Oregon*. US Geological Survey. http://pubs.usgs.gov/sir/2009/5123/.
Lin, Ning, Robert E. Kopp, Benjamin P. Horton, and Jeffrey P. Donnelly. 2016. "Hurricane Sandy's Flood Frequency Increasing from Year 1800 to 2100." *Proceedings of the National Academy of Sciences* 113 (43): 12071–75. https://doi.org/10.1073/pnas.1604386113.
McClelland, Gary H., William D. Schulze, and Don L. Coursey. 1993. "Insurance for Low-Probability Hazards: A Bimodal Response to Unlikely Events." In *Making Decisions About Liability And Insurance: A Special Issue of the Journal of Risk and Uncertainty*, edited by Colin Camerer and Howard Kunreuther, 95–116. Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-94-011-2192-7_7.
Metro Data Resource Center. 2016a. "RLIS Discovery: Home - Rivers (Line)." February 3, 2016. http://rlisdiscovery.oregonmetro.gov/?action=viewDetail&layerID=1556.
———. 2016b. "RLIS Discovery: Home - Flood Plains (FEMA)." December 26, 2016. http://rlisdiscovery.oregonmetro.gov/?action=viewDetail&layerID=1756#.
———. 2018. "RLIS Discovery: Home - Taxlots." January 1, 2018. http://rlisdiscovery.oregonmetro.gov/?action=viewDetail&layerID=41#.
Meyer, Robert, and Howard Kunreuther. 2017. *The Ostrich Paradox: Why We Underprepare for Disasters*. La Vergne: Wharton Digital Press.
National Academies of Sciences, Engineering, and Medicine. 2019. *Framing the Challenge of Urban Flooding in the United States*. Washington, D.C.: National Academies Press. https://doi.org/10.17226/25381.
National Research Council. 2015. *Affordability of National Flood Insurance Program Premiums: Report 1*. https://doi.org/10.17226/21709.
Netusil, Noelwah R., Klaus Moeltner, and Maya Jarrad. 2019. "Floodplain Designation and Property Sale Prices in an Urban Watershed." *Land Use Policy* 88 (November): 104–12. https://doi.org/10.1016/j.landusepol.2019.104112.

NOAA. 2019. "Historical Crests for Johnson Creek near Sycamore." Advanced Hydrologic Prediction Service. June 21, 2019. https://water.weather.gov/ahps2/crests.php?wfo=pqr&gage=syco3&crest_type=historic.

Office of Inspector General. 2017. "FEMA Needs to Improve Management of Its Flood Mapping Program." Department of Homeland Security. https://www.oig.dhs.gov/sites/default/files/assets/ 2017/OIG-17-110-Sep17.pdf.

Oregon Solutions. 2017. "Lents Stabilization and Job Creation Collaborative." 2017. http://orsolutions.org/osproject/lents-stabilization-and-job-creating-collaborative.

Petrolia, D. R., C. E. Landry, and K. H. Coble. 2013. "Risk Preferences, Risk Perceptions, and Flood Insurance." *Land Economics* 89 (2): 227–45. https://doi.org/10.3368/le.89.2.227.

Roder, Giulia, Paul Hudson, and Paolo Tarolli. 2019. "Flood Risk Perceptions and the Willingness to Pay for Flood Insurance in the Veneto Region of Italy." *International Journal of Disaster Risk Reduction* 37 (July): 101172. https://doi.org/10.1016/j.ijdrr.2019.101172.

Royal, Andrew, and Margaret Walls. 2019. "Flood Risk Perceptions and Insurance Choice: Do Decisions in the Floodplain Reflect Overoptimism?" *Risk Analysis* 39 (5): 1088–1104. https://doi.org/10.1111/risa.13240.

Seifert, I., W. J. W. Botzen, H. Kreibich, and J. C. J. H. Aerts. 2013. "Influence of Flood Risk Characteristics on Flood Insurance Demand: A Comparison between Germany and the Netherlands." *Nat. Hazards Earth Syst. Sci.* 13 (7): 1691–1705. https://doi.org/10.5194/nhess-13-1691-2013.

Shah, Paru R., and Nicholas R. Davis. 2017. "Comparing Three Methods of Measuring Race/Ethnicity." *The Journal of Race, Ethnicity, and Politics* 2 (1): 124–39. https://doi.org/10.1017/rep.2016.27.

Shaw, Al, Christie Thompson, and Theodoric Meyer. 2013. "Federal Flood Maps Left New York Unprepared for Sandy — and FEMA Knew It." *ProPublica*, December 6, 2013. https://www.propublica.org/article/federal-flood-maps-left-new-york-unprepared-for-sandy-and-fema-knew-it.

Sherman, Jacob. 2018. "Property-Specific Information Derived Using a GIS," July 25, 2018.

Sherman, Jacob, and Carolyn Kousky. 2018. "Local Solutions to Flood Insurance Affordability: Portland's Flood Insurance Savings Program," Issue Brief, 04 (November): 1750001.

Shr, Yau-Huo (Jimmy), and Katherine Y. Zipp. 2019. "The Aftermath of Flood Zone Remapping: The Asymmetric Impact of Flood Maps on Housing Prices." *Land Economics* 95 (2): 174–92. https://doi.org/10.3368/le.95.2.174.

StataCorp. 2019a. *Stata Base Reference Manual Release 16: Intreg*. College Station, TX: Stata Press.

———. 2019b. *Stata Base Reference MAnual Release 16: Stintreg*. College Station, TX: Stata Press.

U.S. Census Bureau. 2019. "'Summary File' 2013-2017 American Community Survey."

Wolff, Gary. 2018. "Lents Collaborative Hydraulic Modeling Update." March 21.

Wooldridge, Jeffrey M. 2019. *Introductory Econometrics: A Modern Approach*. Seventh edition. Boston, MA: CENGAGE.

APPENDIX A : SUBJECTIVE RISK QUESTIONS

1. **Experienced flood damage variable**: Respondents who answered "Yes, once," "Yes, 2 – 5 times," or "Yes, more than 5 times," were coded as a 1 and those who answered "No" were coded as 0.

Have you ever experienced flood damage either at your current home or elsewhere?

- No
- Yes, once
- Yes, 2 – 5 times
- Yes, more than 5 times

2. **Expected future flooding variables**: Respondents who answered "1-2 times" for either or both questions were placed in the "1-2 times expected future flooding" category, while those who answered "3-4 times," "5-6 times," "7-8 times," or "9-10 times or more" for either or both questions were placed in the "3-4 times or more expected future flooding" category. Respondents who answered "None" to both questions are in the "Zero expected future flooding" category.

How many times do you think you will have basement or crawlspace flooding at your home over the next 30 years?

- None
- 1-2 times
- 3-4 times
- 5-6 times
- 7-8 times
- 9-10 times or more

How many times do you think you will have ground floor flooding (or above) at your home over the next 30 years?

- None
- 1-2 times
- 3-4 times
- 5-6 times
- 7-8 times
- 9-10 times or more

3. Current home's flood risk variable

How would you describe your current home's flood risk?

- Much lower than average for your neighborhood
- Somewhat lower than average for your neighborhood
- Average for your neighborhood
- Somewhat higher than average for your neighborhood
- Much higher than average for your neighborhood
- I don't know

APPENDIX B: WILLINGNESS TO PAY QUESTIONS

B.1: Willingness to Pay question for respondents in the 100-year floodplain

Based on current FEMA flood maps for your neighborhood, your home is located in a 100-year floodplain. This means that you are required to have flood insurance if you have a mortgage. It also means there is a greater than 1-in-4 chance you will experience a flood over the life of a 30-year mortgage. In the Lents and Powellhurst-Gilbert neighborhoods this could result in 1 to 3 feet of water in your home.

Flood insurance is not typically covered in a homeowner's insurance policy, so assume you are considering the purchase of a separate flood insurance policy. The flood insurance policy would fully cover any damage to your home if you are flooded. It has a deductible of $1,000. That means that you need to pay for the first $1,000 of damage and then any damage above that amount will be covered by your flood policy.

Think about your expenses and your household budget. Consider the **maximum amount of money you would be willing to pay this year for flood insurance**. Please consider how much you would pay for the policy described above and not the cost of any flood policy you may currently have. Remember that if you choose not to purchase flood insurance, and a flood occurs, you will have to pay for any damage to your home and contents. Any money from the government would likely be minimal. Also remember that any amount you spend on flood insurance cannot be spent on other items.

Consider the dollar amounts below. Circle the <u>maximum amount</u> you would be willing to pay <u>this year</u> for flood insurance:

$0	$100	$150	$250
$350	$550	$850	$1,250
$2,000	$3,000	More than $3,000	I don't know

B.2: Willingness to Pay question for respondents outside the 100-year floodplain

Suppose you own a home in the Lents or Powellhurst-Gilbert neighborhoods that is located in a 100-year floodplain. This means you are required to have flood insurance if you have a mortgage. It also means there is a greater than 1-in-4 chance you will experience a flood over the life of a 30-year mortgage that could result in 1 to 3 feet of water in your home.

Flooding is generally not covered in a homeowner's insurance policy, so consider purchasing a separate flood insurance policy. Your flood policy will fully cover any damage to your home if you are flooded. It has a deductible of $1,000. That means you need to pay for the first $1,000 of damage and then any damage above that amount will be covered by your flood insurance policy.

Think about your expenses and your household budget. Consider the **maximum amount of money you would be willing to pay this year for flood insurance**. Remember that if you choose not to purchase flood insurance, and a flood occurs, you will have to pay for any damage to your home and contents. Any money from the government would likely be minimal. Also remember that any amount you spend on flood insurance cannot be spent on other items.

Consider the dollar amounts below. Circle the <u>maximum amount</u> you would be willing to pay <u>this year</u> for flood insurance:

$0	$100	$150	$250
$350	$550	$850	$1,250
$2,000	$3,000	More than $3,000	I don't know

APPENDIX C

Table C1: Marginal Effects Evaluated at the Mean for Interval-Censored Survival Regression Models

	Model 1 *Floodplain*	*Model 2* *AE and AH Zones*	*Model 3* *Volume*
In 100-year floodplain	0.4102** (0.2024)		
AE zone		0.6203 (0.4240)	
AH zone		0.3644* (0.2139)	
In 500-year floodplain	-0.1861 (0.2215)	-0.1874 (0.2215)	
Volume of expected flooding			0.1051* (0.0604)
Experienced flood damage	0.0125 (0.2049)	0.0238 (0.2055)	0.0077 (0.2042)
1-2 times expected future flooding	0.3377** (0.1421)	0.3416** (0.1421)	0.3514** (0.1424)
3 or more times expected future flooding	0.1760 (0.2784)	0.1761 (0.2780)	0.1459 (0.2773)
Home's risk much lower than neighborhood	0.3736** (0.1750)	0.3834** (0.1758)	0.3975** (0.1750)
Home's risk somewhat lower than neighborhood	0.3373* (0.1823)	0.3336* (0.1824)	0.3429* (0.1824)
Home's risk average for neighborhood	0.3676* (0.2019)	0.3784* (0.2027)	0.3665* (0.1960)
Home's risk somewhat higher than neighborhood	0.2482 (0.3043)	0.2544 (0.3046)	0.3010 (0.3052)
Home's risk much higher than neighborhood	1.2305* (0.6688)	1.0870 (0.7117)	1.5555** (0.6620)
Mortgage	0.2141 (0.1536)	0.2223 (0.1542)	0.2188 (0.1533)
Property has a basement and/or crawlspace	0.1234 (0.2551)	0.1276 (0.2551)	0.1148 (0.2556)
Property's total value	-0.0115 (0.0098)	-0.0116 (0.0097)	-0.0129 (0.0099)

In FEMA map error area	-0.2725 (0.2411)	-0.2195 (0.2553)	0.0715 (0.1657)
Log Euclidean distance to Johnson Creek	-0.0574 (0.0716)	-0.0394 (0.0779)	-0.1054 (0.0661)
Natural log of income	0.2562** (0.1122)	0.2534** (0.1120)	0.3188*** (0.1147)
Education	0.0089 (0.1268)	0.0123 (0.1270)	-0.0116 (0.1247)
Asian	-0.5687** (0.2749)	-0.5678** (0.2746)	-0.5692** (0.2718)
Race is "prefer not to answer"	-0.7035** (0.2756)	-0.7024** (0.2763)	-0.7317*** (0.2790)
Race is "other"	0.0920 (0.2431)	0.1020 (0.2436)	0.1038 (0.2445)
Respondent's age	0.0001 (0.0057)	0.0005 (0.0058)	-0.0003 (0.0056)
Female	-0.0636 (0.1159)	-0.0629 (0.1159)	-0.0312 (0.1151)
Gender is non-binary or prefer not to answer	0.4737 (0.3837)	0.4810 (0.3847)	0.5059 (0.3853)
Tenancy of 1-3 years	0.1040 (0.2167)	0.1046 (0.2167)	0.0419 (0.2149)
Tenancy of 4-7 years	-0.1099 (0.2211)	-0.1162 (0.2213)	-0.1500 (0.2202)
Tenancy of 8-15 years	0.0350 (0.2242)	0.0405 (0.2244)	-0.0517 (0.2211)
Tenancy of more than 15 years	-0.3708 (0.2400)	-0.3855 (0.2415)	-0.3752 (0.2414)
Observations	279	279	279
Log likelihood	-573.14	-572.97	-574.28
AIC	1204.27	1205.94	1204.56
BIC	1309.58	1314.87	1305.24

Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C2: Summary Statistics for Predicted WTP (Weibull Distribution)

	Model 1 *Floodplain*	*Model 2* *AE and AH Zones*	*Model 3* *Volume*
All respondents (N=279)			
Mean	$404.35	$404.27	$407.24
Median	$349.93	$349.14	$354.49
Standard Deviation	$259.55	$259.67	$278.24
Respondents in 100-year floodplain (N=70)			
Mean	$572.43	$571.74	$540.13
Median	$496.69	$505.63	$454.86
Standard Deviation	$374.15	$373.43	$408.21
Respondents outside 100-year floodplain (N=209)			
Mean	$348.06	$348.18	$362.60
Median	$317.79	$316.88	$318.48
Standard Deviation	$175.81	$176.80	$200.63

Table C3: Summary Statistics for Predicted WTP
("I Don't Know" Responses Coded as $0 WTP)

	Model 1 *Floodplain*	*Model 2* *AE and AH Zones*	*Model 3* *Volume*
All respondents (N=310)			
Mean	$326.29	$329.05	$322.36
Median	$264.56	$258.58	$261.86
Standard Deviation	$279.69	$305.40	$262.39
Respondents in 100-year floodplain (N=80)			
Mean	$490.90	$501.44	$435.20
Median	$369.56	$351.35	$297.46
Standard Deviation	$457.79	$514.55	$425.00
Respondents outside 100-year floodplain (N=230)			
Mean	$269.04	$269.09	$283.11
Median	$227.64	$231.97	$240.84
Standard Deviation	$143.17	$143.27	$156.83