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The Long Road to Adoption: How Long Does it Take to Adopt Updated County-Level Flood Insurance Rate Maps?

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Floods cause the most damage of all natural disasters in the United States. Households and communities receive much of their information on flood hazards from maps produced by the Federal Emergency Management Agency (FEMA). These maps have been criticized for many reasons: they use poor data, do not reflect a changing climate, do not capture rainfall flooding, create misperceptions about risk, and are often out of date. We examine this last concern, investigating how long it takes updated county-level flood maps to be adopted across the country, using a unique nationwide data set from June 2014 to 2017. We find substantial heterogeneity in the time to adopt maps, with multiple outliers where the process far exceeds the time FEMA has estimated should be standard. Many factors may generate delay, including time for new data collection, technical challenges to revised maps, and community opposition. We also find there are differences in appeal rates and the timing of map revisions based on those appeals between inland and coastal counties and between higher and lower income communities. These correlations raise important questions for policymakers and scholars about the equity and accuracy of the nation's current approach to mapping changing flood risk.

KEY WORDS: risk policy and management, hazard management and mitigation, flooding

采纳之路漫长：采用更新的县级防洪保险率地图需要多久？

洪水在美国造成的自然灾害最多。家庭和社区大多从联邦紧急事务管理局（*FEMA*）提供的地图了解水灾信息。这些地图受到批判的原因多种多样：信息不足、不能反映多变天气、无法捕捉降雨造成的水灾、对风险的理解有误，以及经常没有更新信息。笔者检验了最后这一点，通过使用一组独特的全国性数据集（从*2014*年*6*月到*2017*年*6*月），调查了全国需要多久才能都采用更新过后的县级水灾地图。笔者从地图采纳时间中发现了大量的异质性，其中存在许多例外情况，即采纳过程所需时间远超出*FEMA*所预计的标准时间。造成信息更新延误的因素有很多，包括新数据收集所需时间、修订地图的技术性挑战、以及社区反对。笔者还发现，内地和沿海县区，高收入和低收入群体之间，就上诉率和地图修订时间存在差异。针对该国当前提供多变洪水风险信息时的公正性和准确性，上述关联对政策制定者和学者提出了重要问题。

关键词： 风险政策和管理, 灾害管理和缓解, 水灾

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El largo camino hacia la aprobación: cuánto tiempo se necesita para aprobar mapas de tarifa de seguro para las inundaciones a nivel de condado

De todos los desastres naturales en los Estados Unidos, las inundaciones son el que más daños causa. Los hogares y las comunidades reciben la mayoría de su información de los peligros de las inundaciones mediante mapas que produce la Agencia Federal para el Manejo de Emergencias (FEMA). Estos mapas han sido criticados por muchas razones: usan datos deficientes, no reflejan un clima cambiante, no captan las inundaciones de lluvia, crean percepciones erróneas sobre el riesgo y, a menudo, están desactualizados. Examinamos esta última preocupación, investigando cuánto tiempo necesita la aprobación de mapas de inundaciones actualizados a nivel de condado en todo el país, utilizando un conjunto de datos único a nivel nacional desde junio de 2014 hasta junio de 2017. Encontramos una gran heterogeneidad en el momento de aprobar mapas, con múltiples valores atípicos en los que el proceso supera con creces el tiempo que FEMA estima que debería ser estándar. Muchos factores pueden generar demoras, incluido el tiempo para la recopilación de nuevos datos, los desafíos técnicos para los mapas revisados y la oposición de la comunidad. También descubrimos que hay diferencias en las tasas de apelación y el momento en que se realizan las revisiones de los mapas en función de esas apelaciones entre los condados del interior y de la costa y entre las comunidades de ingresos más altos y más bajos. Estas correlaciones plantean preguntas importantes para los responsables políticos y académicos acerca de la equidad y la precisión del enfoque actual de la nación para hacer un mapeo cambiante del riesgo de inundación.

PALABRAS CLAVES: política y gestión de riesgos, gestión y mitigación de riesgos, inundaciones

Introduction

Flooding is the most common natural disaster and causes the most property damage in the United States. According to data from the National Oceanic and Atmospheric Administration, since 1980, over 70 percent of U.S. weather- and climate-related disasters exceeding $1 billion in costs were flood and storm events. These accounted for roughly $1.18 trillion in damages (adjusted to 2017 U.S. dollars) in less than three decades (NOAA National Centers for Environmental Information, 2018). In the last decade alone, 73 percent of major disaster declarations were associated with floods (Higgins, 2017). The upward trend continues, with 2017 being the costliest for weather and climate disasters in U.S. history with $306 billion in economic losses (NOAA National Centers for Environmental Information, 2018). Recent flood events have repeatedly made clear that many residents in the United States are not insured against flooding and are not aware of the flood risk they face. Recent data suggest that on average only roughly 30 percent of households in the highest flood risk areas have flood insurance, although with substantial regional variation—take-up rates are much higher in coastal areas of the south and east coasts (Kousky, Kunreuther, Lingle, & Shabman, 2018).

Maps produced by the Federal Emergency Management Agency (FEMA) for the National Flood Insurance Program (NFIP) generally provide the most comprehensive and authoritative information on flood hazards available to households and communities and in some places are the only source of information on flood risks. The NFIP was developed as a partnership between FEMA and local governments. Communities can voluntarily join the program. When they do, they must adopt certain floodplain regulations and in exchange their residents are eligible to purchase flood insurance. As of January 2018, there were over 5 million policies in force nationwide. For more background on the NFIP (see Kousky, 2018).

The FEMA maps, called Flood Insurance Rate Maps (FIRMs), focus on demarcating Special Flood Hazard Areas (SFHAs), which indicate the 100-year floodplain or area with a 1 percent annual chance of inundation each year. For more information on the mapping program, see: (Bellomo, 2014; Platt, 1999; Technical Mapping Advisory Council, 2015). Identifying the SFHA has historically been necessary for the program in order to enforce flood insurance purchase requirements, guide local floodplain management regulations, and for pricing of flood insurance policies (FEMA, 2016c). Despite being primarily designed for program implementation, FIRMs are also the main source of flood risk information freely available to local communities.

FIRMs have been criticized over the years for many reasons: they don't include all sources of flooding (Ramirez, 2017), they create misperceptions about the risk (Thompson, Meyer, & Shaw, 2013), they may not reflect recent development—in some places for decades (Crow, ; Keller, Rojanasakul, Ingold, Flavelle, & Harris, 2017), and they use poor data and do not reflect a changing climate (Joyce, 2016). Despite their importance, only 52 percent of the nation's flood maps were considered accurate as of 2014, with an additional 4–10 percent becoming no longer current each year (Wilson 2014). Recent work suggests that rather than the 13 million individuals estimated to live in SFHAs as calculated by FEMA's FIRMs, in fact nearly 41 million Americans may be at risk of the one percent annual exceedance probability (100-year) flood (Wing et al., 2018). Congress mandated in the Biggert-Waters Flood Insurance Reform Act of 2012 that FEMA find strategies within its mapping program to address limited historical data, infrequent yet controversial map updates, and its lack of accounting for projected climate change impacts. Rapid improvements in risk assessment technology have encouraged private sector participation and partnership in the production of risk information, but have not addressed the underlying challenges for public flood mapping.

We focus in this paper on the map updating process and concerns about out-of-date maps. Revising FIRMs is complex, costly, and often controversial. In particular, one major issue is that updates take a long time—the ideal timeline is 25 months, but the process may actually take 3–5 years or more (Technical Mapping Advisory Council, 2015). Delays in map updates leave households and communities without accurate information on their risks and prevent floodplain regulations, insurance requirements, and insurance prices from reflecting the current underlying risk.

Using information on FEMA map adoptions between June 2014 and 2017, this paper provides a new quantitative analysis of county-level map adoption. We find statistically significant process heterogeneity by region (coastal versus inland), race, risk levels, wealth, and political leanings. These correlations raise important questions for policymakers about the equity and effectiveness of map updates. In addition, we provide additional analysis of preliminary map revisions in coastal communities.

Background on FEMA's Flood Insurance Rate Maps

This paper examines how flood risk maps are produced, updated, and adopted. FIRMs serve a public good by providing nationally-consistent and reliable information on flood hazards, which some communities do not have the resources or ability to access or analyze themselves (Fischbach & Knopman, 2015). Accurate flood hazard maps are necessary for informed floodplain development, but as currently produced, they may not be meeting risk information needs. While there are many concerns about the maps, we focus on the process and timing of map updates.

With the National Flood Insurance Reform Act of 1994, Congress mandated that FEMA update flood hazard maps every 5 years (with over one hundred thousand panels) for the more than twenty-two thousand jurisdictions participating in the NFIP. As of 2017, however, 63 percent of communities had effective maps that were more than 5 years old, with some even dating back to the start of the program over 40 years ago (Horn & Brown, 2018; Office of Inspector General, 2017). Furthermore, an additional 4–10 percent of maps become no longer current each year as either data and models improve or the built environment changes (Wilson, 2014).

New maps are necessary when data or modeling is updated or improved or when the flood hazard changes. Specifically, maps should be updated if the pervious cover in the watershed has changed, if erosion or subsidence has advanced, if any structural flood protection has been erected, if sea level rise or other climate changes have altered the nature of the flood risk, or if new or better data or models become available. When changes are minor or in sparsely populated areas, the benefits of updating the map may not justify the expenditure. This, coupled with funding constraints, has led to FEMA to adopt a prioritization process for map updates based on where development is greatest and maps most outdated. Still, funding levels have historically proven inadequate to meet either Congress or FEMA's own goals for management, validity, and compliance. There remains a challenge of appropriately allocating scarce mapping dollars to the communities most in need of map revisions. How this prioritization process could be improved is an important policy topic, but beyond the scope of this analysis.

When FEMA maps the flood hazards in a given community, it generally produces a Flood Insurance Study and a FIRM. FIRMs delineate the Special Flood Hazard Area (SFHA), which is equivalent to the 1 percent annual chance (or 100-year) floodplain. The SFHA contains two zones. The A zone is the 1 percent annual chance floodplain in inland areas or in coastal areas where wave action is projected to be under 3 feet. V zones are on the coast where wave action would exceed 3 feet. The V zone is a very small area geographically and responsible for only roughly 1 percent of policies nationwide (Kousky, 2018). For both zones, newer FIRMs also show the base flood elevation (BFE), or the estimated height of water in a 1 percent annual chance flood.

FIRMs are used for many operational and regulatory aspects of the NFIP. The flood zone and the BFE are inputs into premium setting, according to rate tables established by the program. For more details on rate-setting in the program, see Kousky, Lingle, & Shabman (2017). The FIRM is used to enforce the mandatory purchase requirement, which requires lenders to mandate flood insurance on federally backed or regulated loans in the SFHA. And the effective FIRM must be used as the basis for the community floodplain regulations that are required for community participation in the NFIP. These requirements apply to new construction in the SFHA and while they vary by zone, generally require new buildings to be elevated above the BFE shown on the current FIRM.

With almost one hundred thousand individual FIRM panels, maintaining up-to-date maps is a significant endeavor. Even after the Map Modernization (FY2003–2008) and Risk Mapping, Assessment, and Planning programs (FY 2010–2014) intended to address this and other tasks, at the end of 2016, over half of FEMA's inventory required a re-study or had not yet been assessed (Office of Inspector General 2017). We turn now to a detailed description of the updating process.

Description of the Map Update and Adoption Process

As stated above, given limited resources, FEMA uses a rough benefit-cost approach to prioritize map updates where there is either outdated information or rapid development, though communities may also petition for an update of their own maps (FEMA, 2017a). With input from state and local officials, FEMA considers changes to seventeen physical, climatological, and engineering variables including current flood risk, elevation data availability, and changes in population, infrastructure, or land use (FEMA, 2015a, 2016b). A major loss event, in and of itself, is not enough to precipitate a new modeling exercise, despite a community perhaps either experiencing a change in the perception of flood risk or wanting to recover with the best available information.

Upon determination that a map update is warranted and feasible, FEMA's regional contractors typically take 2 years to gather hydrological, infrastructural, hydraulic, land use, and other existing map data and to develop the models that support the initial work maps for the county or watershed. This is followed by approximately a year of quality review, which includes a Flood Risk Review Meeting or Resilience Meeting with local officials. The information is compiled into a formal FIS, which provides detailed flood risk and elevation data on a community's waterways, lakes, and coastal zones.

FEMA estimates that the ideal Risk MAP project should last 25 months, though few do in actuality (Figure 1). According to an estimated timeline provided by the Technical Mapping Advisory Council (TMAC), the first stage, project planning by the contractor and discovery with community officials, should take 5–7 months. Creating the preliminary FIRM should then take 11–21 months for the necessary data development and outreach. At this point, FEMA issues the preliminary FIRM. Adoption by the community may take another 9–15 months. Altogether, TMAC estimates that the typical update and adoption process takes 3–5 years, but sometimes takes 6 or more (Technical Mapping Advisory Council, 2015). That is, the process of updating maps can take longer than the frequency with which FEMA is mandated by Congress to review the maps.

The adoption process is the source of greatest delay. Focusing on this portion, after FEMA releases and presents the preliminary FIRM, a Consultation Coordination Officer reaches out to community officials. FEMA then hosts public meetings to explain the documents to the broader community and collect comments. Roughly 30–60 days after the initial map release, FEMA announces the start of a 90-day appeal period. We define this as the "Preliminary Map Phase," in other words the 90–150 days from when the preliminary FIRM is first issued to when the appeal period begins.

If a community finds scientific and technical concerns during the roughly 3-month appeal window, it may choose to hire and coordinate consultants to compile information documenting why a revision to the preliminary FIRM is necessary. If an appeal is filed, FEMA addresses the validity of the inquiry. Should FEMA's reviewers substantiate these concerns, contractors may issue a revised preliminary map (subject to review by the community once again). If a community and FEMA are unable to come to an agreement after at least 60 days of public consultation after the close of the appeal period, the two parties form a Scientific Resolution Panel managed by the National Institute of Building Sciences to independently review the technical details (RiskMAP, 2016). Although we do not evaluate them, individual property owners and areas smaller than a county or municipality can petition FEMA to be excluded from the SFHA via a Letter of Map Amendment or Revision process.

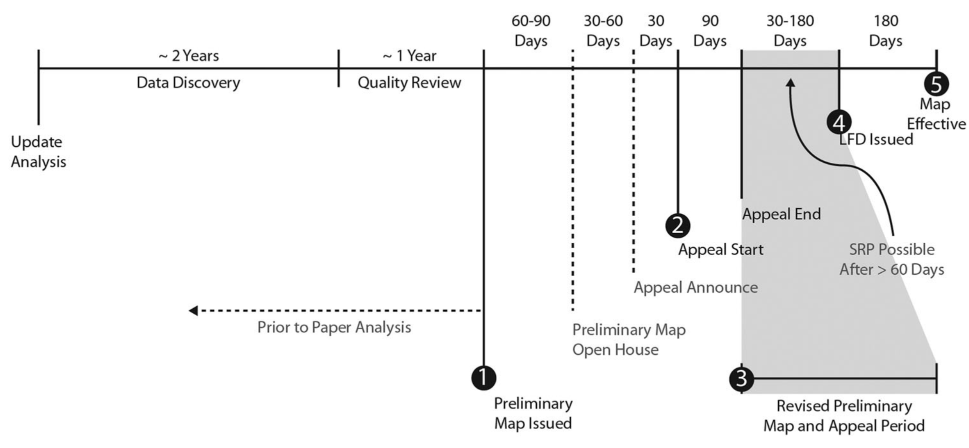

Figure 1. Typical Flood Insurance Rate Map Adoption Process. *Notes:* Analysis considered the beginning of the process as the date of preliminary map issuance. Numbered milestones correspond to actions taken by the administrator in Federal Emergency Management Agency's notices to Congress.

At this point, FEMA should have resolved all valid scientific and technical community-level concerns. The NFIP administrators then finalize the new FIS and FIRM panels, sending out a "Letter of Final Determination." This letter presents the flood hazard data and establishes the effective date for the new FIRM and FIS. This also initiates a 6-month period during which the community is required to update its floodplain management regulations reflecting the new map in order to remain in the NFIP. Simultaneously, Flood Zone Determination Companies use the updated maps to inform lenders and federally insured mortgage holders of whether their property is located in the SFHA and, therefore, requires flood insurance coverage (FEMA, 2016a). In this analysis, the "appeal phase" is the time from when the appeal period begins to when either FEMA issues the Letter of Final Determination or when the community receives a revised preliminary map. Likewise, when applicable, we consider the "revised preliminary map phase" to extend from the issuance of the revised maps to the Letter of Final Determination.

Methodology to Evaluate County-Level Map Adoption Heterogeneity

To examine this topic, we compiled a new nationwide data set of map adoptions between 2014 and 2017. The NFIP reform legislation of 2012 and 2014 directed FEMA to notify Members of Congress when flood maps were being updated. These notifications are publicly available in the FEMA online library for 2014, 2015, 2016, and 2017 (FEMA, 2014, 2015b, 2016d, 2017d). Examining two thousand and ninety-seven actions taken by the administrator from June 2014 to 2017, the data set contains one thousand and five hundred events that represented the release of preliminary maps, the start of an appeal period, or the issuance of revised preliminary maps (excluding Letters of Final Determination or when the maps were made effective). We cleaned the data so that only multiple actions on the same case number remained (i.e., Plymouth County, MA had case 12-01-1695S for release of a Preliminary Map on May 23, 2014, began an Appeal Start on August 7, 2014, issued its Letter of Final Determination on January 16, 2015, and made its maps effective on July 16, 2015). We then calculated the duration of each phase of the process in days. Some places had simultaneously overlapping cases such as Travis County TX, Arapahoe County CO, or Sacramento County CA, which may have been related perhaps to process variation in FEMA Regions VI, VIII, and IX or separate revision processes in those counties. We excluded from the data set 366 yet unresolved processes.

We combined the database on duration of appeal phases with multiple other county-level data sets: sociodemographic data extracted by Social Explorer from the American Community Survey 2011–2015; FEMA loss statistics from January 1, 1978 to April 30, 2017 and active polices as of April 30, 2017 (FEMA, 2017c, 2017b); 2012 campaign finance data (Sibley, Lannon, & Chartoff, 2013); and climate change opinions (Howe, Mildenberger, Marlon, & Leiserowitz, 2015). We also assigned counties (or mapping jurisdictions in the cases of New York City and the Hampton Roads region, for example) a coastal dummy variable of "1" if they fell along the

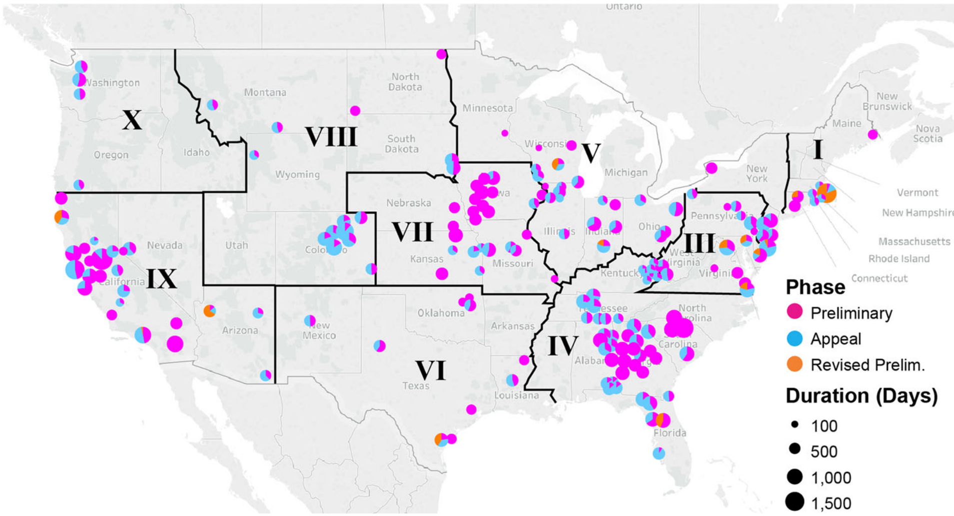

Figure 2. Subsample of One Hundred and Eighty-One Jurisdictions With Completed Map Adoption Processes From June 2014 to 2017.

Atlantic, Gulf, or Pacific coasts according to NOAA (Strategic Environmental Assessment Division, 1998). These data, which includes socioeconomic characteristics, NFIP participation rates, political leanings, and scientific beliefs, were chosen because they have been discussed in prior literature or public debates as influencing flood mapping (Akbar & Aldrich, 2015; Bakkensen & Barrage, 2017; Baldauf, Garlappi, & Yannelis, 2018; Keller et al., 2017; Maantay & Maroko, 2009; Pralle 2017, 2018; Sarmiento & Miller, 2006). Many of our variables serve as proxies for community size, wealth, and risk expertise, which we hypothesize, based on both academic literature and news articles on the topic, will influence the interest and ability of a community to contest flood maps. For example, at the individual level, the personal characteristics of residents who participate in flood recovery influence the broader community's flood risk perception (Albright & Crow, 2015) and the strength of individual participation rates influence the relative success of flood mitigation programs (Oulahen & Doberstein, 2012). We also hypothesize there may be more revisions in areas where the map impacts a larger number of homeowners. Flood insurance is mandatory for properties in the SFHA designated on the FIRM if they have a loan from a federally backed or regulated lender. We thus include in our data the number of homes with a mortgage, but unfortunately, we do not have the number nationwide broken down by flood zone, nor the property value by flood zone.

We explored initial statistical and spatial associations using Tableau and Microsoft Excel pivot tables. Using Stata IC 15.1, a Kolmogorov–Smirnov test confirmed that process durations were not normally distributed, therefore relationships were tested with Spearman's rank correlations, Wilcoxon–Mann–Whitney tests, as well as logistic and multiple regression analyses.

Descriptive Statistics and Results

The final data set represents a total of 441 counties across all FEMA regions (though with different proportions of representation). From the one thousand and five hundred actions described in Section 4, we further excluded locations that either began their process before our 3-year period or had ongoing appeals/ revisions and yet to receive a Letter of Final Determination, focusing on a subsample of six hundred and twenty-three actions in one hundred and eighty-one jurisdictions (Figure 2).

For the communities that completed a preliminary map, appeal, and/or revised preliminary map phase, Table 1 shows the total number of days spent in each phase of the process. On average, the preliminary map phase took 291 days ($n = 302$), the appeal period took 296 days ($n = 241$), and the revised preliminary period took 228 days ($n = 84$). This compares to anticipated ranges of 90–150 days for preliminary maps and 120–270 days for their appeal periods. FEMA does not advise about the length of a typical revised preliminary map phase. All the processes exhibited large standard deviations (greater than 150 days) with some outliers taking a considerable amount of time.

On average, the adoption process took 531 days. Despite the subsample's conservative inclusion criteria (e.g., ongoing actions that could result in larger time frames were not included), the data shows that flood map adoptions are fraught with delays, with a quarter taking longer than 659 days to complete. The extreme cases are of potential concern. For example, in contrast to the average preliminary map adoption phase 291 days ($n = 14$), Plymouth County, MA took 572 days (and 1,028 days overall).

Figure 3 demonstrates the length of time the various parts of the map adoption process take for communities to complete. The bars are counts of communities where the process took the number of months shown on the x-axis, and exhibits a long-tailed distribution. There is substantial heterogeneity in the time to adopt maps, with the process far exceeding the time FEMA estimates the process should take in many instances. It is impossible to attribute the cause of deviations from the typical process. This may happen for many reasons, including the need for more scientific data, technical challenges, and community opposition.

Table 1. Comparison of Typical and Observed Map Update Phase Durations

	Start Administrator Action	End Administrator Action	FEMA Advised Typical Duration	Observed Average Duration	75th Percentile Observed Duration
Preliminary map phase	Issuance	Appeal start	90–150 days	291	405
Appeal phase	Appeal start	LFD or revised prelim. issued	120–270 days	296	378
Revised prelim. phase	Issuance	LFD	N/A	228	302

Note: LFD is Letter of Final Determination.

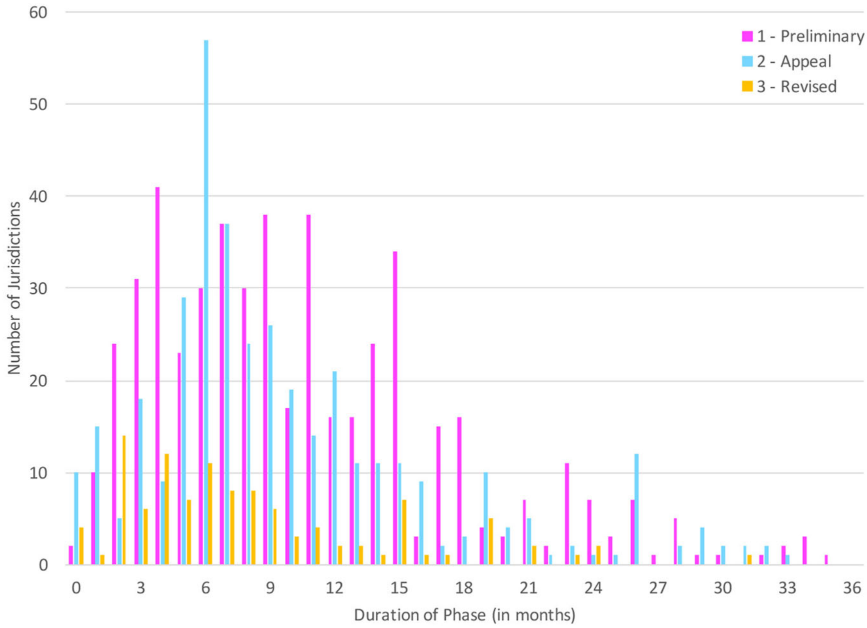

Figure 3. Duration of Adoption Phases.

In addition, there is substantial regional variation in process duration (Figure 4). For example, Regions II, IX, and X have longer appeal processes, and Regions V and IX have longer revisions than average (see Table 2 for states in each FEMA region). Of note, Region IV has a longer preliminary process yet decreased likelihood of a revision (perhaps in part due to the influence of North Carolina's mapping technology and outreach programs).[1] Statistical analysis confirms that although FEMA Regions did not have a significant difference in preliminary map process length ($X^2(9) = 15.552$, $p = 0.077$), they did for the appeal ($X^2(9) = 19.256$, $p = 0.023$) and revision ($X^2(7) = 15.298$, $p = 0.032$) processes, according to a Kruskal–Wallis equality-of-population rank test.

We find heterogeneity in the map adoption process was associated with differing risk levels, sociodemographic characteristics, political leanings, and climate opinions. Counties with a lower percentage of non-white residents had

Table 2. List of States by Federal Emergency Management Agency Region

Region I	Region II	Region III	Region IV	Region V	Region VI	Region VII	Region VIII	Region IX	Region X
CT	NJ	DC	AL	IL	AR	IA	CO	AZ	AK
ME	NY	DE	FL	IN	LA	KS	MT	CA	ID
MA	PR	MD	GA	MI	NM	MO	ND	HI	OR
NH	VI	PA	KY	MN	OK	NE	SD	NV	WA
RI		VA	MS	OH	TX		UT	Pacific	
VT		WV	NC	WI			WY	Islands	
			SC						
			TN						

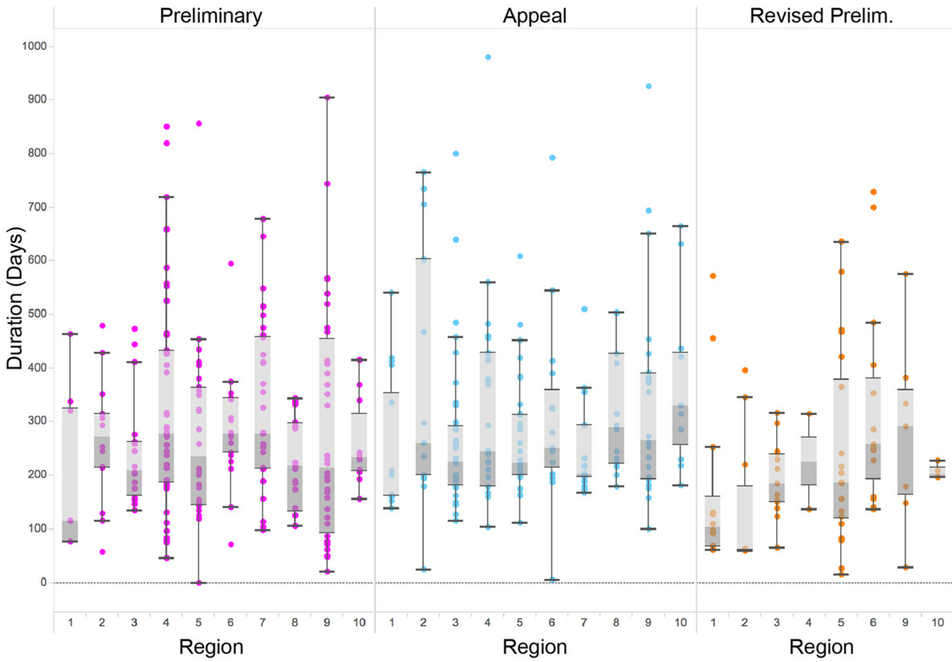

Figure 4. Duration of Map Phases by Region.

longer preliminary ($\rho = -0.130$, $p < 0.05$), appeal ($\rho = -0.134$, $p < 0.05$), and revision ($\rho = -0.009$, $p < 0.05$) phases. This was the only policy, socioeconomic, political, or climate belief variable that was significantly correlated with all three adoption phases. Four other variables were significantly correlated with more than one longer phase. Counties with higher average premiums per housing unit and a smaller percentage of homes with mortgages had shorter appeals (premiums: $\rho = -0.154$, $p < 0.05$; mortgages: $\rho = 0.145$, $p < 0.05$) but longer map revisions (premiums: $\rho = 0.330$, $p < 0.01$; mortgages: $\rho = -0.234$, $p < 0.05$). Counties with higher home values and greater per capita contributions to the 2012 electoral campaign had shorter preliminary maps (home value: $\rho = -0.129$, $p < 0.05$; contributions: $\rho = -0.152$, $p < 0.01$) and map revisions (home value: $\rho = -0.280$, $p < 0.05$; contributions: $\rho = -0.245$, $p < 0.05$). This deserves further investigation, as process length may not necessarily be an indicator of more accurate maps. Several other variables were correlated with only one phase; since some of these correlations are likely to be spurious, we test them with a regression model in Section 6.

Analysis and Multiple Regression Model

Given the complexity of data collection, risk modeling, and accurate mapping, unforeseen scientific and technical challenges may have the effect of cumulative delays. Delays could result in improved maps if a community has acquired better

Table 3. Comparison of Counties with Revision Processes

	All (n = 332)		Revision (n = 96)		Significance	
	Mean	Std. Dev.	Mean	Std. Dev.	z	p
FEMA data						
Premiums/housing unit	0.204	1.025	0.100	0.304	1.902	0.057
Premiums/payments	448.403	3151.51	1,078.264	5,225.059	−3.421	0.001***
Payments/housing unit	818.997	7,771.67	2,357.653	14,379.35	−2.924	0.004**
ACS 2011–2015 data						
Population density/square mile	526.091	1,380.746	860.865	2,090.772	−3.297	0.001***
% Non-White	0.179	0.151	0.190	0.163	0.729	0.466
% Adults with college	0.160	0.063	0.182	0.062	−4.397	0.000***
Per capita income ($2015)	27,540.91	6,579.609	29,860.75	6,643.892	−4.365	0.000***
% Homes with mortgage	0.603	0.111	0.621	0.110	−1.750	0.080
% Single family housing	0.741	0.098	0.726	0.115	1.410	0.159
Median year of construction	1,974.566	11.905	1,974.452	10.794	0.692	0.489
Median home value ($2015)	180,649.2	109,758.7	214,886.0	114,098.5	−4.384	0.000***
Sunlight data						
Per capita contribution to 2012 electoral campaign	8.392	26.289	9.195	10.302	−3.281	0.001***
% Difference 2012 Republican/ Democratic party contributions	0.309	0.415	0.211	0.427	2.564	0.010*
Yale climate survey data						
% Trust climate scientists	69.031	4.579	70.651	4.272	−4.087	0.000***
% Warming happening	67.401	0.329	69.614	5.664	−3.979	0.000***
% Warming human cause	50.673	5.426	52.603	5.368	−3.905	0.000***
% Believe scientific consensus warming	46.079	7.278	48.828	7.051	−4.146	0.000***
% Worried about warming	54.943	6.5555	57.128	6.673	−3.653	0.000***
% Warming personal harm	37.280	4.443	38.330	4.961	−2.548	0.011*
% Warming harm United States	55.298	4.994	56.888	5.273	−3.469	0.001***
% Warming harm future generations	67.810	5.064	69.626	4.860	−3.875	0.000***

Note: Statistical significance of Wilcoxon–Mann–Whitney test indicated by $^{*}p < 0.05$, $^{**}p < 0.01$, and $^{***}p < 0.001$.

data or found errors in the mapping methodology. On the other hand, delays that are unwarranted could prevent updated risk information from being incorporated into regulations and decisions. The ability of communities to evaluate and reform their maps may also vary substantially, potentially creating inequities in the provision of risk information. Indeed, if counties have a map revision, a shorter process is associated with well-educated residents, a greater share of homeowners with a mortgage, and with greater beliefs in global warming who lean Democratic and contribute more to political campaigns. We turn now to regression models to examine these relationships in more detail—and in particular, examine whether in the overall duration of the map adoption process a community elects to lodge an appeal and experiences a revision.

Of the three hundred and thirty-two jurisdictions that completed an appeal process, ninety-six communities successfully petitioned for a revision, whereas two hundred and thirty-six places did not lodge a scientific/technical appeal or were unsuccessful in doing so (our data set does not distinguish). Counties that had a

Table 5. Comparison of Inland Versus Coastal Counties

	Inland (*n* = 217)		Coastal (*n* = 115)		Significance	
	Mean	Std. Dev.	Mean	Std. Dev.	*z*	*p*
FEMA data						
Premiums/housing unit	0.188	0.451	0.234	1.623	3.334	0.001***
Premiums/payments	143.580	1,518.17	1,014.109	4,872.331	−4.648	0.000***
Payments/housing unit	186.074	351.134	1,999.313	1,3102.21	−4.295	0.000***
ACS 2011–2015 data						
Population density/square mile	268.636	487.147	1,007.125	2,167.129	−6.198	0.000***
% Non-White	0.140	0.132	0.251	0.159	7.056	0.000***
% Adults with college	0.150	0.063	0.179	0.057	−4.947	0.000***
Per capita income ($2015)	26,018.06	5,414.674	30,386.25	7,572.941	−5.602	0.000***
% Homes with mortgage	0.586	0.111	0.636	0.102	−4.273	0.000***
% Single family housing	0.758	0.081	0.709	0.117	4.004	0.000***
Median year of construction	194.239	12.624	1975.175	10.456	−0.529	0.597
Median home value ($2015)	140,999.1	69,113.81	254,732.5	131,503.3	−9.732	0.000***
Sunlight data						
Per capita contribution to 2012 electoral campaign	8.092	31.684	8.951	10.489	−3.558	0.000***
% Difference 2012 Republican/ Democratic party contributions	0.420	0.363	0.103	0.427	6.351	0.000***
Yale climate survey data						
% Trust climate scientists	67.435	4.073	72.014	4.579	−8.718	0.000***
% Warming happening	65.263	5.200	71.397	5.144	−8.919	0.000***
% Warming human cause	48.763	4.563	54.241	5.115	−8.553	0.000***
% Believe scientific consensus warming	43.577	6.212	50.753	6.826	−8.438	0.000***
% Worried about warming	52.418	5.315	59.663	6.039	−9.394	0.000***
% Warming personal harm	35.681	3.424	40.268	4.596	−9.023	0.000***
% Warming harm United States	53.425	3.964	58.800	4.847	−9.095	0.000***
% Warming harm future generations	65.988	4.372	71.215	4.489	−8.783	0.000***

Note: Statistical significance of Wilcoxon–Mann–Whitney test indicated by *$p < 0.05$, **$p < 0.01$, and ***$p < 0.001$.

Table 4. Logistic Regression Model Results for Counties with Revision Processes

					95% Confidence Interval	
	Coefficient	Std. Err.	*z*	*p*	Lower	Upper
Coastal	0.836	0.314	2.66	0.008**	0.221	1.451
Premiums/housing unit	−0.313	0.383	−0.82	0.414	−1.064	0.438
Payments/housing unit	0.001	0.003	2.71	0.007**	0.000	0.001
Population density/square mile	0.000	0.000	1.41	0.159	−0.000	0.000
% Non-White	2.590	1.210	2.14	0.032*	0.219	4.961
% Adults with college	9.146	4.294	2.13	0.033*	0.730	17.56
Per capita income ($2015)	−0.000	0.000	−0.57	0.566	−0.000	0.000
Intercept	−4.513	1.167	-3.87	0.000***	−6.800	−2.227

Note: Logistic regression results with a LR $X^2(317)=47.90$, $p < 0.001$. Statistical significance of logit model indicated by *$p < 0.05$, **$p < 0.01$, and ***$p < 0.001$.

higher Wilcoxon–Mann–Whitney rank for revised maps than expected (in other words, more likely to have had a revision than the mean probability) were associated with a higher ratio of premiums to insurance payments ($z = -3.421$, $p < 0.001$), higher average payments (claims) per housing unit ($z = -2.924$, $p < 0.01$), higher population densities ($z = -3.297$, $p < 0.001$), a greater percentage of college-educated adults ($z = -4.397$, $p < 0.001$, greater per capita income ($z = -4.365$, $p < 0.001$), higher median home values ($z = -4.384$, $p < 0.001$), greater per capita contributions to the 2012 electoral campaign ($z = -3.281$, $p < 0.001$), greater Democratic leanings ($z = 2.564$, $p < 0.01$), and greater percentage of individual global warming beliefs (various, all $p < 0.05$). The county's percentage of non-white population did not have a significant relationship with whether that community had revised maps (Table 3).

A logistic regression tested whether our independent variables were predictive of whether a county had a revision (results presented in Table 4). We find that controlling for our other factors, a coastal county is 2.3 times more likely to have a map revision ($\beta = 0.724$, $z = 2.66$, $p = 0.008$). Inland communities with revisions are $2,184 wealthier per person than other inland communities that do not have revised maps, whereas coastal communities with revisions are only $285 wealthier than

Table 6. Multiple Regression Model of Map Adoption Process Duration

	Preliminary	Appeal	Revision
Coastal	6.546	−4.128	−65.462
	(23.272)	(23.846)	(38.620)
	0.779	0.863	0.094
Premiums/housing unit	−2.361	−5.076	42.891
	(21.676)	(8.400)	(51.408)
	0.913	0.546	0.407
Payments/housing unit	−0.005	0.079	0.000
	(0.005)	(0.023)	(0.001)
	0.285	0.001***	0.717
Population density/square mile	−0.020	0.001	−0.015
	(0.009)	(0.009)	(0.009)
	0.024*	0.906	0.114
% Non-white	258.168	95.876	154.823
	(79.121)	(83.927)	(140.824)
	0.001***	0.255	0.275
% Adults with college	−440.974	386.541	186.922
	(317.145)	(307.607)	(534.849)
	0.166	0.210	0.728
Per capita income ($2015)	0.002	−0.000	−0.002
	(0.003)	(0.003)	(0.005)
	0.418	0.947	0.740
Intercept	252.051	204.476	257.891
	(49.945)	(49.961)	(99.376)
	0.000***	0.000***	0.011*
F	(7, 279)	(7, 225)	(7, 72)
p	0.012*	0.007**	0.404
R^2	0.062	0.082	0.093

Note: Multiple regression results include coefficient (standard error), and significance p indicated by *$p < 0.05$, **$p < 0.01$, and ***$p < 0.001$.

other coastal jurisdictions (note coastal jurisdictions are generally wealthier on average than those inland), though these differences do not appear to be significant. Average annual flood claims were also significant ($p = 0.007$), whereas annual premiums, population density, and per capita income are not significant predictors after controlling for other factors, despite strong initial correlations.

Coastal areas are different along a number of dimensions than inland communities. All of our independent variables differ across coastal and inland areas ($p < 0.001$) with the exception of median year of home construction (Table 5). Controlling for all these factors, however, we still find an influence of coastal location on map revision ($X^2 = 18.153$, $p < 0.001$***). This could be due to the different nature of mapping coastal areas, the nature of changing flood risk in coastal areas, or the politics of risk in coastal areas where the amenities values of the risky area are quite high. A recent report from the Congressional Budget Office found that premiums are substantially less than expected costs in coastal counties, in part because many coastal premiums do not include the full expected costs from storm surge (Congressional Budget Office, 2017). This no doubt contributes to the map revision dynamic between coastal and inland areas.

Coastal location also has a differential association with map adoption phase duration. We find that the preliminary map review phase takes about the same time for inland and coastal areas, but the appeal period takes on average a month longer for coastal communities. Among counties that do appeal and get revised maps, FEMA considers the disproportionate number of revised preliminary maps for coastal areas ($n = 45$) for almost 2.5 months less time. Using an ordinary least squares multiple regression model, we find that these coastal location differences are not significant predictors of process duration. For preliminary maps, only the population density ($p < 0.05$) and percentage of non-white population ($p < 0.001$) were significant predictors of duration (Table 6). For the appeal process, only the average payments per housing unit was a significant predictor ($p < 0.001$). These did, however, result in statistically significant models that explained approximately 6 and 8 percent of the variation (R^2 statistic), respectively. There were no significant predictors of revision process duration, nor was the model statistically significant. This reinforces the heterogeneity of the process and the need for additional survey research or detailed case studies to understand the interrelationships of the variables, particularly the differences between coastal and inland communities. Such studies would be a useful complement to this one.

Discussion and Conclusion

With a novel data set of filings related to map revisions, we find that there is clearly heterogeneity across communities in the time taken for map adoption. We were able to uncover a few sources of this variation. First, there seems to be a split between coastal and inland counties. The preliminary map review phase takes about the same time for inland and coastal areas (despite different methodology in coastal and inland areas) but the appeal period takes on average a month longer for coastal communities. Among those that do appeal and get revised maps, they are considered for almost 2.5 months less time in coastal communities. We also see differences between communities according to income. Inland communities with revisions are on average $2,184 wealthier per person than other inland communities that do not appeal their maps, whereas coastal communities with revisions are only $285 wealthier than other coastal jurisdictions (note coastal communities tend to be wealthier on average than inland communities). While we cannot untangle mechanisms behind these correlations, this does point to several areas worthy of more investigation and further policy analysis; we highlight a few here.

First, adoption takes a long time and there are often many delays in all phases of the process. There may be good reasons for this—for example, corrections for accuracy. Arbitrary timetables and deadlines should not stand in the way of public engagement. These delays are problematic, however, when they limit the incorporation of new risk information into the program and into floodplain regulations. If this happens, construction practices may be inconsistent with current risks. This is of greater concern in areas experiencing a changing built environment from development pressures, or those rebuilding after a storm. Since SFHAs are the basis of NFIP rates, having up-to-date maps is also essential for accurate pricing, which send financial signals on risk to the housing market.

Second, it is concerning that there are significant variations in map revisions across inland and coastal areas. There have been accusations in the media that coastal communities are in a better position to exert political leverage to effect revisions to faulty maps (Skibba, 2017). This is in part because the appeal effort must be substantiated by costly and sophisticated scientific and technical data compiled inside of the 90-day period. This is often beyond the means of less wealthy or more politically fragmented communities. If revisions result in improved outcomes for communities, it suggests a need for assistance in appeal costs for lower-income jurisdictions to provide them with commensurate technical expertise for investigation of their maps. While the data does not speak to whether there may be political bias in appeals, the goal of the FIRMs is to be objective, scientific depictions of flood risk. If appeals are occurring for other reasons, that merits further research.

Last, mapping takes resources and for FEMA to deliver high-quality maps in reasonable amounts of time, they need adequate funding. There have been calls by many stakeholders, members of Congress, and FEMA's own TMAC to ensure it has the funding it needs for accurate mapping and outreach. Furthermore, state, local, tribal, and territorial partners will be necessary for public engagement and building broader awareness of revisions to flood maps. The private sector may also be able to offer its own data and tools to supplement the NFIP's regulatory, insurance, and advisory products.

Finally, there is more research necessary on identifying the mechanisms by which different community attributes are correlated with variations in the timing of issuing flood maps. Such relationships could be explored with survey or case study methodologies to determine, for example, why counties with a lower percentage of non-white residents had longer preliminary, appeal, and revision phases or what drives the differences between coastal and inland areas. As FEMA seeks to meet its internal goals for new, valid, and updated engineering maps and improve its external risk communications, a county-level understanding of differential map adoption durations could undergird process improvements.

As Congress continues to debate reform of the NFIP, ensuring equitable, timely, and accurate maps for all communities should be given a high priority. In addition, attention should be paid to new tools and methodologies that could allow for faster incorporation of new risk information. As flood risk increases in many communities around the country, timely risk information will be critical for guiding effective risk mitigation and resiliency decisions.

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1. This is anecdotally based on our personal conversations with several North Carolina flood risk experts in October–November 2016, as well as the state's participation on FEMA's Technical Mapping Advisory Council. More information can be found at: https://flood.nc.gov/ncflood/.

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