Online Appendix

Wetlands, Flooding, and the Clean Water Act

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Data

A1. National Land Cover Database

We derive our data on the spatial extent of wetlands from the National Land Cover Database (NLCD). The NLCD provides gridded data on land cover and land cover change in the US at 30 meter spatial resolution. The product is remotely sensed using data from Landsat Thematic Mapper (TM), and includes 21 classes of land cover. The NLCD defines wetlands following Cowardin and Golet (1995) as "areas where the soil or substrate is periodically saturated with or covered by water." It maps both woody wetlands ("areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water") and emergent herbaceous wetlands ("areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water"). Because wetlands classes are difficult to identify from Landsat TM spectral information alone, the NLCD uses of ancillary information such as National Wetlands Inventory (NWI) to provide the most accurate mapping (Homer et al., 2020).

We use Google Earth Engine to access the NLCD and derive our zip code-level data on wetland area. We classify land use codes 91 (woody wetlands) and 92 (emergent herbaceous wetlands) as wetlands, and do not distinguish between these two wetland types. We aggregate the data to the zip code level by intersecting the NLCD raster with zip code shapefiles, and then summing the total wetland area in each polygon. Summary statistics are provided in Table A1. Between 2001 and 2016, the nation lost approximately 330,000 hectares of wetland area, but these losses were offset by 306,000 hectares of wetlands gains—thus achieving at a national level the long-standing federal objective of "no net loss" of wetlands.

A2. National Hydrography Dataset

We use geospatial data on the US surface water network and hydrologic drainage areas from the National Hydrography Dataset (NHD).[15] The NHD is vector-based data that maps the Nation's rivers, streams, canals, lakes, ponds, and related features. It also includes the Watershed Boundary Dataset (WBD), which represents the Nation's drainage areas as nested levels

[15] https://www.usgs.gov/core-science-systems/ngp/national-hydrography/access-national-hydrography-products

of hydrologic units. According to the USGS, the NHD and WBD are the most up-to-date and geographically inclusive hydrography datasets for the US. We use the NHD in two distinct ways: (i) to calculate the upstream and downstream wetland area for each zip code and (ii) to compute the distance of all wetland areas in our sample from the surface water network, enabling our evaluation of the relative contribution of 'isolated' wetlands to flood mitigation.

(i) Calculating upstream and downstream wetland area for each zip code

The WBD provides a map of hydrologic units (HU), which represent the area of the landscape that drains to a portion of the stream network.[16] To construct our data, we use 12-digit hydrologic units (HUC12), which are the most spatially granular data available for the complete US. We calculate the spatial extent of wetlands upstream and downstream of each zip code using the following steps:

1) Intersect the WBD with the NLCD to determine the spatial extent of wetlands within each HUC12.

2) Construct a HUC12-HUC12 flow matrix that identifies which HUC12s are upstream and downstream of every other HUC12 in the watershed. This matrix is constructed using the $ToHUC$ attribute, which identifies which HUC12 is immediately downstream from another HUC12 unit.

3) Intersect the HUC12 flow matrix with a shapefile of zip code boundaries to generate a zip-HUC12 flow matrix that identifies which HUC12s are upstream, downstream, and inside of each zip code.

4) Use the zip-HUC12 matrix in combination with the data on wetland area within each HUC12 to calculate the spatial extent of wetlands upstream and downstream of each zip code. Notably, we exclude wetland area that lies within the focal zip code because we cannot discern whether these wetlands are located upstream or downstream of the NFIP claims we observe in that zip code.

5) Calculate the amount wetland area upstream and downstream of each zip code.

(ii) Computing the distance of wetland areas to the surface water network

We use three sets of features from the NHD to construct the water surface network for the continental US: NHDFlowline, NHDArea, and NHDWaterBody. With the aim of generating policy-relevant estimates, we subset the line and polygon features in the NHD to include only those that are included in the 2020 definition of WOTUS.[17] Specifically, we include features with the following FCodes:

NHDFlowline: 55800 (Artificial paths), 33600-33603 (Canals), 56600 (Coastline), 46000-46006 (Streams and rivers, excluding ephemeral).

[16] `https://www.usgs.gov/core-science-systems/ngp/national-hydrography/watershed-boundary-dataset?qt-science_support_page_related_con=4#qt-science_support_page_related_con`

[17] `https://www.epa.gov/sites/production/files/2020-01/documents/navigable_waters_protection_rule_prepbulication.pdf`

NHDArea: 31200 (Bay/Inlet), 33600-33603 (Canals), 46000-46006 (Streams and rivers, excluding ephemeral), 46100 (Submerged stream).

NHDWaterbody: 49300 (Estuaries), 39000-39012 (Lake/pond), 36100 (Playa).

Note that NHDFlowline and NHDArea have some overlapping FCodes. NHDFlowline are line features, and thus do not accurately represent the spatial extent of large streams, rivers, and canals. Features with widths greater than 50 feet are represented as polygons in the NHDArea dataset.

Next, we calculate the distance of all wetland areas in our sample from the water surface network in distance bands of 250 meters out to a maximum distance of 1000 meters. We do so by creating consecutive buffers around the NHD shapefile and intersecting these buffers with the data on wetland extent from the NLCD. This process is depicted in Panel B of Figure 4. Note that these distance bands are comparable to the thresholds of 1,500 feet (460 meters) and 4,000 feet (1,220 meters) from the high water mark used in the 2015 WOTUS rule (EPA & Army Corps, 2015) to determine which waters are adjacent to navigable waters.

A3. NFIP Redacted Policies Dataset

Data on our dependent variable, flood insurance claims, come from the National Flood Insurance Program (NFIP) Redacted Policies Dataset (FEMA, 2020*a*). This dataset comprises the NFIP's full claim history and represents more than 2 million transactions. We construct the dependent variable as the sum of claims payments for property damage to buildings and contents. We identify the time and location of flood damages using the $yearofloss$ and $reportedzipcode$ variables. Due to privacy concerns, the NFIP does not provide address-level data.

To match data on NFIP claims with the years in which we observe wetland extent (2001 and 2016), we average NFIP claims over the 5-year periods surrounding these dates (1999 to 2003 and 2014 to 2018). We elect to use five-year averages because the amount in NFIP loss dollars paid is highly variable across individual years due to the infrequent nature of flood events. We show the sensitivity of our main results to using alternative time windows in Appendix D.1. Summary statistics are provided in Table A1, and a map of claims is in Figure A1.

A4. Ecoregions

We assess whether the impact of wetlands on flood damages differs by geographic region (results shown in main text). Specifically, we examine the differential effect of wetlands on either side of the 100° meridian, a boundary long thought to separate the humid eastern US and the arid Western plains (Powell et al., 1879). We also evaluate the effect of wetlands in nine broad ecoregions. Ecoregions were derived by Omernik (1987) in collaboration with the EPA to highlight areas generally similar in their ecosystems and environmental resources and to serve as a spatial framework for ecosystem research and management (EPA, 2020*b*). A map of US ecoregions is shown in Figure A2.

Additional Robustness Checks

B1. Sensitivity of main results

Inclusion of more flexible controls for development. The developed area control is important to the credibility of the results, since urban expansion is correlated with both wetland loss and an increase in flood damages as people and capital move into flood-prone areas. In the main results, we include a linear control for developed area in our estimating equations. Here, we show the robustness of our results to more flexible parameterizations of developed area. Table A2 repeats the long difference, panel, and upstream-downstream differences-in-differences estimation (shown in Table 1) with binned controls for development in Panel A (binned by quartile) and a restricted cubic spline in development in Panel B (knots at quartiles). The coefficient estimates are consistent across all estimation strategies, whether the effect of development on claims is specified as linear, binned, or using a restricted cubic spline.

Controlling for changes in precipitation. One concern is that changes in wetland extents may be associated with changes in climate that also affected flood risk. For example, places experiencing increased precipitation could plausibly gain wetlands and see an increase in flood insurance claims. To test whether changes in climate are confounding our results, we re-estimate the main results shown in Table 1 with flexible controls for precipitation (binned by quartile). The results are shown in Table A3. Our point estimates remain largely unchanged, indicating that changes in precipitation are not driving our results.

Alternative temporal aggregation of NFIP claims. We only observe the spatial extent of wetlands for two time periods, but we observe NFIP claims on an annual basis. In order to conduct our analysis, we must decide how to match NFIP claims with the two periods (2001 and 2016) in which we observe wetlands. Because the amount in NFIP loss dollars paid is highly variable across individual years due to the infrequent nature of flood events, we elect to average NFIP claims over the 5-year periods surrounding these dates (1999 to 2003 and 2014 to 2018) in the main analysis. In Table A4, we show how the results differ when we instead use 3-year periods (Column 2) and 7-year periods (Column 3). Across all three methods, our main findings—that wetland loss significantly increases NFIP claims but wetland gain has no identifiable effect—holds. However, the magnitude of the estimates is somewhat sensitive, with larger effect sizes when we use a 3-year window and smaller effect sizes when we use a 7-year window. It is not surprising that the effect size differs when we include different years in the sample given how variable NFIP claims paid are over time.

Limiting the sample to flooded locations. We also examine how our results differ when we limit our sample to only include locations that experienced flooding over the study period (as indicated by having positive NFIP claims). In the main analysis, we include all localities in the US in our sample in order to estimate the average treatment effect of US wetlands. However, because flooding is an infrequent event, it is possible that large wetland losses are not associated with changes in NFIP claims in our data simply because no flood event occurred in those locations during the sample period. In column 4 of Table A4 we show that, as expected, the estimated effects are larger in magnitude when we limit our sample to only including localities with flooding. Again, we see that that wetland loss significantly increases NFIP claims but wetland gain has no identifiable effect.

Specifying the outcome as claims per policy. One threat to identification is if NFIP uptake is correlated with changes in wetland area. To address this concern, we control for the primary drivers of NFIP uptake—including population, income, number of housing units, housing values, and local governance (as measured by participation in the NFIP Community Rating System)—in our baseline specification. An alternative way to control for uptake is to specify the outcome variable as NFIP claims per policy. Unfortunately, this approach is difficult in our setting because zip code-level data on the number of NFIP policies are only available since 2009, whereas NFIP claims are available prior to 2000. Therefore, we cannot specify our outcome as the difference in claims per policy between 2001 and 2016. However, as a robustness check, we approximate the number of policies-in-force backwards to 2001 through extrapolation.

We implement this approach using a ridge regression predictive model that takes into account (i) the change in policies between 2009 and 2016 and (ii) observable factors driving NFIP uptake including population, income, number of housing units, housing values, and CRS ratings. We train and validate the prediction model on county-level data, where we can observe policies going back to 2001. Specifically, the model is trained on 80% of county-level observations and then evaluated on a 20% held-out test set to assess out-of-sample performance.

The model achieves an R-squared of 0.68 on the held-out test data, implying that we can explain nearly 70% of the variation in the number of policies in 2001 at the county-level using our predictions. We then apply the model to zip code-level data in order to estimate claims per policy in 2001 at the zip code-level. Finally, we estimate the long differences specification using estimated change in claims per policy between 2001 and 2016 as the outcome variable. Our results are shown in Column 5 of Table A4. We estimate that each hectare of wetland loss is associated with a $9.9 increase in NFIP claims per policy (significant at the 10% level). Thus our main result, that wetland loss significantly increases damages from flooding, holds when considering claims relative to NFIP policies.

Leave-one-out sensitivity analysis. We test whether our main results are driven by a particular state using a "leave-one-out" sensitivity test. This test re-runs the long differences model 49 times, each time dropping one state (or Washington D.C.) from the sample. Figure A3 plots the range of effects estimated using this procedure. The results imply that there is no one state that is fully responsible for the estimated effect of wetlands on flood damages. While some states, such as Texas, do influence the magnitude of our point estimates, this is to be expected given the size of the state and the fact that flooding is an infrequent event that does not affect all localities in all years.

Use of real values for NFIP claims. Our main results use nominal NFIP claims as the outcome variable. Table A5 shows that our results are invariant to instead using real values.

B2. Heterogeneity in wetland benefits by distance to surface water network

In this section we test whether the relationship between wetland benefits and distance to the surface water network depends on local levels of development. To do so, we re-estimate equation 7 with interactions between wetland area changes in each distance bin and a binary indicator for whether the zip code is at least 10% built-up area, as measured by the NLCD. Approximately 25% of zip codes are considered developed using this threshold.

Our findings follow the same pattern in developed areas as in the pooled sample: we find evidence that wetlands at intermediate distances from the nearest stream or river have large flood mitigation benefits ($63,276 per ha), and there is no detectable effect of wetlands that are directly connected to the surface water network or those that are further removed. In undeveloped areas, we find no evidence that wetlands at any distance from the surface water network reduce damages from flooding. These results are consistent with our findings throughout the main text that follow the intuition that wetlands ought to mitigate flood damages in areas with exposed properties, but not in undeveloped areas.

B3. Sensitivity of regional effects

We check that the regional heterogeneity we identify in the effect of wetlands on NFIP claims is not simply an artifact of where wetlands are located or where flooding occurs. To do so, we limit our sample to only include zip codes in which there was flooding over the sample periods (as indicated by positive NFIP claims) and zip codes in which there are at least 10 hectares (25 acres) of wetlands. The results are shown in Figure A5. The point estimates are highly consistent across the samples except in two regions when we limit the sample to zip codes with flooding. In the Great Plains, wetlands provide greater flood-mitigating benefits in the restricted sample, and in the Southern Highlands, wetlands appear to actually increase flood damages in the restricted sample.

B4. County-level estimates

As a robustness check, we also estimate the long differences model at the county level. The core benefit of repeating the analysis at the county level is that we can obtain data on the number of policies-in-force at the county-level going back to 2001 from Gallagher (2014), which allows us to control for NFIP uptake in the estimating equation. We estimate the same regression models as in equations (1) and (2) with and without flexible controls for the number of NFIP policies-in-force.

The results are shown in Table A6. Columns (1) and (5) do not control for number of NFIP policies. Columns (2) and (6) include linear controls for number of policies. Columns (3) and (7) include non-linear policy controls, binned by quartile. Columns (4) and (8) include non-linear policy controls, specified using a restricted cubic spline. The resulting point estimates are highly consistent across models with and without policy controls, indicating that NFIP uptake is not driving our results. Across all models, one hectare of wetland loss is associated with an increase between $8,200 and $8,800 in county-level NFIP claims. We find no significant effect of gains in wetland area on NFIP claims. These estimates are qualitatively consistent with the zip code-level estimates of wetland benefits.

Hedonic estimates

Our main results use NFIP claims as the outcome variable because they provide a direct measurement of actual damages from flooding. An alternative approach to estimating the value of wetlands is hedonic analysis. However, as discussed in the main text, we believe hedonic analysis is ill-suited to the estimation of wetland benefits since the classic hedonic model assumes a fixed housing stock. Because we are studying the conversion of wetlands into other land uses, including developed area, it is highly likely that our treatment is closely related to changes in the housing stock. Thus any effect of wetland loss on home prices cannot be interpreted as the effect of wetland loss alone—these price effects are most likely also driven by changes in the supply of housing.

Nevertheless, in this section, we conduct a hedonic analysis for completeness. Critically, we employ the upstream-downstream differences-in-differences design to try to separate the capitalization of wetland benefits into home prices from the effect of wetland loss on the supply of housing. By looking only at the effect of upstream wetlands and controlling for wetland area changes within the same zip code, we can estimate willingness to pay for the flood mitigation value of wetland benefits independent of changes in the housing stock.

The results are shown in Table A7. Positive coefficients for upstream wetland changes and wetland gains are consistent with positive impacts of wetland area on home prices. Positive coefficients on wetland loss are consistent with negative impacts on home prices (since wetland loss always takes a negative value). While all the coefficients have the expected sign (wetland loss is harmful and wetland gains are beneficial), none are significantly different from zero. These weak results are consistent with the idea that wetland benefits are unlikely to fully capitalize into home values for at least two reasons. First, heavy subsidies for flood insurance ought to prevent full capitalization of flood risk into property prices. Second, if home buyers are unaware of wetland area changes in their area or of the value of wetlands for flood mitigation, willingness to pay for this ecosystem service will not be reflected in the sales price of the home.

Table A1—Summary statistics.

	Mean	Std. Dev.	Min.	Max.
Zip code-level				
Wetland area, 2001 (ha)	1,497.4	4,848.1	0.0	260,164.8
Wetland area, 2016 (ha)	1,496.5	4,849.2	0.0	260,063.7
Wetland change, 2001 to 2016 (ha)	-0.9	105.5	-3,805.2	4,540.2
Wetland gain, 2001 to 2016 (ha)	10.9	78.6	0.0	4,540.2
Wetland loss, 2001 to 2016 (ha)	-11.8	68.6	-3,805.2	0.0
Average annual NFIP claims, 2001 ($1000)	20.1	236.0	0.0	18,289.5
Average annual NFIP claims, 2016 ($1000)	114.1	1,636.5	0.0	122,001.6
Change in NFIP claims, 2001 to 2016 ($1000)	94.0	1,569.9	−9,169.4	112,977.7

Note: Data on the spatial extent of wetlands is from the National Land Cover Database (NLCD) and is reported at a resolution of 30 meters for the years 2001 and 2016. We aggregate these data to the zip code level and calculate the change in the spatial extent of wetlands over time, differentiating between wetland gains and losses. Data on NFIP claims are from the NFIP Redacted Policies Dataset and are reported at the transition level. We aggregate these transitions to the annual level for all counties and zip codes, and calculate the claims for 2001 and 2016 as the average for the 5-year windows surrounding these dates. We include claims payouts for property damage to both buildings and contents.

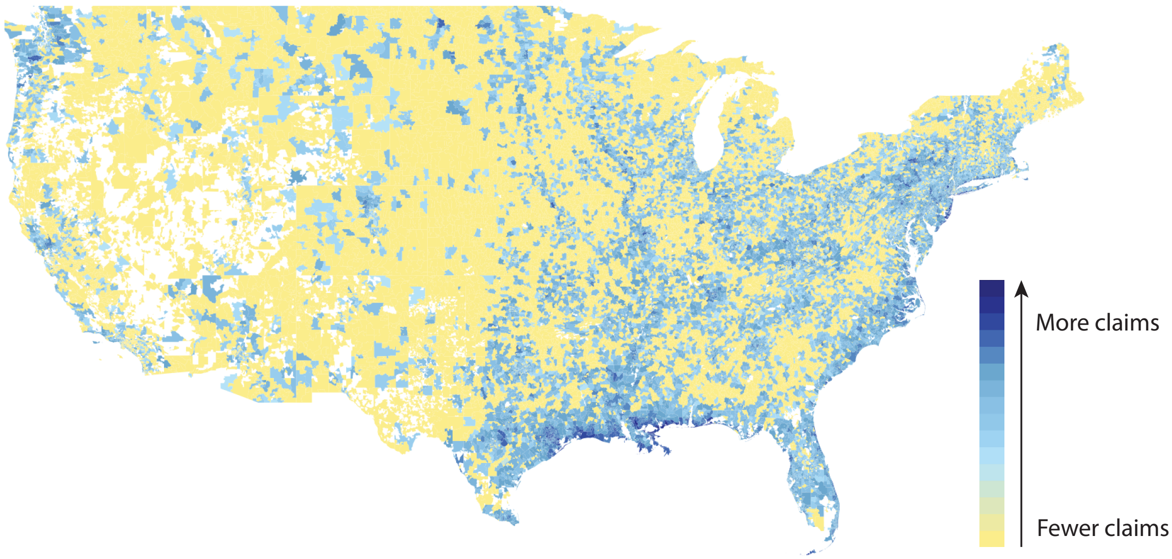

Figure A1. NFIP flood insurance claims

Note: Plots zip code-level NFIP claims for the period 2001 to 2016. Data are from the NFIP Redacted Claims Dataset and claims are calculated as the sum of payments for buildings and contents.

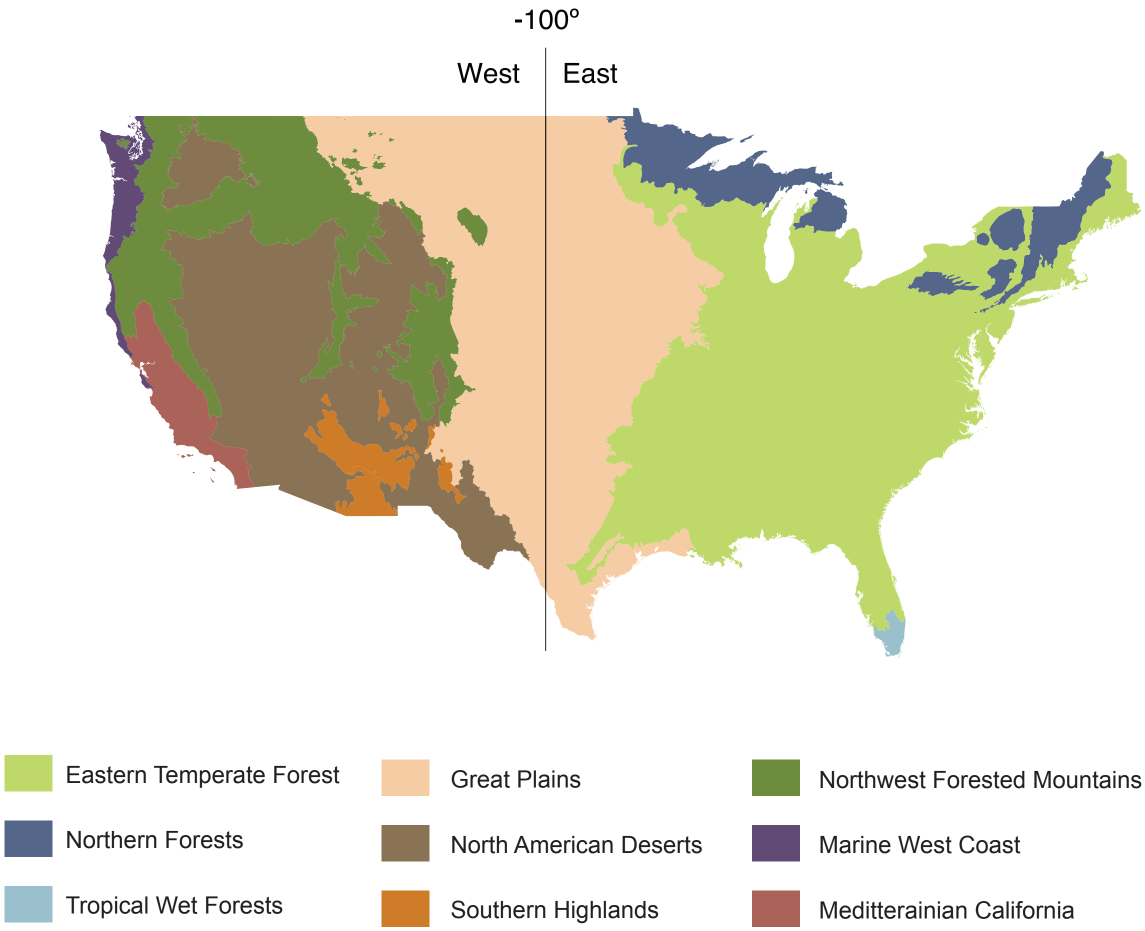

FIGURE A2. MAP OF LEVEL-1 ECOREGIONS OF THE US.

Note: We use ecoregions as the sub-samples in our regional heterogeneity analysis.

Table A2—Sensitivity of main results to using flexible controls for development.

	Dependent variable: NFIP claims					
	LD	DID	Panel	LD	DID	Panel
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Binned development controls						
Local wetland change (ha)	−273.2	−197.9	−144.9			
	(136.8)	(110.2)	(65.4)			
Local wetland gain (ha)				−30.8	33.9	184.6
				(116.5)	(74.4)	(186.4)
Local wetland loss (ha)				−582.9	−530.6	−421.5
				(273.6)	(264.0)	(261.2)
Upstream wetland change (ha)		−495.9				
		(211.0)				
Upstream wetland gain (ha)					−68.7	
					(77.4)	
Upstream wetland loss (ha)					−807.1	
					(341.2)	
Panel B: RCS development controls						
Local wetland change (ha)	−247.2	−170.8	−209.7			
	(130.9)	(103.7)	(94.1)			
Local wetland gain (ha)				−41.1	24.8	37.7
				(117.6)	(74.3)	(251.2)
Local wetland loss (ha)				−513.7	−457.7	−416.4
				(253.0)	(244.8)	(272.2)
Upstream wetland change (ha)		−499.7				
		(211.2)				
Upstream wetland gain (ha)					−78.9	
					(80.6)	
Upstream wetland loss (ha)					−804.4	
					(342.7)	
Observations	25,734	24,475	93,111	25,734	24,475	93,111

Note: Corresponds to Table 1 of the main text, where (1-3) are specified as linear in wetland changes and (4-6) as piecewise linear in wetland gains and losses. Columns (1) and (4) use long differences (LD), (2) and (5) use the upstream-downstream differences-in-differences (DID) and (3) and (6) use panel fixed effects (Panel). While the results in the main text use linear controls for developed area, the results presented here use more flexible parameterizations. Panel A bins developed area by quartile. Panel B specifies developed area as a restricted cubic spline with knots at each quartile.

TABLE A3—SENSITIVITY OF MAIN RESULTS TO ACCOUNTING FOR CHANGES IN PRECIPITATION.

	Dependent variable: NFIP claims					
	LD (1)	DID (2)	Panel (3)	LD (4)	DID (5)	Panel (6)
Local wetland change (ha)	−224.3	−155.2	−165.0			
	(127.6)	(102.0)	(74.6)			
Local wetland gain (ha)				−50.3	16.2	153.8
				(118.7)	(73.4)	(209.7)
Local wetland loss (ha)				−450.4	−408.9	−432.9
				(241.4)	(237.0)	(263.2)
Upstream wetland change (ha)		−498.8				
		(211.3)				
Upstream wetland gain (ha)					−82.2	
					(80.3)	
Upstream wetland loss (ha)					−799.7	
					(341.5)	
Observations	25,509	24,381	81,176	25,509	24,381	81,176

Note: Corresponds to Table 1 of the main text, where (1-3) are specified as linear in wetland changes and (4-6) as piecewise linear in wetland gains and losses. Columns (1) and (4) use long differences (LD), (2) and (5) use the upstream-downstream differences-in-differences (DID) and (3) and (6) use panel fixed effects (Panel). The only difference is that here we control flexibly for changes in precipitation using a flexible parameterization, where average monthly precipitation (in mm) over the same period over which claims are aggregated is binned by quartile.

Table A4—Sensitivity of the main results to different specifications of flood damages.

	(1)	(2)	(3)	(4)	(5)
Wetland gain (ha)	−24.1	−40.8	−12.7	−107.9	0.9
	(116.4)	(194.4)	(84.5)	(263.7)	(1.3)
Wetland loss (ha)	−495.3	−780.4	−385.8	−1,032.0	−9.9
	(250.8)	(408.5)	(184.6)	(534.6)	(6.0)
Observations	25,734	25,734	25,734	10,726	25,734

Note: Column (1) shows the main results for the long differences model, as reported in Table 1. Columns (2) and (3) show the estimated effects for the same regression, but calculating the NFIP claims paid as averages over 3 year and 7 year windows, respectively, rather than over a 5 year window as in the main results. Column (4) shows the results when the sample is limited to localities in which there was flooding over the sample period, as indicated by positive NFIP claims. Column (5) is an alternative outcome variable: claims per policy. Because data on zip-code level policies are not available before 2009, we predict the number of policies-in-force for 2001 using information on the change in policies between 2009 and 2016 and observed factors that influence NFIP uptake (see text for details). Standard errors are clustered by county.

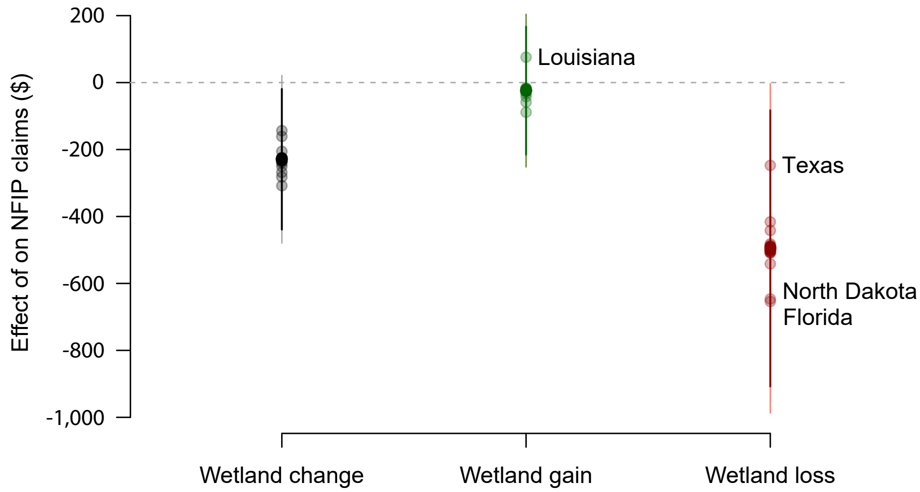

Figure A3. Leave-one-out sensitivity analysis.

Note: This test re-runs zip code-level LD model 49 times, each time dropping one state (or Washington D.C.) from the sample. Circles plot the range of effects estimated for each coefficient of interest using this procedure. Whiskers show 90% (dark) and 95% (light) confidence intervals for our main results, using the full sample of data. States with an outsized influence on the point estimates are labelled for reference.

Table A5—Sensitivity of main results to using real values for claims.

	Dependent variable: NFIP claims					
	LD	DID	Panel	LD	DID	Panel
	(1)	(2)	(3)	(4)	(5)	(6)
Local wetland change (ha)	−208.9	−147.6	−193.4			
	(120.3)	(96.7)	(91.1)			
Local wetland gain (ha)				−23.4	31.6	176.6
				(109.7)	(70.1)	(236.7)
Local wetland loss (ha)				−449.8	−415.7	−504.1
				(234.3)	(232.5)	(300.4)
Upstream wetland change (ha)		−454.8				
		(199.7)				
Upstream wetland gain (ha)					−64.5	
					(71.4)	
Upstream wetland loss (ha)					−738.0	
					(324.5)	
Observations	25,734	24,475	93,111	25,734	24,475	93,111

Note: Corresponds to Table 1 of the main text, where (1-3) are specified as linear in wetland changes and (4-6) as piecewise linear in wetland gains and losses. Columns (1) and (4) use long differences (LD), (2) and (5) use the upstream-downstream differences-in-differences (DID) and (3) and (6) use panel fixed effects (Panel). While the results in the main text use nominal values for NFIP claims, the results presented here use real (deflated) values. We use the Gross Domestic Product: Implicit Price Deflator [GDPDEF] from the U.S. Bureau of Economic Analysis with base year 2012.

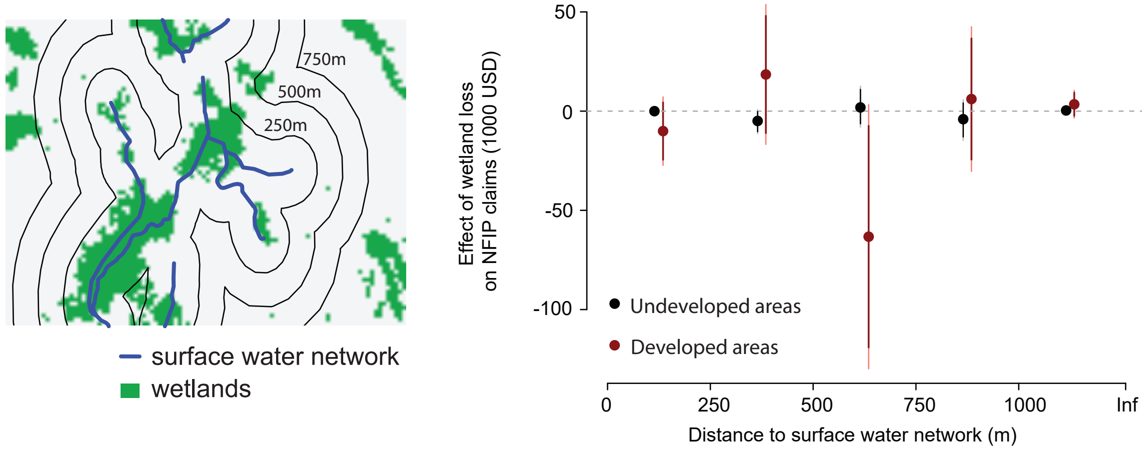

FIGURE A4. HETEROGENEITY IN DISTANCE TO SURFACE NETWORK ESTIMATES BY LEVEL OF DEVELOPMENT.

Note: We estimate how the flood mitigation value depends on distance from the surface water network, conditional on local levels of development. Left shows an example of how the distance from the surface water network is calculated. Right plots the estimated effect for each distance bin in developed (red) and undeveloped (black) areas. Lines show 90% (dark) and 95% (light) confidence intervals.

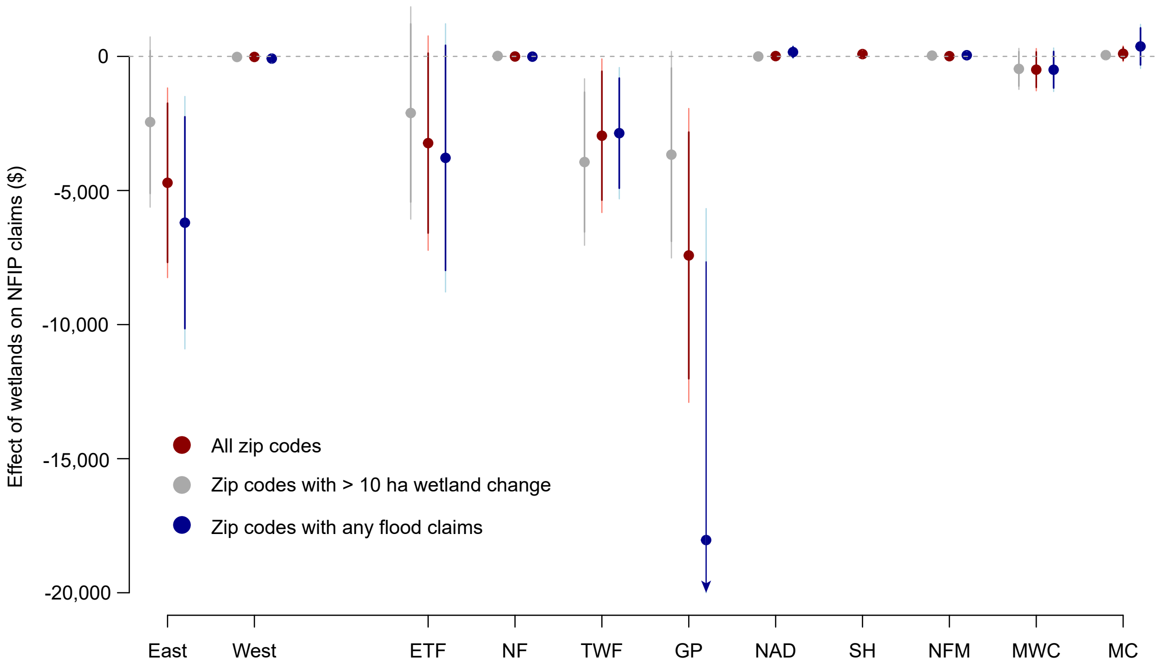

FIGURE A5. ROBUSTNESS OF REGIONAL EFFECTS.

Note: We estimate the effect of wetland loss on NFIP claims in the eastern and western US, as well as nine level-1 ecoregions: Eastern Temperate Forests (ETF), Northern Forests(NF), Tropical Wet Forests (TWF), the Great Plains (GP), North American Deserts (NAD), Southern Highlands (SH), Northern Forested Mountains (NFM), Marine West Coast (MWC), and Mediterranean California (MC). The coefficient estimates using the full sample are shown in red, with whiskers indicating 90% (dark) and 95% (light) confidence intervals. As a robustness check, we also estimate these effects limiting our sample to zip codes in which flooding occurred over the sample period (blue) and zip codes with at least 10 hectares of wetland area (grey).

Table A6—Sensitivity of the main results to estimation at the county-level.

	Dependent variable: NFIP claims paid							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Wetland change (ha)	−2,581	−2,721	−2,574	−2,557				
	(489)	(491)	(490)	(489)				
Wetland gain (ha)					101	113	110	113
					(601)	(600)	(602)	(601)
Wetland loss (ha)					−8,211	−8,842	−8,204	−8,165
					(890)	(901)	(890)	(890)
Observations	3,209	3,209	3,209	3,209	3,210	3,210	3,210	3,210

Note: Columns (1) and (5) do not include controls for the number of NFIP policies-in-force. Columns (2) and (6) include linear policy controls. Columns (3) and (7) include non-linear policy controls, binned by quartile. Columns (4) and (8) include non-linear policy controls, specified using a restricted cubic spline.

Table A7—Hedonic estimates of upstream wetland benefits.

	Dependent variable:					
	Log median home value		Log housing units		Log value of housing stock	
	(1)	(2)	(3)	(4)	(5)	(6)
Upstream wetland change (1000 ha)	0.09		0.01		0.11	
	(0.06)		(0.03)		(0.08)	
Upstream wetland gain (1000 ha)		0.13		−0.01		0.13
		(0.11)		(0.06)		(0.16)
Upstream wetland loss (1000 ha)		0.07		0.03		0.09
		(0.05)		(0.02)		(0.06)
Observations	24,476	24,476	25,039	25,039	23,346	23,346

Note: Using the upstream-downstream DID design, we estimate the effect of upstream wetland area changes on log median home value (columns 1-2), log housing units (columns 3-4), and the total value of the housing stock (columns 5-6). Observations are at the zip code level. All regressions include controls for local wetland changes, watershed wetland changes, developed area, median income, population, and CRS discount, as well as state fixed effects. Standard errors are clustered by county.