



Assessing Flooding Hazard Exposure

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Presentation Outline

- FEMA flood hazard data
- Geoprocessing: data cleaning and reclassification
- Case study to illustrate this process and quantification of exposed elements
- Conclusions and some possible alternatives to assess flooding exposure

Flood Hazard Data Sources

- A hazard can be studied in different ways:
 - By **models** or **simulation** of extreme events (deterministically or stochastically);
 - Engineering or physics-based models (hydrological and hydraulic).
 - By **specific occurrences** (historical events, but often not well documented, even today).
 - By **local knowledge**.
- FEMA provides flood hazard data to support the National Flood Insurance Program (NFIP).
 - **National Flood Hazard Layer** (NFHL) is a **geospatial database** that contains current effective flood hazard data for a variety of official policies/programs.
 - These data establish **flood insurance requirements** (often imposed by federally backed mortgage lenders).
 - Help communities develop strategies and programs to reduce flood risk, understanding **risk exposure** and evaluating/quantifying exposure.
- NFHL data is not uniformly available, but covers the area occupied by 90% of US population.

History of FEMA Flood Maps

- In 1968 the US Congress created the NFIP.
 - FEMA has been creating and updating flood hazard maps for the program after its creation.
- These maps are based on the combination of a variety of methods:
historical occurrences and insurance claims;
meteorological, hydrologic, and hydraulic data;
and these can incorporate **assessment of land-use/land cover** conditions,
flood-control infrastructure, and development.
- Updates to flood maps are a collaboration between the communities and FEMA.
 - Every community that participates in the NFIP has a floodplain administrator who works with FEMA during the mapping process.
 - After their creation they are subject to public review/comment, amendment, prior to adoption.
 - Updates are not timely nor regular.

History of FEMA Flood Maps

Over time, FEMA has produced **two** digital flood map products

Paper Maps	Q3 Flood Data	DFIRM (Digital Flood Insurance Rate Maps)
<ul style="list-style-type: none">• Flood Hazard Boundary Maps (FHBM), later Flood Insurance Rate Maps (FIRM).• Essential tool for the Mitigation Directorate (now the Federal Insurance and Mitigation Administration (FIMA), responsible for the NFIP and a range of programs designed to mitigate against future losses from all hazards including floods, earthquakes, tornadoes, and other natural disasters.	<ul style="list-style-type: none">• Started as digitization of paper maps, for the entire US.• Less precise scale 1:24,000 (±40 ft.)• Was available for over 1,300 counties• Q3 cannot be used as the official NFIP map for site design or flood risk determinations.• Last updated late 1999.	<ul style="list-style-type: none">• Started in 2000.• More precise scale 1:12,000 (±33 ft.)• NFHL (National Flood Hazard Layer) geospatial database.• New counties and updates to existing ones are an ongoing process.• Currently covers the area occupied by 90% of US population.

Current FEMA Websites

- FEMA Flood Map Service Center
 - <https://msc.fema.gov/portal/home>
 - Dynamic map
 - Document/letters of revisions, amendments, and revalidations
- National Flood Hazard Layer (NFHL) Status
 - <https://www.floodmaps.fema.gov/NFHL/status.shtml>
 - NFHL inventory: table with the most updated DFIRMs for download (by county)

Observations Regarding the NFHL Data

- Areas likely to have additional wave action (**flood with velocity** are identifiable).
- **Limited flood depth data;**
 - Some flood classifications indicate depth ranges, but mostly they reflect a dichotomous classification.
- NFHL boundaries are **not perfectly aligned** with Census TIGER shapefiles.
 - Data are presented by county, but county boundaries (and hence other geographies) can be **inconsistent** with Census boundaries.
 - Since flooding designations are distributed county by county, **neighboring**, cross-county areas, can have different flood risks.
 - This can be potentially problematic when places, cities, metro-areas, are cross counties.
- Data are presented to capture probabilities of flooding, **annual exceedance probability**.

FEMA Floodplain Designations

- Special Flood Hazard Areas (SFHA)
 - Areas subject to flood inundation at **1.0% *or greater chance*** of flooding in any given year. Sometimes referred to as having a 1.0% chance of flooding per year.
 - “*100-year floodplain*”
- Moderate Flood Hazard Areas
 - Areas subject to flood inundation between the **limits of the SFHA and 0.2% chance** of flooding in any given year.
 - “*500-year floodplain*”
- Areas of Minimal Flood Hazard
 - Areas **outside the SFHA** and higher than the elevation of the 0.2% chance of flooding in any given year.

Floodplain Reclassification

Q3 and NFHL flood zones and subtypes and our simplified recodes ...

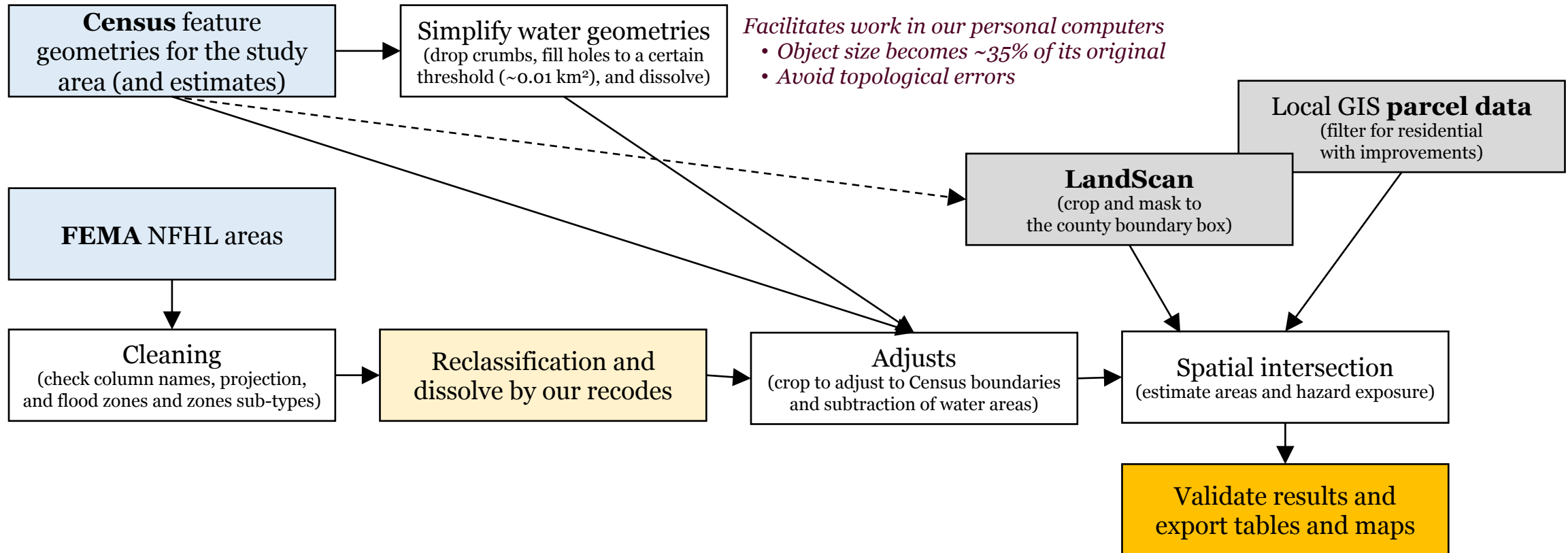
Q3 classification	NFHL classification	<i>Reclassification</i> *
V, VE	VE	100-year (with velocity)
A, A1-A30, A99, AE, AH, AO, AR	A, AE, AH, AO	100-year
B, X500, X (shaded)	X (0.2 pct annual chance flood hazard)	500-year
X (reduced flood risk due to levee)	Area with reduced flood risk due to levee	Levee protected
C, D, X, X (unshaded), UNDES	X (area of minimal flood hazard), ANI (area not included)	Out of the floodplain

Many sources ... ultimately referring to FEMA, such as:

- <https://help.riskfactor.com/hc/en-us/articles/360048256493-Understand-the-differences-between-FEMA-flood-zones>
- <http://www.floodmaps.com/zones.htm>
- <http://www.mass.gov/anf/docs/itd/services/massgis/q3floodzonescodetable.pdf>

Data Cleaning and Geoprocessing

Load, tidy, reclassify, dissolve, adjust and water subtraction, and quantification of exposure



Case Study: Flooding Hazard Exposure in Galveston Co.

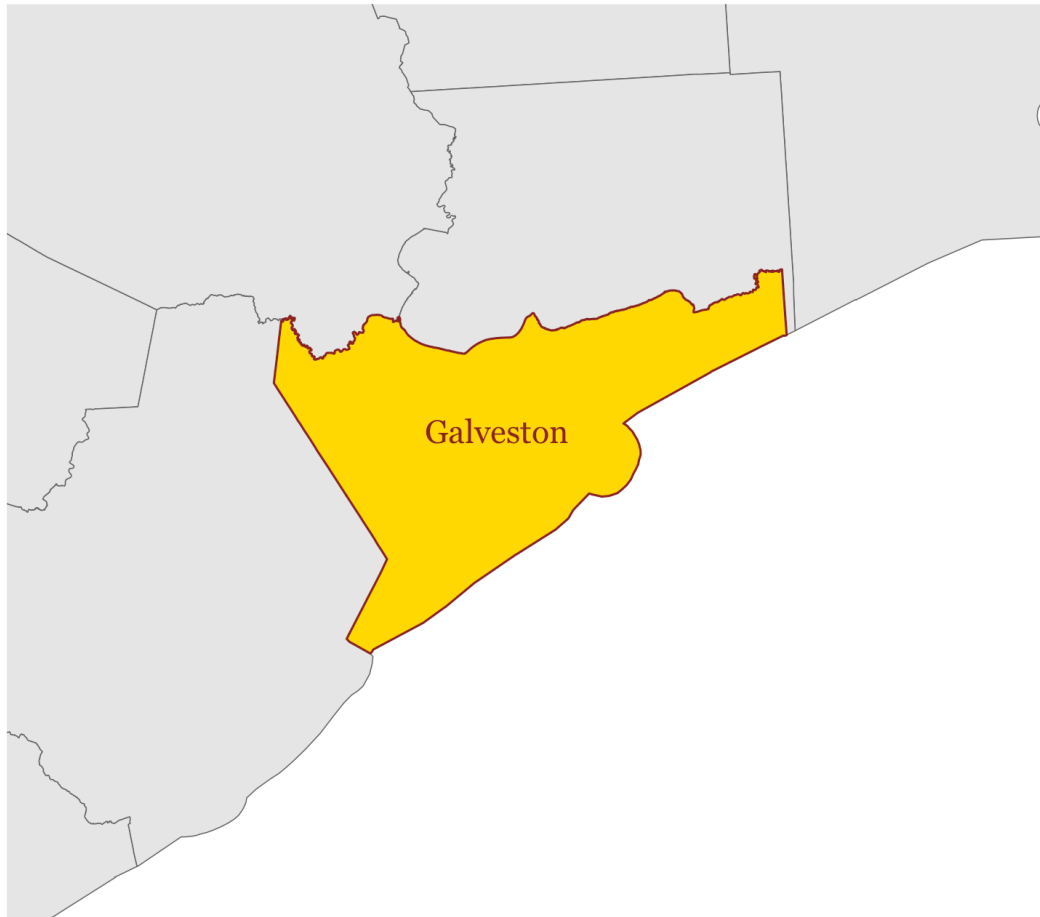
R-script for this case study: https://github.com/abuabara/flooding_hazard_exposure.git

Data sources

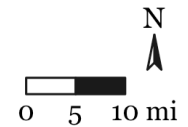
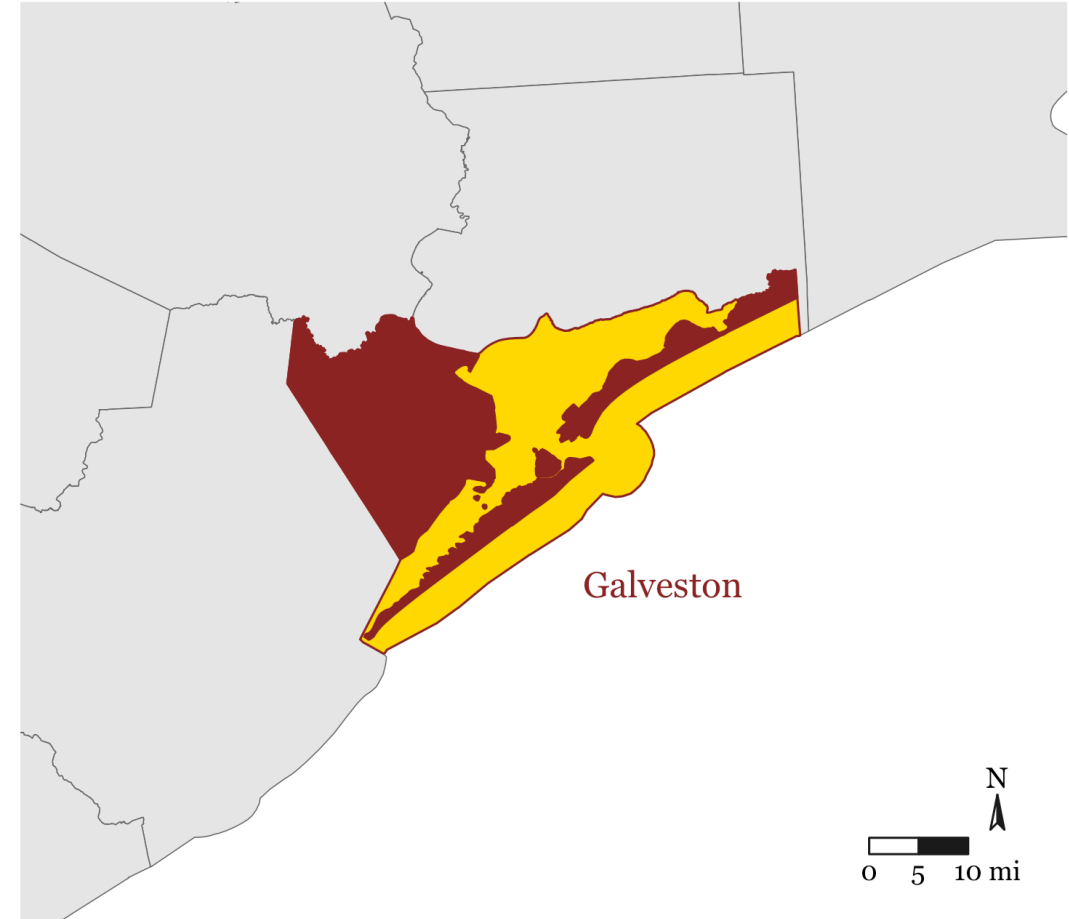
- **Census** boundaries and perennial and intermittent areas of hydrography features
 - R/tigris <https://github.com/walkerke/tigris>
- **ACS** estimates
 - R/tidycensus <https://github.com/walkerke/tidycensus/>
- **FEMA NFHL Flood Maps**
<https://www.floodmaps.fema.gov/NFHL/status.shtml>
- **ORNL LandScan USA Conus Night**
Raster dataset that provides population estimates for the Homeland Infrastructure Foundation-Level Data (HIFLD) database: <https://landscan.ornl.gov>
- **Galveston Central Appraisal District – Parcel Information**
<https://galvestoncad.org/gis-data/>

Case Study: Flooding Hazard Exposure in Galveston Co.

Case Study

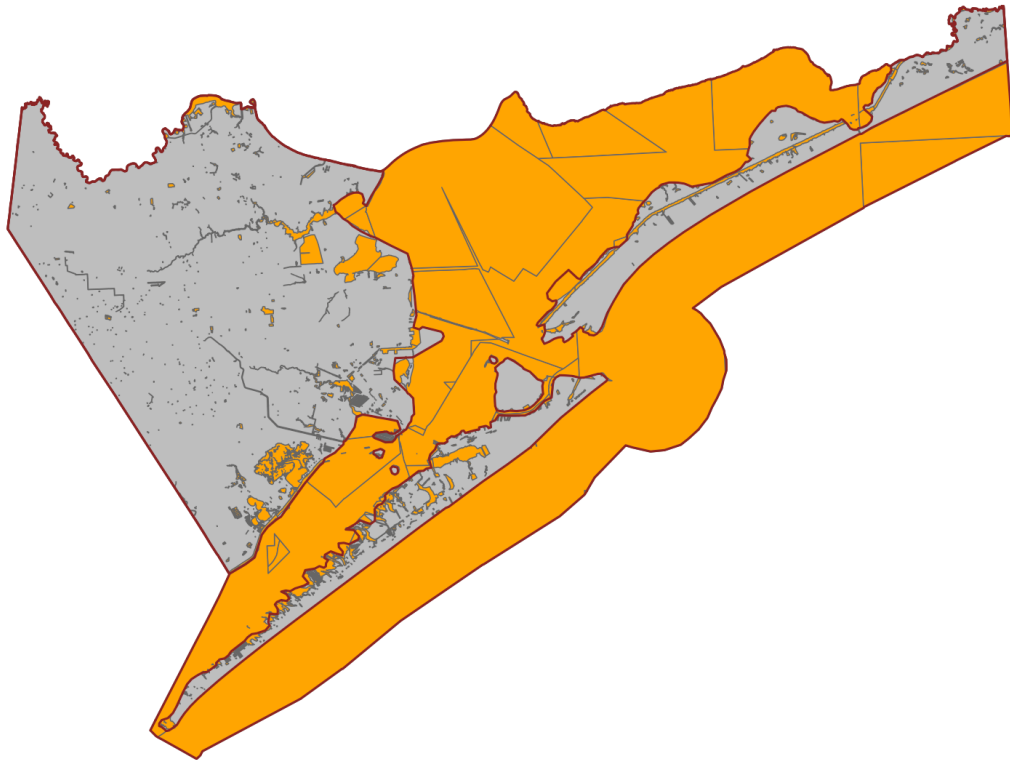


Cartographic Boundary

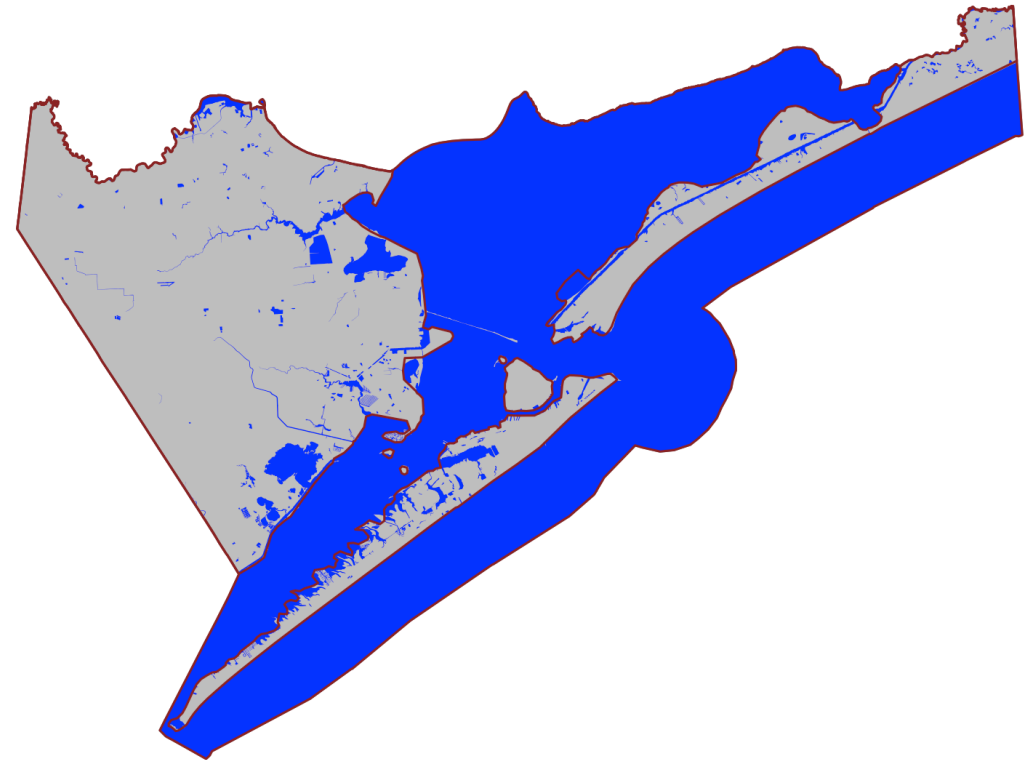


Case Study: Flooding Hazard Exposure in Galveston Co.

Original Census County Water

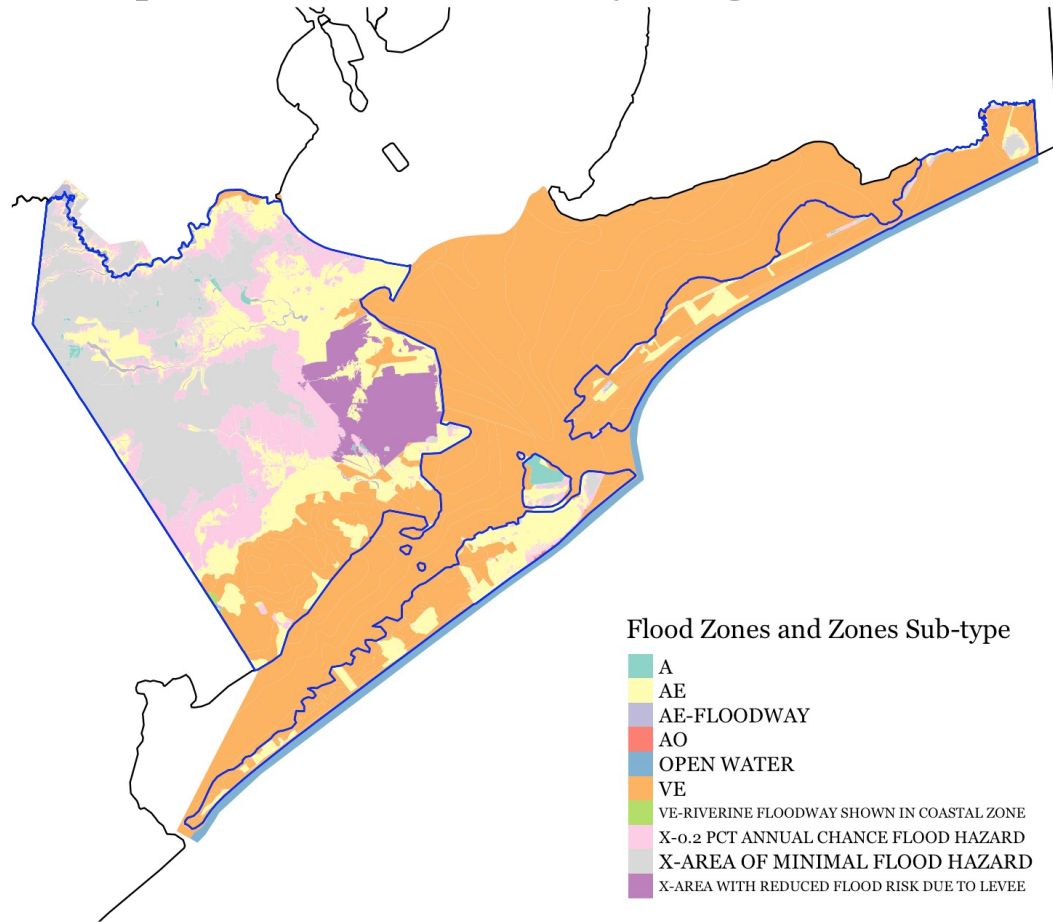


Simplified County Water



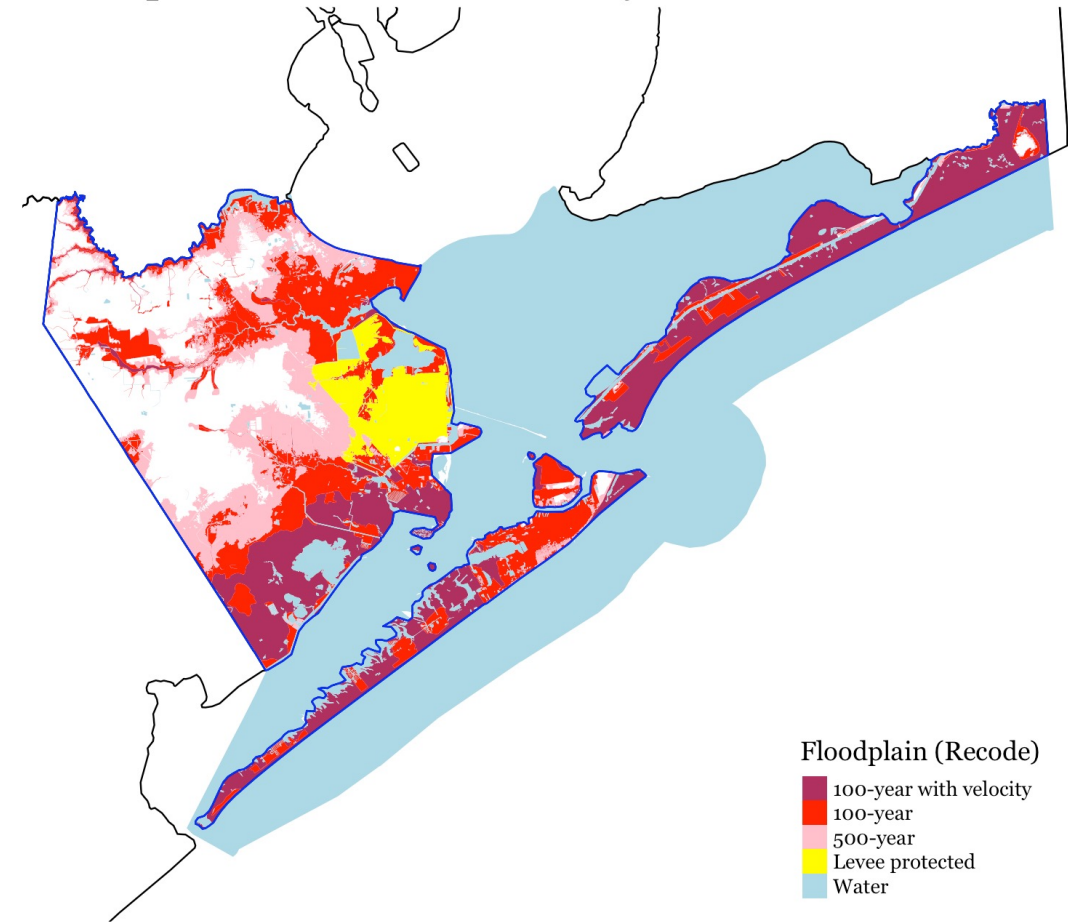
Case Study: Flooding Hazard Exposure in Galveston Co.

Floodplain in Galveston County (Original)



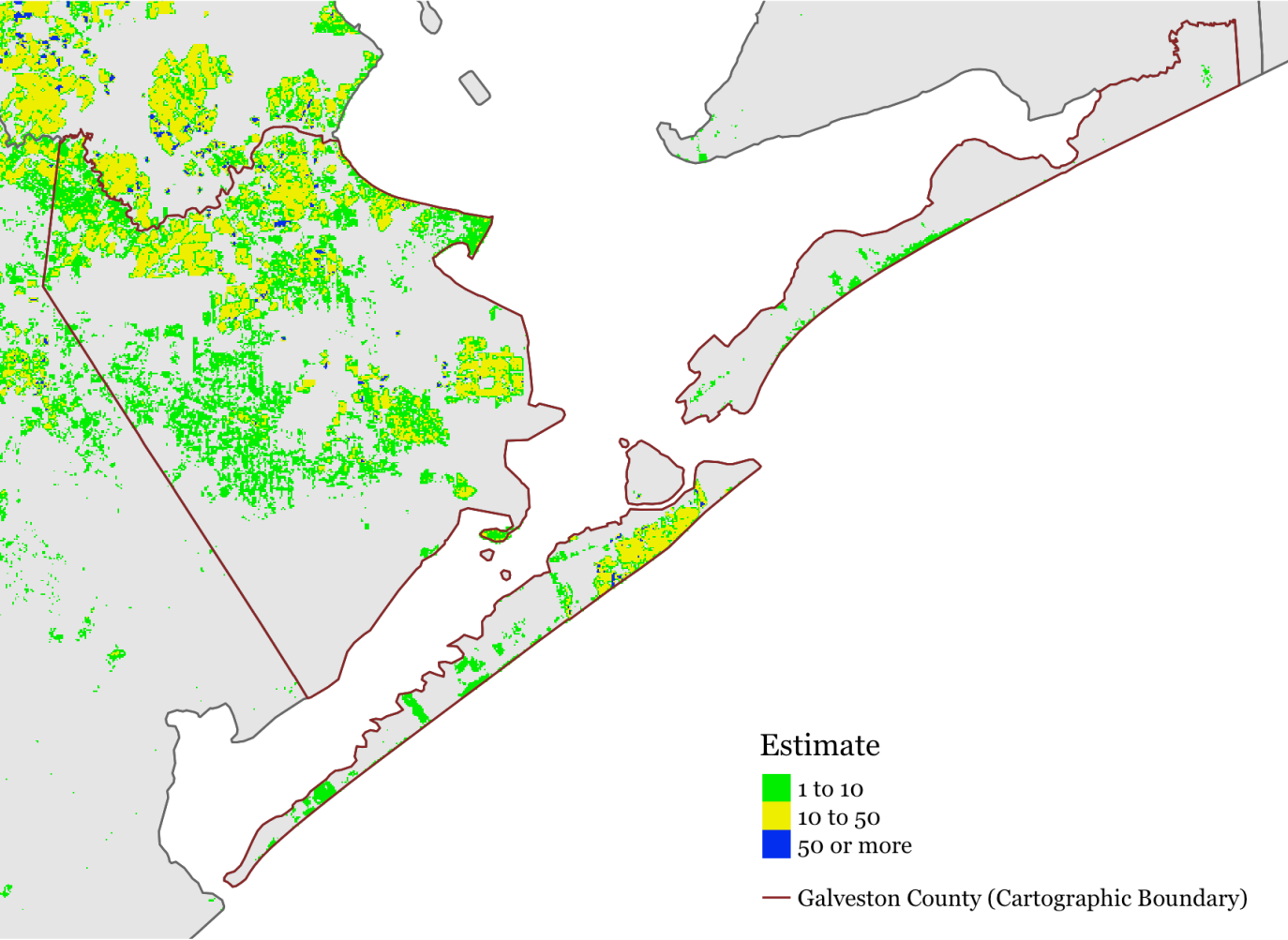
NFHL update date: 2022-11-20

Floodplain in Galveston County (Reclassified)



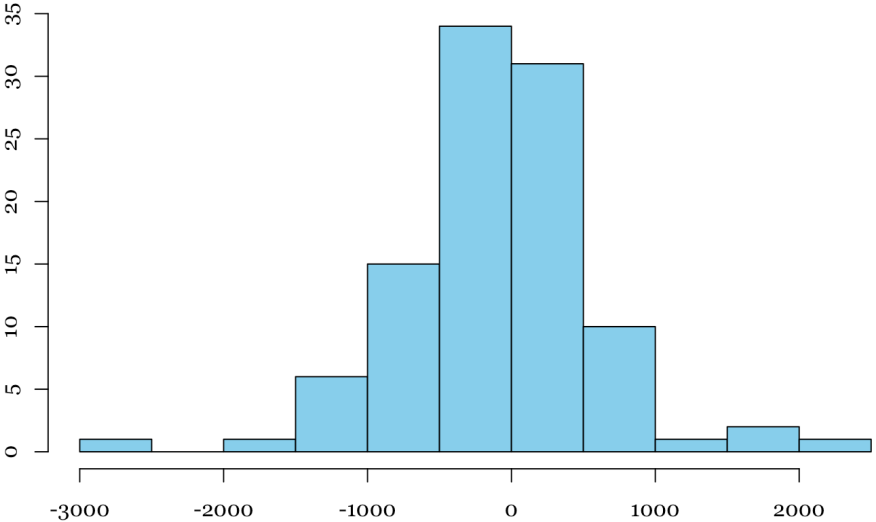
PS: need to use LandScan that is the mid-year of the 5-year ACS estimate

Landscan 2019 Population Counts (Conus Night)



Census Tracts

Histogram for Census Estimate - Landscan Counts



Paired t-test

Data: Census Estimate and Landscan Counts (Population)

t = -1, df = 101, p-value = 0.3

Alternative hypothesis: true mean difference is not equal to 0

95 percent confidence interval: **-203.28 65.55**

Sample estimates: mean difference **-68.87**

	Census 2021-2017 ACS 5-Year	Landscan 2019
Total County Population	347,084 (MOE 38,817)	354,112

Galveston County

(–Illustrative Estimates–)

View of Galveston Island Downtown Area



Floodplain	Population Count* 2019 LandScan	Residential Parcels** Appraisal District	Area*** (sq mi)
Water	–	–	493.0
100-year (with velocity)	12,854	5,289	103.0
100-year	99,136	27,387	93.9
500-year	81,637	24,867	61.1
Levee protected	40,243	11,540	24.8
Out of floodplain	120,242	42,795	171.6
Total	354,112	111,878	775.8

* Landscan pixel is **aerial weighted** to estimate the population estimate in the area covered by the flood category.

** Total of **parcel centroids** that are within each floodplain area. Land use coded as **residential (R)** with **improvement value greater than \$0 in 2022**.

*** Projection used **EPSG:3081** NAD83 / Texas State Mapping System

Image features part of Galveston Island to illustrate the location of parcels and residential parcels with improvement.

Possible Alternatives to Assess Flooding Risk

Commercial

- *Katrisk*
 - <https://www.katrisk.com/hazard-data>
 - Inland flood data at **multiple return periods**.
 - 2-d hydraulic **modeling** of pluvial (surface water) and fluvial (riverine) flooding.
 - Resolution varies by region dependent on available DTMs, down to 10 meters in the US.

Academic

- Wing, O. E., Bates, P. D., Smith, A. M., Sampson, C. C., Johnson, K. A., Fargione, J., & Morefield, P. (2018). Estimates of present and future flood risk in the conterminous United States. *Environmental Research Letters*, 13(3), 034023.
 - https://www.unisdr.org/preventionweb/files/57470_wing2018environ.res.lett.13034023.pdf
 - 30 m resolution **model** of the entire conterminous US with a 2-d representation of flood physics to produce estimates of flood hazard.
 - Match to within **90% accuracy** the skill of local models built with detailed data.