The Center of Excellence for Risk-Based Community Resilience Planning: The 2016-2019 Lumberton, NC, Field Study

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The Center of Excellence for Risk-Based Community Resilience Planning

Contributions from: Bruce Ellingwood, Therese McAllister, Judith Mitrani-Reiser, Stephen Cauffman, and Jennifer Heligson

The Center Thrusts

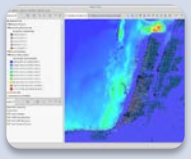
Thrust 1: A Multidisciplinary computational environment with fully integrated supporting databases: "The **I**nterconnected **N**etworked **- Co**mmunity **R**esilience Modeling **E**nvironment".

Thrust 2: Data management tools for community resilience systems": A standardized data ontology, robust data architecture, and effective tools to support IN-CORE.

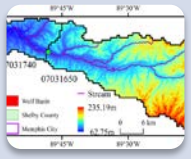
Thrust 3: Resilience data architecture validation studies: Hindcasts and forecasts to test the data collection process and its integration into IN-CORE. Validate risk-informed intelligent search and decision algorithms; field studies.

Thrust 1: The Development of IN-CORE

Individual Hazards



Multiple and Competing Hazards



Nonstat. in Long-term Resilience Assessment

Centerville

EQ

Tornado

Seaside Oregon

EQ

Tsunami

Memphis TN, MSA

EQ

Flood

Galveston, TX Hurricane

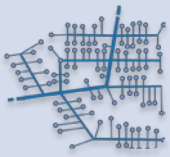
-Surge

-Waves

-Wind

Buildings

Transpo. Networks



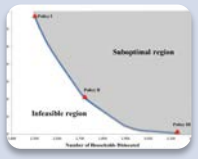
Water & Wastewater

Energy

Comm. Networks

Social Systems

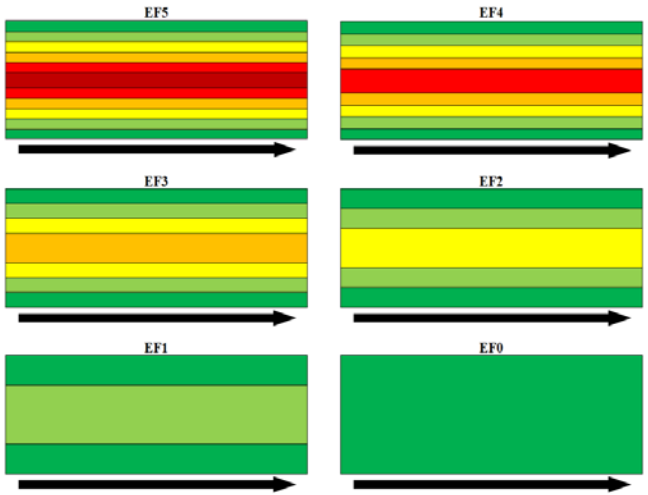
Economic Systems



Optimization Strategies

Thrust 3: Resilience Architecture Validation Studies

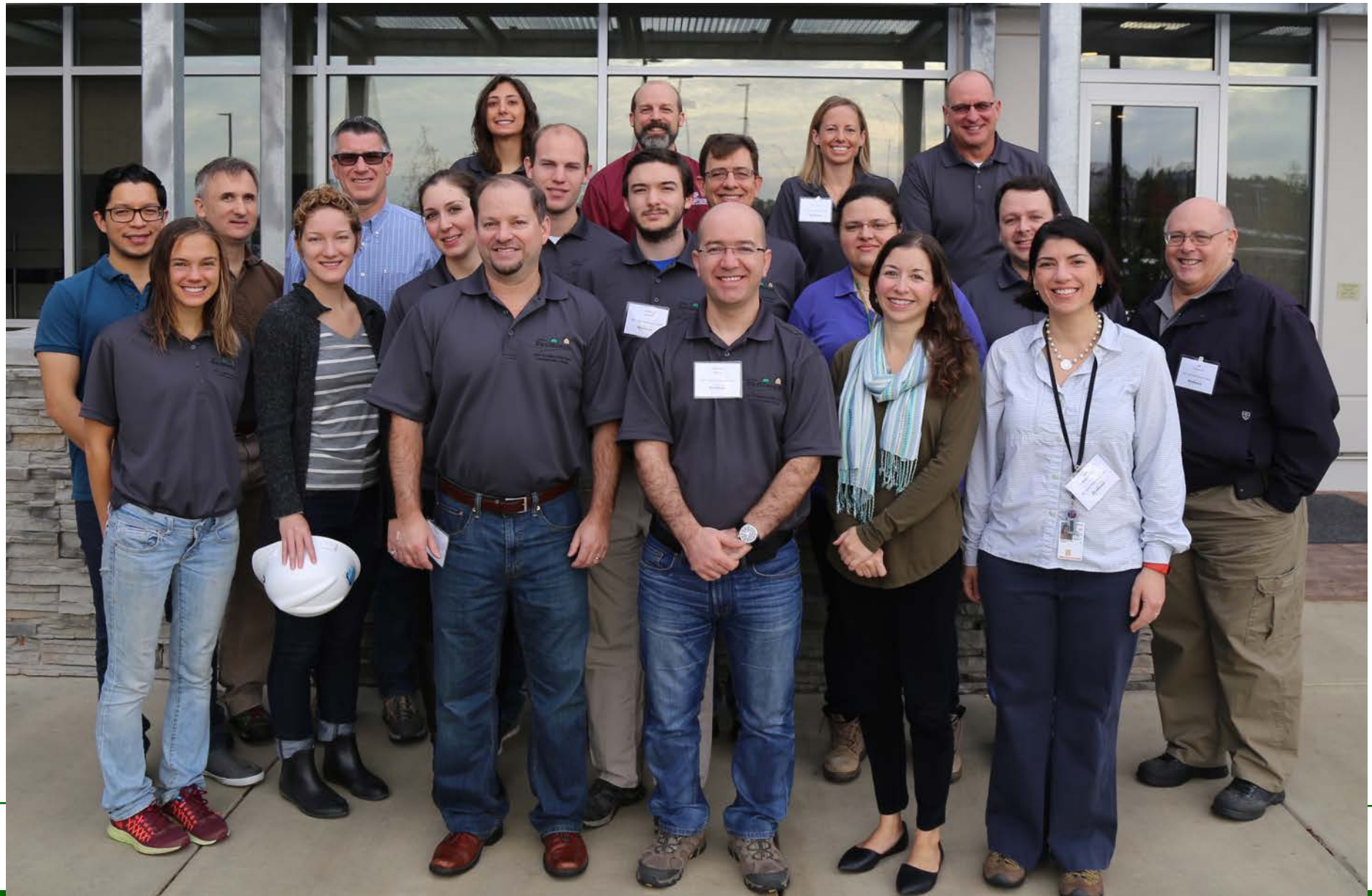
- Systematic validation of the numerical models and data in Tasks 1 and 2.
- 2011 Joplin, Missouri tornado
- Lumberton, NC Field Study
- Single sector, multi-sector, and full architectural validation



Field Study Team–Lumberton, NC

Name of Researcher	Affiliation	Role in Field	Ethics Training Completed	IAA Signed
Bill Coulbourne	FEMA	N/A	N/A	N/A
Lori Peek	CSU	Data Collection	Yes	Yes
Todd Clapp	CSU	Data Collection	Yes	Yes
Maria Koliou	CSU	Data Collection	Yes	Yes
Derya Deniz	CSU	Data Collection	Yes	Yes
Jennifer Tobin-Gurley	CSU	Data Collection	Yes	Yes
John van de Lindt	CSU	Data Collection	Yes	Yes
Mehrdad Memari	CSU	Data Collection	Yes	Yes
Sara Hamideh	ISU	Data Collection	Yes	Yes
Elaina Sutley	KU	Data Collection	Yes	Yes
Judy Mitrani-Reiser	NIST	No Human Subjects Data	Yes	Yes
Jennifer Helgeson	NIST	No Human Subjects Data	Yes	Yes
Maria Dillard	NIST	No Human Subjects Data	Yes	Yes
Ken Harrison	NIST	No Human Subjects Data	Yes	Yes
Steve Cauffman	NIST	No Human Subjects Data	Yes	Yes
Juan Fang	NIST	No Human Subjects Data	Yes	Yes
Hana Chmielewski	NIST	No Human Subjects Data	Yes	Yes
Tori Johnson	OSU	Data Collection	Yes	Yes
Dan Cox	OSU	Data Collection	Yes	Yes
Andre Barbosa	OSU	Data Collection	Yes	Yes
Nathanael Rosenheim	Texas A&M	Data Collection	Yes	Yes
Walt Peacock	Texas A&M	Data Collection	Yes	Yes
Andy Graettinger	UA	Data Collection	Yes	Yes
Shane Crawford	UA	Data Collection	Yes	Yes
Jamie Kruse	ECU	No Human Subjects Data	Yes	N/A

Field Study Team–Lumberton, NC



Field Studies Thrust in the CoE

- In order to measure a community's resilience, the NIST CoE will collect practical metrics that can be divided into two categories:

1) Metrics that require field study data:

a) Population dislocation: Households displaced
b) Business interruption: Businesses closed
c) Employee dislocation: Employees failing to report to work
d) Critical facilities impact: Critical facilities closed
e) Housing loss: Units lost

2) Metrics that do not require field study data:

a) Physical and mental morbidity
b) Mortality
c) Fiscal impact: Loss of property tax and sales tax

- The community dimensions that are described in NIST GCR 16-001 are embedded into these metrics
  - Dimensions include: sustenance, health, housing and shelter, education and personal development, security and safety, culture and identity, and belonging and relationships

CoE/NIST Collaborative Field Studies

- Collect data and establish likely technical factors responsible for poor/successful performance of buildings and infrastructure in the aftermath of disasters.
- Collect data related to community impact and recovery.
- Collect data to validate models under development.
- Test new field sampling protocols.
- Assess new field equipment.
- Recommend frequency of data collection to capture community functioning over time.
- Recommend, as necessary, specific improvements to standards, codes, and practices based on field studies.
- Inform IN-CORE data flow for calibration to provide a model for communities US and worldwide

Robeson County (Lumberton) Impacts

Aerial photo of neighborhoods off of Almanac Road in Lumberton, N.C. Archive photo was captured on Oct. 25, 2013 and present day photo was captured on Oct. 11. (NOAA/NGS/Google)

- **Demographics: 40% white; 37 percent black; 13% Native American (Lumbee Indian)**
- **Per capita income was $15,321**
- **1/3 population in poverty**

- **5,000 displaced**
- **7,057 structures affected**
- **>5,000 power customer outages**
- **133 roads impacted or damaged**
- **4 public housing developments damaged, totaling 545 units**

Field Deployment Research Goals

Flooded district office in Robeson County (ABC15 News).

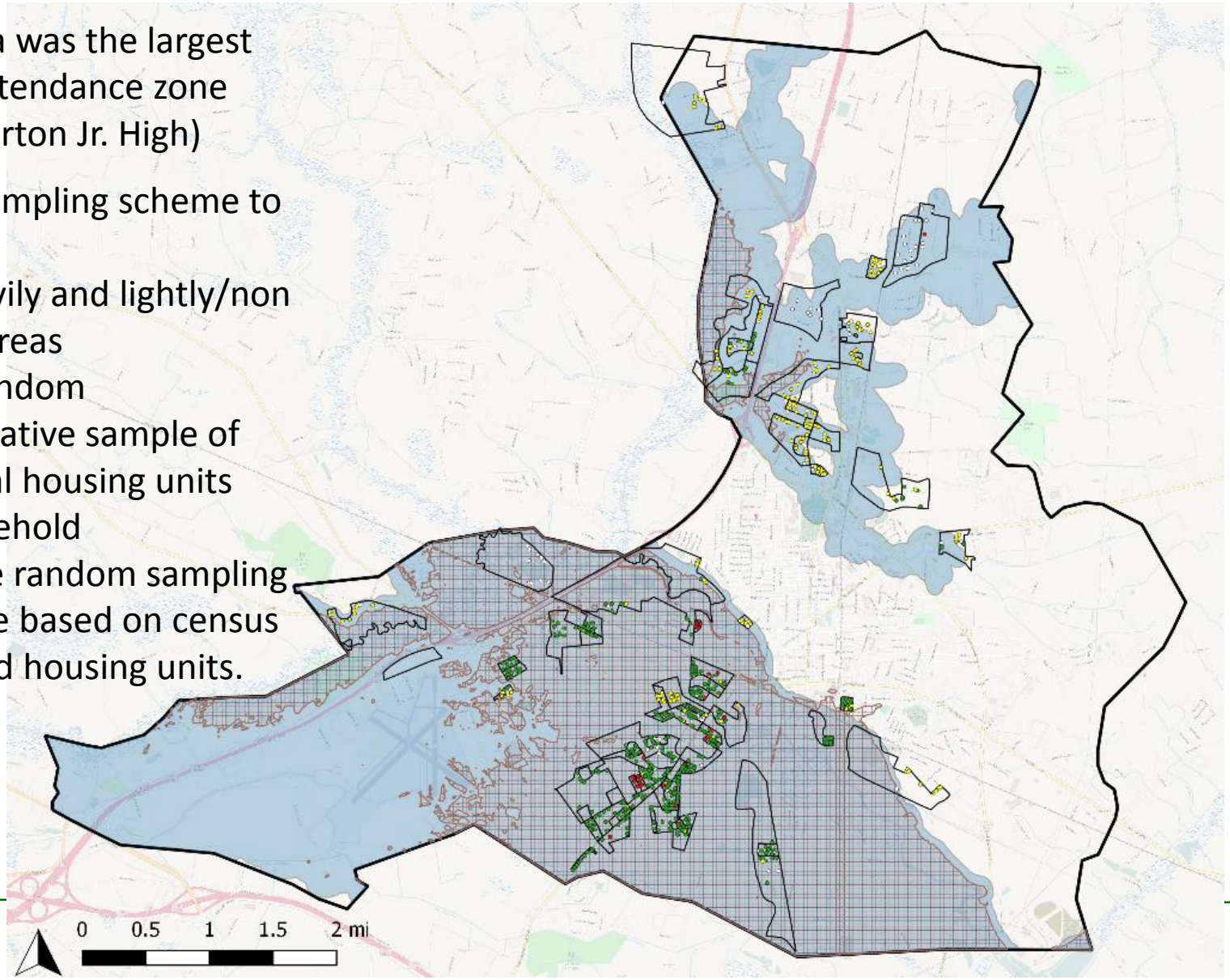
(1) Assess damage to school buildings and impact on educational system (e.g., school closures, food programs, other services);
(2) Study how the floods impacted housing stock (collect empirical data to compare to existing fragility curves) and population displacement;
(3) Investigate the dependency of these important community functions on distributed infrastructure networks (e.g., power, water, wastewater, etc.).

Random sample of Housing Units/Households

Target area was the largest school attendance zone (Lumberton Jr. High)

Developed sampling scheme to capture:

1) Both heavily and lightly/non flooded areas
2) Obtain random representative sample of residential housing units and household
3) Two stage random sampling procedure based on census blocks and housing units.



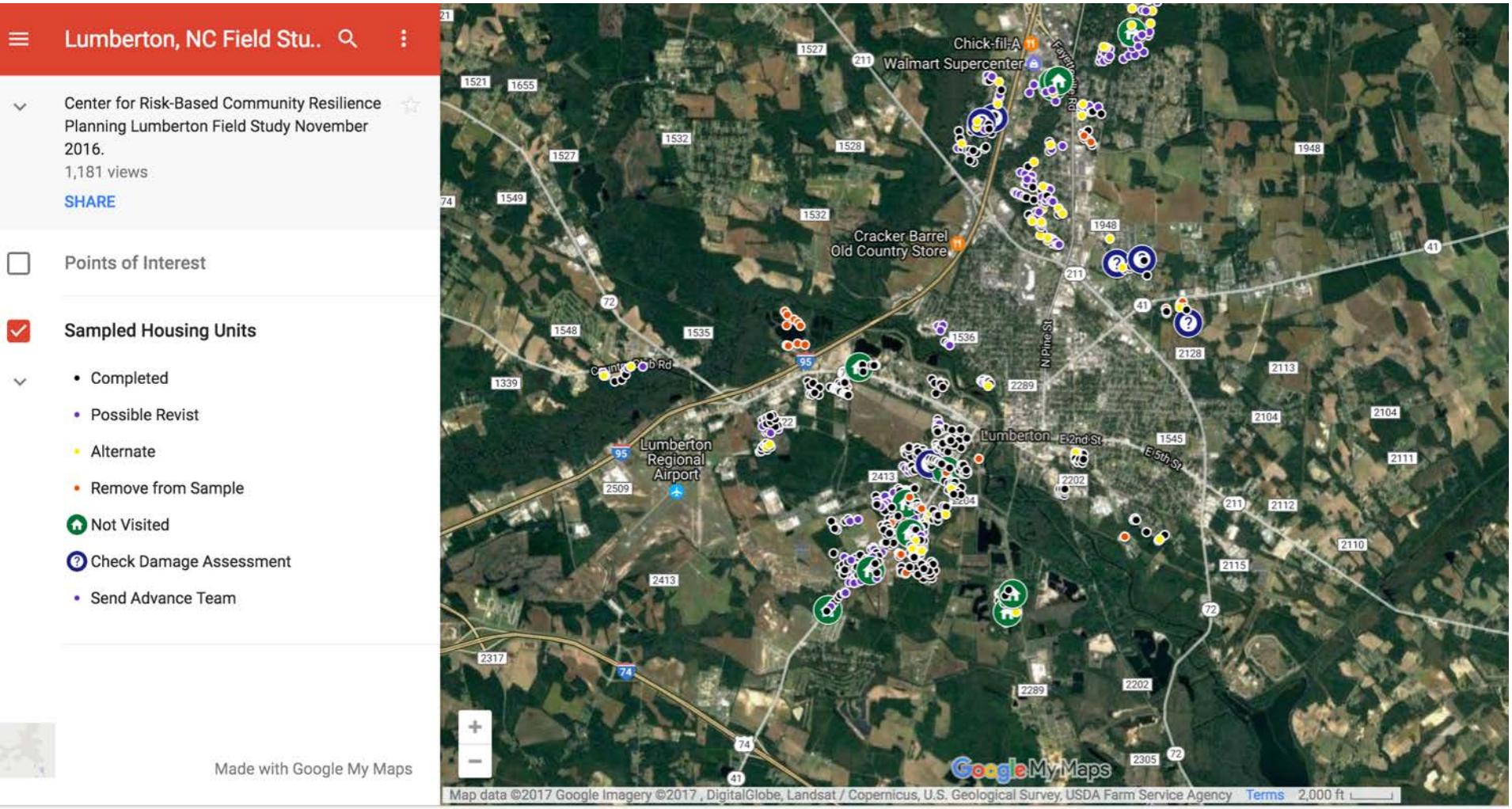
Implementing Field Research Tools

- **Engineering**
  - Structured damage assessment tools for HUs to inform fragility curves
- **Social Science**
  - Random sample of HUs and households to inform general population models
- **Engineering + Social Science**
  - Qualitative survey of community leaders and stakeholders to understand impact, response, and recovery planning and activities

IRB Field Study Protocol

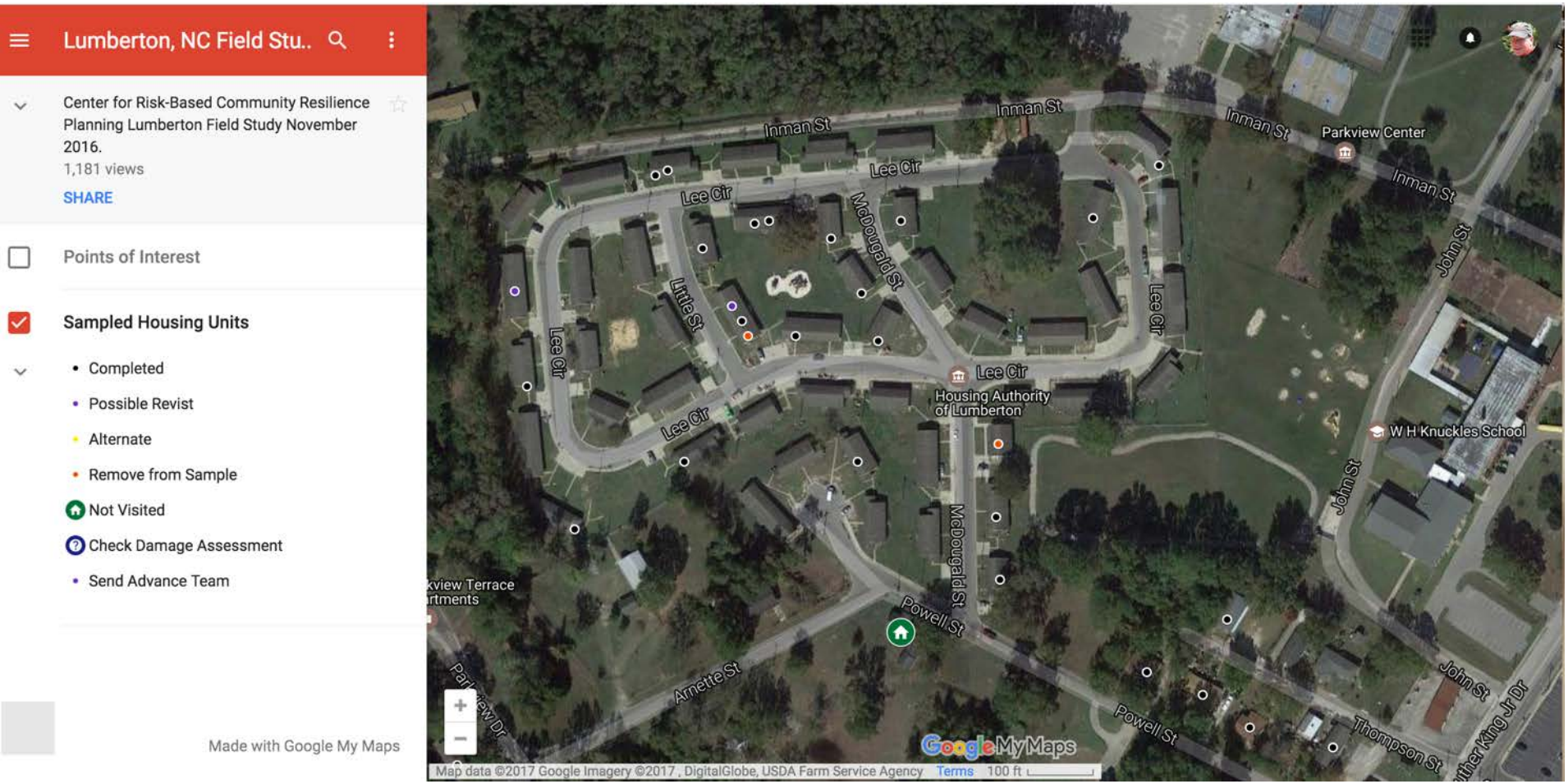
- Institutional Review Board (IRB) approval from all participating Universities
- Recruitment, Informed Consent, Data Collection Methods, and Data Collected
  - In-depth semi-structured interviews
    - Recruitment
      - Focused on community leaders and key stakeholders in the education sector who were willing and available to speak with our team
      - Recruited participants through internet searches, targeted emails, and word of mouth to identify, contact, and recruit community leaders.
    - Conducted by at least 2 team members
    - Consent and demographic forms were be explained and signed
    - Lasted 30-45 minutes each
    - Audio recorded
    - Nature of questions
  - Brief in-person, closed ended, household survey questionnaires
    - Random sample of housing units and households residing in these residences
    - The survey questions were administered door-to-door in our sampled area. When residents were home and willing to speak with us, the questions were asked out loud and recorded on paper surveys. When residents were not available, data was collected through visual identifiers and through neighbor interviews when possible.
  - Photos of building, damage assessment of building, and community damage
    - Taken to track flood and wind damage, clean-up, reconstruction, and recovery processes over time.
    - Protocols regarding the taking of photos included only taking publically viewable/available photos when permission was not attained. If photos were taken internally, photo release forms were filled out and signed by participants.

Used Google Mapping tools to guide teams



To facilitate teams finding the sampled HUs we employed Google Maps (Google My Maps) that could be view on smart phones.

Used Google Mapping tools to guide teams



The sample linked to a Google Doc Spreadsheet – providing information on each HU and updated each evening on status of damage assessment and HH interview.

Damage Assessment Data

Foundation Type (with Number of Buildings)	Building Type	Distribution of Buildings (%)	Distribution of Number of Stories (%)		Distribution of Construction Type (%)		
			One	Two	Wood	Masonry	Both
Crawlspace (273)	Single	96.3	90.1	8.4	60.0	28.1	8.0
	Multi	1.8	100	0.0	80.0	0.0	20.0
Slab (116)	Single	33.6	89.7	10.3	56.4	25.6	15.4
	Multi	64.7	86.7	12.0	41.3	29.3	18.7

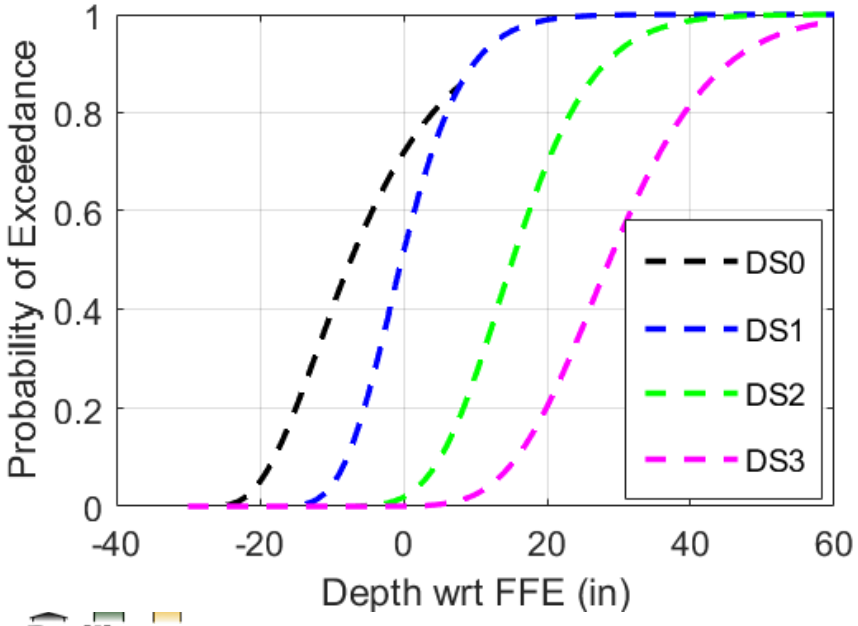
- Most of the damaged homes are wood light-frame structures (many with brick veneer).
- Average quality and typically one to two stories.
- Almost two-thirds have crawlspaces.
- Generally single floor
- Majority single family, many multi-family duplexes or triplexes.

Damage State Descriptions

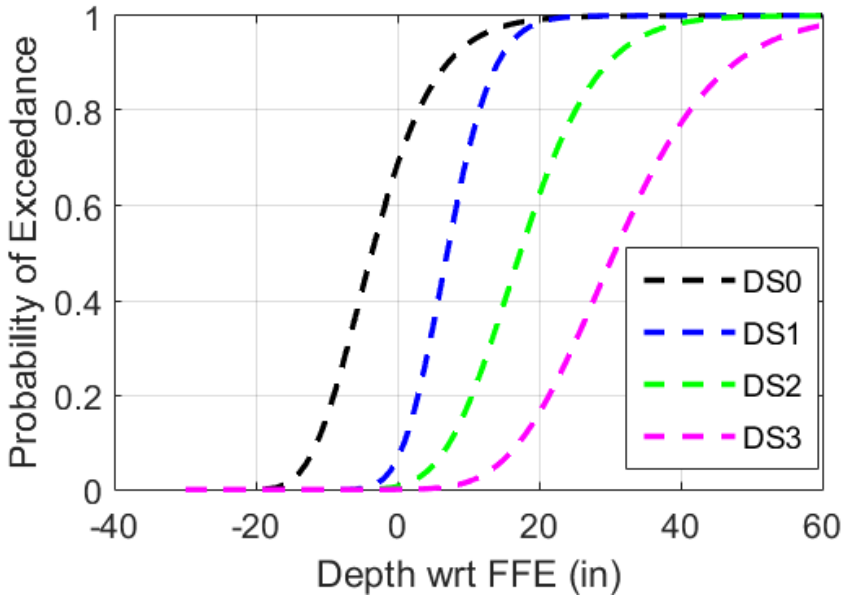
DS Level	Description
0	No damage although water enters crawlspace or touches foundation (crawlspace or slab on grade). No contact to electrical or plumbing, etc. in crawlspace. No contact with floor joists. No sewer backup into living area.
1	Minor water enters house; damage to carpets, pads, baseboards, flooring. Approximately 1”, but no drywall damage. Touches joists. Could have some mold on subfloor above crawlspace. Could have minor sewer backup and/or minor mold issues.
2	Drywall damage up to approximately 2 feet and electrical damage, heater and furnace and other major equipment on floor damaged. Lower bathroom and kitchen cabinets damaged. Doors or windows need replacement. Could have major sewer backup and /or major mold issues.
3	Substantial drywall damage, electrical panel destroyed, bathroom/kitchen cabinets and appliances damaged; lighting fixtures on walls destroyed; ceiling lighting may be ok. Studs reusable; some may be damaged. Could have major sewer backup and/or major mold issues.
4	Significant structural damage present; all drywall, appliances, cabinets etc. destroyed. Could be floated off foundation. Building must be demolished or potentially replaced.

Empirical Flood-Damage Fragilities

Homes with Crawlspaces



Homes with Slabs



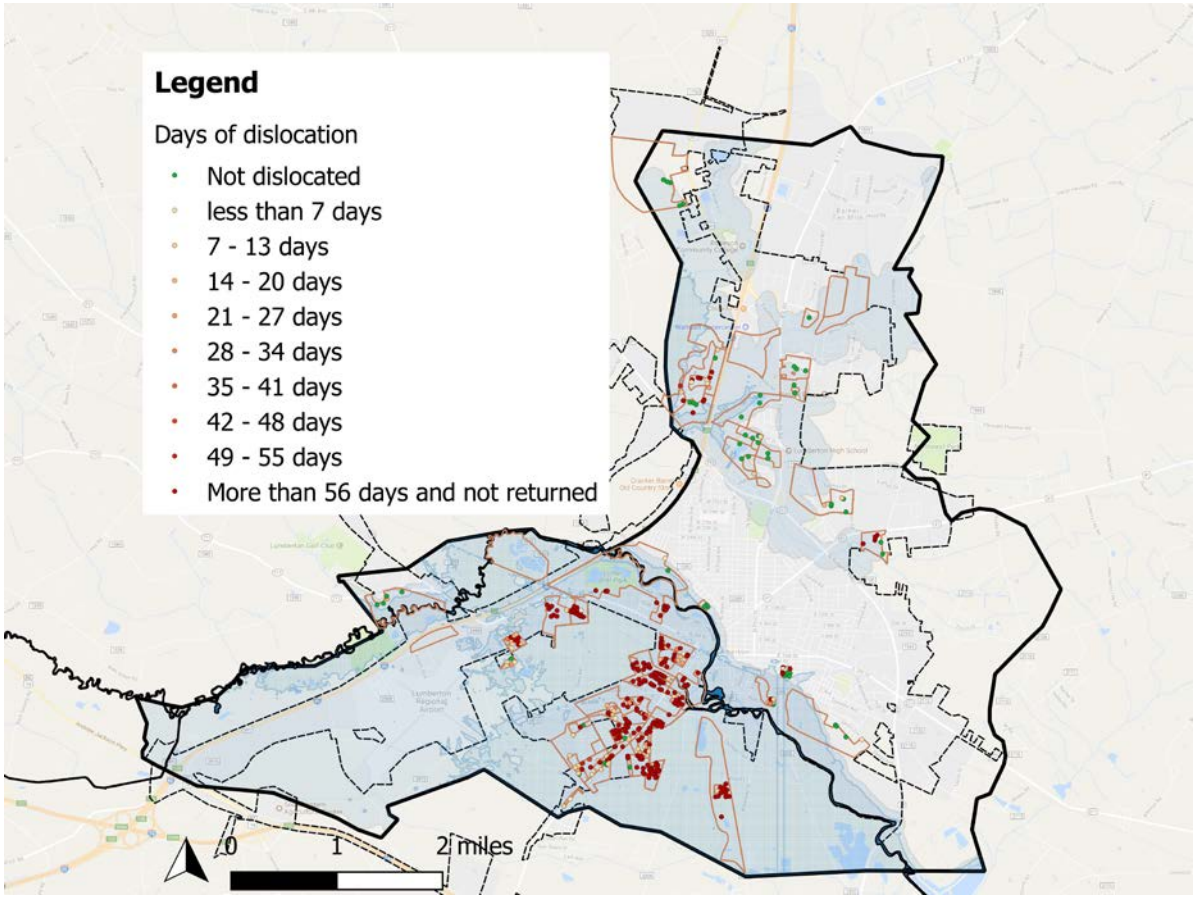
Dislocation and Infrastructure Disruption

Household Dislocation and Lifeline Disruption

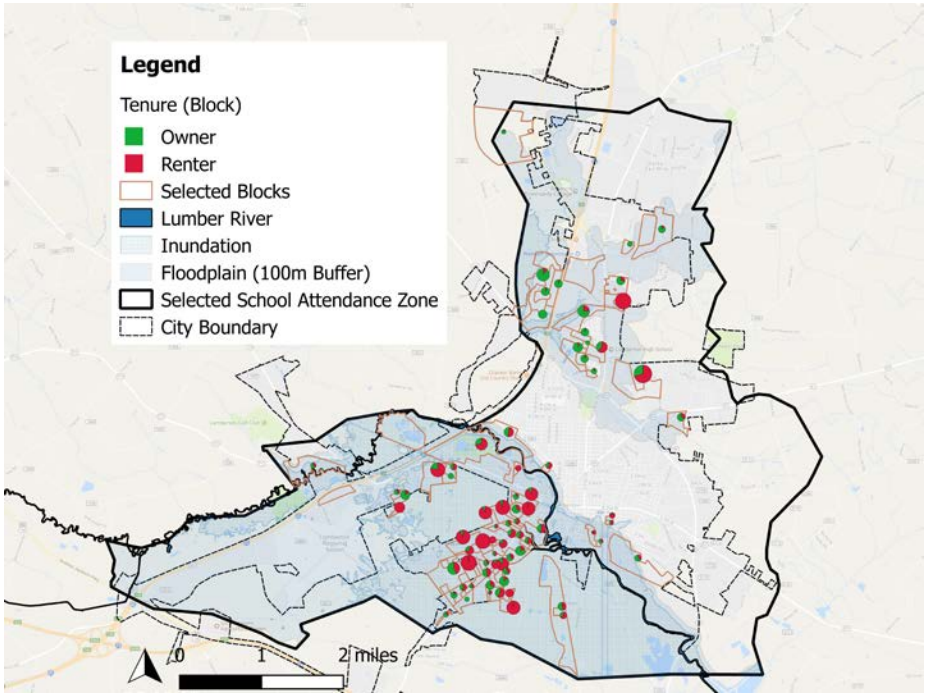
Impact Assessment	% or Mean	MoE*	Minimum	Maximum**	Obs.
% Dislocated Households	75.6%	3.6%	0	1	542
Days Dislocated	34.4	2.39	0	61	542
Days Without Electricity	10.9	2.38	2	61	280
Days Without Water	14.6	1.44	1	61	265
Days Without "Safe" Water	27.2	1.58	1	61	248
Days Without Natural Gas	27.7	2.45	3	61	44
Days Without Phone	11.3	6.71	1	61	136
Days Without Internet	13.9	2.20	1	61	190

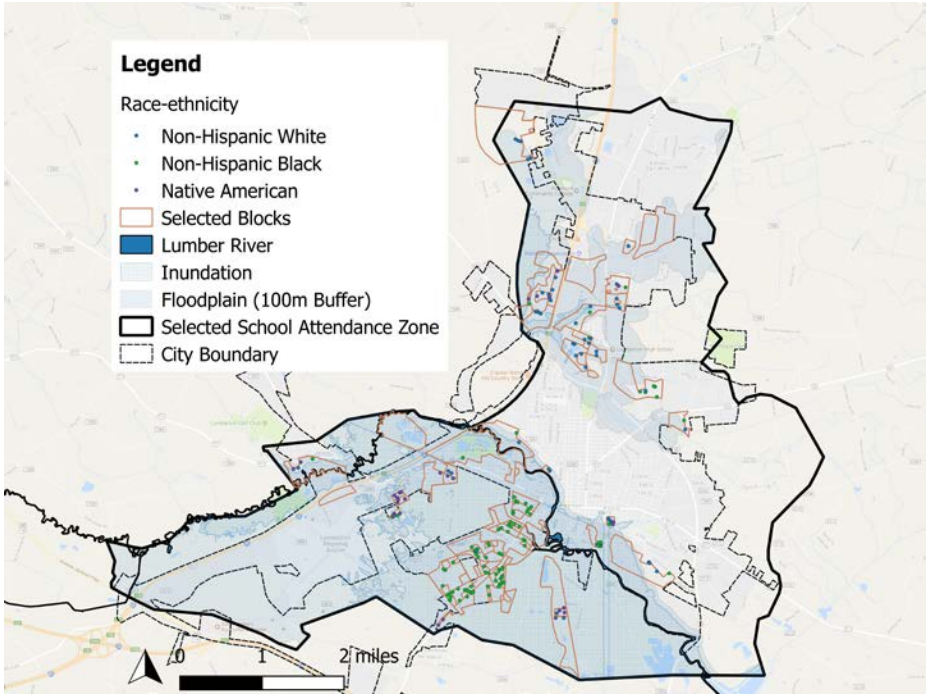
Notes: * MOE = Margin of error based on a 95% confidence interval; ** Maximum is set by the number of days since flooding that interview was conducted.

Dislocation in Lumberton

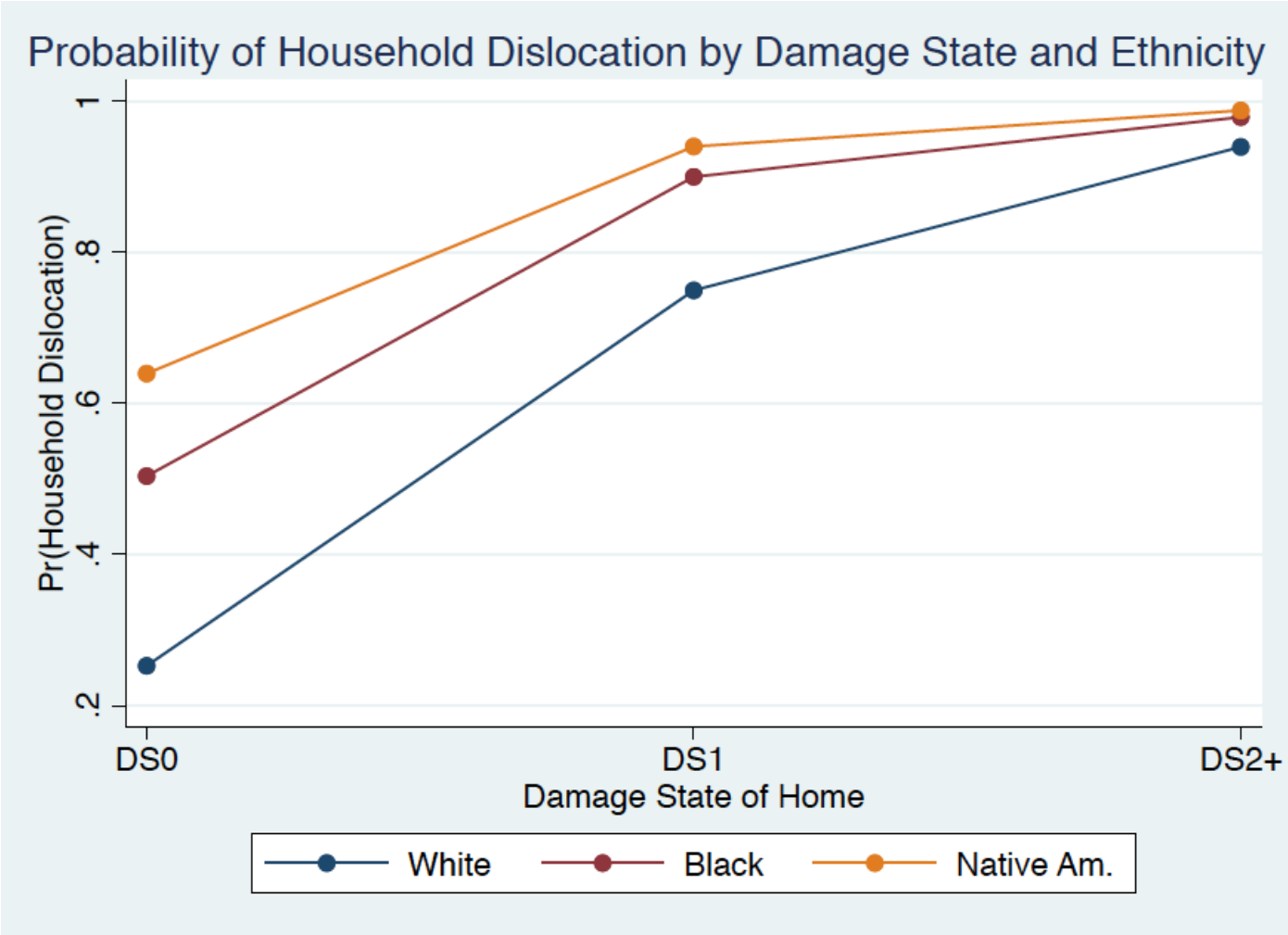


Socio-Demographic Characteristics

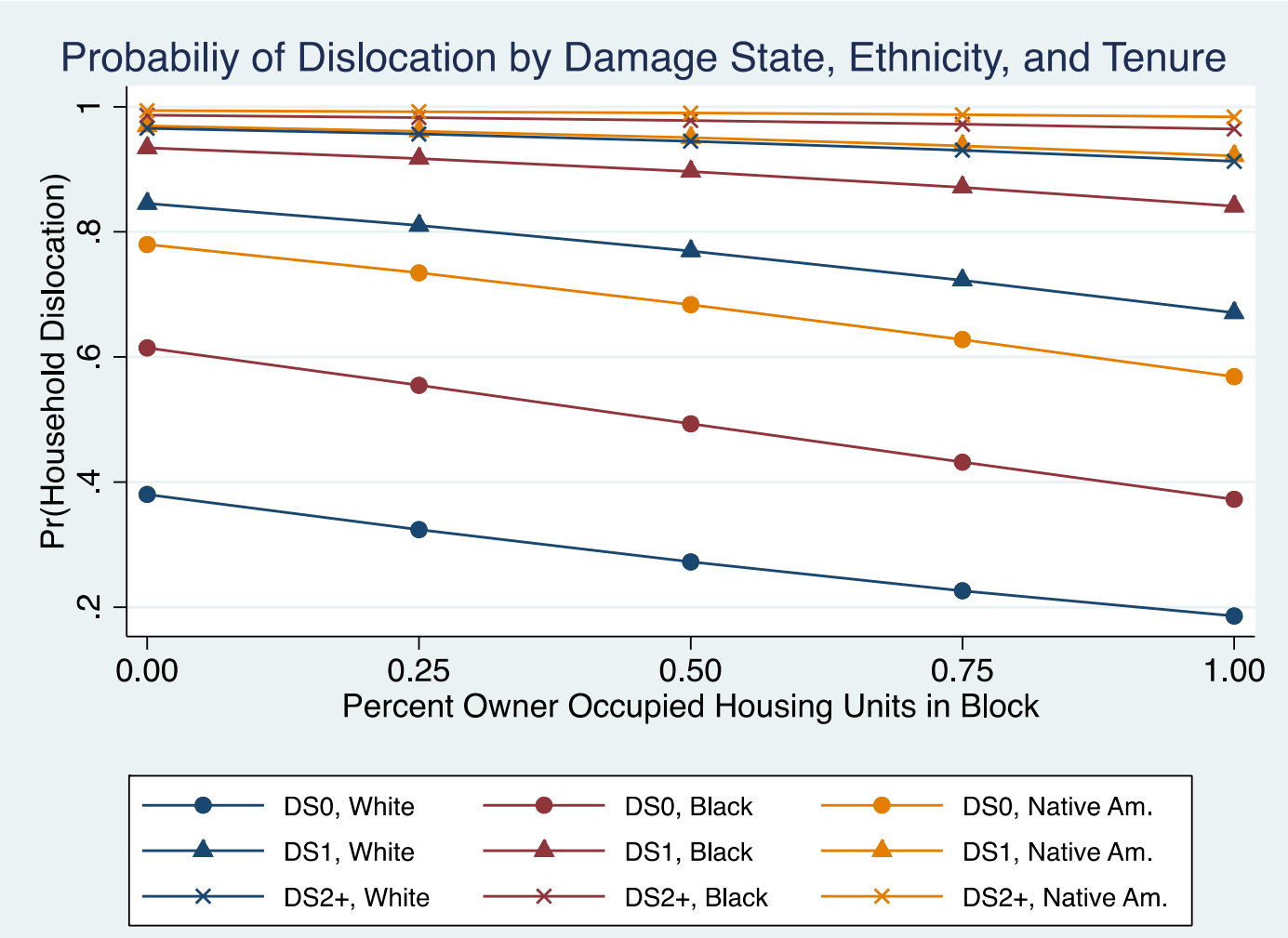




Household Dislocation, Damage, and Socio-Economic Data



Household Dislocation, Damage, and Socio-Economic Data



The Lumberton Study Moving Forward…

- A smaller CoE team will return at the one year point to:
  - Identify outmigration by race/ethnicity, income, and tenure status
  - Collect data to compute 4 to 7 recovery metrics described earlier at 12 months, 18 months, etc.
  - Identify and record decisions made at the community level for recovery
  - Record the inflow of financial capital, other fund mechanisms, i.e. bonds.

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