

# An Interdisciplinary Approach to Household Strengthening and Insurance Decisions

**Prof. Rachel Davidson**

University of Delaware, Civil and Environmental Engineering  
rdavidso@udel.edu

**Prof. Jamie Kruse**

East Carolina University, Economics

**Prof. Linda Nozick**

Cornell University, Civil and Environmental Engineering

**Prof. Joseph Trainor**

University of Delaware, Public Policy and Administration

## Project Overview

- Advance understanding of **homeowner insurance purchase and retrofit** decisions and role they play in system-wide efforts to **manage coastal hurricane disaster risk**
- Key building blocks
  - Rich survey dataset as basis for homeowner decision models
  - Math modeling framework that includes:
    - Insurance and retrofit
    - Multiple stakeholders (homeowners, insurers, reinsurers, government)

## End User Engagement

### Advisory Panel

	Acting Division Director	FEMA Federal Insurance and Mitigation Administration, Risk Analysis Division
	Senior Policy Advisor	FEMA Individual and Community Preparedness Division, National Preparedness Directorate
<b>Chad Berginnis</b>	Executive Director	Association of State Floodplain Managers (ASFPM)
	Research Economist	NIST Applied Economics Office/ Community Resilience Group
	Disaster Resilience Lead	NIST Materials and Structural Systems Division

## End User Engagement

### Interactions to date

- Phone calls before project officially began
- Group calls 1/16 and 8/16
- Discussions at CRC meetings
- Multiple conversations between Jackie Snelling and Joe Trainor

### Plans for remainder of project

- Calls 1/17 and 7/17

## Evolving View of Our End User

### Initial view

- Use previously collected data to model homeowner protective action decisions
- Quick deliverables
- Independently valuable to DHS/FEMA



### Emerging view

- Broader vision for system win-win tool is more compelling
- Help think thru value of mitigation investments
- Whole community focus on homeowners, govt., and insurers (+ possible additions)
- What drives homeowner mitigation behavior (e.g., affordability, culture)
- Flexibility to add features

## Research Work and Accomplishments

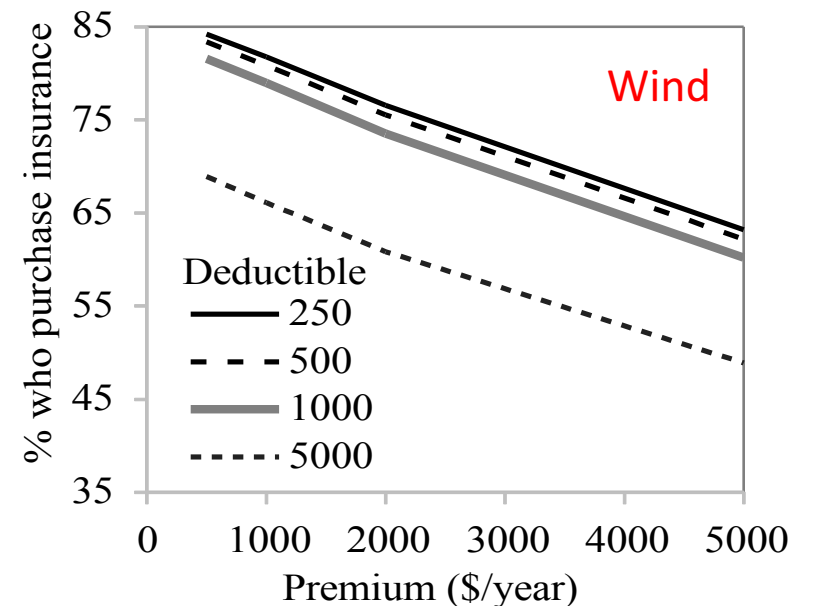
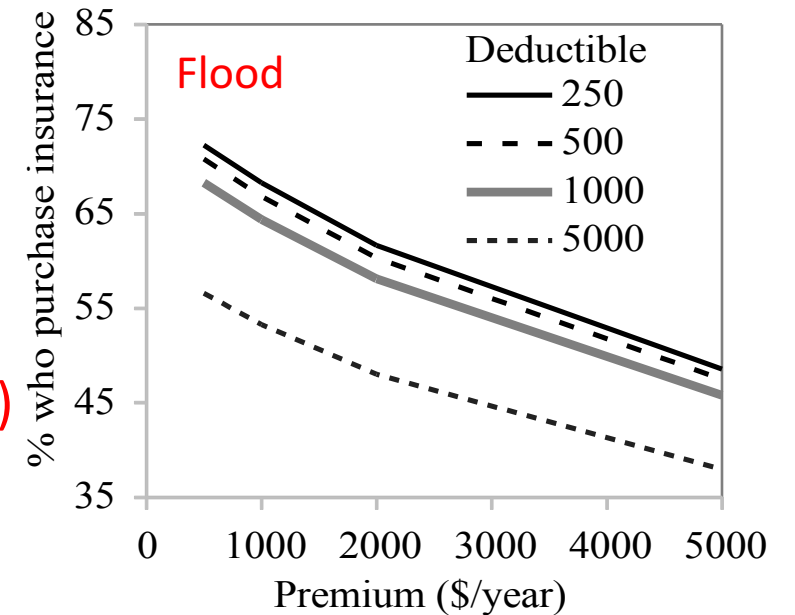
Activity	Specific tasks	Due date	Status
1. Homeowner insurance purchase decision-making	<ul style="list-style-type: none"> <li>• Analysis (discrete choice model).....</li> <li>• Journal paper.....</li> <li>• Policy brief.....</li> </ul>	<p>--</p> <p>11/16</p> <p>11/16</p>	<p>Done</p> <p>Done</p> <p>75% done</p>
2. Homeowner retrofit decision-making	<ul style="list-style-type: none"> <li>• Analysis (discrete choice model).....</li> <li>• Journal paper.....</li> <li>• Policy brief.....</li> </ul>	<p>--</p> <p>12/17</p> <p>12/17</p>	<p>95% done</p> <p>--</p> <p>--</p>
3. Past hurricane experience effect on protective actions	<ul style="list-style-type: none"> <li>• Analysis (structural equation model).....</li> <li>• Journal paper.....</li> <li>• Policy brief.....</li> </ul>	<p>--</p> <p>12/16</p> <p>12/16</p>	<p>Done</p> <p>90% done</p> <p>75% done</p>
4. Prototype decision tool	Excel tool to predict homeowner decision-making under different policies	<p>v1 — 6/17</p> <p>v2 — 6/18</p>	(see future plans)
5. System win-win white paper	White paper on new approach to & framework to support risk reduction policymaking	3/17	50% done

## 1. Homeowner Insurance Purchase Decision-making

Discrete choice models with stated preference data

$$P(\text{buy wind (flood) insurance}) = f(\text{household, home, policy attributes})$$

- Flood and wind models are quite similar
- Demand not very sensitive to premium and deductible
- Higher probability of purchasing insurance if:
  - More recent hurricane experience
  - Higher income
  - In a floodplain
  - Younger homeowners
  - Closer to the coast
- Recency of hurricane experience more influential when experienced damage
- Insurance and retrofit are complements, not substitute (for flood)
- Can use models to predict homeowner decisions for a region



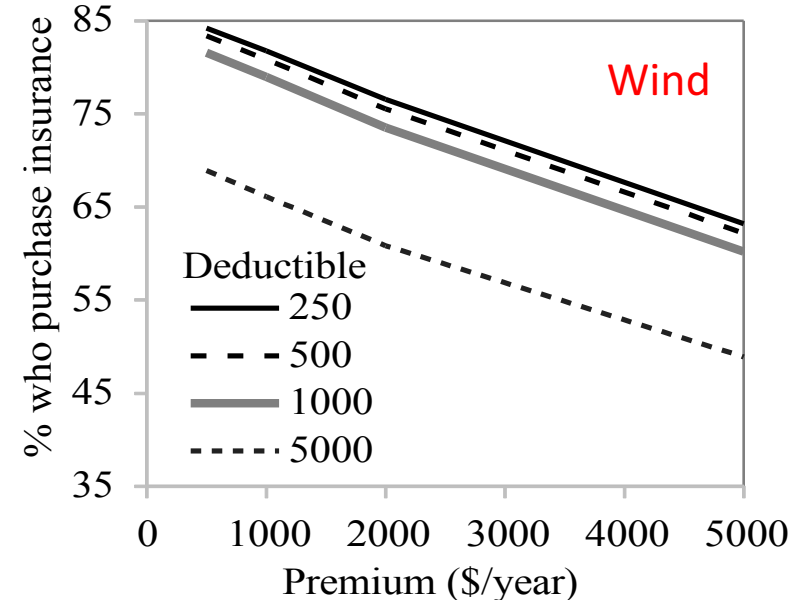
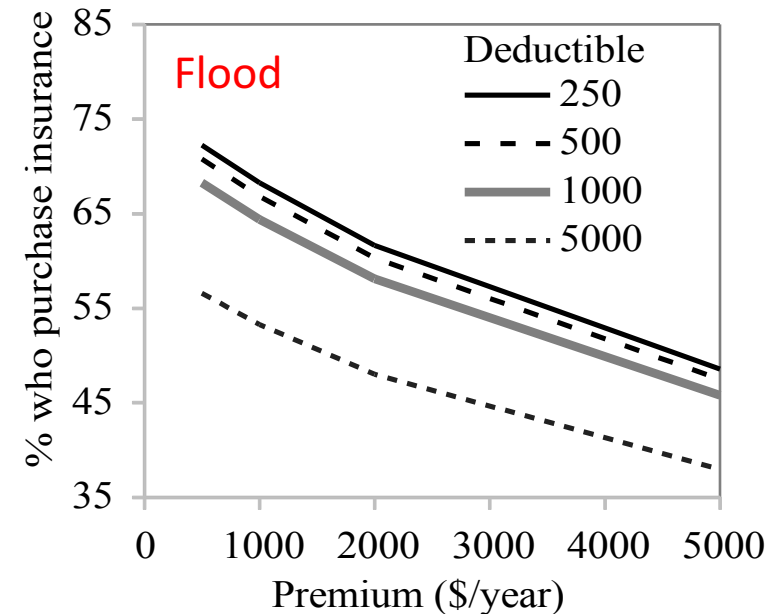
## 1. Homeowner Insurance Purchase Decision-making

### Uses

- Have to price insurance so high enough for solvency, low enough for adequate takeup rates.
- Need to know how homeowners respond to price changes to do that
- What's highest voluntary penetration we can expect?
- Differences in behavior help target customers

### End Users

NFIP, insurance companies, government agencies that regulate the industry, FEMA agency personnel focused on insurance penetration and risk reduction, State Mitigation Officers





## 2. Homeowner Retrofit Decision-making

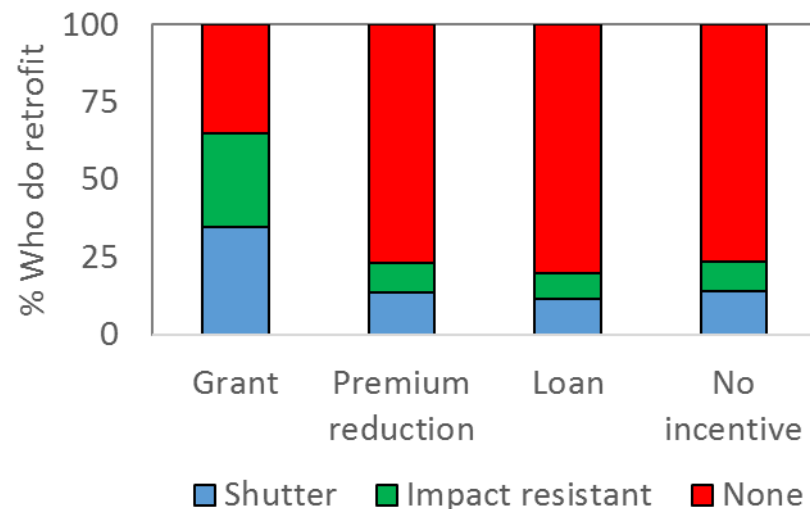
Discrete choice models  
with stated preference data

$P(\text{retrofit}) = f(\text{household \& home attributes, incentive})$

- Grant has a significant effect  
Loan and premium reduction do not
- Higher probability of retrofitting if:
  - Closer to the coast
  - In a floodplain
  - Newer home
  - <1 year since last hurricane

*Preliminary results*

Model	Alternatives
Roof	Shingles, adhesive, none
Openings	Shutters, impact resistant windows, none
Roof-to-wall	Roof-to-wall, none
Flood	Elevate home, siding, elev. appliances, none



Incentive
None
Low interest loan
Premium reduction
Grant

## 2. Homeowner Retrofit Decision-making

### Uses

- Programs to encourage retrofit are being developed in different states
- Need to know how to design those (e.g., type of incentive, amount), which depends on how homeowners will respond
- Differences in behavior help target customers

### End Users

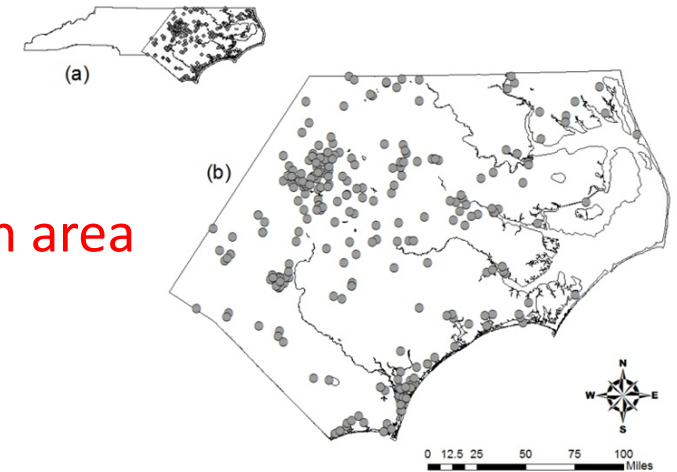
- Hazard Mitigation Grant Program (HMGP)
- Pre-Disaster Mitigation Grant Prgm (PDM)
- Flood Mitigation Assistance Grant Program (FMA)
- State Mitigation Officers
- Insurance companies, NFIP

## 3. Effect of Past Hurricane Experience and Risk Perception on Homeowner Protective Action Decision-making

### Structural Equation Model

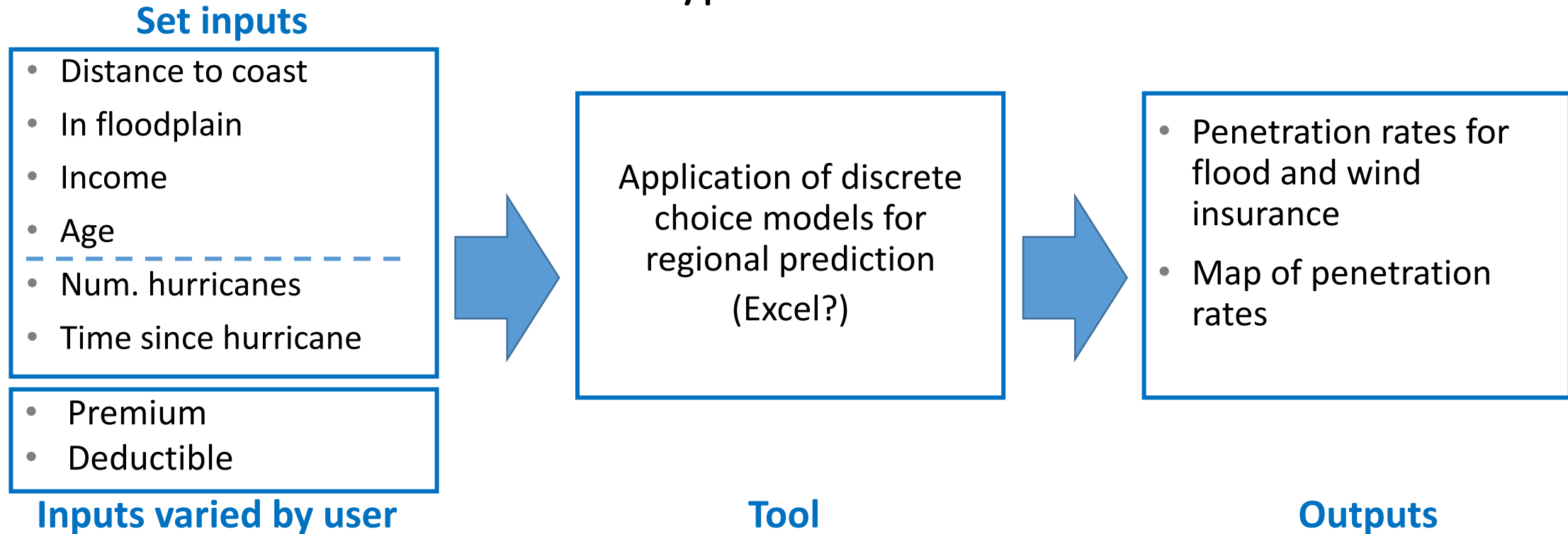
- Examined link between hurricane experience and emotions
- Examined mediating effect of emotion/affect and insurance purchase
- Controlled for income, race, education, perception of govt. aid, tenure in area
- Support past findings on role of prior hazard experience, length of tenure, race, gender, income, and location in flood insurance purchase
- Strong support for mediation effects of fear in linking prior hazard experience to protective action decisions

**Uses:** Understand effect of hazard events on decision-making, how to consider it in policymaking



Geographic distribution of (n=318) survey respondents in (a) state of North Carolina, and (b) study area.

## 4. Prototype Decision Tool

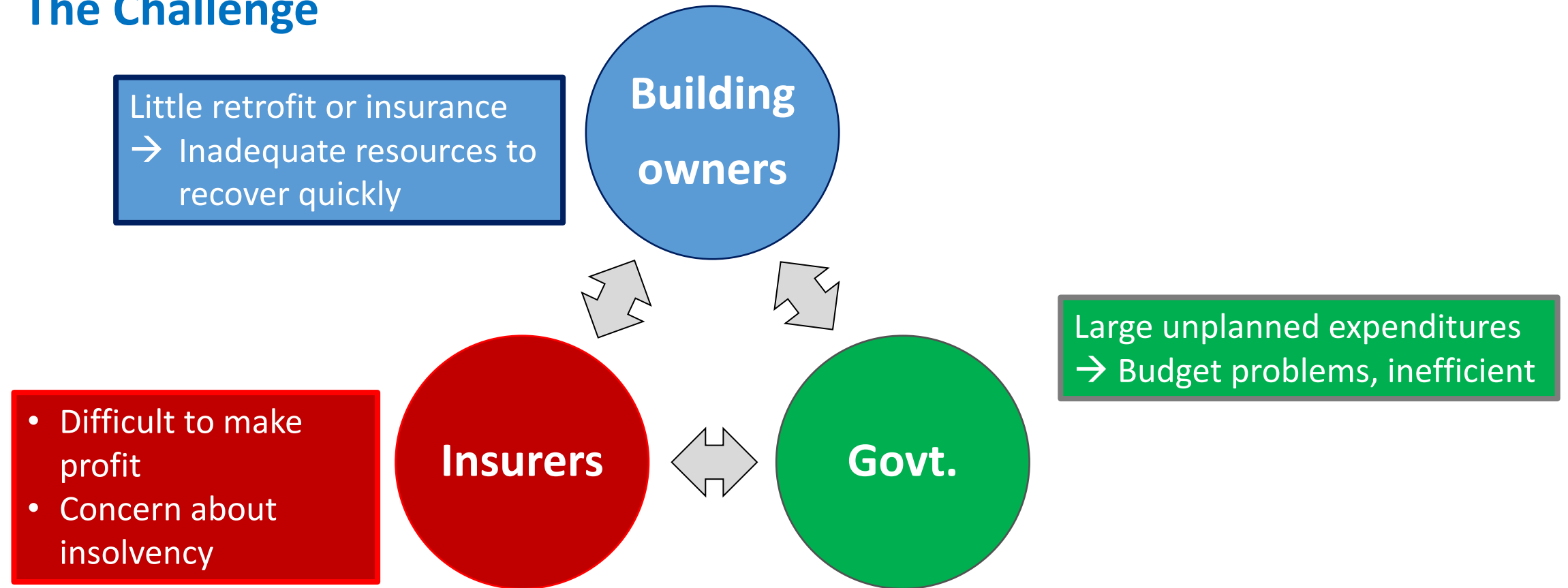


**End user feedback:**

**More interested in system win-win framework/tool than this tool**

## 5. System Win-Win Approach, Tool, White Paper

### The Challenge



**Current system has limitations for all stakeholders**

## 5. System Win-Win Approach, Tool, White Paper

### Challenges in managing regional risk

- Multiple stakeholders involved



- Homeowners, govt, insurers, reinsurers
- Different
  - Objectives
  - Available alternatives
  - Biases
  - Timelines
  - Constraints
  - Available information

## 5. System Win-Win Approach, Tool, White Paper

### Challenges in managing regional risk

- Multiple stakeholders involved
- Complex individual decision-making processes




### Depends on:

- Biases
  - Aversion to upfront costs
  - Underestimation of probability of disaster
  - Preference for status quo
  - Use of short time horizon
- Other factors
  - Attributes of protective actions
  - Social influences
  - Risk perception, hazard experience
  - ...

## 5. System Win-Win Approach, Tool, White Paper

### Challenges in managing regional risk

- Multiple stakeholders involved
  - Complex individual decision-making processes
  - Technical complexity of risk
- 

- Multiple types of impact (\$ loss, injuries, disruption)
- Multiple strategies (e.g., insurance, retrofit, education)
  - Each has different cost, effect on risk, other benefits
- Magnitude and nature of risk varies



## 5. System Win-Win Approach, Tool, White Paper

### Challenges in managing regional risk

- Multiple stakeholders involved
- Complex individual decision-making processes
- Technical complexity of risk



### Vision for system win-win tool

- Win-win solutions
- Aligned with natural decision-making processes
- Tailored to actual risk

## 5. System Win-Win Approach, Tool, White Paper Proposed Vision

Develop a **software tool** to help state-level officials identify and evaluate alternative public policies aimed at finding effective, sustainable, win-win solutions to better manage natural disaster risk associated with existing buildings.

## 5. System Win-Win Approach, Tool, White Paper Proposed Vision

### End Users

State-level officials (e.g., emergency mgr, mitigation officer, insurance commissioner)

### Use

- Help identify and evaluate possible government policies based on effects on:
  - Each stakeholder separately
  - Community risk
  - Insurance market
- Support cost, feasibility, and effectiveness analyses
- Guidance documents exist (e.g., Hazard Mitigation Asst Guidance) but no science-based tool

## 5. System Win-Win Approach, Tool, White Paper Proposed Vision

### Policy types considered

- Strengthening buildings
- Insurance
- Property acquisition
- (perhaps others later)

### Modes of operation

- What-if mode
- Recommendation mode

### Outputs

#### Government policy recommended

- Retrofit grant (max limit; % paid)
- Acquisition offer (amount, timing)
- Insurance mandate

#### Expected decisions by each:

- Primary insurers
- Homeowners

#### Consequences for each:

- Primary insurers
- Homeowners
- Community risk

### Specific policy examples

- Offer grant to pay 50% of cost of homeowner retrofit up to \$5000
- Offer acquisition program for damaged homes up at 90% of market value

## 5. System Win-Win Approach, Tool, White Paper Proposed Vision

### Benefits

- Help agencies develop, evaluate, and compare tangible, detailed policy options. Improve decisions to reduce risk.
- Help agencies think about role each group can play and how different possible policies affect different groups. Consistent with FEMA's whole community effort.
- Help make business case for doing interventions (or not)
- Analogous to HAZUS in that provides new structure that can be extended, modules can be improved as science advances
- More efficient and consistent program development. Too expensive for each state to do on its own, and since many extreme events cross state boundaries, better to be consistent.

## Example Results from System Win-Win Software Tool

### Summary of possible policies compared

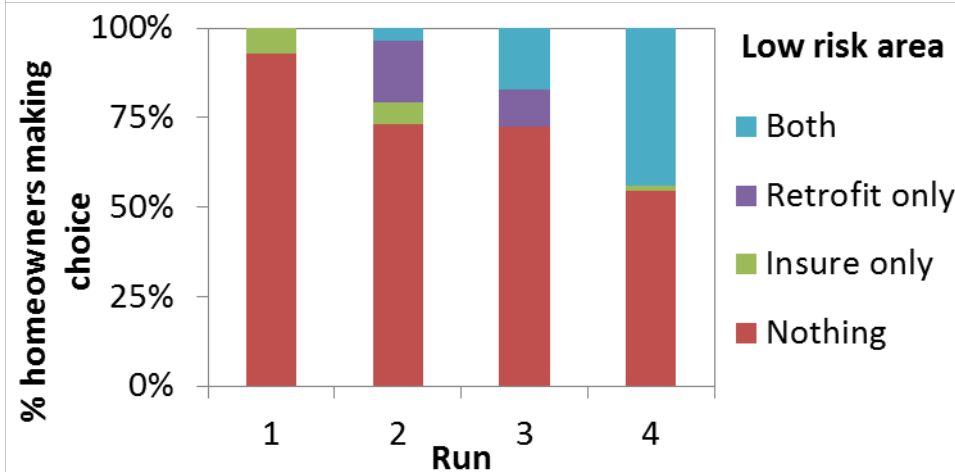
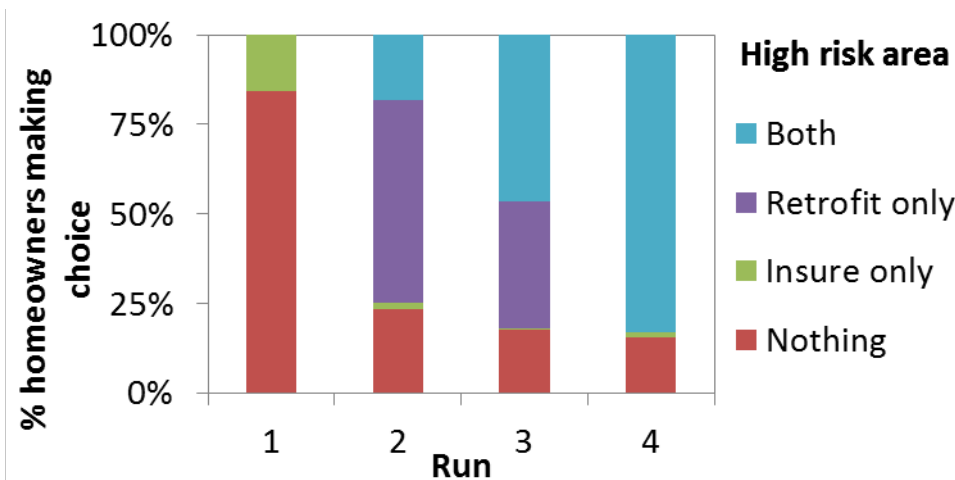
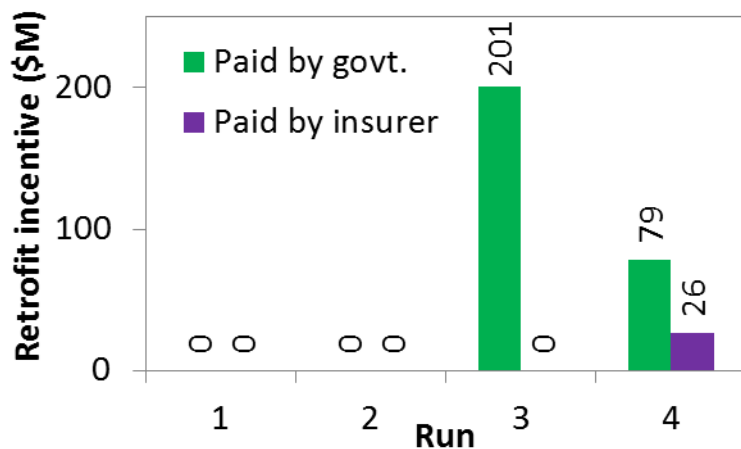
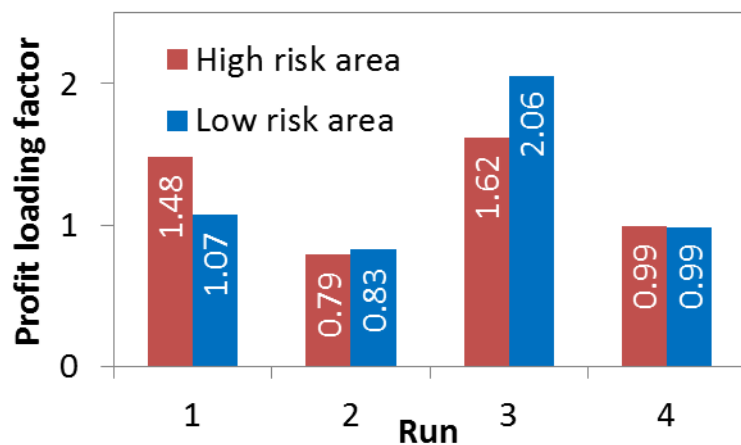
Run	Retrofit allowed?	Profit loading factors $\lambda_H, \lambda_L$	Insurance choice	Who pays retrofit incentive	Retrofit incentive
1	N	Unrestricted	Optional	---	0%
2.1	Y	Unrestricted	Optional	---	0%
2.4	Y	Unrestricted	Optional	Government	75%
3.2	Y	Max=1	Mandatory	Govt 75%/Insurer 25%	25%

Retrofit incentive paid by government, only for *insured* homeowners

- 1 No retrofit
- 2 Retrofit
- 3 Retrofit w/subsidy
- 4 Mand. ins. w/subsidy

## Example Results from System Win-Win Software Tool

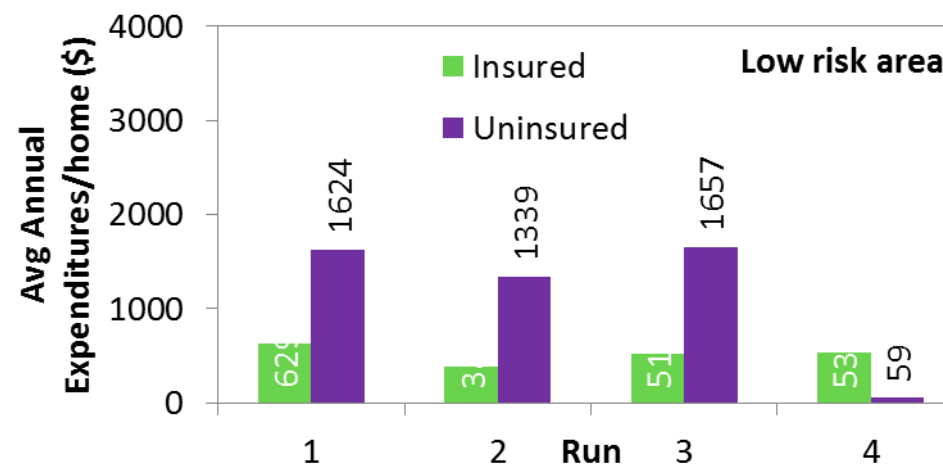
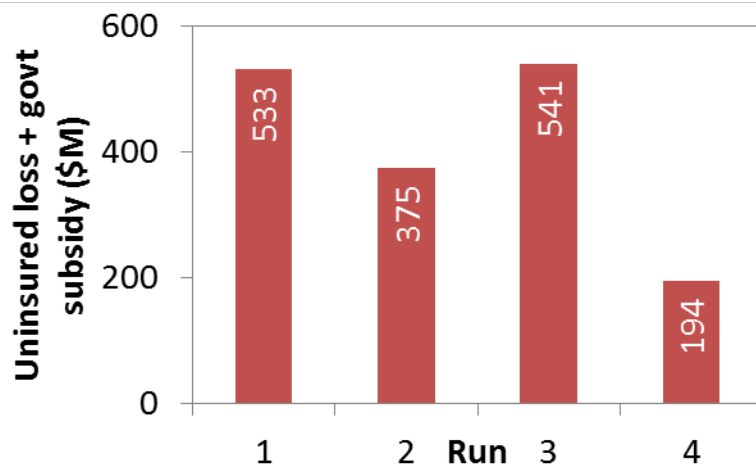
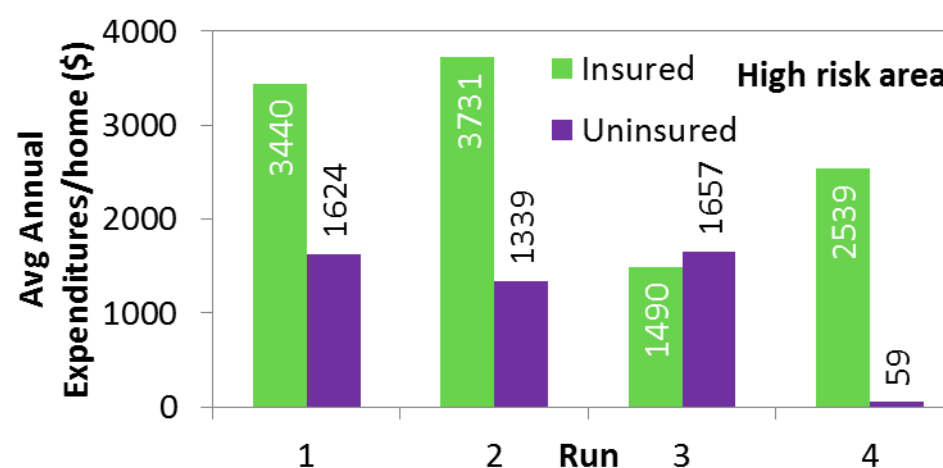
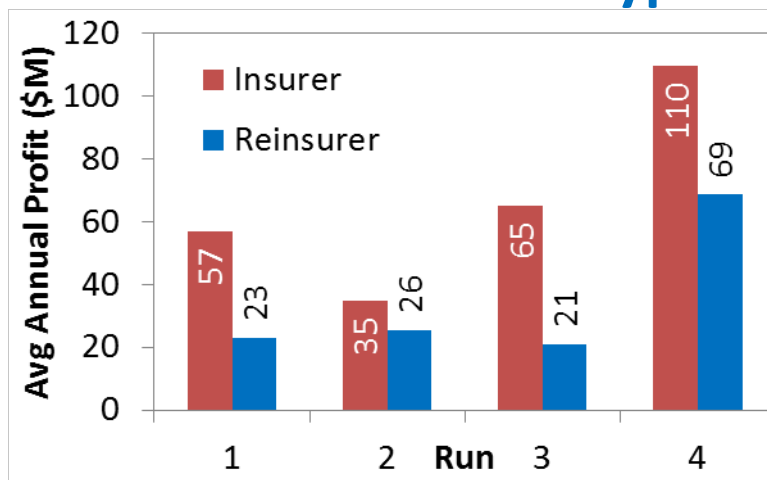
### Expected decisions made



- 1 No retrofit
- 2 Retrofit
- 3 Retrofit w/subsidy
- 4 Mand. ins. w/subsidy

## Example Results from System Win-Win Software Tool

### Outcomes for each stakeholder type

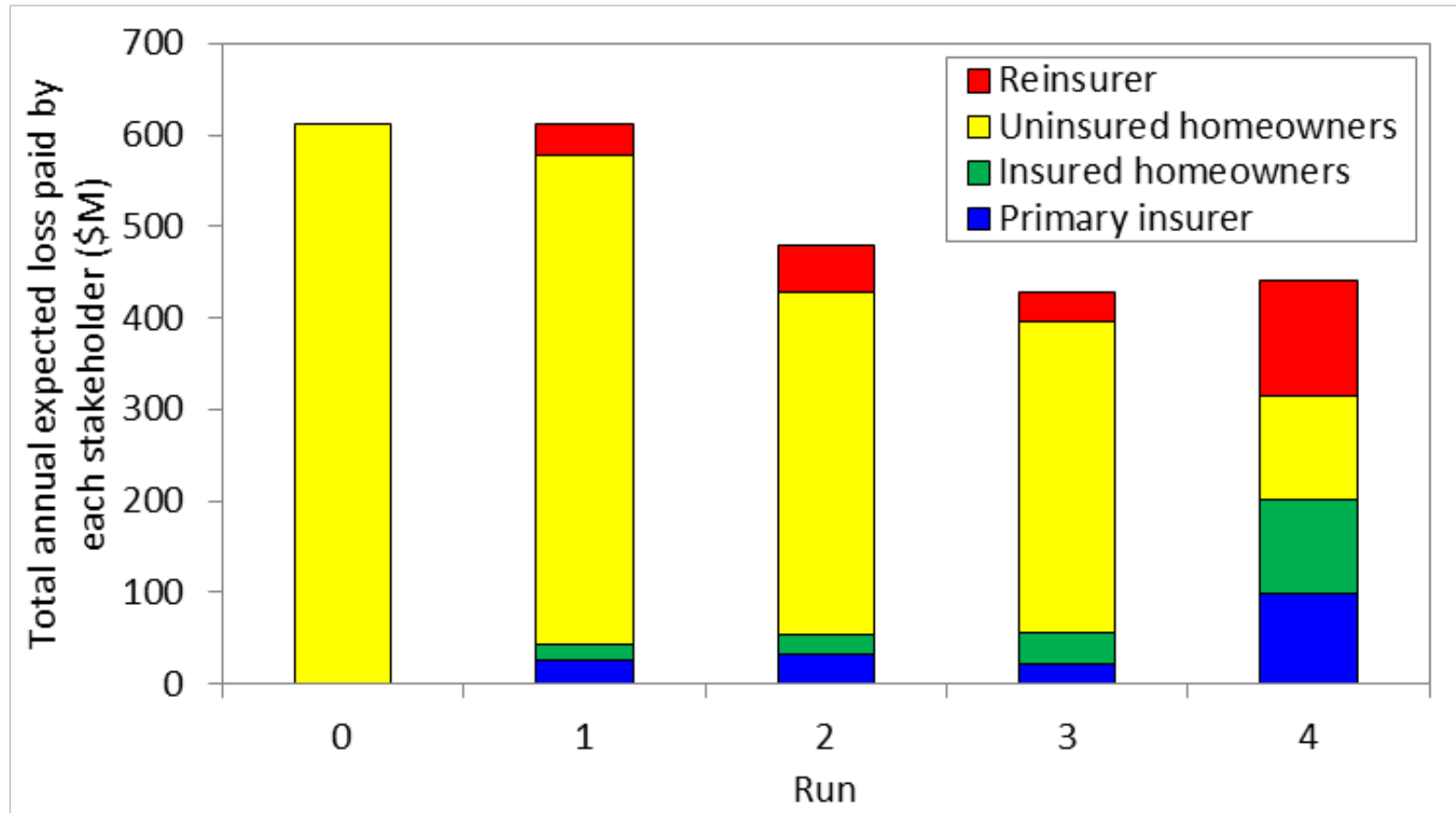




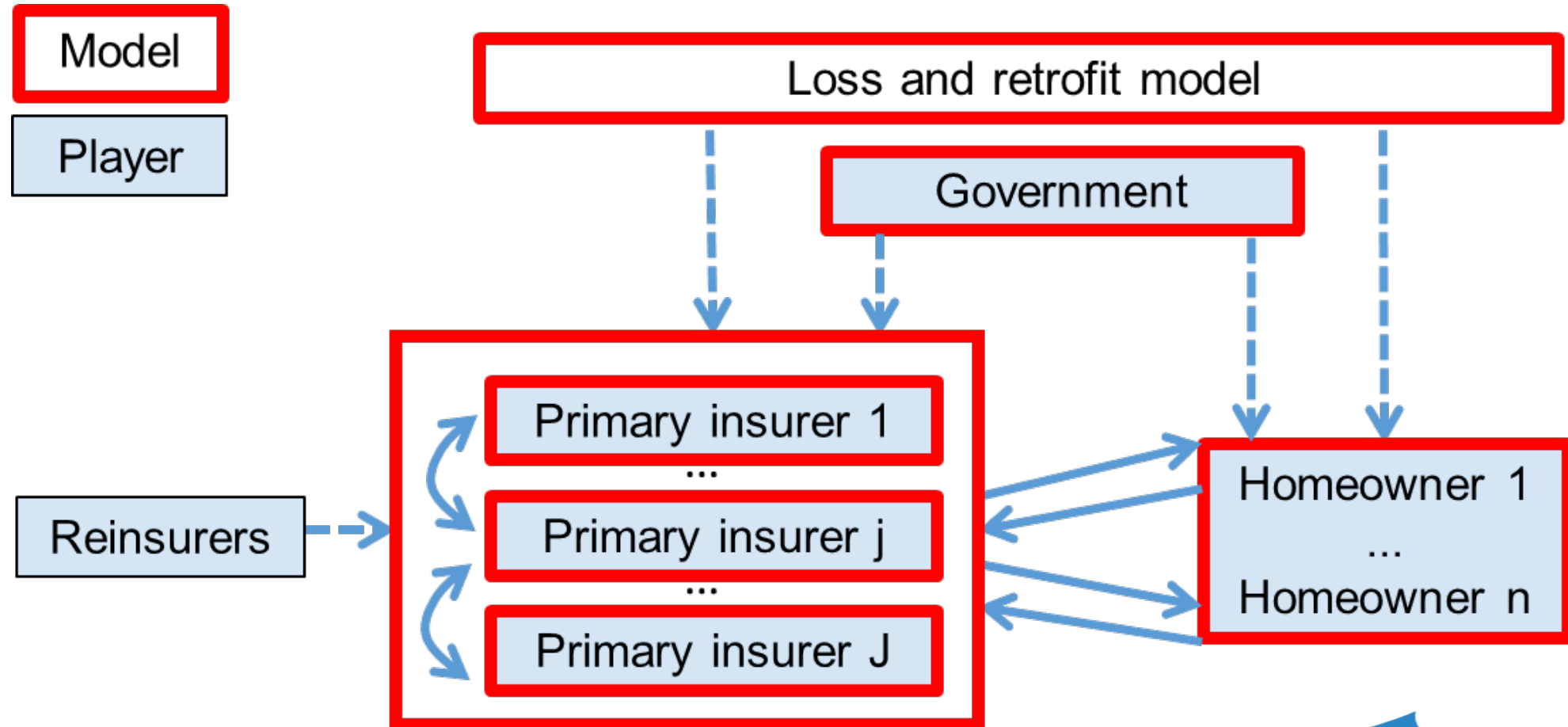
- 1 No retrofit
- 2 Retrofit
- 3 Retrofit w/subsidy
- 4 Mand. ins. w/subsidy

## Example Results from System Win-Win Software Tool

### Who pays?



## How the Tool Works (Inside the black box)



## 5. System Win-Win Approach, Tool, White Paper Current Status and What's Needed Next

### Current status

- Most of science required exists
- Initial version of computational modeling framework that will form basis of tool exists
- Demonstrated for full-scale realistic application for single-family homes subject to hurricanes in Eastern North Carolina



### What's needed next

- End user engagement
- Completion of model development and continued testing
- Commercial development of tool

## Anticipated Project Impact

- Statistical models inform policy makers' thinking about what response to expect from homeowners and how to encourage them to undertake risk reduction activities
- System win-win framework white paper informs thinking about how to develop policies that consider multiple stakeholder types from start and are more likely to be effective and implementable
- Closer to policy analysis tool based on system win-win framework

## Proposed Follow-on Work

### Objective

Develop a significant End User Engagement initiative to explain the proposed win-win tool and gather input on how to make it useful as possible

### Method

- Phone and/or in-person interviews with SMO's and FEMA employees
- Gather info about:
  - Processes they use now to choose, evaluate household risk reduction programs
  - Needs for such a tool

### Sample questions

- What level of interest is there in such a tool?
- What major policies should be compared?
- What hazards? What building types?
- What contextual conditions matter for communities?
- What constraints matter for Federal vs. Local actors?
- What risks should be measured?
- What form/interface do they prefer?

### Expected result

Prioritized set of needs and next directions for developing system win-win framework and tool