Building Coastal Resilience In The Gulf Of Mexico: Decision Support Tools For Assessing The Costs And Effectiveness Of Ecosystem Restoration

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science for a changing world

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natural capital PROJECT

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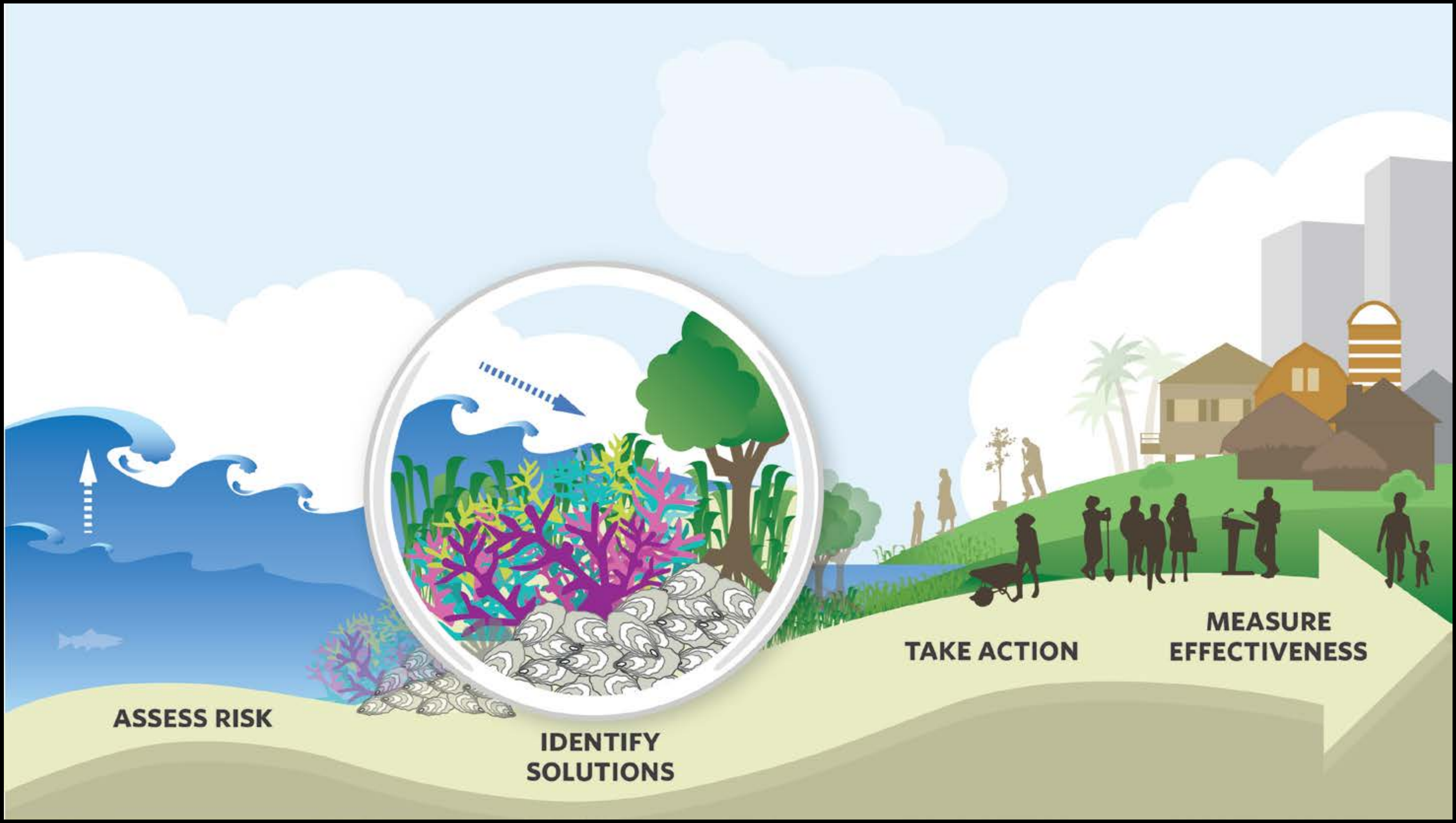
Association of State Floodplain Managers

Coastal Resilience

Approach



Risk Reduction Involves Multiple Solutions

Total Risk

Traditional defenses- seawalls

Natural defenses

Risk Transfer- insurance

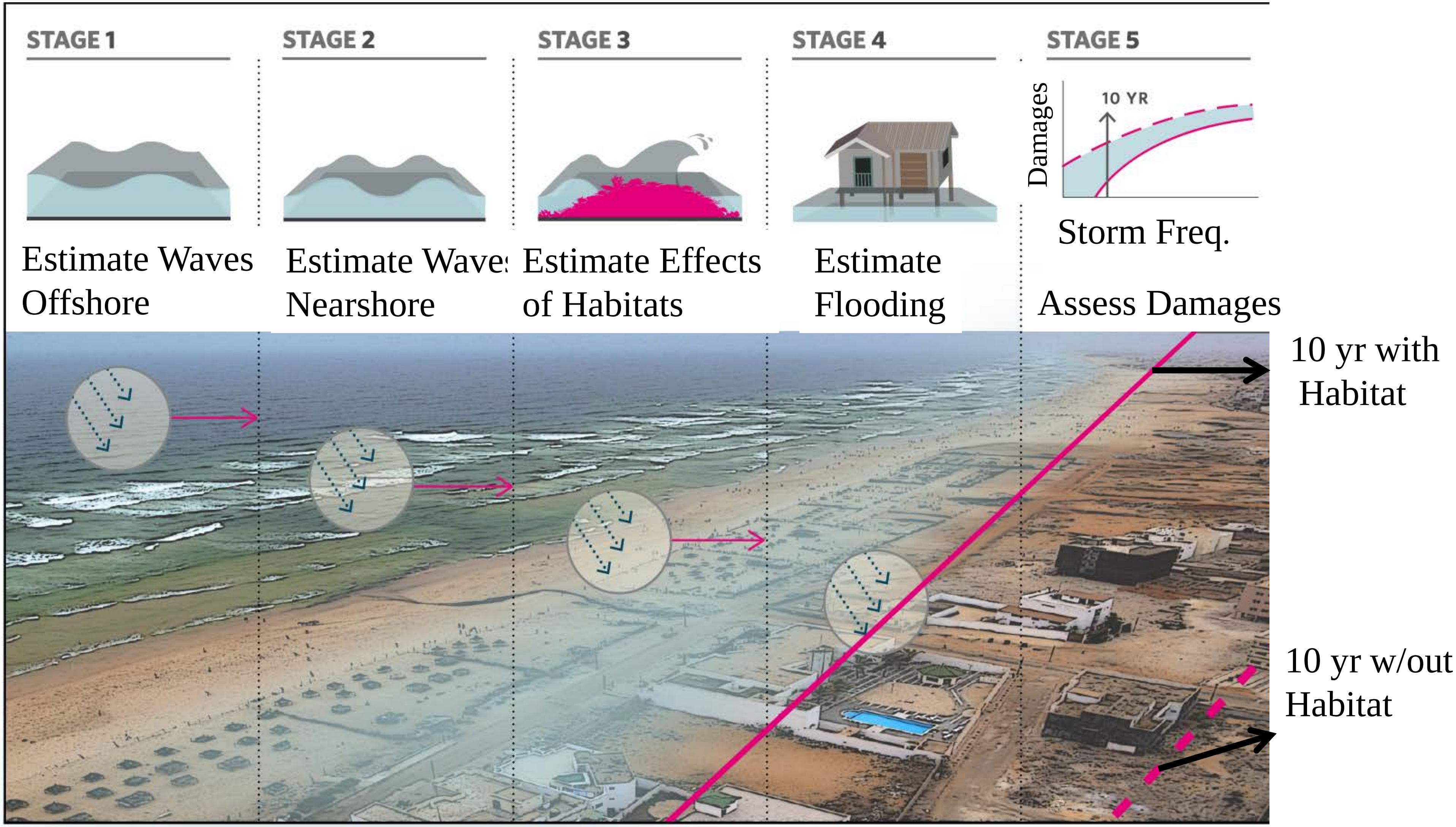
Development choices

How do we identify where nature-based solutions make sense?

Dependent upon:

- Risk reduction
- Cost/benefit
- Feasibility

Recommended Approach for Assessing Coastal Protection Value: Expected Damage Function

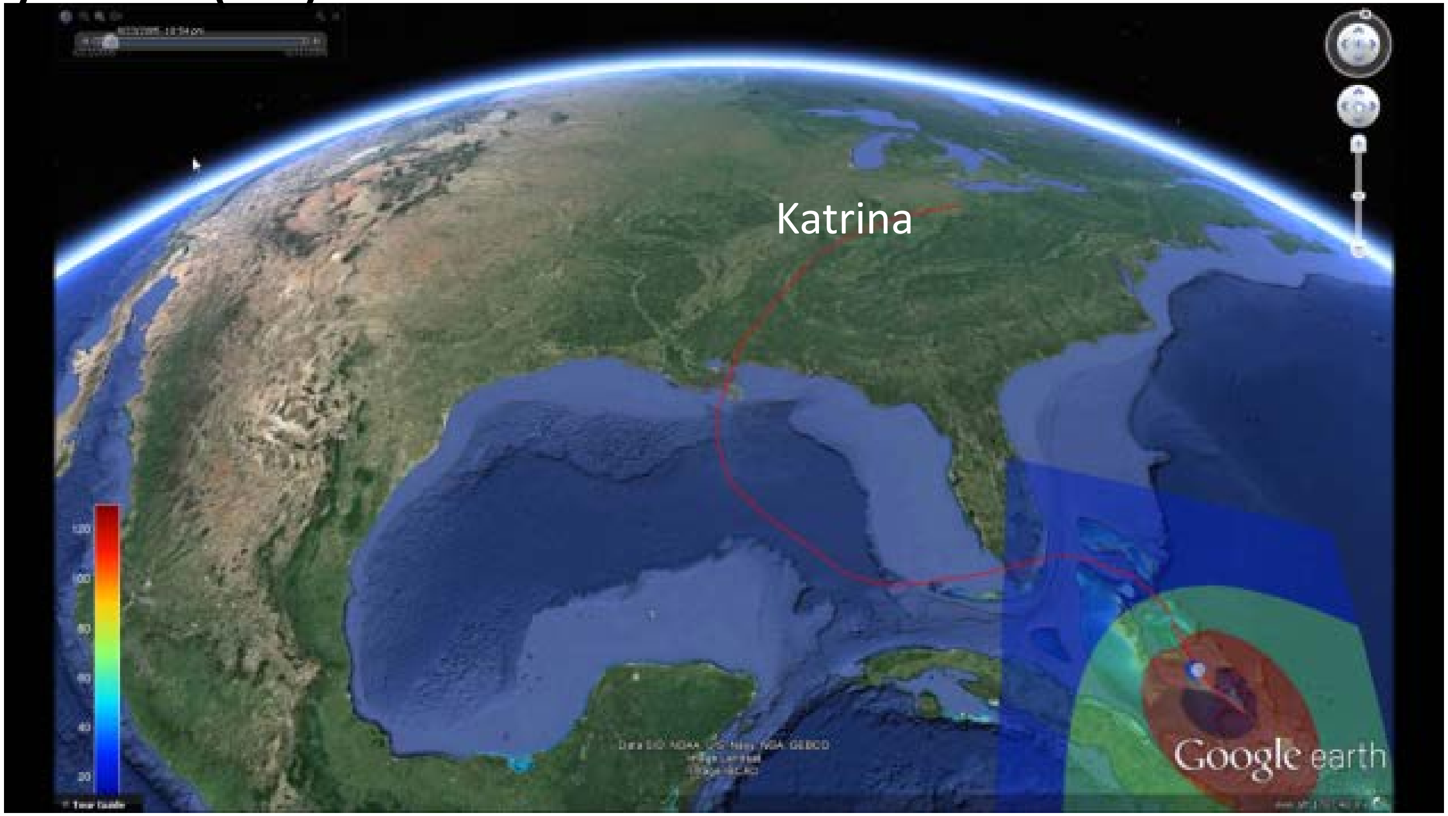


Partnership with Swiss Re

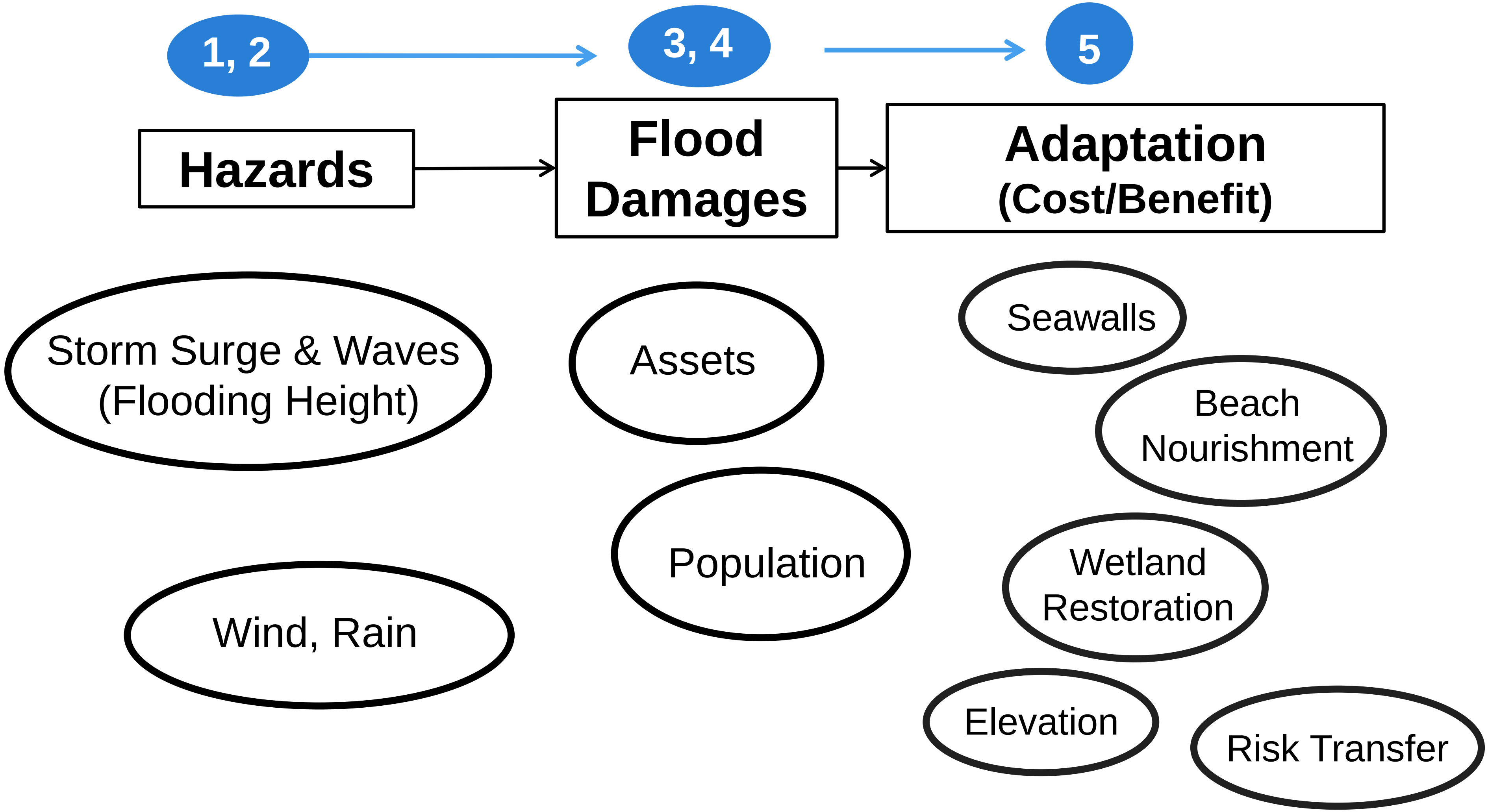
Where are nature-based defenses cost effective?

Aims

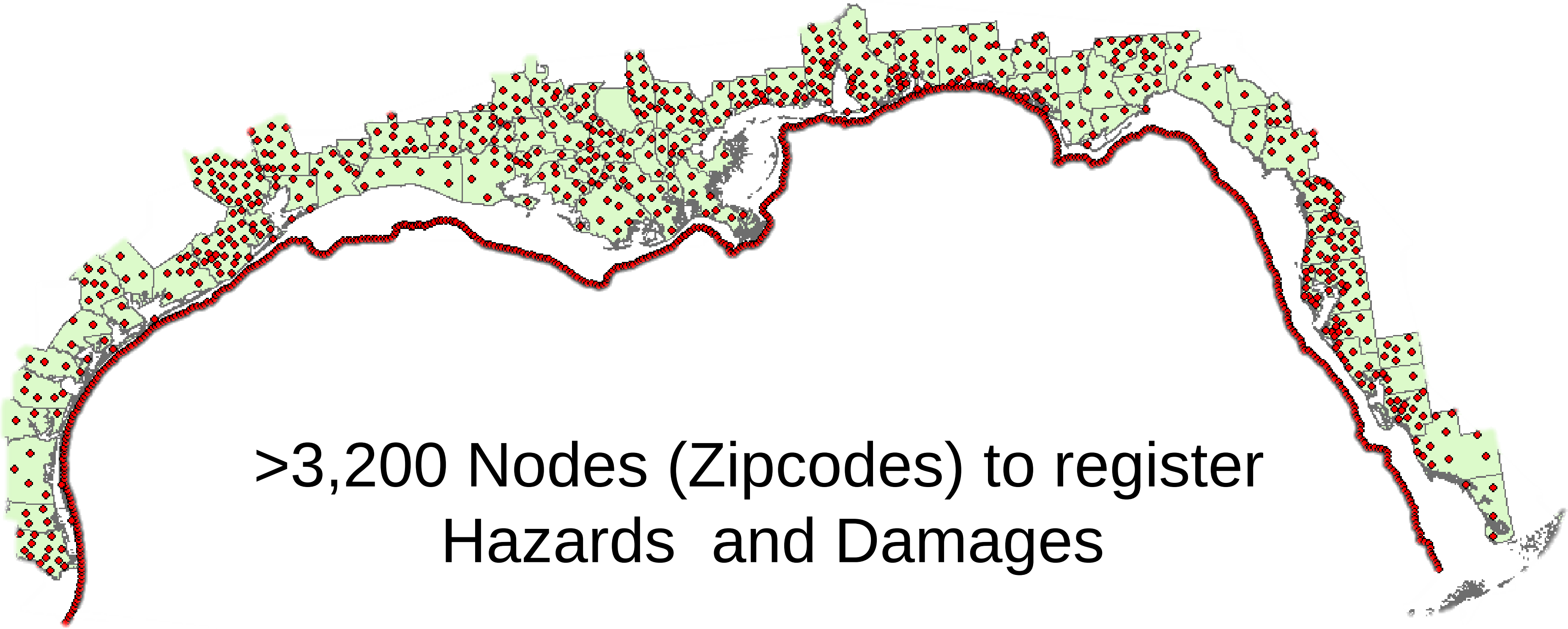
- Work with worlds 2nd largest re-insurer
- Public cost effectiveness model that includes nature
- Add ecosystem (co)benefits



Reguero, Bresch, Beck et al. 2015. *Coastal Eng. Proc.* & in review *Scientific Reports*


1, 2
3, 4
5
Hazards
Flood Damages
Adaptation (Cost/Benefit)
Storm Surge & Waves (Flooding Height)
Wind, Rain
Assets
Population
Seawalls
Beach Nourishment
Wetland Restoration
Elevation
Risk Transfer

The regional domain: The Gulf Coast of US



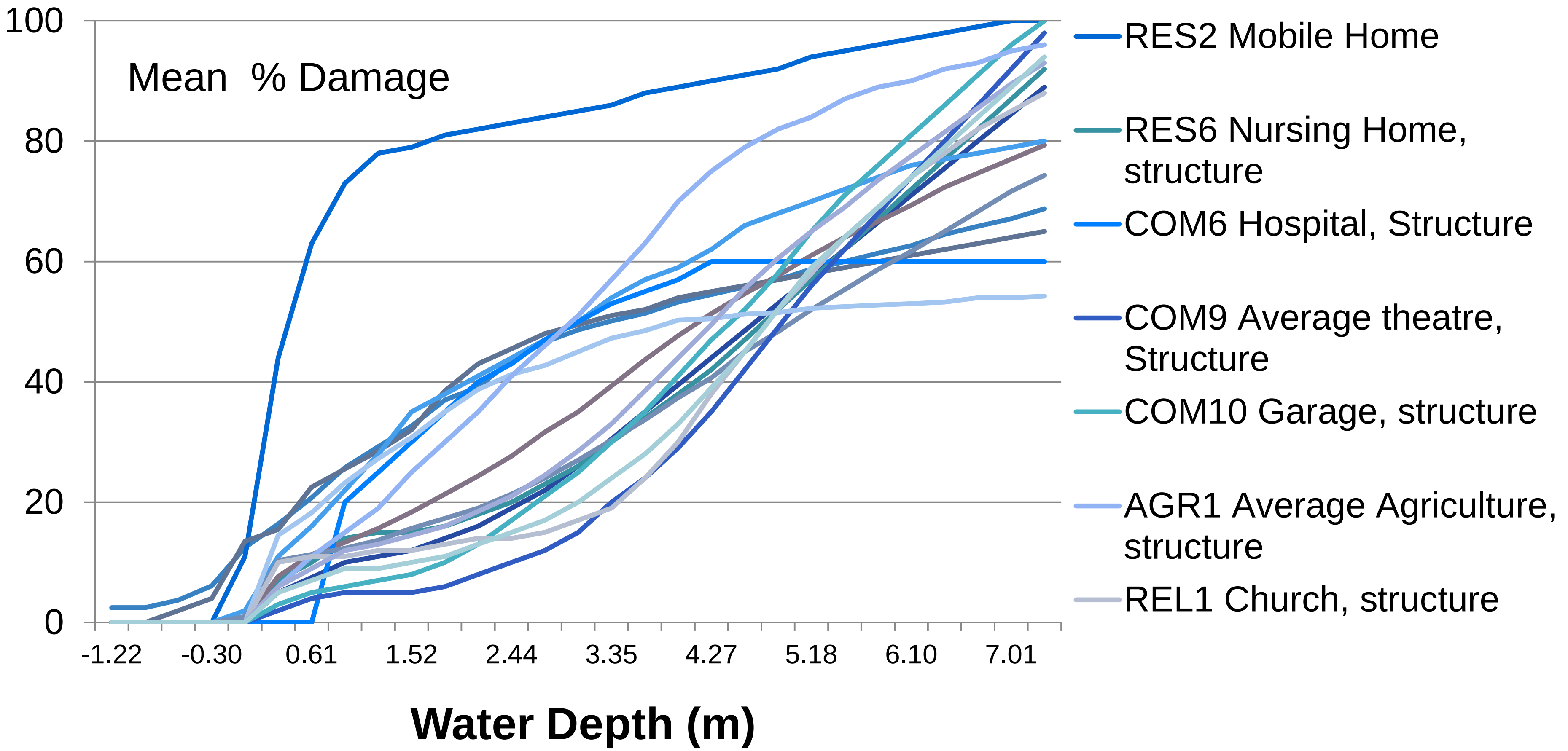
>3,200 Nodes (Zipcodes) to register
Hazards and Damages

Damages Curves

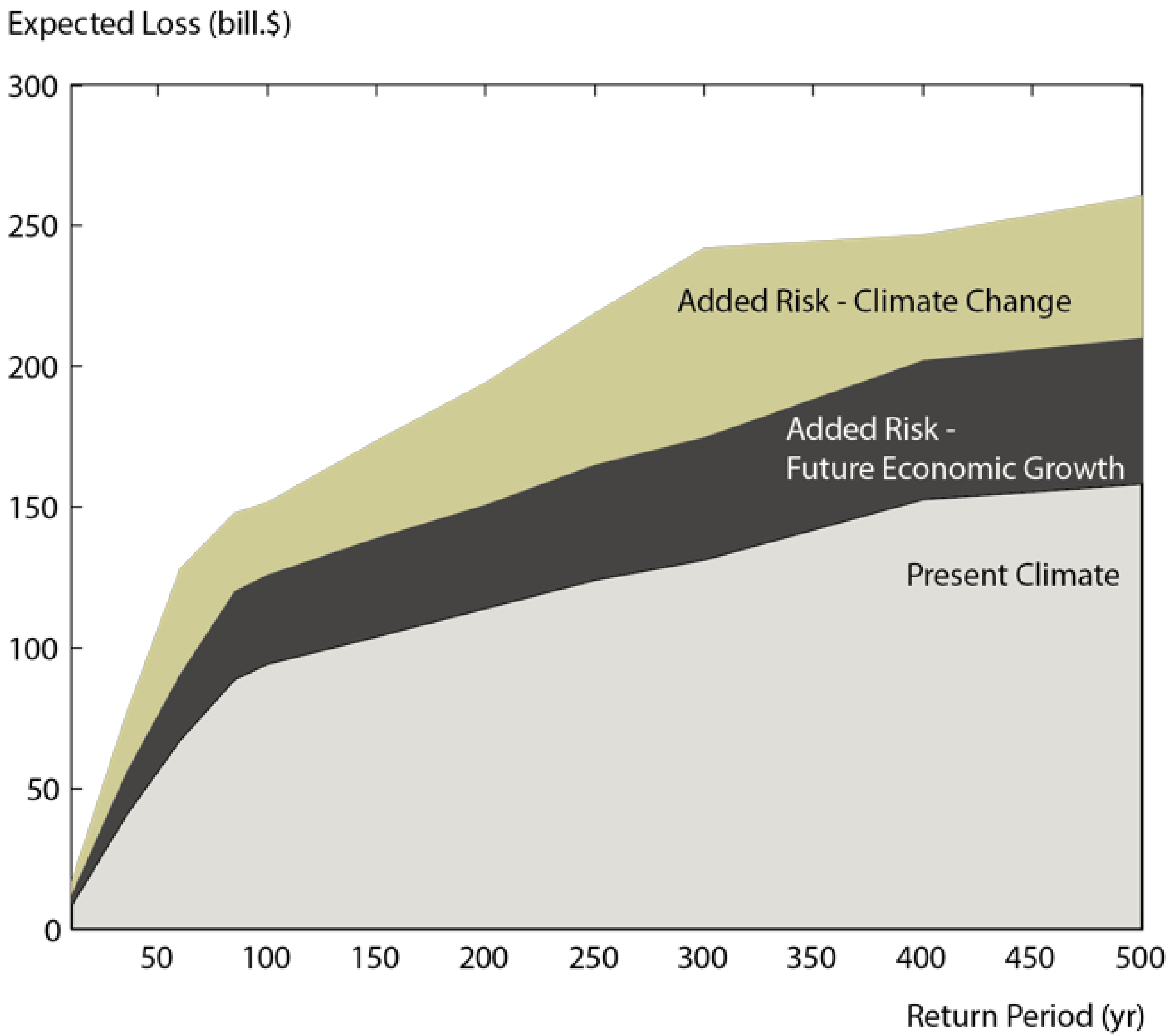
Damage curves (water depth) for different types of buildings

Aggregated into 17 types from the full USACE-FEMA catalogue

Wind Damage curve used from Climada default wind model



Effects of Economic Growth & Climate Change on Losses



Risk Reduction Measures

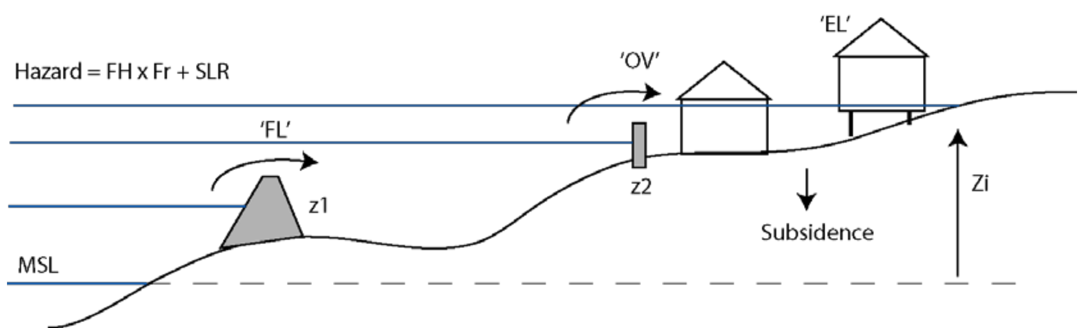
Measure	Criteria
Wetland Restoration	6 Counties with the highest losses in assets where at least 25 miles of salt marsh could be restored by bay.
Wetland Conservation	125 miles of wetlands protected
Local Levees Priority	6 ft “hills” built to protect 532,000 existing houses on the 6 counties that experience most damages
Sandbags	Used in 2.9 million houses for all Cat 3 hurricanes across all counties in the study area.
Local Floodwalls	Concrete blocks (4 ft) built to protect 1.9 million houses across all counties
Levees	20 ft levees constructed around Houma & New Orleans, LA - 340 miles.
Barrier Island Restoration	All Mississippi coastal counties
Oyster Reef Restoration	1000 miles restored in all counties with high suitability
Beach Nourishment	All Coastal Counties in Texas.
Home Elevation	Elevate 481,841 existing houses by 8ft in 6 counties that experience the most damages

• Adaptation Parameterization

MEASURE	SCENARIO 1 (CONSERVATIVE)			
	% Wave Reduction	% Surge Reduction	hazard elevation cutoff (m)	type cutoff
Local levees - homes	20	0	1.8	overtopping
Levees	60	0	6	frontline
Sandbags	0	0	0.6	overtopping
Beach Nourishment	75	0	0	
Local Floodwalls	0	0	1.2	overtopping
Home Elevation	0	0	3	elevation
Wetland restoration	30	10	0	
Barrier island restoration	20	5	0	
Oyster reef restoration	20	0	0	

dz = Hazard + subsidence - Zi

D(i) = MDD(dz) * PAA(dz)



Oyster Reef Restoration

1050 miles of Oyster Reefs restored in 24 counties with high restoration suitability

***see* Restoration Explorer in www.maps.coastalresilience.org**

Penetration varied 15% to 50%

Unit Cost of Measure :

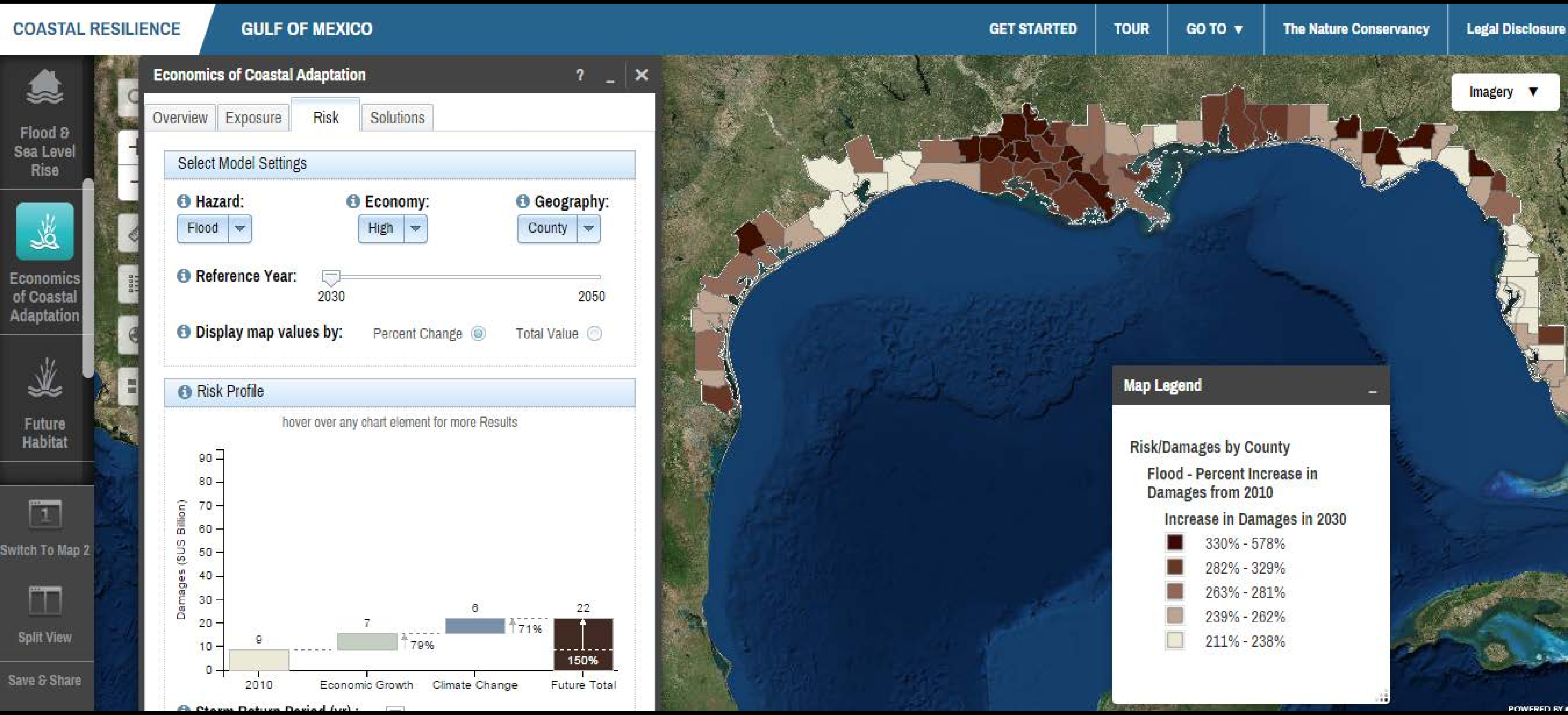
$1,500,000/mile of protected shoreline

Total Cost : $1.6 Billion

Co-Benefits of Oyster Reefs to Fisheries:

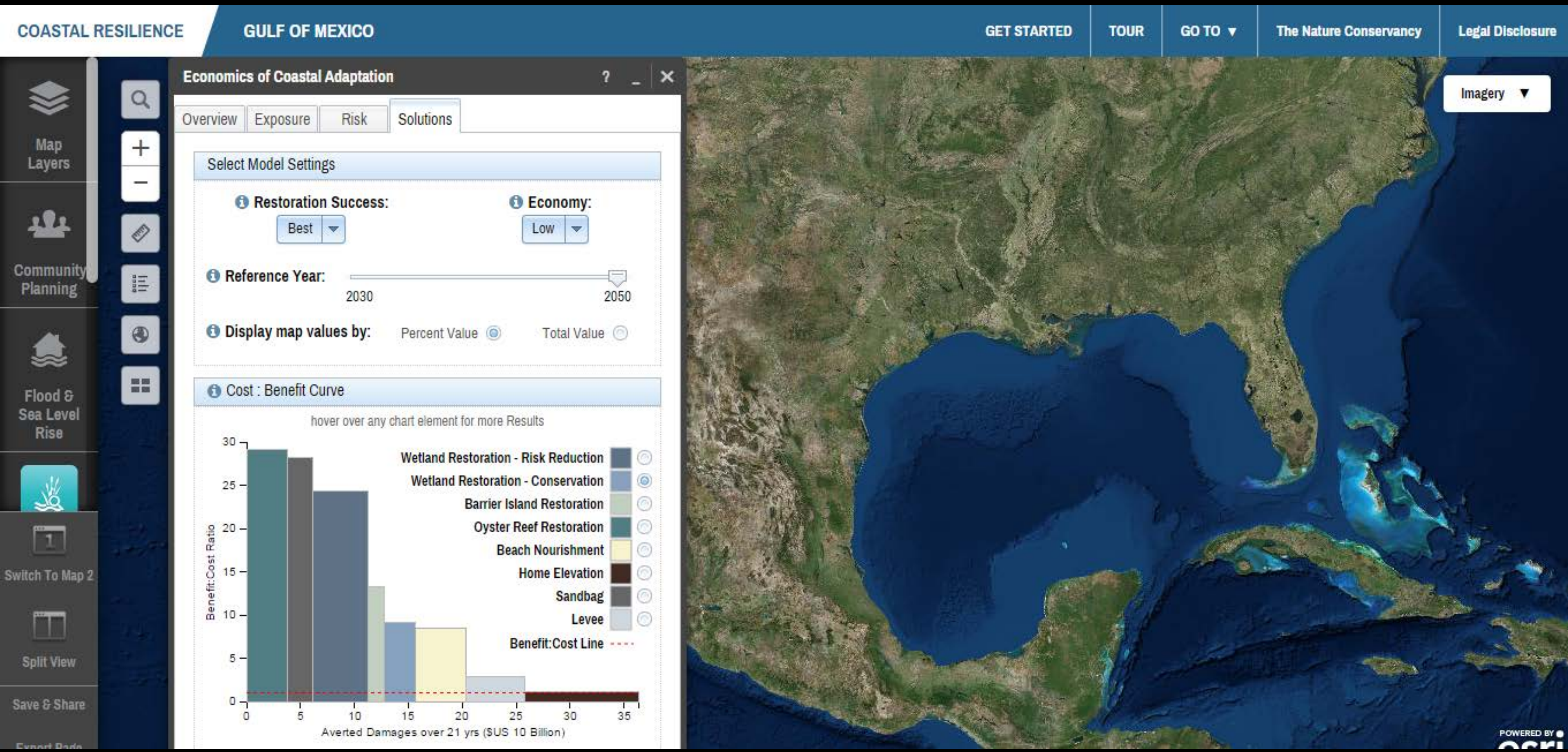
$23,241/ mile of reef restored / year.

Economics of Coastal Adaptation App



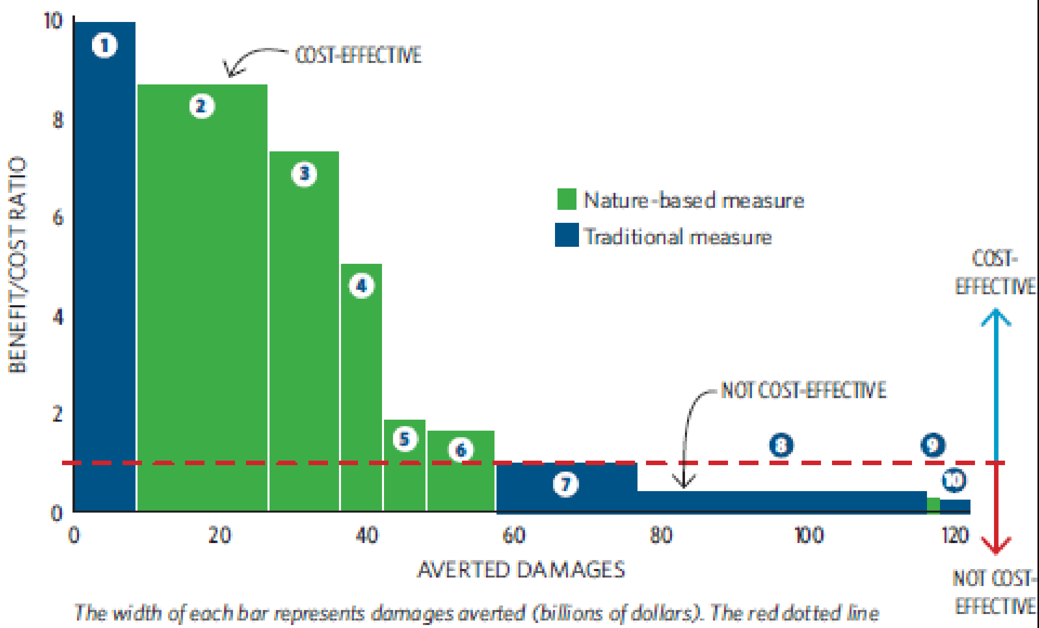
maps.coastalresilience.org/gulfmex

Economics of Coastal Adaptation App



maps.coastalresilience.org/gulfmex

Comparison of the costs and benefits of Risk Reduction measures



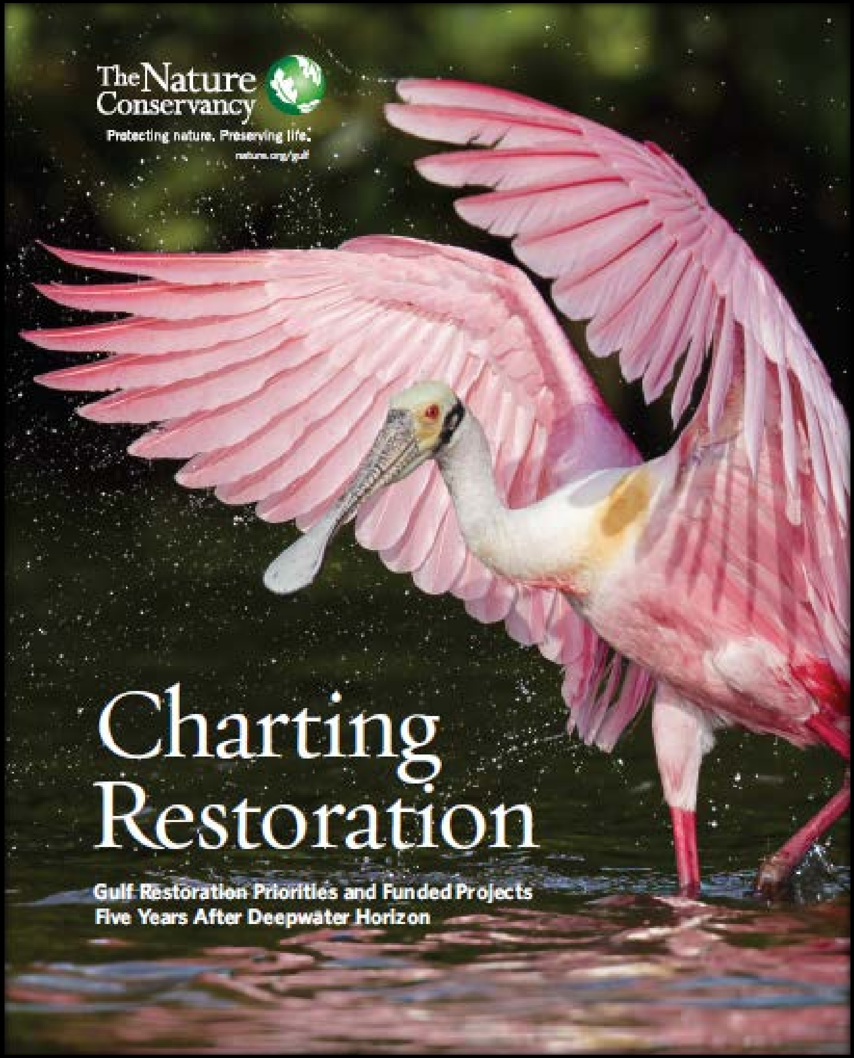
The width of each bar represents damages averted (billions of dollars). The red dotted line indicates a benefit to cost ratio of 1. Measures above the line are cost-effective.

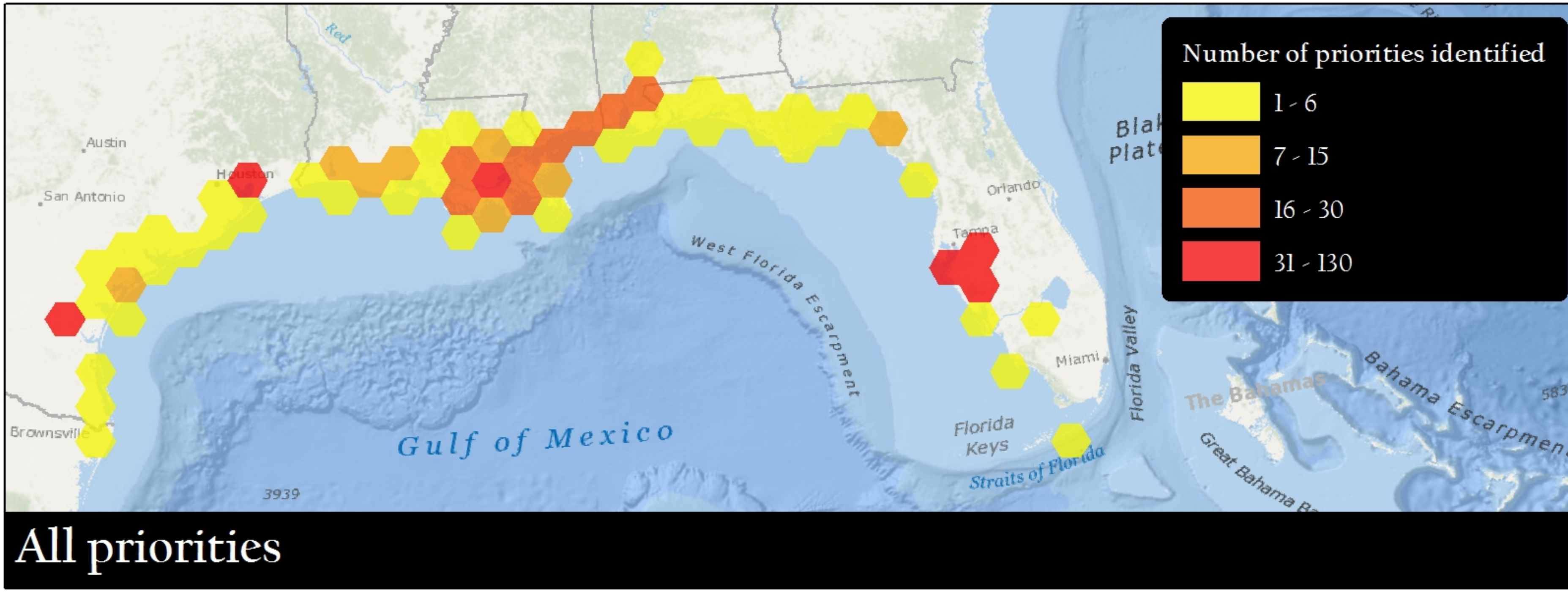
MEASURE	CRITERIA
1 Sandbags	Used in 2.9 million houses for all category 3 hurricanes across all counties in the study area
2 Wetland Restoration	6 counties with the highest losses in assets where at least 25 miles of salt marsh could be restored by bay
3 Oyster Reef Restoration	1,000 miles restored in all counties with high suitability
4 Barrier Island Restoration	All Mississippi coastal counties
5 Wetland Conservation	125 miles of wetlands protected
Beach Nourishment (6 East Coast and 9 West Coast)	All coastal counties in Florida (East Coast) and Texas (West Coast)
7 Local Levees Priority	6ft "hills" built to protect 532,000 existing houses on the 6 counties that experience most damages
8 Home Elevation	Elevate 481,841 existing houses by 8ft in 6 counties that experience the most damages
10 Shoreline Levees	20ft levees constructed around Houma & New Orleans, LA - 340 miles

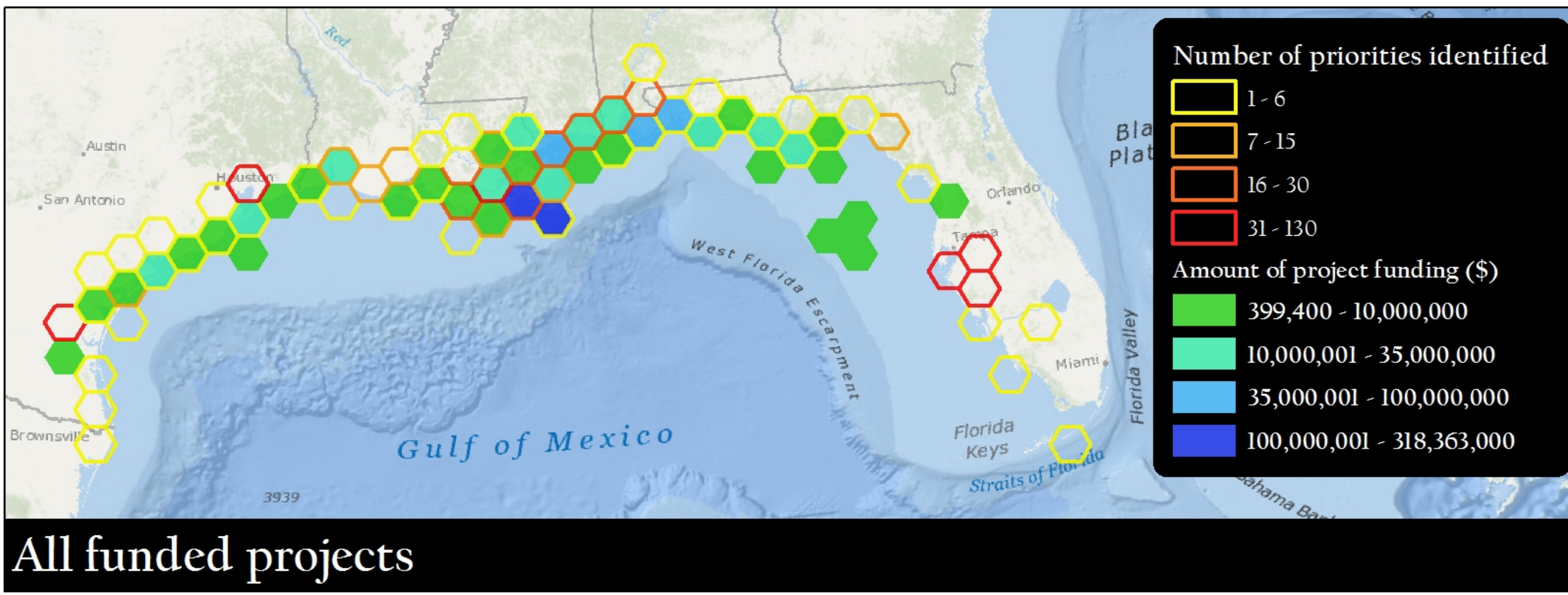
Science and tools to inform comprehensive restoration of the Gulf of Mexico

Photos by: Beth Maynor Young © TNC

Look to existing plans

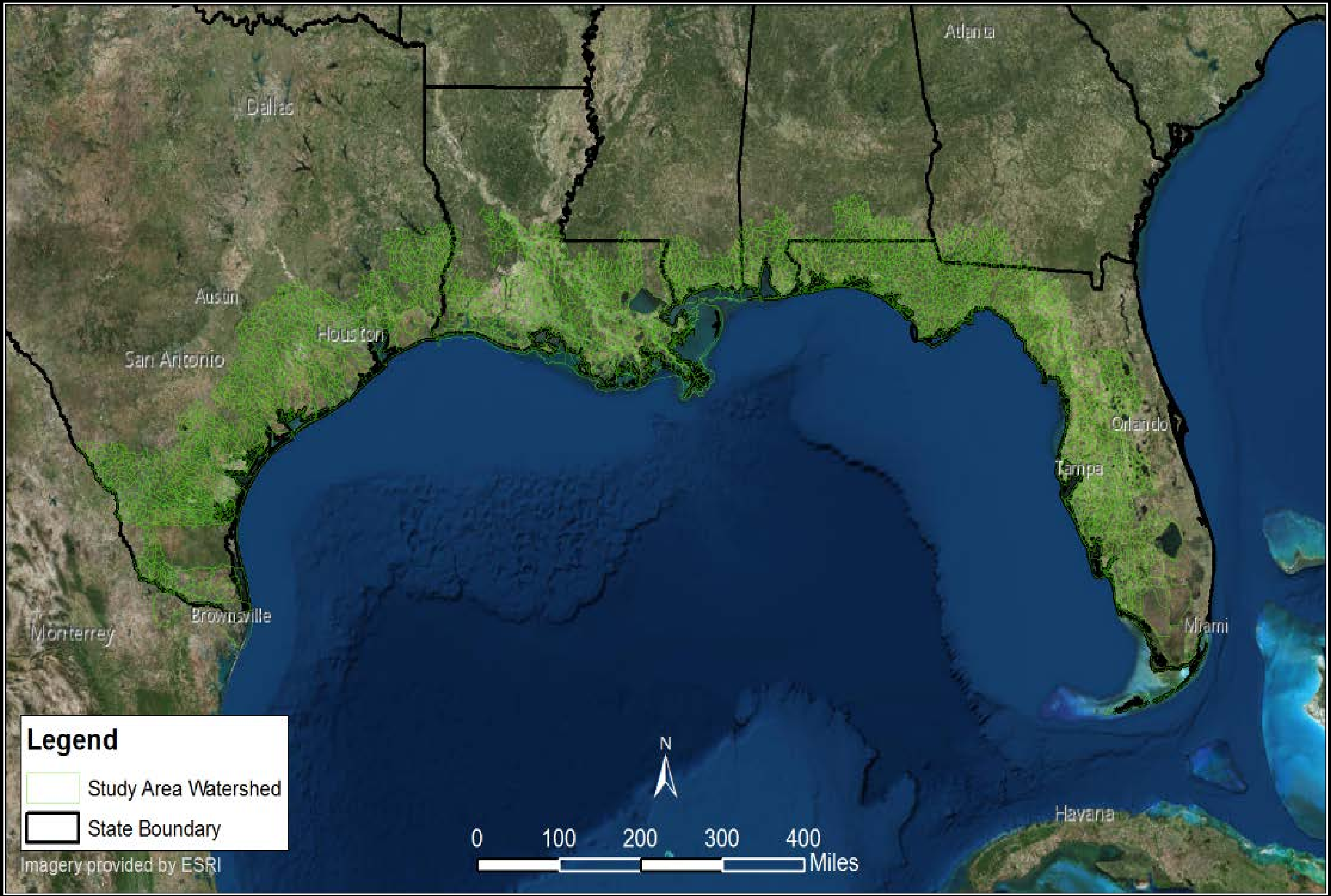



Number of priorities identified
1 - 6
7 - 15
16 - 30
31 - 130
Austin
San Antonio
Houston
Brownsville
Orlando
Tampa
Miami
Gulf of Mexico
West Florida Escarpment
Florida Keys
Straits of Florida
Florida Valley
The Bahamas
Bahama Escarpment
Great Bahama Ba
3939
5837
All priorities


Number of priorities identified
1 - 6
7 - 15
16 - 30
31 - 130
Amount of project funding ($)
399,400 - 10,000,000
10,000,001 - 35,000,000
35,000,001 - 100,000,000
100,000,001 - 318,363,000
Austin
San Antonio
Brownsville
Orlando
Miami
Gulf of Mexico
West Florida Escarpment
Florida Keys
Florida Valley
3939
All funded projects

FEMA's Community Rating System and flood risk reduction

Open space and flood risk reduction



Variable	Mean	Std. Dev.	Min	Max
Damage (natural log)	1.74	3.94	0	17.60
Damage (untransformed)	60422.73	1165714.00	0	43800000.00
Percent SFHA	32.59	28.73	0	100.00
Sum of number of days with >= 1" of rain	75.01	17.64	22.42	98.96
Average Number of NFIP policies	685.70	2851.02	1	56989.75
Median Household Income	48081.14	14140.78	1397.73	138218.40
Mean Slope	0.91	0.78	0.01	4.46
Soil Hydraulic Conductivity	42.57	33.03	0.4	108.73
Percent High-Intensity Development	0.88	2.65	0	30.13
Percent Low-Intensity Development	4.87	6.79	0	52.06
Agriculture	25.48	24.46	0.0004	97.03
Forest	17.00	16.18	0.0001	73.30
Grassland	4.50	4.55	0.0013	61.58
High-Intensity Developed	0.88	2.65	0.0004	30.13
Medium Intensity Developed	1.92	5.03	0.0007	44.98
Low-Intensity Developed	4.38	6.52	0.0006	52.06
Open-Space Developed	2.61	4.17	0.0006	40.66
Estuarine	7.13	15.46	0.0001	84.95
Palustrine	23.21	20.09	0.0062	99.52
Scrub/Shrub	11.94	11.58	0.001	79.49
Area (HA)	12927.19	24829.70	1558.71	923835.70

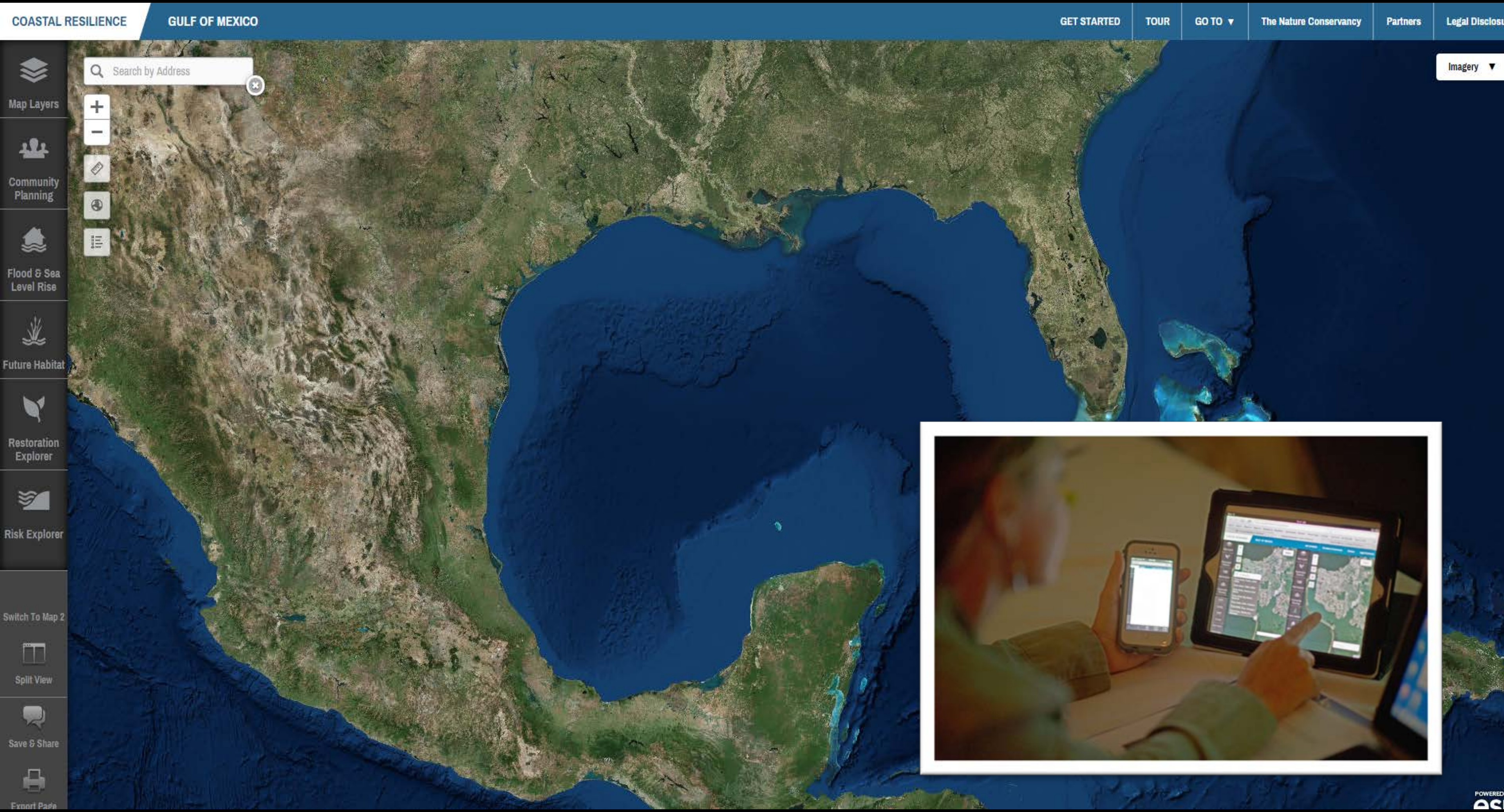
Variable	Measure	Mean	Std. Dev.	Min	Max
Mean Patch Size (Area)	Ave. patch size	484.0842	1428.105	0.3225	19516.77
Number Patches (NP)	Total number of patches	171.4789	261.6628	1	3680
Patch Density (PD)	NP/watershed area	1.448596	1.404827	0.0051	8.125
Percent Natural (PLAND)	% watershed natural cover	62.68106	27.59358	0.0123	99.9787
Largest Patch Index (LPI)	% largest patch	53.59356	32.25023	0.0038	99.9787
Radius of Gyration (GYRATE)	Avg. distance between patch and centroid	296.1694	643.442	24.2938	7622.561
Euclidian Nearest Neighbor (ENN)	Shortest distance btw. Patches.	120.4184	71.15026	60	2131.3
Contiguity (CONTIG)	Avg. contiguity value for the cells in a patch – 1 / sum of the template values - 1	0.366976	0.125093	0.1299	0.9953
Cohesion (COHESION)	1- the sum of patch perimeter/sum of patch perimeter x sq. rt. of patch area/ 1 - 1 over the sq. rt. of total number of cells in the landscape x 100	98.92701	2.787928	56.5664	100

Control Variable	Direction of Impact
Percent SFHA	+
Sum of number of days with >= 1" of rain	+
Average Number of NFIP policies	+
Median Household Income	+
Mean Slope	-
Soil Hydraulic Conductivity	-
Percent High-Intensity Development	+
Percent Low-Intensity Development	+
Percent Developed Open Space	~

Gulfwide Results of open space analysis

- **Larger mean patch (AREA) sizes correspond with lower amounts of flood loss ($p<.01$)**
- **Greater number of patches (NP) increase the amount of damage ($p<.001$) caused by floods at the watershed level.**
- **Unit increases in both PLAND ($p<.05$) and LPI ($p<.001$) result in major decreases in flood loss.**
- **Among landscape configuration metrics, both GYRATE ($p<.01$) and CONTIG ($p<.05$) reduce watershed-level flood losses.**
- **The presence of palustrine wetlands appears to have a significant effect on reducing flood impacts.**
- **The study results also show that forest land cover can effectively reduce insured flood loss at the watershed level.**

Coastal Resilience DS tool



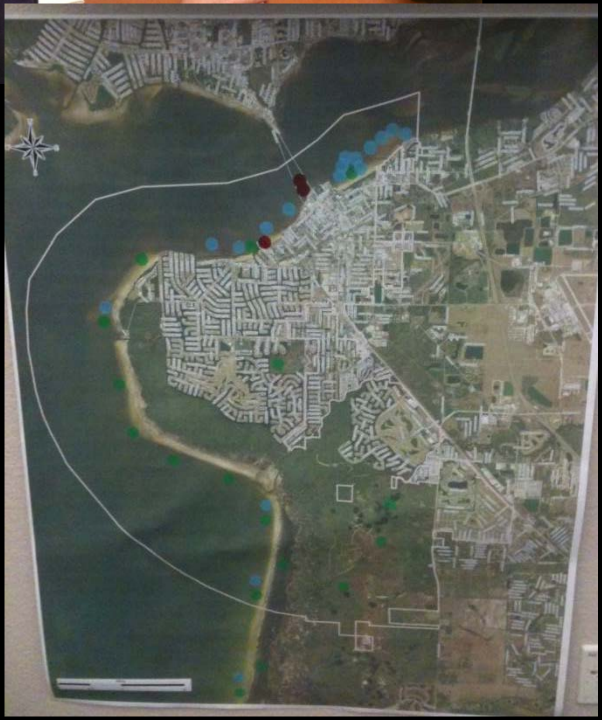
maps.coastalresilience.org

How can you use the Coastal Resilience tool?

- Inform selection of restoration investments

- Raise awareness of the societal benefits of coastal restoration

- Engage communities interested in reducing their flood insurance premiums through the Community Rating System



“Building Coastal Resilience” Workshops

Using Coastal Resilience 2.0
to support decision making
in Coastal Communities

www.maps.coastalresilience.org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