DEVELOPMENT OF A QUANTIFIABLE COMMUNITY RESILIENCE INDEX TOOLKIT

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NATIONAL CENTER FOR GEOGRAPHIC INFORMATION AND ANALYSIS

MCEER
EARTHQUAKE ENGINEERING TO EXTREME EVENTS

Center for GeoHazards Studies

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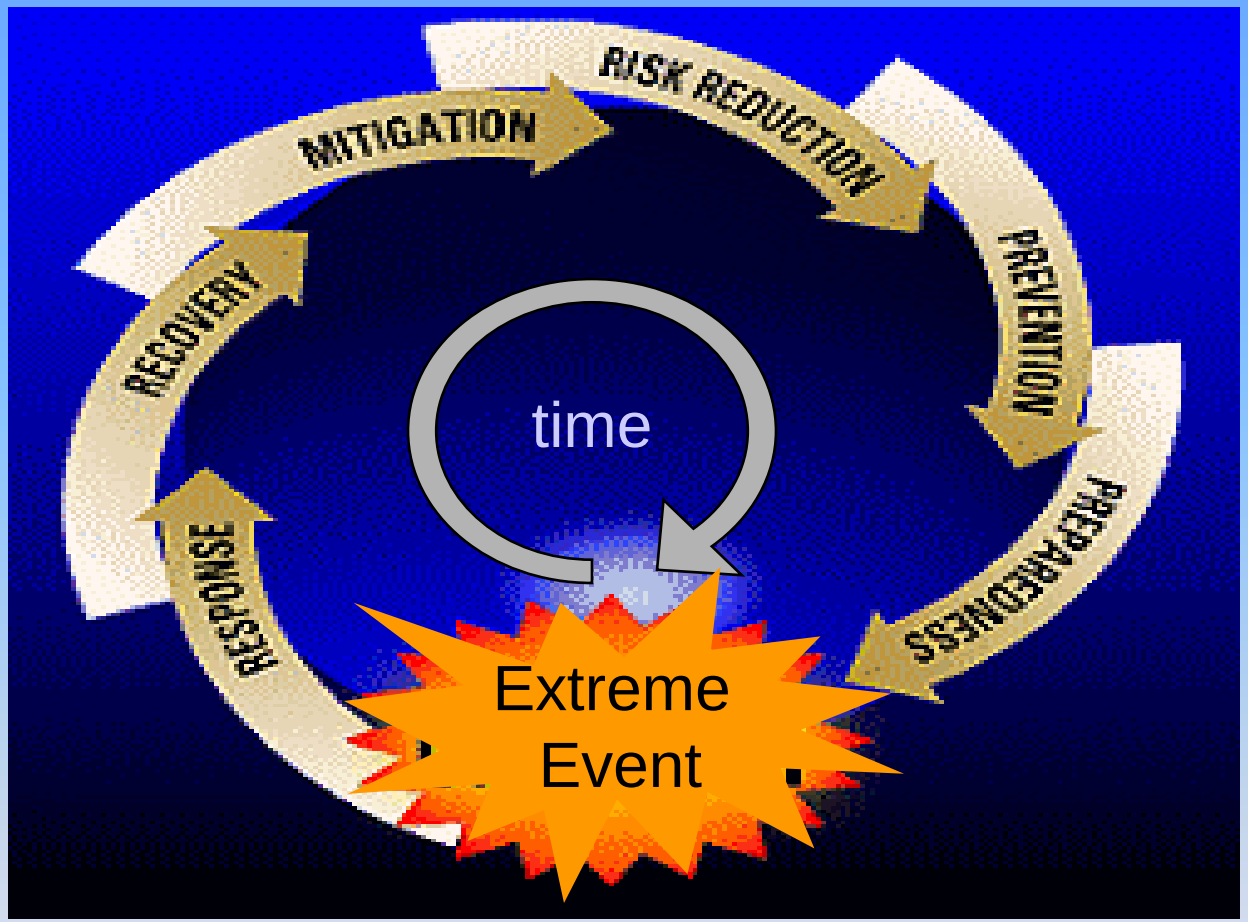
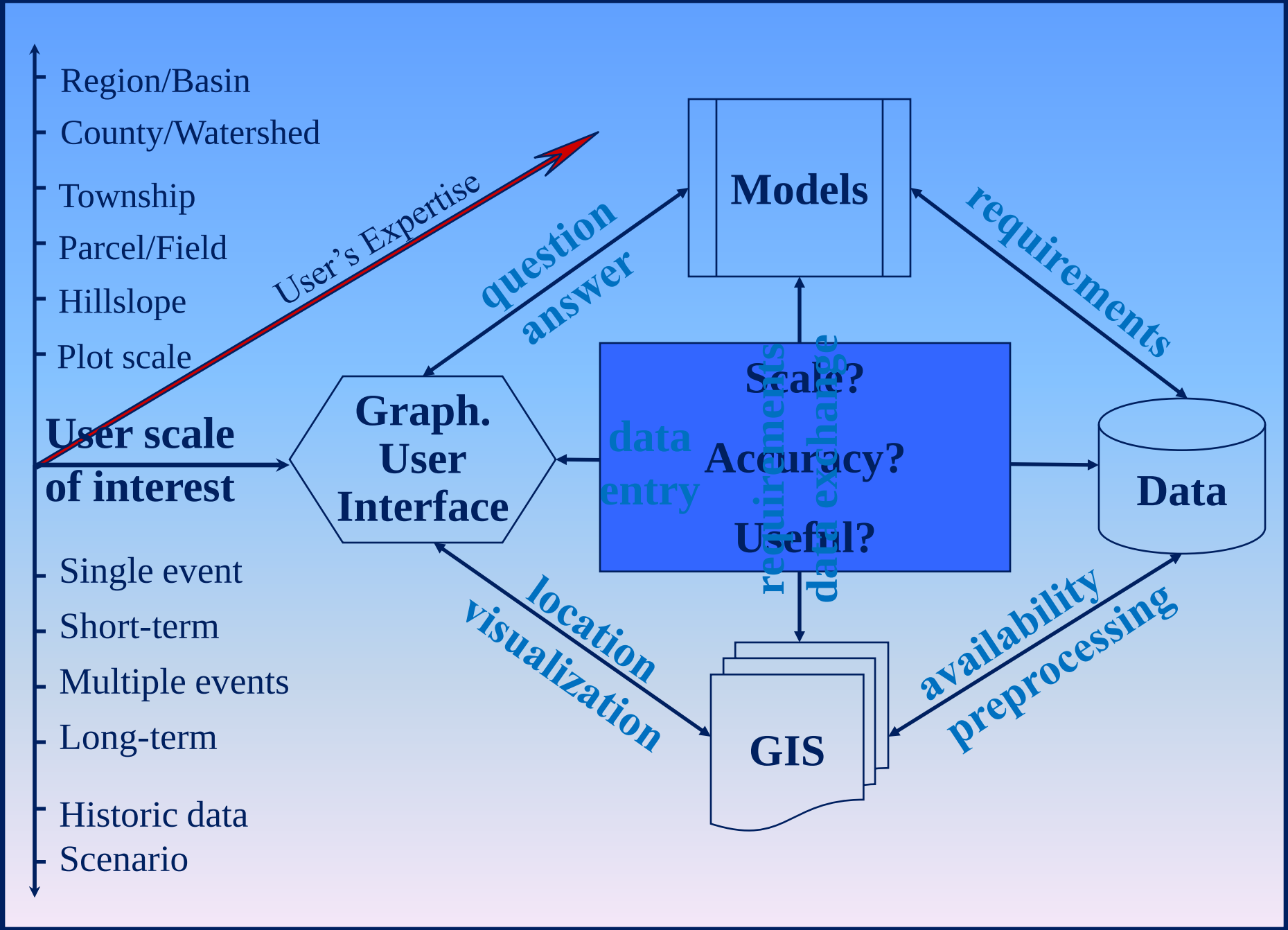
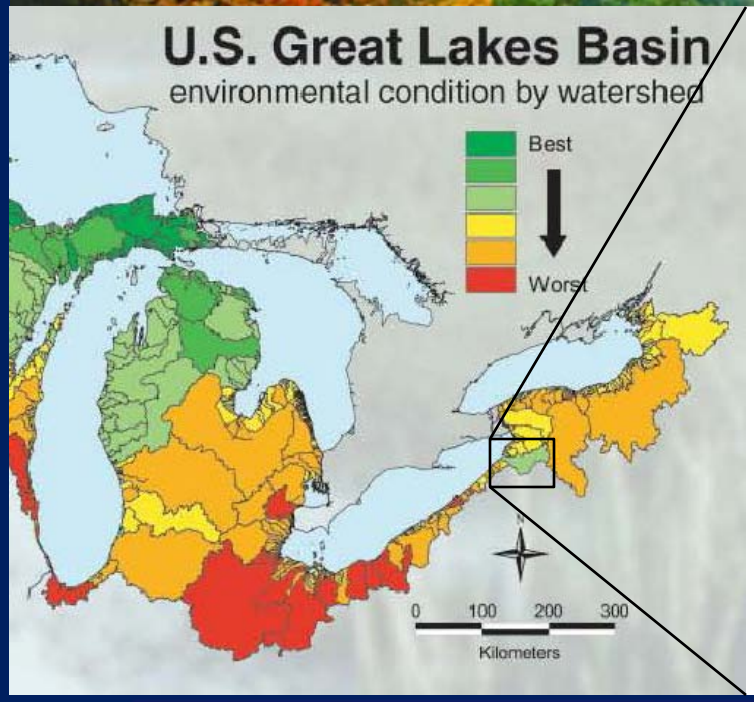
Adam Rose, Univ. of Southern California


MITIGATION
RISK REDUCTION
PREVENTION
PREPAREDNESS
RESPONSE
RECOVERY
time
Extreme
Event


Region/Basin
County/Watershed
Township
Parcel/Field
Hillslope
Plot scale
User's Expertise
User scale of interest
Single event
Short-term
Multiple events
Long-term
Historic data
Scenario
Models
question
answer
requirements
Graph. User Interface
Scale?
Accuracy?
Useful?
data entry
requirements
data exchange
Data
location
visualization
GIS
availability
preprocessing

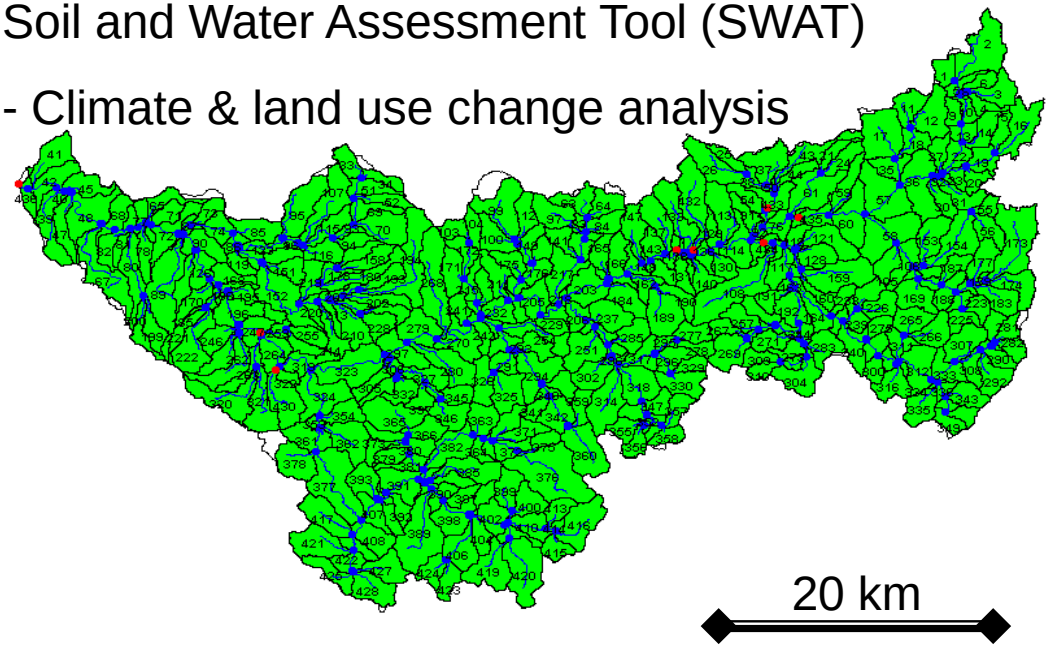
The GeoWEPP Project – Decision Support for Post-Wildfire Rehabilitation & Fuel Load Reduction to prevent Soil Erosion in Forest and Rangelands

Cattaraugus Creek Watershed Strategy



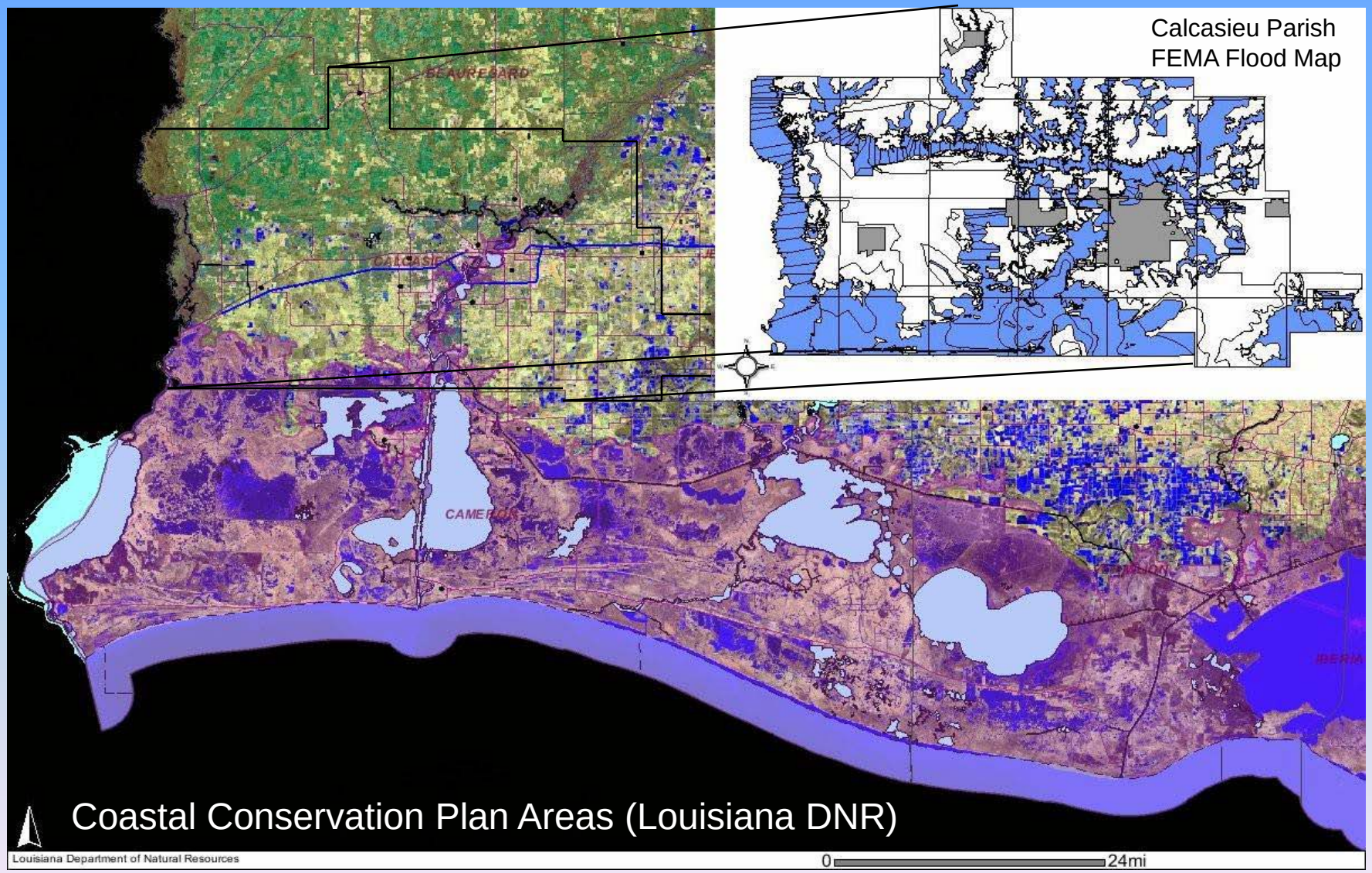
Soil and Water Assessment Tool (SWAT)

- Climate & land use change analysis



LESAM - Landscape-based Environmental System Analysis & Modeling

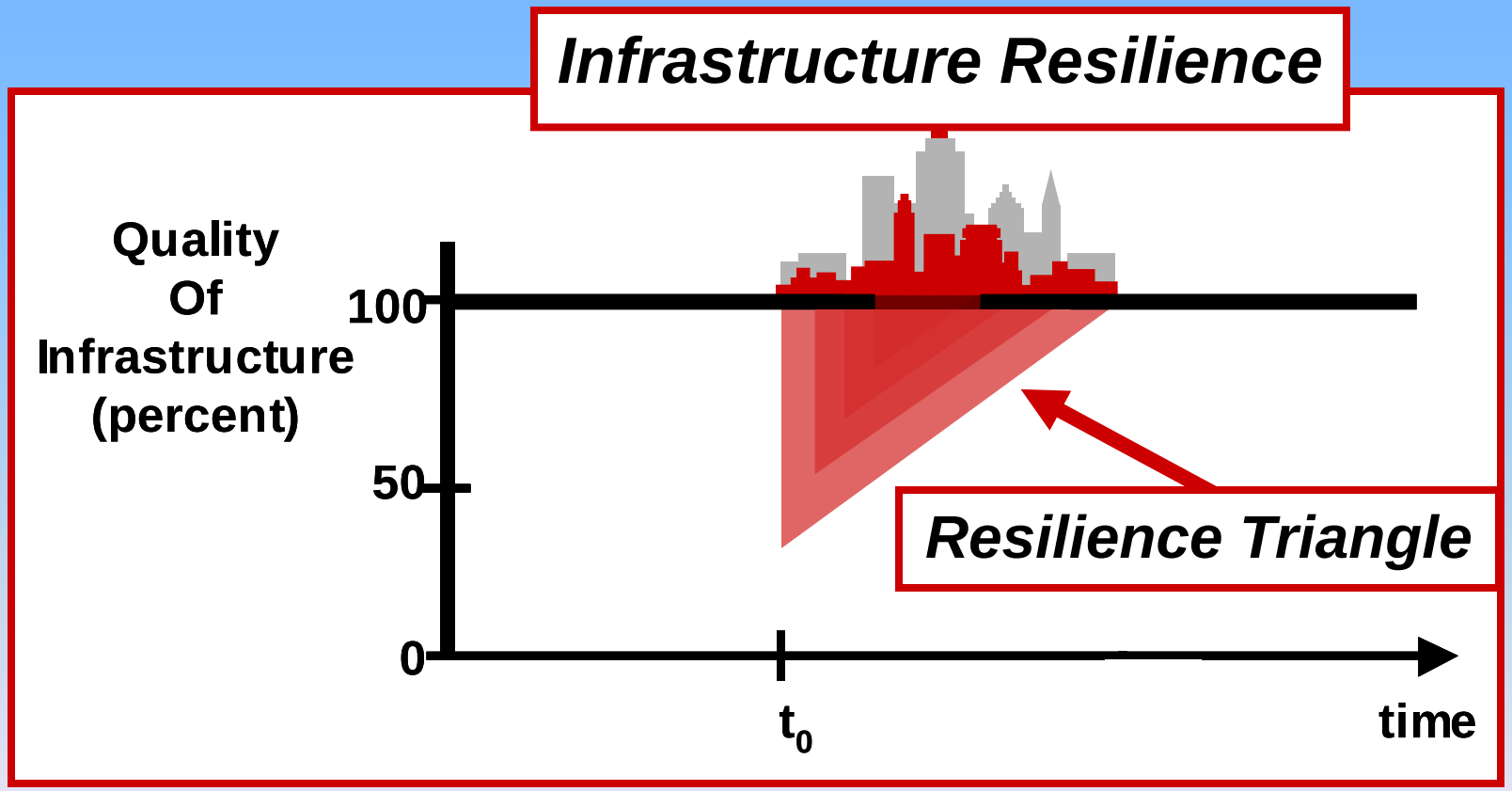
Integrated planning for slow- (e.g. SLR) and fast-approaching extreme events (e.g. hurricanes) in coastal watersheds



Resilience of Systems

The Impact of Extreme Events
on System Functionality

MCEER's main goal is to enhance the resilience of communities against multiple hazards.



MITIGATION
RISK REDUCTION
PREVENTION
PREPAREDNESS
RESPONSE
RECOVERY
R4 Resilience is
Robustness, Rapidity,
Resourcefulness,
Redundancy.
Extreme
Event

Resilience Modeling Engine: Modeling Indicators of Community Disaster Resilience

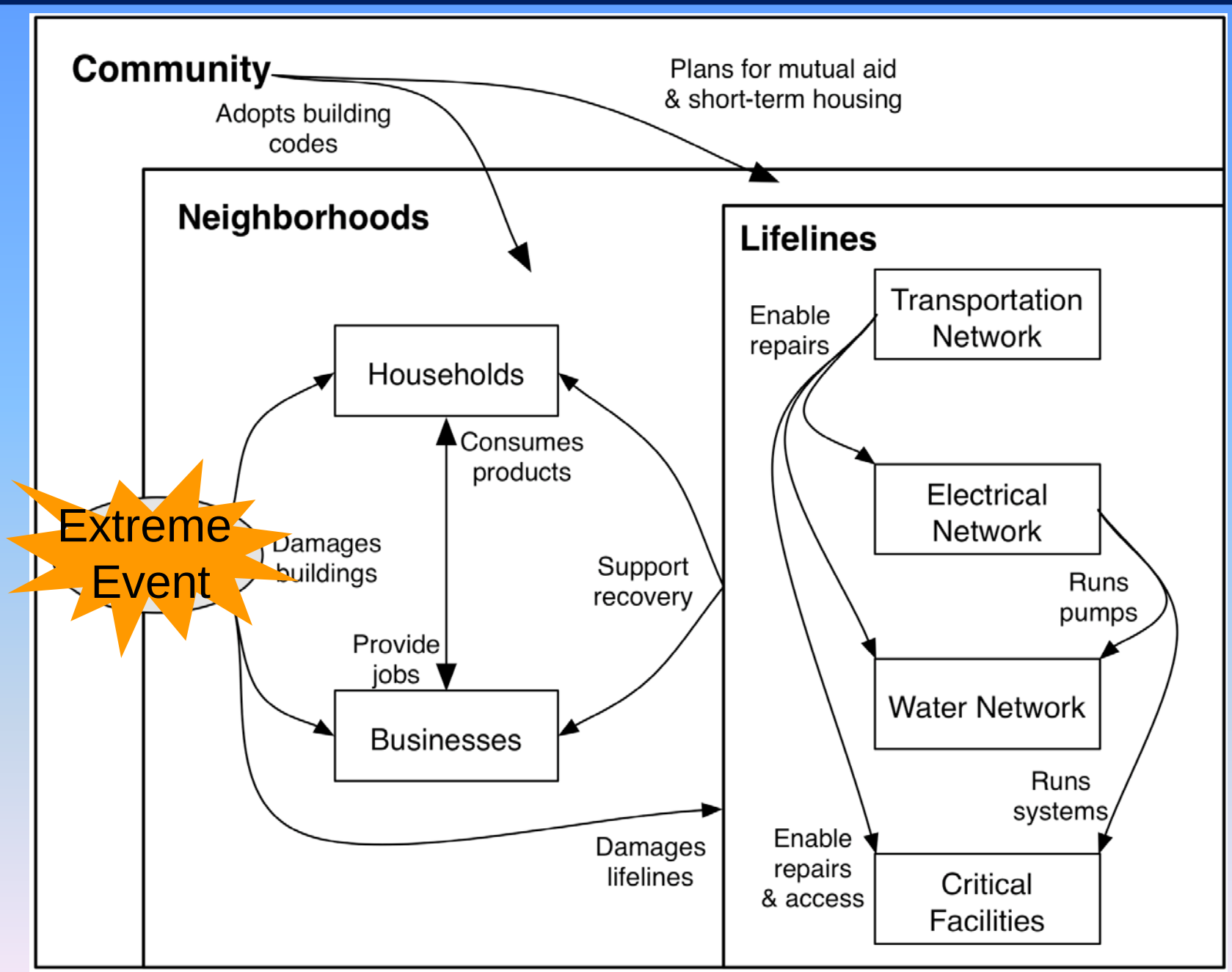
Scott B. Miles

Western Washington University

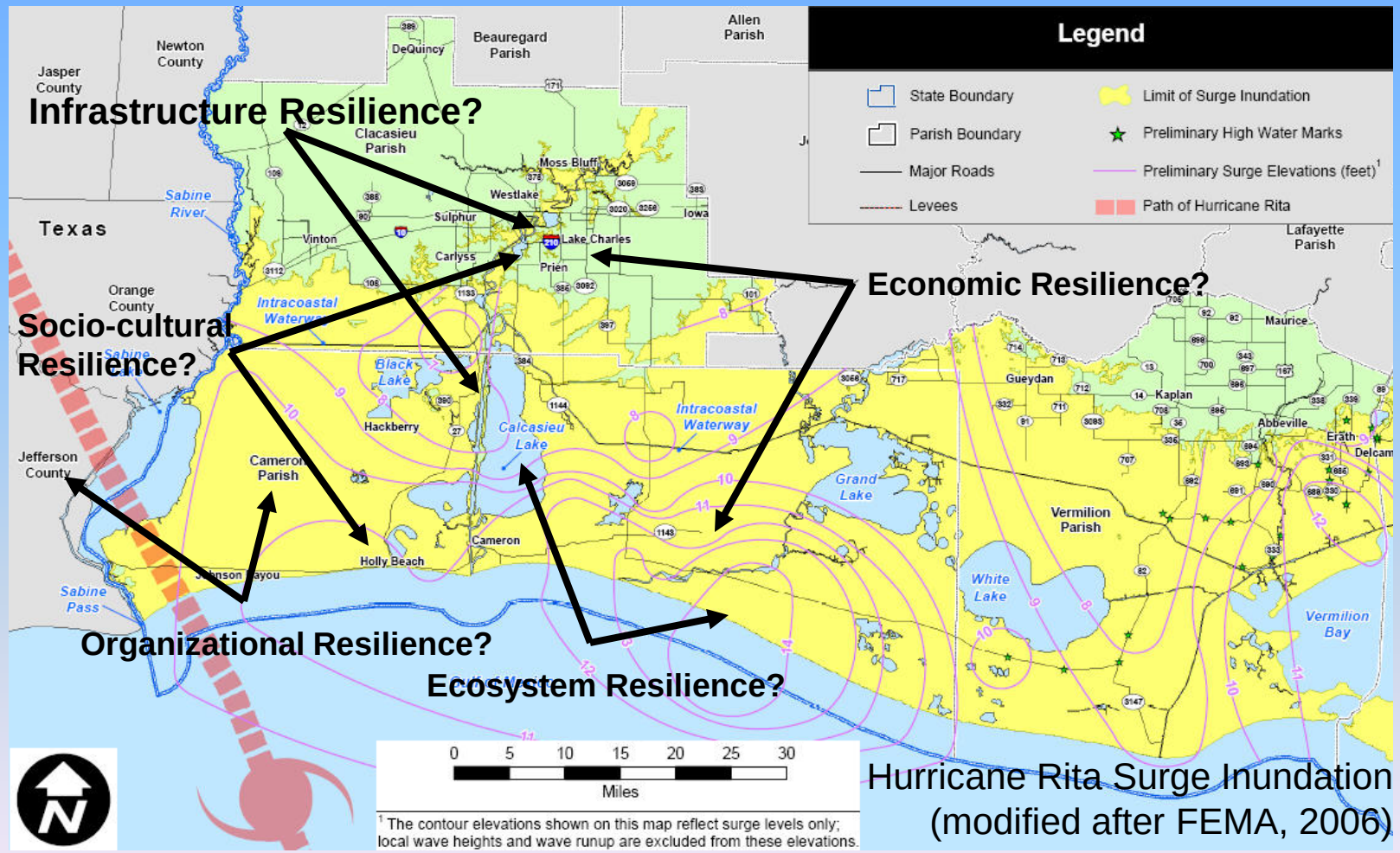
Stephanie E. Chang

University of British Columbia

A project of the MCEER – Earthquake Engineering to Extreme

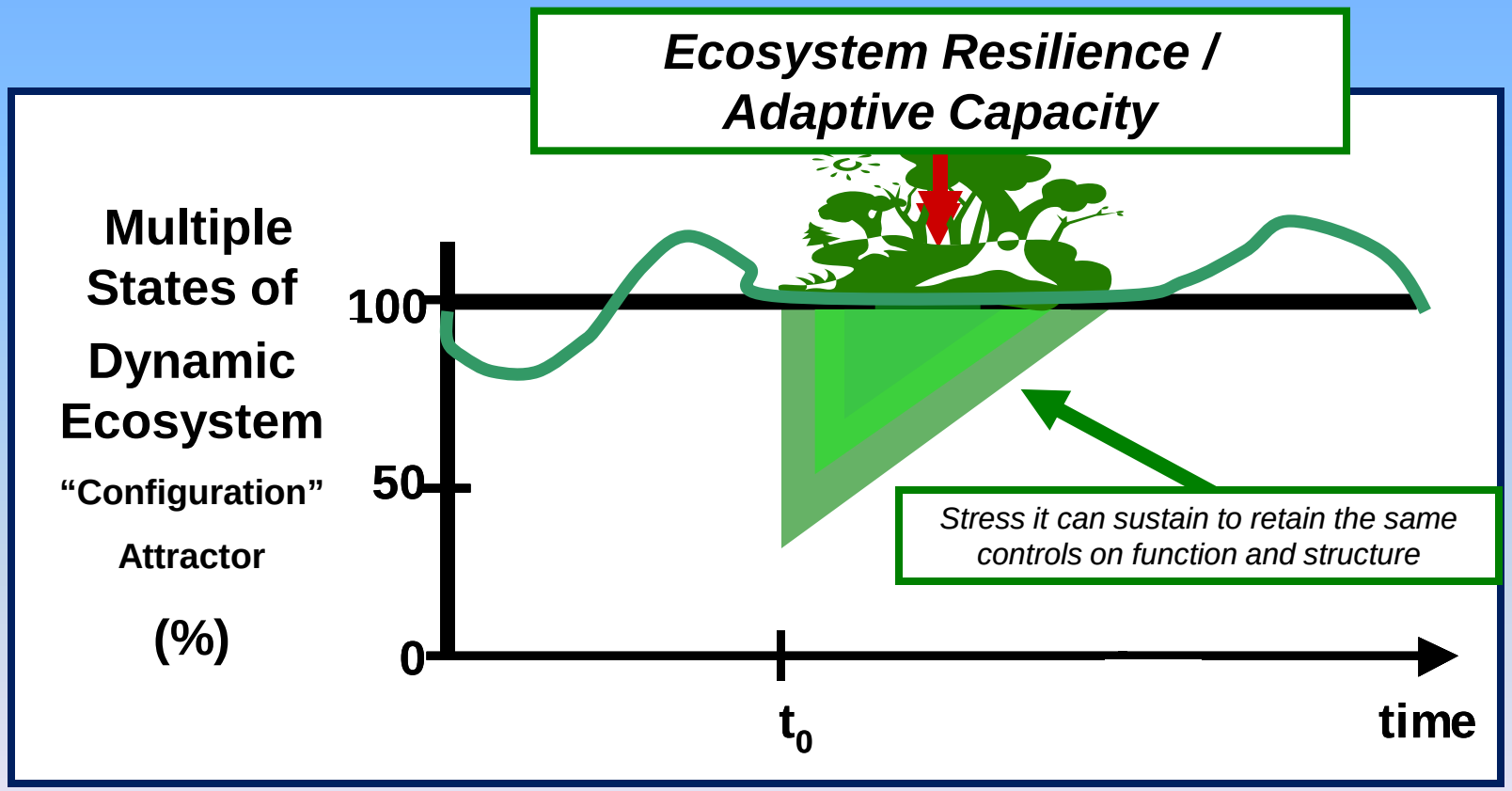

Community
Plans for mutual aid
& short-term housing
Adopts building
codes
Neighborhoods
Lifelines
Transportation
Network
Enable
repairs
Households
Consumes
products
Extreme
Event
Damages
buildings
Support
recovery
Electrical
Network
Runs
pumps
Provide
jobs
Water Network
Businesses
Runs
systems
Enable
repairs
& access
Damages
lifelines
Critical
Facilities

Assess community resilience against multiple slow- and fast-approaching extreme events

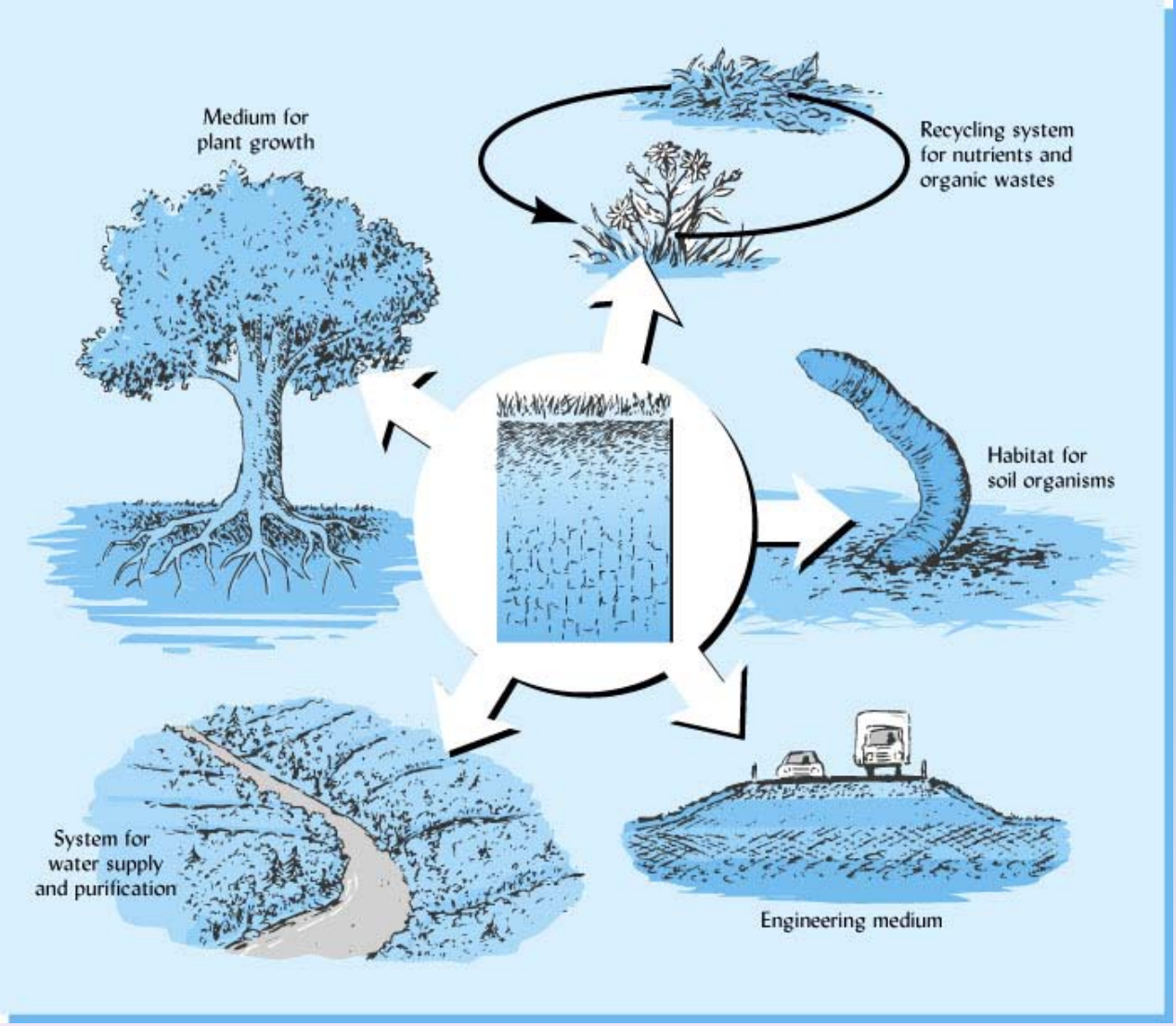


Hurricane Rita Surge Inundation (modified after FEMA, 2006)

Understand and account for the dynamic variable resilience of ecosystems against multiple hazards



Soils - Five crucial ecological roles



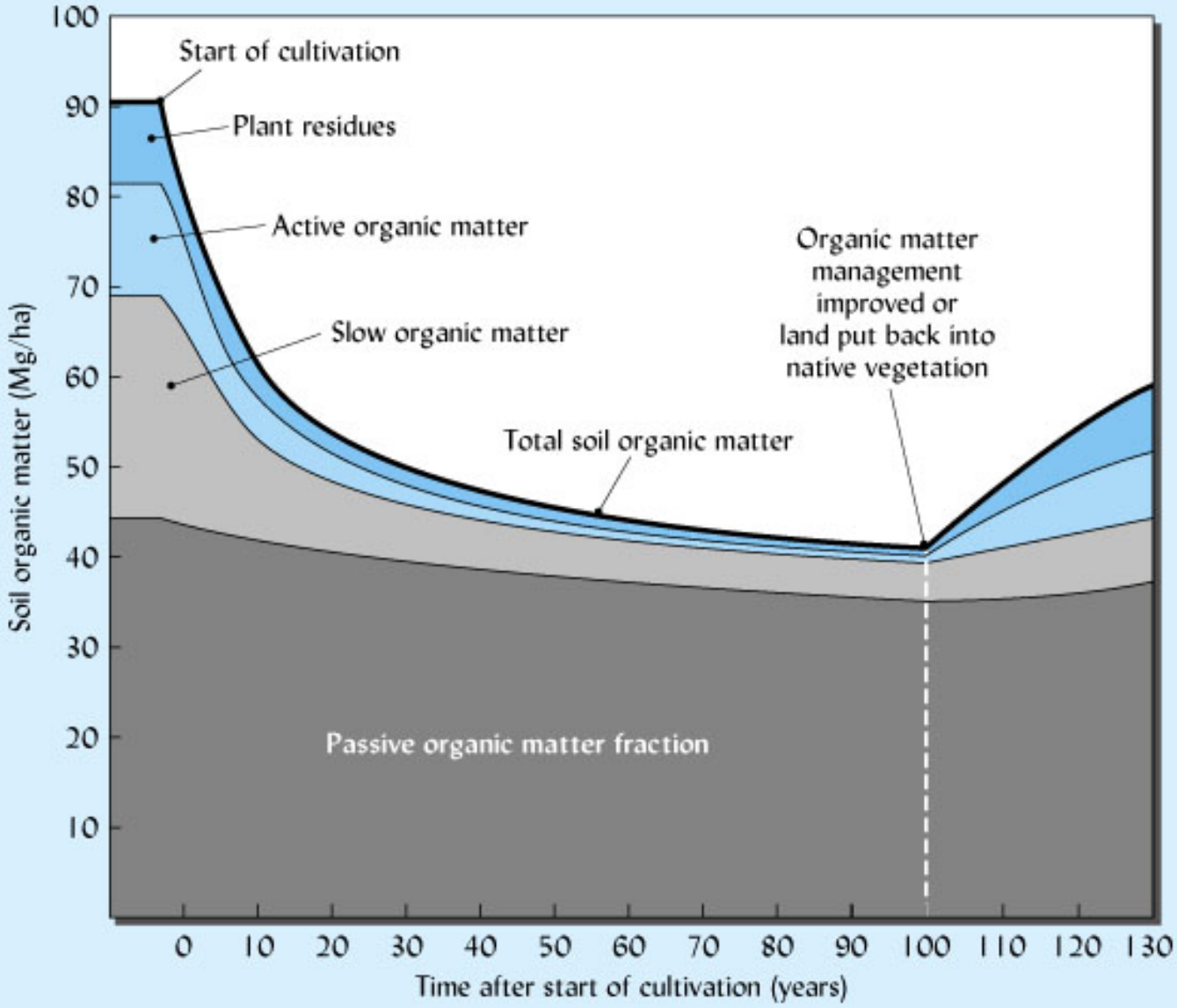
(Brady & Weil, 2004)

Soil Quality, Degradation & Resilience

Soil quality = measure of the ability of a soil to carry out ecological functions.

Soil erosion, salt accumulation, nutrient depletion and organic matter depletion ➔ processes by which poor management can lead to **soil degradation**.

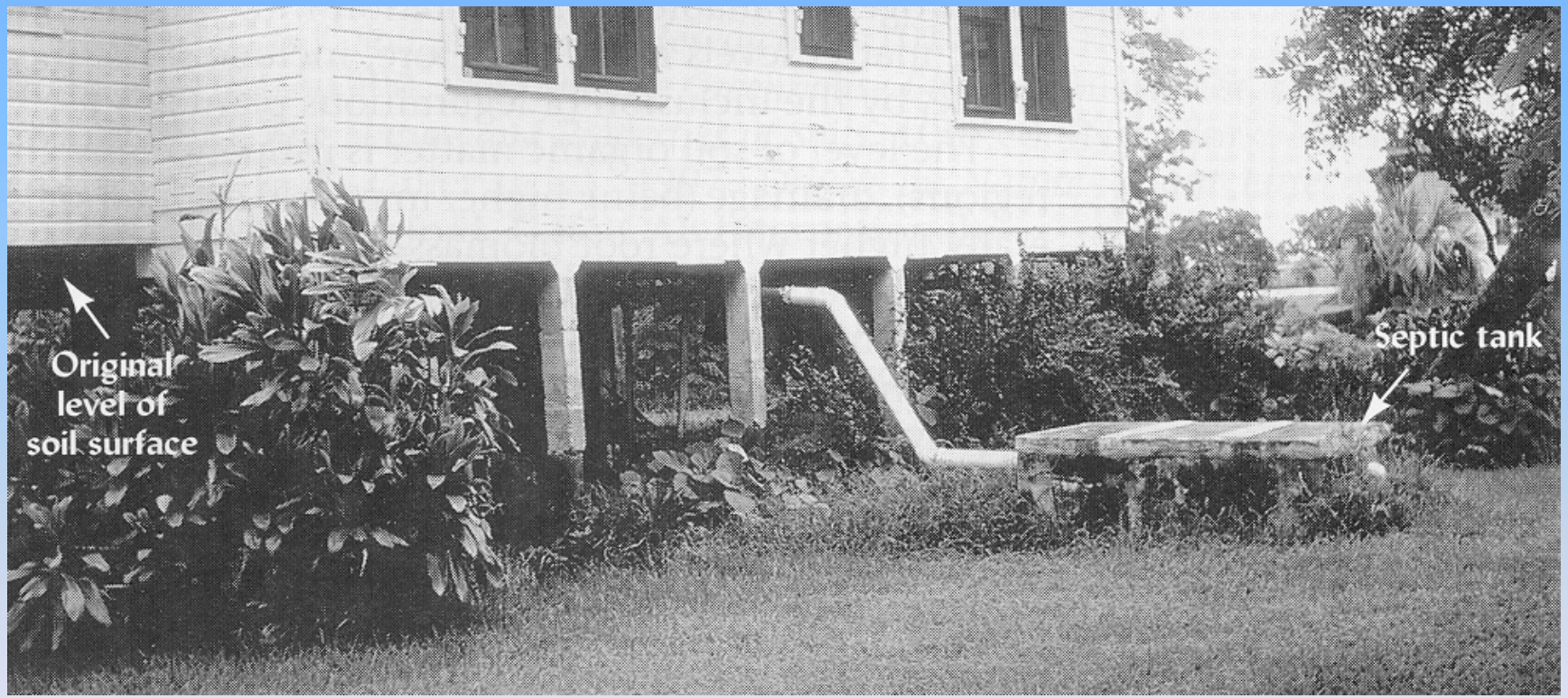
Some soils are more **resilient** than other as evidenced by their ability to recover their quality more rapidly after such disturbances (or extreme events).



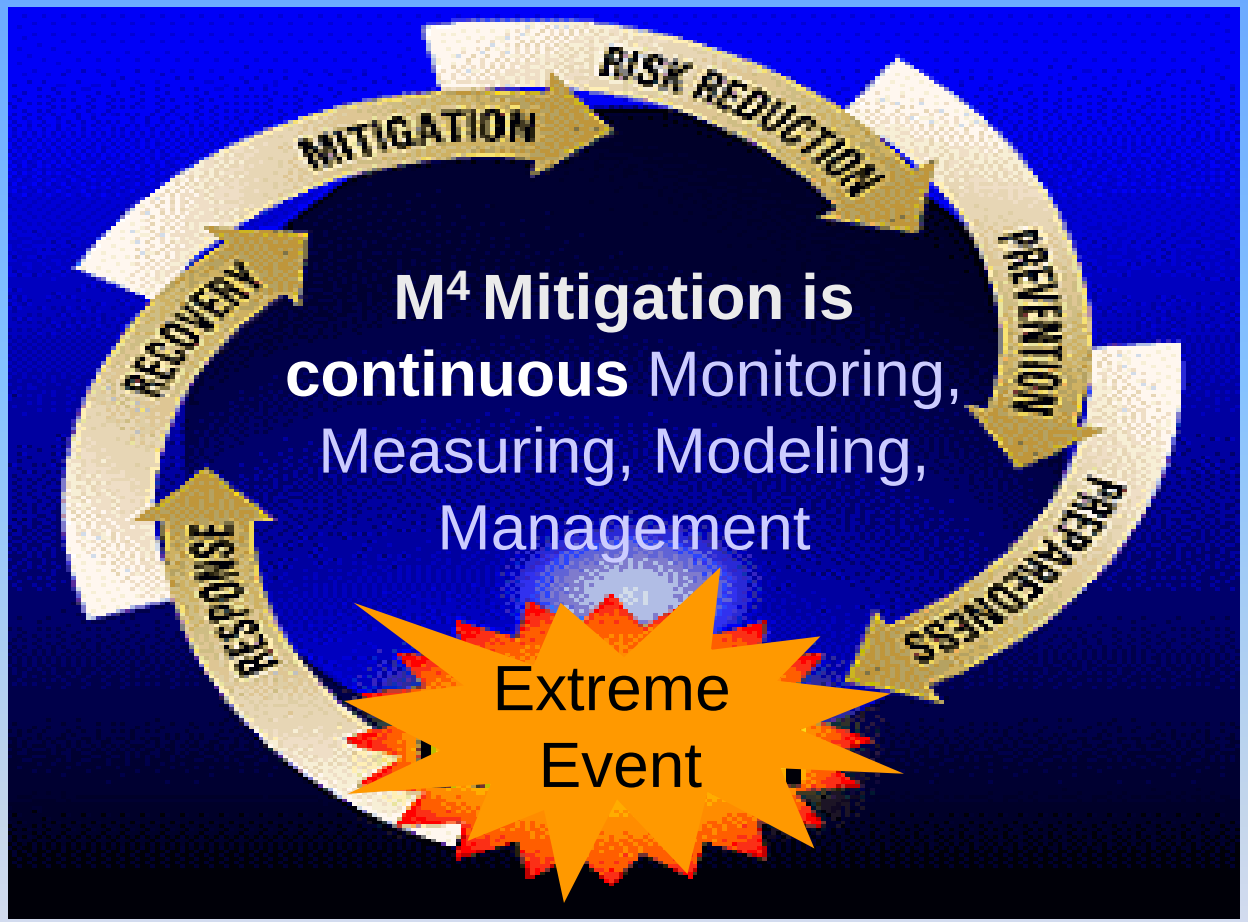
Changes in various fractions of organic matter
(in upper 25 cm of a representative soil after bringing virgin land under cultivation)

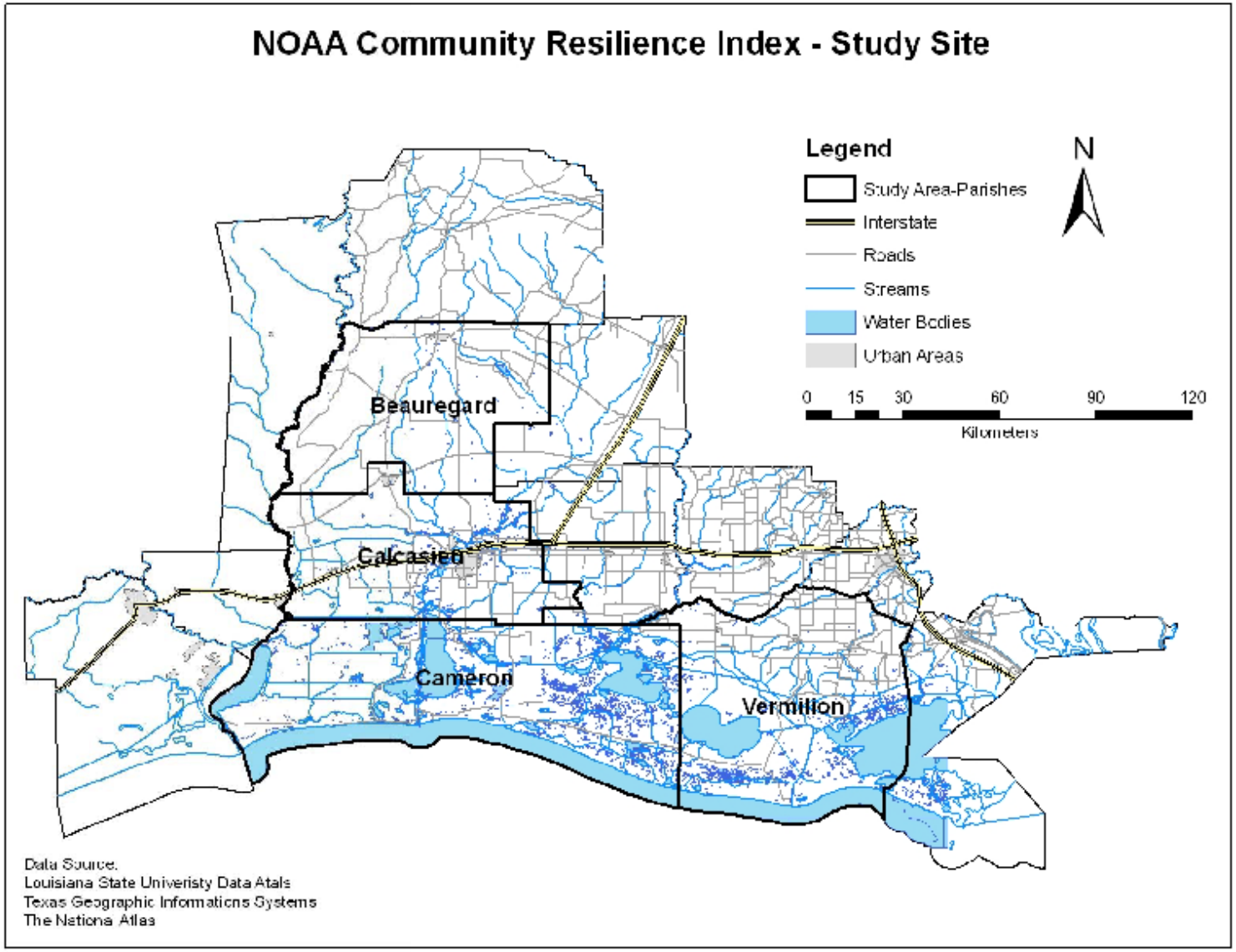
(Brady & Weil, 2004)

Drained Wetlands - Soil Subsidence due to rapid organic matter decomposition after artificial drainage (1.2 m in 60 years)



(Brady & Weil, 2004)


MITIGATION
RISK REDUCTION
PREVENTION
PREPAREDNESS
RESPONSE
RECOVERY
M4 Mitigation is continuous Monitoring, Measuring, Modeling, Management
Extreme Event

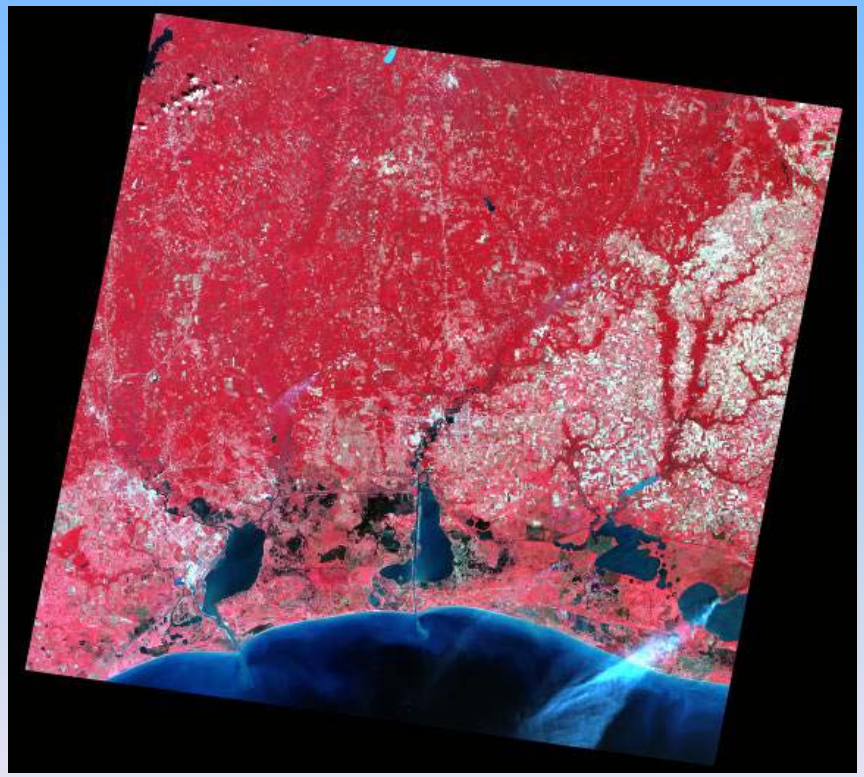

NOAA Community Resilience Index - Study Site
Legend
Study Area-Parishes
Interstate
Roads
Streams
Water Bodies
Urban Areas
N
0 15 30 60 90 120
Kilometers
Beauregard
Calcasieu
Cameron
Vermilion
Data Source:
Louisiana State Univeristy Data Atals
Texas Geographic Informations Systems
The Nationa Atlas

Remote Sensing Imagery

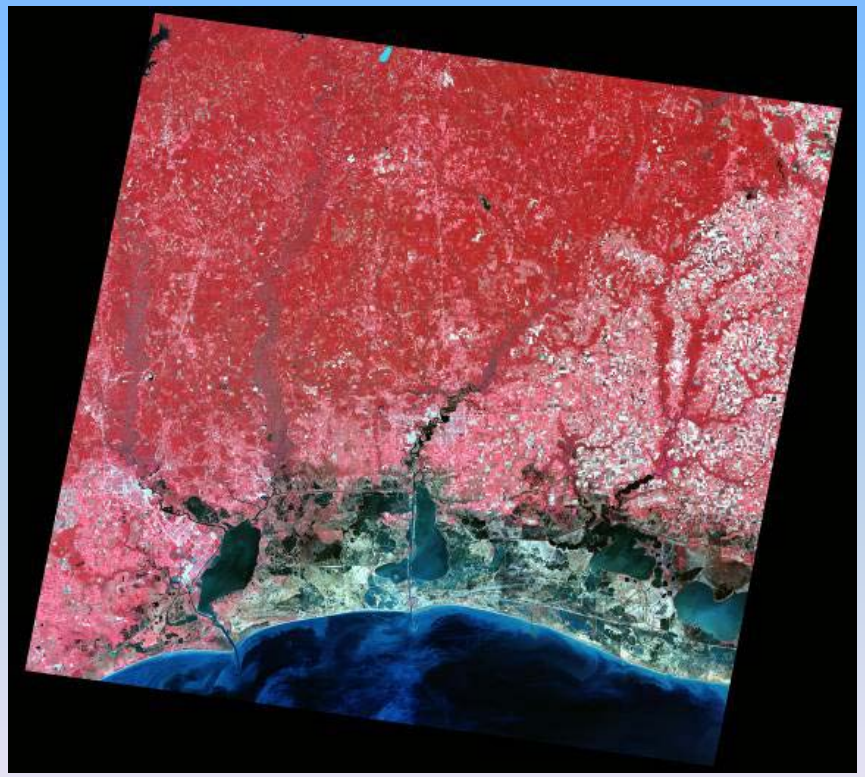
- monitor and quantify recovery/change in environmental service/quality following an extreme event (Hurricane Rita)
- develop a series of resilience indices and methodologies to provide input and validation for resilience/recovery model
- integrated index assessments at regional, local, and individual scales (e.g. NDVI)

Change in vegetation reflectance (Landsat TM 5)

Before Rita (21st Sep 2005)



After Rita (23rd Oct 2005)



Change in vegetation reflectance (Landsat TM 5)

Before Rita (21st Sep 2005)

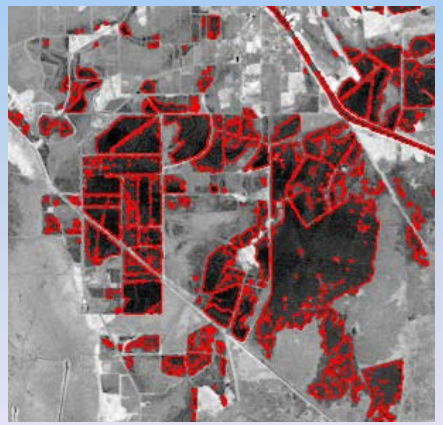
After Rita (23rd Oct 2005)

Land Cover Change Detection

Pre-event

13rd Oct 2004

Post-event I



16th Oct 2005

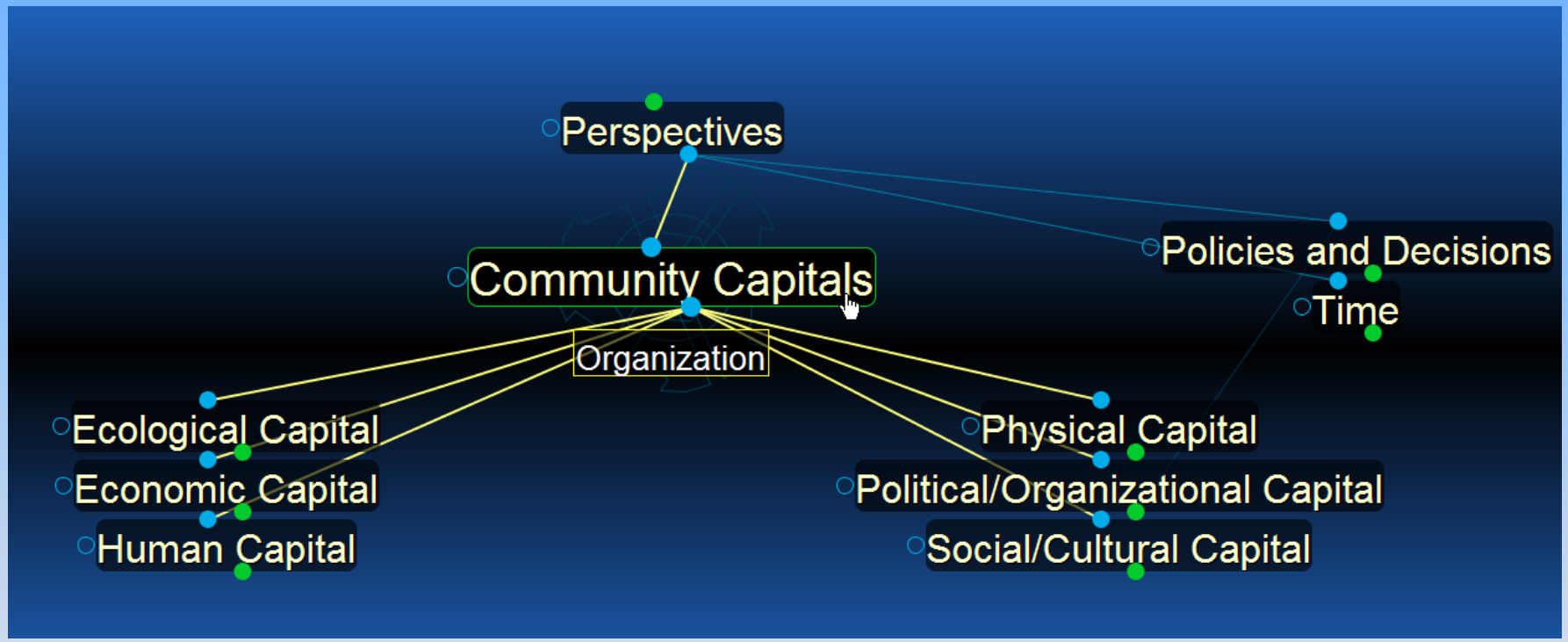
Post-event II

13rd Jun 2006

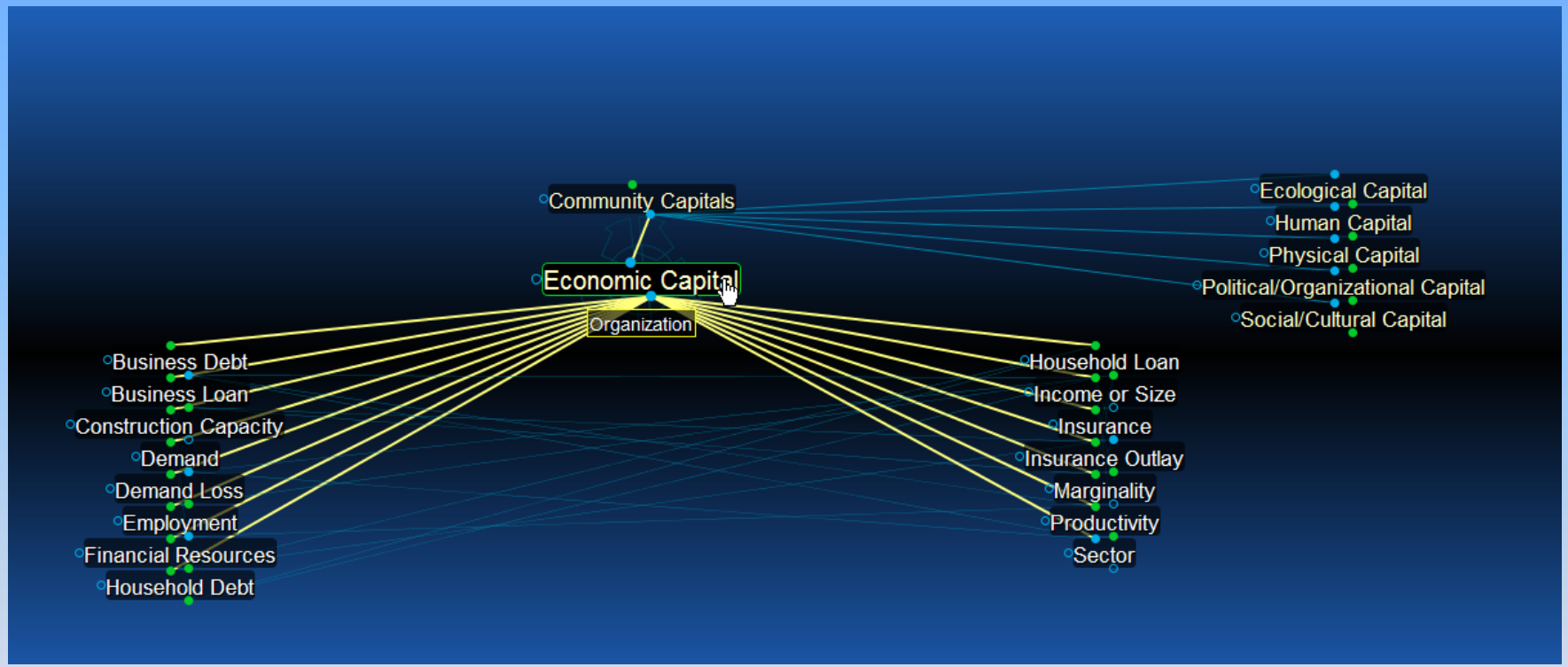
Model Implementation - ResilUS

- MATLAB & Simulink -- modular design
- Co-event and Post- Event Modules
- Majority of *co-event* functionality based on log-normal fragility curves
  - Calibrate by adjusting log-normal distribution
- Majority of *post-event* functionality implemented as Markov Chains
  - Variables treated as probabilities (0-1)
  - Calibrate by adjusting random distribution
- Any number of neighborhoods & agents

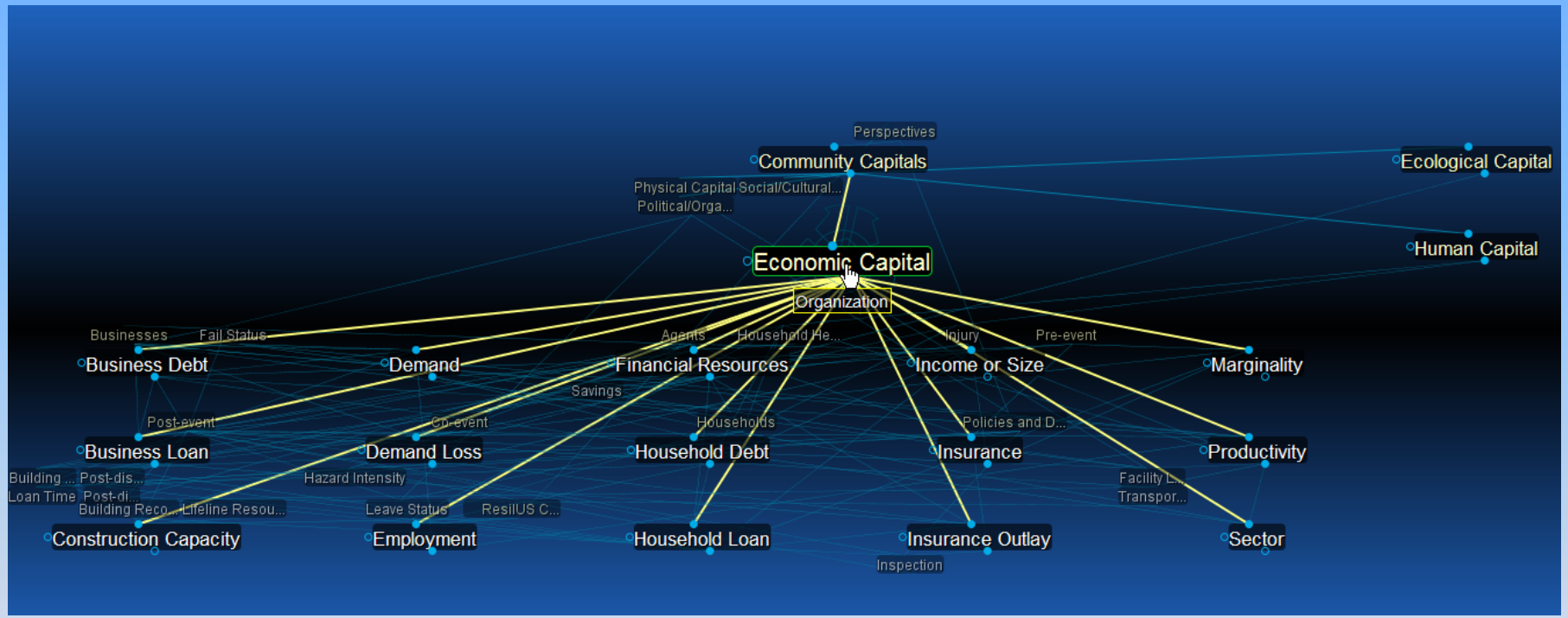
ResilUS alpha version –
Modeling toolkit for assessing community resilience



ResilUS alpha version –
Assessing resilience of economic system



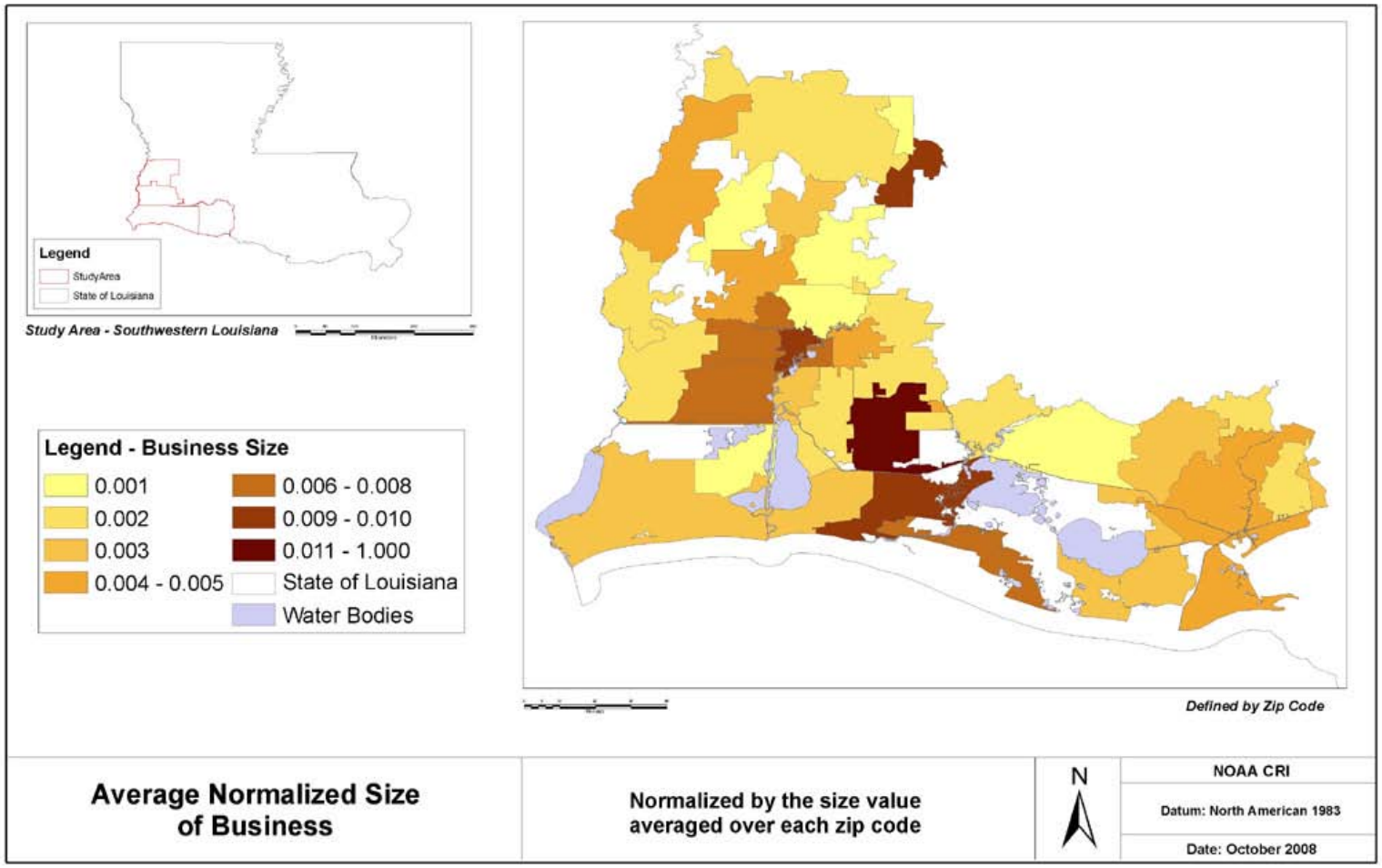
ResilUS alpha version –
Assessing resilience of economic system



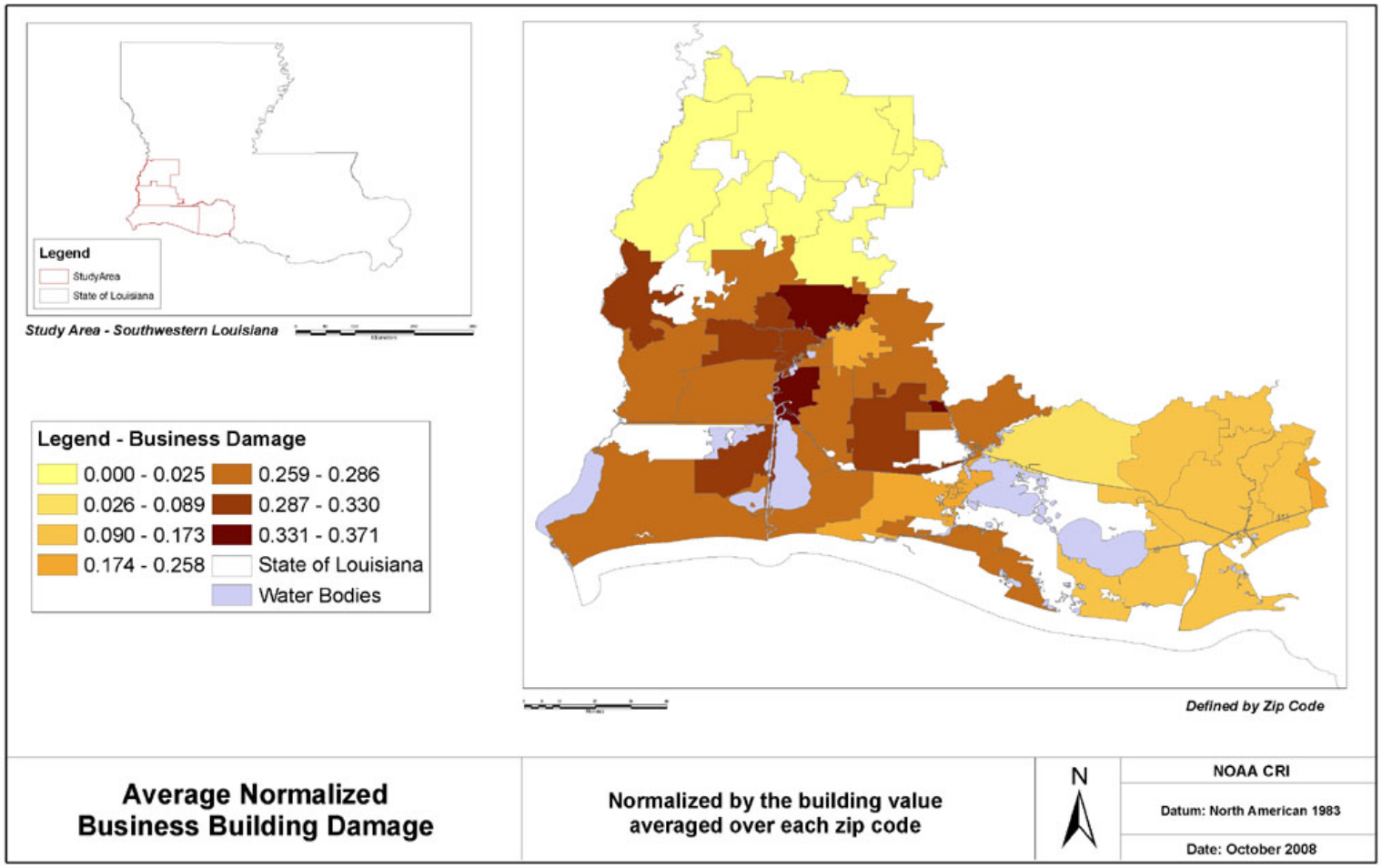
ResilUS alpha version –
Assessing community resilience (post-event)

(LOS = level of service)

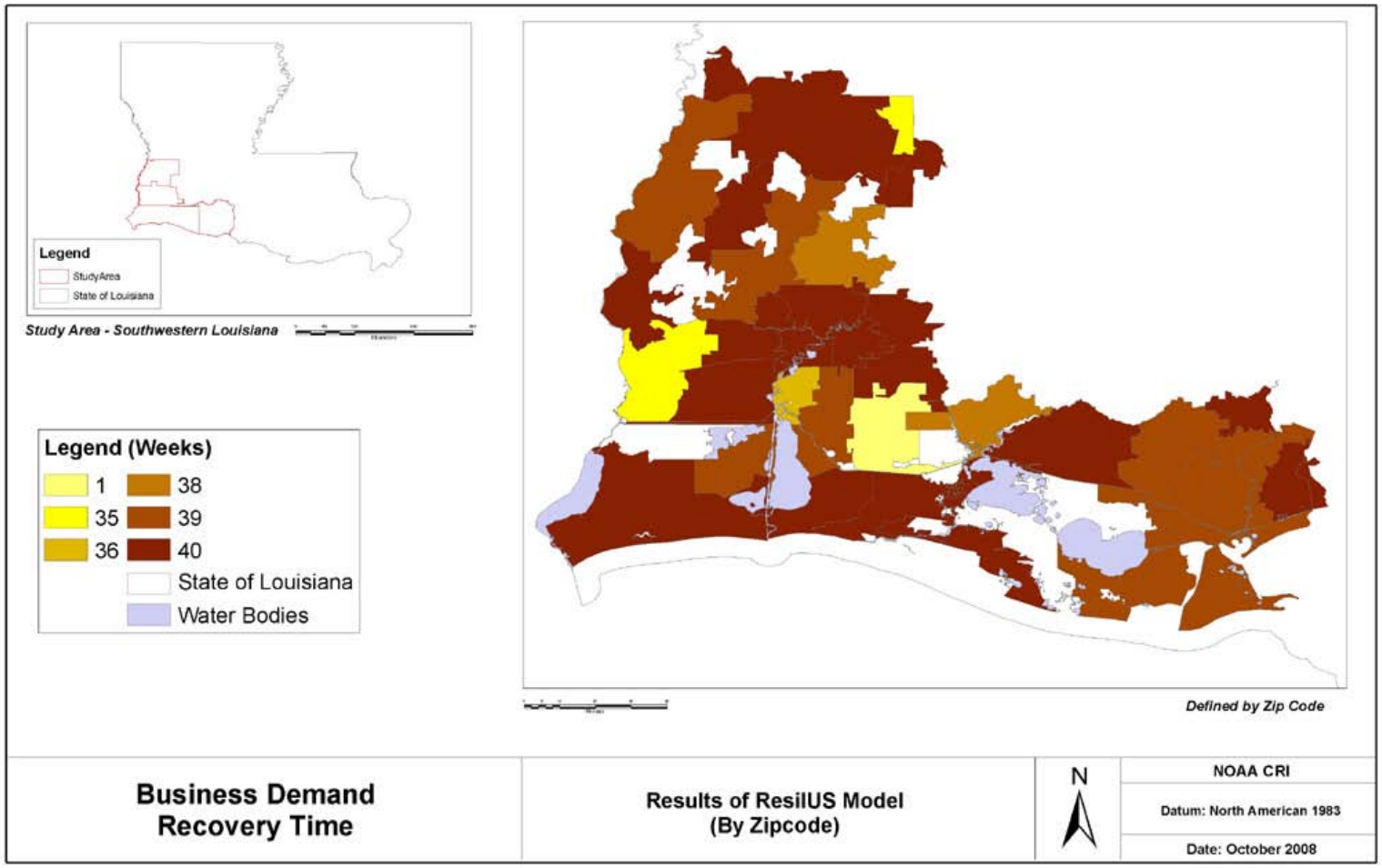
ResilUS alpha version – Model input



ResilUS alpha version – Model input

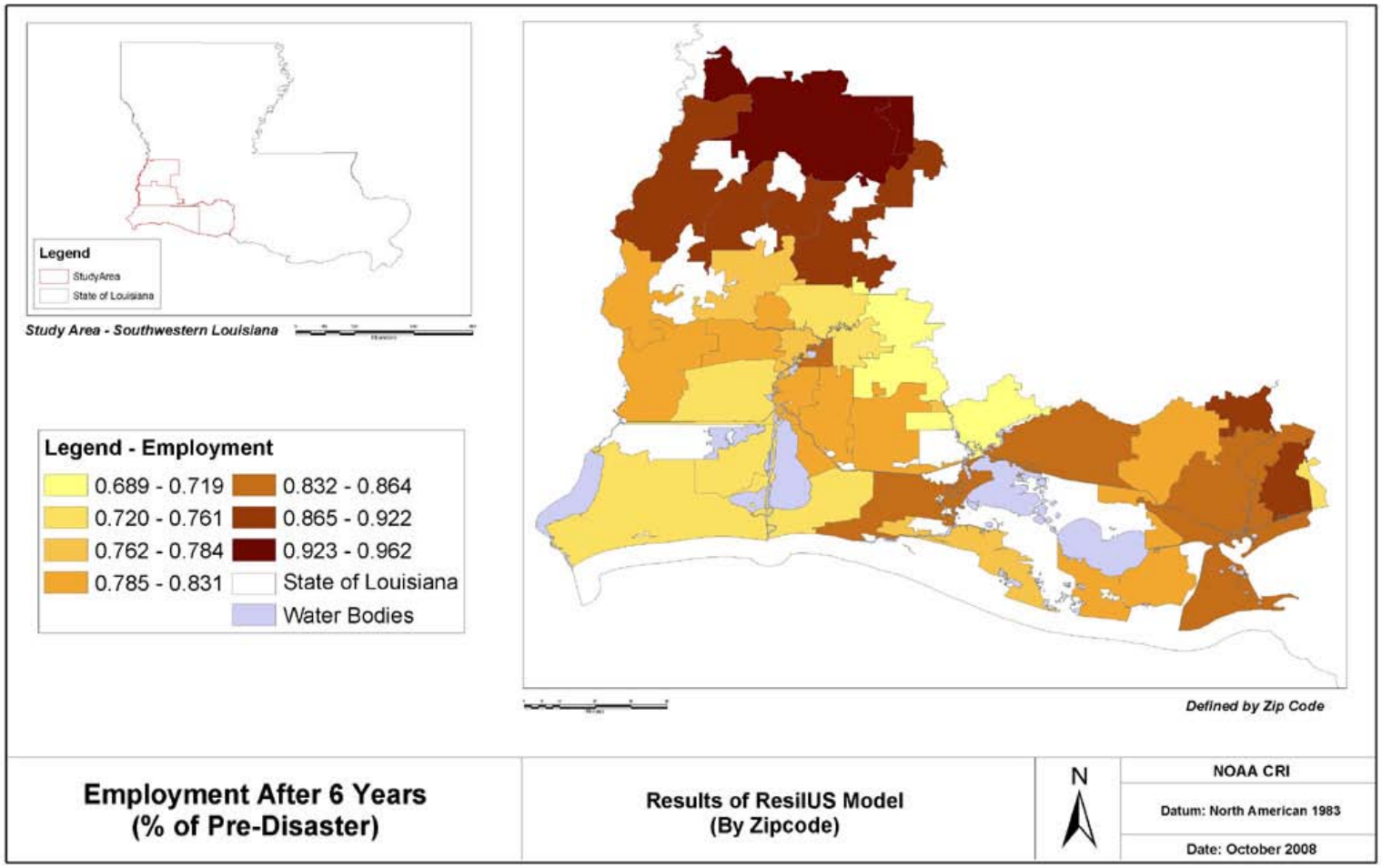


ResilUS alpha version – Model output



Please note that this figure is based on preliminary data and used for illustration purposes only

ResilUS alpha version – Model output



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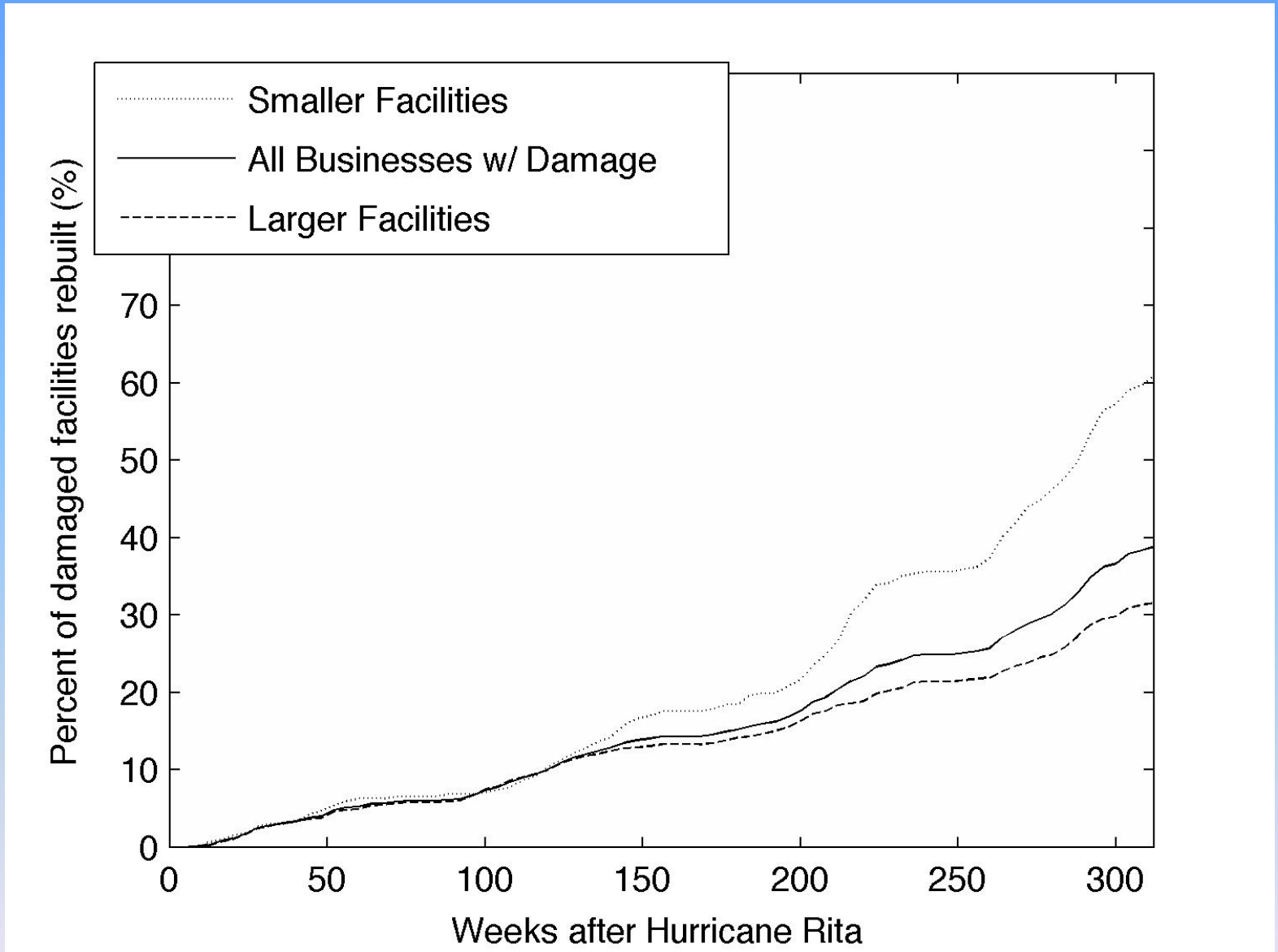


Please note that this figure is based on preliminary data and used for illustration purposes only

Continuous Data Input from all research initiatives
(incl. remote sensing, GIS, census, surveys)

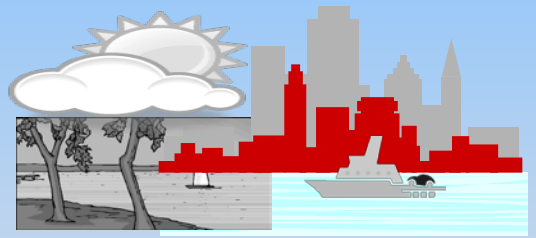
Ecosystem & Socio-cultural Resilience
Infrastructure Resilience
Social Resilience
Economic Resilience

Continuous Monitoring
over time and space …

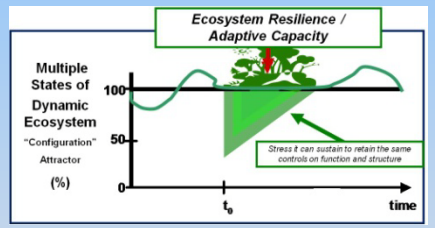
Continuous Management Decisions to Increase Resilience
over time and space …

time

Continuous Quantification of Resiliencies
over time and space …

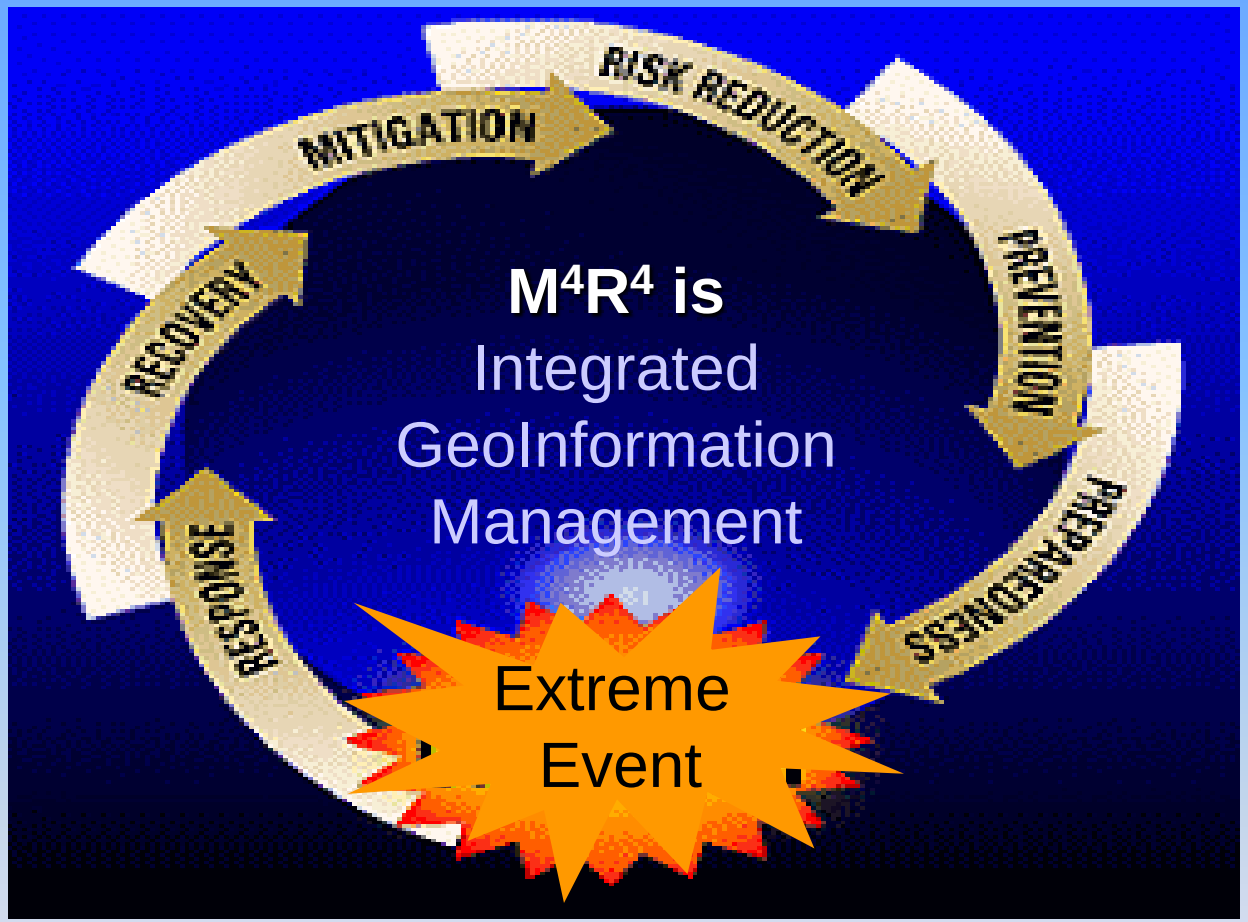


Continuous Resilience Modeling
over time and space …



Continuous Feedback
over time and space …

NOAA CSC Coastal Community Resilience Index


MITIGATION
RISK REDUCTION
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M4R4 is
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Event

Conclusions – Model engine ResilUS

- Big improvement over previous prototypes
- Model input and calibration data requires community input
- Need to make model interface more user friendly
- Model output data is vast and complex
- Further expanding range of modeled indicators

Conclusions

The Integrated GeoInformation Management M^4R^4 **and** Community Resilience Index **approach will allow interdisciplinary teams to continuously**

monitor dynamic environmental processes,
measure spatiotemporal properties,
model natural process variability & extremes, and
manage geospatial data

to effectively communicate and assess
community resilience against
extreme events across various scales.