

DATA AND DECISION MAKING: THE FUTURE OF THE WATER SPACE

COASTAL COMMUNITY RISK & RESILIENCE MANAGEMENT

DECEMBER 8, 2015

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Outline

- Socio-Ecological-Technological Systems Perspective
- Big Data Opportunities for Smart Cities Facing Risk and Resilience Challenges from Infrastructure and Climate Change Perspectives
- A Strategy to Navigate Change and Uncertainty
- Modeling Resilience in a Contrived System as an Exercise of Fun and Learning
- Summary/Comments

Urban SETS Perspective

“People are the reason for urban infrastructure”

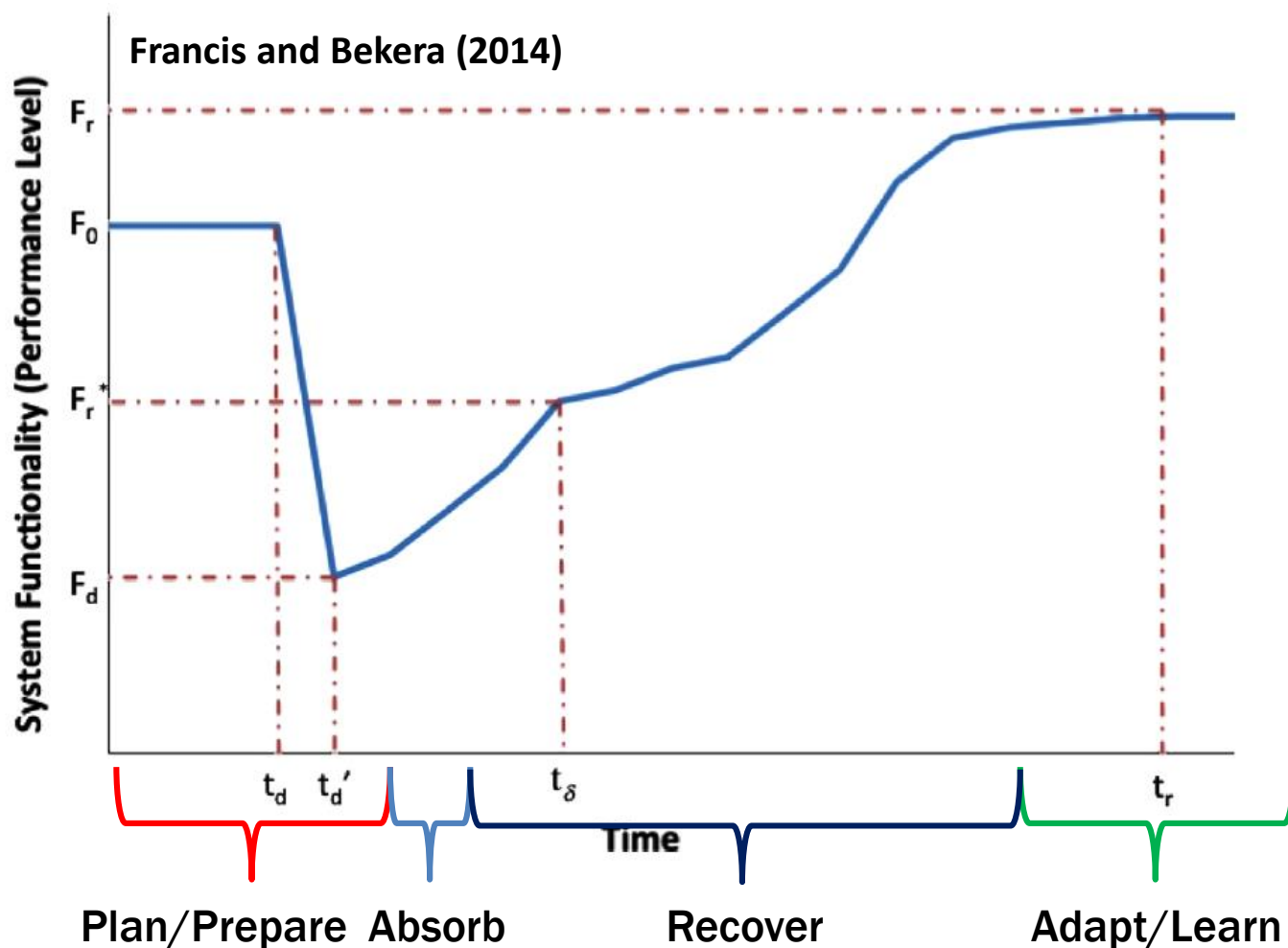
- We assume urban areas are comprised of interdependent Socio-Ecological-Technological Systems (**SETS**)
- Fundamental to managing urban systems is understanding the structure, services, functions, resources, inter-dependencies, and resilience of urban **SETS**.

Urban SETS Perspective

Potential Components of SETS

Social Institutions	Ecosystems	Technology Systems
Family and Kinship	Coastal Beach	Buildings
Economic	Coastal Wetland/Marsh	Transportation
Government	Woodland	Communication and Information
Education	Lake/Wetland/Marsh	Energy
Community Service Organizations	Riparian watershed	Water and Waste water
Religious Organizations	Desert	Remote Sensors
Media	Green Urban Infrastructure	Reactive/Adaptive Control Systems

Loss & Recovery Stages for SETS Services



Big Data Opportunities for Smart Cities Facing Risk and Resilience Challenges from climate change perspectives

- The frequency and intensity of extreme events are increasing for precipitation, heat waves, hurricanes, and winter storms
- Sea level rise 1 to 4 feet by 2100
- Significant uncertainty over the location, magnitude, and rate of climate change
- Climate change uncertainties increase with the planning time horizon
- Climate change uncertainties increase when downscaling to infrastructure or construction scales

Big Data Opportunities for Smart Cities Facing Risk and Resilience Challenges from Infrastructure Perspectives

- Infrastructure lives 50 to 100 years
- Right-of-ways and footprints survive > 100 years
- Urban SETS today are highly connected and as a consequence vulnerable to emergent or cascading system failures
- Urban SETS are poorly understood and still poorly monitored

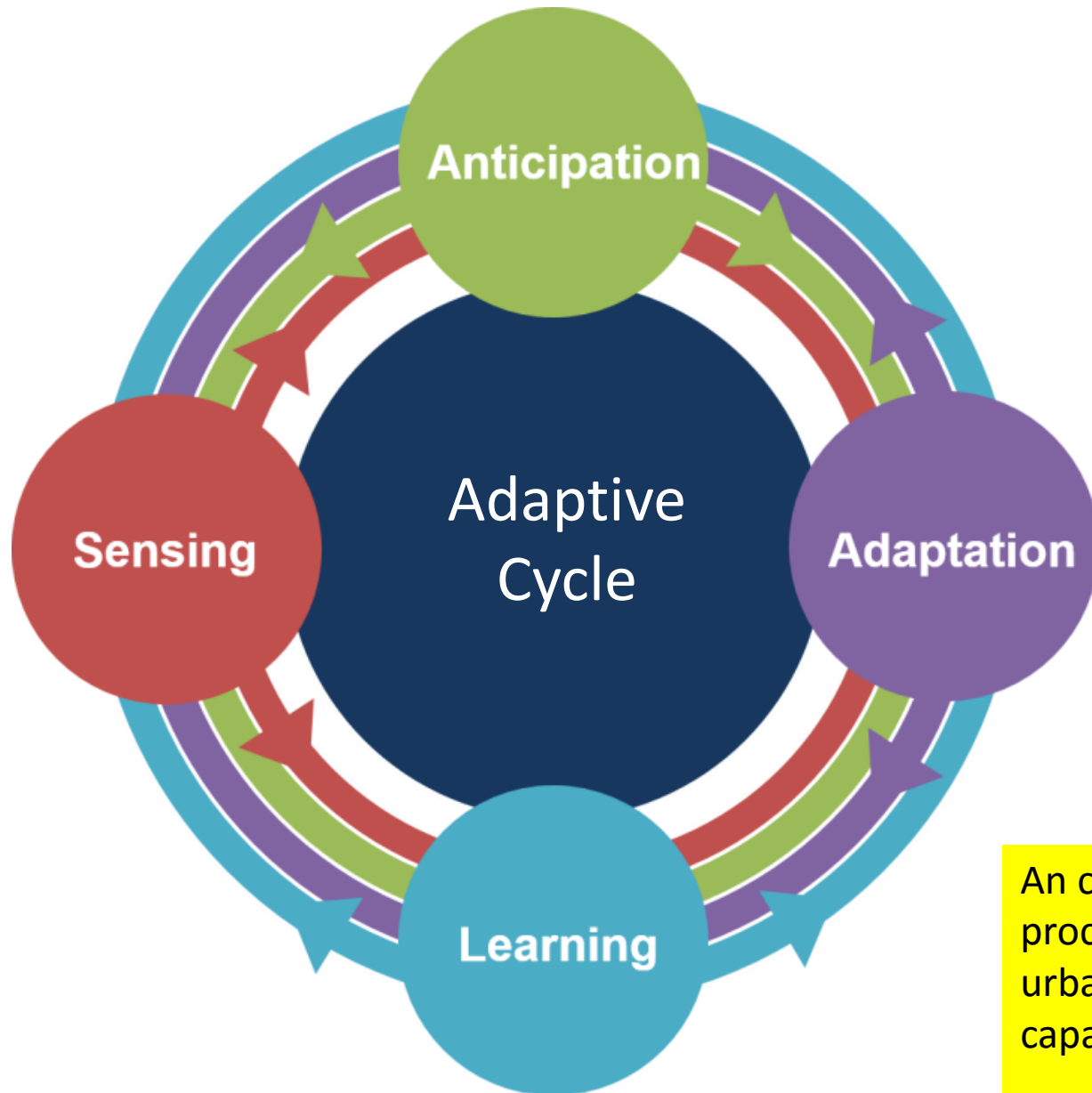
Engineering Challenges Where Big Data Can Help

- Climate change will be more difficult to estimate at the local scale and for the service life of infrastructure systems – **continuous monitoring and forecasting**
- Infrastructure systems of the future will need to be adaptable – **continuous adaptation and learning**
- A new paradigm will be needed for urban risk and resilience engineering – one based on the adaptive management of urban SETS – **reliance on Big Data**

A Strategy to Navigate Change and Uncertainty

- The adaptive management of services and resources of Urban SETS to facilitate system-wide resilience and the inevitable navigation of system failures.
- The continued analyses of Risk, ROI, and Costs & Benefits to inform decisions; but at:
 - short time scales for local venues; and
 - long time scales over regional areas.

Adaptive Management



An continuous
process for building
urban adaptive
capacity

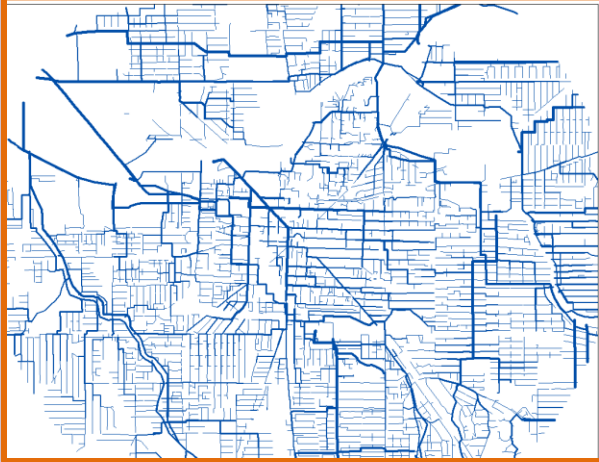
What is Adaptive Capacity?

For urban SETS, the adaptive capacity is the collective intellectual, financial, physical, and technological resources combined with cooperative institutional resources that can be brought to bear on SETS adaptation to changing conditions.

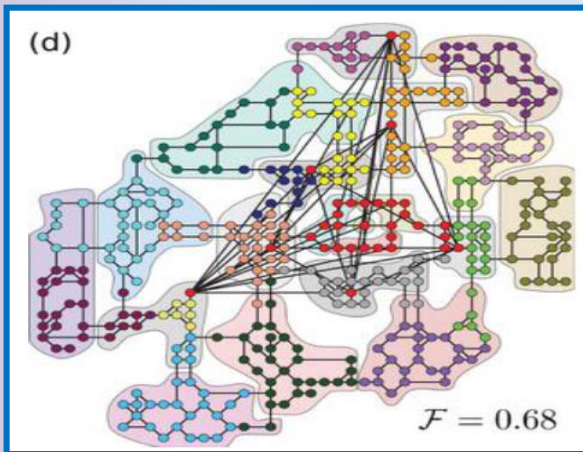
We should invest long-term in building adaptive capacity and Big Data will be a critical component!

Infrastructure & Institutions: Coupled Complex Networks

Critical Infrastructure Network



Formal/Informal Institutions



Loss of Services
“unemployment”
 $[\phi(t)]$

$$(0 \leq \phi \leq 1)$$

Stochastic
SHOCKS

Adaptive
Capacity

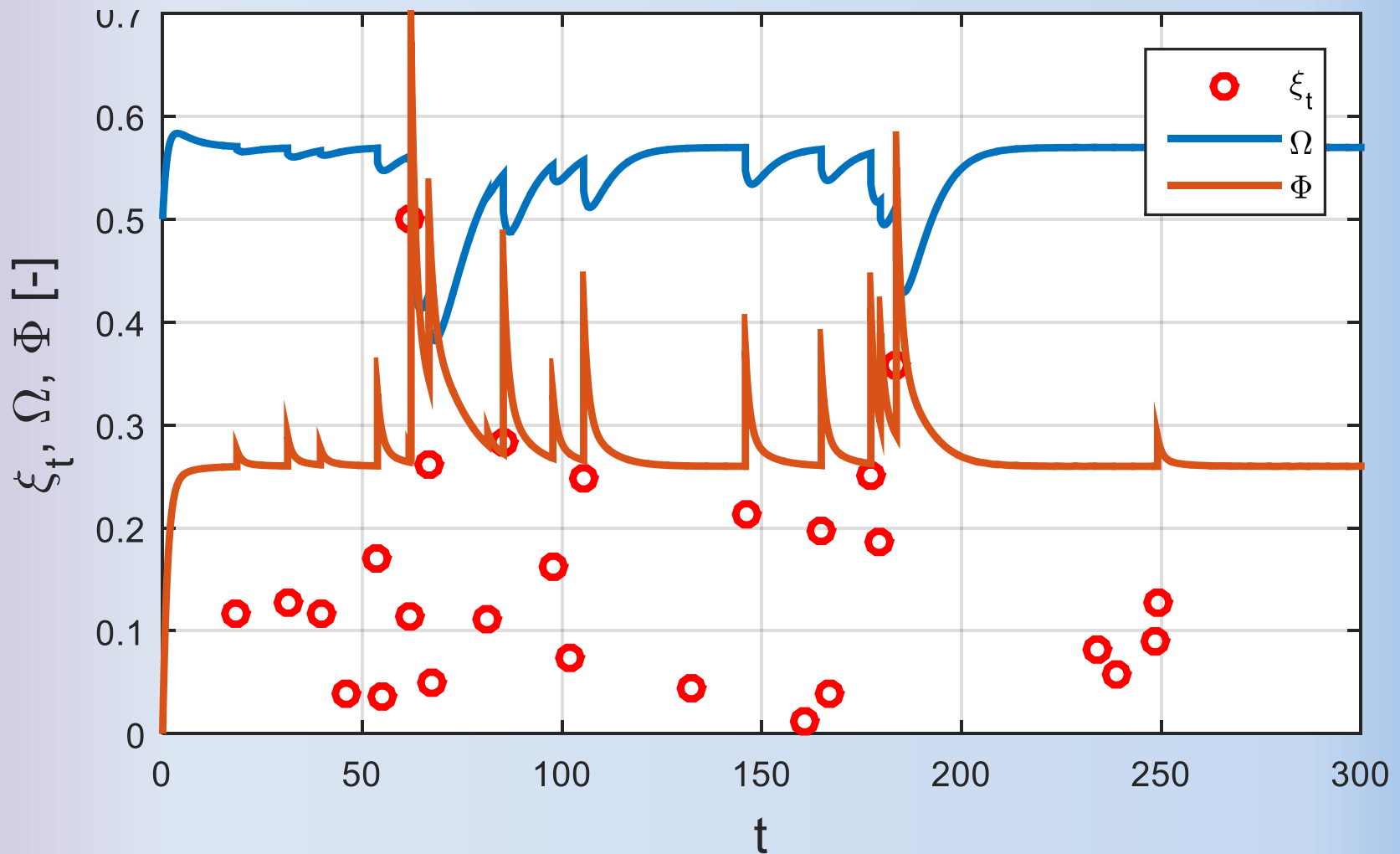
“community resources”
 $[\Omega(t)]$

$$(0 \leq \Omega \leq 1)$$

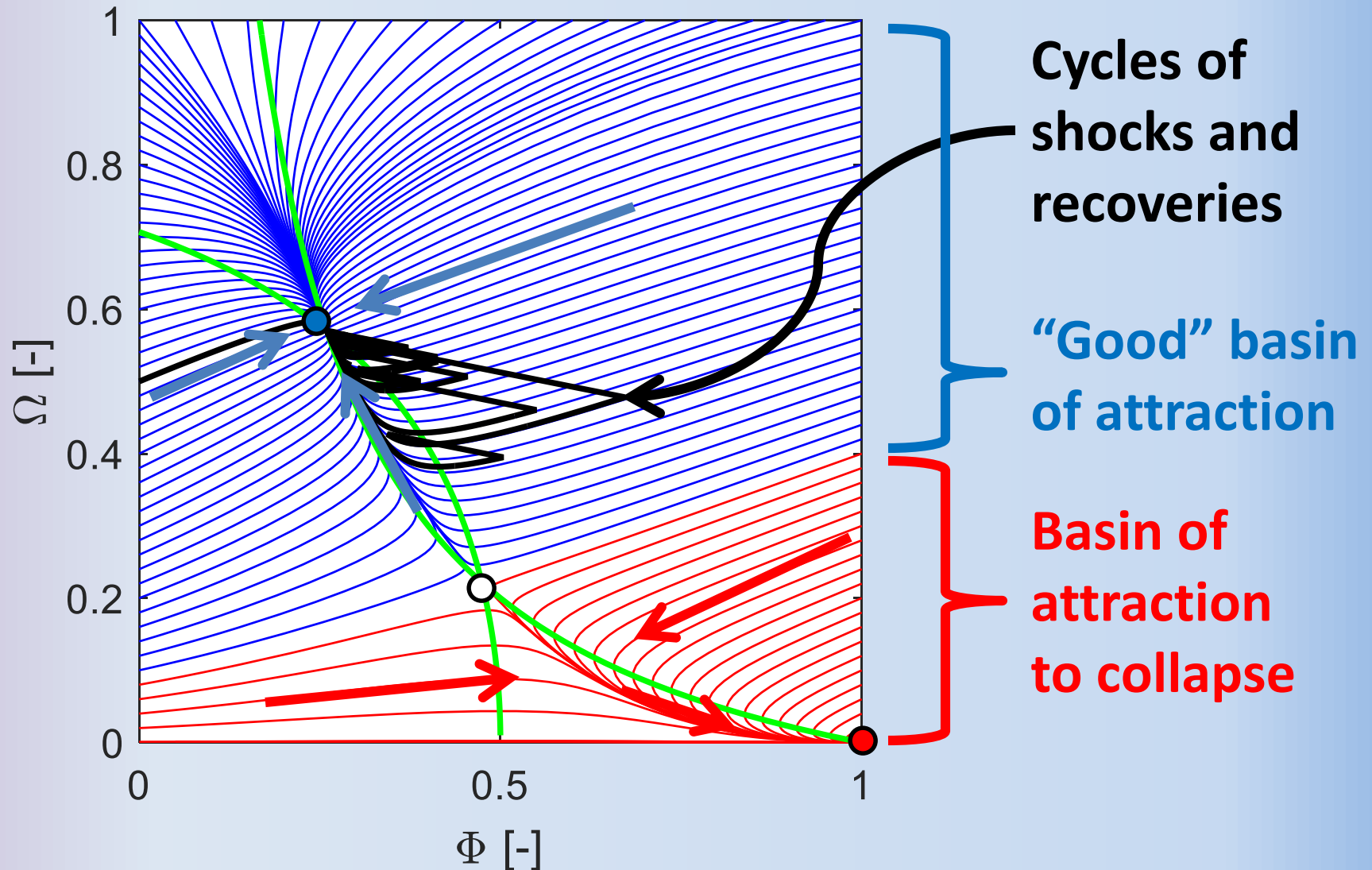
The capacity of a system to self-organize
when conditions change

Simulated Complex System Dynamics

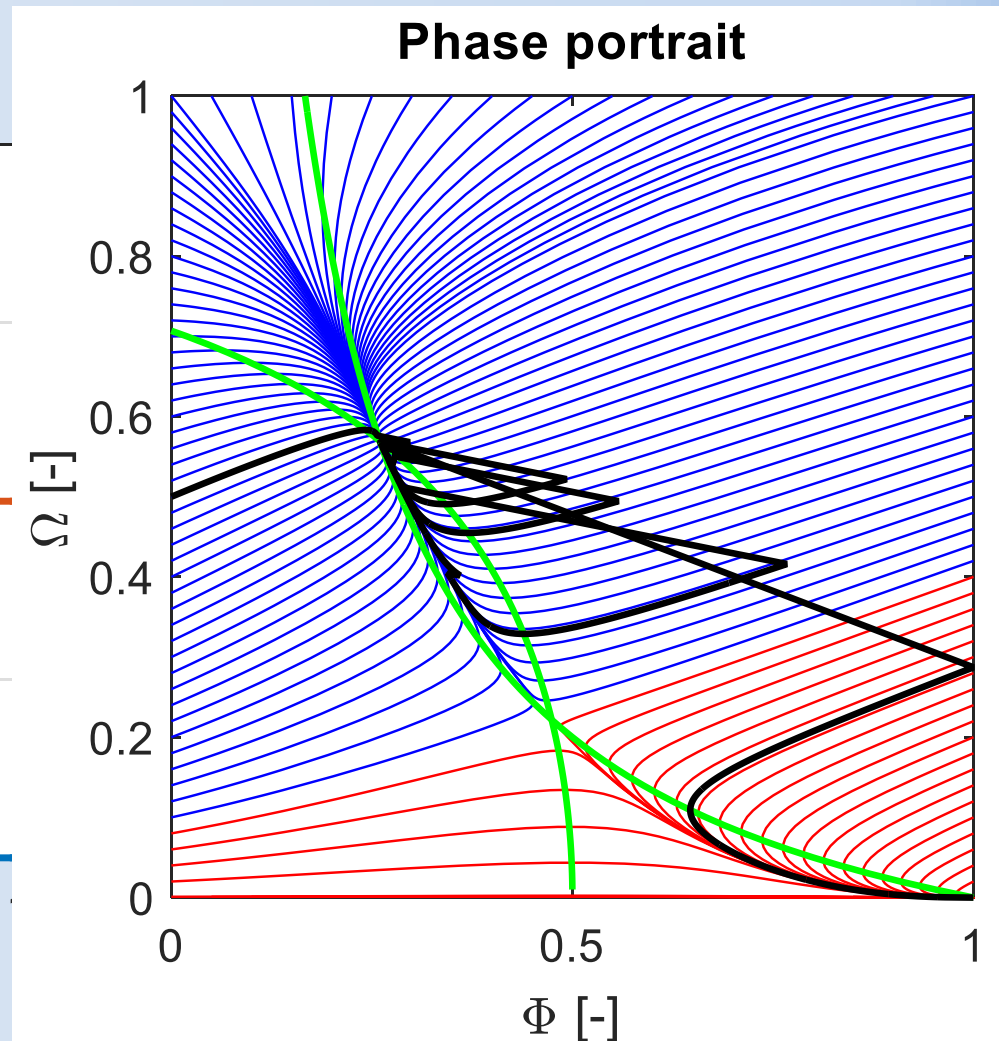
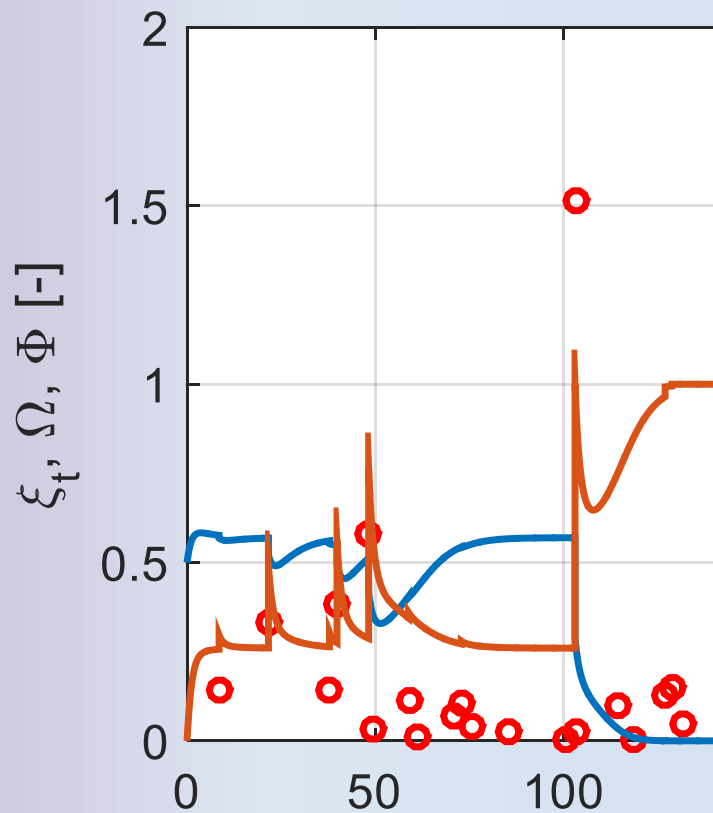
Scenario 1: Time series



Scenario 1: Phase Portrait



Scenario 2: “Collapse” from Impacts of an Extreme Event



Resilience Enhancing Strategies: From “Fail-Safe” to “Safe-Fail”

- **Resistance (Reliability/Robustness)**
 - Hardening (increased rigidity)
 - Redundancy (substitution)
- **Adaptations (Flexibility/Diversity)**
 - Re-routing
 - Modularity (Isolation/De-Centralization)
 - Diversity (Alternate service providers)
- **Transformations (Reorganization/Repurpose)**
 - Re-design
 - Re-invent
 - Replace

Summary/Comments

- No agreement exists on resilience terminology & metrics
- Resilience depends on one's perspective – which will change with Big Data
- Innovation & Diversity are fundamental to flexibility and adaptation and in turn urban resilience
- Resilience is an emergent & stochastic attribute of Urban SETS and not their isolated social-ecological-technical components
- Bad decisions are emergent, stochastic, and unavoidable and analogous to a self-imposed system disturbances or changes that must be navigate – with the aid of Big Data
- Increasing urban adaptive capacity fosters urban resilience
- We must invest in building system-wide adaptive capacity for the long term...and then resilience will follow

Invest long-term in Building Adaptive Capacity

As applied to human social systems:

- Invest in the ability of institutions and networks to learn, and store knowledge and experience.
- Invest in creative flexibility in decision making and problem solving
- Invest in power structures that are responsive and consider the needs of all stakeholders
- Promote community-wide savings
- Invest in SETS monitoring
- Invest in education and research...