

IOWA STATE UNIVERSITY

Department of Industrial and Manufacturing Systems Engineering

Metrics for Community and Engineering Resilience

Cameron MacKenzie, Assistant Professor

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Resilience definition

- “Ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events” (U.S. National Academies, 2012)

Good reviews of resilience measures

- Hosseini, S., K. Barker, and J.E. Ramirez-Marquez 2016. A review of definitions and measures of systems resilience, *Reliability Engineering and System Safety* 145, 47-61.
- Cutter, S.L. 2016. The landscape of disaster resilience indicators in the USA. *Natural Hazards* 80, 741-758.

Disaster or community resilience

- Divide resilience into 4 or 5 categories (e.g., social, infrastructure, economic, information)
- Indicators or measures gathered at a state or regional level (20-40 measures)
- Normalize indicators on a 0-1 scale
- Aggregate indicators through a weighted linear additive equation (often equal weights)
- Examples: Cutter et al. 2008, Berke et al. 2012, 2014, Frazier et al. 2013, Linkov et al. 2013

Example of resilience indicators

Social resilience

Educational equity	Percent of population with college diploma
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Age	Percent of non-elderly population
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Economic resilience

Housing capital	Percent homeownership
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Employment	Percent employed
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Institutional resilience

Mitigation	Percent population covered by hazard mitigation plan
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Political fragmentation	Number of governments and special districts
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Infrastructure resilience

Shelter capacity	Percent vacant rental needs
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Medical capacity	Number of hospital beds per 10,000 people
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Community capital

Place attachment	Percent people who reside in state where they were born
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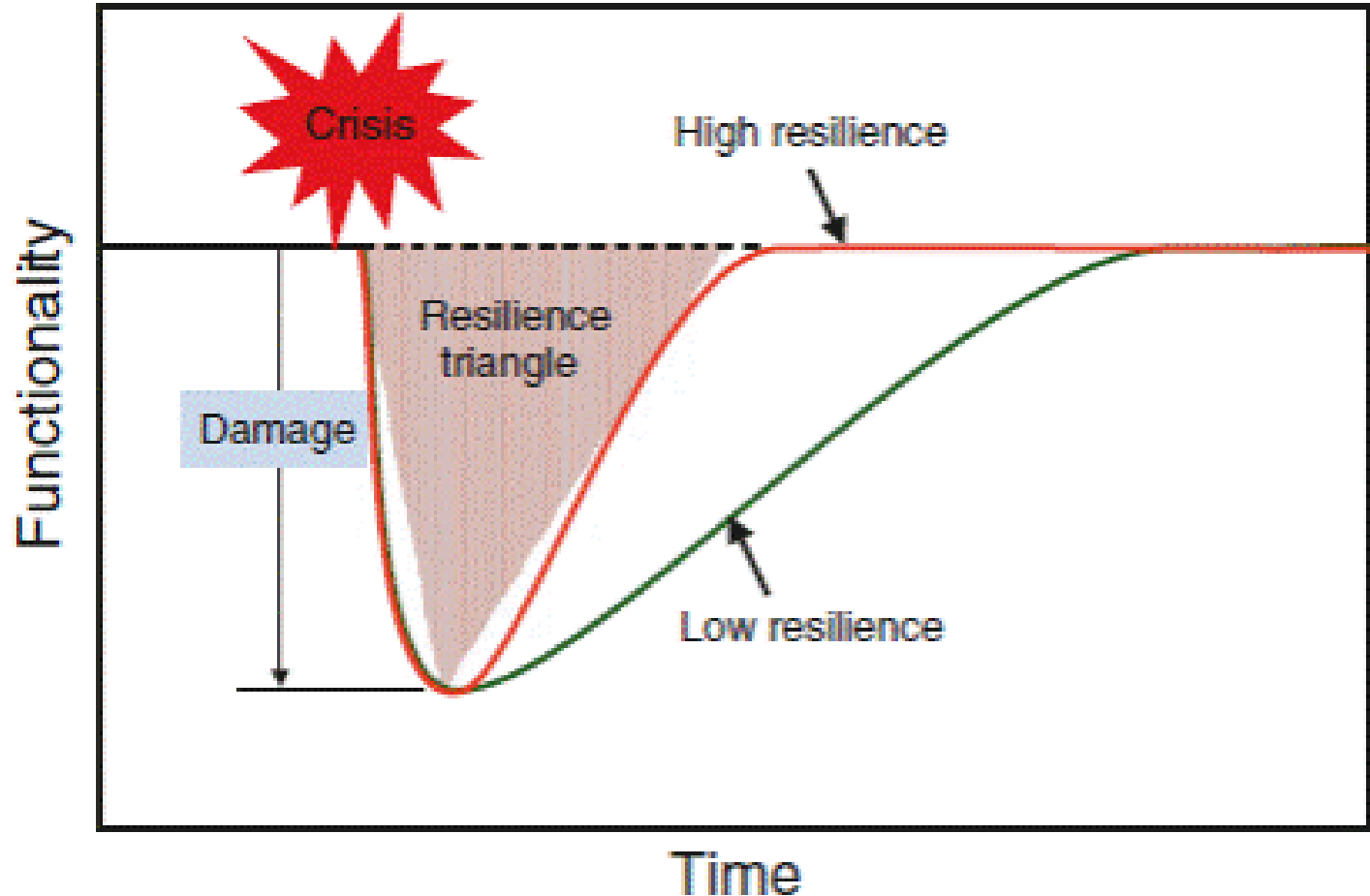
Social capital	Number of civic organizations per 10,000 people
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Resilience indicators

- Focus on means objectives rather than fundamental objectives
- Fundamental objectives in a disaster
 - Fatalities, injuries, disease
 - Shelter and food
 - Economic well being
 - Disadvantaged groups
 - Environmental quality
- Focus on inputs rather than outputs into the system

But indicators are easier to measure!

Engineering perspective: Resilience triangle



<https://ebrary.net/25636/environment/resilience>

Variations on a theme

- Linear and nonlinear recovery (Bruneau et al. 2003, Tierney and Bruneau 2007)
- Resilience for businesses (Zobel 2014):
 - Trade-offs between robustness and restoration (Zobel 2011)
- Stochastic resilience with multiple failure and recovery profiles (Ayyub 2014)
- Probabilistic resilience (also includes speed of recovery) (Francis and Berka 2014)
- Time-dependent measure (Henry and Ramirez-Marquez 2012): only measures proportion of recovery

Challenges with engineering resilience metrics

- Resilience definition implies that concept is a property of system (Haimes 2009) → separate from threat or hazard
- Application of resilience metrics are usually very disruption specific
- Little connection to community resilience

Questions around resilience metrics

- Do resilience indicators for community resilience provide insight into how a community will absorb or recover from a disaster?
 - Would a model and simulation have more predictive value?
- How should measures for engineering and infrastructure resilience be integrated into community resilience concepts?
- What resilience metrics and concepts provide the greatest insight into making decisions and allocating resources to enhance community resilience?

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