Assessing Resilience of Coastal Ecosystems

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US Army Corps of Engineers
BUILDING STRONG®

Incomprehensible jargon is the hallmark of a profession.

Kingman Brewster Jr.

Ecosystem Services

Process

Model

Metric

Function

Sustainability

Stakeholders

Restoration

Watershed Approach

Adaptive Management

Interdisciplinary

What is this session about?

- **Resilience**: the ability of a system to absorb or recover from a disturbance
- **Disturbance**: any relatively discrete event in time that is characterized by a frequency, intensity, and severity outside a predictable range (Resh et al. 1988)

- Three types of resilience:
  - ►Recovery following disturbance
  - ►Resistance against regime change
  - ►Adaptive capacity

Recovery (Engineering Resilience)

- How fast will a system return to its pre-disturbance state?
- Rapidity: speed (or time) of performance recovery
- Robustness: performance during disturbance

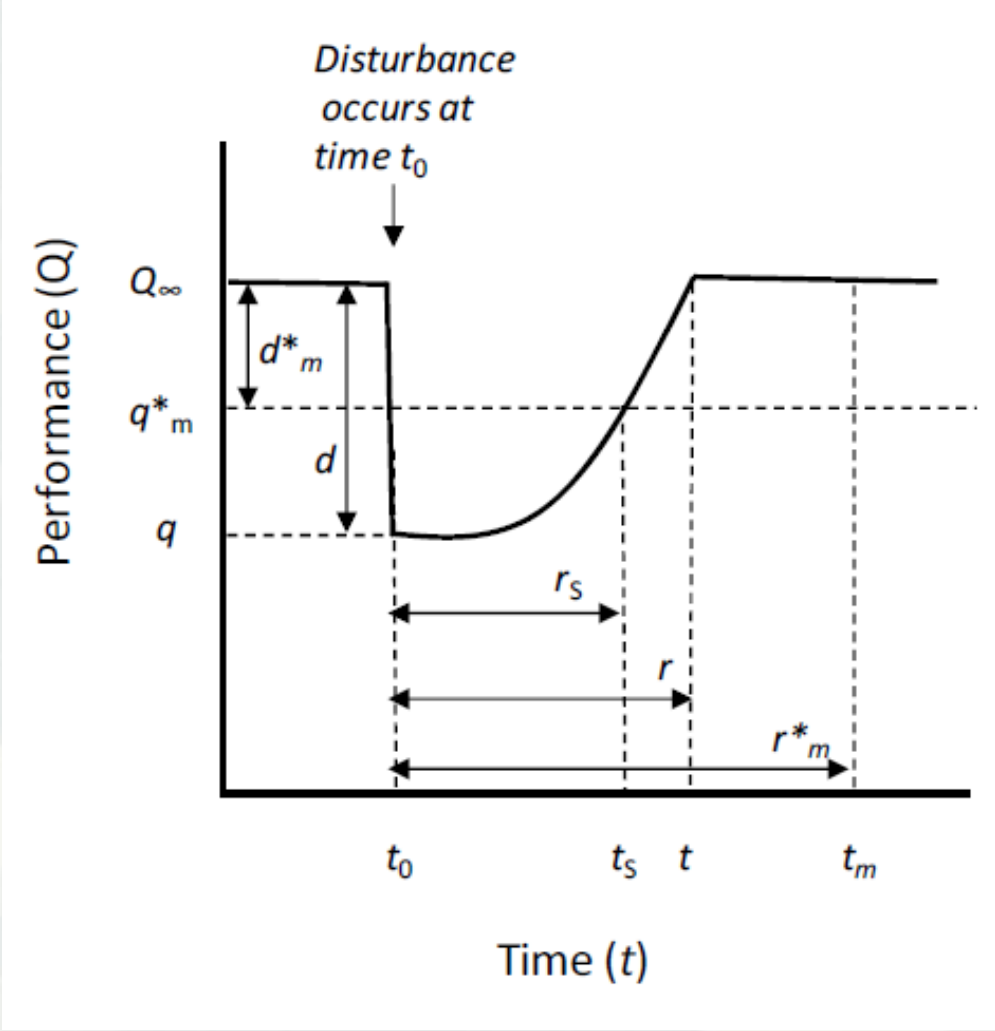


Figure: Martin Schultz

Resistance (Ecological Resilience)

- How much disturbance can a system absorb before switching to an alternate state?
- What are the critical thresholds for a system?

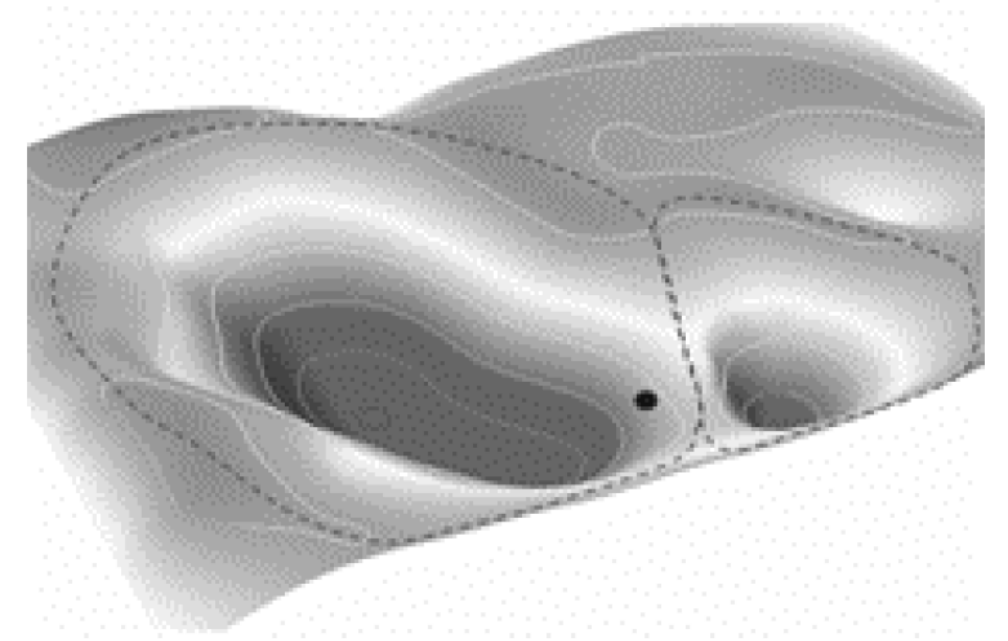


Figure: Walker et al. (2004)

Adaptation (Community Resilience)

- How can the system self-manage to avoid disturbance and maintain a desired state?

Figures: USACE Rock Island District, Illinois State Museum

Examples of Types of Resilience

System	Tidal Wetland	Flood risk management
Disturbance	Hurricane	Riverine Flood
Recovery	Re-establishment of vegetation following erosive event	The rate of re-established flood protection following a levee breach
Resistance	Vegetation's ability to resist washout and resulting state change to a mudflat	Levee robustness to overtopping flows
Adaptive Capacity	Mobile fauna (e.g., birds) that can rapidly move to intact habitat before, during, or after the storm	Reservoir drawdown in expectation of an oncoming flood event

Resilience of what? Resilience to what?

- General Resilience
  - Centered on system integrity
  - Comprehensiveness can cloud metric selection
  - Balance of the system
  - Quantification: metrics
- Targeted Resilience
  - Centered on management objectives
  - Focused objectives and straightforward link to metrics
  - Optimization across objectives
  - Quantification : metrics and probabilistic analyses

Sources: Walker and Salt (2006)

Metrics of Resilience

- What are you measuring?
- How are you measuring it?
- What are you measuring it relative to?
- Objective Setting
- Metric Development
- Threshold Selection

Objective	**Metric**	**Threshold**
Maintain water supply provision	Time to restored service (sojourn time)	Needs of critical utility users (e.g., hospitals) v. users' critical needs (e.g., drinking water)
Maintain population of crabs	Colonization rate of crabs from nearby sources	Complete recolonization within 10 years
Sustain wetland ecosystem	Sojourn time of primary productivity	Wetland accretion rate > sea level rise

Probabilistic Analyses

- Schultz et al. (2011)
- Based on loss of system performance
- Probabilistic treatment of failure and disturbance
- Combination of many performance curves

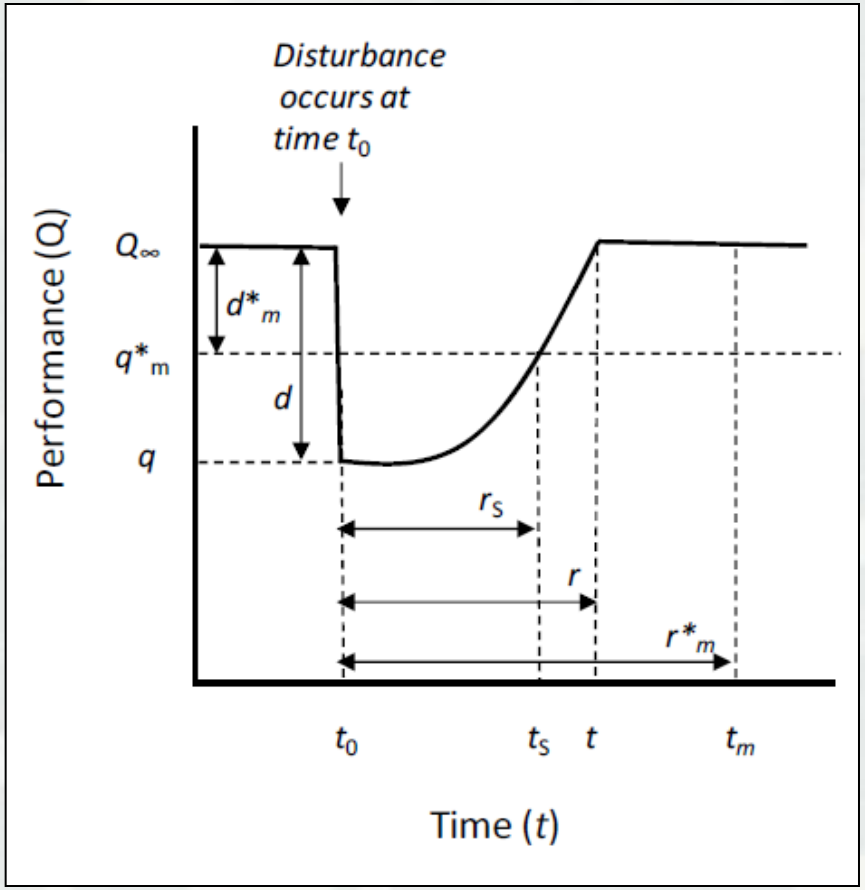


Figure: Martin Schultz

Can resilience change over time?

- Resilience evolves over time with long, slow changes in boundary conditions (press disturbances)
  - Examples: sea level rise, climate change, urbanization

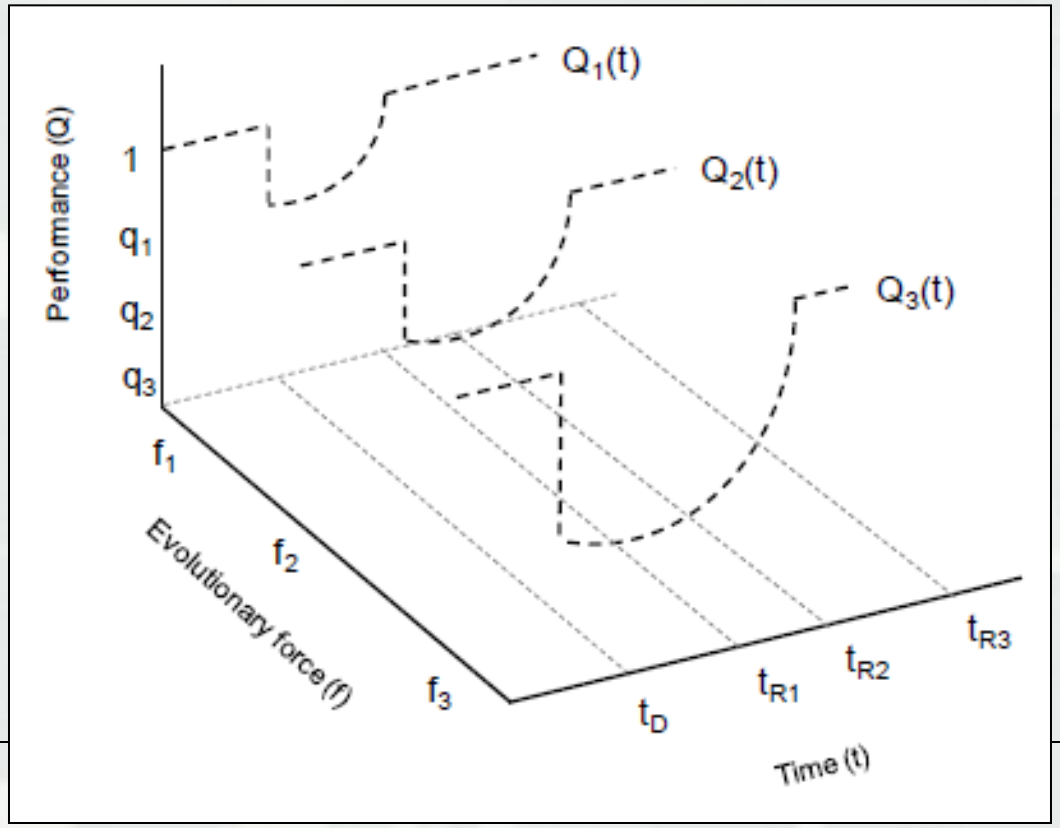


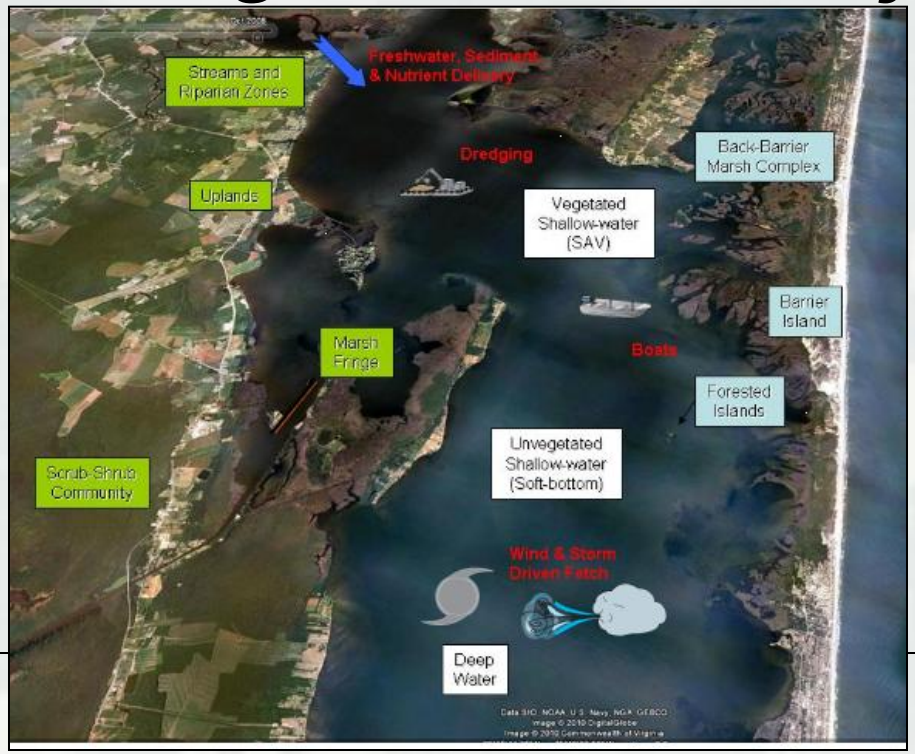
Figure: Martin Schultz

How does this relate to restoration?

- Ecosystems are naturally dynamic
- Resilience could preclude restoration (i.e. “no action”)
- Disturbance regimes are changing, so we’ve got to be ready (e.g., drought length, hurricane magnitude, budget peaking)
- Many of our systems are already on the verge of a regime change. How much more can they take?
- We screw up…a lot. (e.g. Macondo oil discharge)
- New mandates appear to be coming down the line…
  - New P&R: “Healthy, ***resilient*** ecosystems”

One more complexity

- Quantifying and tracking the performance of a SYSTEM of projects with many purposes may be more challenging, but also more rewarding.
- We work in ***integrated coastal systems***.



Take-away Points

- Resilience is **not** an empty concept.
- Three types of resilience:
  - ►Resistance
  - ►Recovery
  - ►Adaptive capacity
- Quantification techniques exist and may be adapted to project needs

Case Studies in Resilience

- Bhaskaran Subramanian
  - ►Enhancing Coastal Resilience with Integrated Planning by the State of Maryland
- Leslie Suazo
  - ►Resilience in Coastal Louisiana
- Craig Fischenich
  - ►A framework for adaptively managing restoration projects in Coastal Louisiana

Questions and Feedback

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Discussion Questions

- What techniques are being applied to quantify resilience?
- Do you think of resilience as an objective for your projects?
- What aspects of coastal systems are the most and least resilient (natural or engineered)?
- How can resilience inform planning of integrated systems?
- How can local, state, and federal agencies build resilience into their organizational structures?
- How can federal and non-federal partners better coordinate to enhance resilience of integrated coastal systems?