Managing Crises, Climate Change and Ecological Resilience in Complex Resource Systems

LANCE GUNDERSON* & KATHLEEN D. WHITE**

*EMORY UNIVERSITY
ATLANTA GA, USA

**U.S. ARMY CORPS OF ENGINEERS,
INSTITUTE FOR WATER RESOURCES
WASHINGTON DC USA
CRISIS = ABRUPT CHANGE, INSTABILITY

Exogenous Crises
- Variation at larger scales
- Need for robust, diverse responses across scales

Tsunami, Japan, March 2011
Hurricane Katrina, August 2005
CRISIS = TURNING POINT

Endogenous Crises
Increased Connections, Accumulation of Capital
Increase vulnerability, Shifting controls
Climatic Driven Changes!
CLIMATE DATA - SOUTH FLORIDA

Rainfall

Stationarity?
Increased variation

Evaporation
Climate Change: Increasing Surprises

- Changing long-term (Slow) variables
  - Flood and Drought cycles
    - Evaporation
    - Rainfall
  - Rising Sea Level
- Increase in Cyclonic frequency and intensity
- Increase in temperate wind variability
ADAPTIVE RESPONSES TO CLIMATE CHANGE

• **Linear Response**
  o scale bound
  o few variables
  o predictable responses

• **Resilient Response**
  o Non linear dynamics
  o Multiple regimes in socio-ecological systems
  o Knowledge of regimes

• **Transformational Response**
  o Little or no experience
  o No analytic solutions, hard to define issues/problems (Wicked)
  o New systems, configurations and interactions
Glen Canyon Dam, N. Arizona

Sand for Beaches
Endangered species
Recreation - fishing, rafting, camping, hiking
Power generation
Non-native species
Cultural history - claims
Water allocation & delivery
ADAPTIVE MANAGEMENT EXPERIMENTS

FLOW EXPERIMENTS
Sediment, Beaches, Biology?

PREDATION CONTROL
2002- present
Trout eating humpback chub
Grand Canyon: Experiments Critical to Social Learning and Restoration

• Experiments are costly
• Changed understanding
• Embedded leadership was necessary
• Forced addressing alternative hypotheses
• No long-term experimental design
Everglades Restoration
1) Restore historic hydrologic regime
2) Detect and Avoid thresholds - undesired regimes

Nutrient Thresholds in Everglades
REGIME MANAGEMENT

■ Is Regime Shift Reversible?
  ■ Do Nothing (Ignore)
  ■ Manage to desirable state
    ■ Active adaptive management - actions, hysteresis
    ■ Passive adaptive management - time during transition
  ■ Is Regime Shift Irreversible?
    ■ Do Nothing (Ignore)
    ■ Adapt to new state
      ■ Foster experiments for adaptation
      ■ Provide incentives for new solutions
Hydrologic Hierarchy Florida
Panarchy
Panarchy

large and slow

intermediate size and speed

small and fast

remember

revolt
Rigidity Trap

- Maintenance of status quo
- Lots of capital/power
- Innovation/experimentation stifled
- Requires crisis to unlock
Poverty Trap

• Maintenance of status quo
• Decline in natural capital/structure
• Erosion of external inputs
• Unable to contain cascading effects

1927 - Mississippi Flood
2005 - Hurricane Katrina
SUGGESTIONS

• Navigate Transitions
  o Prepare for change
  o Develop shared views of alternative futures

• Design flexible processes
  o Discourses and collaborations, not fixed structures.
  o Focus on new ideas, solutions

• Recognize opportunities
  o Variation in climate = opportunities for experimentation
SUGGESTIONS

• Develop Learning Based Institutions
  o Evaluate and monitor outcomes of past interventions
  o Engage across sectors (ecological, economic, social)
  o Epistemic organizations (skunkworks)

• Create incentives for flexibility
  o Develop and maintain a portfolio of projects, waiting for opportunities to open.
  o Stimulate experiments
  o Actions that are safe to fail for individuals, institutions