Future Directions in SES Research

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How Do the Social and Ecological Interact to Generate Resilient SESs

- Ecological systems vary immensely
- Social systems also exhibit immense variety
- No blueprint policy can improve productivity, diversity, resilience of ALL SESs!!!!
- Each SES is unique – as is each human
- SESs are structured by multiple variables that affect patterns of outcomes over time
- Need to develop our diagnostic skills so we can develop capacity to predict, explain and improve
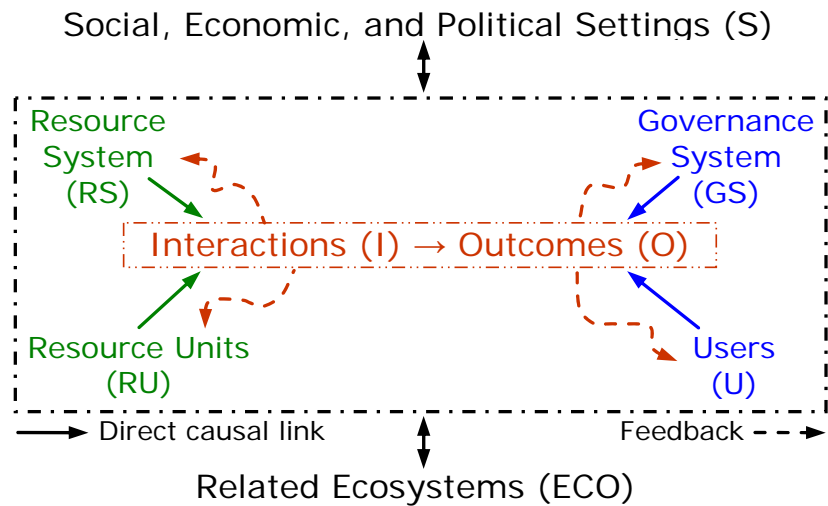
Narrow Disciplinary Boundaries Limit Our Scientific Progress

- We need to be developing analytical approaches that draw on disciplinary knowledge but help us to integrate inter-disciplinary understanding
- One approach to is building a common diagnostic framework and using it to conduct research related performance of SESs in regard to governance, productivity, resilience, equity etc
- In the short time of this talk, I will discuss a framework published in *PNAS* in 2007 and in *Science* this July 24 & future research plans

A Common Diagnostic Framework

- We need to build a common meta-theoretical language for positing the effect of a common set of structural variables on interactions and outcomes over time.
- A diagnostic framework provides a method for unpacking the common components of social-ecological system (SES)
- The type of focal system could be a lake, a system of lakes, a fishery, a forest, or the global atmosphere
- A focal system is composed of four internal systems embedded in two external systems

A Multitier Framework for Analyzing Sustainable Social-Ecological Systems

Social, Economic, and Political Settings (S)

Resource System (RS)

Governance System (GS)

Interactions (I) → Outcomes (O)

Resource Units (RU)

Users (U)

→ Direct causal link

Feedback - - →

Related Ecosystems (ECO)

How Does a Diagnostic Framework Help Us Understand Complex SESs?

- Helps to identify variables that affect interactions and outcomes (can be modeled as an action situation, a game, an ABM or an experiment)
- Helps us to study similar systems that share some variables while differing in others.
  - Avoids over-generalization (all resources should be privately or government owned) or over-specification (my case is different than yours).
- To diagnose why some systems are not resilient have to study similar systems over time and examine which variable did differ to enable some system to survive disturbances or other not

Initial Second Tier Variables

- Identified a broad set of variables frequently mentioned in empirical studies of SES as being important
- Most of these variables have sub-types and sub- sub-types which may be themselves very important in affecting interactions and outcomes
- Several groups of scholars in the US and Europe are working on developing the diagnostic framework further but lets looks at the currently identified second-tier variables
  - Stars next to variables identified by researcher as associated with self-organization to govern resources

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Second-Tier Variables of a SES

Social, Economic, and Political Settings (S)
S1- Economic development. S2- Demographic trends. S3- Political stability.
S4- Government resource policies. S5- Market incentives. S6- Media organization.

Resource Systems (RS)

RS1- Sector (e.g., water, forests, pasture, fish)
RS2- Clarity of system boundaries
RS3- Size of resource system*
RS4- Human-constructed facilities
RS5- Productivity of system*
RS6- Equilibrium properties
RS7- Predictability of system dynamics*
RS8- Storage characteristics
RS9- Location

Governance Systems (GS)

GS1- Government organizations
GS2- Nongovernment organizations
GS3- Network structure
GS4- Property-rights systems
GS5- Operational rules
GS6- Collective-choice rules*
GS7- Constitutional rules
GS8- Monitoring and sanctioning processes

Resource Units (RU)

RU1- Resource unit mobility*
RU2- Growth or replacement rate
RU3- Interaction among resource units
RU4- Economic value
RU5- Number of units
RU6- Distinctive markings
RU7- Spatial and temporal distribution

Users (U)

U1- Number of users*
U2- Socioeconomic attributes of users
U3- History of use
U4- Location
U5- Leadership/entrepreneurship*
U6- Norms/social capital*
U7- Knowledge of SES/mental models*
U8- Importance of resource*
U9- Technology used

Interactions (I) → Outcomes (O)

I1- Harvesting levels of diverse users
I2- Information sharing among users
I3- Deliberation processes
I4- Conflicts among users
I5- Investment activities
I6- Lobbying activities
I7- Self-organizing activities
I8- Networking activities

O1- Social performance measures
    (e.g., efficiency, equity, accountability, sustainability)
O2- Ecological performance measures
    (e.g., overharvested, resilience, biodiversity, sustainability)
O3- Externalities to other SESs

Related Ecosystems (ECO)
ECO1- Climate patterns. ECO2- Pollution patterns. ECO3- Flows into and out of focal SES.

*Subset of variables found to be associated with self-organization.

To Do Good Research — Must Choose a Question Carefully

- One question is: When will the users of a CPR self-organize?
- Hardin said never!
- Many policies based on that conclusion
  - Governments must impose uniform solutions on all forests, or fisheries, or water systems in their jurisdictions
  - Many failures — and some successes
- But when will the users themselves organize?
- And why will some survive disturbances and other collapse?

Research has now identified Variables Conducive to Self-Organization

- Have developed a formal model of the calculus that users are likely to use in calculating whether they invest or not in costly self-organization
- Relevant benefits & costs specified in the model extremely difficult to measure in the field
- Scholars have identified the starred variables as affecting probability of self-organization
- These are the potentially relevant variables for diagnosing likelihood of self-organization
- Empirical research is supportive of this theory -- more is needed

To Illustrate Use of Framework — Compare Three Cases in Mexico

- Rarely have quantitative information about the specific benefits and costs for particular users
- With good fieldwork, however, can make an estimate of the differences among cases on a key set of diagnostic variables similar to those that are starred in the framework and discussed above
- Illustrate the variables discussed above with an example for the Northern Gulf of Mexico studied by Xavier Basurto

Three Fishing Villages in the Northern Gulf of California, Mexico
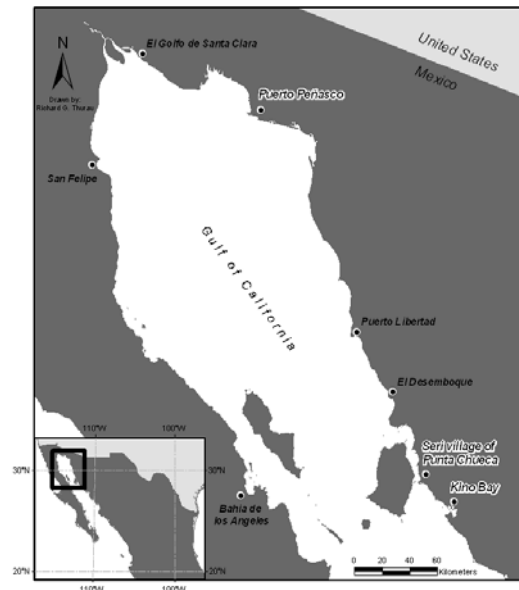
Harvesting of the Sessile Mollusk Sea Pen Shell

Left to right. **Photo#1:** Two adult specimens of the sessile bivalve mollusk commonly known as sea pen shell (Atrina tuberculosa) and harvested by small-scale fishers of the three communities under study. **Photo #2:** Shows two abductor muscles pertaining to the two individuals of photo#1. Sea pen shells are harvested for their abductor muscle, which reaches high prices in the Mexican national seafood market. Fishers are paid up to $20 usd per kilogram at the beach – therefore there is great demand for them. Only shrimp and abalone reach such high prices. Their U.S. analogue are bay scallops. **Photo #3:** Typical small-scale fishing boat used in the Gulf of California, Mexico. Benthic mollusks are harvested by diving (photo #4), note the air compressor in the middle of the boat in photo 3 that provides air to the diver in photo # 4. Diver in **Photo # 4** is walking on the bottom (using plastic boots) harvesting sea pen shells in a shallow fishing area.

Comparison of Key Variables for Three Coastal Fisheries in the Gulf of California

	Kino	Peñasco	Seri
Users (U)			
U1 (number of users)	Rapid growth	Rapid growth	Slow growth
U5 (local leadership)	Absent	Present	Present
U6 (trust and reciprocity)	Lacking	High levels	High levels
U7 (shared local knowledge-mental models)	Lacking	High levels	High levels
U8 (dependence on resource)	Low	High	High
U9 (technology)	Same	Same	Same
Governance System (G)			
GS4 (formal property rights)	Absent	Absent	Present
GS5 (operational rules)	Present	Present	Present
GS8 (monitoring and sanctioning)	Mostly absent	Mostly present	Mostly present
Resource System (R)			
RS3 (resource size)	Large	Small	Small
RS5a (indicators)	Least available	Moderately available	Mostly available
RS7 (predictability)	Least predictable	Moderately predictable	Moderately predictable
Resource Units (RU)			
RU1 (Resource unit mobility)	Low	Low	Low
Successfully self-organized	No	Yes	Yes

Two SESs Are Self-Organized

- Peñasco and Seri SESs were similar on most variables
- Kino was different — the Resource Size (RS3) of Kino was MUCH larger
- Indicators of the productivity of the system (RS5a) less in Kino than the other two
- Predictability of system (RS7) less for Kino
- Local leadership (U5) in Kino was absent
- Trust and reciprocity (U6) in Kino were absent

Kino Bay = Open access
Sea pen shells have been overexploited (Moreno et al., 2005)

This is a picture showing the number of boats working off Kino Bay fishing grounds. Kino Bay is governed under an open access regime. Our boat counts regularly yielded 70+ boats, a symptom of their inability to control access to other fishers. As a result of the open access regime, their sea pen shell fishery (sea pen shells =a sessile mollusk that lives buried in the sand) has been overexploited. In this context, overexploitation is measured by fishers' inability to sustain constant harvesting of sea pen shells year-round before they become too scarce and small in size. In contrast, the Seri are able to sustain their fishery year-round.

Seri Village of Punta Chueca

In the Seri village of Punta Chueca (which means crooked point), the Seri have developed a common-property regime to govern their sea pen shell fishery, and successfully control the number of boats that have access to their fishing grounds. At any given time, you observe only 10-15 outboard motor boats using their fishing grounds.

Two SESs have a chance of being robust over time because they self-organized, but is self-organization sufficient?

- No!
- The reserve set up in Peñasco was so successful it attracted fishers from miles away after they had destroyed their own fisheries. Mexican government did not support their right to their own rules. One of the key design principles not present.

The Next Essential Research Steps

- Over time research to assess what combination of variables are associated with good ecological conditions and with resilience over time.
- Focus on small to medium-scale CPRs
- Must identify core attributes of forestry, water, and fishery SESs and study these rigorously
- Lets look at some initial findings for forestry research and then talk about how to study this question related to water institutions

Importance of Local Monitoring

- An initially surprising finding
  - Monitoring by local forest users of the harvesting practices by other users is strongly associated with improved forest conditions
  - Studies by Gibson et al., Hayes, Ostrom & Nagendra found that user monitoring strongly associated with better forest conditions
  - Two recent studies focus on monitoring – Coleman in JPAM (2009) & Coleman and Steed in Ecol. Econ (2009)

Study 100 forests in 14 countries

- Data collected by International Forestry Resources and Institutions program
- Data base contains variables in the SES Diagnostic framework
- Coleman & Steed found when local user groups have right to harvest from the forest, they are more likely to engage in M&S
- Somewhat counterintuitive to many that giving the right to harvest trees from a forest may actually improve forest conditions
- But those with that right do monitor each other

Over-time Study of 46 forests in 6 countries

- Coleman measured Basal Area & Shannon Index (in random sample for forest plots)
- When local users monitor activities both ecological measures are sustained or improved over time – controlling for SES, forest governance arrangements and other factors
- Forests that allow users to harvest some products and where they monitor are more sustainable than when forests disallow any local harvesting
- Community-managed forests are not statistically different from government- or privately managed forests controlling for other factors

Study of Irrigation Systems

- Over 200 irrigation systems in Nepal
- Here measured conditions at the time of study Farmer Managed Irrigation Systems and Agency Managed Systems
- Farmer Managed Systems have much higher performance measures than Agency Managed Systems

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Relationships between Governance Structure and Physical Condition of Irrigation Systems

Physical Condition of Irrigation Systems		Types of Governance Structure		Chi-Square Value	Sig.
		FMIS (%)	AMIS (%)		
Overall condition	Excellent [37]	18.2	8.4	23.02	.00
	Moderately good [144]	67.4	45.8		
	Poor [48]	14.4	45.8		
Technical efficiency	Highly efficient [58]	28.9	12.5	27.30	.00
	Moderately efficient [137]	62.8	50.0		
	Inefficient [33]	8.3	37.5		
Economic efficiency	Highly efficient [66]	33.2	12.5	45.35	.00
	Moderately efficient [140]	63.5	52.1		
	Inefficient [23]	3.3	35.4		

Note: Number of irrigation systems is in brackets.
Source: Joshi et al. (2000: 78).

Now Beginning to Plan Over-time Study of Irrigation Systems

- Have initial time period coded for 40+ irrigation systems from around the world initially studied by Tang (1994)
- Trying to locate second or third visits for many of these and enter into a database
- Need input from colleagues to tell us about studies that give good info about structure and performance of irrigation systems that we can put in data base

Plans to further develop SES framework

- Working with colleagues to develop clear definitions of key terms—in general and as used in forestry, irrigation, and fishery regimes
- Try to develop a common inter-disciplinary research foundation and theoretical applications using common definitions
- Can address which propositions hold in regard to resource system type at diverse scales

Questions?