Scale Matters!

Boundary-Setting in Mental and Ecophysical Models

When agencies and the public direct their attention to an environmental problem, they explicitly or implicitly bound that problem by associating it with a particular system at a particular scale. Our research focuses on the problem formulation phase of the decision process and on the role of spatial modeling in that process.

Scale matters in the formulation of environmental problems, and problem formulation remains the weakest point in environmental management processes. We are examining how spatial issues manifest in people's mental models, how these models change in a deliberative process, and how scale affects problem-oriented behaviors.

Central Research Question:
How do scientists and stakeholders engaged in resource management disputes "bound" the systems to which they attribute a problem?

The Problem of Problem Formulation

Beyond Problem Solving

"Managers are not confronted with problems that are independent of each other, but with dynamic situations that consist of complex systems of changing problems that interact with each other. I call such situations *messes*. **Problems are abstractions extracted from messes by analysis**. . . Managers do not solve problems: they manage messes."
- Russell Ackoff (1979: 99-100)

Wicked Problems

"Messes" can be viewed as "wicked problems" in Rittel and Webber's (1973) classic formulation. Many environmental problems are wicked problems. A-contextual models are not adequate for wicked problem solving. This table outlines characteristics of a-contextual versus contextual models.

Characteristics of Wicked Problems:
- No definitive formulation
- Different interest groups see different problems
- No ultimate test of a solution
- Temporal open-endedness
- **Problem is only properly formulated once solved**

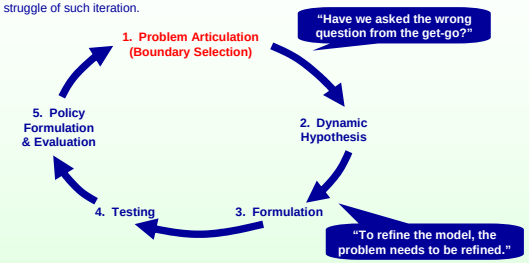
Approaches to Wicked Problem Solving:
- Value pluralism
- Contextual analysis
- Iteration
- Systems science approach
- **Orientation to Process**

A-CONTEXTUAL MODELS	CONTEXTUAL MODELS
Shared Characteristics: • Outcome oriented • Algorithmic[1]	**Shared Characteristics:** • Seek Rationality in Better Process • Non-Algorithmic[2]
Examples: • Rational choice • Decision trees • CBA • Game theory • Operations research, optimizing	**Examples:** • Muddling through • Critical systems theory • Post-positive policy analysis • Adaptive management
WICKED PROBLEMS REQUIRE CONTEXTUALLY SENSITIVE ANALYSIS	

[1] Algorithmic = best computational solution
[2] Non-Algorithmic = no computational solutions

The Modeling Process

The modeling process as articulated by Sterman (2000) operates as a feedback loop that returns to the step of problem articulation after struggling to evaluate a completed model. Relevant quotes from a workshop observed as part of this project help to humanize the struggle of such iteration.



Scales of Environmental Justice

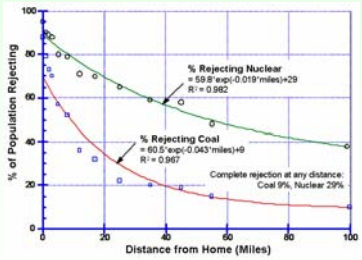
	Scale and Scope Effects on EJ Variables	SCALE: County	Zip Code	Tract	Block Group
SCOPE: Nation	% Black	+*	+***	+***	+***
	% Hispanic	–*	+***	+***	+***
	Income	0	0	–***	–***
California	% Black	0	0	+***	+***
	% Hispanic	0	0	+***	+***
	Income	0	0	0	0
L.A. County	% Black	n/a	0	0	0
	% Hispanic	n/a	0	+*	+***
	Income	n/a	0	–**	–**

* significant at 10%; ** significant at 5%; *** significant at 1%

Environmental Justice (EJ) has plagued boundary and scale selection problems. Our research pushes for clarity in defining the "environmental problem" at stake with environmental justice, and shows how ambiguity and inconsistency in problem definition for EJ can lead to arbitrary and inconsistent findings. The above table shows the varying significance of EJ variables at different scales (Baden, Noonan and Turaga 2006).

Spatial Discounting

As we try to understand the effect of distance, time, and spatial locations on a subject's perception, we appeal to existing analyses that demonstrate spatial discounting of concern. This figure from Hannon (1994) demonstrates the spatial discounting of concern regarding proposed hazardous waste facilities, based upon evidence from Mitchell and Carson (1986). We expect individuals to show more concern, and be more active, in addressing problems and opportunities close to their home place.



Objective and Subjective Models of Spatial Discounting

Null Hypothesis NH1: Concern is a-spatial. Distance and location have no effect on concern.

Null Hypothesis NH2: Concern is a function of location alone: concern declines uniformly across distance.

Hypothesis 3: Concern for a place is a function of individual, subjective experiences, feelings, attachments, as well as objective spatial factors such as the distance from a hazard or amenity.

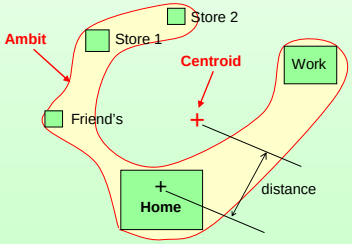
- Aggregated data provide objective evidence that people's concern declines across distance (reject NH1).
- Aggregated data cannot account for the effect of individual experience and behavior on attitudes and values that shape sense of place (reject NH2).

Sense of Place

By distinguishing location from place, we recognize that
- **Location** can be represented in Euclidean space (**objective** aspect).
- Defining **place** involves more subjectivity and personal relationships between a person and the space around his/her place (**subjective** aspect).

Developing Measures for Sense of Place

Two proxy variables emerge as possible scale-sensitive measures of a person's sense of place:
1. The centroid of a person's movement through space.
2. The outline of a person's "ambit," or path through space over a period of time.



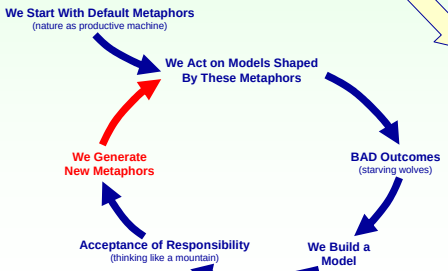
The illustration above demonstrates how both centroid and ambit measures may be derived from information about how much time a person spends in particular locations (time spent is represented by the size of the boxes).

Boundaries and Scale

How does one's place in the system shape the way they define and bound problems? How do people's conceptions of environmental problems change as a result of new science and social learning?

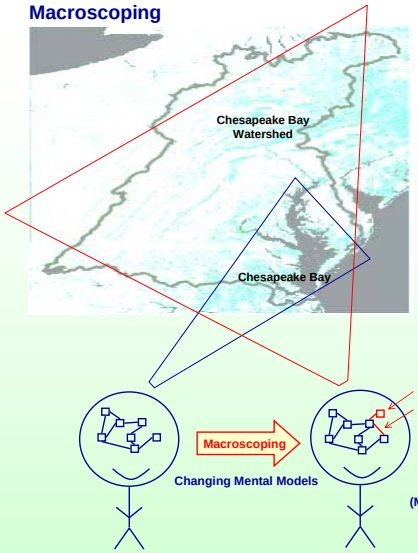
Getting the boundaries right:
- Analytical challenge (multiple scales, uncertain science)
- Ethical challenge (multiple perspectives, plural values)
- **Political challenge** (boundaries organize power relationships)

Metaphors and Iteration



Ecological metaphors offer ways of "bounding" problems that bring together ethical and analytical aspects of problem bounding, as in Leopold's (1949) simile of thinking like a mountain (diagram based on Pickett and Cadenasso 2002).

Macroscoping



Macroscoping refers to an expansion in the spatial scale deemed relevant for understanding and solving environmental problems. In the Chesapeake region, macroscoping occurred when new science highlighted non-point nutrient pollution, from agricultural activity as far away as Pennsylvania and New York, as having a significant impact on the Bay ecosystem.

Different mental models are presumed to correspond with differences in the way stakeholders conceive of the spatial bounds of an environmental problem. Changes in mental and cultural models of pollution in the Chesapeake Bay are tracked through analysis of conceptual and argumentative networks in relevant discourses.

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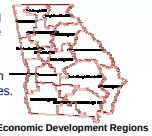
Spatial Bounding in Action: Policy Application

Choosing the spatial boundaries for environmental problem solving often has important **political implications**. The state of Georgia is currently engaged in a public process of choosing the boundaries for sub-state water planning. From an ecological perspective, Georgia's major river basins are a clear choice for structuring future water planning. But stakeholders who define Georgia's water issues differently may have other boundaries in mind. A possible alternative boundary framework is Georgia's Economic Development Regions.

Major River Basins

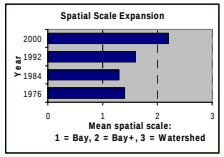
Through participant observation and interviews with stakeholders, we are exploring the way a stakeholders' sense of place, organizational interests, values, and perspective on science shape their boundary choices.

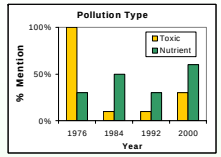


Economic Development Regions

Discourse Analysis

Discourse analysis of newspaper and scientific publications aims at documenting changing conceptions of pollution that catalyzed the apparently important case of **"macroscoping"** in the Chesapeake Region.





The above initial discourse analysis of newspaper articles in a local Annapolis, MD paper over three decades yields empirical support for construction of the mental model example illustrated below.

Modeling Mental Models

Agent-based modeling techniques are used to explore how individual mental models evolve in the group context. Each agent contains a unique, dynamic mental model of concepts linked by association (a.k.a, **"conceptual network"**). Mental models may be updated via messages, such as the impact of farming on pollution (highlighted).

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