Representing the Dimensions of an Ecological Niche

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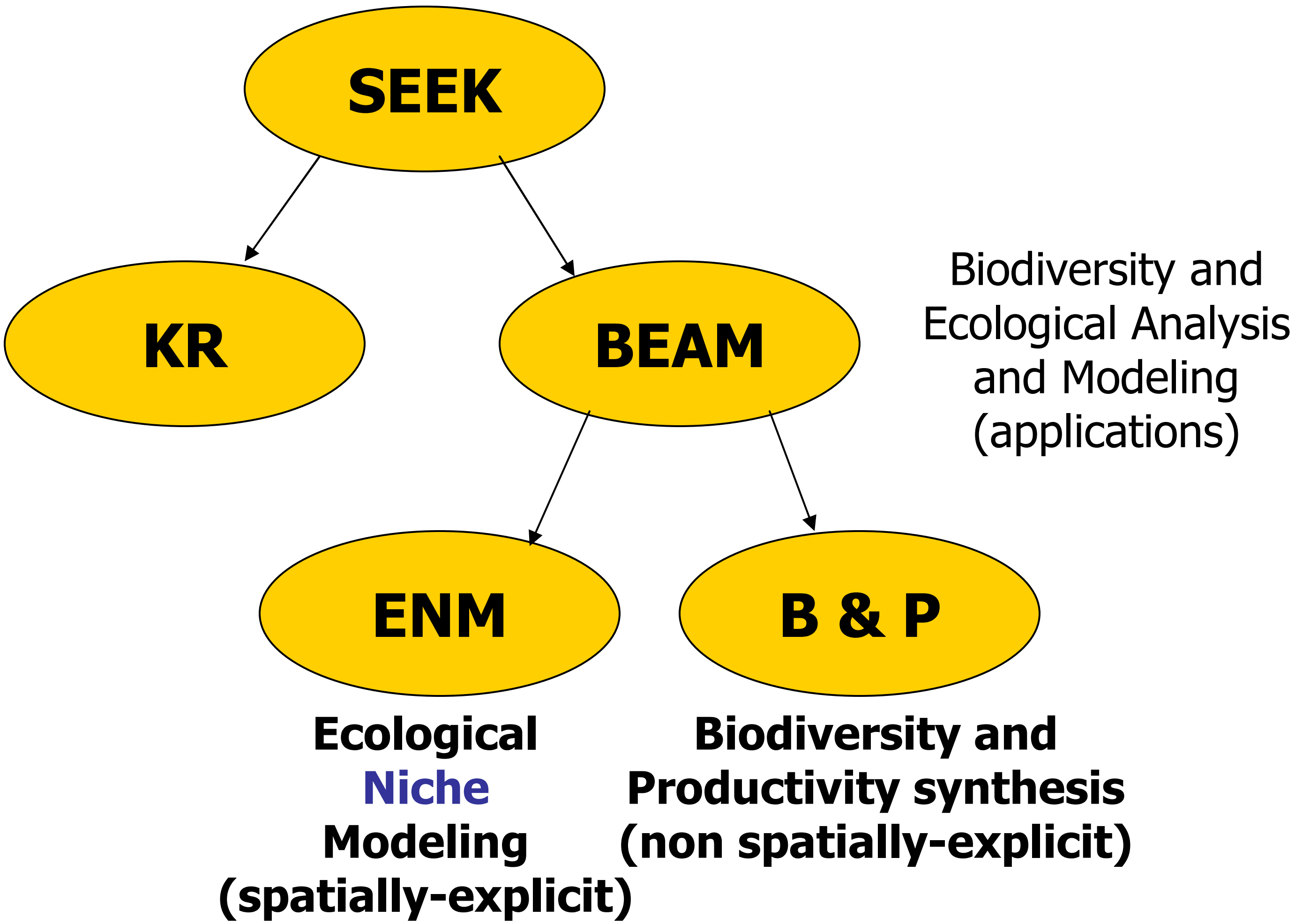
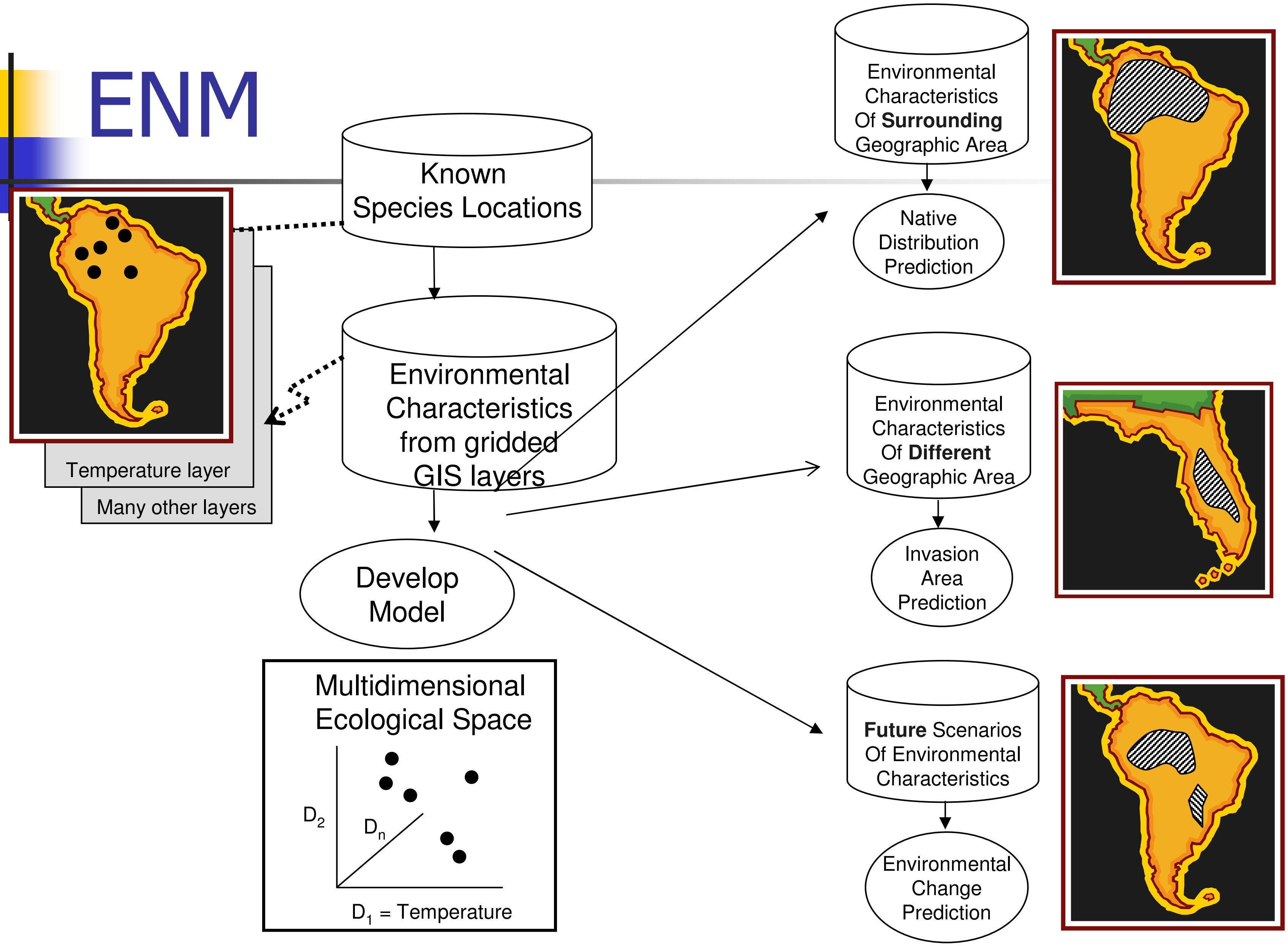
PI CI-Team: Educating, Training, and Mentoring
Science Communities in Cyberinfrastructure

CoPI Science Environment for Ecological Knowledge (SEEK) Project

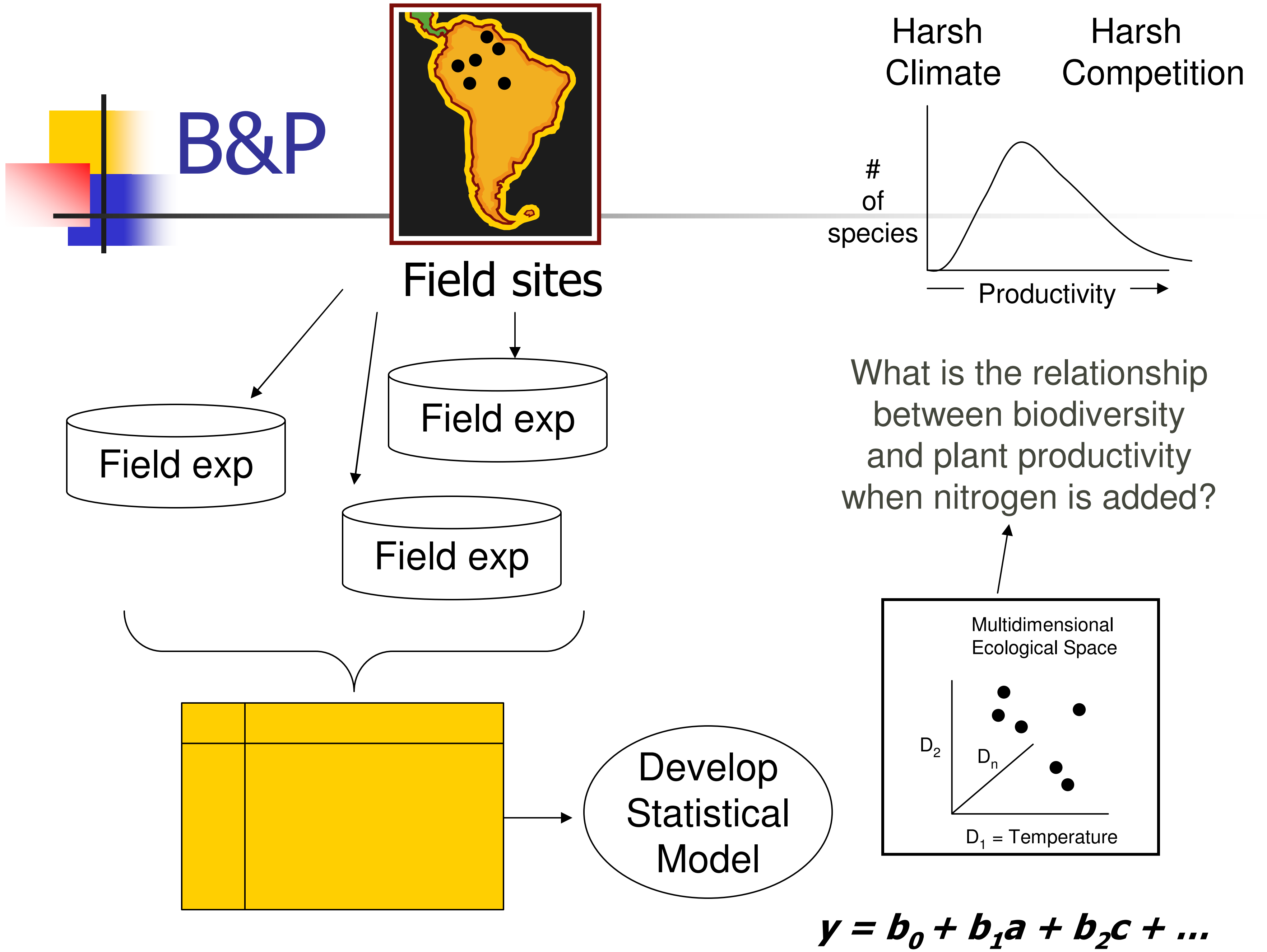
Project Context



ENM



Known Species Locations
Temperature layer
Many other layers
Environmental Characteristics from gridded GIS layers
Develop Model
Multidimensional Ecological Space
D2
Dn
D1 = Temperature
Environmental Characteristics Of Surrounding Geographic Area
Native Distribution Prediction
Environmental Characteristics Of Different Geographic Area
Invasion Area Prediction
Future Scenarios Of Environmental Characteristics
Environmental Change Prediction


B&P
Field sites
Field exp
Field exp
Field exp
Develop Statistical Model
Harsh Climate
Harsh Competition
# of species
Productivity
What is the relationship between biodiversity and plant productivity when nitrogen is added?
Multidimensional Ecological Space
D2
Dn
D1 = Temperature
y = b0 + b1a + b2c + ...

BEAM Projects

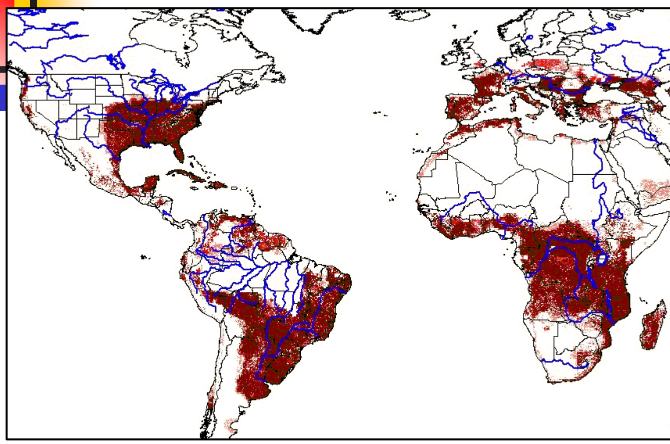


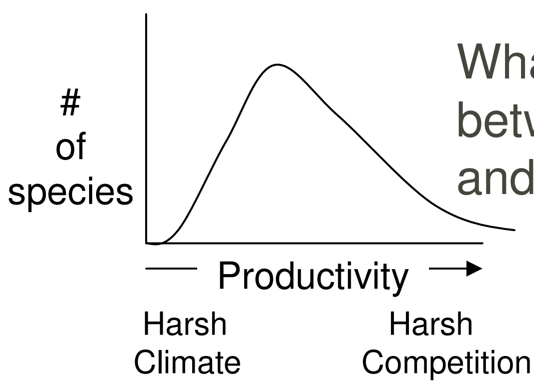
Image from http://www.lifemapper.org

Where do species occur now?

Where will they occur in the future?

Niche: as a theoretical explanatory framework for spatial observations

Niche: as a theoretical explanatory framework for thematic observations



What is the relationship between biodiversity and productivity?

Does nutrient addition decrease biodiversity?

Niche: as a theoretical explanatory framework for temporal observations (evolutionary history)

What is a niche? Wikipedia

A term describing the **relational position of a species or population in an ecosystem**. More formally, the niche includes how a population responds to the abundance of its **resources and enemies** (e. g., by growing when resources are abundant, and predators, parasites and pathogens are scarce) and how it affects those same factors (e. g., by reducing the abundance of resources through consumption and contributing to the population growth of enemies by falling prey to them). The **abiotic or physical environment** is also part of the niche because it influences how populations affect, and are affected by, resources and enemies.

The description of a niche may include descriptions of the organism's **life history, habitat, and place in the food chain**. According to the competitive exclusion principle, no two species can occupy the same niche in the same environment for a long time.

Niche theories

Long, volatile semantic history

- Reflects fundamental theoretical arguments
- Dropping the term doesn’t resolve the arguments
- Semantic clarification of how the term is being used

↳ Semantic clarification of technical and information resources that refer to the term directly or indirectly

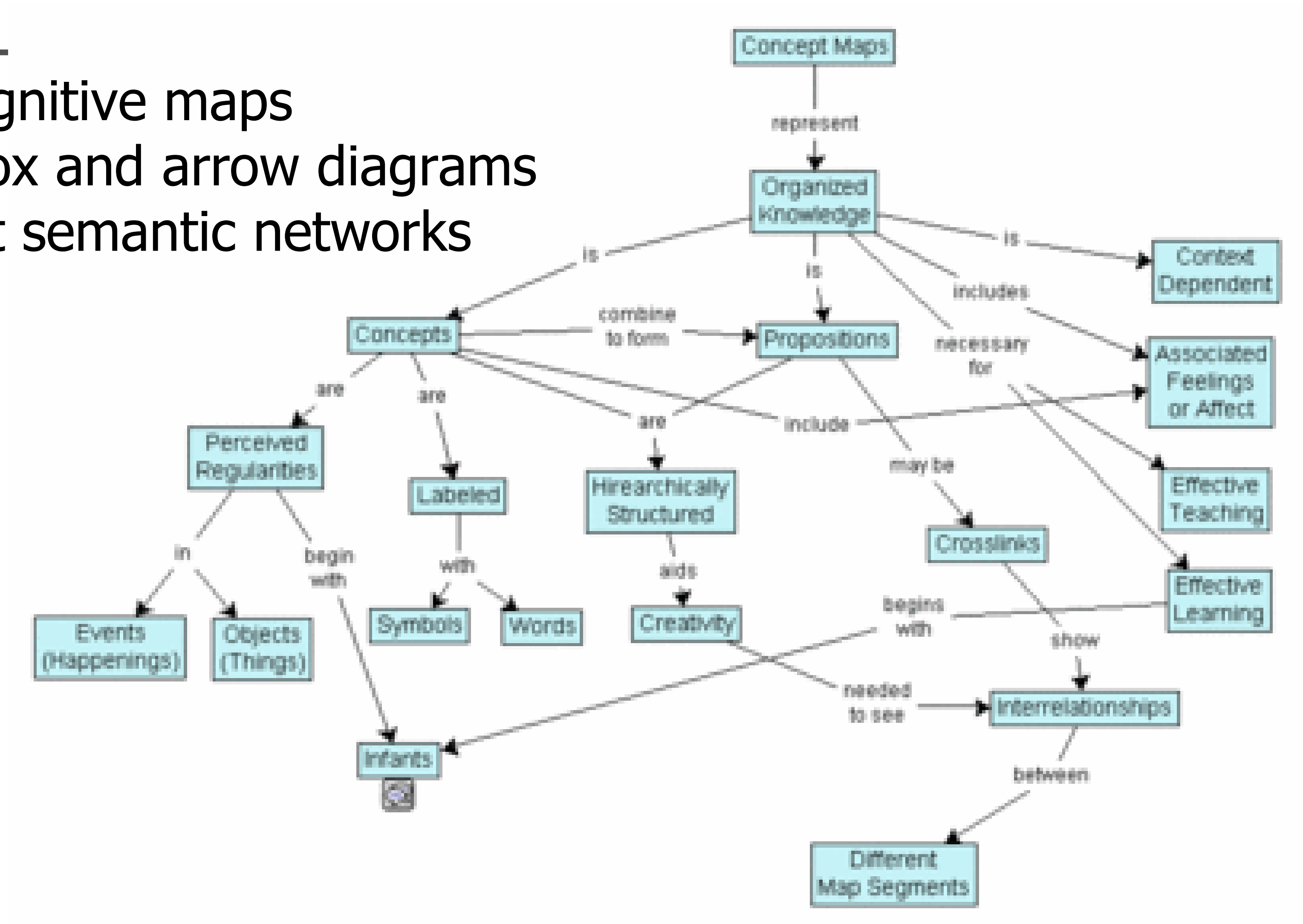
This project

Goal: capture and make explicit the existing semantic framework of ecologists regarding the term “niche”

- Informal diagrammatic representation with concept maps
- Share maps (blind)
- Revise maps
- List of terms
- Resolve minor differences (tense, etc)
- Synonyms
- Taxonomy development

Concept Maps

Cognitive maps
Free-form box and arrow diagrams
Represent semantic networks



Concept Mapping

- Pros:
  - Represents how a scientist conceptualizes a problem semantically
  - Easy to do – no training required
  - Intellectually interesting to the scientist
- Cons:
  - Difficult to migrate from this to a formal ontology

Concept maps collected

11 scientists

- 6 geospatial
- 5 not

11 concept maps (illustrate)

Term overlap

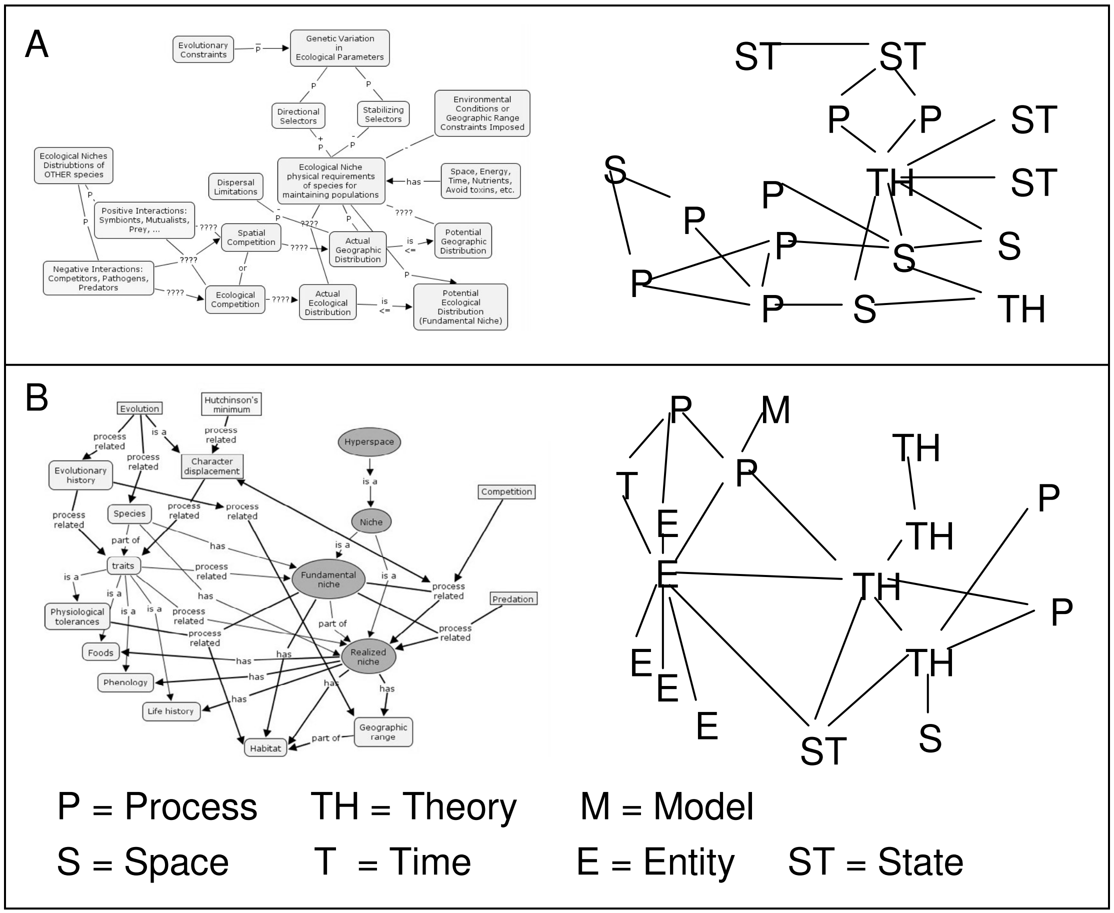
< 20% semantic overlap in the terms used between any two maps (mean = 7.5%, range = 0% to 19.5%)

traditional ecologists (mean = 8.7%; maximum = 19.5%)

biogeographers (mean = 7.9%; maximum = 18.2%)

between the two (mean = 4.6%; maximum = 13.9%

Term categories



process (33.0%)
state (38.5%)
spatial (9.5%)
theoretical (8.0%)
models (4.5%)
temporal (2.8%)
researcher (2.8%)

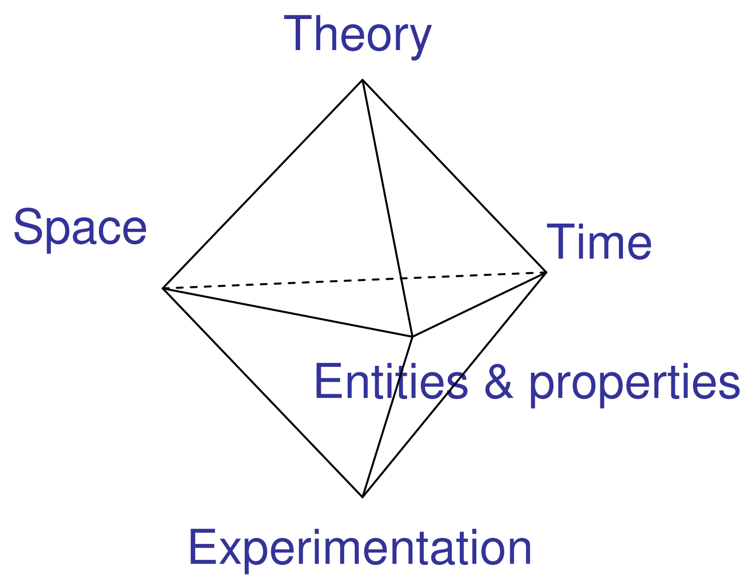
Conceptual Framework

<u>Processes</u>

How?

Who, what,
Where, when?

Test of How
Does it fit?
Implications?



<u>Observation Model</u>

Conceptual context

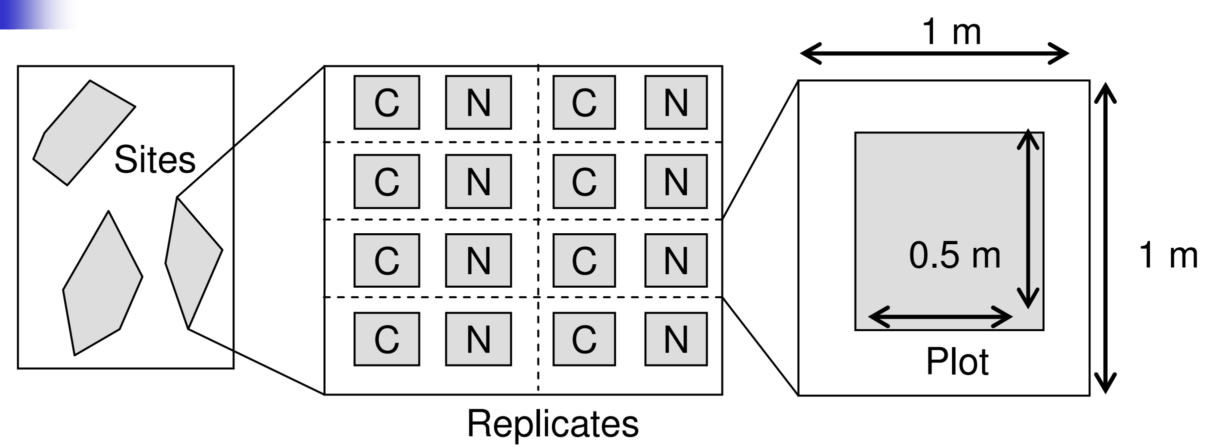
Space/time context
Relational context

Methodological context

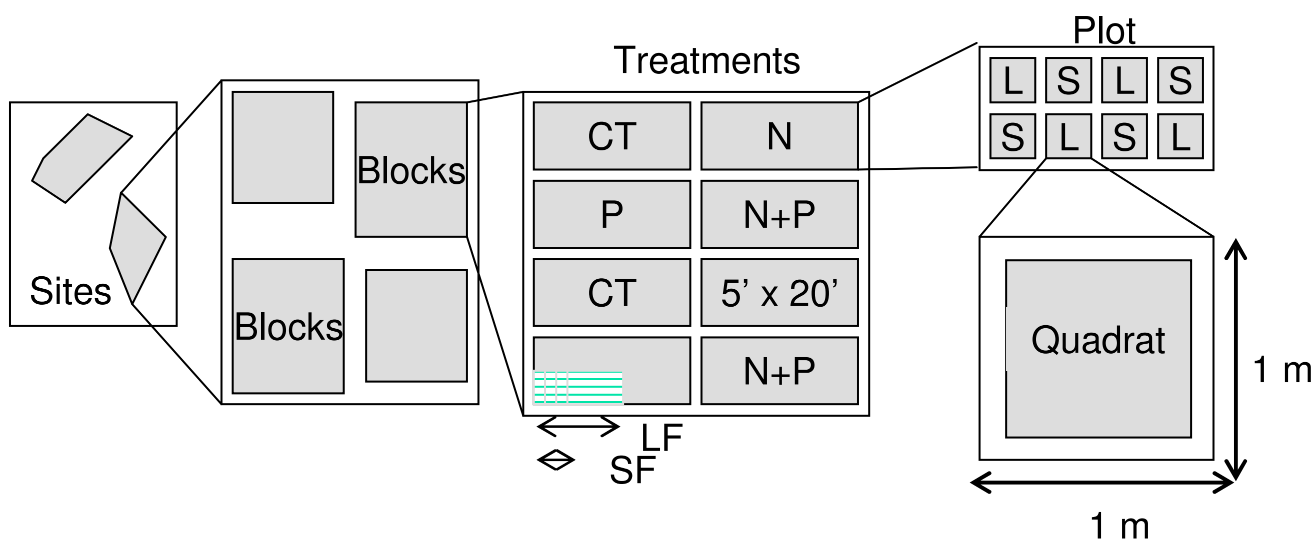
Observation

<u>Productivity experiment</u>

Entity = Plant individuals by species
Space = Volume
Time = Snapshot



Measured:
biomass per
species

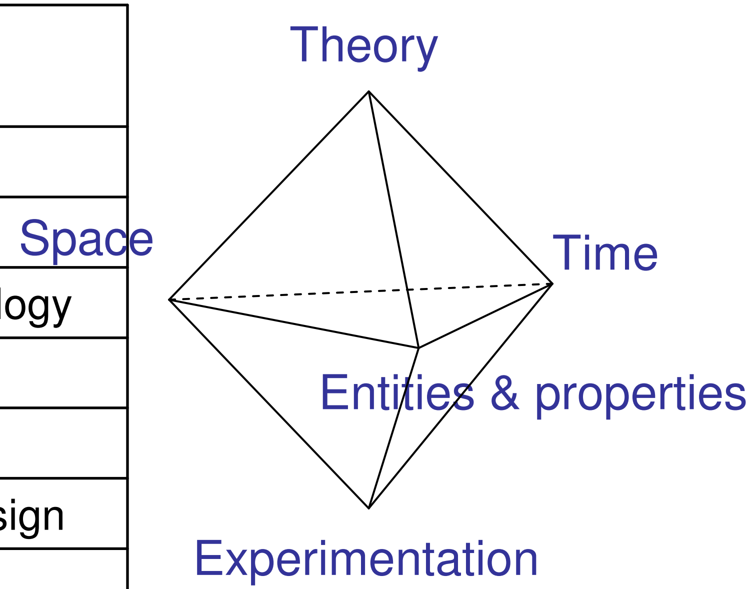


Measured:
% cover
per
species

Disciplinarity

Table 1. Different dimensions of the scientific method polyhedron shown in Figure 2, and examples of perspectives that make use of that facet.

Theory, experimentation, entities	Ecology
Space, entities, point in time	Cartography
Time, entities, point in space	History
Entities, theory, time	Evolutionary ecology
Entities, theory, space	Spatial analysis
Theory, space, time	Issue timeline
Experiment, space, time	Experimental design
Experimentation, theory, entities	Statistics

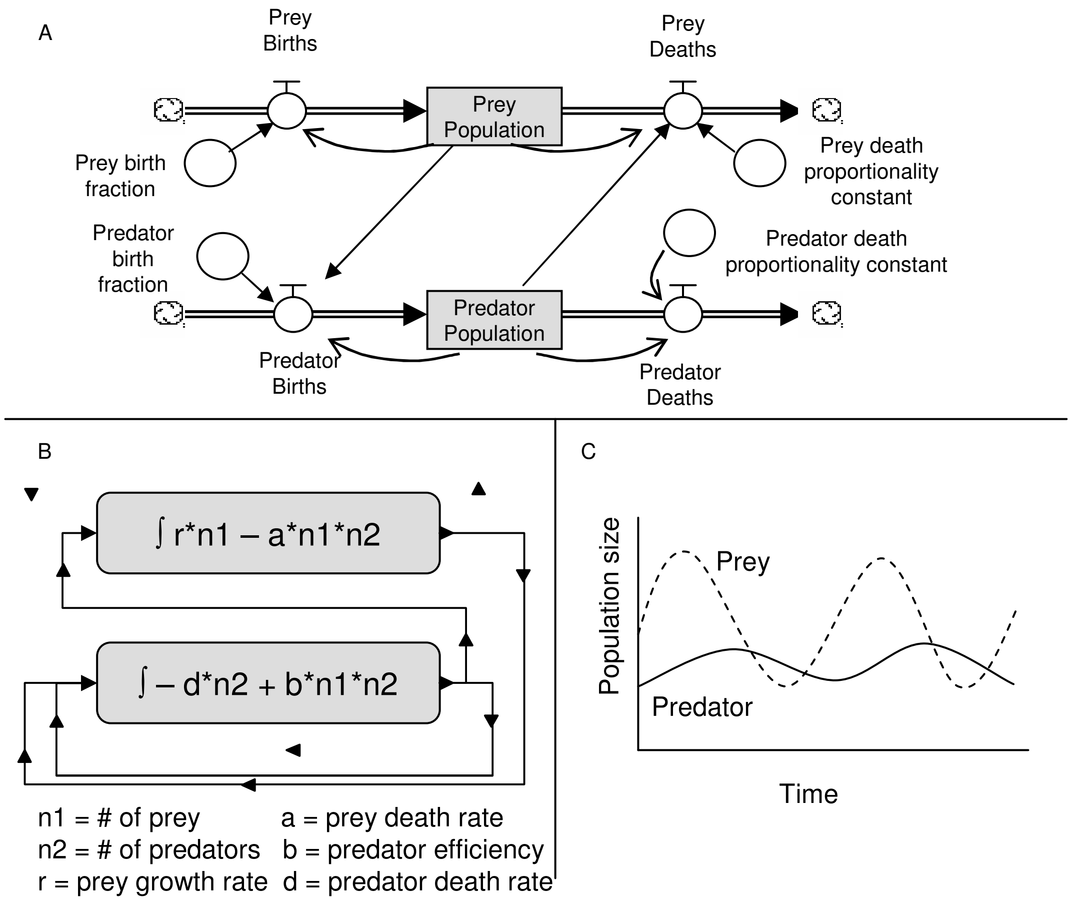


Representing Process

Fonseca [2002, 2004] investigated eco-ontologies using the niche concept, observing that ecological ontologies differ from geo-ontologies in that they are temporal and recursive

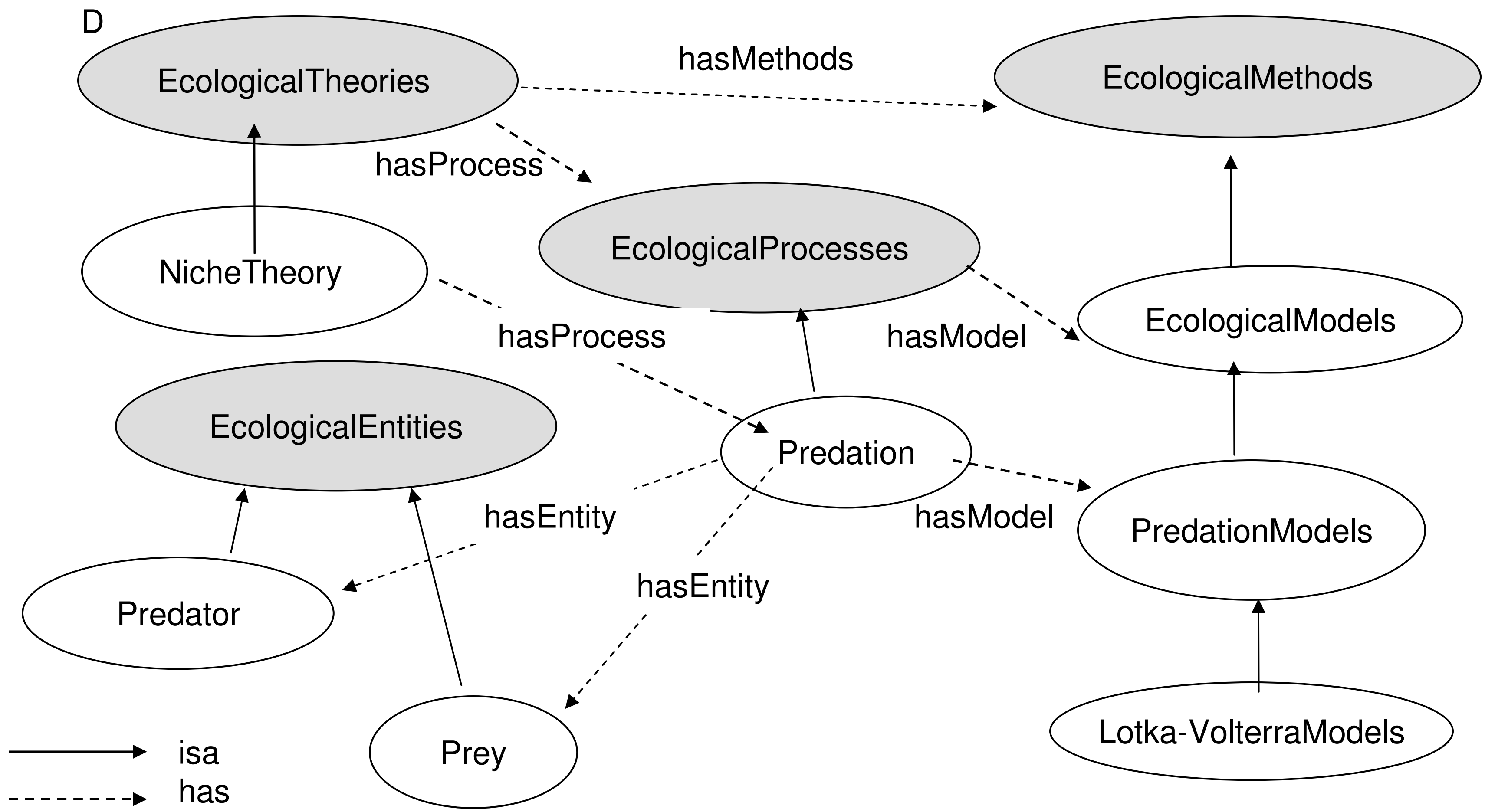
Keet [2005] investigated the use of ecological models to generate ontologies, and discussed the need to represent flow

Lotka-Volterra



Stella

Lotka-Volterra



Ontology-driven automation