

# Approaches to Landscape Ecology

(landscape ecology and the scientific method)

# The Scientific Method

- Observational context: broad conjecture about a process
- Experimental context: specific conjecture intended for experimental test
  - Includes control and replication

# Induction and Hypothetico-deduction

- Hypothetical Deduction:

Theory > Hypothesis > experiment > results

- Induction

Observed association > Conclusion



# Four Approaches:

- Large scale experiments
- Observational Studies
- Experimental model systems
- Modeling

# Large Scale Experiments

1. Manipulate landscapes to test hypotheses
2. Take advantage of “natural treatments”

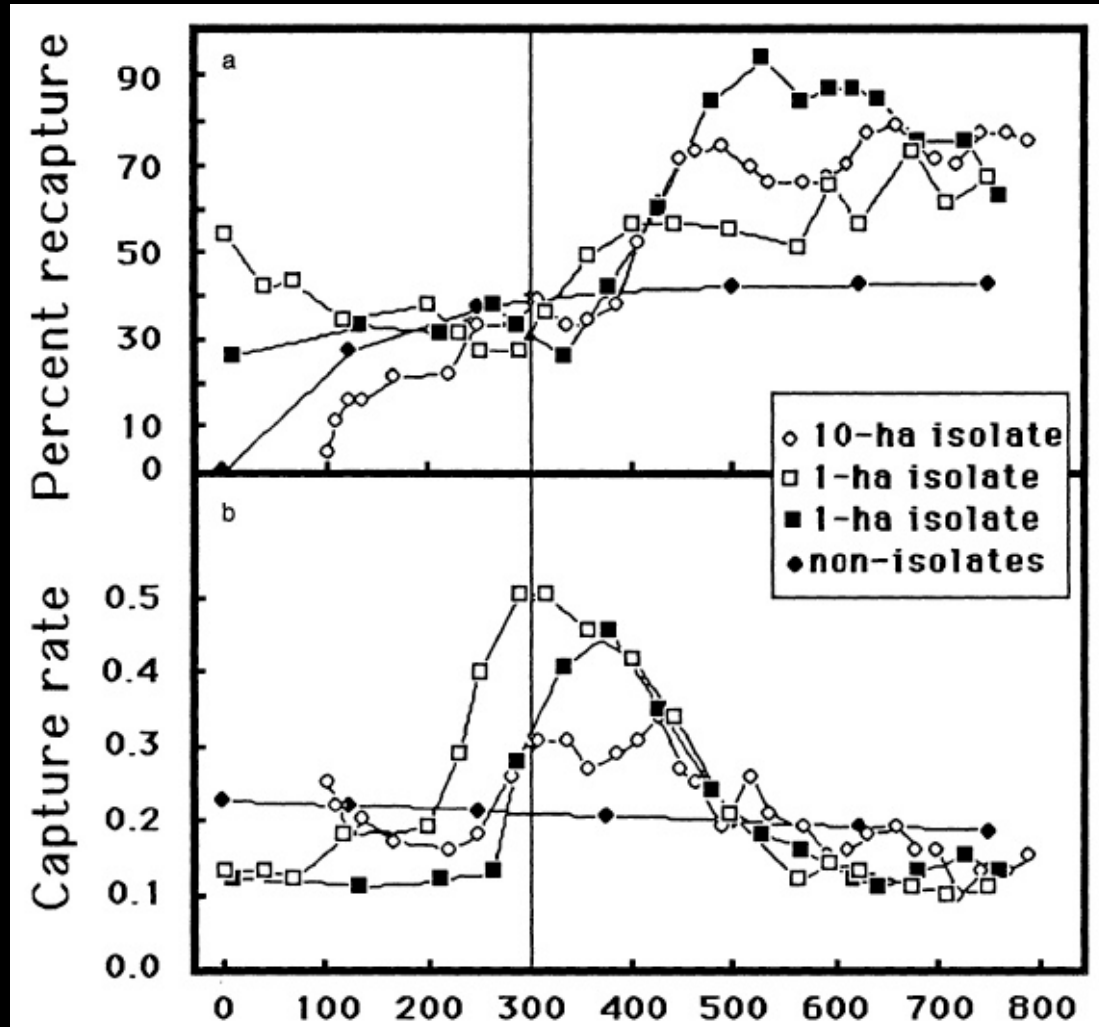
Pro = controlled hypothesis testing

Con = unfeasible

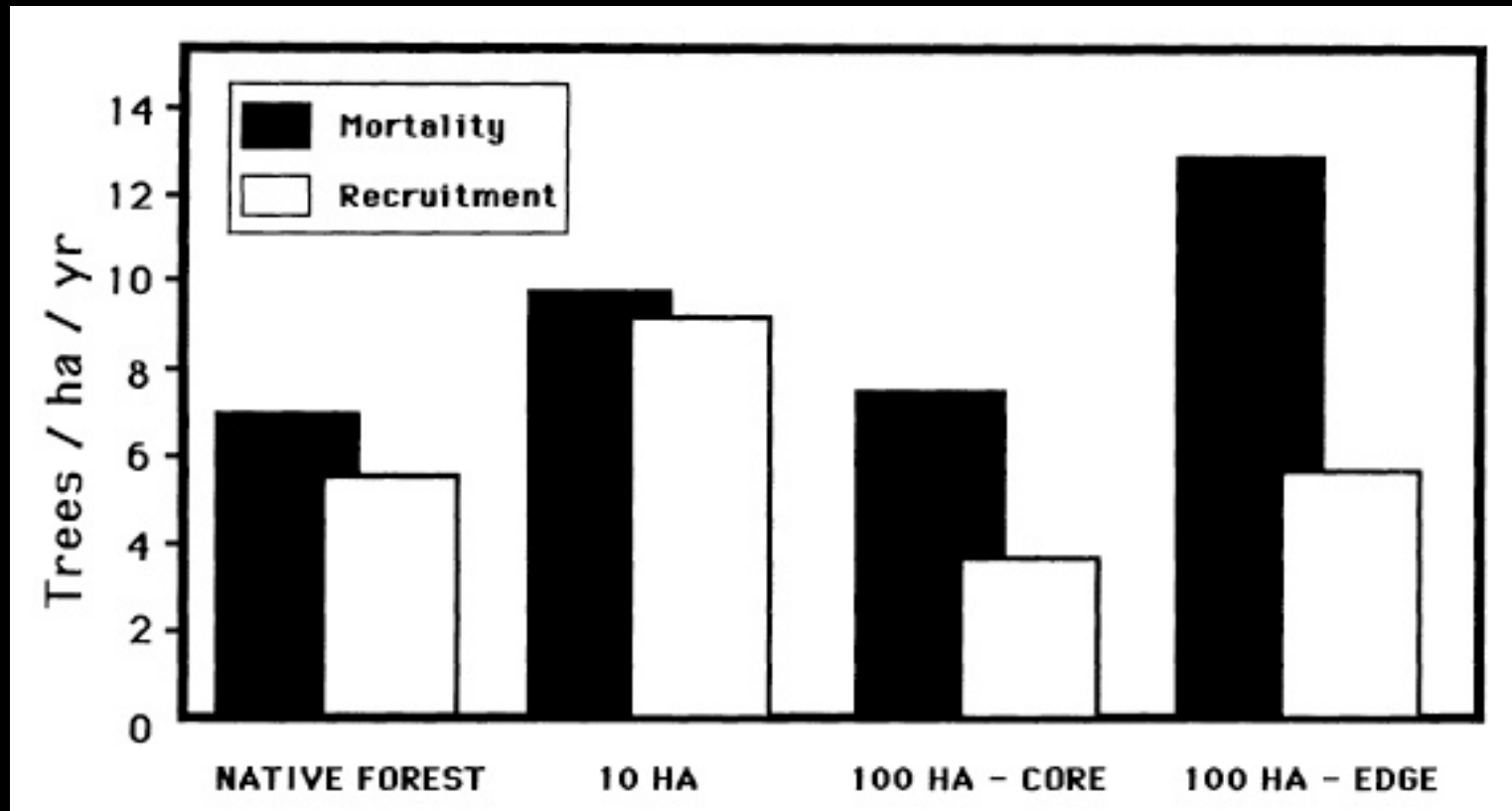
# Tropical Rainforest Fragmentation



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# Observational Studies

1. Identify patterns that generate hypotheses.
2. Search for patterns that support or do not support a given hypothesis

Pro = manageable studies

Con = correlation is not necessarily causation

# Forest Patch Size and Breeding Success



TABLE 1. Characteristics of 11 forest study sites and Wood Thrush nest success in Berks County, Pennsylvania, 1990–1991.

Study site	Forest area (ha) <sup>a</sup>	Forest core area (ha) <sup>a</sup>	Distance to contiguous forest (km) <sup>b</sup>	Percentage forest area within 2-km radius <sup>c</sup>	Nest success <sup>d</sup> (n) <sup>e</sup>
Owl's Head	>10,000 <sup>f</sup>	>10,000	0.0	96.5	1.00 (258)
River of Rocks	>10,000 <sup>f</sup>	>10,000	0.0	97.2	0.72 (162)
Spitzenberg	126.5	45.3	2.4	35.7	0.72 (656)
Gun Club	103.4	47.8	10.6	50.5	0.65 (258)
Snook	79.8	6.5	11.2	42.7	0.33 (206)
Laudadio	40.4	10.0	8.2	29.0	0.43 (32)
Kunkle	23.4	2.5	9.1	20.9	0.29 (260)
Kehl	19.4	0.04	3.3	27.4	0.24 (94)
Lilienthal	18.7	1.4	11.8	42.7	0.35 (229)
Dixon	16.4	2.3	7.0	22.9	0.34 (287)
Bauscher	9.2	0.5	6.7	23.4	0.12 (96)

# Forest Patch Size and Breeding Success

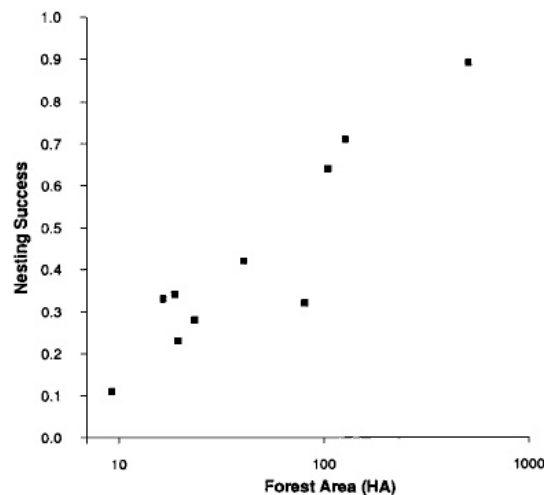


Fig 1. Relationship between Wood Thrush nesting success (1990–1991 combined) and forest patch size on 10 study sites, Berks County, Pennsylvania ( $R^2 = 0.86$ ,  $P < 0.001$ ).

TABLE 2. Percentage<sup>a</sup> of Wood Thrush nests that were successful, lost to predators, or parasitized by cowbirds in small fragments (<80 ha), large fragments (>100 ha), and within contiguous forest in Berks County, Pennsylvania, 1990–1991.

Nest fate	Forest fragments		Con- tig- uous forest (21)	$\chi^2$
	Small (96 <sup>b</sup> )	Large (54)		
Successfully pro- duced young	43	72	86	20.2***
Lost to predators	56	22	10	25.8***
Parasitized by cowbirds	13	2	10	4.9 <sup>ns</sup>

\*\*\*,  $P < 0.001$ ; <sup>ns</sup>,  $P > 0.05$ .

<sup>a</sup> Percentages do not add up to 100 because some failed nests are not included (e.g. loss to weather) and all parasitized nests were successful (e.g. fledged at least one host young).

<sup>b</sup> Total number of nests.

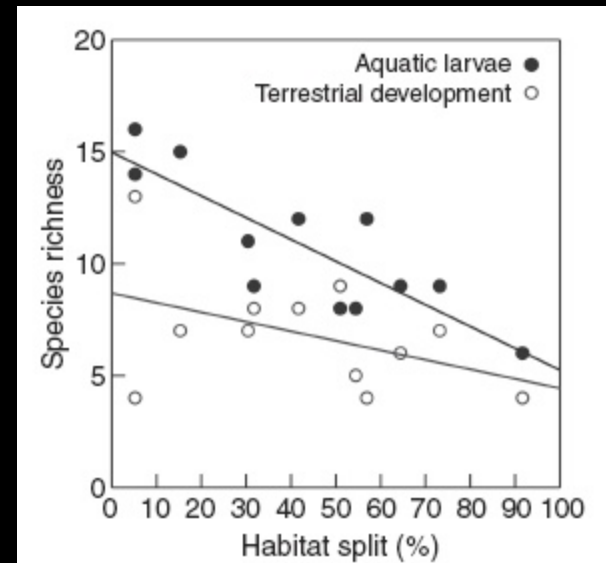
# Brazilian Frogs and Habitat Fragmentation



Frog in São Paulo, Brazil  
Photograph by George Grill

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**Fig. 1.** Effect of habitat split on species richness of leaf-litter amphibians with aquatic larvae and with terrestrial development across 12 Brazilian Atlantic Forest landscapes. Habitat split is calculated as the percentage of the total stream length that does not overlap with natural forest cover. Linear regression lines are shown.

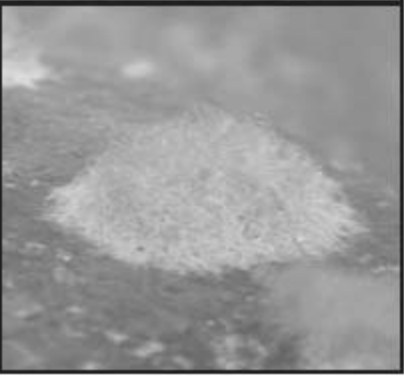
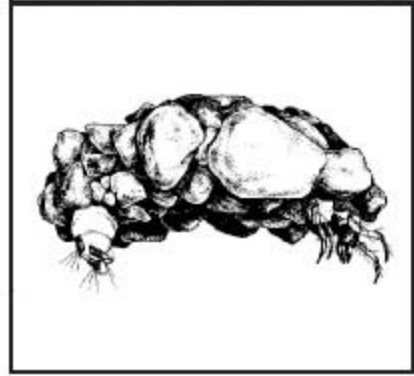
# Experimental Model Systems

- Use smaller, more easily manipulated systems to test hypotheses with implications for larger landscapes.
- Con = simplification / abstraction
- Pro = control

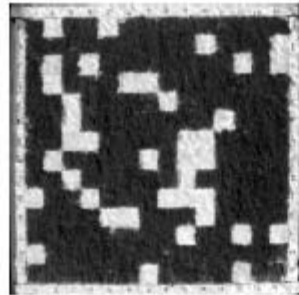
# Caddis Fly Larvae



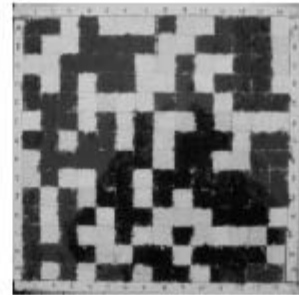
# Caddis Fly Larvae



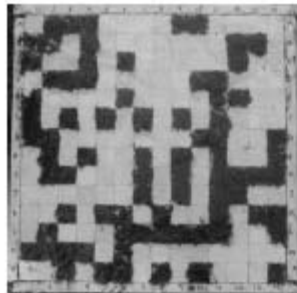
$p = 0.20$



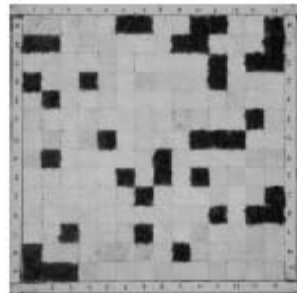
$p = 0.40$



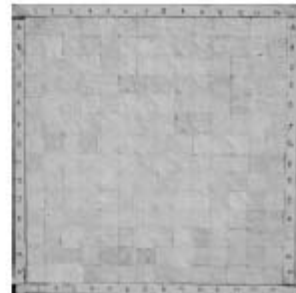
$p = 0.60$



$p = 0.80$



$p = 1.00$



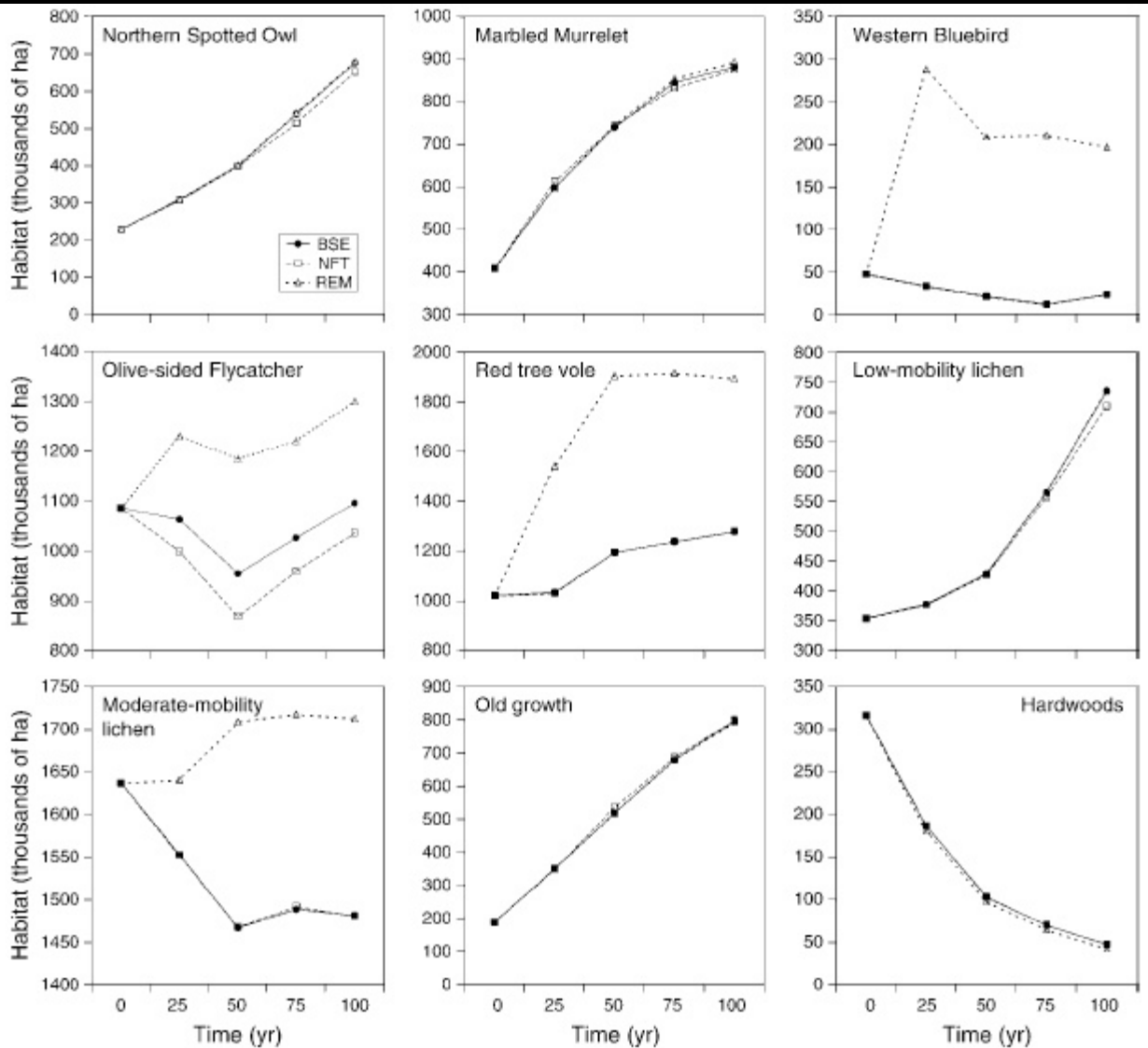
# Modeling

- Use models (abstract mathematical representations) to test hypotheses.
- Con = simplification / abstraction
- Pro = simulate large scales
- Pro = replication

# Modeling Forest Change



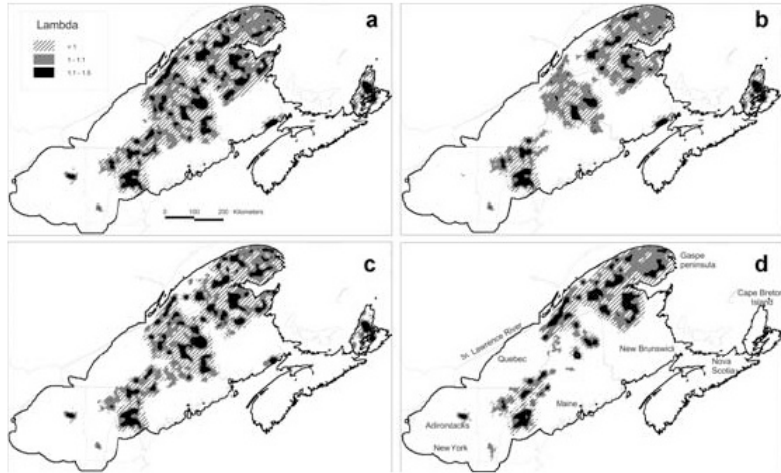
# Modeling Forest Change



# Martin and Lynx in changing landscapes



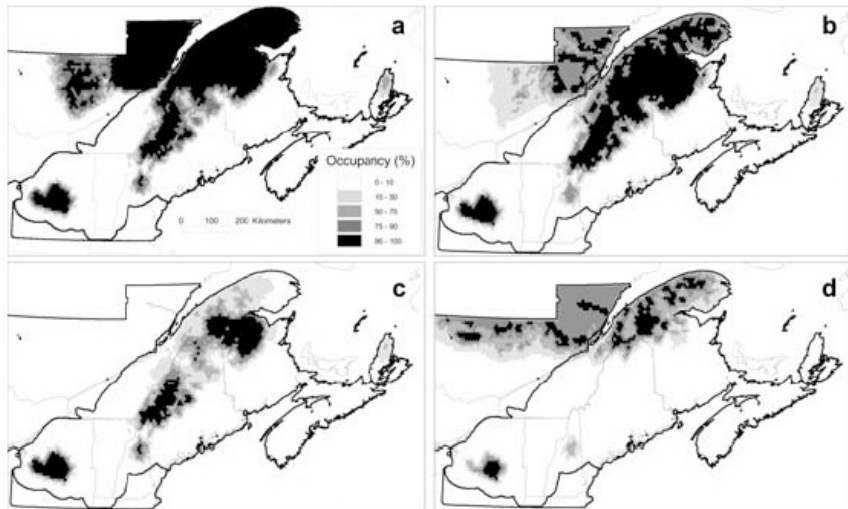
# Martin and Lynx in changing landscapes



*Figure 1. Demographic potential and distribution of martens in the northern Appalachians region under (a) current landscape conditions (scenario B2, Table 2), (b) increased trapping pressure (scenario B4), (c) increased timber harvest (scenario L2), and (d) decreased snowfall (scenario FB2). Population growth rate (lambda) predicted by the PATCH model simulations. Areas with < 50% probability of occupancy are white. Because the raw results would be difficult to distinguish on a regional-scale map, the demographic structure shown represents output of the PATCH model averaged over a 300-km<sup>2</sup> moving window.*



# Martin and Lynx in changing landscapes



*Figure 3. Distribution of lynx predicted by the PATCH model simulations in the northern Appalachians region under (a) no population cycling (scenario A1, Table 2), (b) population cycling only in Gaspé (scenario B1), (c) population cycling only in Gaspé with increased trapping pressure (scenario B2), and (d) decreased snowfall (scenario FB1). Unlike with marten, lynx population simulations included areas north of the St. Lawrence River within the outer black line.*



# Patches and Patchworks



# Richard Foreman

- Brought landscape ecology to the forefront in the United States

# Patch, Matrix, Corridor

- Much of the literature in landscape ecology was the study of patches and their interactions including corridors and matrix.

# Aquatic systems are better characterized by networks



# Patch

- Non-linear surface area differing in appearance from surroundings
- Homogenous area in terms of structure and composition
  - Although may have high level of heterogeneity
- Polygons
  - Landscape planning

# Patches are the building blocks of Landscape Ecology

- recognized by changes in structural or compositional change



# Scale at which you choose to recognize your patches is important

- heterogeneity at some smaller spatial scale
- Select scale and content of patches based upon objective of interest (subjective?)
- Once this is done and criteria for recognizing patches/polygons established (objective)

# Strong bias toward recognizing patches on basis of structure and composition

- could recognize patches on the basis of environment

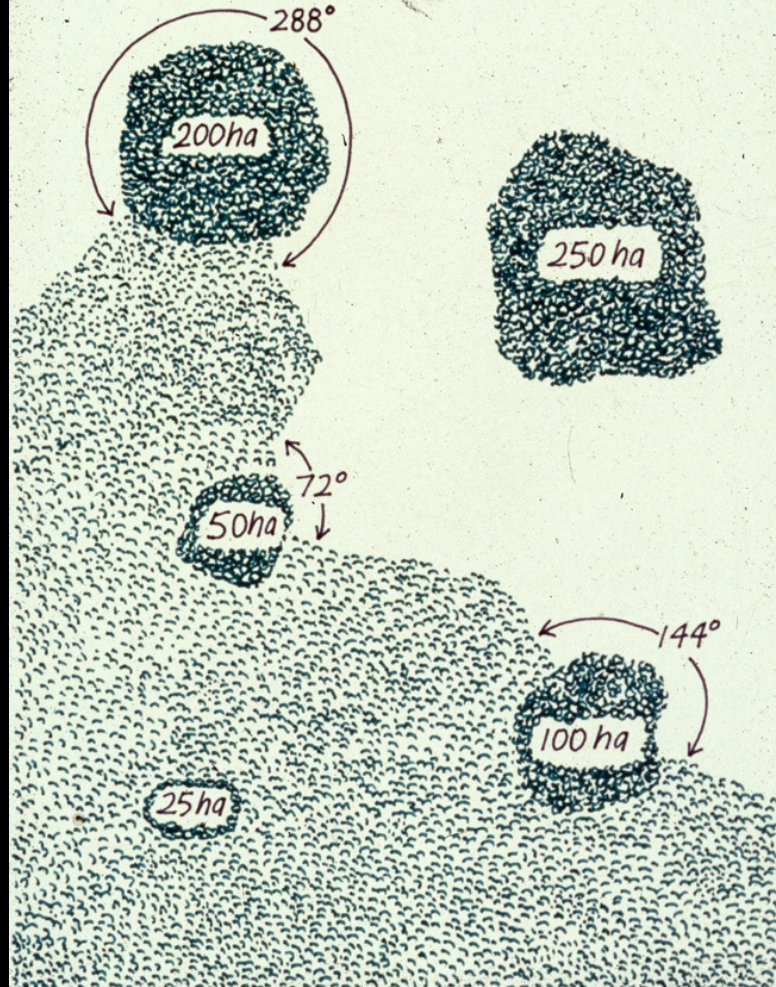
- could be physical but not structural

- atmosphere and aquatic (marine) ecosystems

# Characteristics of Patches

- Size- Why is this important?
  - Mean patch size
  - Distribution of patches
  - Size of the patch
- Shape- Why is this important?

# SIZE VS SURROUNDING



100%

10 ha  
(25 a)

95%

20 ha  
(50 a)

67%

40 ha  
(100 a)

48%

80 ha  
(200 a)

33%

160 ha  
(400 a)

Corridors are typically linear patches,  
all edge regarding to some attributes



Important distinction of patches deals with whether the patch is permanent or transient depending upon what your timeline is?

# Permanent patches tend to be defined by geophysical template

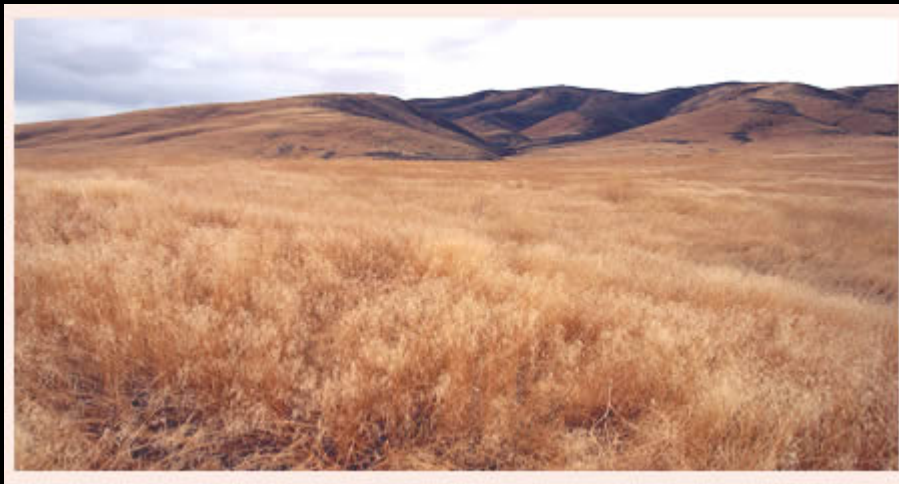
- Desert and tundra landscapes are defined and controlled by the geophysical template



# Transient patches are often associated with disturbance

- Forest landscapes are very much transient patch types which are altered or reset by disturbances

Exotics can modify the basic patchwork by modifying homogenizing the environment and altering disturbance regimes



# Patch Content Matters

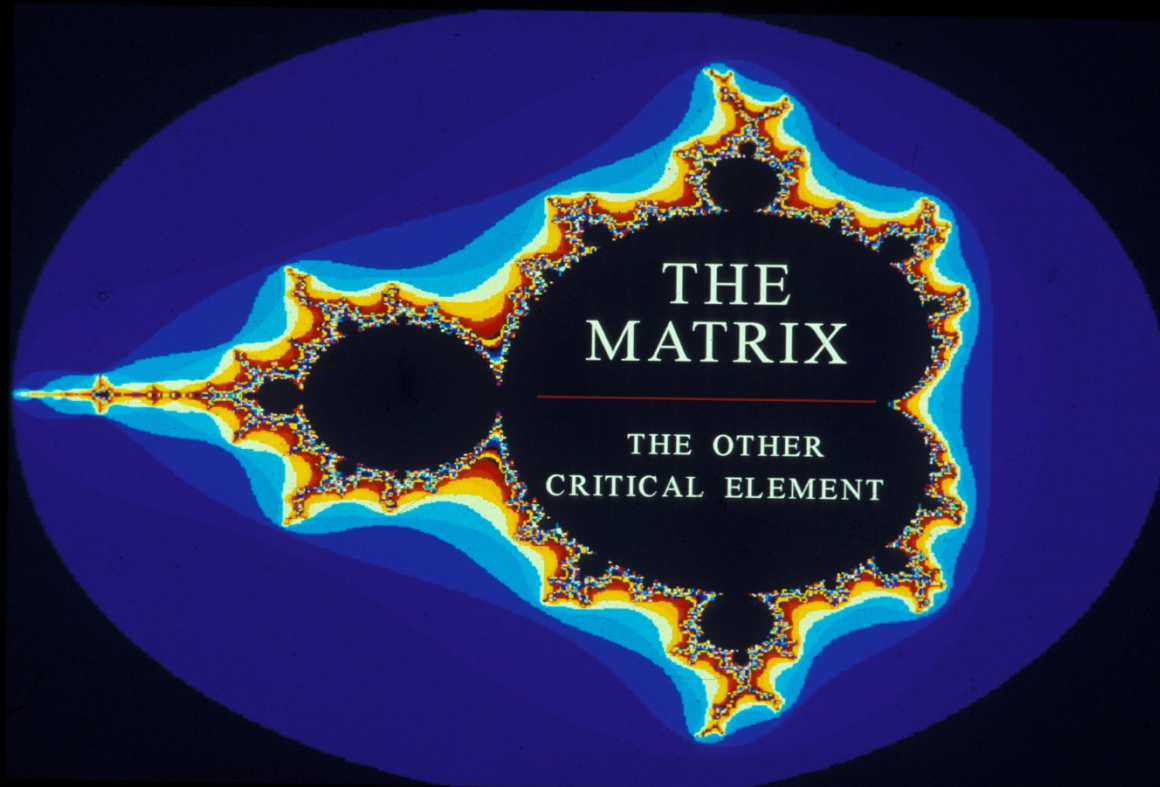
- Patches need to be viewed and managed as shades of gray and not as black and white
- Many conservation biologists do not recognize the gradients of habitats and therefore do not focus on the importance of the matrix



Landscapes as “black and  
white”?  
(habitat or non-habitat, etc.)



...or even “shades of green”!



THE  
MATRIX

THE OTHER  
CRITICAL ELEMENT

# Matrix

- Dominant patch type with the landscape (the background)
  - Recognized by relative area
  - Recognized as most connected element
  - Recognized as patch type controlling dynamics





# Two definitions

matrix: dominant patch type  
unreserved portion of the landscape

Matrix:  
Land designation under the NWFP

# Why is the matrix important?



# Matrix is important because...

- Controls the major functions of the landscape
  - Productivity
  - Hydrologic regulation
  - Habitat
- In conservation biology the matrix has the ability to:
  - Provide the bulk of the habitat
  - Buffer the effectiveness of reserves, corridors, etc.
  - Controls the connectivity or movement of organisms (with either positive or negative consequences)

# My argument...

- What we do in the matrix is more important in determining the success of a conservation strategy than the characteristics of a reserve system.

# Columbia River Gorge

- Ends of the gorge
- Profound example of natural and anthropomorphically influenced landscape
- Great floods flowed over vista rock
- Important passage for pre-modern and modern human beings

# 3 things that influence

- What is the pattern of the resources
- The biota that utilize those sources and development communities which differ in form
- Disturbance which continue to interact and change patches