Consequences of Landscape Patterns on Flows of Energy, Nutrients, Organisms

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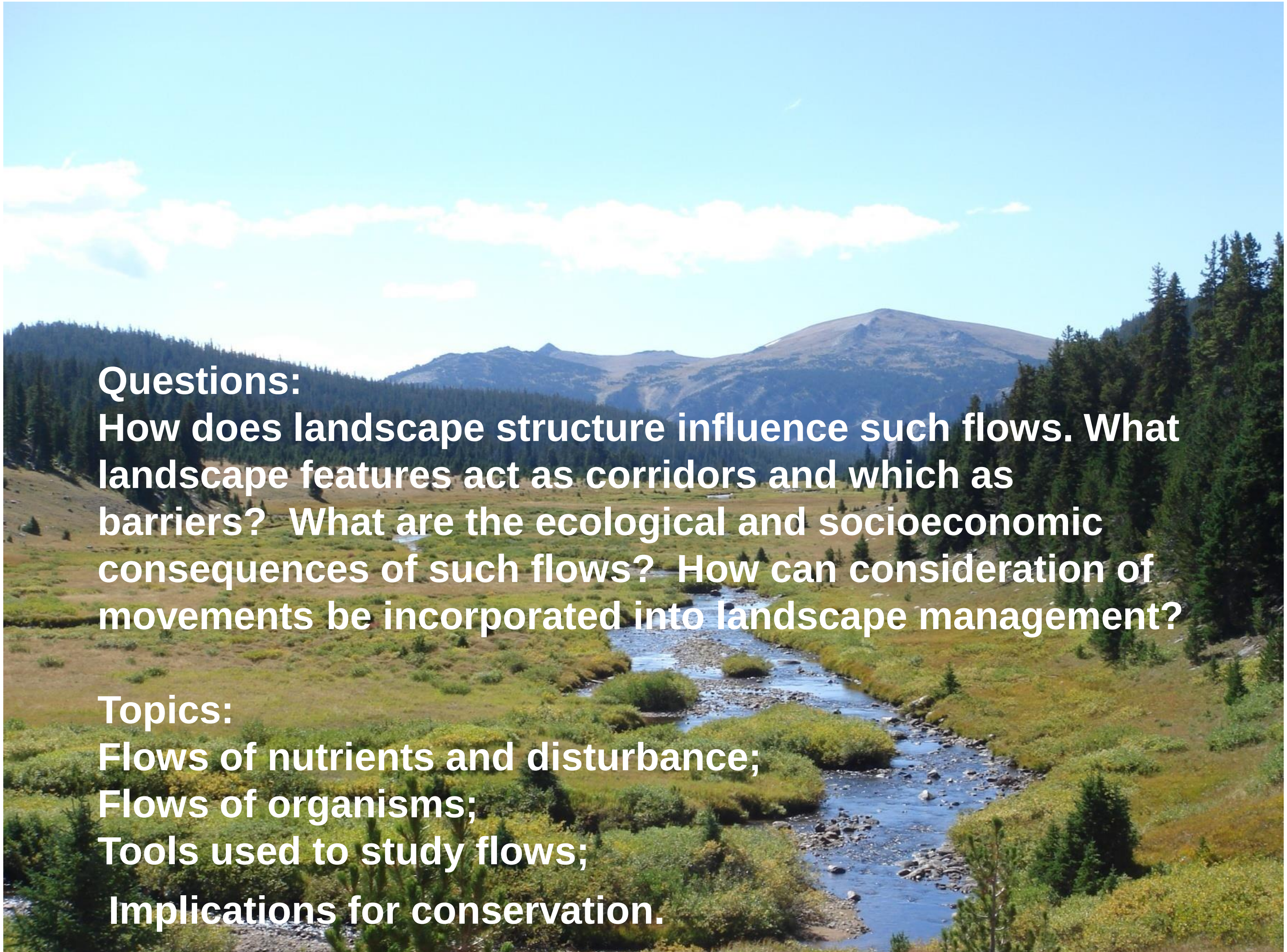
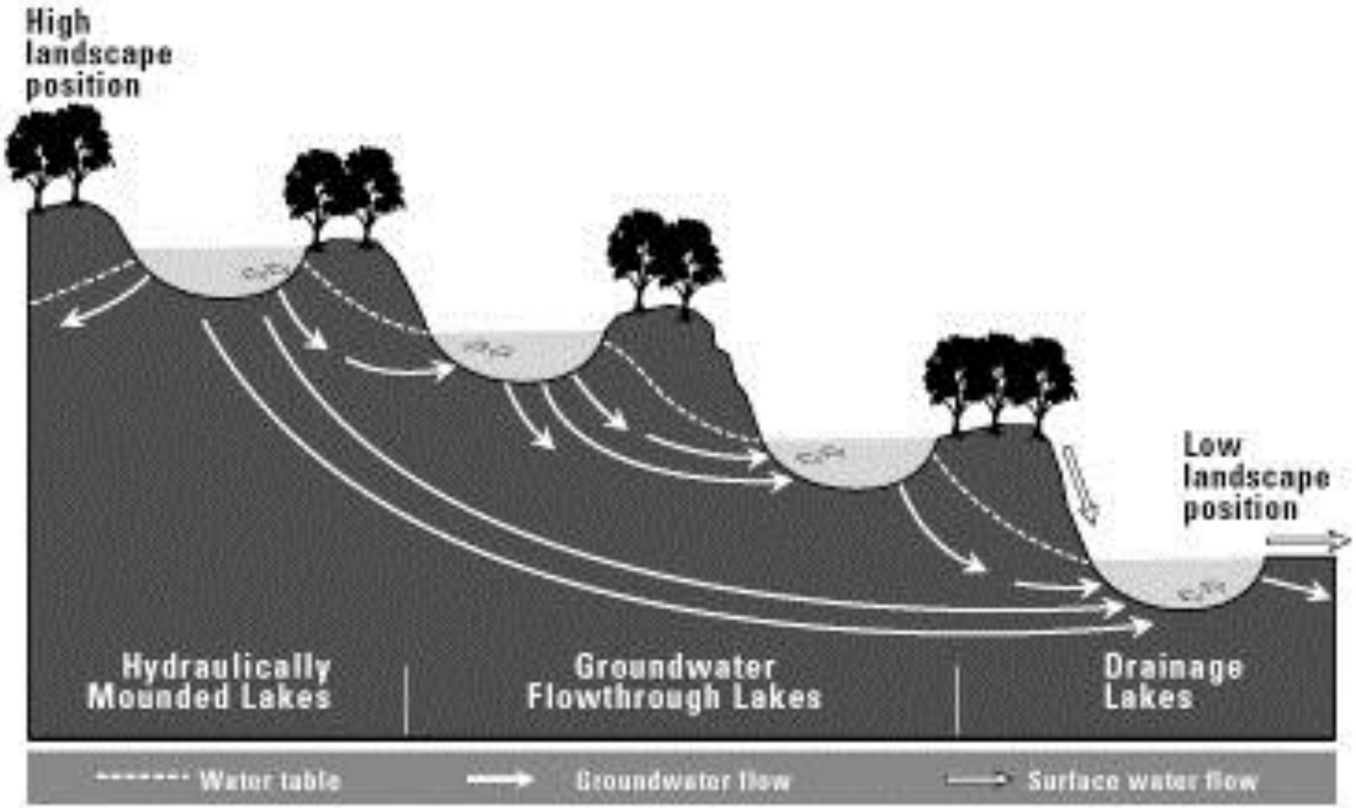
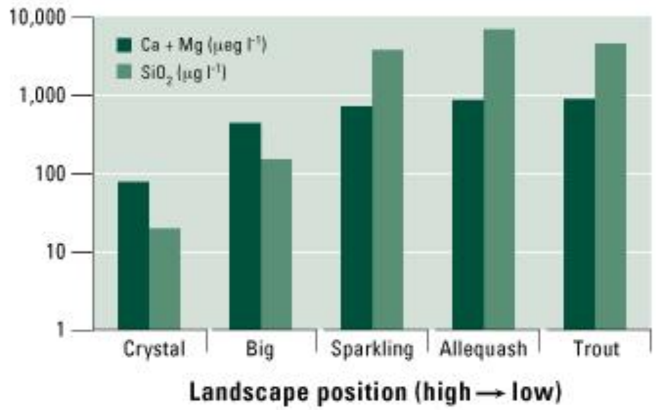


Questions:
How does landscape structure influence such flows. What landscape features act as corridors and which as barriers? What are the ecological and socioeconomic consequences of such flows? How can consideration of movements be incorporated into landscape management?

Topics:
Flows of nutrients and disturbance;
Flows of organisms;
Tools used to study flows;
Implications for conservation.

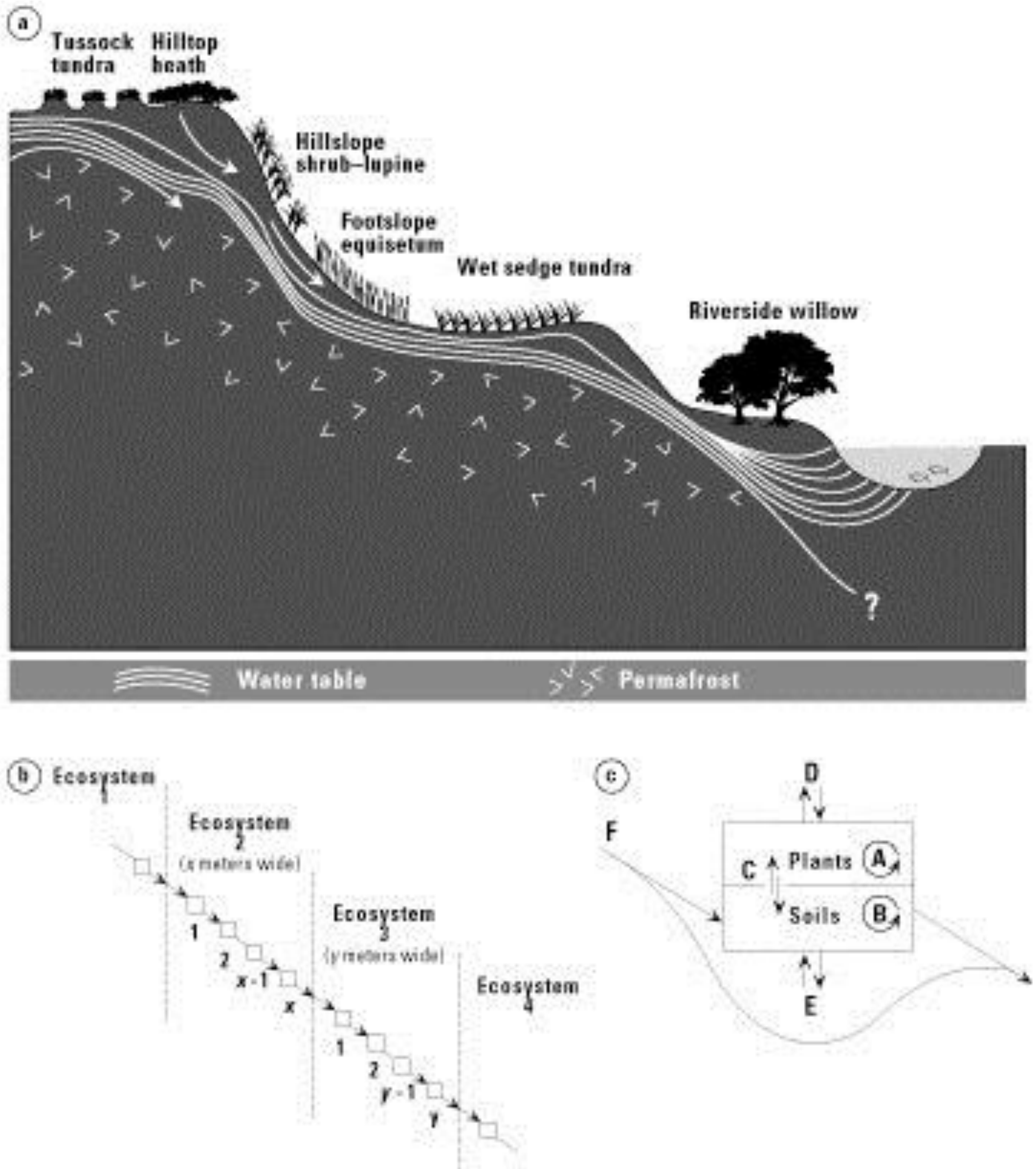
Lake Position in Landscape





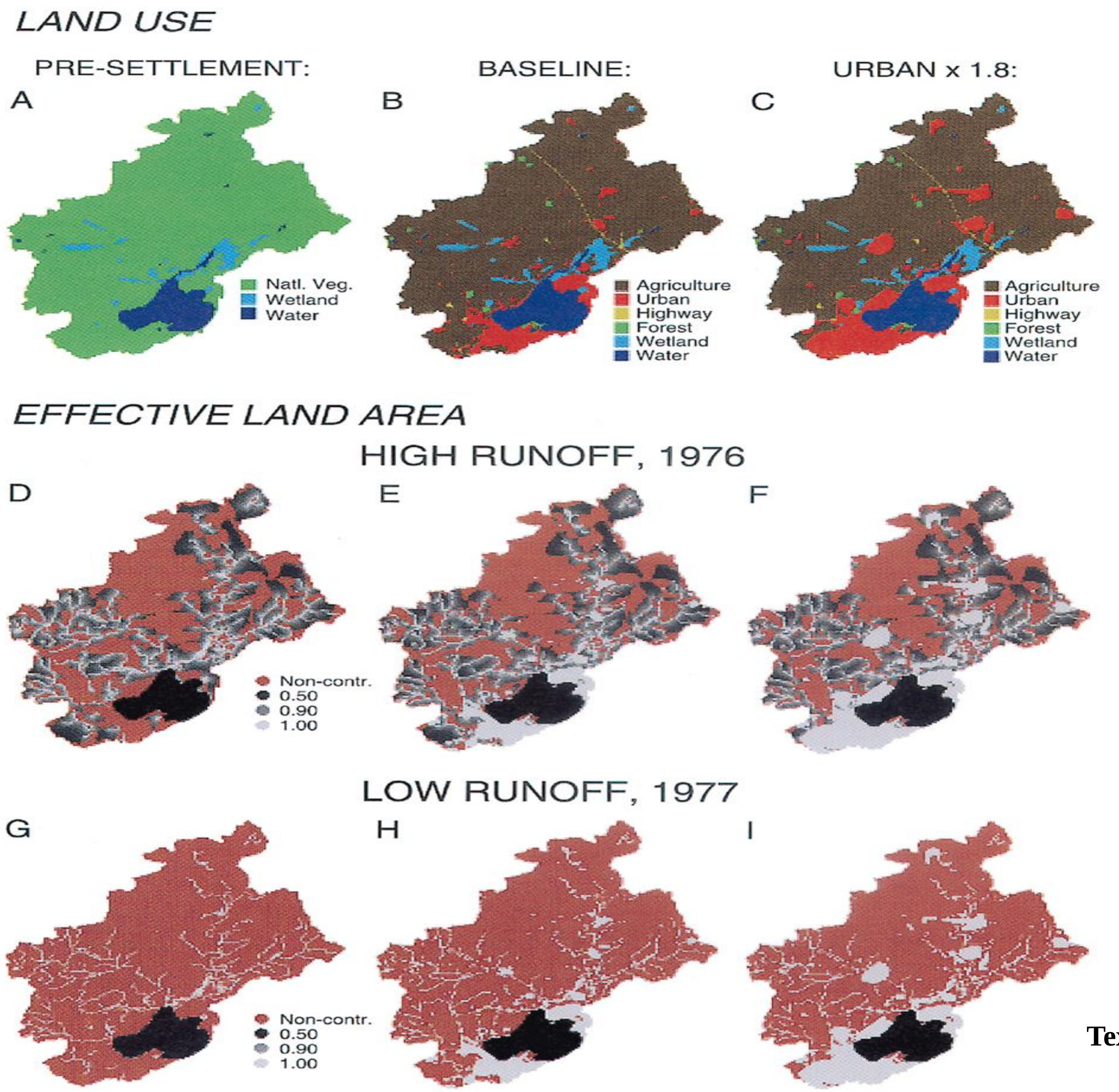
Text Fig 9.3, 9.4

Aquatic and Terrestrial Interactions in a Natural Landscape



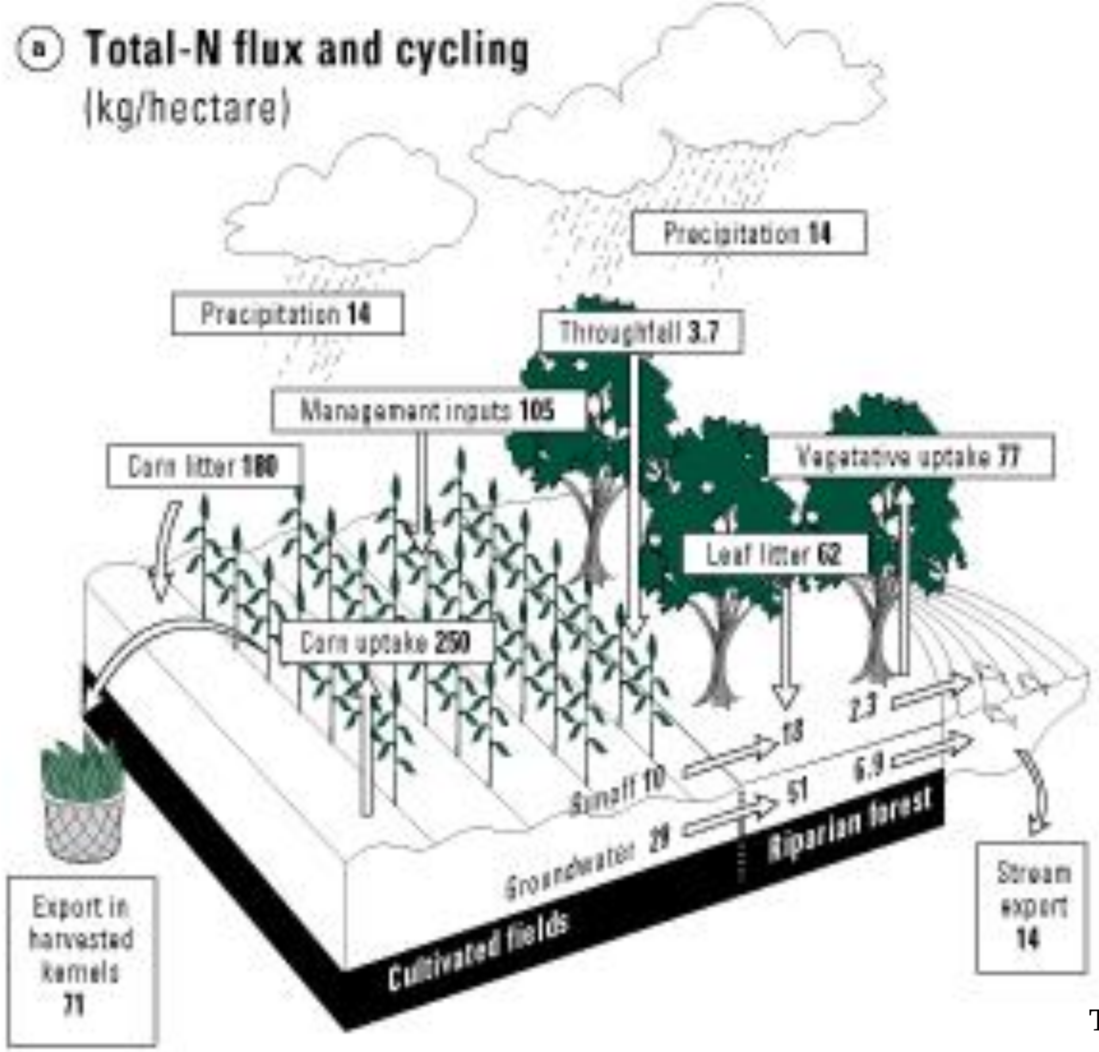
Text Fig 9.5

Phosphorus Routing in the Lake Mendota Watershed



Text Fig 9.6

Effect of riparian vegetation on Nitrogen flows in the Chesapeake Bay area.



Text Fig 9.8

Discussion Question

Do organisms move significant amounts of nutrients around the landscape? Examples?

Discussion Question

Consider nitrogen movements in the Gallatin River Watershed. What are sources of inputs? Major pathways of flows? Drivers of these flows? What are potential ecological consequences of these flows?

Types of Movements of Organisms

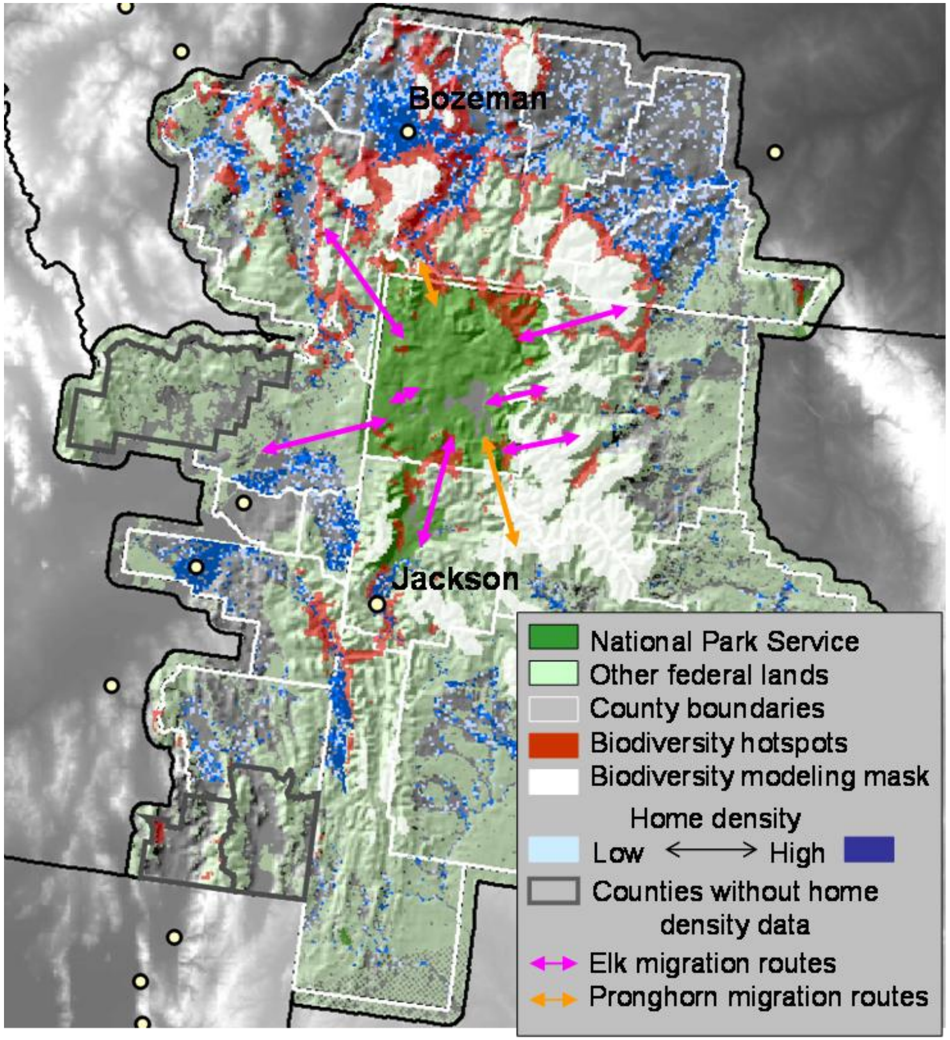
Passive – movement not controlled by organism, but rather by wind, water, gravity, other organisms, etc.

Active – organism moves under its own power.

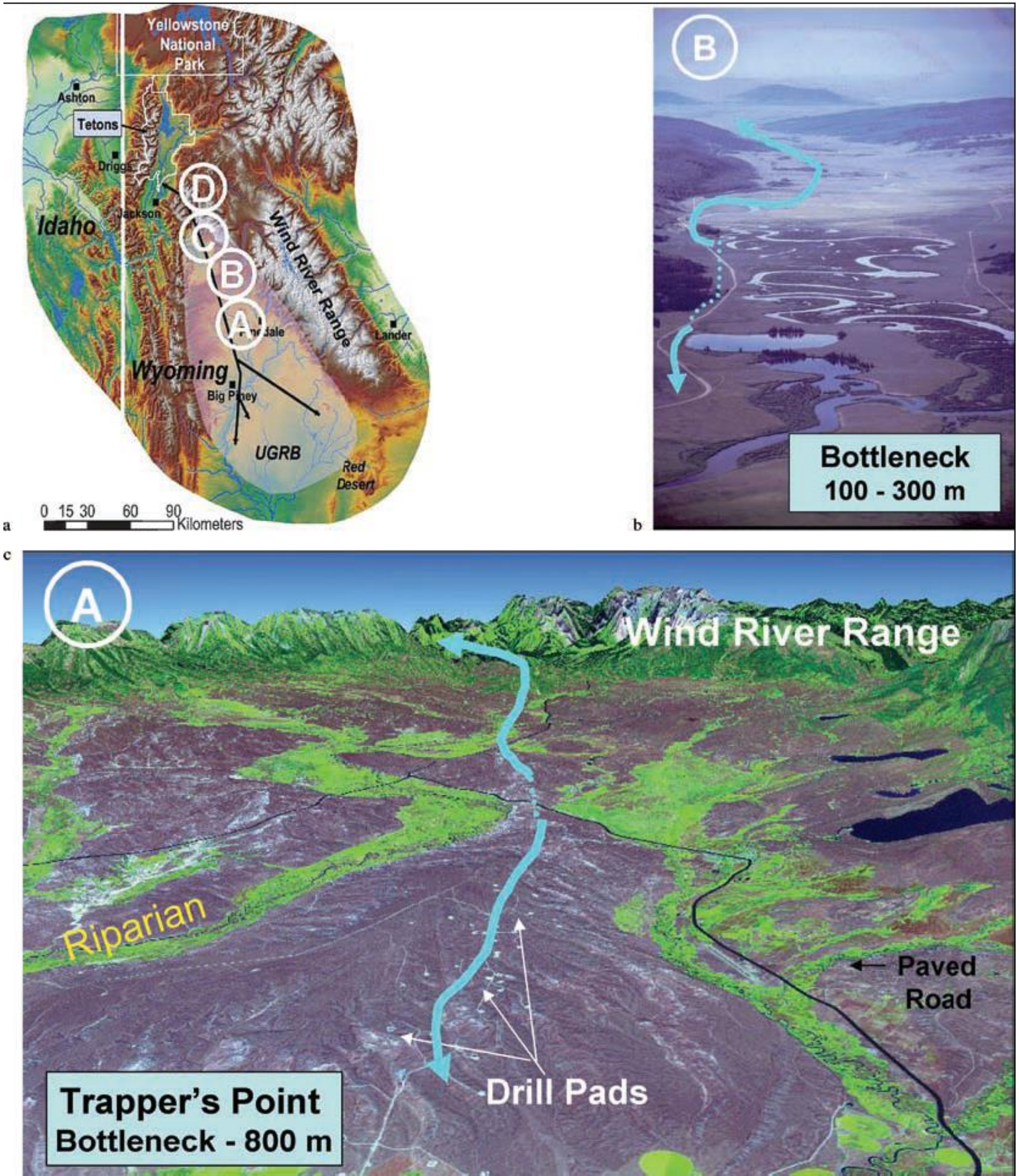
Dispersal – one way movement away from natal area to get to areas of lower density.

Migration – one or two way mass movement among resource patches.

Effects of landscape pattern on migrations

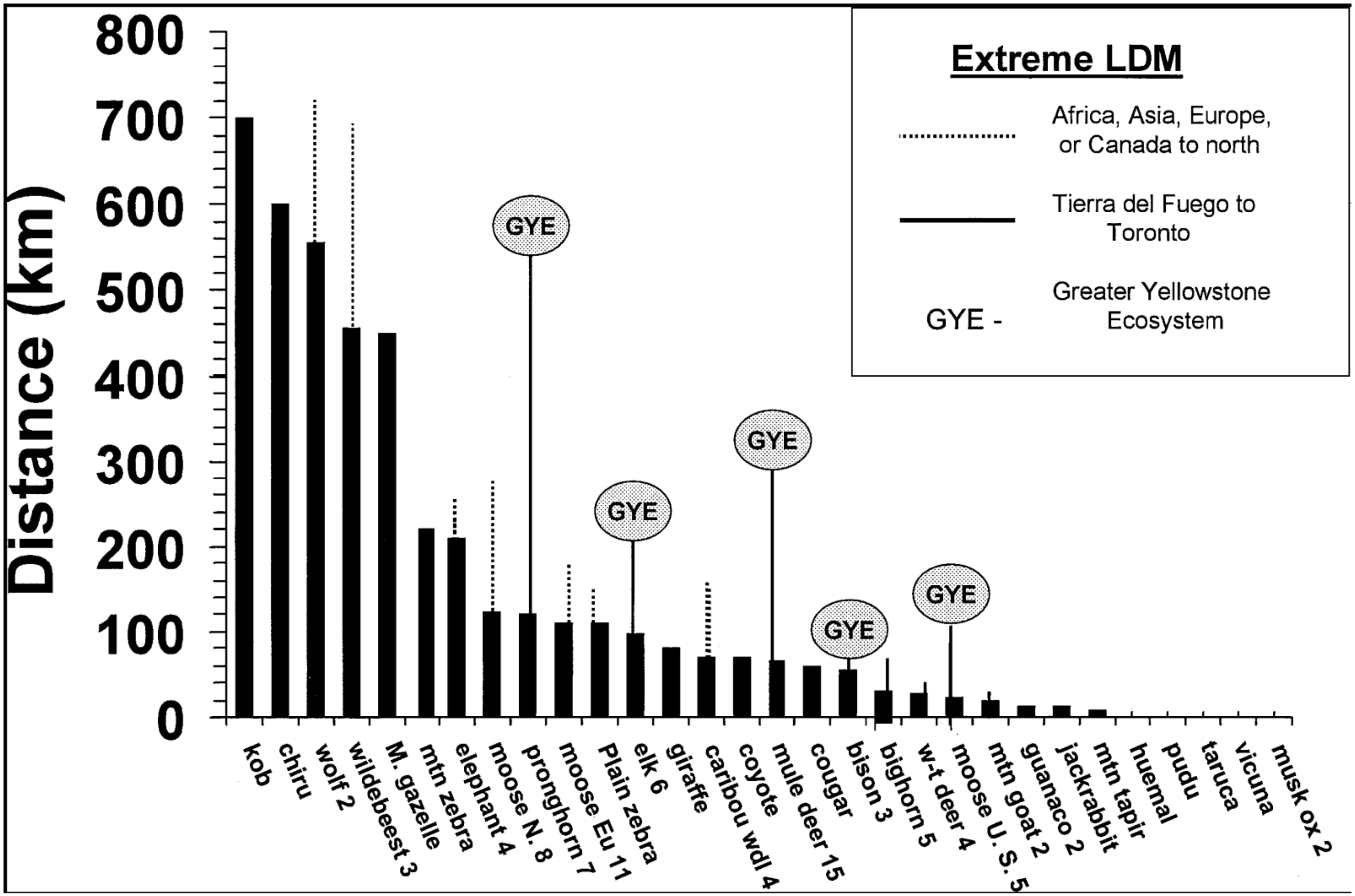


Pronghorn Movements



Berger 2004

Organism Movements



Mean and extreme (extended lines) long-distance migration round-trip distances for terrestrial mammals

Berger 2004

Concepts and Definitions

Connectivity

“the degree to which the landscape facilitates or impedes movement among resource patches”. Taylor et al. (1993)

“the functional relationship among habitat patches, owing to the spatial contagion of habitat and the movement responses of organisms to landscape structure” With et al. (1997)

Concepts and Definitions

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In summary, landscape connectivity encapsulates the combined effects of:
(1) landscape structure and
(2) the species’ use, ability to move and risk of mortality in the various landscape elements, on the movement rate among habitat patches in the landscape.
(T&F 2000).

Concepts and Definitions

Structural connectivity is equated with habitat contiguity and is measured by analyzing landscape structure, independent of any attributes of the organism(s) of interest

Functional connectivity explicitly considers the behavioral responses of an organism to the various landscape elements (patches and boundaries).

Concepts and Definitions

Patch isolation is determined by the rate of immigration into the patch; the lower the immigration rate, the more isolated is the patch. (inverse of connectivity).

Corridors are narrow, continuous strips of habitat that structurally connect two otherwise non-contiguous habitat patches.

Concepts and Definitions

Do corridors necessarily need to be defined as strips of the same habitat between patches? Why could corridors not be some sort of intermediate?

What is the influence of the shutting of corridors on the population ?

Methods for quantifying connectivity

Structural connectivity
- **Landscape metrics**
- **Percolation theory**

Functional connectivity
- **Least cost path**
- **Graph theory**
- **Circuit theory**
- **Resistance kernel approaches**

Methods

Structural Connectivity: Landscape Metrics

e.g., nearest neighbor distance, proximity index

Integrated Landscape Connectivity Index (ILCI)

$$I_j = \sum_i^n p_i p_c \Big/ n$$

where *pc* and *pi* is the proportion of a class in the center and neighboring cell (8 neighbors), at resolution (or scale) *k*. Note that the center cell *c* is included in the neighborhood of *i* to *n*

cells, so *n*=9.

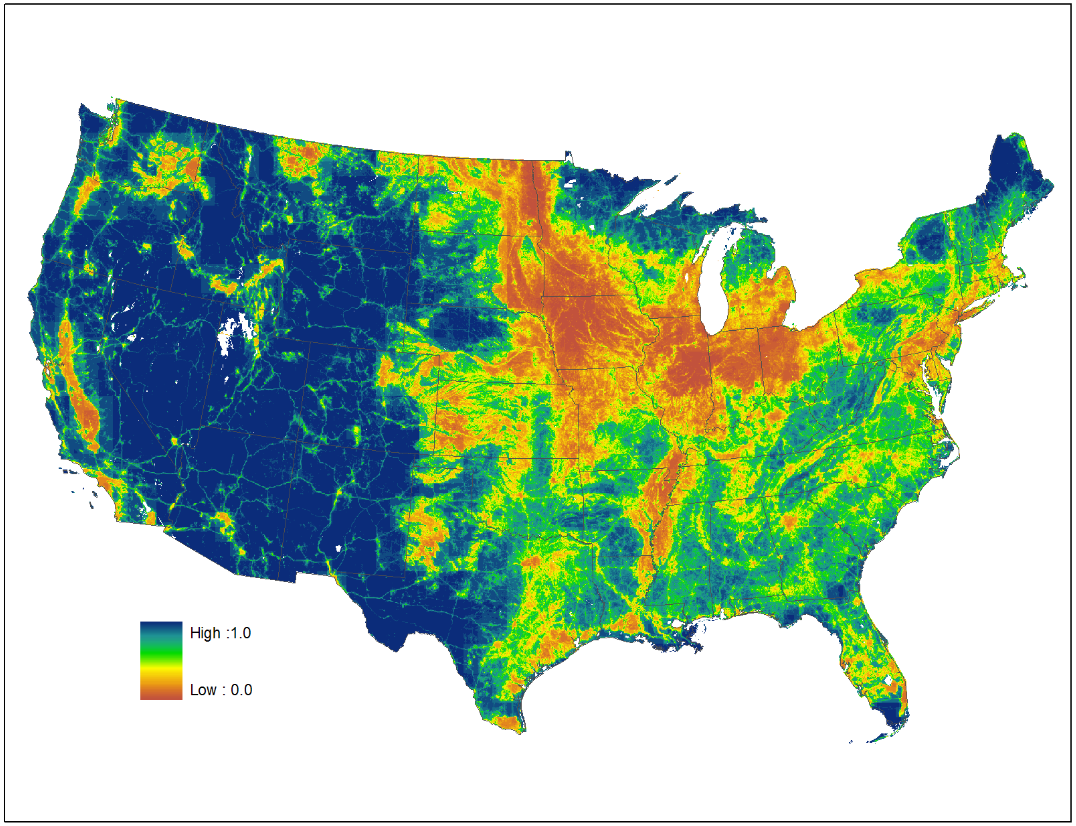


Figure 1. The pattern of natural landscapes in 1992 (scenario *S4*) for the coterminous US using the Integrated Landscape Connectivity Index (ILCI). Much of the western US and northern Minnesota, Wisconsin, and Maine are dominated by “natural” landscapes (high ILCI values) that are shown in blue. Areas dominated by urban and/or cropland agriculture appear as highly-modified areas, shown in red. Theobald 2011.

Methods

Neutral Models

Concept

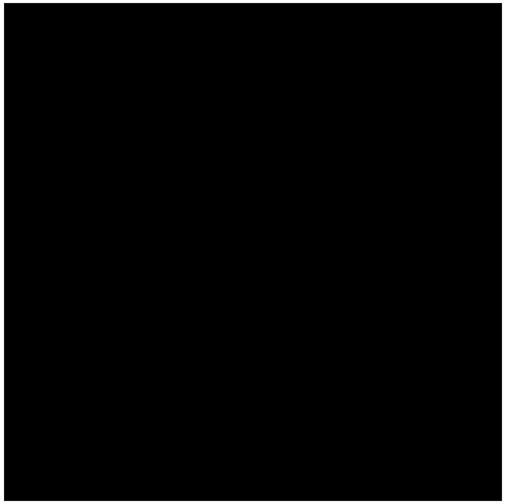
Generate landscapes based on rules that are “neutral to the processes that shape real landscapes.

Compare these neutral landscapes to reality to see if any additional explanation is needed for reality.

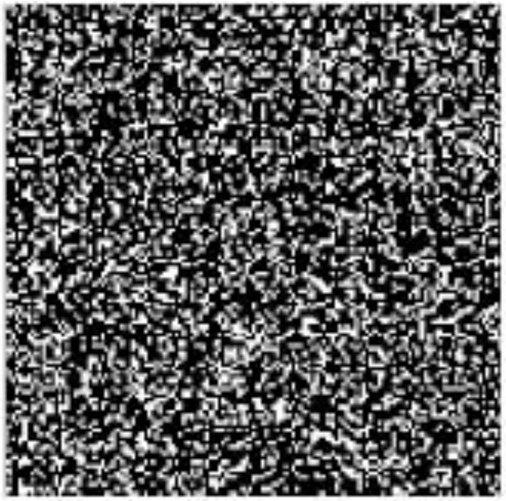
Methods

Null Landscapes

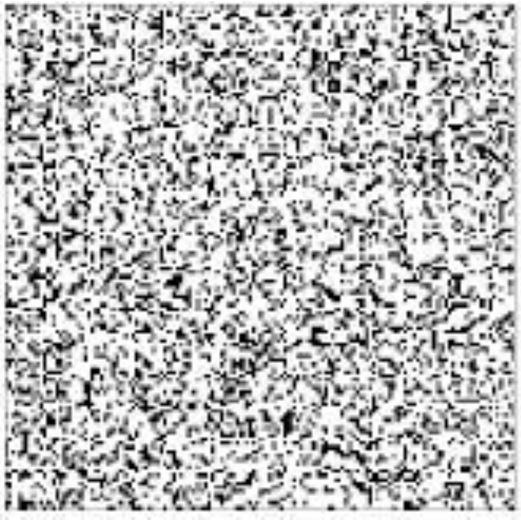
Example: Start with solid habitat and randomly remove small patches. Ask if fragmented habitat is connected under certain rules. Then compare rules to movement of real organisms to estimate level of fragmentation that will inhibit connectivity for this species.



P=1.0



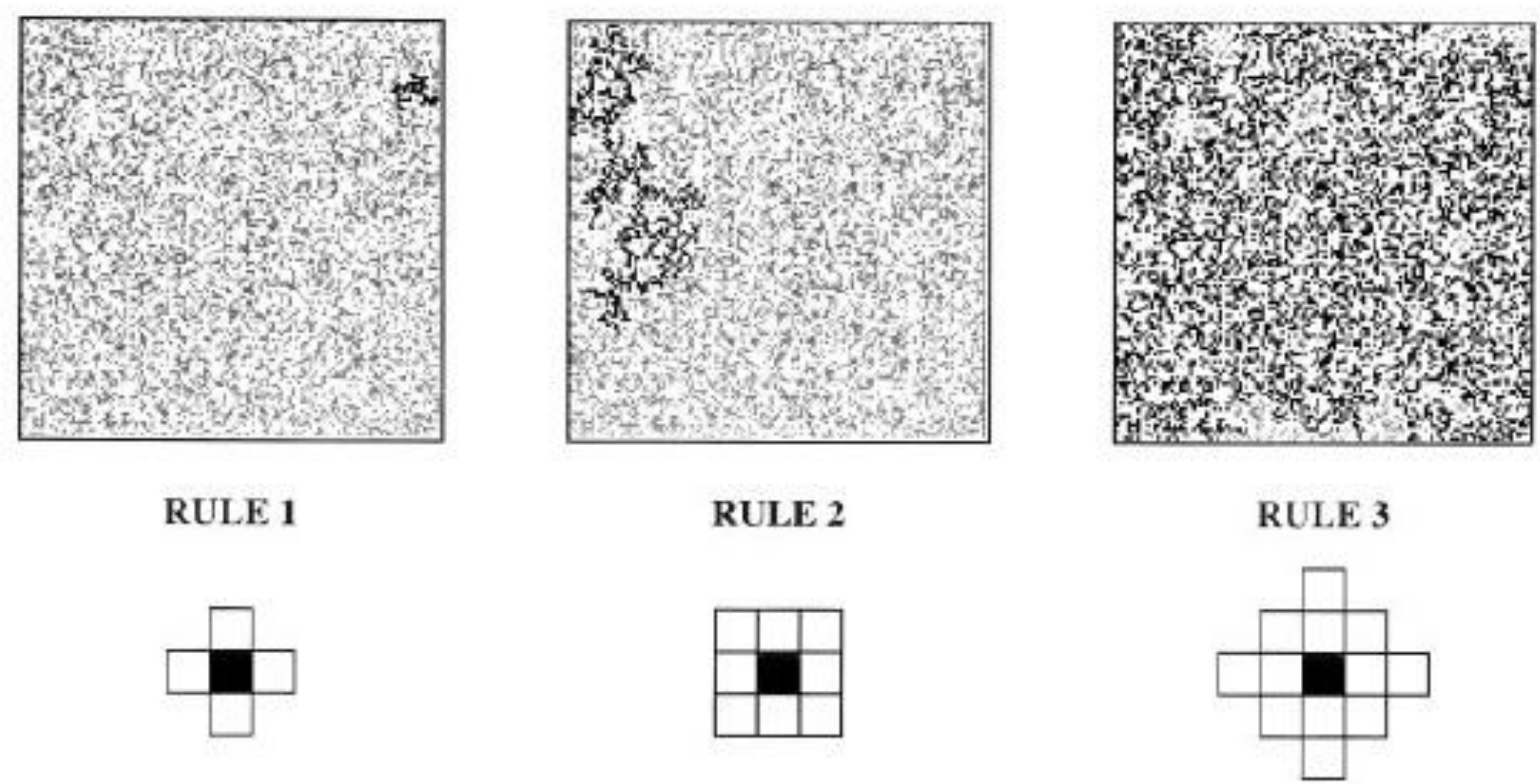
P=.7



P=.3

P = Probability a cell is a particular land cover type

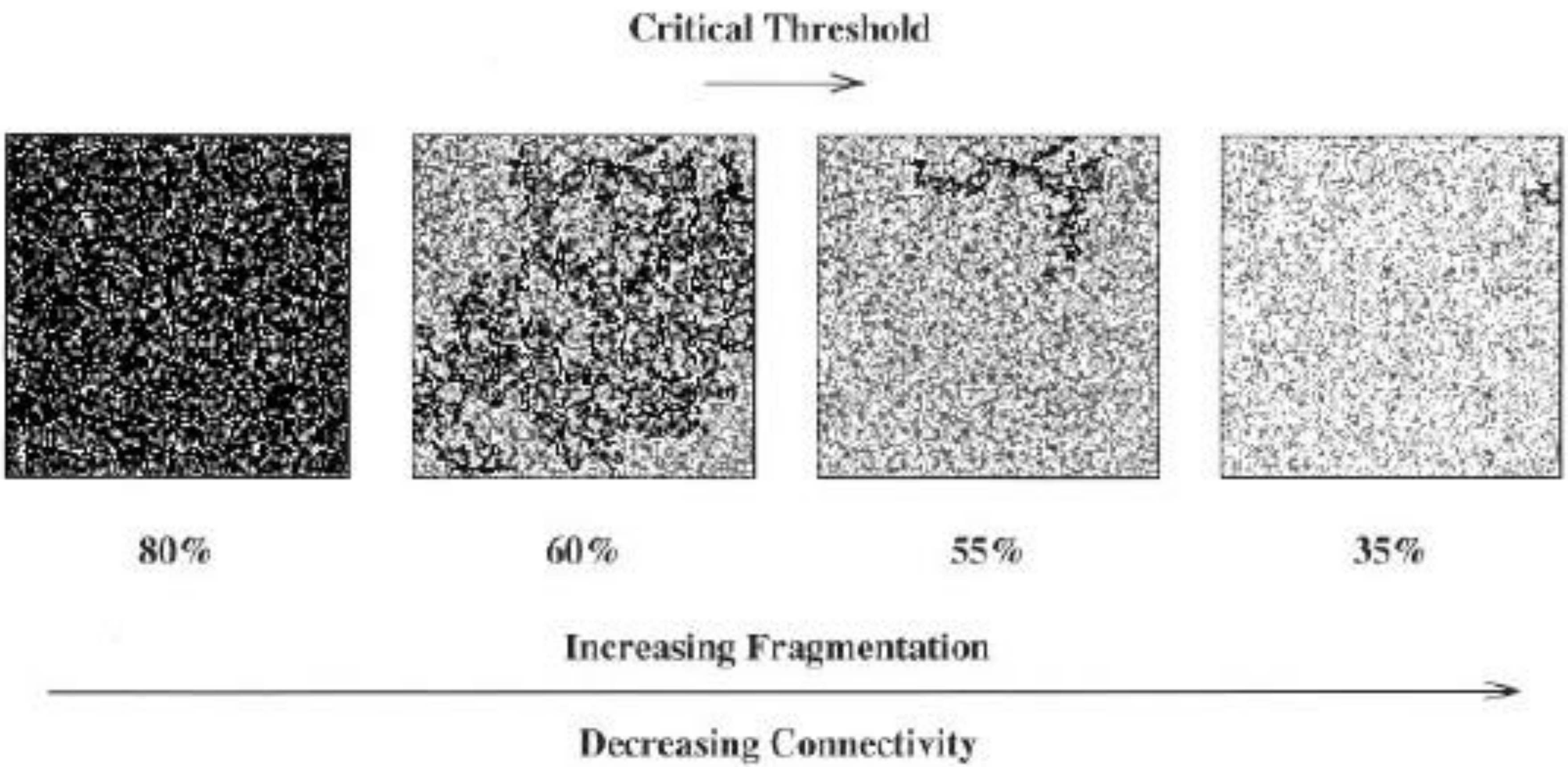
Null Landscapes



P=.35 in this map. The landscape is connected and contains a single cluster that "percolates" across the map only under Rule 3. The landscape would not be connected for species operating under rule 1 or 3.

With 1997

Null Landscapes



As proportion of available habitat is reduced, connectivity is disrupted. Black areas are connected under Rule 1. Only P>=.59 does the map percolate.

With 1997

Levels at which connectivity has been quantified:

Naturalness

Land facets / climate zones

Vegetation groups (habitat types (subalpine), lifeforms (forest))

Guilds of species

Individual species

Gene flow

When do we want to increase connectivity?

When do we want to increase connectivity?

1. When we want to increase species richness and diversity as suggested by island theory.
2. Permit reestablishment of extinct subpopulations.
3. Increase the size of a population to reduce chance of extinction (rescue effect)
4. To maintain gene flow and avoid inbreeding depression and genetic drift within a population.
5. To maintain ecological processes like predation in a subhabitat.
6. Provide escape routes from large disturbances.
7. To maintain communication between source and sink populations (flows back to source could be helpful at times).

When do we want to decrease connectivity?

When do we want to decrease connectivity?

1. Minimize spread of disease, invasives, pests, etc.
2. Want to maintain genetic distinctness of subpopulations.
3. Minimize risk that catastrophic disturbance will wipe out all subhabitats.
4. Decrease use of sink habitat.
5. Decrease exposure to hazards in corridors.