Land use and Land cover Change

Learning Objectives

- Gain familiarity with the effects of land use and land cover change including habitat loss and fragmentation
- Gain and understanding of how habitat connectivity is measured
- Ways to study the influence of connectivity on processes

Definitions

Land use- category of how humans use areas
Their natural habitats are declining due to major changes in land use.

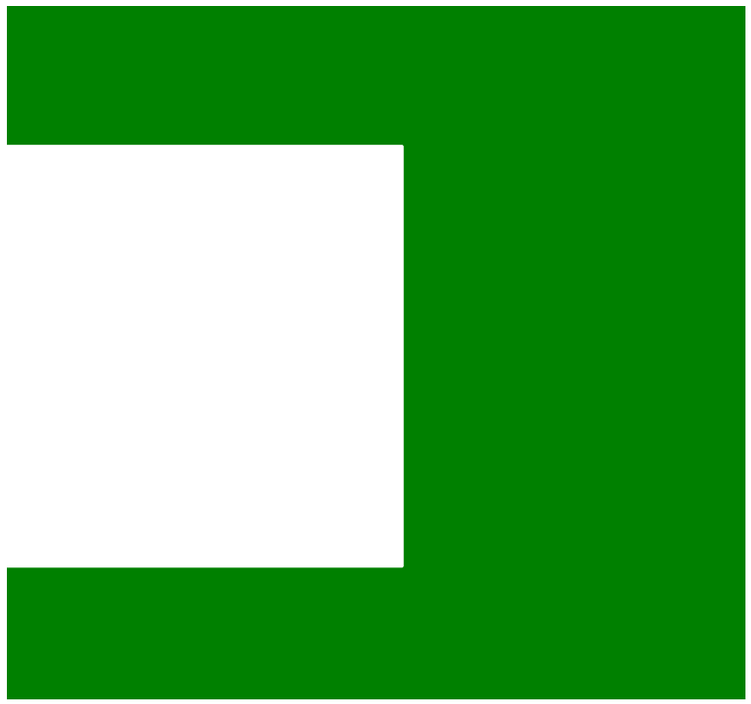
Land cover- category of physical material of an area
Agricultural land cover is approximately 65 % of the total land area.

Land use and Land cover change (LULC)

- requires quantifying the pattern
- typically from categorical maps
- can be for continuous information (NDVI)

Habitat loss versus fragmentation

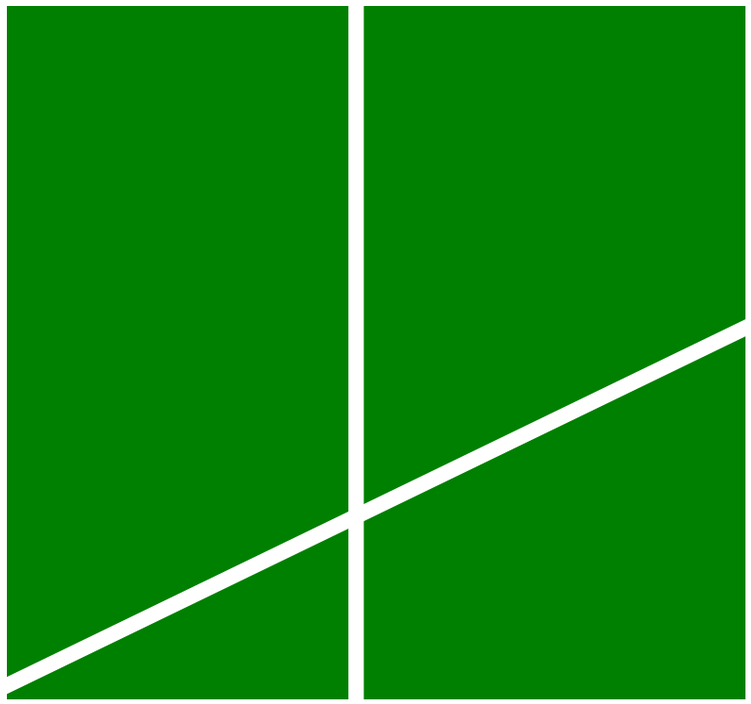
Landscape at time 1



Landscape at time 2

Habitat loss versus fragmentation

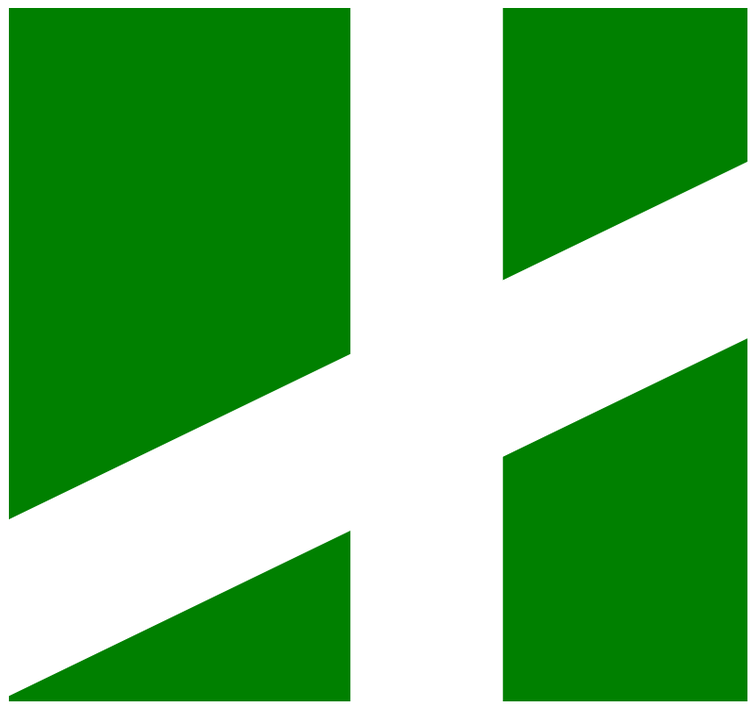
Landscape at time 1



Landscape at time 2

Habitat loss versus fragmentation

Landscape at time 1



Landscape at time 2

Defining habitat loss & fragmentation

- Fragmentation is *sensu stricto*:
  "Breaking up of a habitat or cover type into smaller, disconnected parcels, *independent of habitat loss*."
- Habitat loss:
  - change in the amount of habitat
  - change in the number (+), size (-) and configuration (more scattered, more edge, more isolation) of habitat parcels

Habitat fragmentation effects are conditional on the amount of loss because can't have the former without the latter

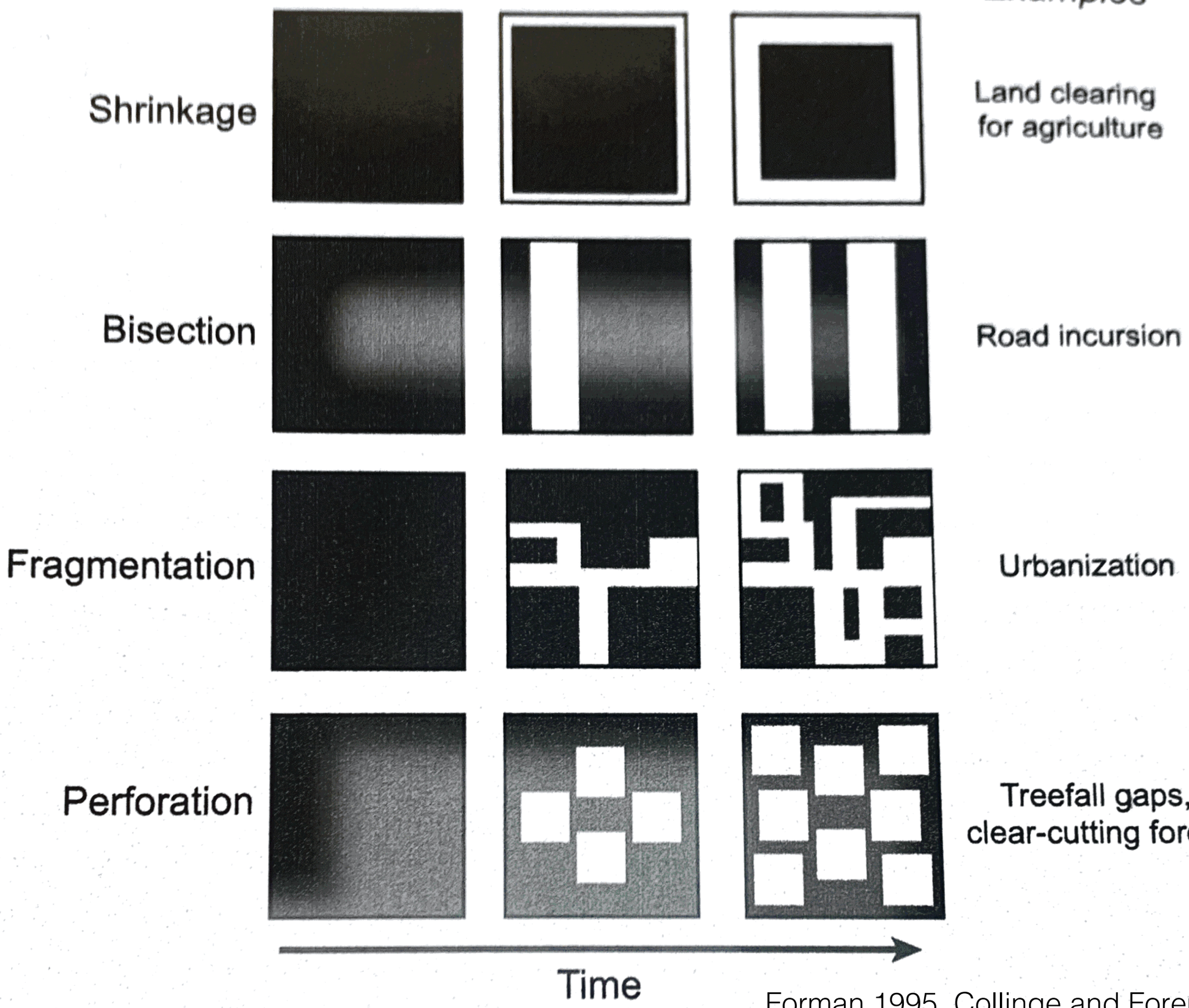
Elements of fragmentation
…. or things patch metrics measure

Composition

1. number of land cover classes present - *N*
2. proportion of each class type - *p*

Configuration

3. spatial arrangement
4. patch shape/size



Forman 1995, Collinge and Foreman 1998

Fragmentation indices
&
their relationship
to proportion of each
habitat type (*p*)

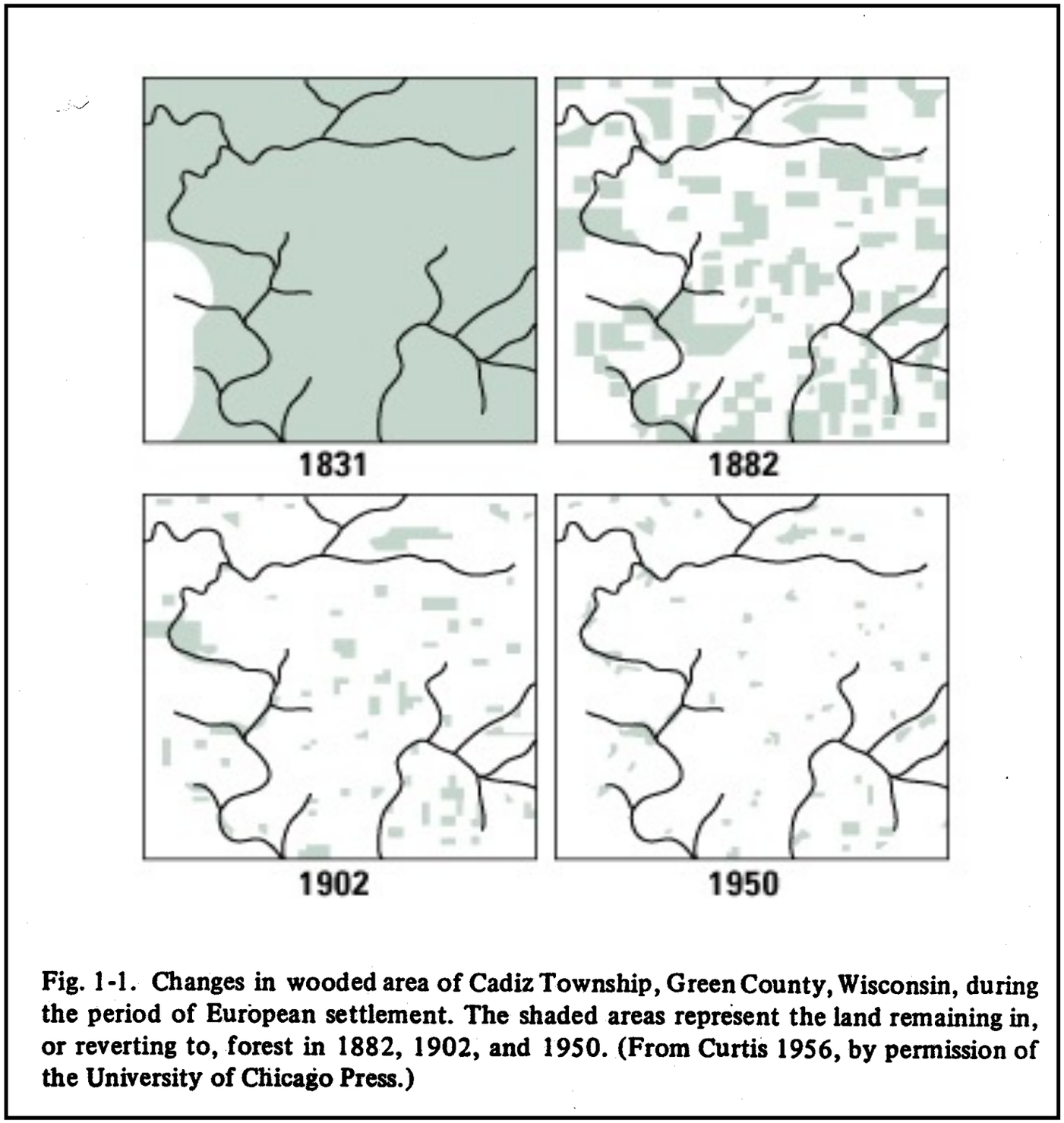
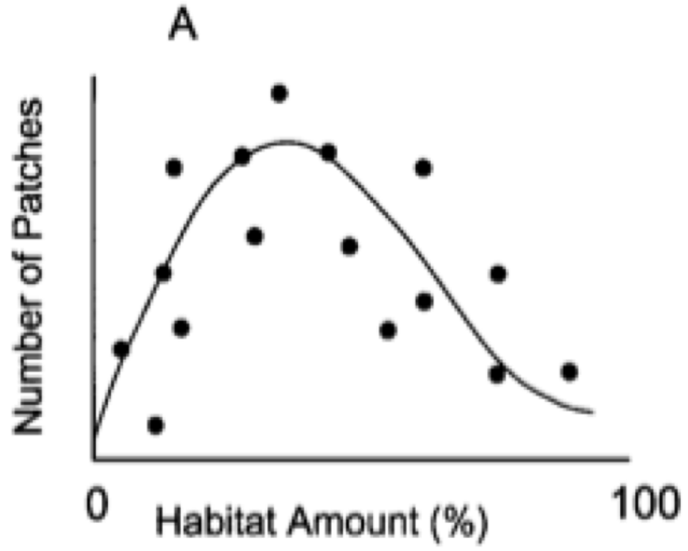


Fig. 1-1. Changes in wooded area of Cadiz Township, Green County, Wisconsin, during the period of European settlement. The shaded areas represent the land remaining in, or reverting to, forest in 1882, 1902, and 1950. (From Curtis 1956, by permission of the University of Chicago Press.)



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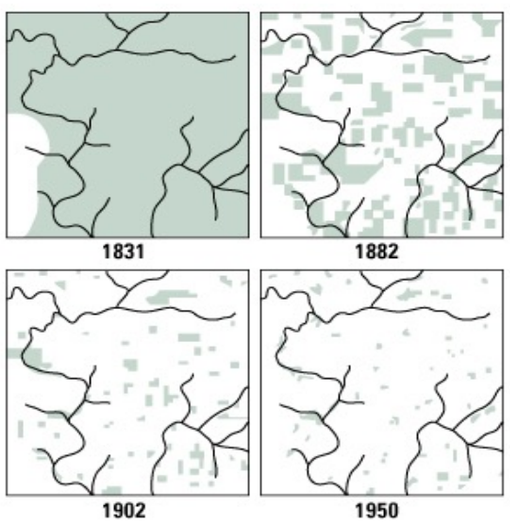

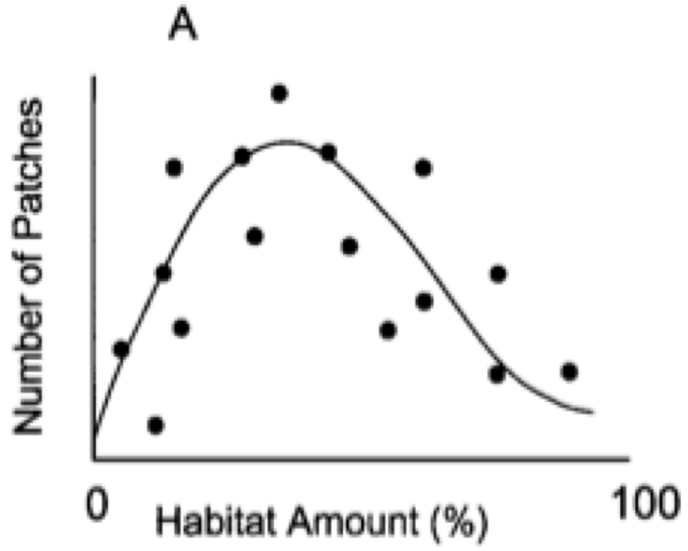

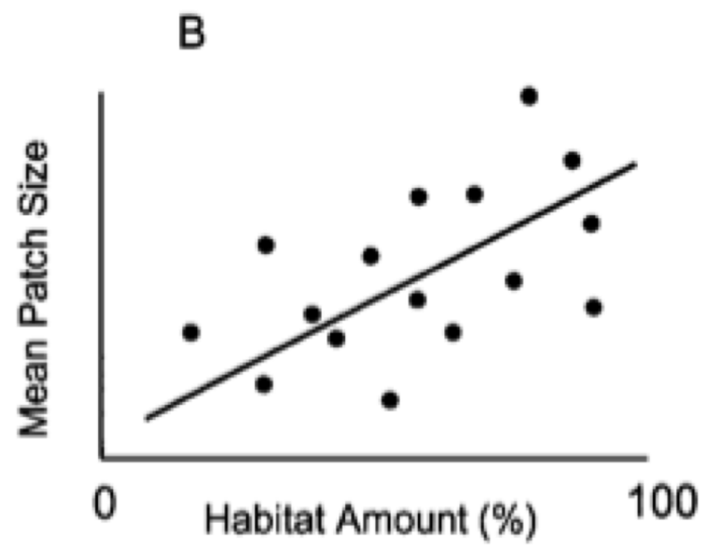

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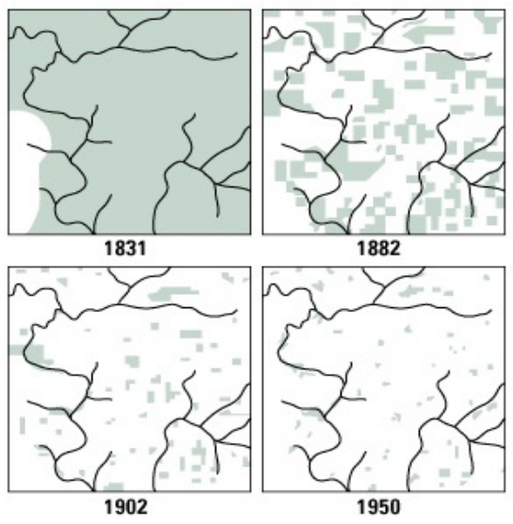

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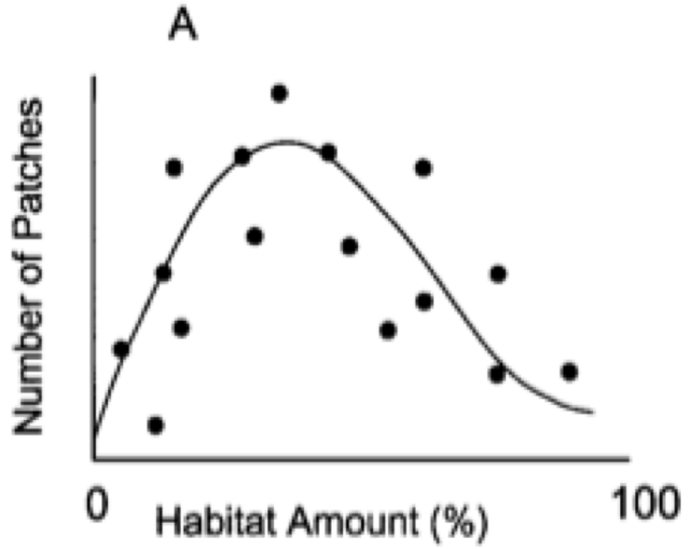

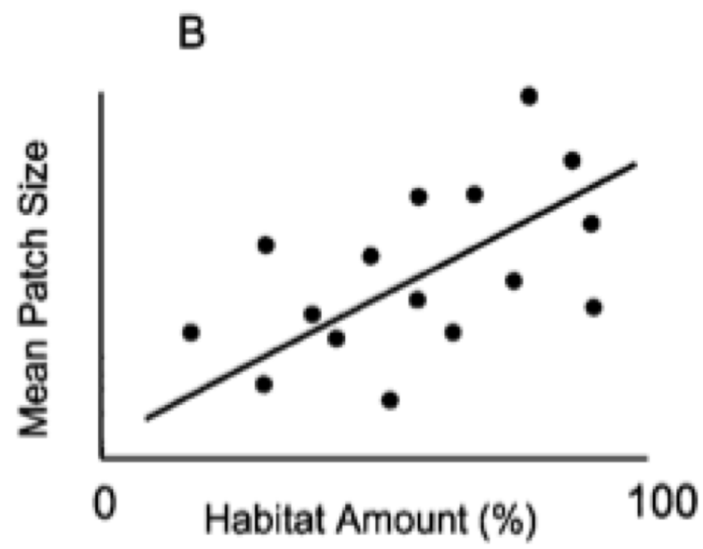

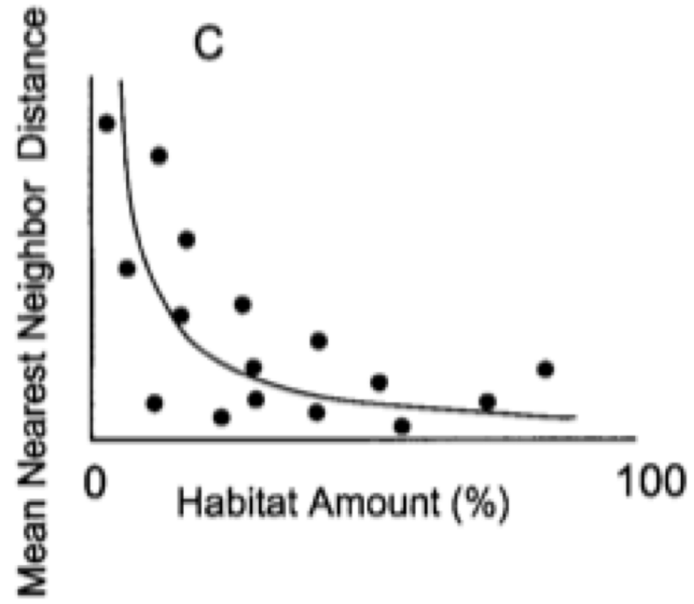

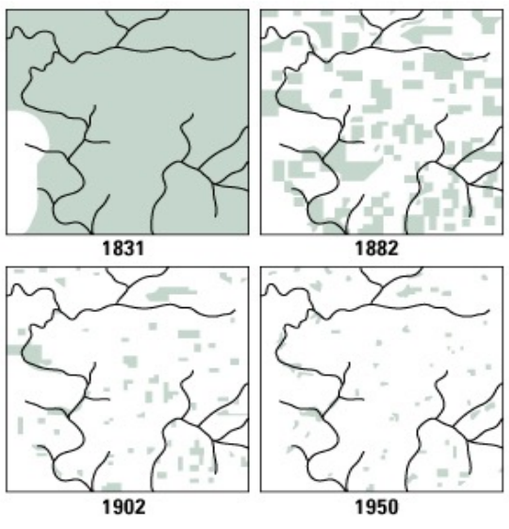

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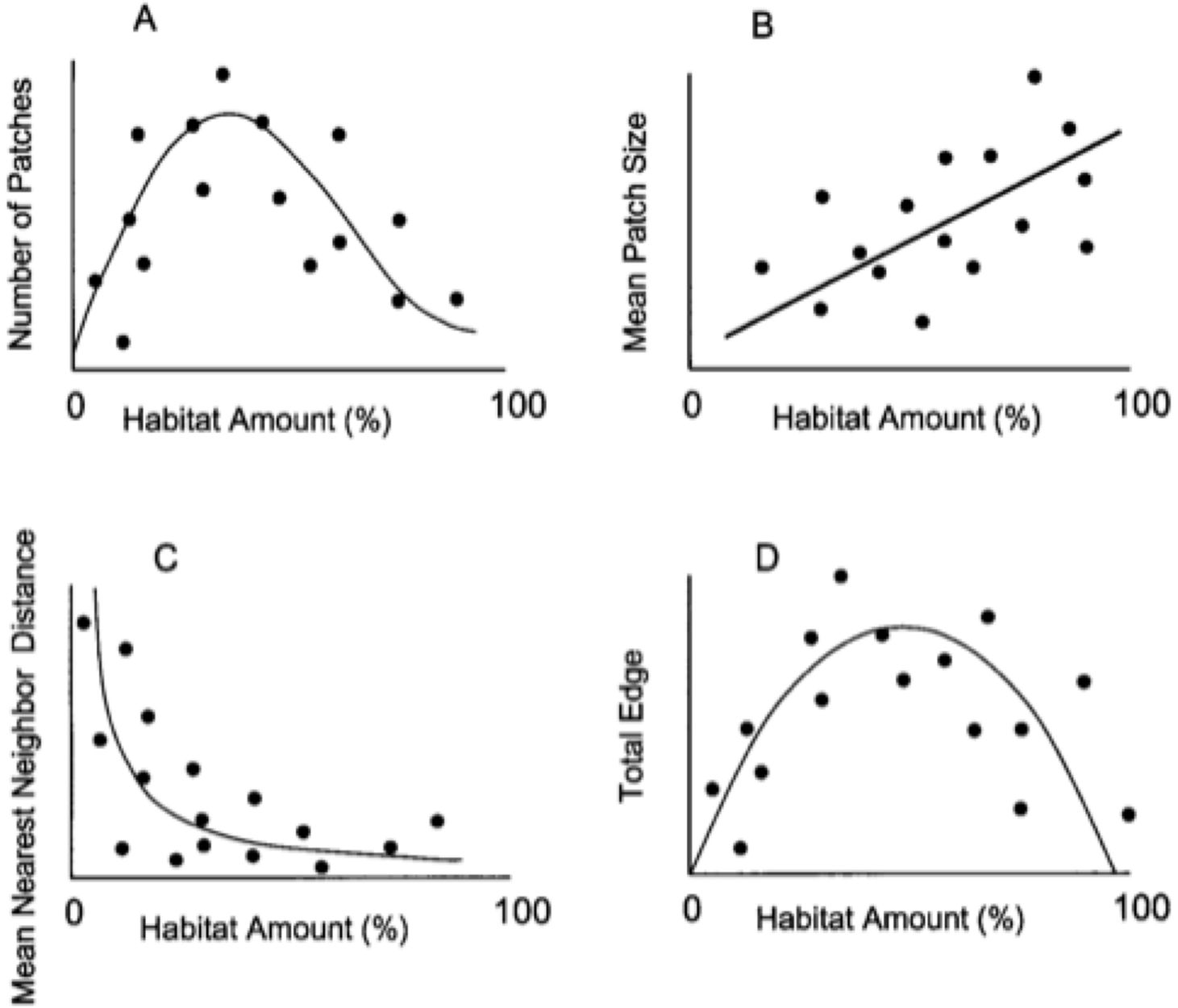

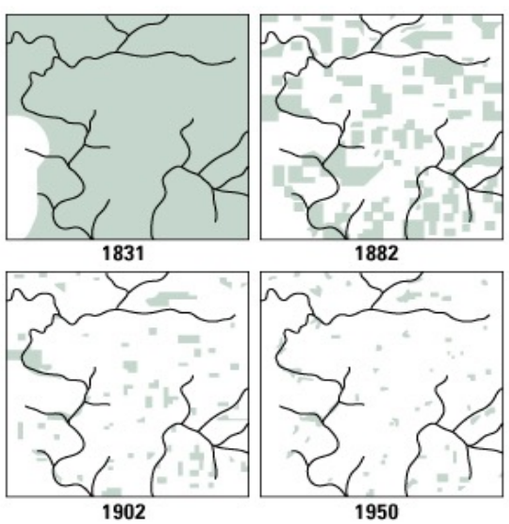

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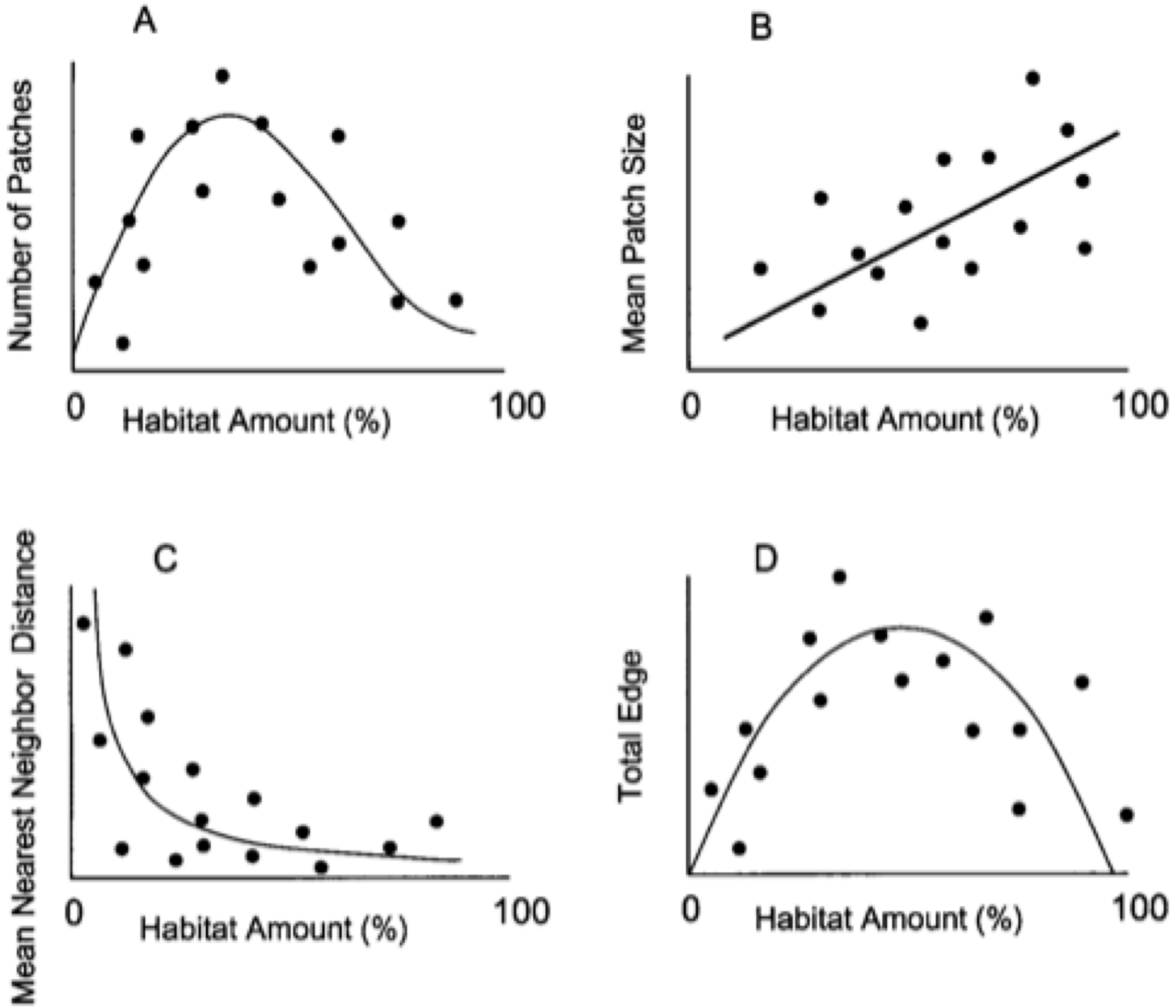
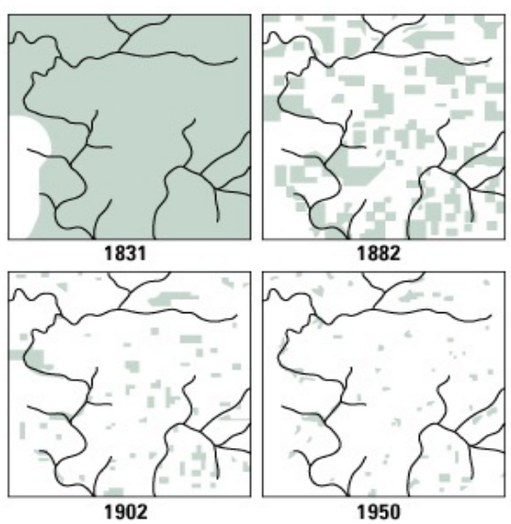
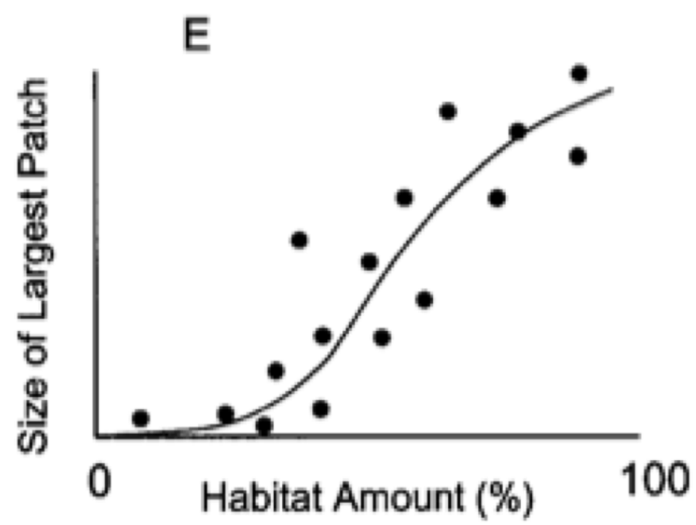






Habitat loss and fragmentation considered greatest threats to biodiversity

- Reduction in species richness, population abundance, genetic diversity, and distribution
- Local extinction (large bodied species)
- Alters species interactions, predation rates, foraging
- Dispersal success
- Impacts not limited to terrestrial ecosystems
- LINK TO VIDEO

Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology and Systematics 34:487-515.

Landscape Connectivity

The functional relationship among habitat patches owing to the spatial contagion of habitat and the movement responses of organisms to landscape structure

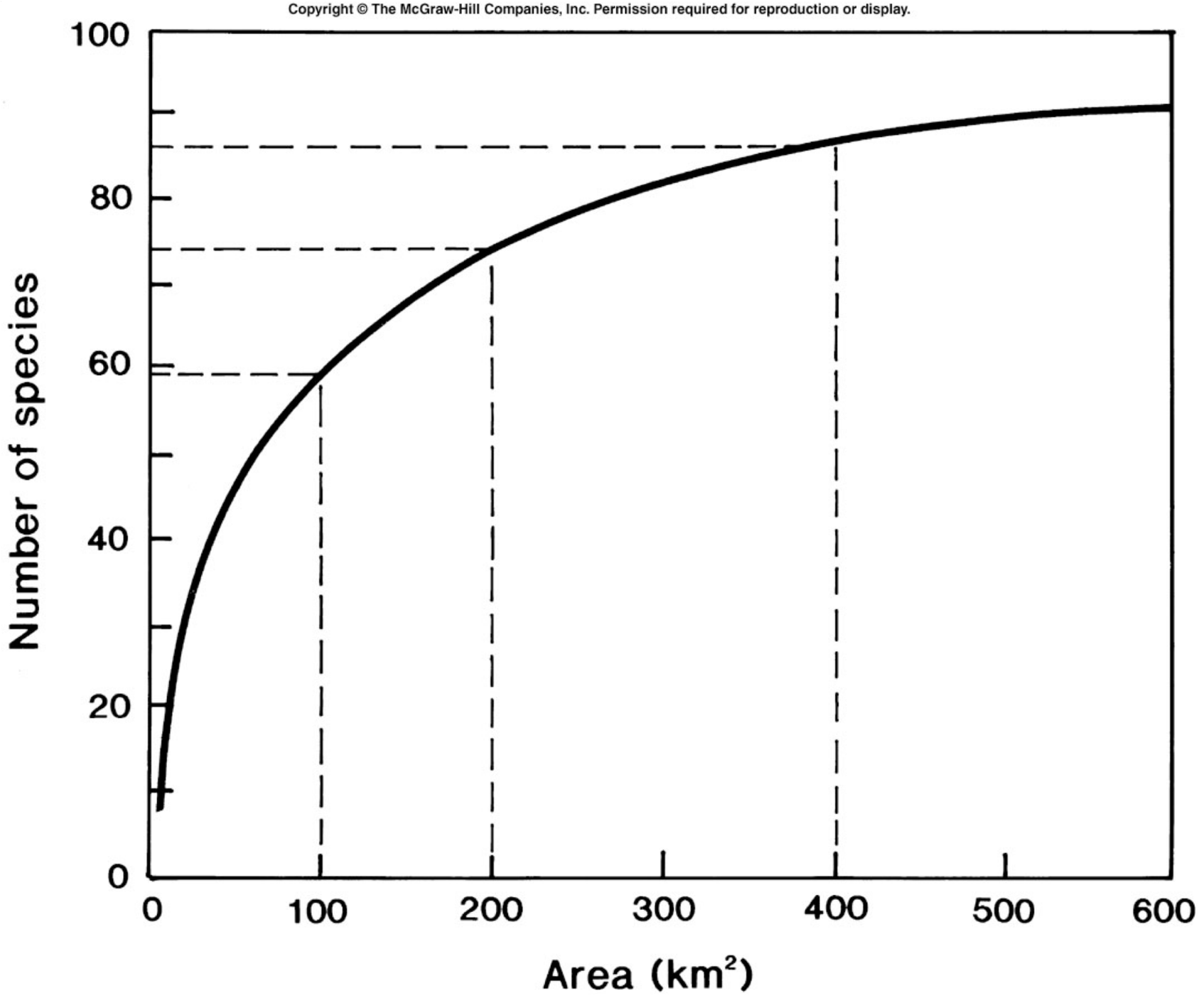
Why does it matter?

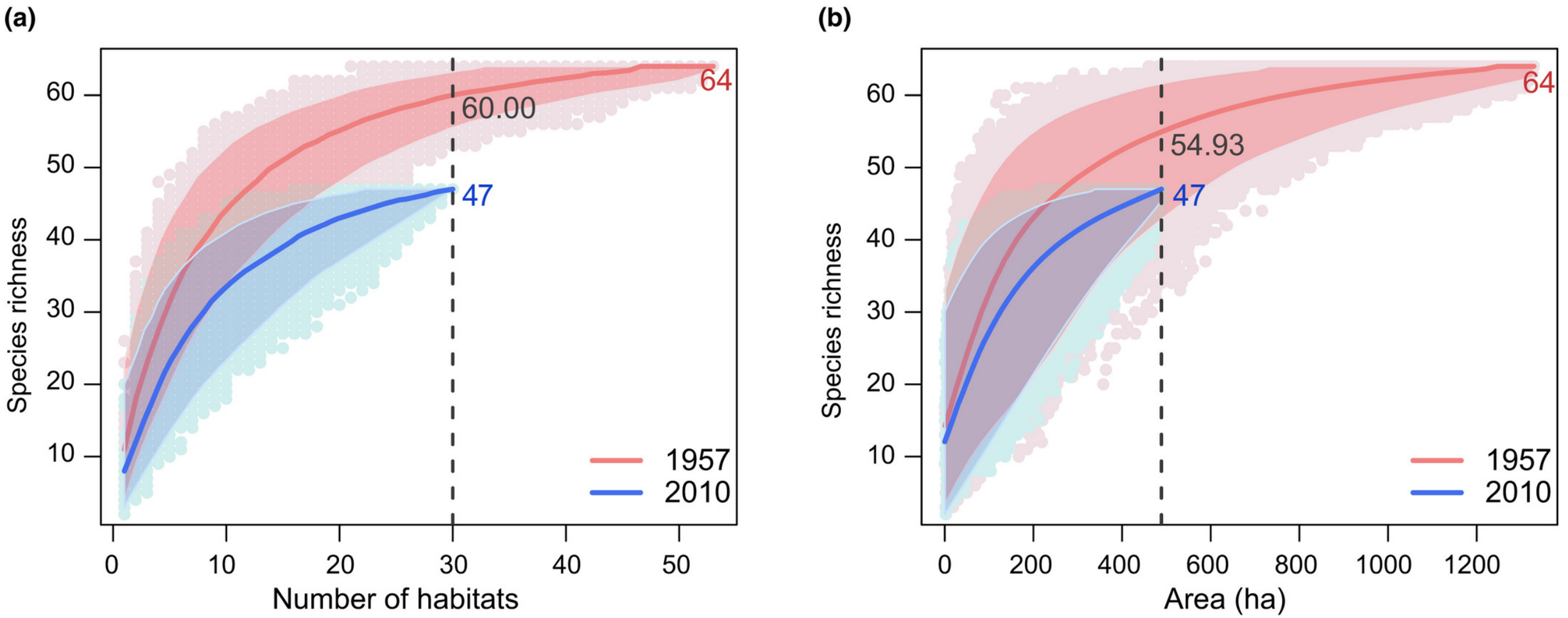
DISPERSAL

- Gene flow
- Species expansion
- Population persistence
- Invasions?

contagion is a measure of clumpyness of the patches ie. how much edge is there

Habitat loss: species-area curve

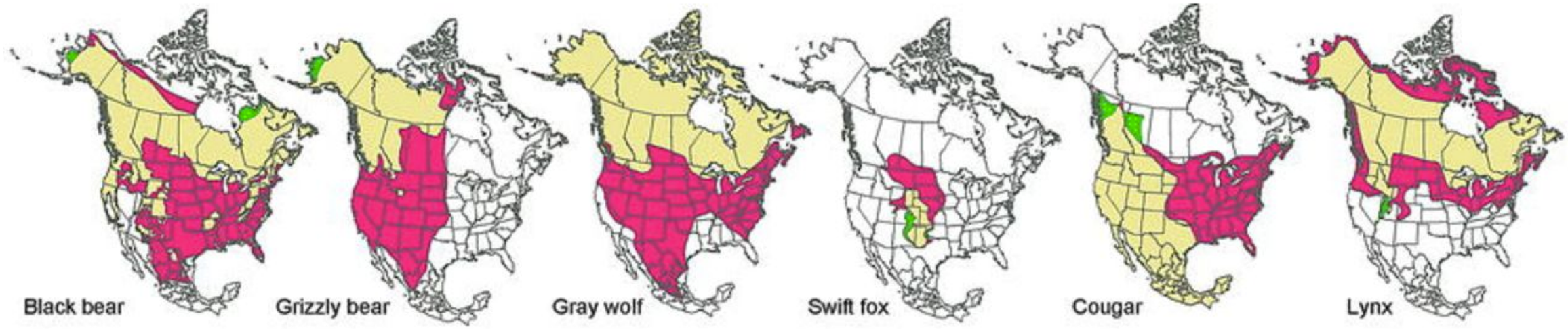


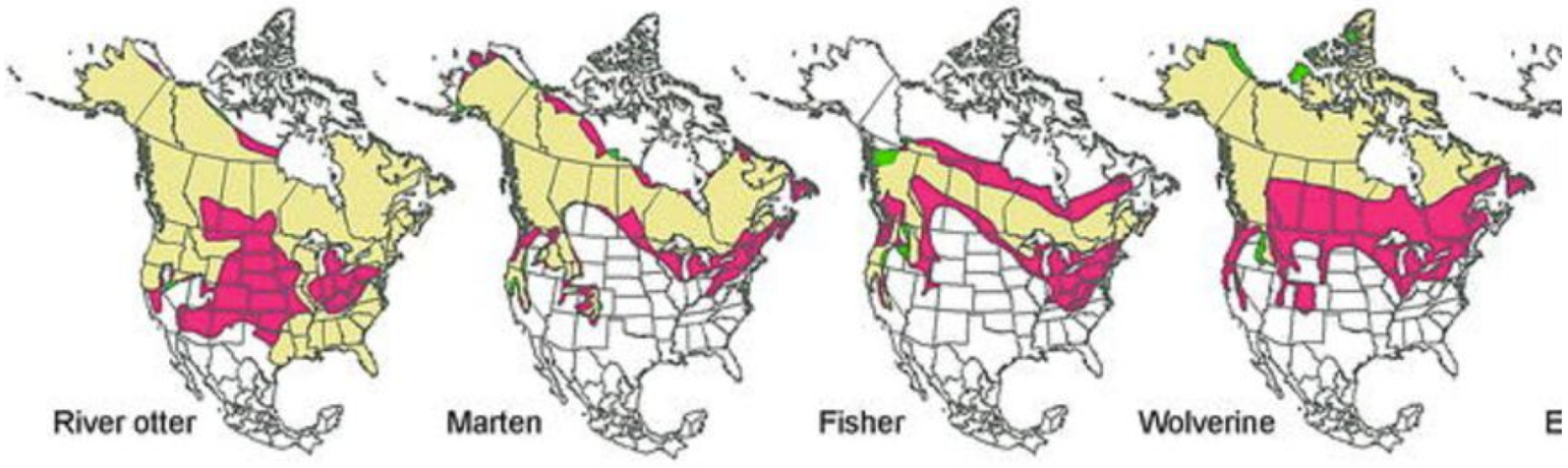


Temporal changes in invertebrate species in 30 ponds spanning six decades of habitat loss to show that both regional and local species richness declined, indicating that species loss is compounded by habitat loss via connectivity loss, and not a result of a sampling process or changes in local environmental conditions

Horváth et al 2019. Habitat loss over six decades accelerates regional and local biodiversity loss via changing landscape connectance

Habitat loss: Range contractions





- 43 North American carnivores and ungulates historic and current ranges
- 17 > 20% contractions

Laliberte and Ripple 2004

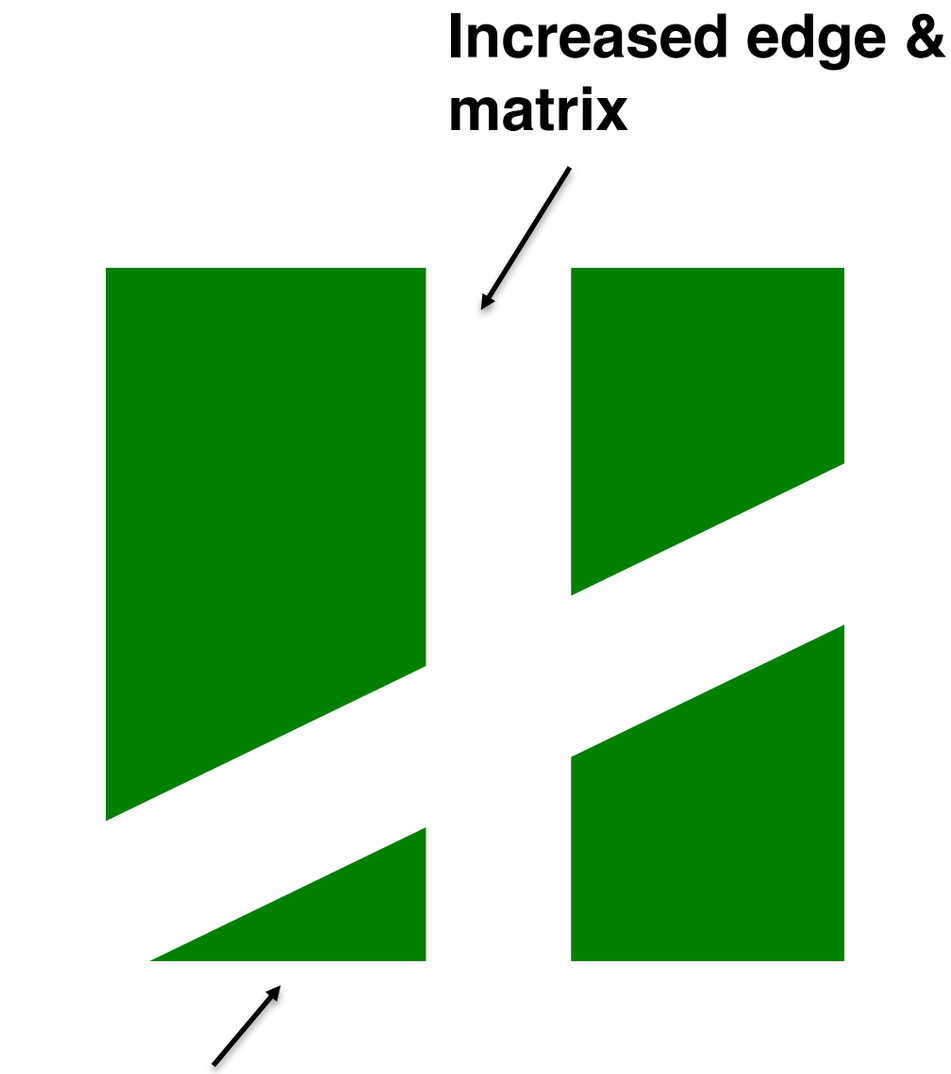
Fragmentation effects

- May enhance invasive spread (in effect, disturbed sites become less fragmented as habitat fragmentation increases)

- Can be strongly a function of:
  - dispersal ability, behavior, movement, etc.
  - Abundance & spatial arrangement of habitat

- Hard to consider fragmentation effects without consideration of the organism of interest

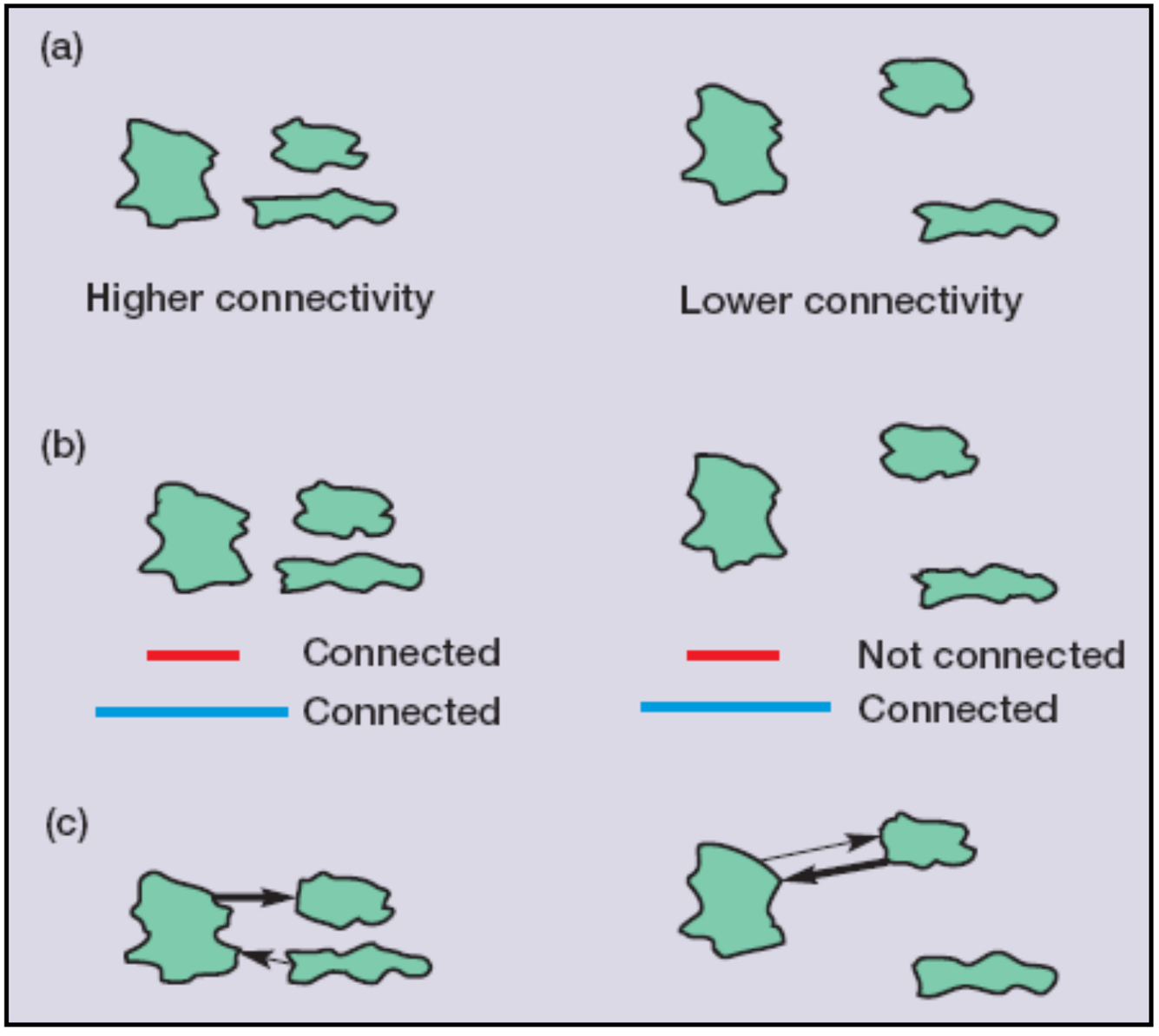
Negative effects of fragmentation



How is connectivity measured?

Three ways:

(a) *Structural connectivity* - depends on physical attributes of landscape elements.



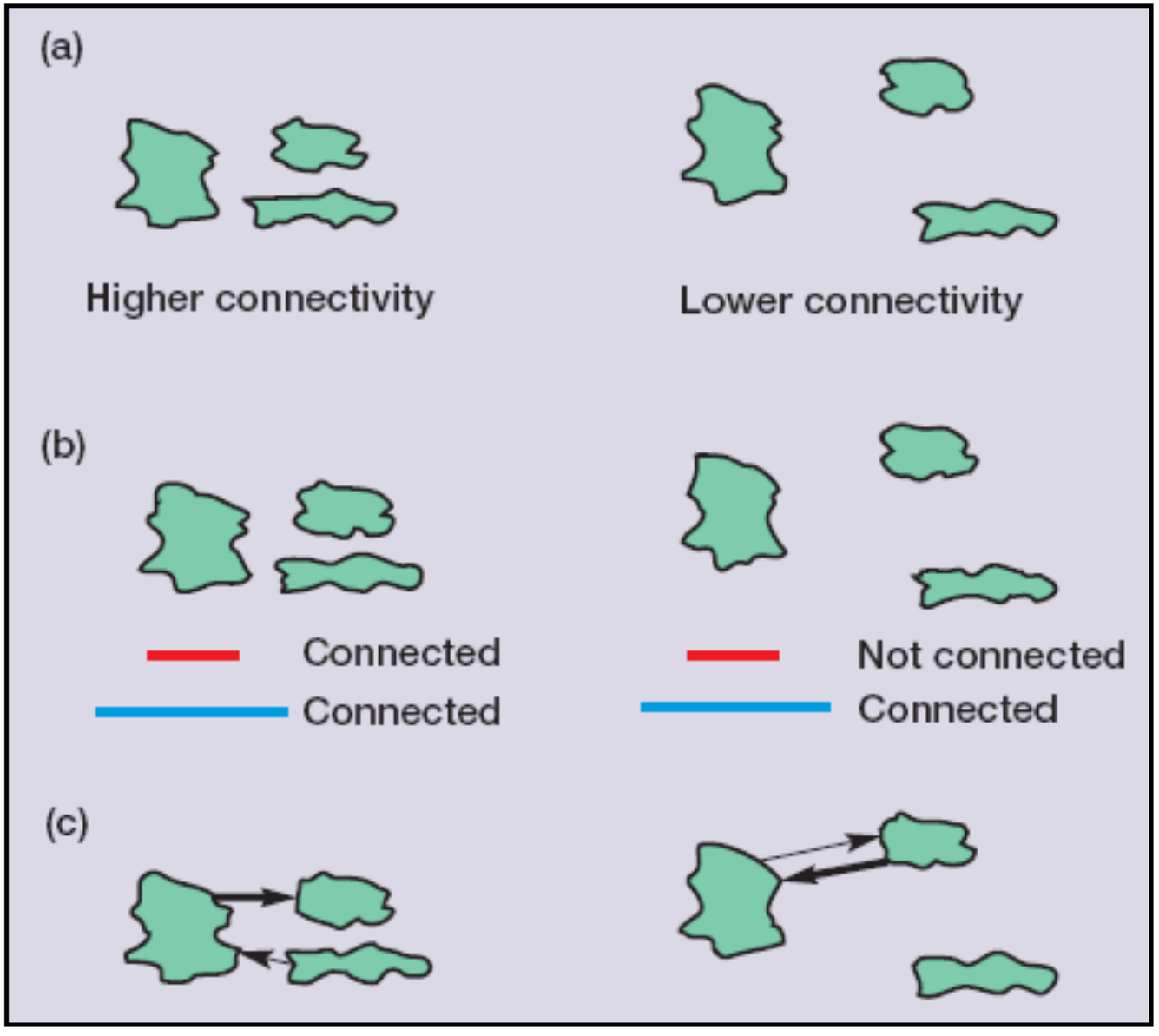
Calabrese & Fagan 2004

How is connectivity measured?

Three ways:

(a) *Structural connectivity* - depends on physical attributes of landscape elements.

(b) *Potential connectivity* - depends on physical attributes but also dispersal ability of focal species.



(Calabrese & Fagan 2004)

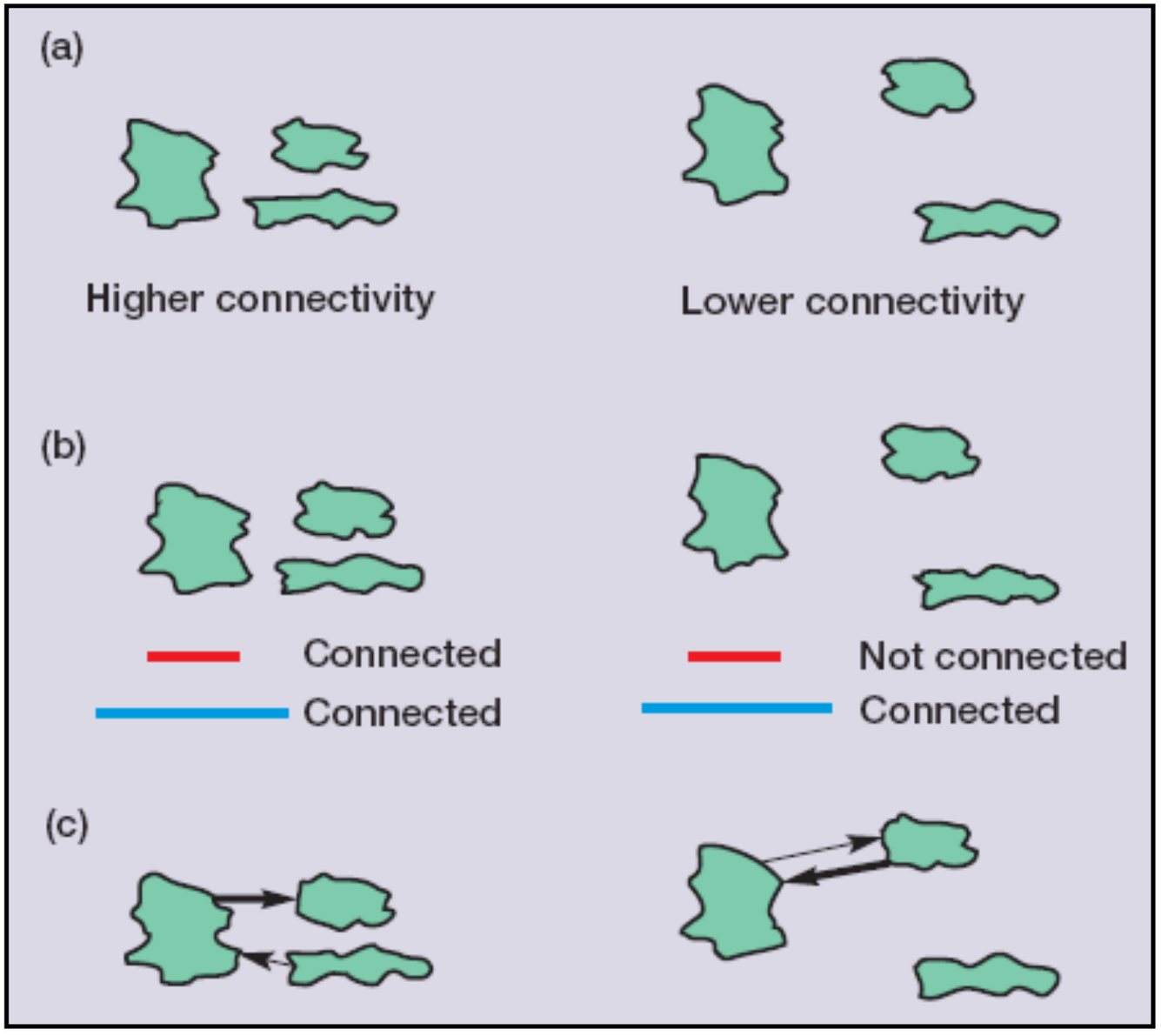
How is connectivity measured?

Three ways:

(a) *Structural connectivity* - depends on physical attributes of landscape elements.

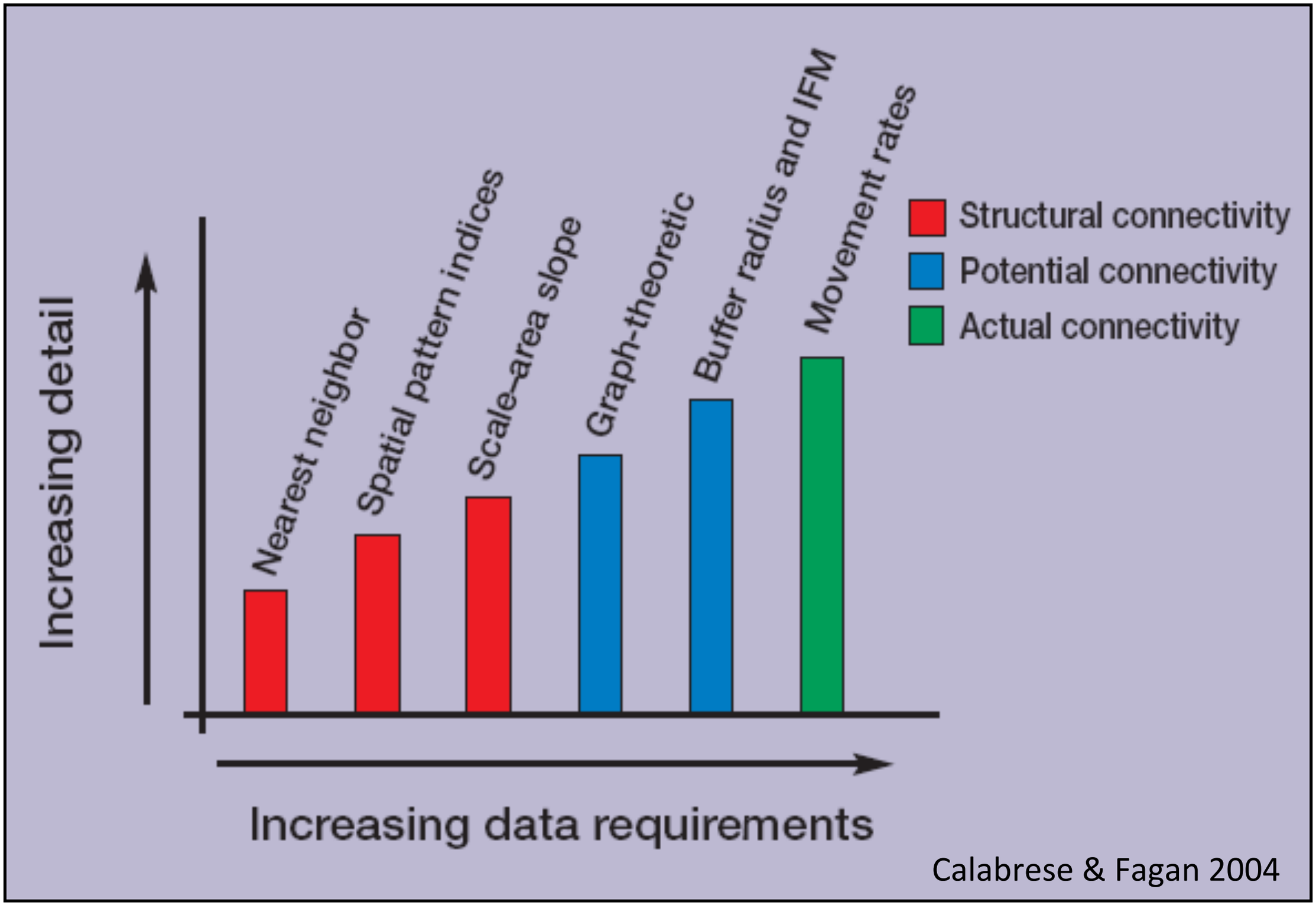
(b) *Potential connectivity* - depends on physical attributes but also dispersal ability of focal species.

(c) *Actual connectivity* - based on observed movement pathways.



(Calabrese & Fagan 2004)

Measures of connectivity



Calabrese & Fagan 2004

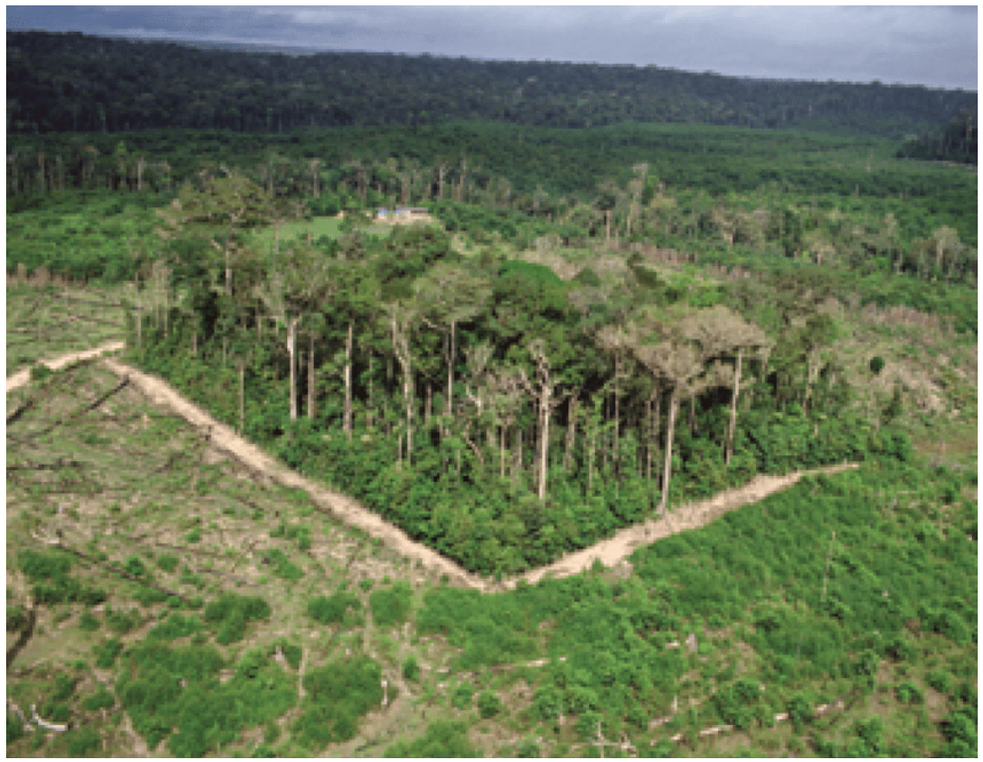
Studying the influence of connectivity on process

Three broad approaches

1. Experiments
2. Simulation models
3. Empirical data / pattern analysis
    - Animal movement data
    - Range expansion (invasive species, range shifts)

Biological Dynamics of Forest Fragments Project (BDFFP)

- 1979- present, largest and longest-running study of habitat fragmentation with data from the continuous forest before fragments were created
- **Impacts of habitat isolation, edge effects, and movement corridors**
- To date over 760 published studies of the effects of fragmentation

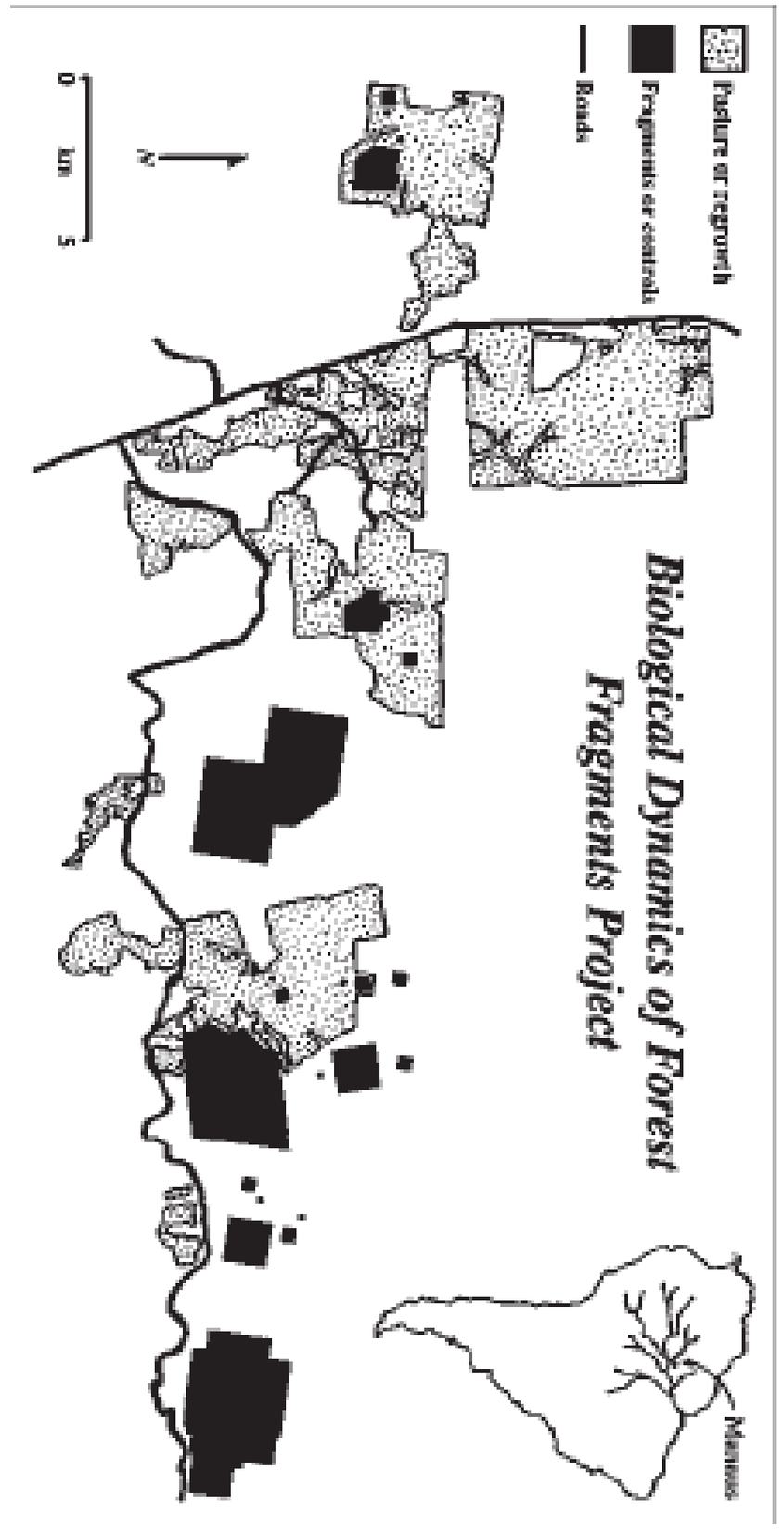


70 km north of Manaus, Brazil

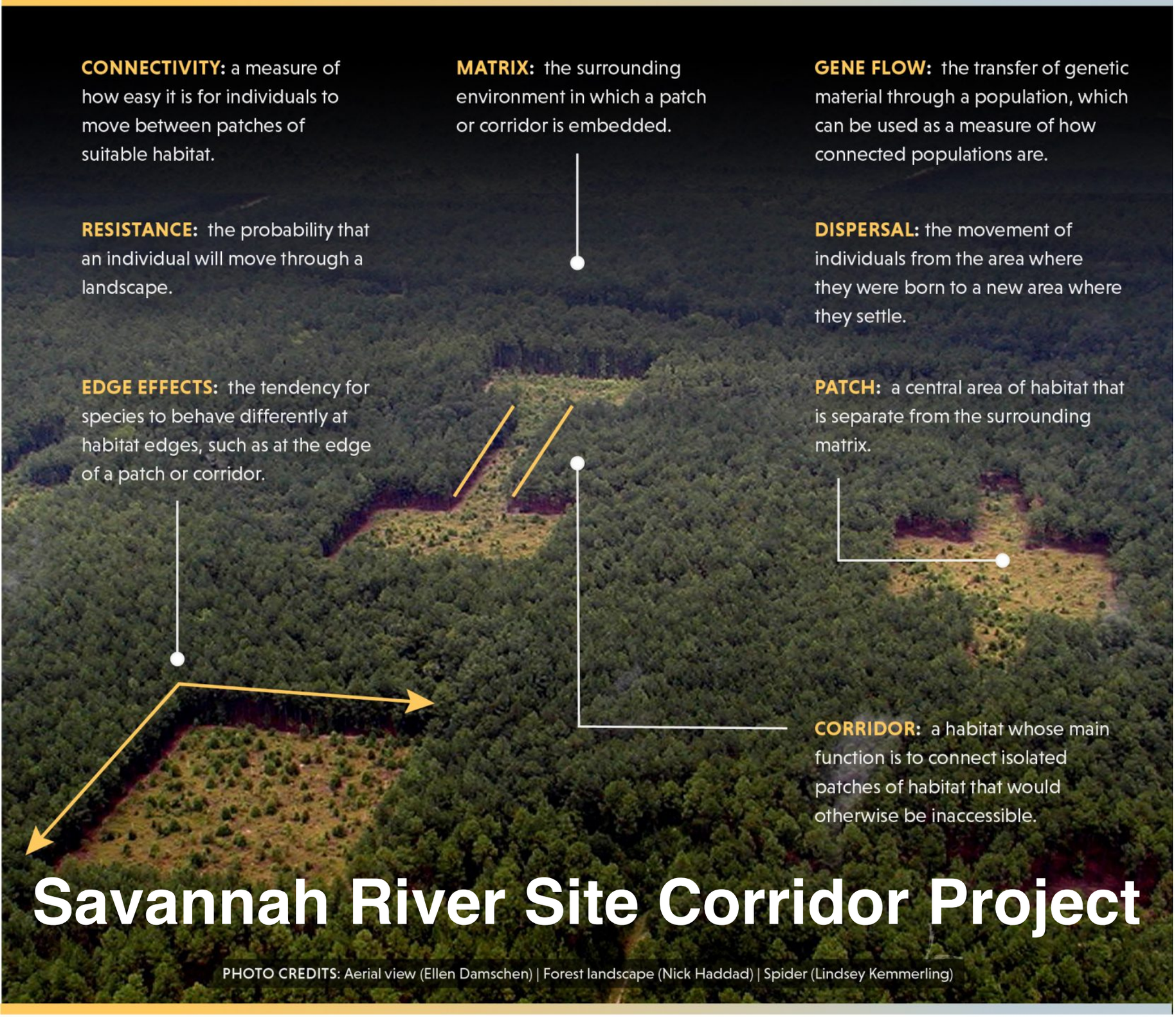
https://www.amazonbiodiversitycenter.org/

What did they find?

- Many species are naturally rare and missing entirely or have little chance of long-term survival
- Edge effects are a prominent driver
- Matrix surrounding fragments has changed over time, (cattle pastures, clear cuts, secondary regrowth)
- Rare weather events have had strong impacts with lasting change
- Large-scale environment exacerbates fragmentation effects
- Current work: broad landscape dynamics, forest regeneration and restoration, global-change



Laurance et al 2017 Biological Reviews



CONSERVATION CORRIDOR · Wilburforce Foundation · CENTER for LARGE LANDSCAPE CONSERVATION · MICHIGAN STATE UNIVERSITY · NSF

http://nickhaddadlab.com/landscape-corridors/srs-corridor-project/

Since 1993, large landscape experiments to test for effects of corridors on plant and animal dispersal, population persistence, and biodiversity

<u>What have they found?</u>

Corridors:

- increase dispersal of plants and animals
- Corridors increase plant diversity

Corridors create habitat edges, which can have negative effects

Edges:

- can cause birds to nest in places where their nests are more likely to fail, creating ecological traps
- create unsuitable habitat for butterflies

Studying the influence of connectivity on process

Three broad approaches

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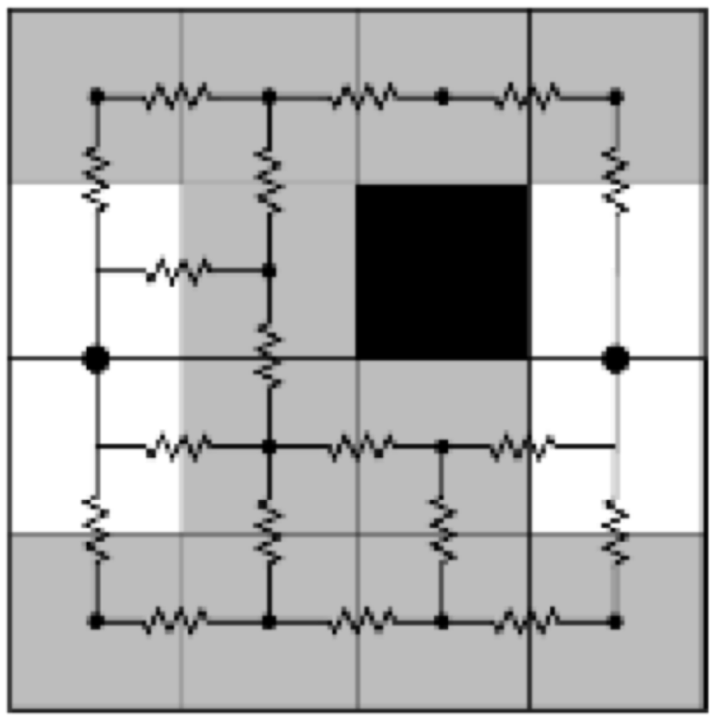
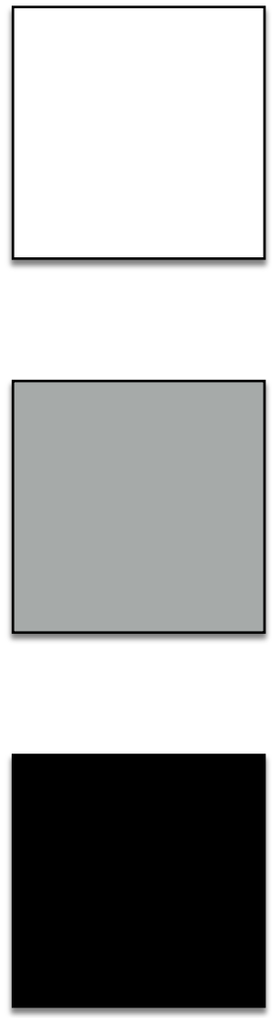
Circuitscape

Model species movement and gene flow across fragmented landscapes, and to identify areas important for connectivity conservation

Incorporates all possible pathways across a landscape simultaneously





Habitat

Matrix

barrier

https://circuitscape.org/

Global mammal movement probability between terrestrial protected areas

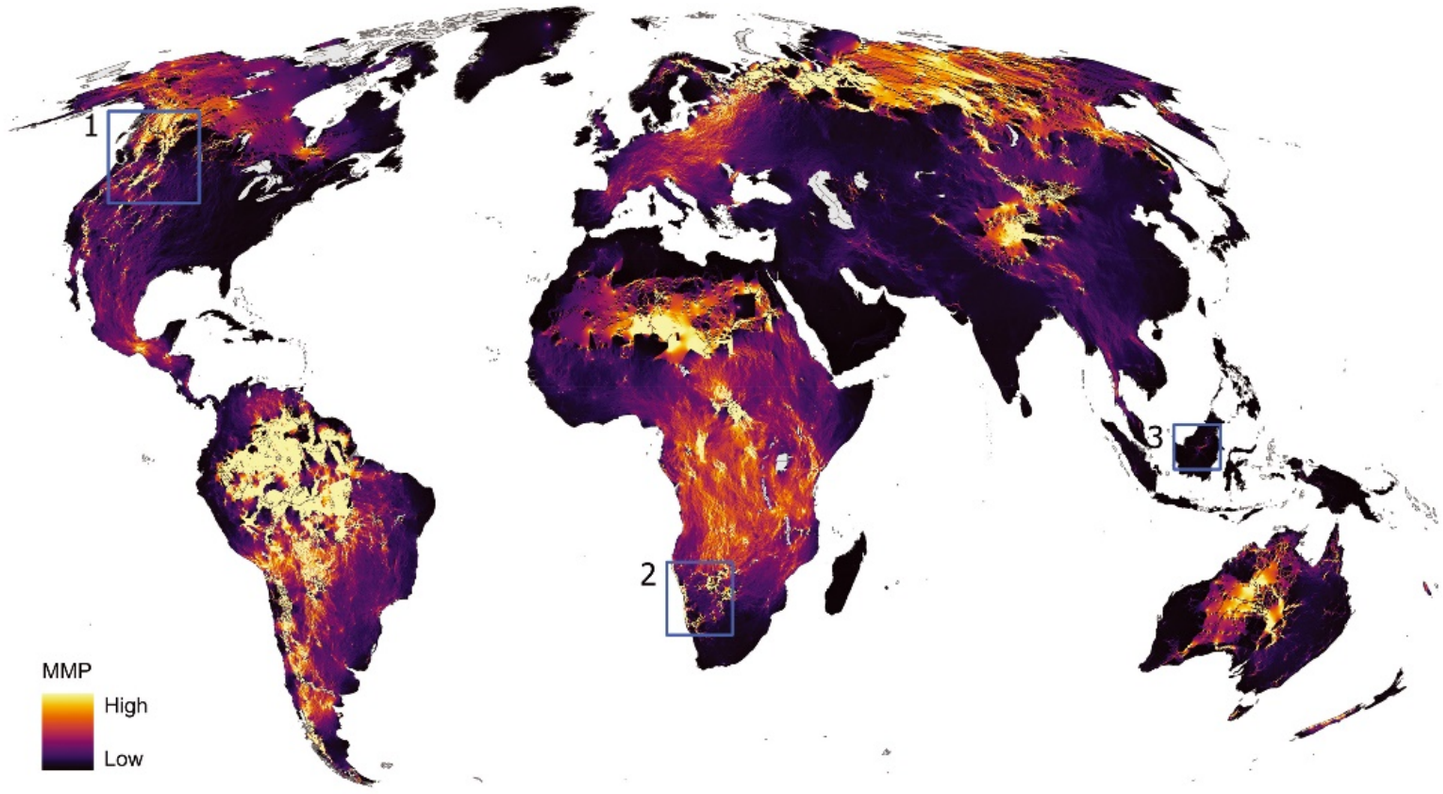
Yellow = high movement prob.

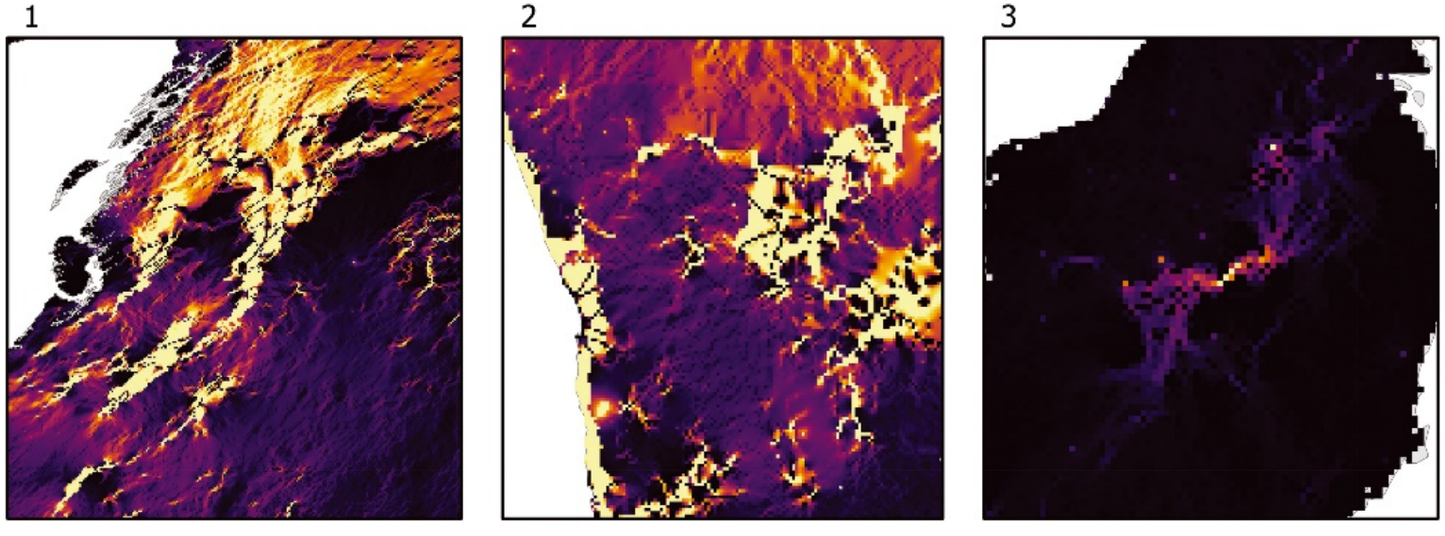
- concentrated within corridors between less permeable
- large blocks within a network of large PA (Amazon basin)

Orange and Purple= dispersed movement prob. across many pathways

- both concentrated and dispersed flow are important to connectivity
- dispersed areas have a lower risk of total loss of connectivity

Black = areas of lower flow at global scale





Yellowstone to Yukon corridor

Brennan et al., Science June 2022

Increasing & restoring connectivity: Corridors

Studying the influence of connectivity on process

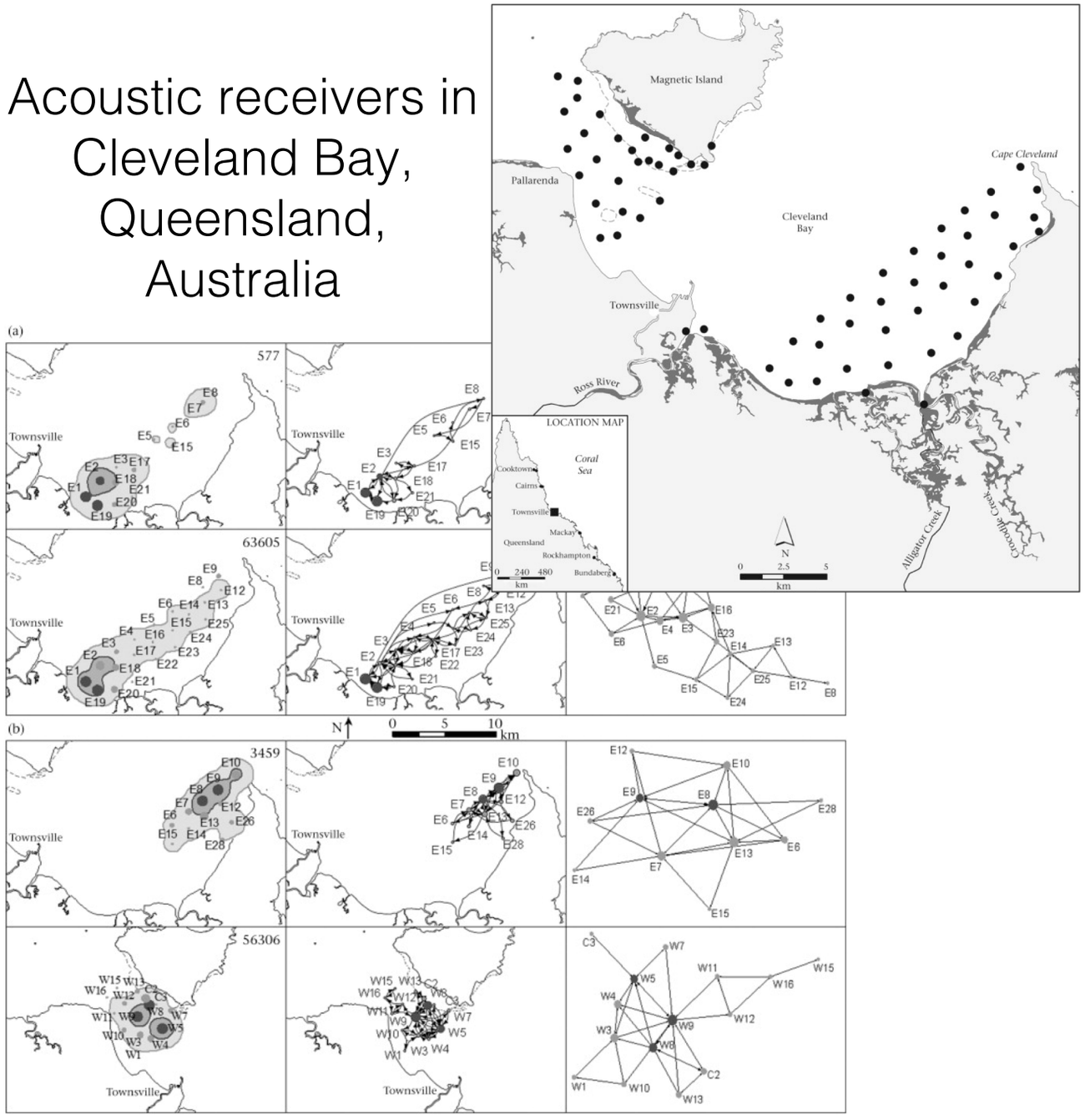
Three broad approaches

1. Experiments
2. Simulation models
3. Empirical data / pattern analysis
    - Animal movement data
    - Range expansion (invasive species, range shifts)

Marine connectivity and flows

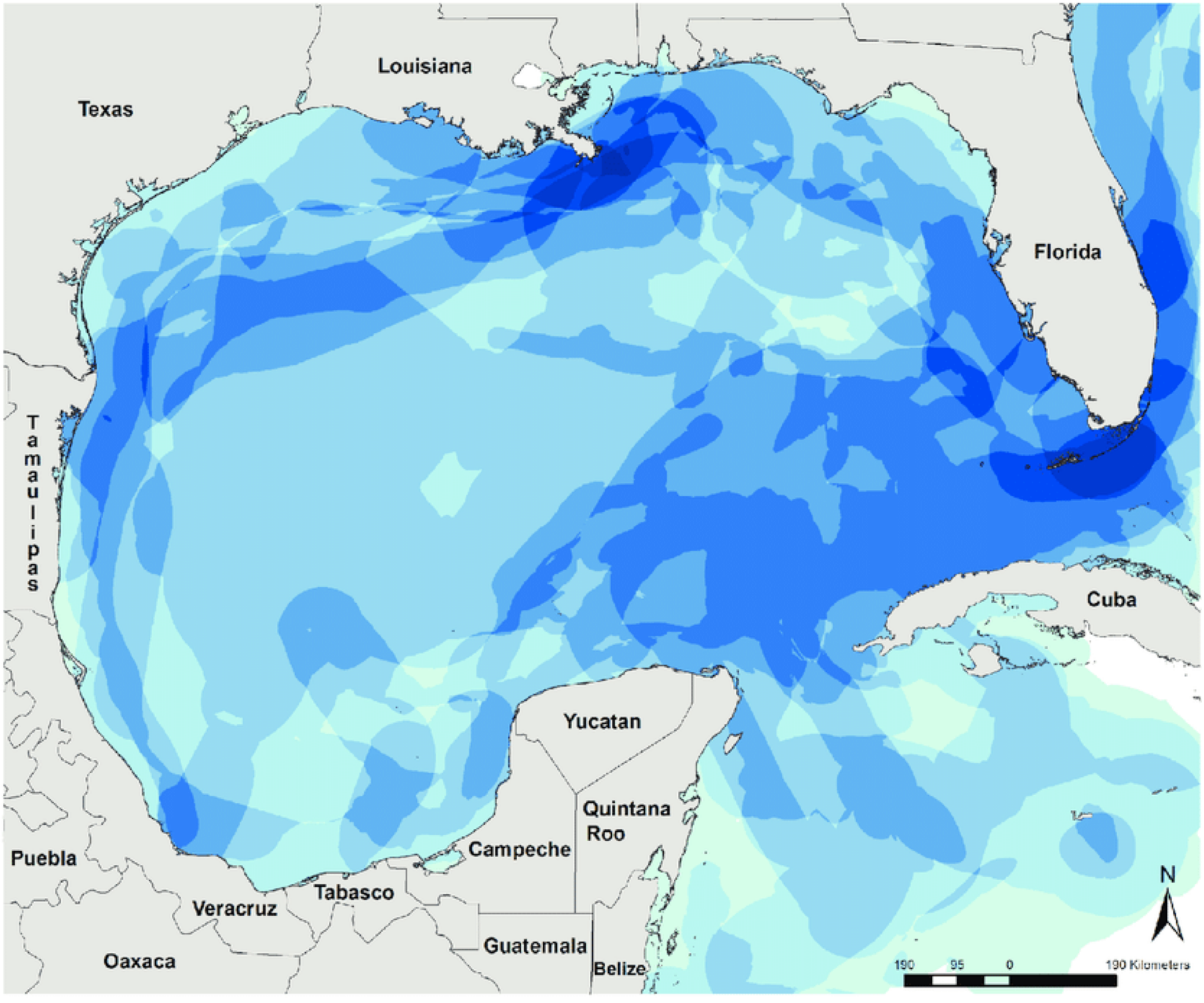
- Network analysis using an array of acoustic monitors as nodes and marine animal tracks as edges
- movement pathways within activity spaces to identifying movement corridors
- may help inform management plans to maintain or restore connectivity

Acoustic receivers in Cleveland Bay, Queensland, Australia



Lédé et al 2015 Animal Behavior

and marine mammal (1).



All Marine Species Corridors

Number of Species (n = 10)

1 2 3 4 5 6 7 8

The Nature Conservancy
Protecting nature. Preserving life.

Created by Carly Voight, April 2015

What determines the spatial extent of landscape effects on species?

Miguet et al 2016 Landscape Ecology

Reading for Wednesday