Quantifying Landcover Patterns

Schedule

- This week: no homework, reading and discussion for Wednesday
- Google doc posted later today in the weekly folder and linked on Slack, 8am Wednesday
- Coming up: time to start thinking about your project ideas
- Oct 10 (Mon) Project Proposals

Learning Objectives

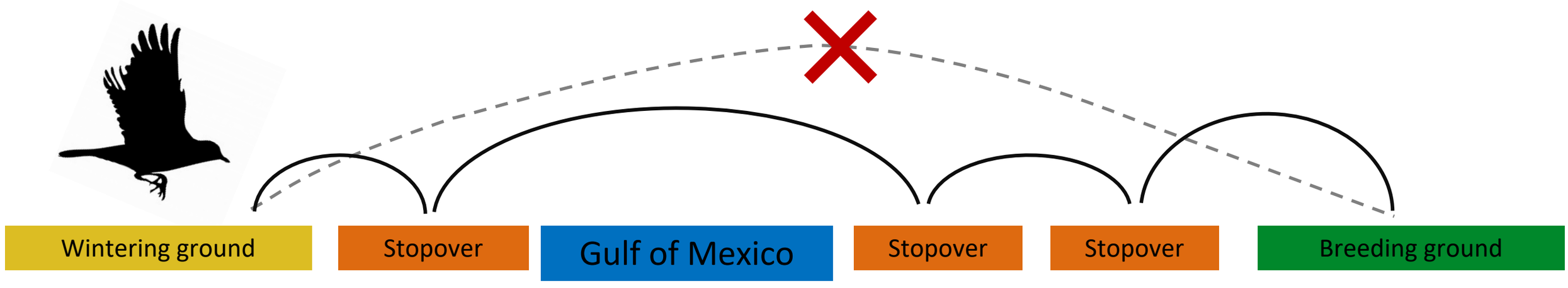
- Gain familiarity with the commonly used metrics for composition and configuration
- Distinguish between metrics that describe patch, class, or entire landscape extent
- Be able to describe the ways of thinking about environmental variability in landscapes

Outline

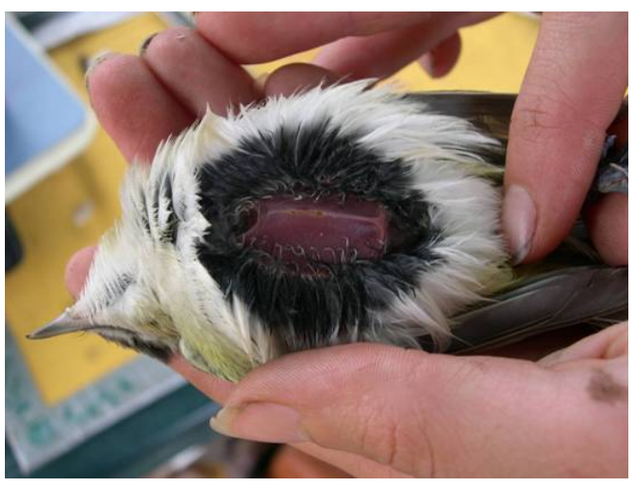
- An Example Study
- What are the Metrics?
- What level of complexity is appropriate for quantification of landscape variability?
- Why care about landscape pattern?

Pattern affects ecological processes:
How do landscapes affect birds during migration?

Intercontinental Migration

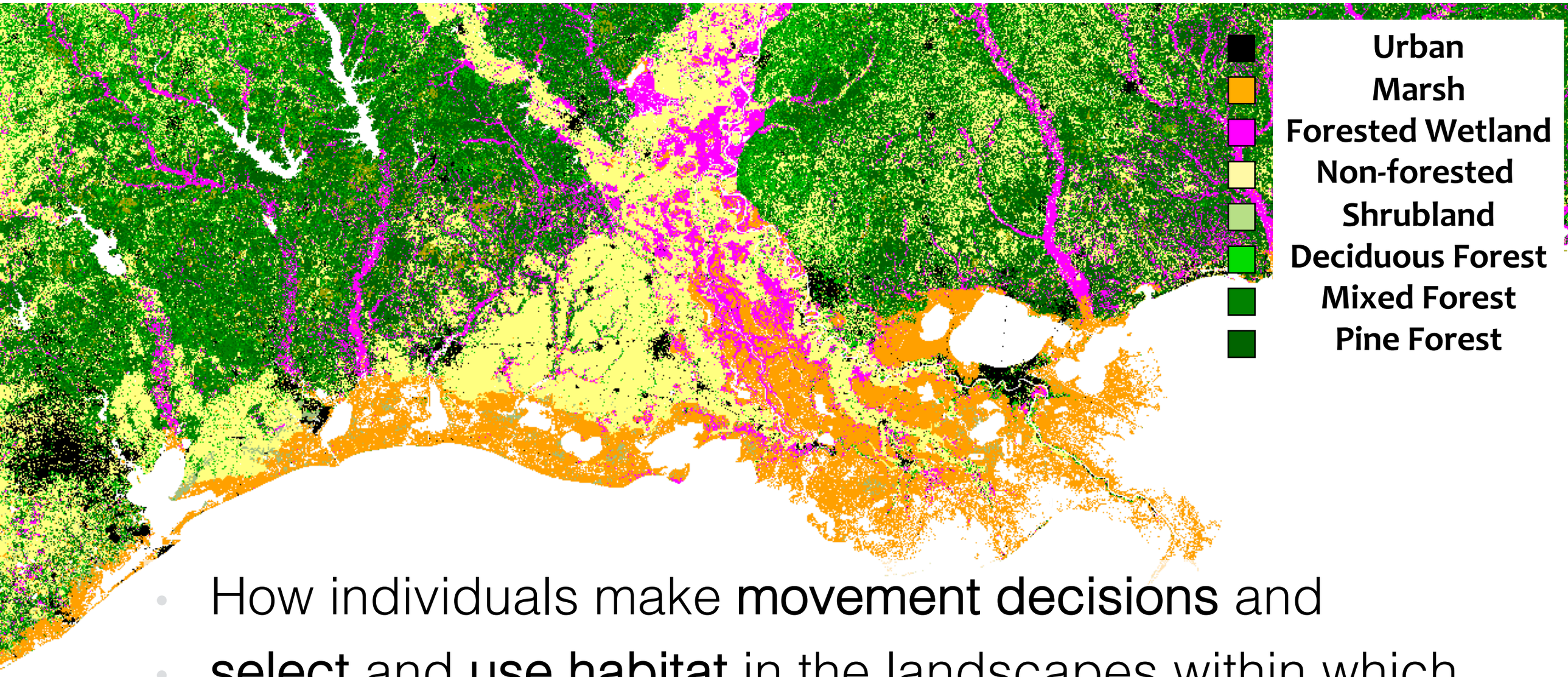


- Frequent stops during migration
- Time spent at stopover habitat > time spent flying
- Replenish depleted fuel reserves for flight



Stopover Landscapes

How will landscape change impact migrating birds?



- How individuals make **movement decisions** and
- **select** and **use habitat** in the landscapes within which they must refuel?
- What are the landscape **consequences** in **time** and **condition** of those behaviors?

Approach

1. Understand the influence endogenous and exogenous factors on movement behavior during stopover

   Translocation experiment and tracking (field work)

2. Quantify the effects of changing landscapes on movement and refueling

   Spatially explicit individual-based model (simulation modeling)

Kistachie National Forest

De Soto National Forest

Johnsons's Bayou

Gulf of Mexico

0 75 150 300 Km

N

Individual-based simulation model

Input

A. Import cellular landscape

-mass gain values corresponding to habitat types

-simulated patterns to test predictions

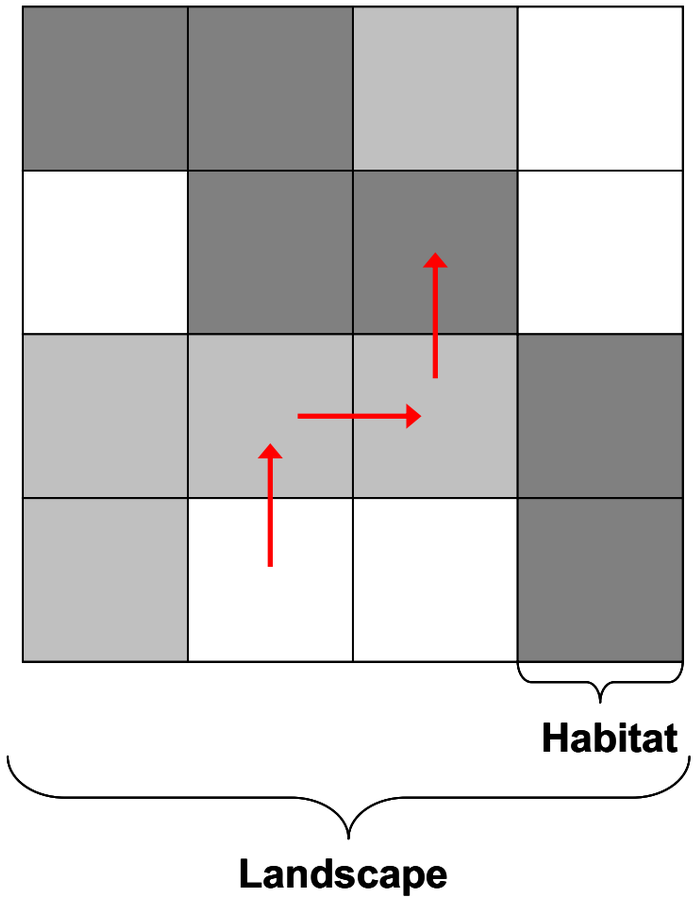
B. Initialize bird

-duration of simulation, 12 hour days

-starting location on map, random or defined

-arrival condition of bird

-number of map cells to move on hourly time steps as a function of habitat, energetic condition, day of stopover and hour of day (45 integers).



Hourly steps:

Movement rules

Gain calculated

Output

A. Mass change

B. Movement pattern

white is simulation track of flight

Legend

Bird 881

Release

Four_simulations

Hardwood

Mixed

Pine

0.5

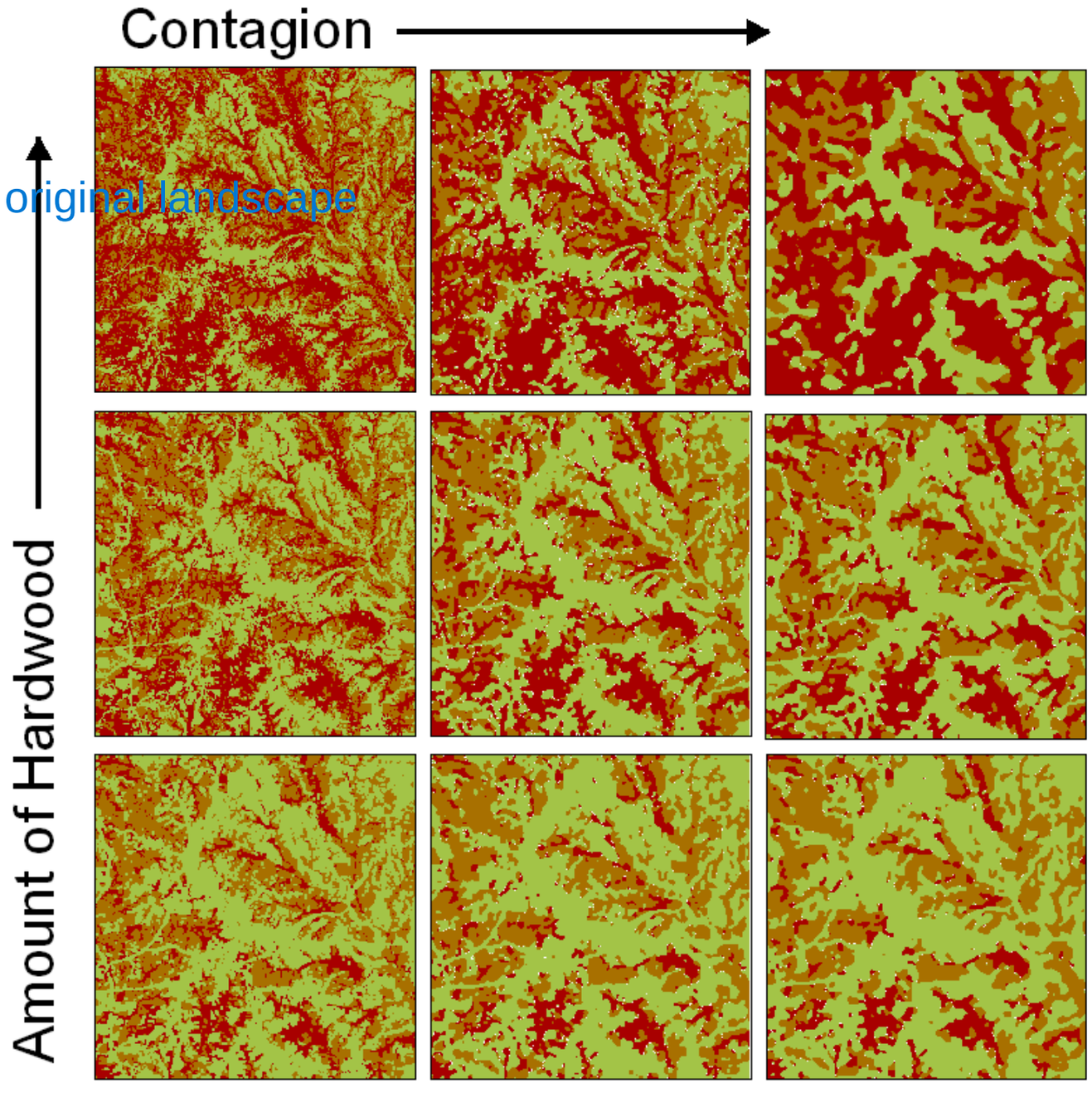
Km

Factorial simulation: composition and configuration of hardwood

Factorial simulation results: amount hardwood and contagion

A. Fuel deposition rates positively influenced by the amount of
   1. hardwood forest cover
   2. habitat contagion

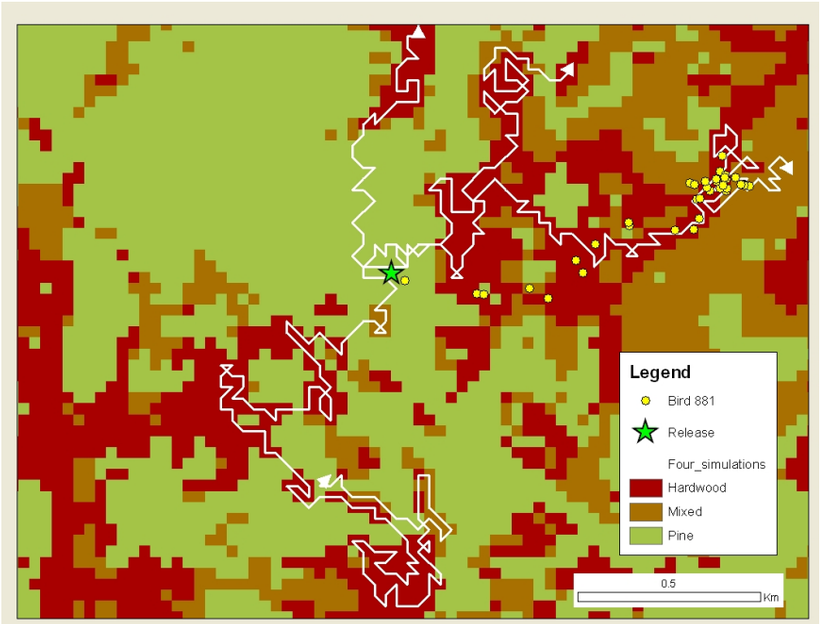
B. Fuel deposition rates are greater for migrants that "arrive" in hardwood habitat



Definitions

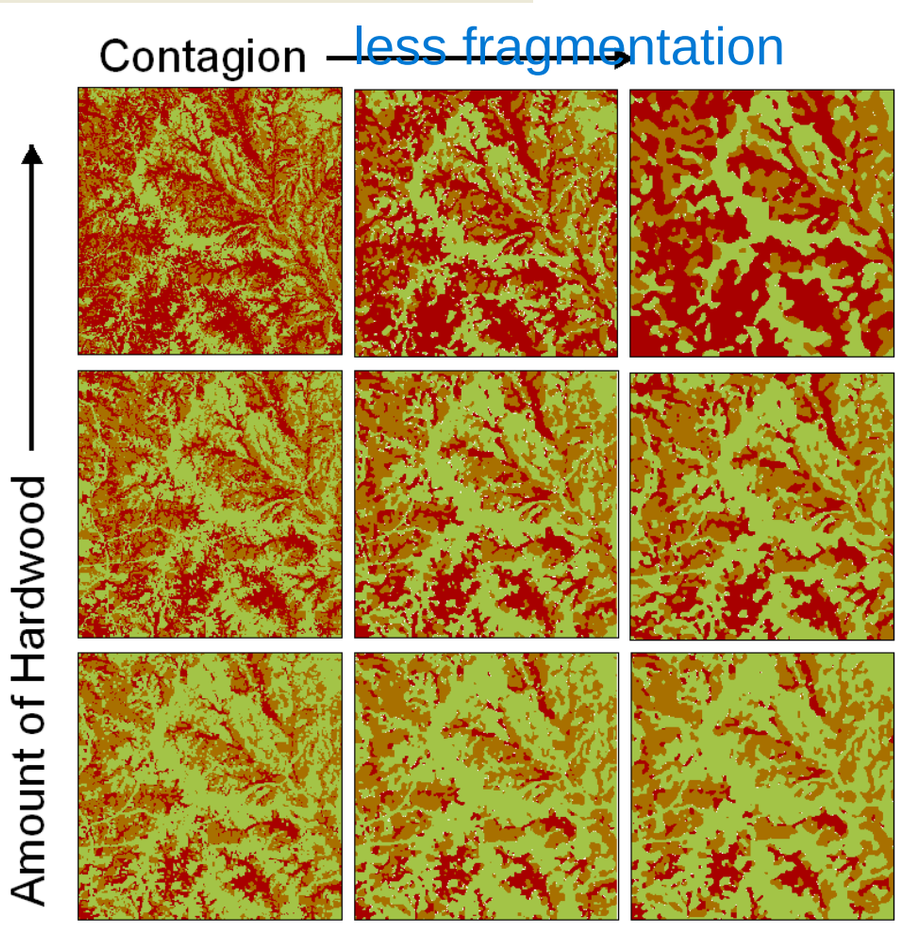
Composition- variety and abundance

- number of habitat types present - N
- proportion of each habitat type - p



Configuration- spatial characteristics of elements

- spatial arrangement
- patch shape/size

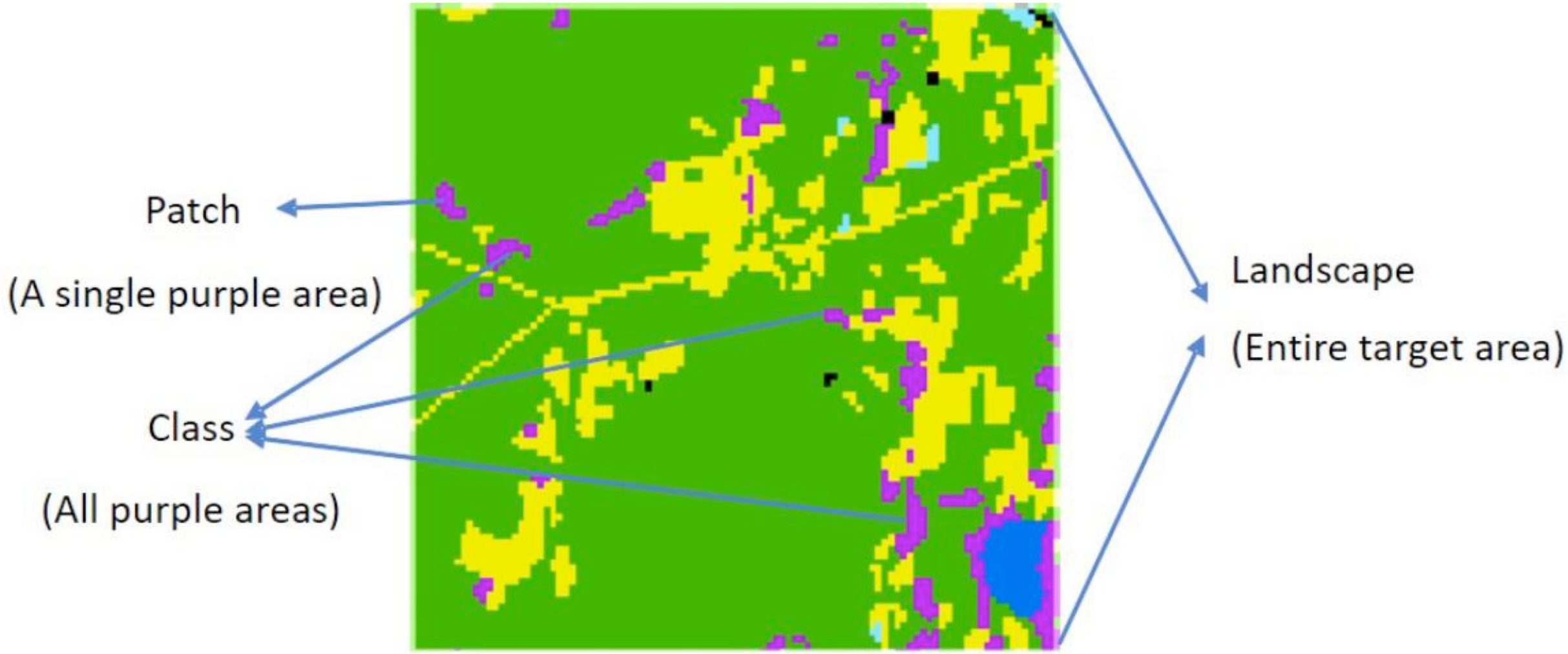


Definitions

Patch- relatively discreet area containing homogenous conditions (internal variation is ignored)

Class- land cover type of patches in the landscape

Matrix- non-focal land cover types in the landscape



Metrics

	Patch	Class	Landscape
Information about	each patch in a landscape	all patches of a given class	pooled classes/patches over an entire extent
Useful for information about	specific locations on a landscape	specific to a particular class type in a landscape	heterogeneity of the entire landscape
Example question:	Does a species select nest locations in some minimum size of forest patch?	Is there a threshold level of forest fragmentation beyond which a species cannot disperse between forest patches?	Is biodiversity greater in landscapes with more diverse composition and/or configuration?
Also…	Generates lots of information (each patch)!	Most interpreted as fragmentation indices because they measure fragmentation of a particular class type	There are many many landscape metrics because they are presumed to play the primary role in ecological processes

Scale	Acronym

Area metrics

Patch	AREA
Patch	LSIM
Class	CA
Class	%LAND
Class/landscape	TA
Class/landscape	LPI

Patch density, patch size and va

Class/landscape	NP
Class/landscape	PD
Class/landscape	MPS
Class/landscape	PSSD
Class/landscape	PSCV

Edge metrics

Patch	PERIM
Patch	EDCON
Class/landscape	TE
Class/landscape	ED
Class/landscape	CWED
Class/landscape	TECI
Class/landscape	MECI
Class/landscape	AWMEC

Scale	Acronym

Shape metrics

Patch	SHAPE
Patch	FRACT
Class/landscape	LSI
Class/landscape	
Class/landscape	
Class/landscape	
Class/landscape	
Class/landscape	

Core area metrics

Patch	
Patch	
Patch	
Class	
Class/landscape	
Class/landscape	
Class/landscape	
Class/landscape	
Class/landscape	
Class/landscape	
Class/landscape	
Class/landscape	
Class/landscape	
Class/landscape	

Scale	Acronym

Nearest-neighbor metrics

Patch	NEAR
Patch	PROXIM
Class/landscape	MNN
Class/landscape	NNSD
Class/landscape	NNCV
Class/landscape	MPI

Diversity metrics

Landscape	SHDI
Landscape	SIDI
Landscape	MSIDI
Landscape	PR
Landscape	PRD
Landscape	RPR
Landscape	SHEI
Landscape	SIEI
Landscape	MSIEI

Contagion and interspersion metrics

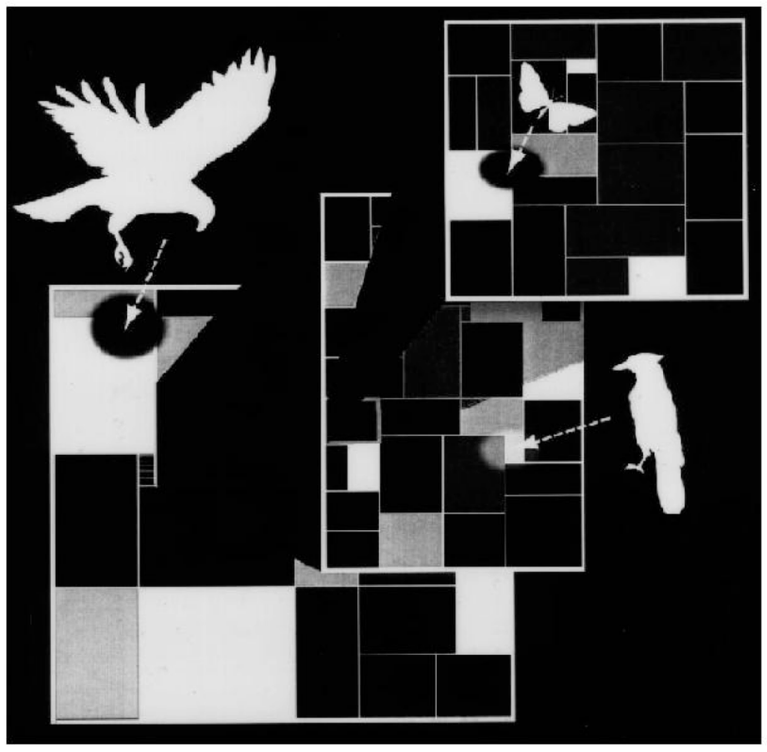
Class/landscape	IJI
Landscape	CONTAG

United States Deparment of Agriculture

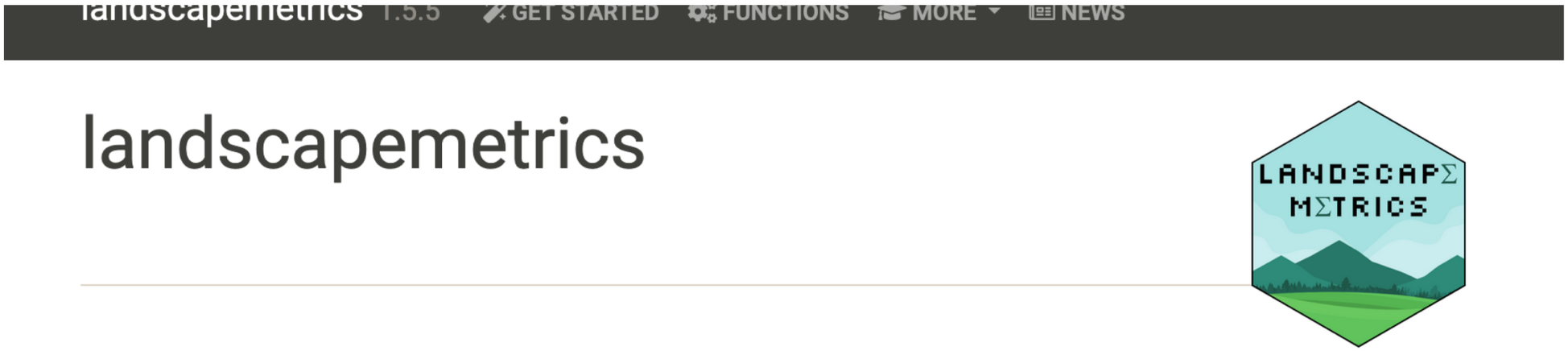
Pacific Nrothwest Research Station

General Technical Report PNW-GTR-351. August 1995

FRAGSTATS: Spatial Pattern Analysis Program for Quantifying Landscape Structure



textbook code is slighly out of date. Use this instead:



Hesselbarth, M.H.K., Sciaini, M., With, K.A., Wiegand, K., Nowosad, J. 2019. landscapemetrics: an open-source R tool to calculate landscape metrics. Ecography, 42: 1648-1657 (ver. 0).

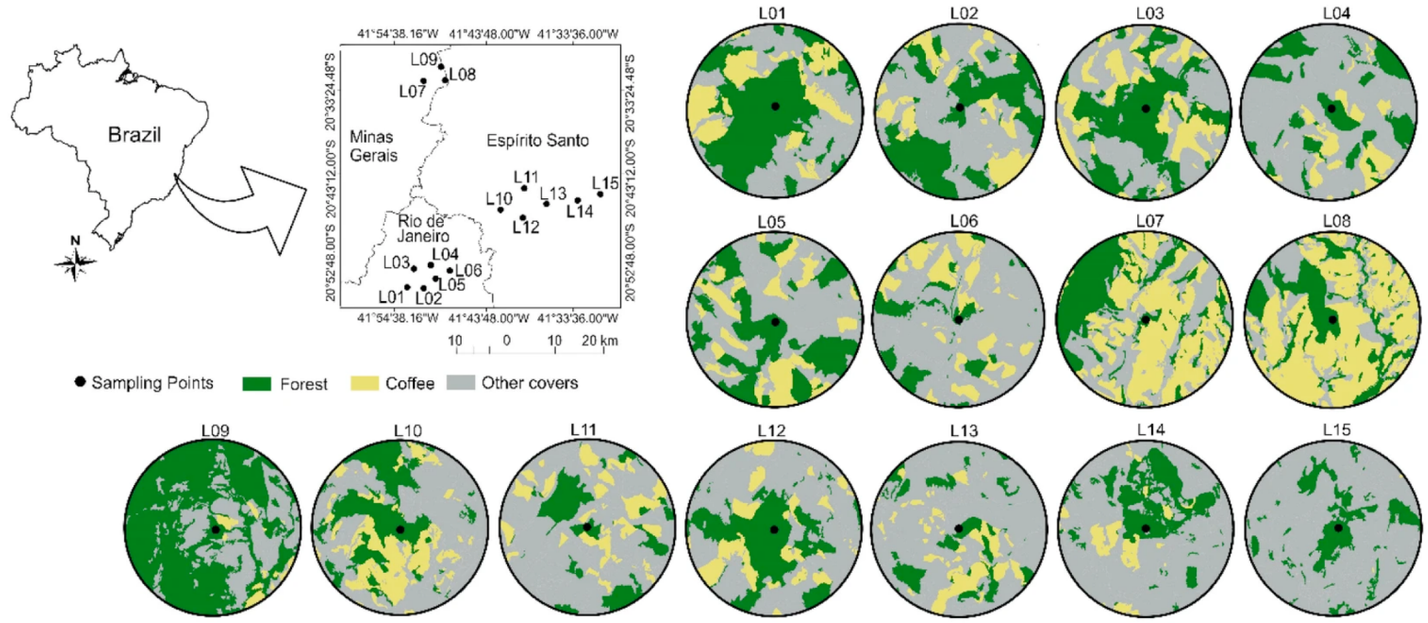
Chp. 3 code
install.packages("remotes")
remotes::install_version("SDMTools", "1.1-221")

Which metric?

- Just because it can be measured, doesn't mean you should
- Is the metric biologically relevant for the question?
- Minimize redundancy (avoid correlation)
- Capture the relevant variability in pattern (composition, configuration)

Example: Landscape Metrics

Does coffee cover surrounding forest patches affect tropical bee community structure in 15 agricultural landscapes?

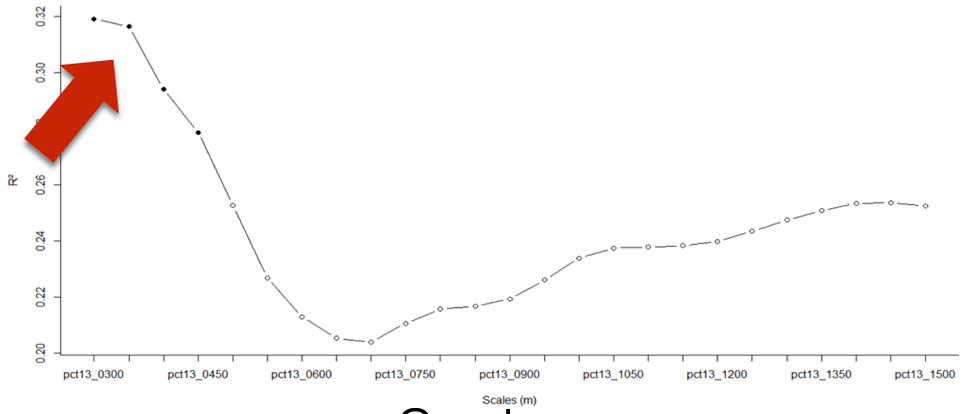


Lázaro da Silva Carneiro et al 2022 *Apidologie*

1. PLAND metric % cover class in the landscape
2. Scales: 50-m intervals from 300 to 1500 m
3. Accounted for geographic location, abundance of common and rare species

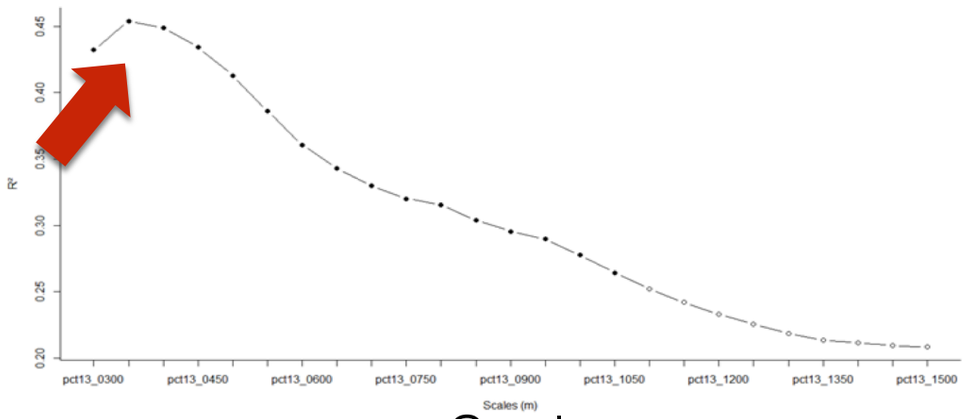
Coffee floral resources are unattractive for euglossine species

common species abundance

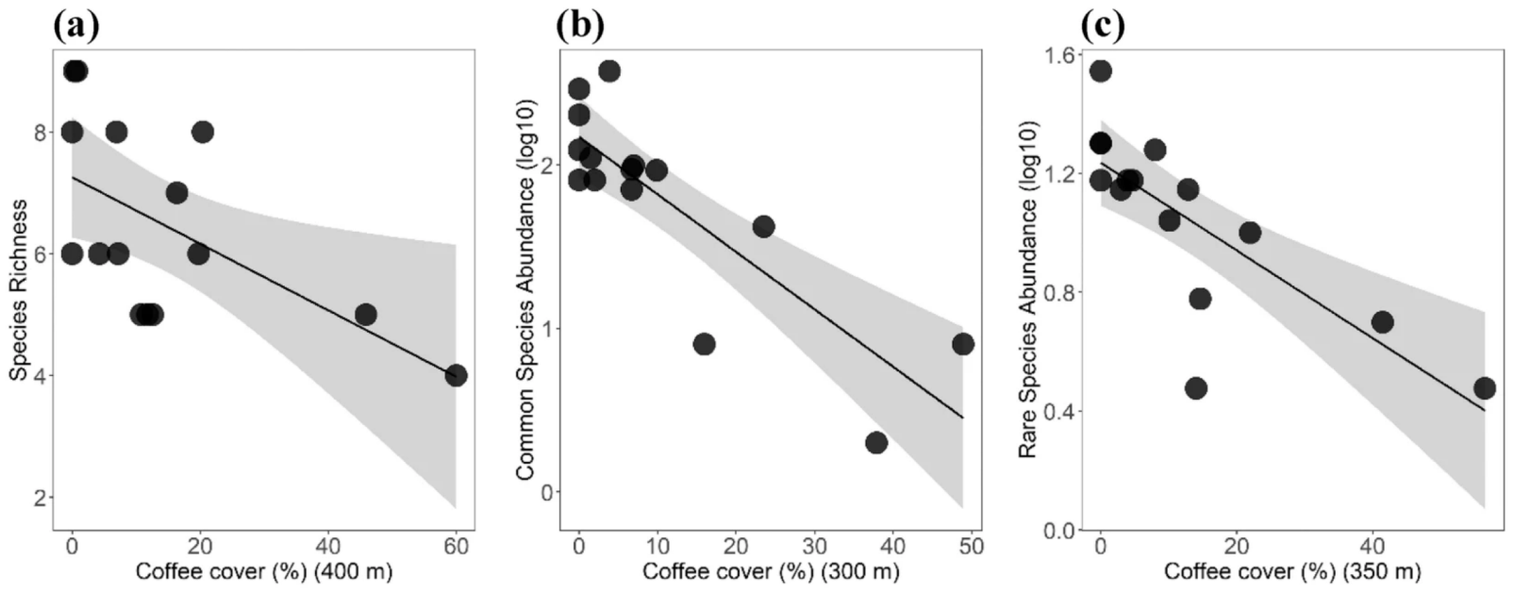


Scale

rare species abundance



Scale



the scale of effect for the coffee cover bc the bees responded at different scales to this landscape metric

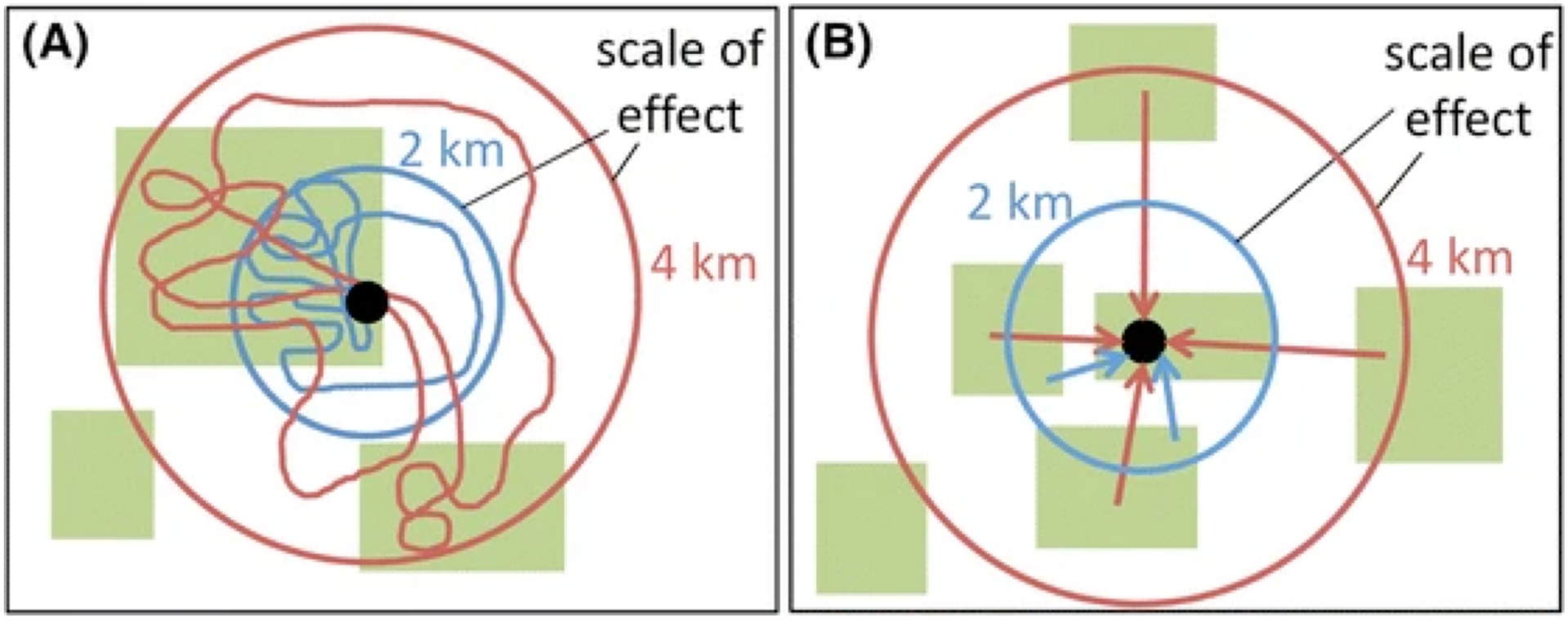
The scale of effect

is the spatial scale of a landscape attribute that best explains biological parameters

What determines the spatial extent of landscape effects on species?

Miguet et al 2016 Landscape Ecology

Reading for Wednesday



What level of complexity is appropriate for quantification of landscape variability?

Curtis 1950

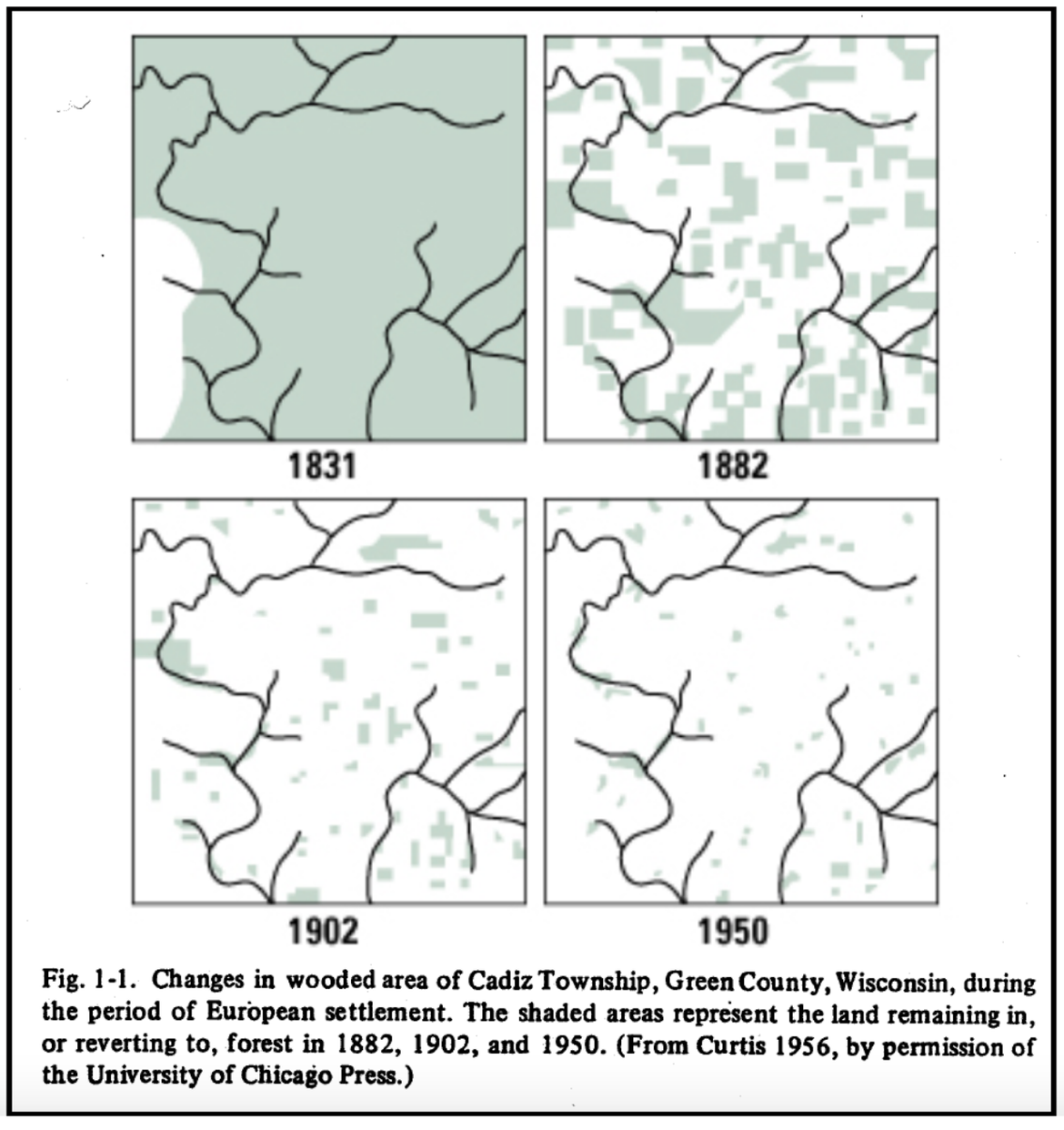
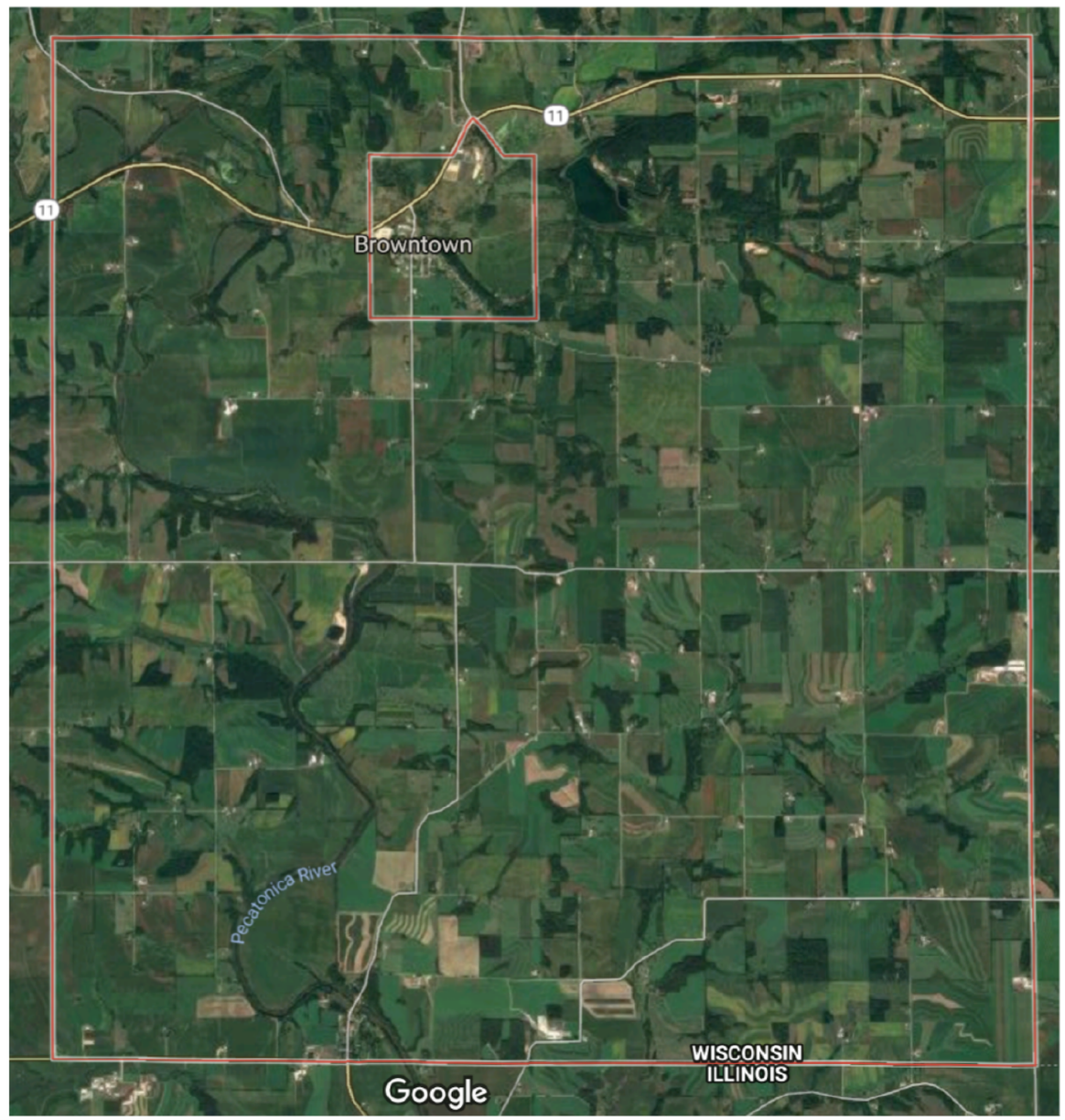


Fig. 1-1. Changes in wooded area of Cadiz Township, Green County, Wisconsin, during the period of European settlement. The shaded areas represent the land remaining in, or reverting to, forest in 1882, 1902, and 1950. (From Curtis 1956, by permission of the University of Chicago Press.)

Today



Interpretation of landscape variability

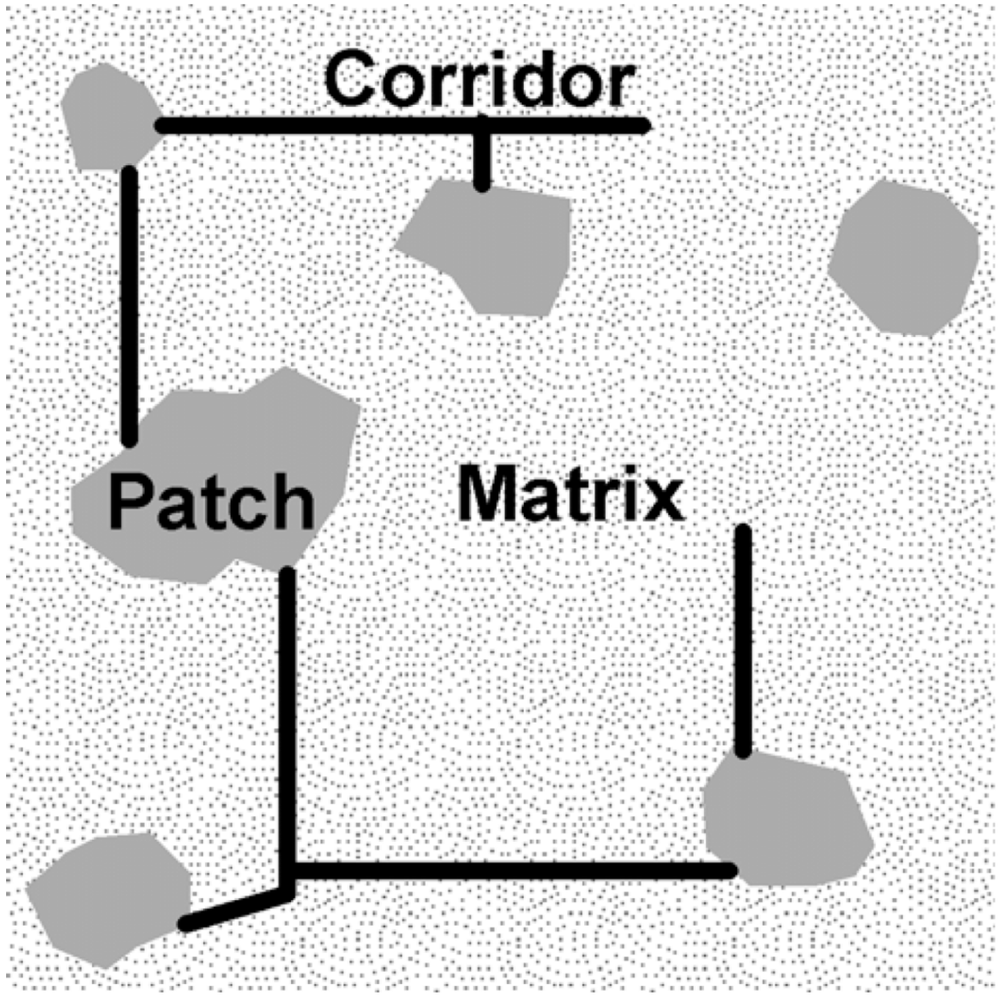
Island model

- focused on patches of a focal cover type
- ignoring all other variation
- simplest, <u>habitat loss & fragmentation</u>

Interpretation of landscape variability

Patch matrix model

- discreet habitat patches
- corridors connecting patches
- also considers the "matrix" or non-focal land cover type in the landscape generally considered unsuitable for the species of interest
- corridors and matrix permeability



Example: Patch matrix model

Does the landscape matrix mediate the effect of forest fragmentation on Neotropical birds?

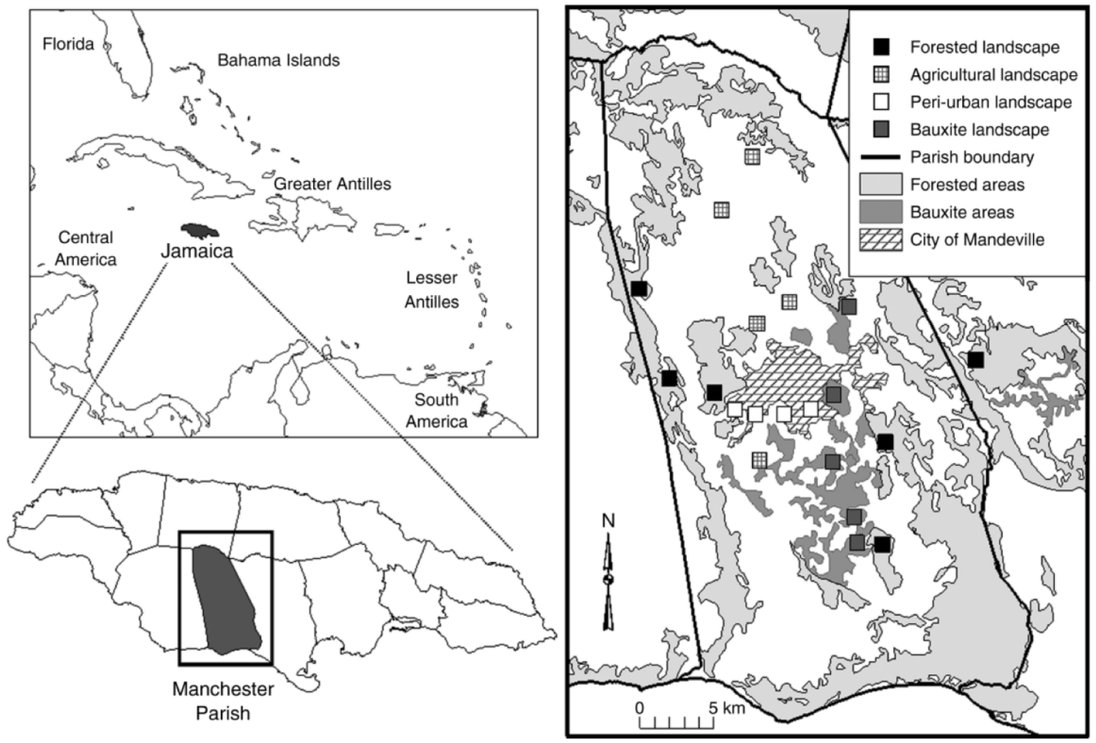


FIG. 1. Locations of the 20 1-km^2 landscapes surveyed in Manchester and Clarendon Parishes on the island of Jamaica as shown in the context of the West Indies.

Kennedy et al 2010. *Ecological Monographs*

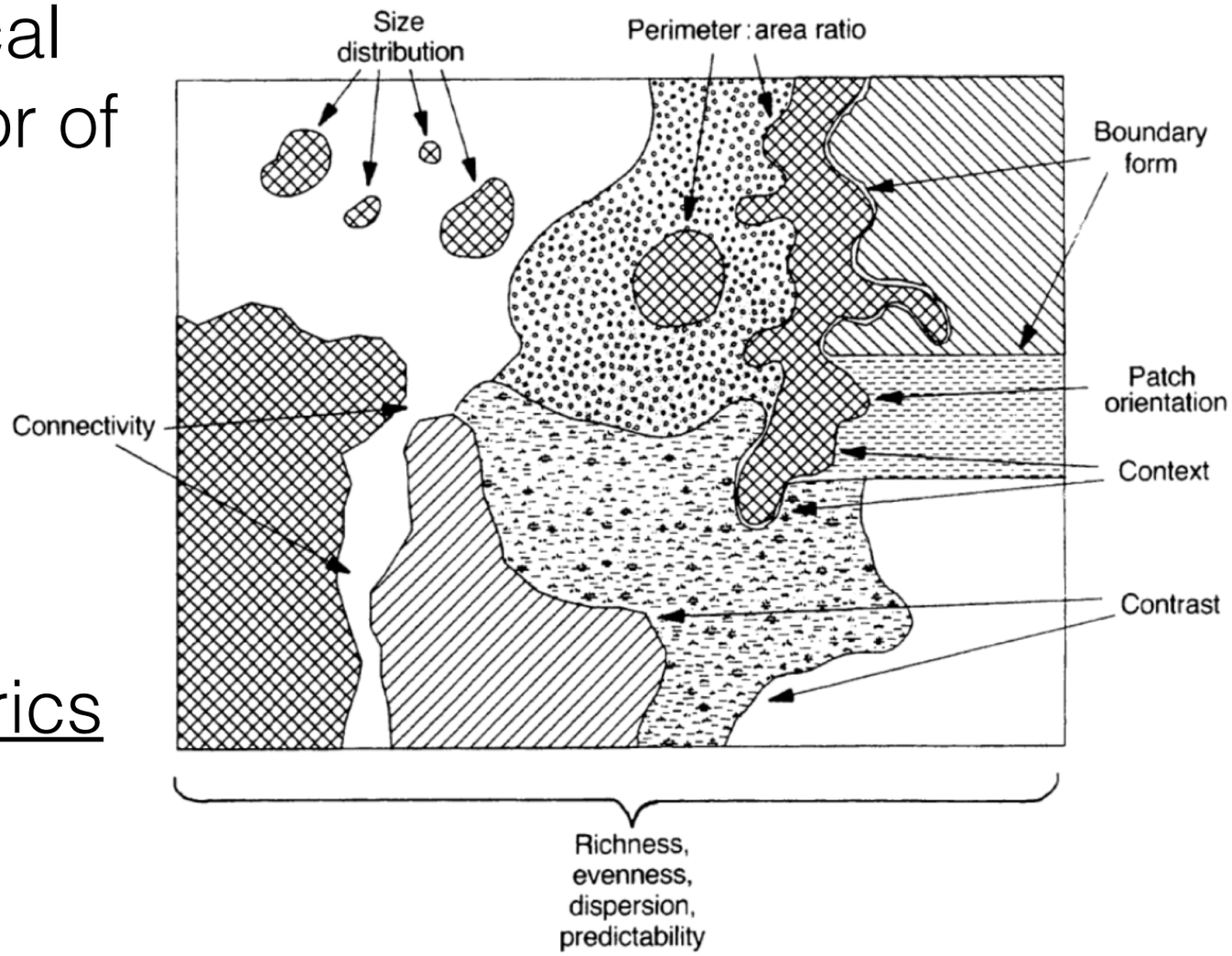
1. Forest patches in 3 types of human-dominated matrix habitat (ag, residential, or mining)
2. Compared with sites in forest
   - patches in ag > richness than residential or mining
   - patches in forest > richness than residential & mining, not ag
   - ~70% species differed in among landscape matrix types.

Species are affected not only by the primary habitat, but also by the structure and composition of the surrounding land cover (“the matrix”)

Interpretation of landscape variability

Landscape mosaic model

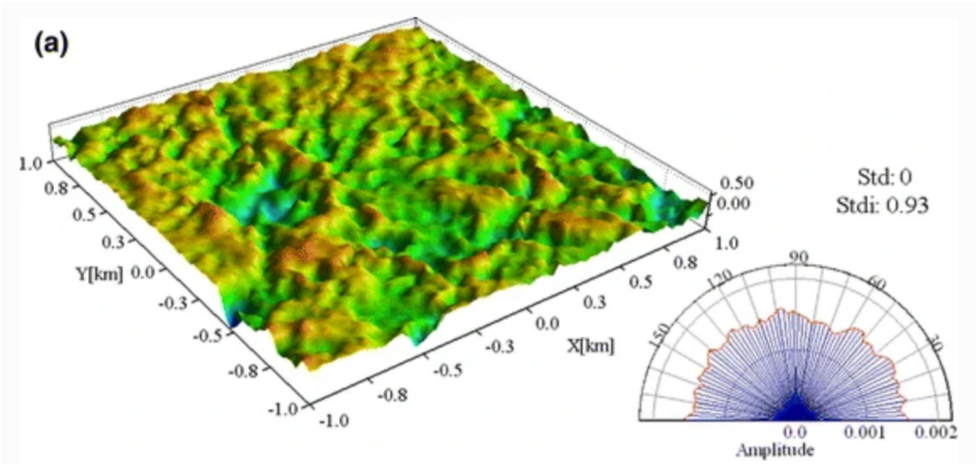
- de-emphasizes a single focal habitat or cover type in favor of relative suitability and prioritization among cover types
- Still largely categorical
- <u>prioritization of land among uses, landscape-scale metrics</u>



Interpretation of landscape variability

Continuum/ Gradient model

- considers landscapes as a combination of environmental gradients, no reason to assume environmental variability is usually categorical
- tailor the grain, extent, and resolution to the hypotheses and system
- captures a less equivocal picture of how the system is organized and what mechanisms may be at work
- Niche concept, SDM, Gradient surface models (GSMs)



NDVI landscape gradient models
McGarigal et al 2009

Interpretation of landscape variability

- **Island model-** focal cover type (habitat loss & fragmentation)
- **Patch matrix model** – similar but also considers the role of the "matrix" (corridors and matrix permeability)
- **Landscape mosaic model** - de-emphasizes a single focal type (prioritization of land use and conservation)
- **Continuum model** - a combination of environmental gradients (niche concept, SDMs)

Why care about Landscape Pattern?

Habitat fragmentation, loss, and alteration, agricultural intensification, agroforestry, urbanization

- Central problem in management of ecosystems
- Can ultimately result in:
  - species loss
  - species invasion
  - degradation of ecosystem goods and services

What kind of metrics?

- How much hardwood forest do Cerulean warblers need during breeding? class
- What composition of habitat types increase occurrence of songbirds during fall migration? landscape
- How much core area do wood thrush need to successfully fledge young? patch or class
- Is there a threshold level of forest fragmentation beyond which a species cannot disperse between forest patches? class (configuration)
- Comparing among landscapes, is biodiversity greater when configuration is more diverse? landscape