

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

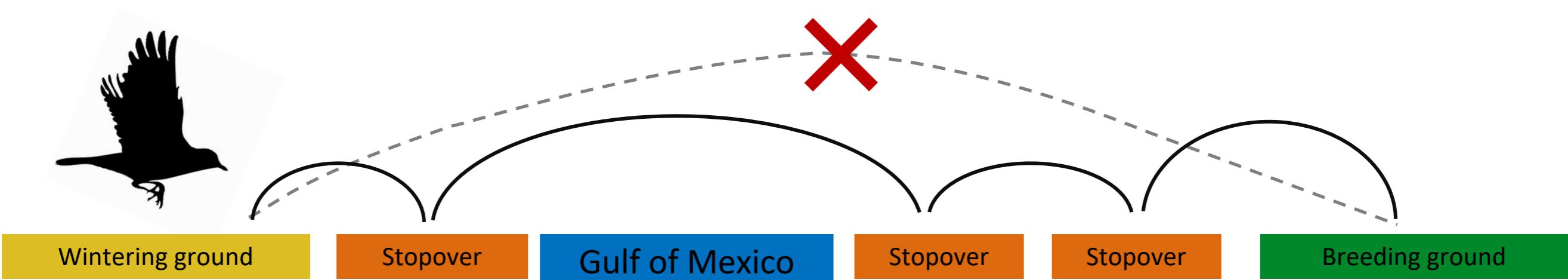
Outline

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

A landscape photograph featuring a variety of birds. In the foreground, a brown-throated thrush and a wood thrush are on the ground. A blue Grosbeak is perched on a branch. In the middle ground, a colorful bird with red, yellow, and green plumage is on a branch, and a yellow warbler is nearby. A small orange bird is on a branch in the background. Several other birds are flying in the sky. A white rectangular box contains the text.

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

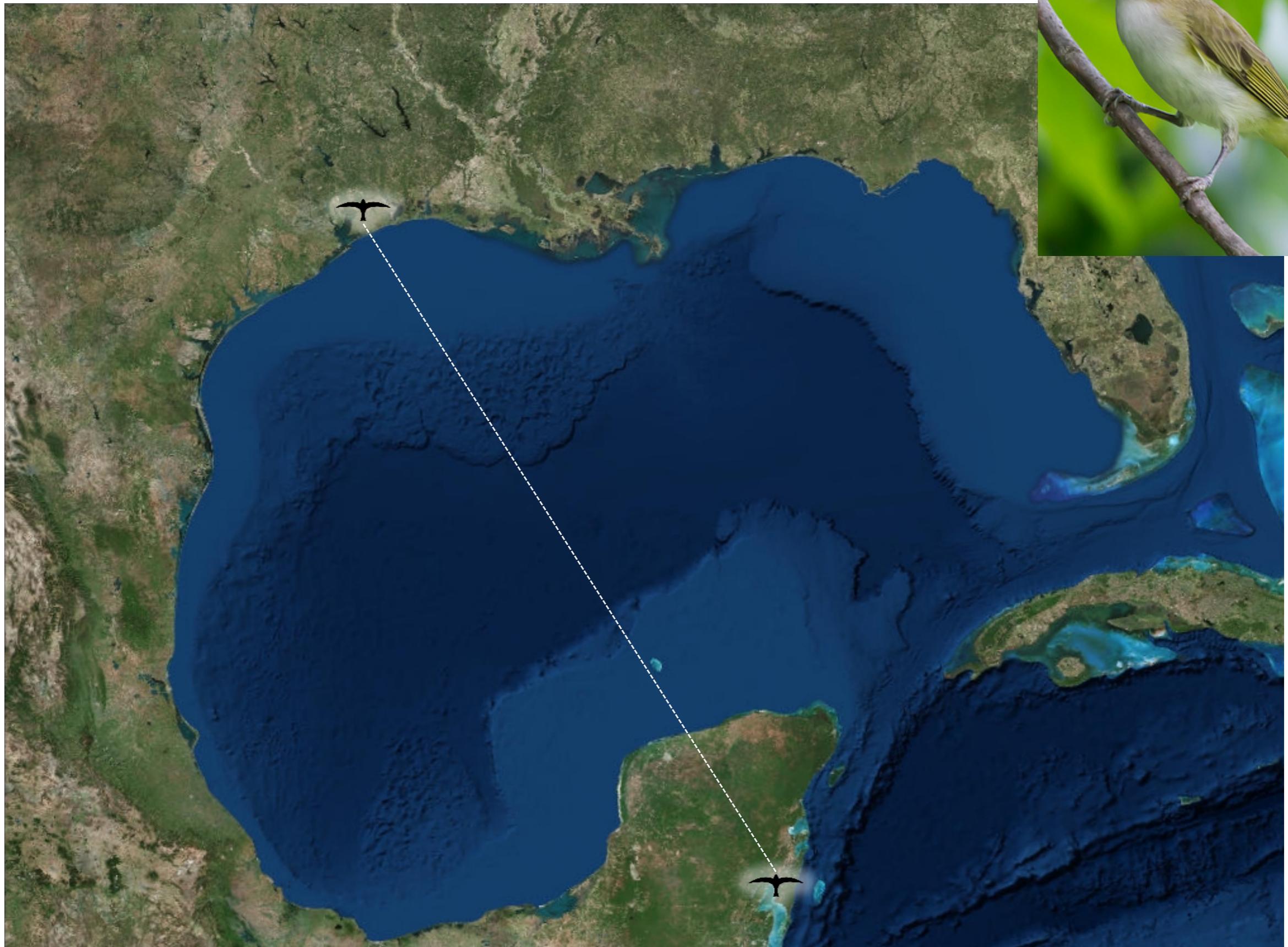
Intercontinental Migration



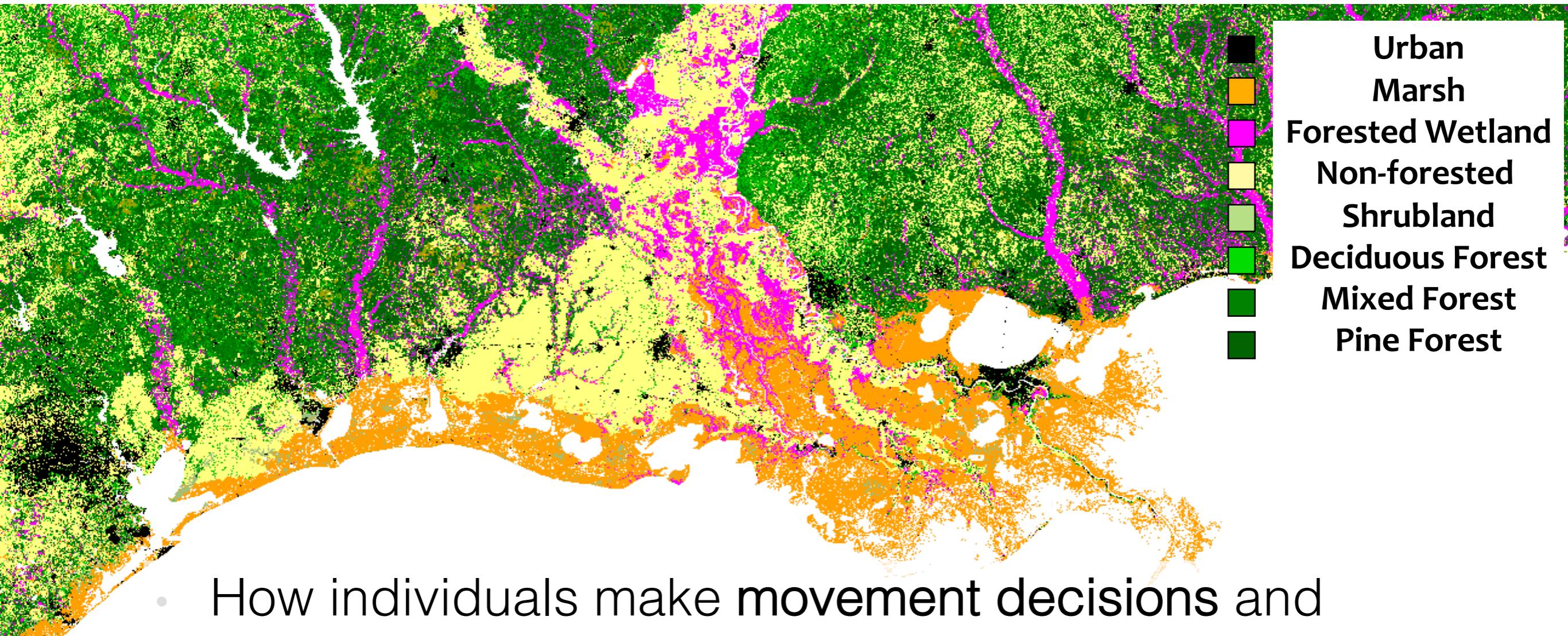
- Frequent stops during migration
- Time spent at stopover habitat > time spent flying
- Replenish depleted fuel reserves for flight



Stopover Landscapes



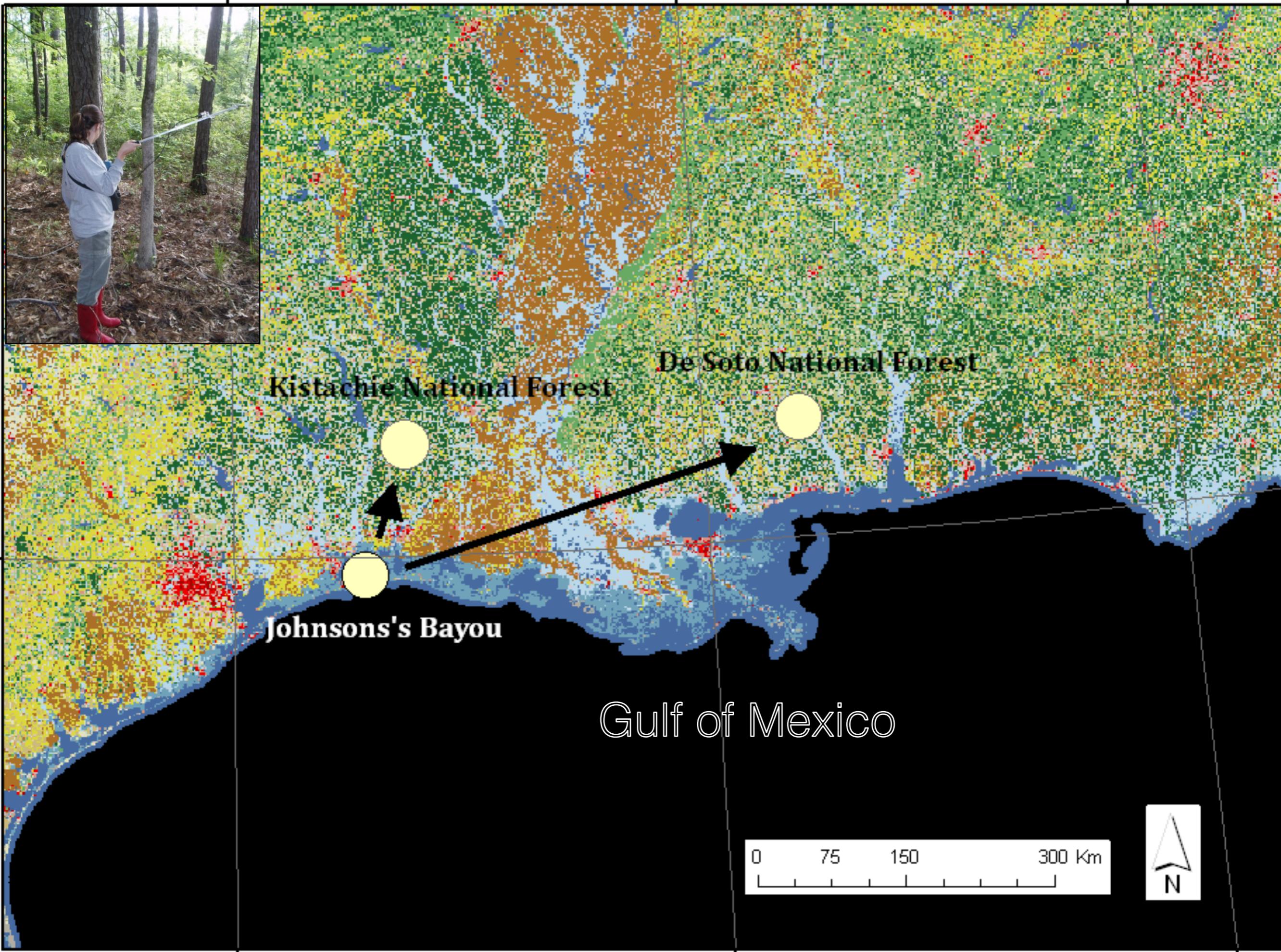
How will landscape change impact migrating birds?



- 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)



Individual-based simulation model

Input

A. Import cellular landscape

- mass gain values corresponding to habitat types
- simulated patterns to test predictions

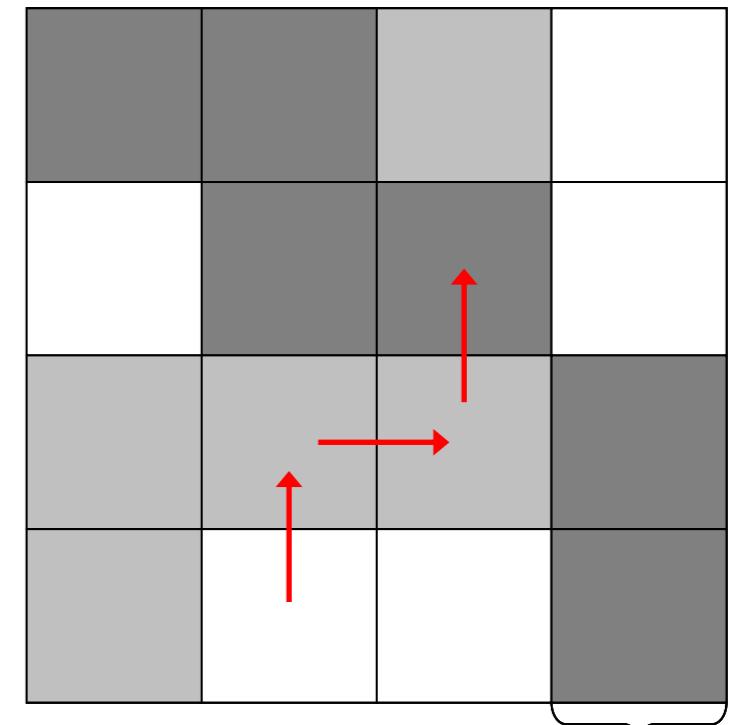
B. Initialize bird

- 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).

Output

A. Mass change

B. Movement pattern

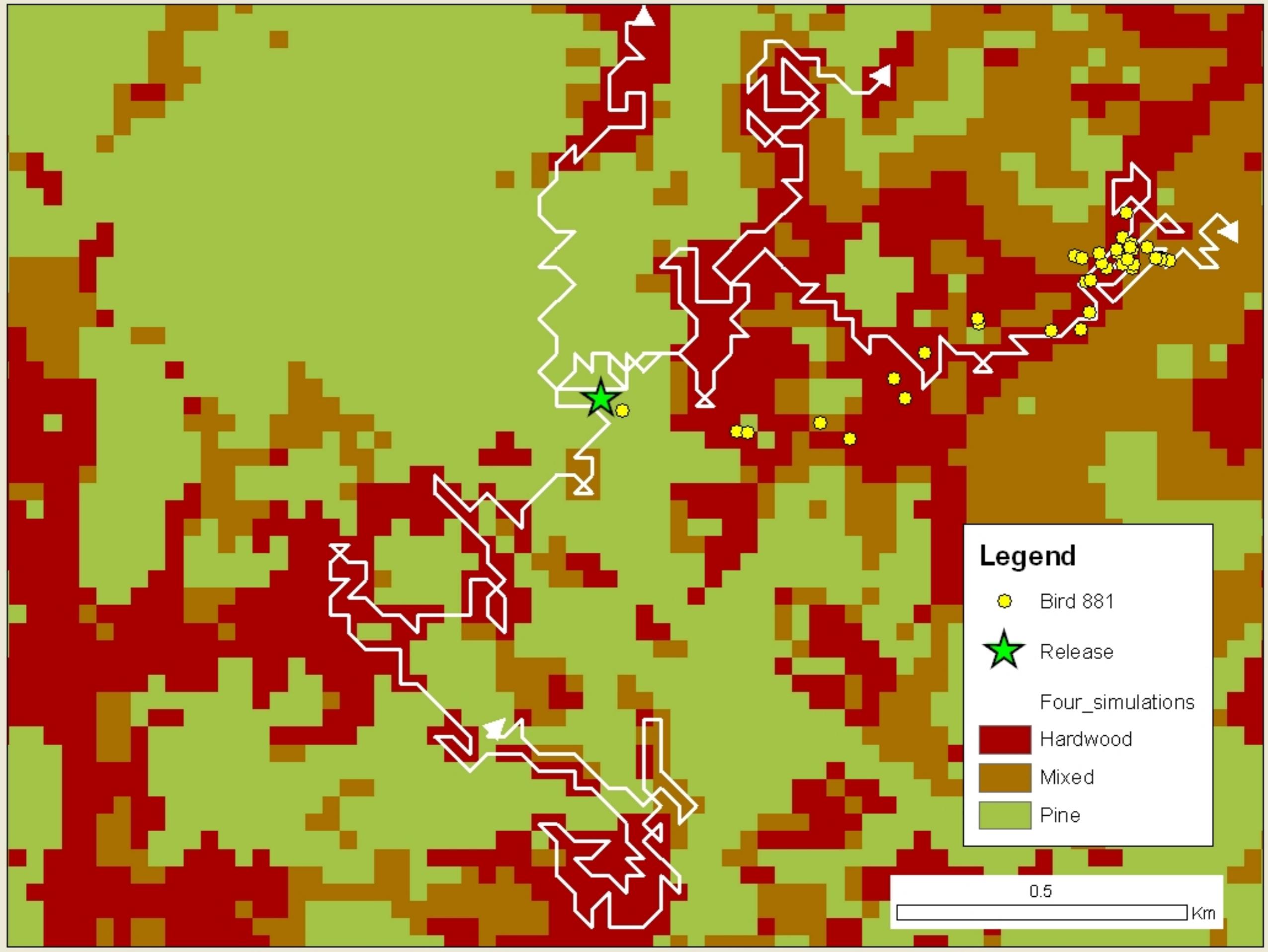


Landscape

Hourly steps:

Movement rules

Gain calculated

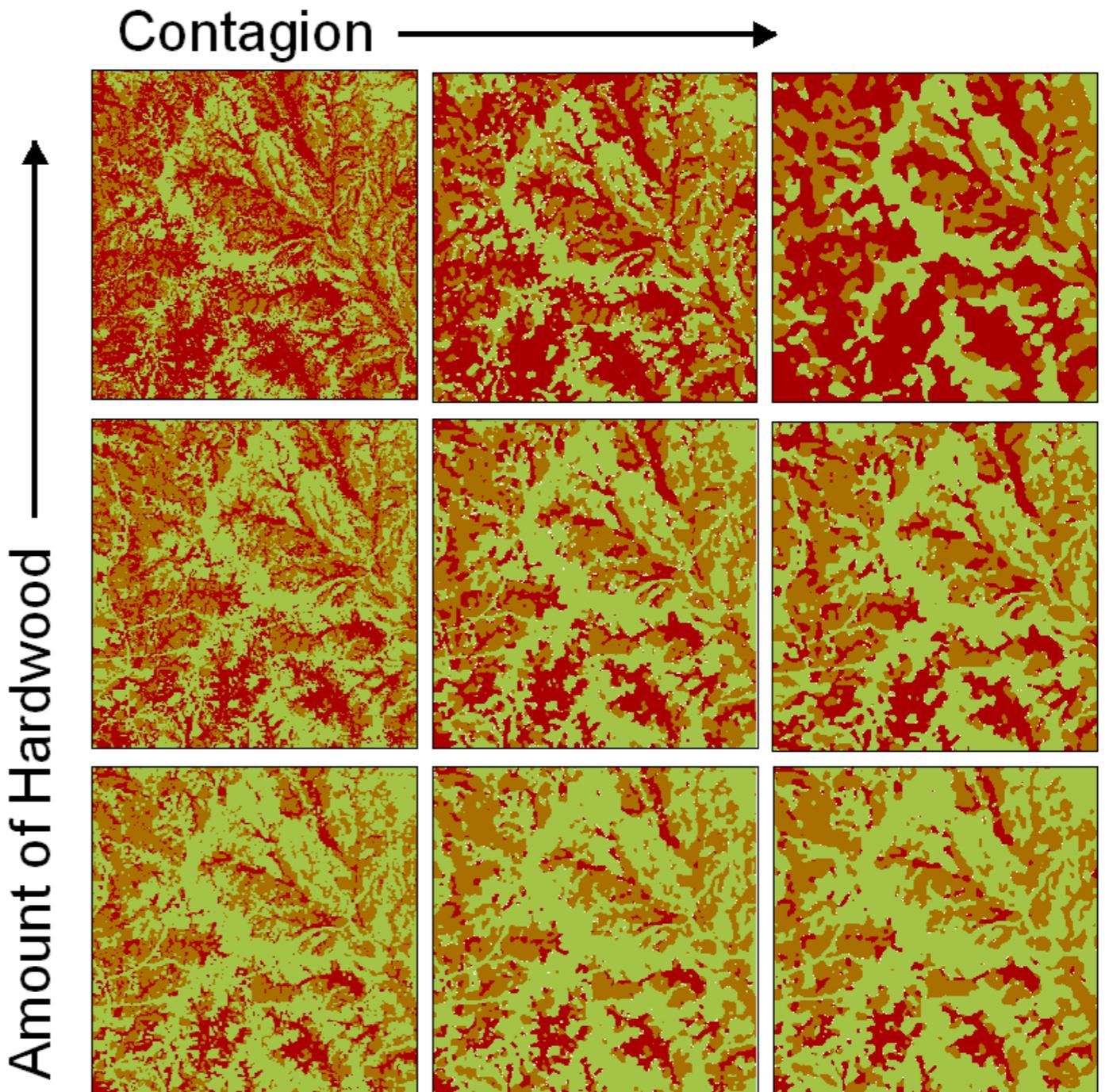


Factorial simulation: composition and configuration of hardwood



Factorial simulation results: amount hardwood and contagion

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

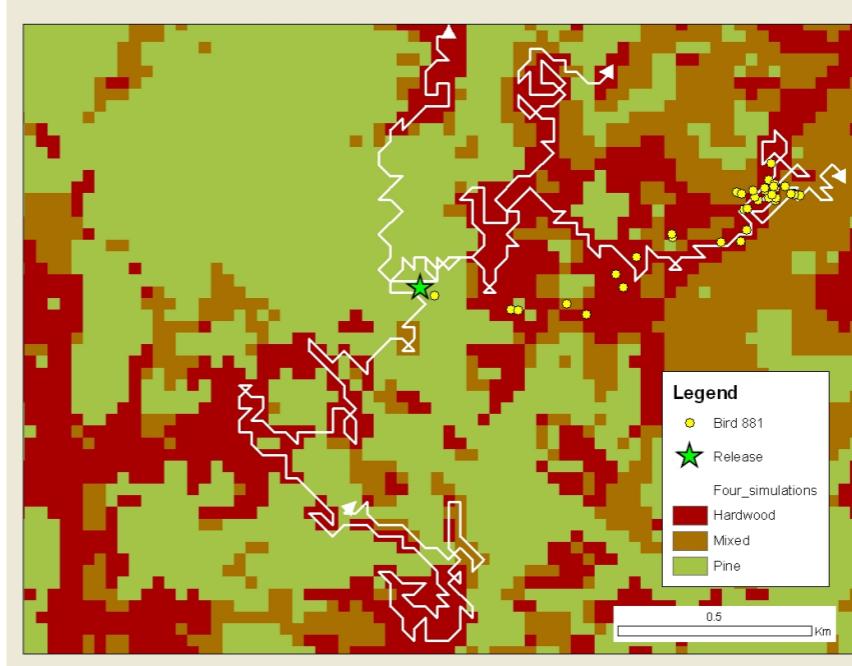


B. Fuel deposition rates are
greater for migrants that
“arrive” in hardwood habitat

Definitions

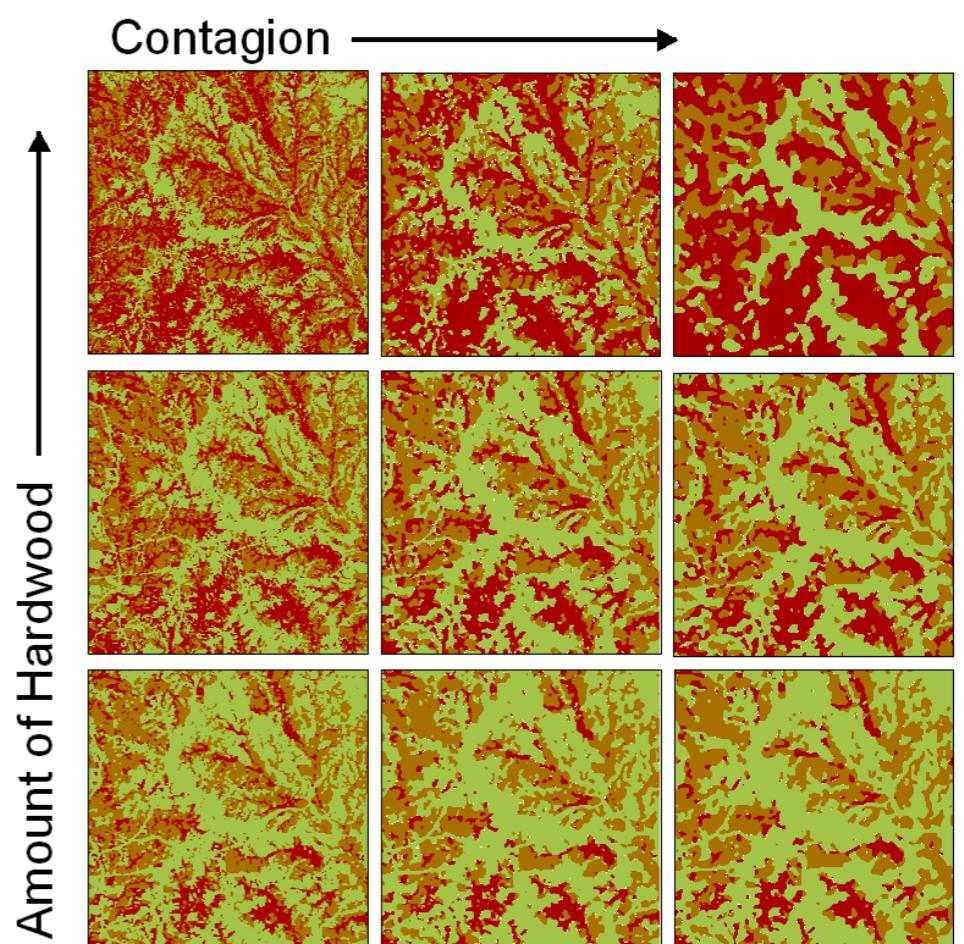
Composition- variety and abundance

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



Configuration- spatial characteristics of elements

- spatial arrangement
- patch shape/size

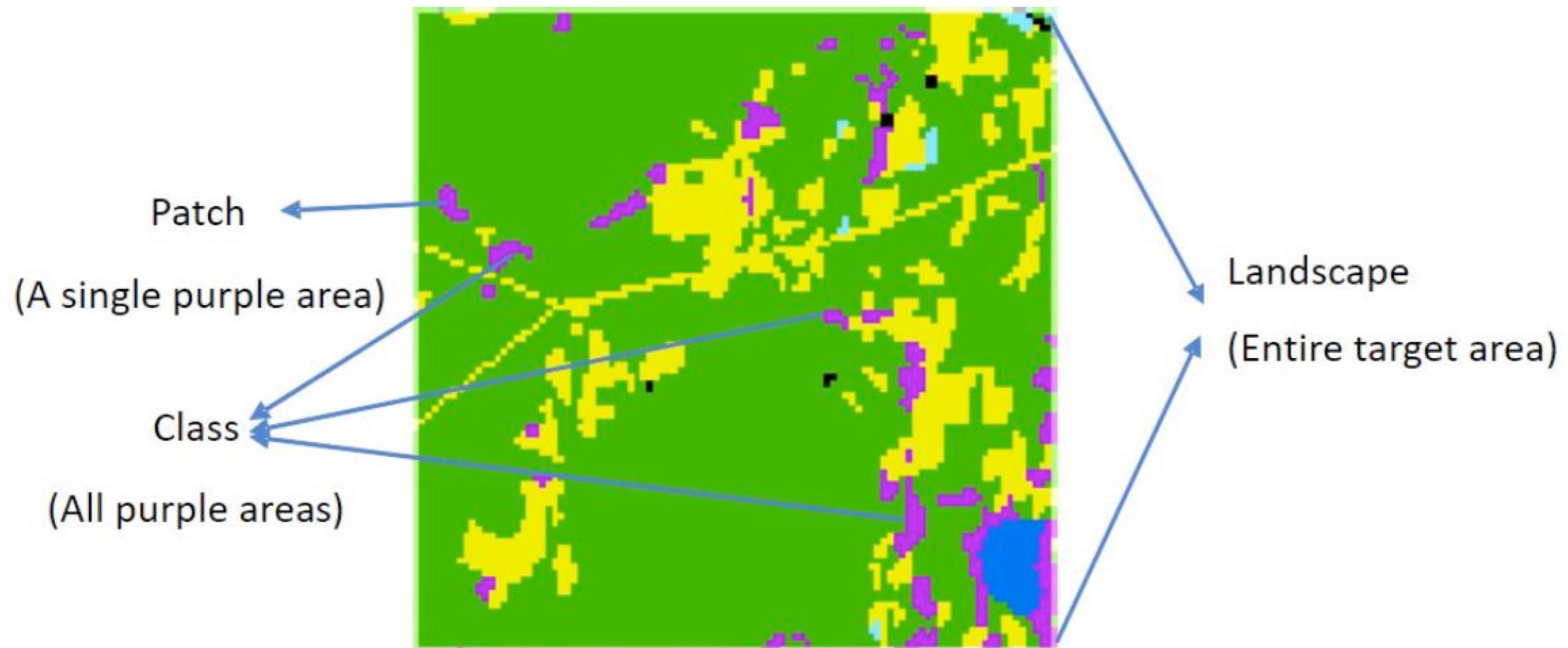


Definitions

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

Class- land cover type of patches in the landscape

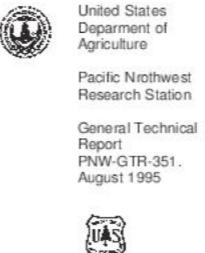
Matrix- non-focal land cover types in the landscape



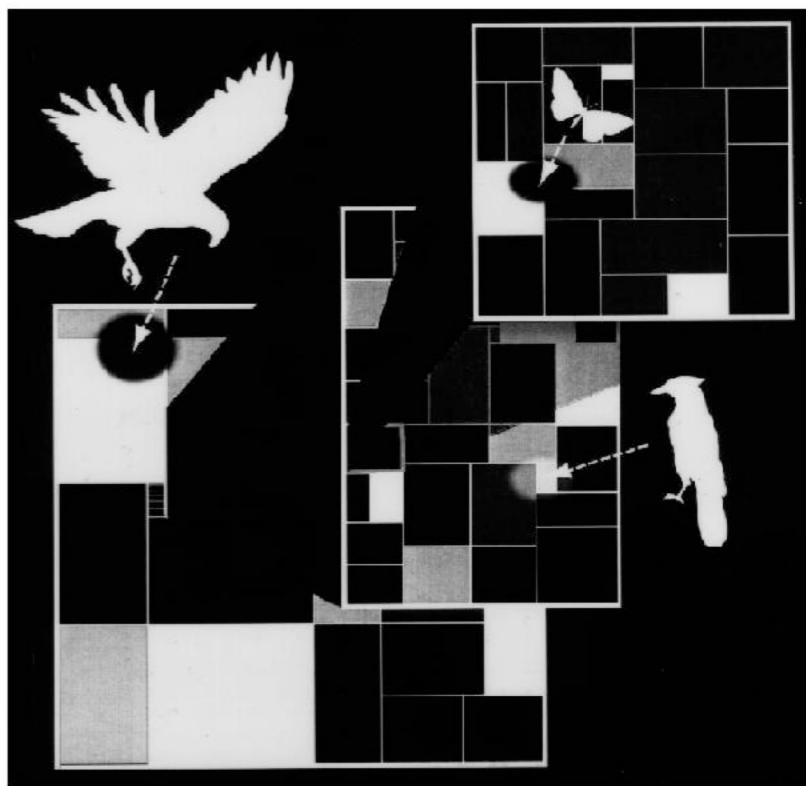
Metrics

	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	Scale	Acronym
<u>Area metrics</u>		<u>Shape metrics</u>	
Patch	AREA	Patch	SHAPE
Patch	LSIM	Patch	FRACT
Class	CA	Class/landscape	LSI
Class	%LAND	Class/landscape	---
Class/landscape	TA	Class/landscape	---
Class/landscape	LPI	Class/landscape	---
<u>Patch density, patch size and variance metrics</u>		<u>Scale</u>	
Class/landscape	NP	Class/landscape	---
Class/landscape	PD	Class/landscape	---
Class/landscape	MPS	Class/landscape	---
Class/landscape	PSSD	Class/landscape	---
Class/landscape	PSCV	Class/landscape	---
<u>Edge metrics</u>		<u>Nearest-neighbor metrics</u>	
Patch	PERIM	Patch	NEAR
Patch	EDCON	Patch	PROXIM
Class/landscape	TE	Class/landscape	MNN
Class/landscape	ED	Class/landscape	NNSD
Class/landscape	CWED	Class/landscape	NNCV
Class/landscape	TECI	Class/landscape	MPI
Class/landscape	MECI	Class/landscape	---
Class/landscape	AWMEC	Class/landscape	---
<u>Diversity metrics</u>		<u>Core area metrics</u>	
Patch	Class/landscape	Patch	---
Patch	Class/landscape	Patch	---
Patch	Class	Patch	---
Class	Class/landscape	Class	---
<u>Diversity metrics</u>		<u>Contagion and interspersion metrics</u>	
Class/landscape	Class/landscape	Landscape	SHDI
Class/landscape	Class/landscape	Landscape	SIDI
Class/landscape	Class/landscape	Landscape	MSIDI
Class/landscape	Class/landscape	Landscape	PR
Class/landscape	Class/landscape	Landscape	PRD
Class/landscape	Class/landscape	Landscape	RPR
Class/landscape	Class/landscape	Landscape	SHEI
Class/landscape	Class/landscape	Landscape	SIEI
Class/landscape	Class/landscape	Landscape	MSIEI
Class/landscape	Class/landscape	Class/landscape	---
<u>Contagion and interspersion metrics</u>		<u>IJI</u>	
Class/landscape	Class/landscape	Landscape	CONTAG



FRAGSTATS: Spatial Pattern Analysis Program for Quantifying Landscape Structure



landscapemetrics



CI	Development	CRAN	License
R-CMD-check failing	lifecycle stable	CRAN 1.5.4	License GPLv3
codecov 95%	repo status Active	downloads 73K	DOI 10.1111/ecog.04617

Overview

landscapemetrics is a R package for calculating landscape metrics for categorical landscape patterns in a tidy workflow. The package can be used as a drop-in replacement for FRAGSTATS (McGarigal *et al.* 2012), as it offers a reproducible workflow for landscape analysis in a single environment. It also allows for calculations of four theoretical metrics of landscape complexity: a marginal entropy, a conditional entropy, a joint entropy, and a mutual information (Nowosad and

Hesselbarth, M.H.K., Sciaiani, 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).

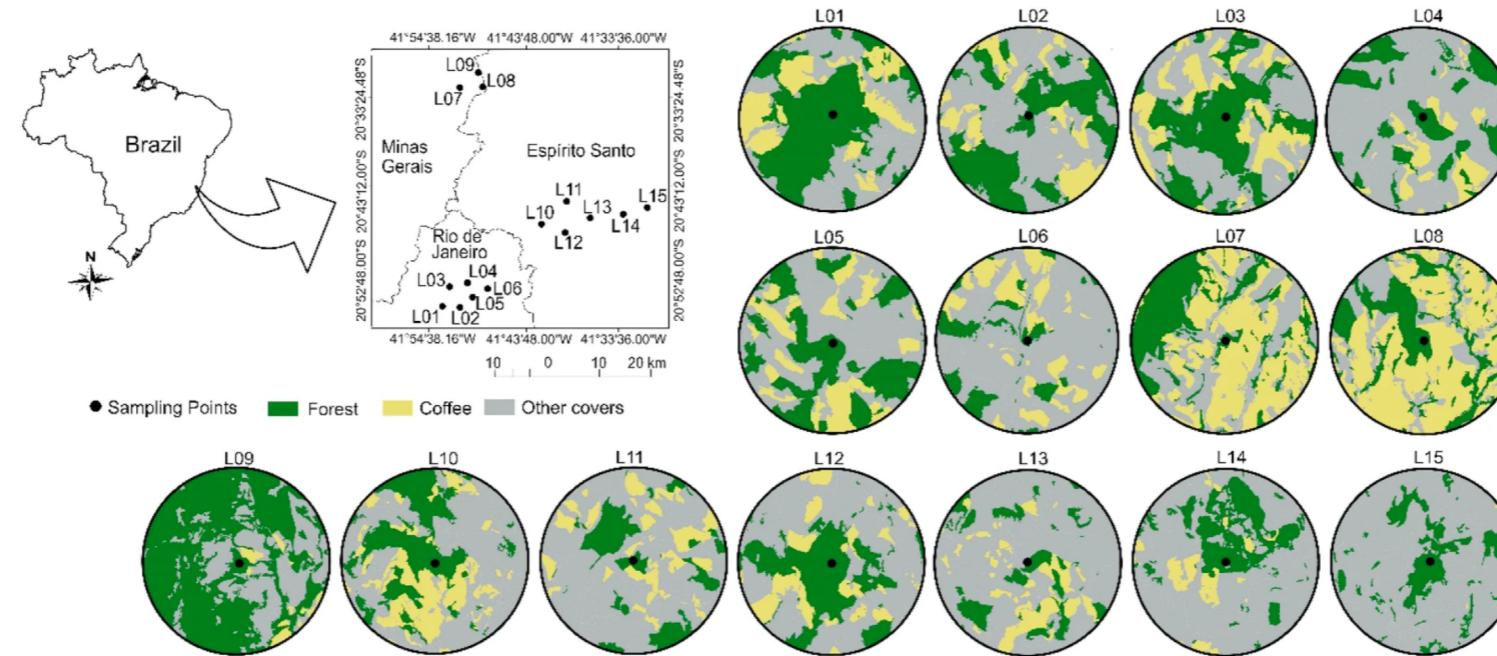
Chp. 3 code
install.packages("remotes")
remotes::install_version("SDMTools", "1.1-221")

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?

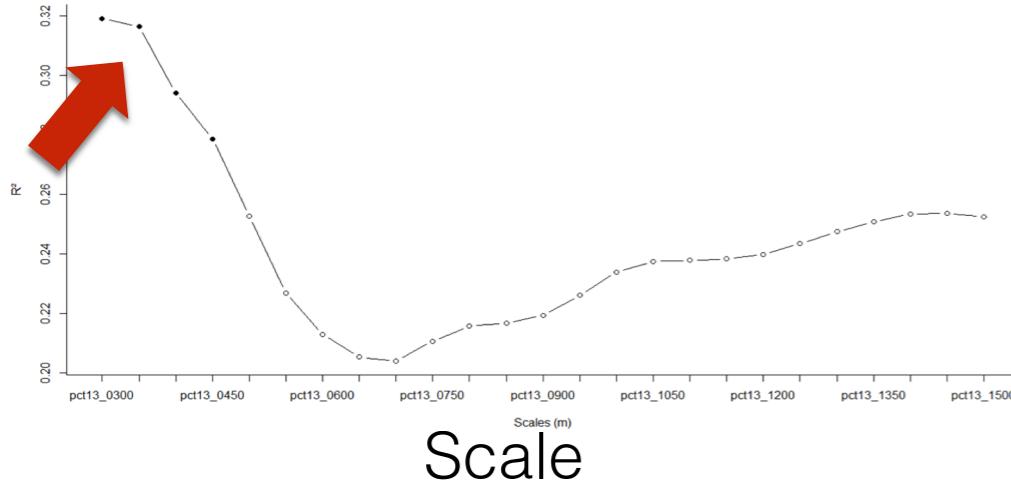


Lázaro da Silva
Carneiro et al
2022 *Apidologie*

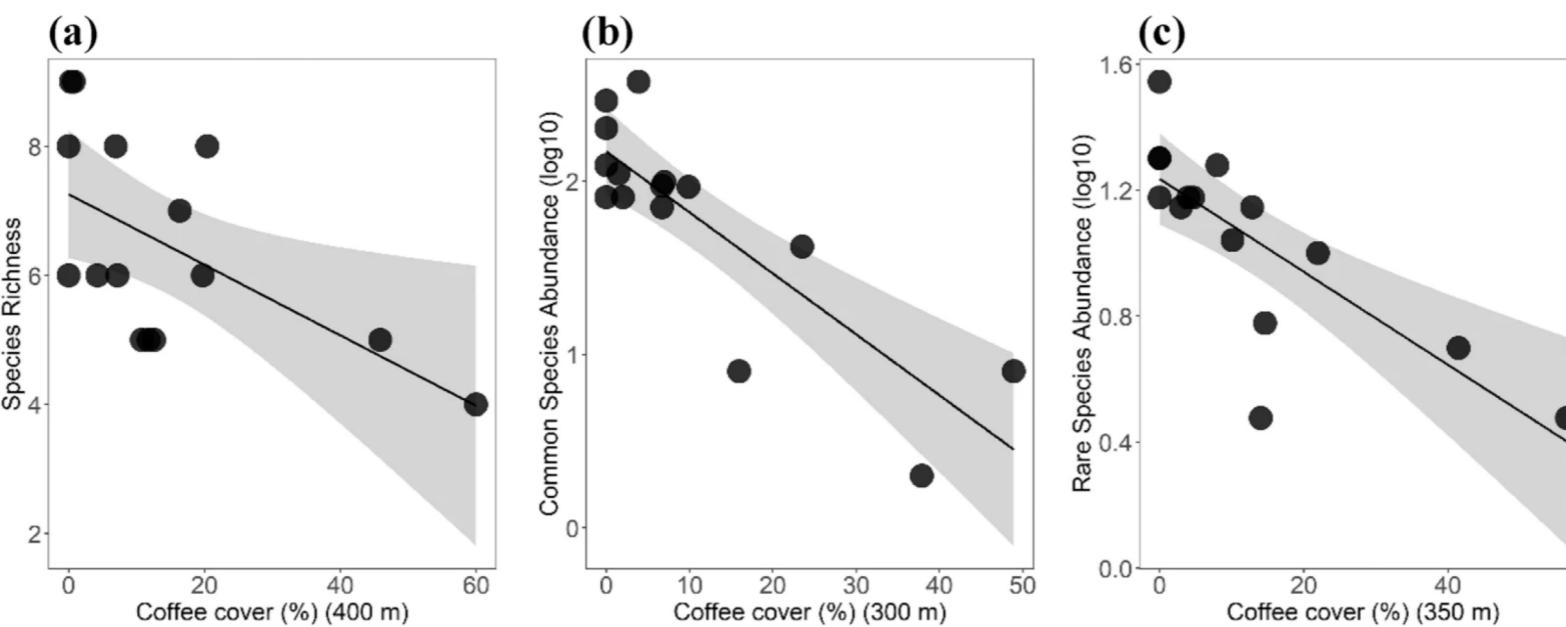
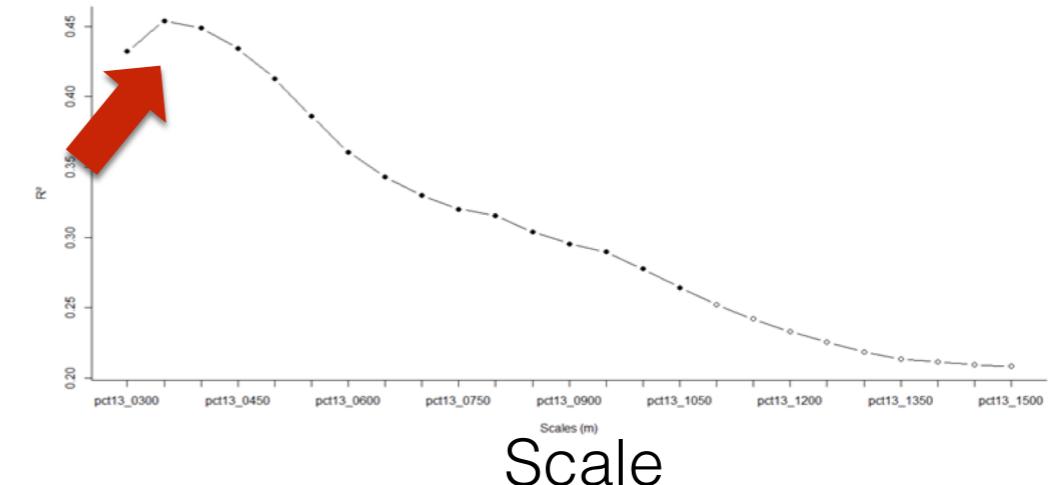
1. PLAND metric % cover class in the landscape
2. Scales: 50-m intervals from 300 to 1500 m
3. Accounted for geographic location, abundance of common and rare species

Coffee floral resources are unattractive for euglossine species

common species abundance



rare species abundance



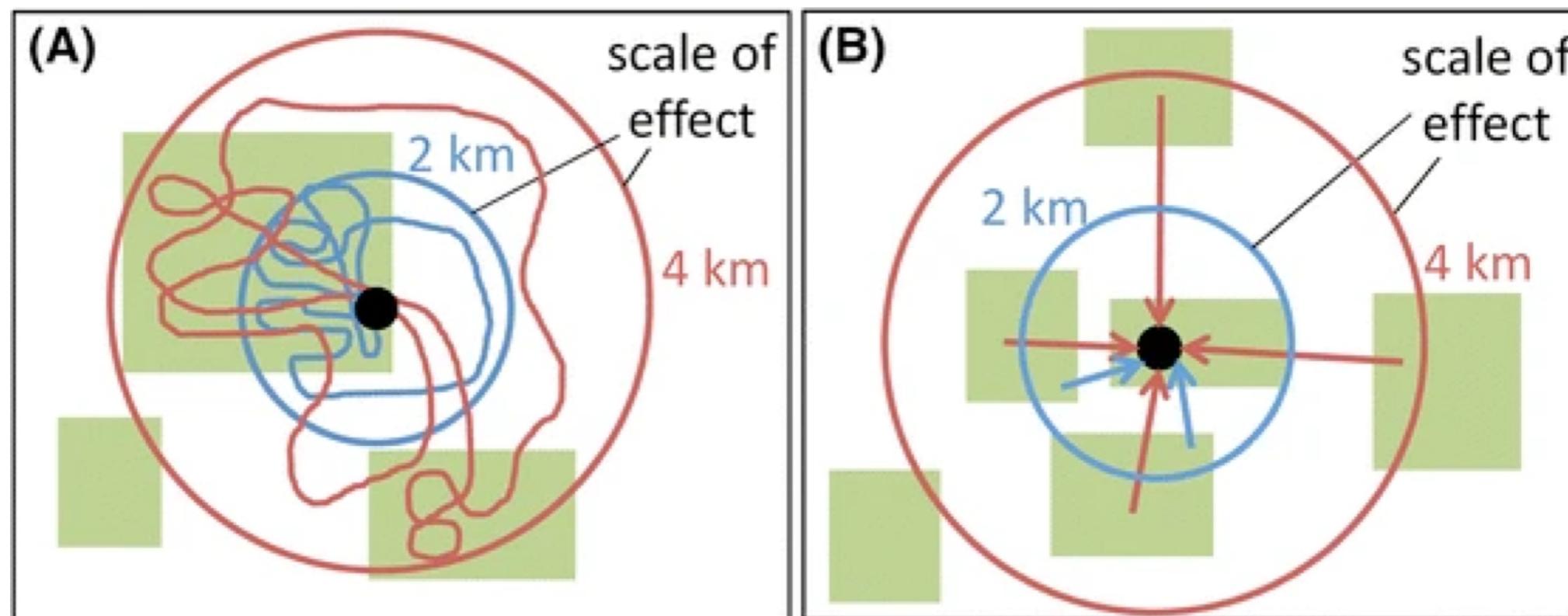
The scale of effect

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

Today

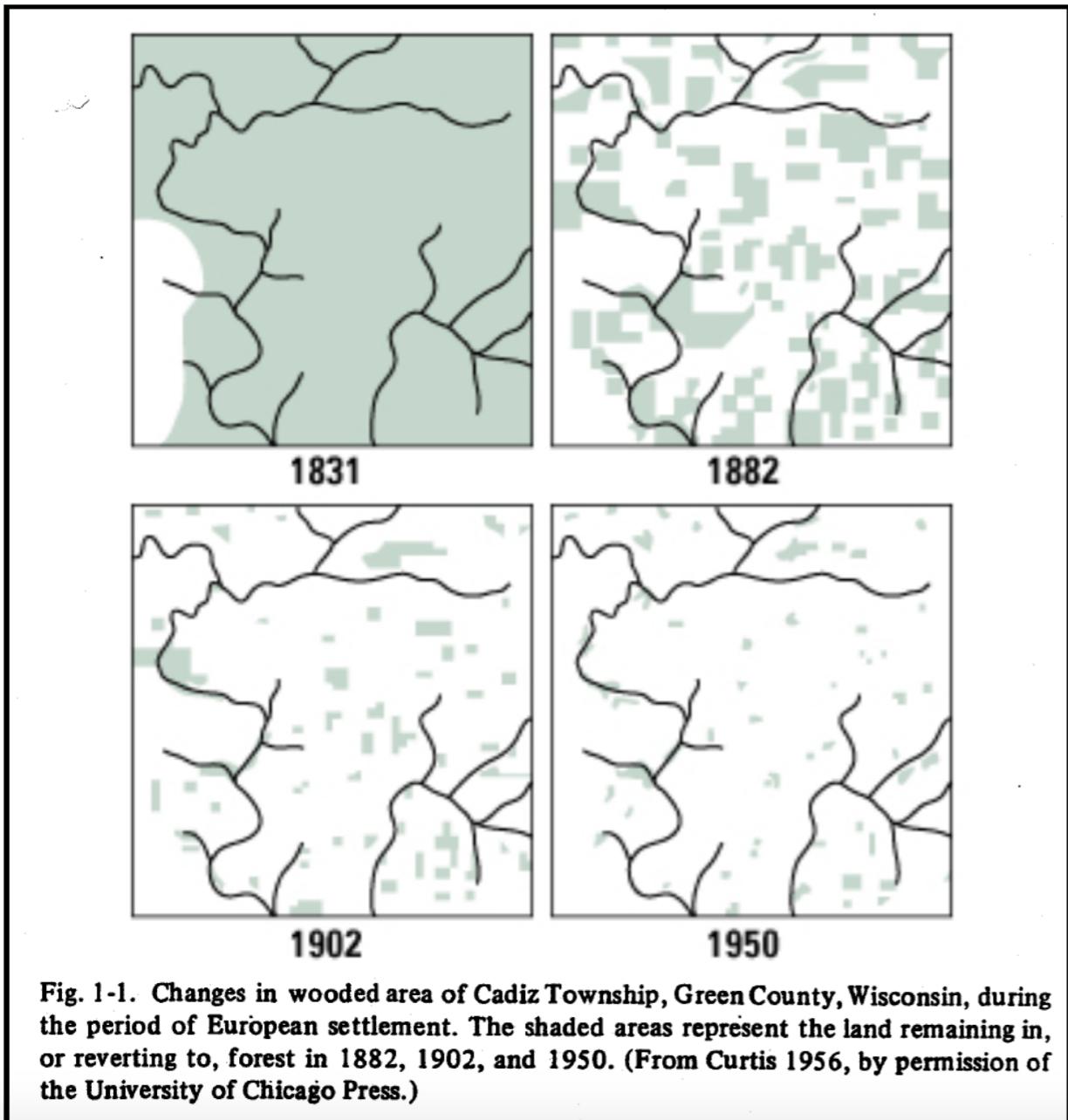
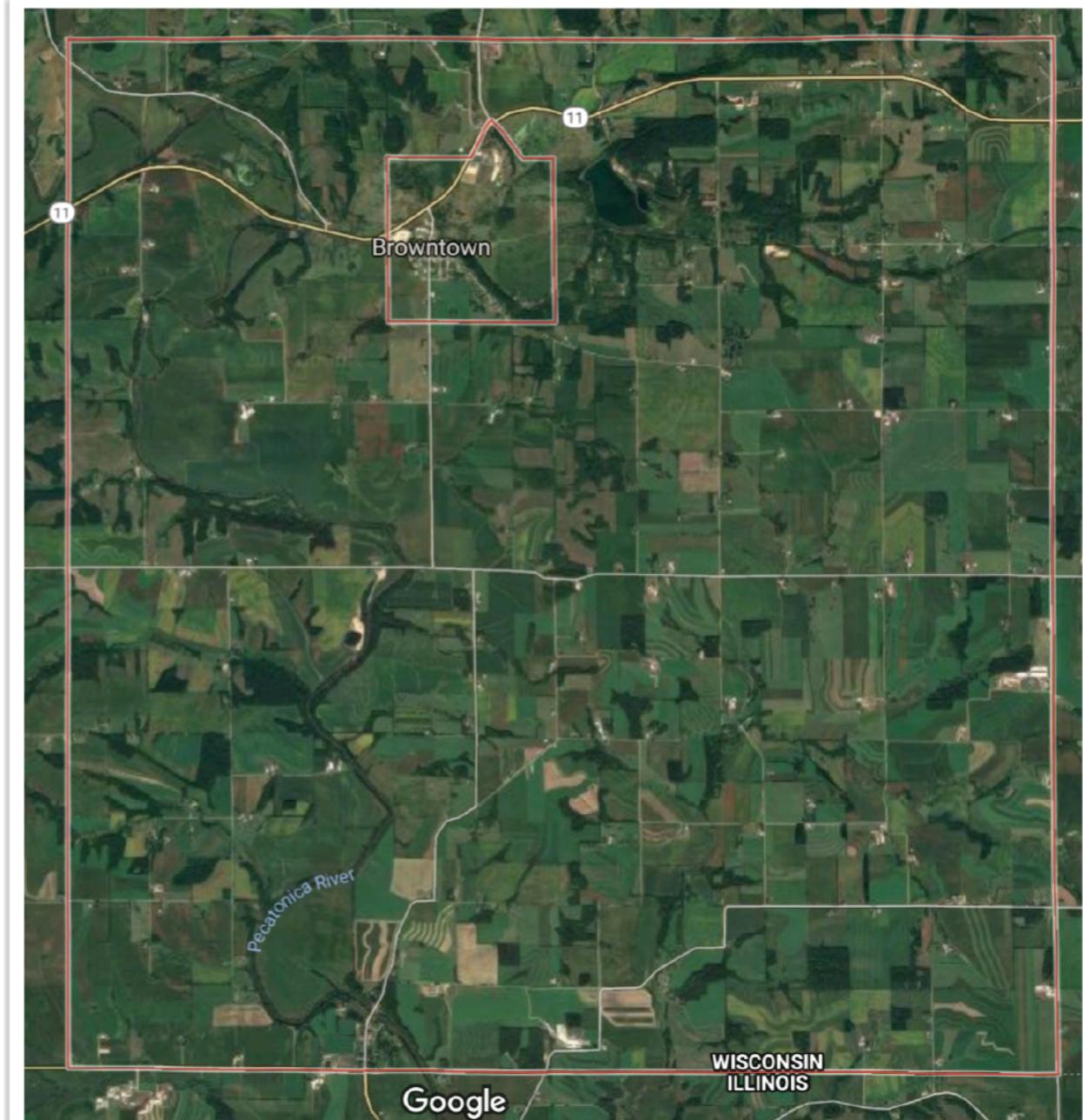


Fig. 1-1. Changes in wooded area of Cadiz Township, Green County, Wisconsin, during the period of European settlement. The shaded areas represent the land remaining in, or reverting to, forest in 1882, 1902, and 1950. (From Curtis 1956, by permission of the University of Chicago Press.)



Interpretation of landscape variability

Island model

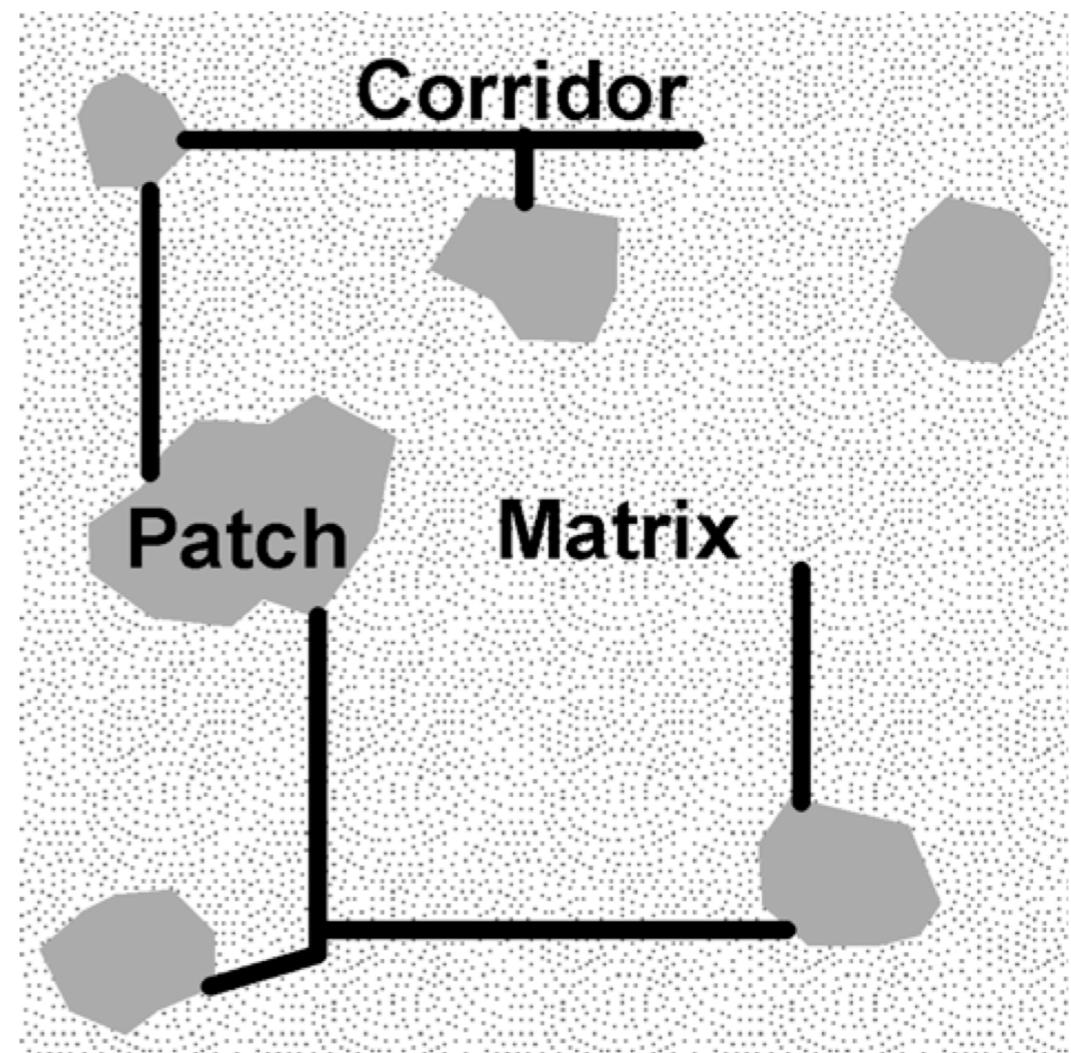
- focused on patches of a **focal cover type**
- ignoring all other variation
- simplest, habitat loss & fragmentation



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?

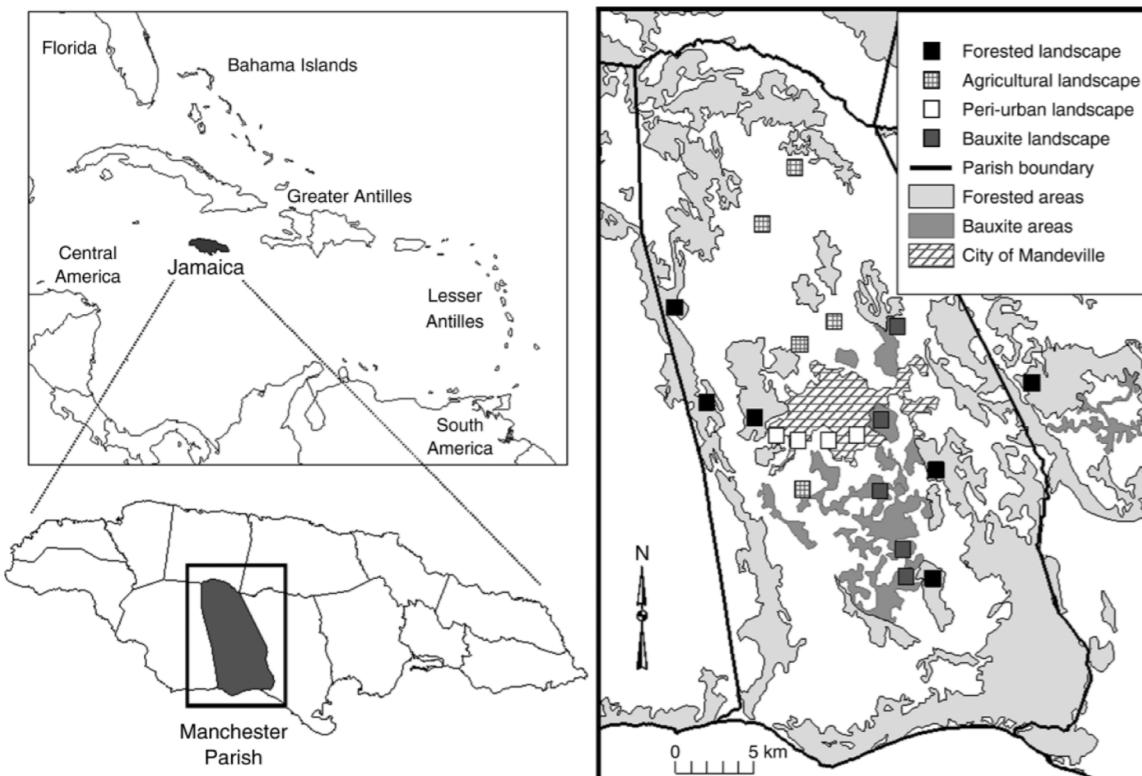


FIG. 1. Locations of the 20 1-km² landscapes surveyed in Manchester and Clarendon Parishes on the island of Jamaica as shown in the context of the West Indies.

Kennedy et al 2010. *Ecological Monographs*

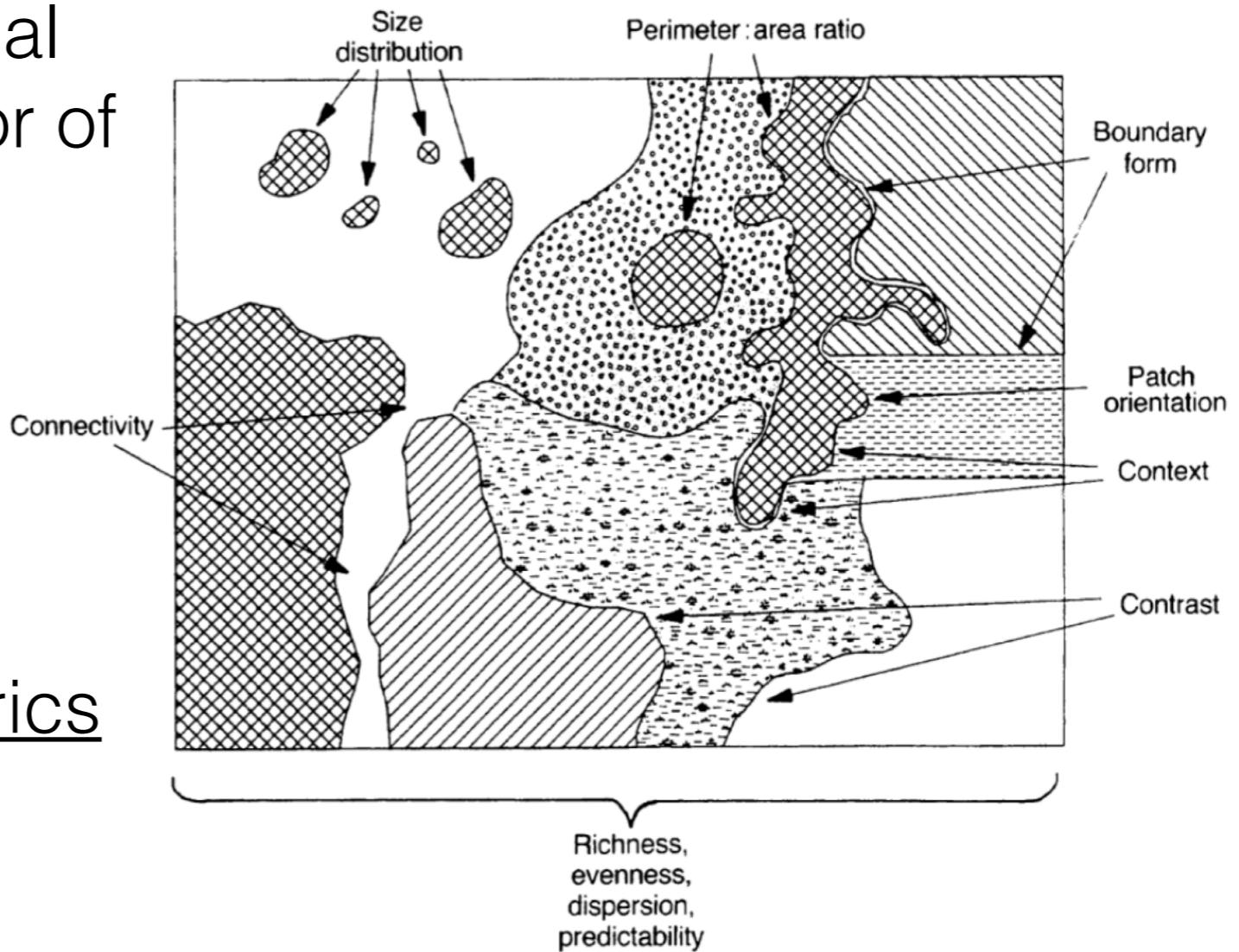
1. Forest patches in 3 types of human-dominated matrix habitat (ag, residential, or mining)
2. Compared with sites in forest patches in ag > richness than residential or mining patches in forest > richness than residential & mining, not ag
 - ~70% species differed in among landscape matrix types.

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

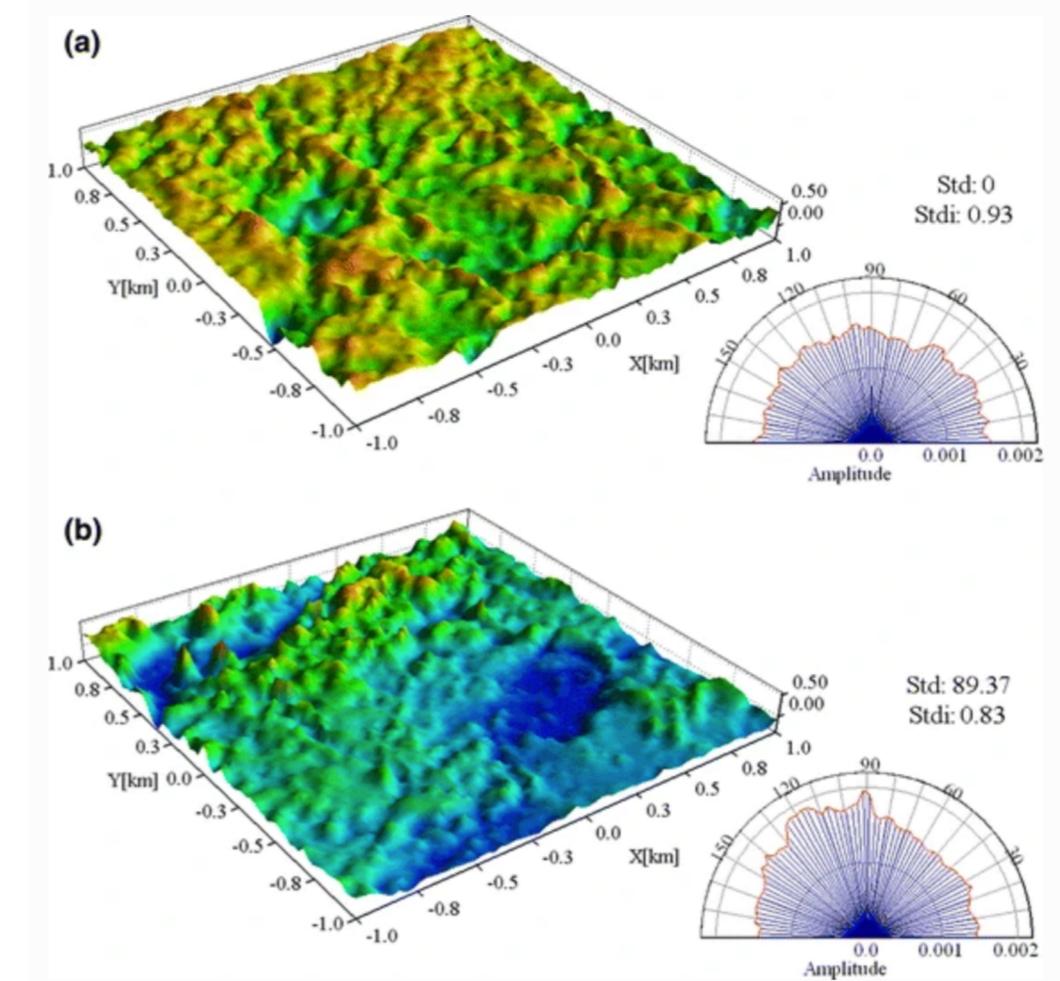
- de-emphasizes a single focal habitat or cover type in favor of relative suitability and prioritization among cover types
- Still largely categorical
- prioritization of land among uses, landscape-scale metrics



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