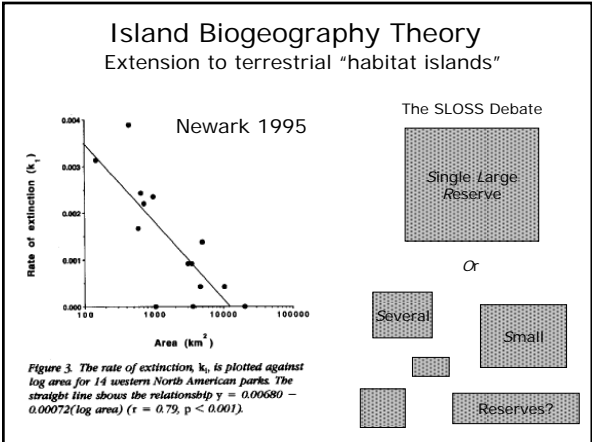
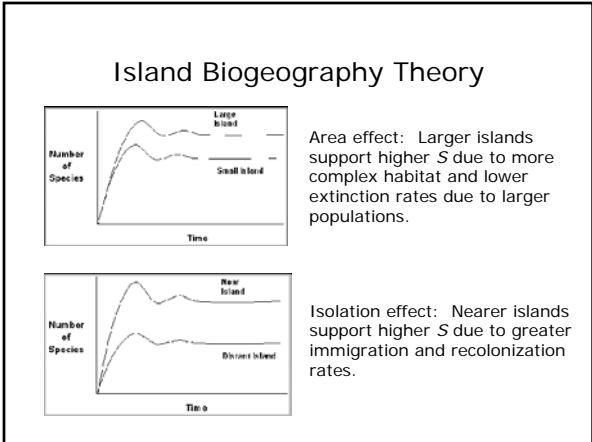
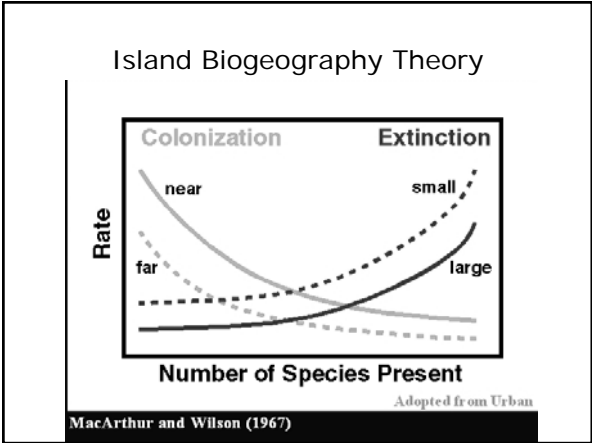
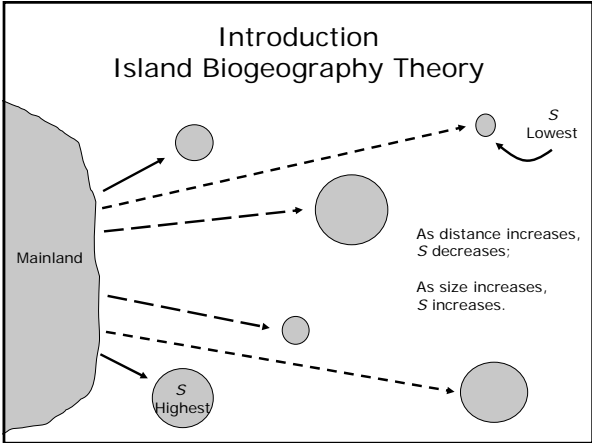


# Populations and landscape structure I

## Organisms/populations and Landscapes

Landscape effects on individuals and populations:

- Individual behavior and habitat use and the ability to survive and reproduce (aka fitness).
- Population structure and viability - the spatial subdivision of populations and their ability to reproduce.
- Landscapes modify inter-specific interactions (predator-prey, competition).



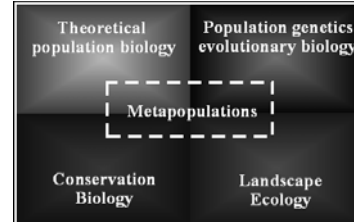
## What are metapopulations?

Can be applied to animals, plants, humans.

- Metapopulations reflect a hierarchy of aggregation  
Individuals ->  
Populations ->  
Populations of Populations = Metapopulations
- Metapopulations are spatially structured.

Example: Consider populations of butterflies in urban patches. If there is some exchange of individuals between patches, then all the patch populations considered together are a metapopulation.

## Metapopulations and Landscapes Context and Questions



Essential Question: How does habitat loss and fragmentation affect population subdivision and viability?

## Metapopulations and Landscapes

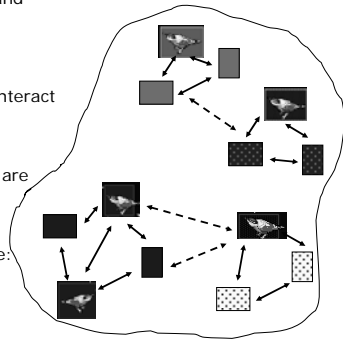
Metapopulations: scales and definitions

Hanski and Gilpin (1991):

Local scale: Individuals interact

Metapopulation scale:  
A set of local populations are linked by dispersal

Species' geographic range:  
Encompasses all local populations and metapopulations



## Metapopulations and Landscapes

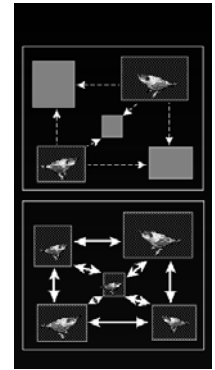
What is the landscape process affecting metapopulations?

Movement!

Individual movement between patches may be the most defining feature of a metapopulation.

Most metapopulation models use inter-patch distance and migration rates as the major determinants of patch colonization.

How fast and far organisms move imposes a scale on the landscape – differently for each organism.



## Metapopulations and Landscapes

Metapopulation terminology

Habitat patch – where a local population exists

Local extinction – disappearance of a population from a given patch

Recolonization – re-establishment of a local population by new immigrants

Population turnover – how often the population is renewed

Population persistence time – how long a population may maintain itself

## Metapopulations and Landscapes

Factors affecting local extinctions

Broad scale threats

Deterministic



Stochastic

Stochastic Causes  
demographic, genetic,  
environmental, catastrophe

Broad Scale Threats

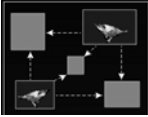
Global Climate Change  
Land-use change and fragmentation  
Altered disturbance regimes  
Invasive Species

## Metapopulations and Landscapes

### Factors affecting local extinctions

Broad scale threats

Deterministic



Stochastic

Stochastic Causes  
demographic, genetic,  
environmental, catastrophe

**Demographic stochasticity:**  
Random changes in population vital rates.

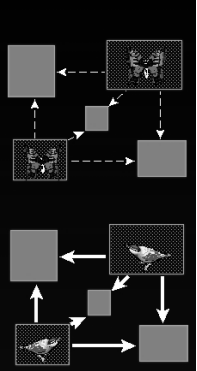
**Genetic stochasticity:**  
Loss of fitness due to inbreeding in very small local populations

**Environmental stochasticity:**  
Environmental changes, especially weather, that may result in fluctuations in resources.

**Catastrophe:**  
Extreme stochastic events that affects the entire metapopulation.

## Metapopulations and Landscapes

### Factors affecting local recolonization



Factors influencing recolonization reflect the interplay between life history traits and the connectivity to habitat.

For plants: seed size and viability, dispersal vector, seedbed requirements.

For animals: simple distance, resistance of intervening habitats, dispersal behavior, mortality rates during dispersal.

## Metapopulations and Landscapes

### Empirical studies of metapopulations: current approaches

Genetic similarities – A metapopulation should show spatial patterns of genetic similarities of individuals collected in different patches.

Percent occupancy – Or constancy of occupancy in habitat patches as a function of some index of isolation.

Similarities in demographic rates – autocorrelation in population levels.

Complete long term census – Logistically difficult, but most reliable.

## Metapopulations and Landscapes

### Empirical studies of metapopulations

Conclusions:

Most studies have dealt with short-lived species – where short generation times make observation of metapopulation processes much easier.

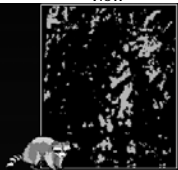
For larger organisms, the processes are inferred from long term presence/absence data.

## Metapopulations and Landscapes

### Metapopulations and connectivity

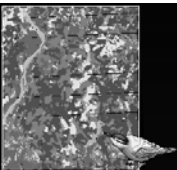
Connectivity = the degree to which the landscape facilitates or impedes movement among habitat patches, and, therefore, the rate of movement among local populations in a metapopulations.

Island biogeographic view



Habitat = islands in inhospitable matrix

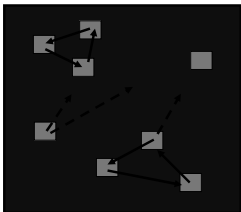
Landscape mosaic view



Complex landscapes with multiple habitat

## Metrics of Landscape Configuration

### Connectance



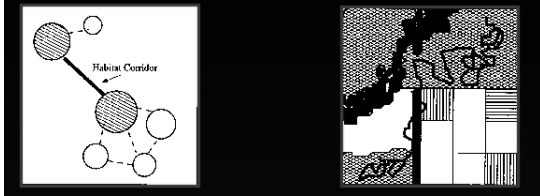
- Defined as the number of functional joins
- Each pair of patches is either connected or not (0/1) based on a user-specified distance.
- Distance can be Euclidean or resistance-weighted.
- Expressed as a percent of all possible joins between patches of the same type.

## Metapopulations and Landscapes

### Metapopulations and connectivity

Island biogeographic view

Landscape mosaic view



Connectivity is a function of the size and arrangement of habitat patches and connections via corridors.

Connectivity depends on how well movement can occur across different habitats on a landscape.

## Metapopulations and Landscapes

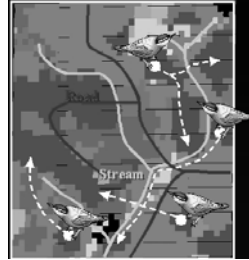
### Metapopulations and connectivity

What influences connectivity?

Patch structure: Number, size, and distribution of habitat patches.

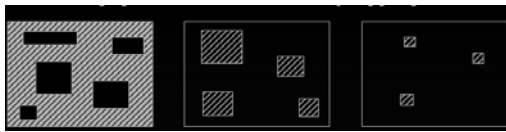
Corridors: Barriers, filters, and facilitated movement corridors.

Matrix: Resistance to movement.



## Metapopulations and Landscapes

When is a metapopulation approach appropriate?



Highly Connected

Near vicinity of connectivity threshold

Strongly disconnected

- Habitat is abundant, widespread, and connected

- Metapopulations unlikely

- Landscape structure is important and interacts with organisms

- Metapopulations are most appropriate

- Habitat is rare, isolated, and strongly disconnected

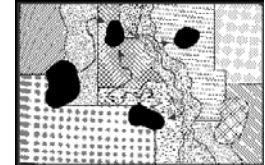
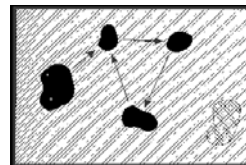
- Metapopulations may be appropriate

## Metapopulations and Landscapes

Island Biogeography vs. Metapopulation

Island biogeographic view

Landscape mosaic view



- Featureless matrix
- Local populations "blink" in and out.
- Recolonization based on movement rates and distance between patches.

- Complex matrix
- Matrix affects movement patterns between patches – thus recolonization.
- Patch distances are not Euclidean

## Metapopulations and Landscapes

Island Biogeography vs. Metapopulation

### Island Biogeography Model

Variables include:

- Island area
- Distance from source (mainland)

### Metapopulation model

Habitat patch variables include:

- Patch area
- Microhabitat abundance or variety
- Distance to other habitat patches
- Core area, edge, factors affecting habitat quality

## Metapopulations and Landscapes

Island Biogeography vs. Metapopulation

### Island Biogeography Model

Variables include:

- Island area
- Distance from source (mainland)

### Metapopulation model

Species variables include:

- Demographic parameters for local population dynamics
- Dispersal range and/or mobility; dispersal behavior
- Habitat affinities, territory or home range size
- Interactions with other species

## Metapopulations and Landscapes

### Island Biogeography vs. Metapopulation

<p><u>Island Biogeography Model</u></p> <p>Prediction:</p> <ul style="list-style-type: none"> <li>• Equilibrium number of species</li> </ul>	<p><u>Metapopulation model</u></p> <p>Prediction:</p> <ul style="list-style-type: none"> <li>• Presence/absence or abundance per species per patch</li> </ul>
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## Metapopulations and Landscapes

### 5 Variations on the Metapopulation Theme

## Metapopulations and Landscapes

### Variations on the metapopulation theme

1. The classic metapopulation:

The system contains multiple patches whose populations are linked by dispersal, with turnover measured on time scales of  $>1$  but less than several generations.

## Metapopulations and Landscapes

### Variations on the metapopulation theme

2. Mainland/island (core satellite) populations:

The mainland population resists extinction while a subset of island populations go extinct repeatedly and are recolonized by the mainland population.

This is a direct analogy to island biogeography cases.

## Metapopulations and Landscapes

### Variations on the metapopulation theme

3. Source/sink populations:

Source and sink populations are usually defined by habitat quality.

The source population has a positive local recruitment rate and thus provides a net surplus of emigrants.

The sink population requires dispersal from other sources.

The source population resists extinction. The sink population goes extinct repeatedly and is recolonized.

## Metapopulations and Landscapes

### Variations on the metapopulation theme

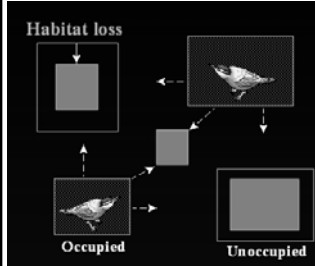
4. Patchy populations:

Populations are so well mixed and connected by dispersal that they function essentially as a single population.

Local extinctions are recolonized immediately, and a single individual might live in multiple patches over its lifetime.

## Metapopulations and Landscapes

Variations on the metapopulation theme



5. Non-equilibrium metapopulations:

Local extinctions are symptomatic of a general decline of the metapopulation. Many local extinctions are not recolonized.

Typical of "relaxing" island-system populations and of landscape subject to broad-scale habitat loss.