FWF 410:
"Landscape Ecology"

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Goal of the Lecture

To familiarize students with spatial aspects of wildlife ecology.

Reading Assignments:

1) Chapter 24: pp. 638-645:
   - "Conservation of Genetic Diversity"
     - Four processes that influence patterns of genetic diversity
     - Bottleneck population
     - Genetic diversity & population viability

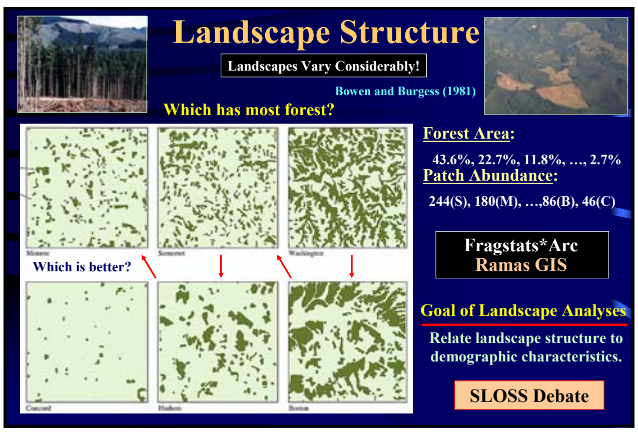
Lecture Structure

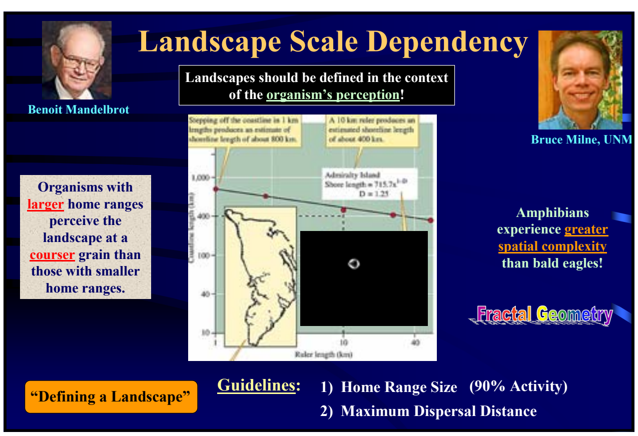
I. **Landscape Ecology Terms**
   Juxtaposition, Geometric Complexity, Permeability/Viscosity

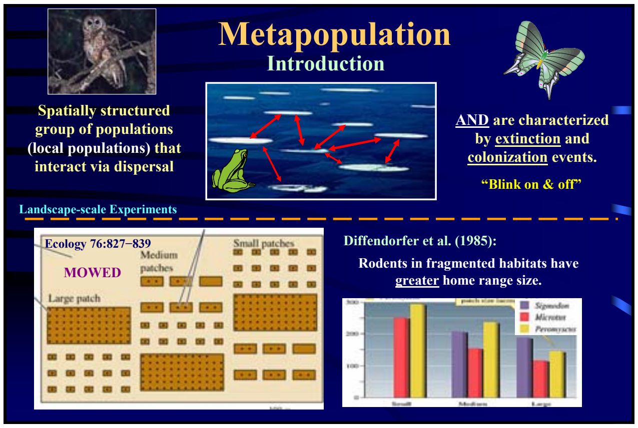
II. **Metapopulations, Dispersal, and Habitat Patch Size**
   Blinking "on" and "off" in space.

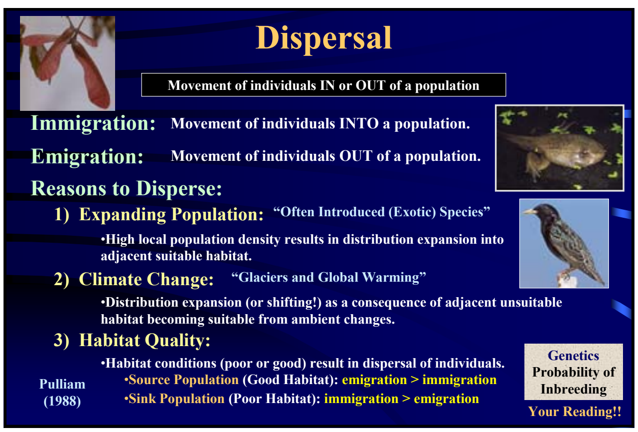
III. **Landscape Ecology Study**
   Agricultural Landscapes & Amphibians

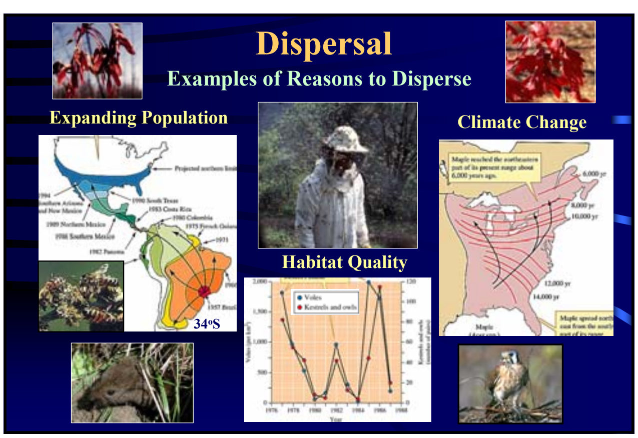

Landscape Ecology
Introduction
The study of landscape structure and spatially structured population processes.
Landscape: Heterogeneous area consisting of habitat (i.e., where populations reside) and non-habitat (areas inhospitable for survival and reproduction, IPM).
Organism Dependent:
Salamander vs. Coyote
Habitat Patch
Wetland
Inter-patch Matrix
Oak Savannah, Agriculture
Landscape Structure:
1) Spatial Position of Habitat Patches:
Distance between habitat patches, which is affected by patch abundance & size.
2) Geometric Complexity of Interpatch Matrix:
Edge density (# edges/km), Edge Permeability, IPM Permeability.
3) Others:
Patch Shape, Patch Quality (i.e., habitat quality: respective birth/death rates)
Population Processes: Populations that are spatially structured must interact periodically!
Successful Dispersal Rate & Intra-patch Population Dynamics
Probability of Single and Multiple Population Extinction.

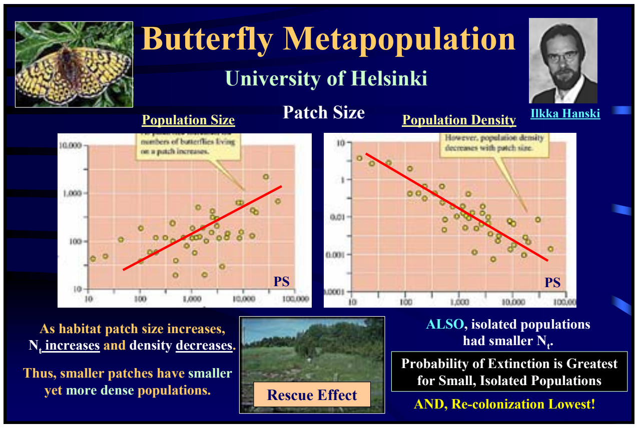

Landscape Structure
Landscapes Vary Considerably!
Bowen and Burgess (1981)
Which has most forest?
Which is better?
Forest Area:
43.6%, 22.7%, 11.8%, …, 2.7%
Patch Abundance:
244(S), 180(M), …,86(B), 46(C)
Fragstats*Arc
Ramas GIS
Goal of Landscape Analyses
Relate landscape structure to demographic characteristics.
SLOSS Debate

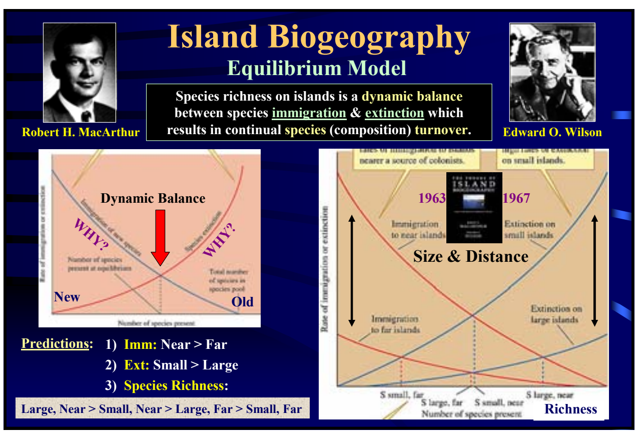

Landscape Scale Dependency
Benoit Mandelbrot
Landscapes should be defined in the context of the organism's perception!
Bruce Milne, UNM
Stepping off the coastline in 1 km lengths produces an estimate of shoreline length of about 800 km.
A 10 km ruler produces an estimated shoreline length of about 400 km.
Ruler length (km)
Organisms with larger home ranges perceive the landscape at a courser grain than those with smaller home ranges.
Amphibians experience greater spatial complexity than bald eagles!
Fractal Geometry
"Defining a Landscape"
Guidelines: 1) Home Range Size (90% Activity)
2) Maximum Dispersal Distance

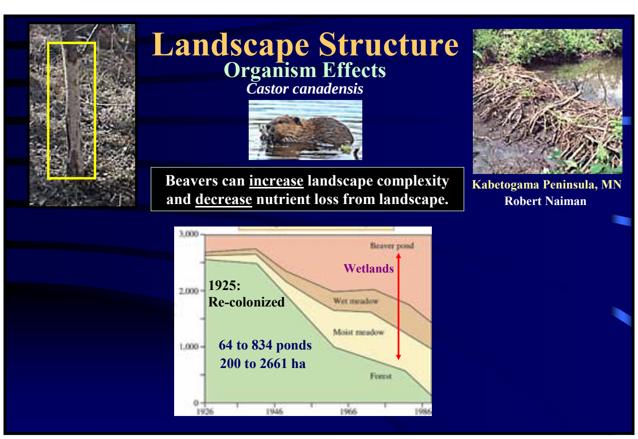

Metapopulation
Introduction
Spatially structured group of populations (local populations) that interact via dispersal
AND are characterized by extinction and colonization events.
"Blink on & off"
Landscape-scale Experiments
Ecology 76:827–839
MOWED
Small patches
Medium patches
Large patch
Diffendorfer et al. (1985):
Rodents in fragmented habitats have greater home range size.
Sigmodon
Microtus
Peromyscus
Small
Medium
Large

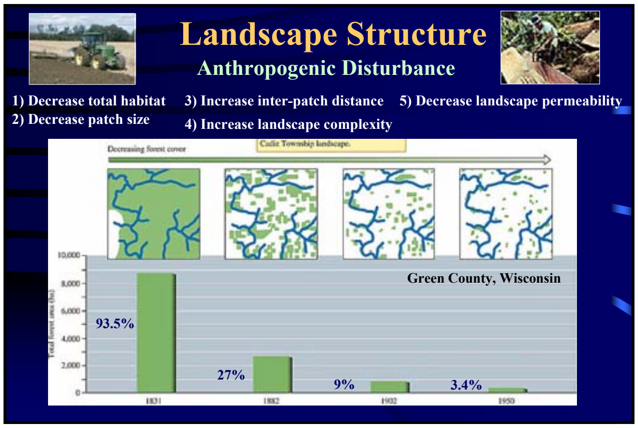

Dispersal
Movement of individuals IN or OUT of a population
Immigration: Movement of individuals INTO a population.
Emigration: Movement of individuals OUT of a population.
Reasons to Disperse:
1) Expanding Population: "Often Introduced (Exotic) Species"
•High local population density results in distribution expansion into adjacent suitable habitat.
2) Climate Change: "Glaciers and Global Warming"
•Distribution expansion (or shifting!) as a consequence of adjacent unsuitable habitat becoming suitable from ambient changes.
3) Habitat Quality:
•Habitat conditions (poor or good) result in dispersal of individuals.
•Source Population (Good Habitat): emigration > immigration
•Sink Population (Poor Habitat): immigration > emigration
Pulliam (1988)
Genetics
Probability of Inbreeding
Your Reading!!

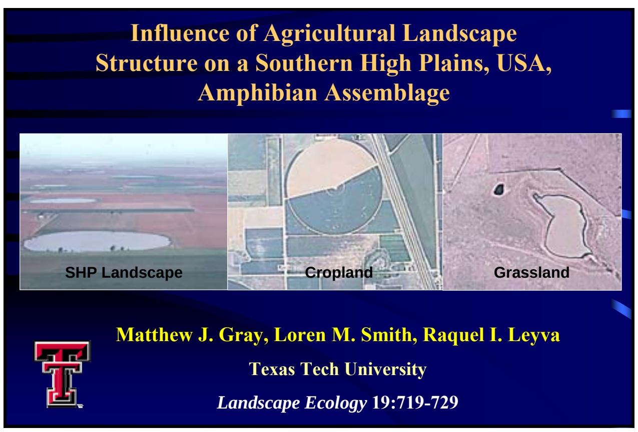

Dispersal
Examples of Reasons to Disperse
Expanding Population
Habitat Quality
Climate Change
34°S
Voles
Kestrels and owls
Year

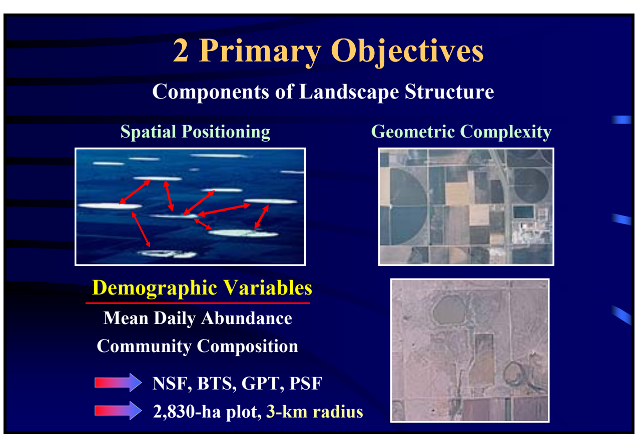

Butterfly Metapopulation
University of Helsinki
Ilkka Hanski
Population Size
Patch Size
Population Density
PS
PS
As habitat patch size increases,
N_t increases and density decreases.
Thus, smaller patches have smaller
yet more dense populations.
Rescue Effect
ALSO, isolated populations
had smaller N_t.
Probability of Extinction is Greatest
for Small, Isolated Populations
AND, Re-colonization Lowest!

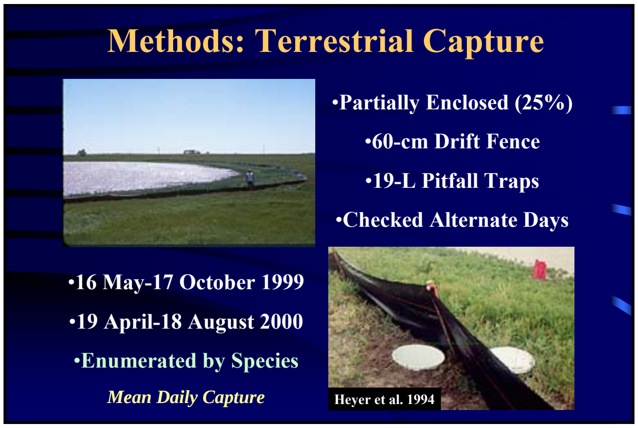

Island Biogeography
Equilibrium Model
Species richness on islands is a dynamic balance
between species immigration & extinction which
results in continual species (composition) turnover.
Robert H. MacArthur
Edward O. Wilson
Dynamic Balance
WHY?
WHY?
New
Old
1963
1967
Size & Distance
Richness
Predictions: 1) Imm: Near > Far
2) Ext: Small > Large
3) Species Richness:
Large, Near > Small, Near > Large, Far > Small, Far

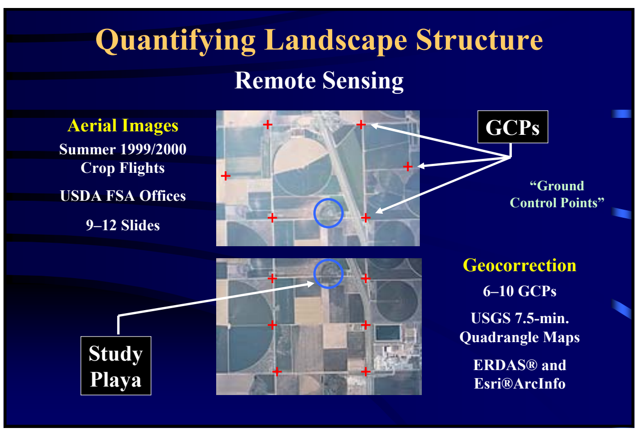

Landscape Structure
Organism Effects
Castor canadensis
Beavers can increase landscape complexity
and decrease nutrient loss from landscape.
Kabetogama Peninsula, MN
Robert Naiman
Wetlands
1925:
Re-colonized
64 to 834 ponds
200 to 2661 ha

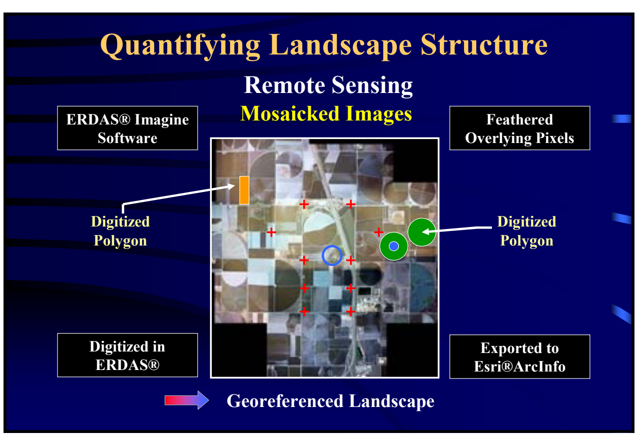

Landscape Structure
Anthropogenic Disturbance
1) Decrease total habitat
2) Decrease patch size
3) Increase inter-patch distance
4) Increase landscape complexity
5) Decrease landscape permeability
Decreasing forest cover
Cadiz Township landscape.
Green County, Wisconsin
93.5%
27%
9%
3.4%
1831
1882
1902
1950


Influence of Agricultural Landscape Structure on a Southern High Plains, USA, Amphibian Assemblage
SHP Landscape
Cropland
Grassland
Matthew J. Gray, Loren M. Smith, Raquel I. Leyva
Texas Tech University
Landscape Ecology 19:719-729


2 Primary Objectives
Components of Landscape Structure
Spatial Positioning
Geometric Complexity
Demographic Variables
Mean Daily Abundance
Community Composition
NSF, BTS, GPT, PSF
2,830-ha plot, 3-km radius


Methods: Terrestrial Capture
•Partially Enclosed (25%)
•60-cm Drift Fence
•19-L Pitfall Traps
•Checked Alternate Days
•16 May-17 October 1999
•19 April-18 August 2000
•Enumerated by Species
Mean Daily Capture
Heyer et al. 1994

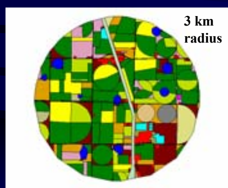

Quantifying Landscape Structure
Remote Sensing
Aerial Images
Summer 1999/2000
Crop Flights
USDA FSA Offices
9–12 Slides
GCPs
"Ground
Control Points"
Geocorrection
6–10 GCPs
USGS 7.5-min.
Quadrangle Maps
ERDAS® and
Esri®ArcInfo
Study
Playa

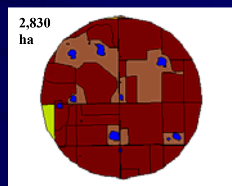

Quantifying Landscape Structure
Remote Sensing
Mosaicked Images
ERDAS® Imagine
Software
Feathered
Overlying Pixels
Digitized
Polygon
Digitized
Polygon
Digitized in
ERDAS®
Exported to
Esri®ArcInfo
Georeferenced Landscape

Quantifying Landscape Structure

Spatial Analysis

Cleaned and Classified Polygons (FSA Farm Folders) and Built Coverages in Esri®ArcInfo





Analyzed Structure using FragStats*Arc

n = 16 Landscapes

Quantifying Landscape Structure

Spatial Analysis

FragStats*Arc ➔ 13 Spatial Metrics

Playa Positioning

- Shape Index (PSI)
- Playa Size (PS)
- MNN Study Playa (PNN)
- MNN All Playas (MNN)
- Percent & Number of Playas (PP, NP)
- Interspersion/Juxtaposition Index (IJI)

Geometric Complexity

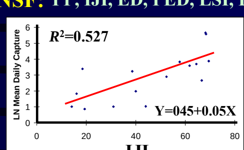
- Playa Edge Density (PED)
- Edge Density (ED, m/ha)
- Landscape Shape Index (LSI)
- Land-use Richness (LU)
- Shannon Evenness (SEI)
- Shannon Diversity (SDI)

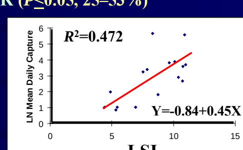
McGarigal and Marks (1995)

Results: Pearson and SLR

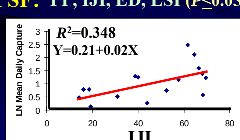
P>0.05 GPT & BTS

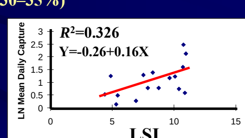
NSF: PP, IJI, ED, PED, LSI, LR ($P \leq 0.05$, 25–53%)

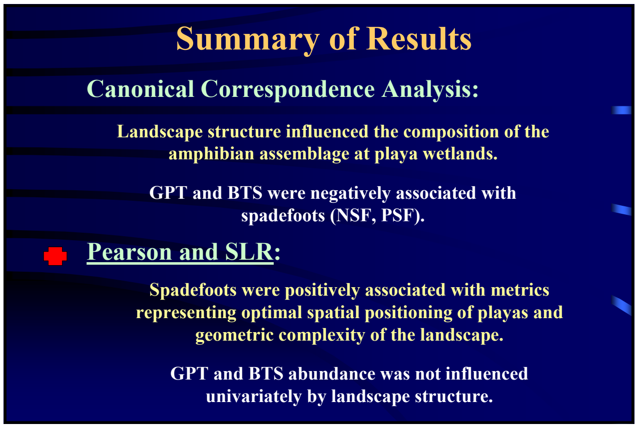


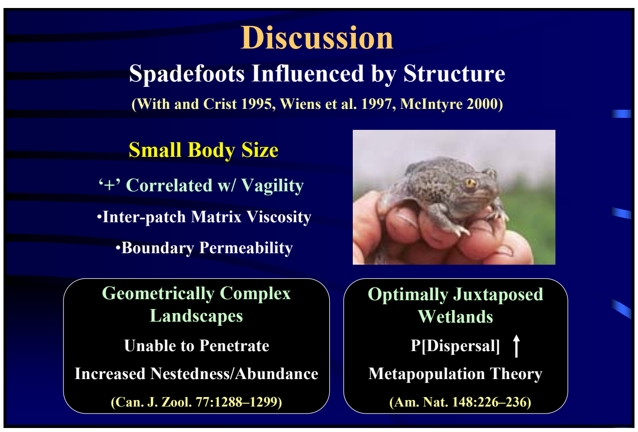


PSF: PP, IJI, ED, LSI ($P \leq 0.05$, 30–35%)






Summary of Results
Canonical Correspondence Analysis:
Landscape structure influenced the composition of the amphibian assemblage at playa wetlands.
GPT and BTS were negatively associated with spadefoots (NSF, PSF).
Pearson and SLR:
Spadefoots were positively associated with metrics representing optimal spatial positioning of playas and geometric complexity of the landscape.
GPT and BTS abundance was not influenced univariately by landscape structure.


Discussion
Spadefoots Influenced by Structure
(With and Crist 1995, Wiens et al. 1997, McIntyre 2000)
Small Body Size
'+' Correlated w/ Vagility
•Inter-patch Matrix Viscosity
•Boundary Permeability
Geometrically Complex Landscapes
Unable to Penetrate
Increased Nestedness/Abundance
(Can. J. Zool. 77:1288–1299)
Optimally Juxtaposed Wetlands
P[Dispersal] ↑
Metapopulation Theory
(Am. Nat. 148:226–236)