Landscapes, spatial technologies, and wildlife

Objectives:
1) Identify some key principles of wildlife landscape ecology
2) Contrast different ways to determine landscape pattern
3) Apply some landscape principles to interpreting effects of landscape structure on wildlife

What is a landscape, really?
area that is spatially heterogeneous in at least one factor of interest

What is landscape ecology?
= the study of the reciprocal effects of spatial pattern on ecological processes (Pickett and Cadenasso 1995)
= the study of the effect of pattern on process (Turner 1989)

What is Landscape Ecology?

What Is Landscape Ecology?

Wildlife Landscape Ecology

What Is Landscape Ecology?
Wildlife landscape ecology seeks to:

1) Understand how landscape structure affects the abundance and distribution of wildlife

2) Provide management and conservation solutions at landscape scales

Outline

- Quantifying spatial pattern: some nuts-and-bolts
  - Issues of spatial scale
  - Kinds of data
  - Types of pattern: point and categorical
- Quantifying and interpreting wildlife responses to spatial pattern
  - Quantitative approaches at different organizational levels

The critical concept of scale

Components of Scale

Grain: The minimum resolution of the data, defined by the cell or minimum polygon size

Extent: the scope or domain of the data, defined as the size of the study area (e.g., management unit) under consideration

Organism-centered perspectives

Grain: the finest component of the environment that can be distinguished

Extent: the distance at which an object can be distinguished

Management-centered perspectives

Grain: the finest unit of management considered (e.g., stand, patch)

Extent: the total area under management consideration (e.g., forest, National Park)
A key for embracing and dealing with scale in wildlife studies:

1. Grain and extent must be defined to capture the ecological question/issue of interest for organisms and environments

2. Employ scaling techniques to consider different spatial scales in an objective manner, and how relationships change

An example: Bald eagle habitat use on the Hudson River, NY

Bald eagle habitat requirements
Access to foraging areas
- water depth
Available perch trees
- Canopy structure
Isolation
- Human activity
- Shoreline development

So, lots of information, but do not know the characteristic scales for how eagles use this information

Systematic change in the grain of analysis

Systematic change in the extent of influence on eagles
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Geographic Information Systems (GIS) for storing and using large-scale data

- A system of hardware and software used for storage, retrieval, mapping, and analysis of geographic data
- Increasingly used for scientific investigations, resource management, development planning, marketing analyses, etc.

How does GIS work?

Different kinds of data sources for quantifying landscape pattern and using in GIS

1. Aerial photography
2. Digital remote sensing
3. Published data and censuses
4. Field-mapped data

Aerial photography
Remote sensing

*Digital measurements from a distance.*

- Measurement by satellite- or air-borne sensors
- Often uses reflectance spectra of vegetation for quantification
- e.g., Landsat, SPOT, hyperspectral imagery, etc.

Published data/censuses

- e.g., historic surveys

Historic Iowa Landscape

Current Iowa Landscape

Native tallgrass prairie shown in RED

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Field mapping

- With both aerial photos and remote sensing, we tend to classify maps with GIS into categories
- Classification usually occurs via raster or vector processing

Given these data sources, there are two main types of data for interpreting landscape pattern
2 flavors of point data

‘Point patterns’: when point data represent discrete processes

‘Geostatistics’: when point data represent an underlying continuous process

Point pattern characteristics

- Data comprise collections of the locations of entities of interest (e.g., GPS locations)
- The ‘entities’ are discrete, rather than points describing a continuous surface
- Examples: map of trees in a stand, locations of wetlands, map of nests

- Relevant kinds of wildlife questions:
  - At what spatial scale (extent) do plovers avoid human recreation in placing their nests on beaches?
  - At what spatial scales are raccoons aggregated near towns?

Geostatistics

- Points are sampled from an underlying continuous distribution
- Examples: elevation, canopy height, species richness

- Relevant kinds of wildlife issues it can address:
  - The spatial scale at which variation occurs
  - The spatial scale at which monitoring locations are statistically independent
  - Interpolating patterns from the sampled points

Categorical analysis: the most common approach for quantifying pattern and relating it to wildlife ecology and management

Land use and land cover

Levels of heterogeneity in map patterns

- **Cell-level:** metrics defined for individual cells (regardless of patch affinity)
- **Patch-level:** metrics defined for individual patches or stands
- **Class-level:** metrics defined for a given type (class) of land cover/habitat
- **Landscape-level:** metrics defined using all classes/types for the entire extent
Components of landscape structure

Landscape composition: the variety and amounts of elements in the landscape (e.g., habitats)

Landscape configuration: the spatial characteristics and distribution of elements in the landscape

Quantifying pattern...Questions to ask before using!

• What is my question (or what is the problem) and how/why do I need landscape metrics?
• Are my data and questions more suited to ‘point data’ analyses or categorical analyses?
• What processes are likely influencing patterns and how can metrics be chosen to capture those processes?
• Is landscape composition or configuration more relevant?
• What is the appropriate spatial and temporal framework for my question (extent, grain, time)?

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Interpreting wildlife responses to landscape structure

• Individuals
  – Dispersal and movement behavior
• Populations
  – Species distributions
  – Demographic variation with landscape structure

Connectivity: a key ingredient of landscapes

= the degree to which a landscape facilitates or impedes movement of organisms among resource patches

Larkin et al. (2004)
Measuring movement behaviors

- Mark-recapture

Trapping webs

Multi-state: movement & survival

- Mark-recapture
- Radio-telemetry

Trajectories from radio-telemetry

Step length (d_i)
Total distance (Σd_i)
Net displacement (δ)
Turning angle (θ)

Predator movement in landscapes with different amounts of habitat (Phillips et al. 2004)
Interpreting wildlife responses to landscape structure

- **Individuals**
  - Dispersal and movement behavior

- **Populations**
  - Species distributions
  - Demographic variation with landscape structure

**Populations: species distributions**

Species distribution models attempt to explain (and map) distributions/locations of individuals within a species

- Habitat suitability index (HSI) models
- Habitat models
- Envelope models
- GAP models
- Resource selection models (RSF)
- Occupancy models
- Niche models

**Just some uses of species distribution models in conservation**

1. Assessing species invasion and proliferation

![Hydrilla verticillata](image1)

*Peterson et al. (2003)*

2. Assessing the impact of climate, land use, or other environmental changes on species distribution

![Faunal change map](image2)

*Lawler et al. (2009)*

3. Identifying unsurveyed sites of high potential of occurrence for rare species

*Chameleons in Madagascar (Raxworthy et al. 2003)*

Blue and green show areas that were surveyed because of predicted suitability—yielded 7 new species!

**The key ingredients of a species distribution model**

1. **Response variables** (dependent variables): presence/absence, abundance, etc. of a target organism
2. **Predictor variables** (independent variables): environmental factors associated with the location (preferably GIS-based layers)
Once you have a statistical model, it needs to be linked to GIS for mapping. Therefore, must have relevant variables represented as GIS files.

$$y = \alpha + \beta x_1$$

**GAP analysis as an example** (Scott et al. 1993)

- Goal: identify gaps in biodiversity protection
- Maps of existing vegetation are prepared from satellite imagery (LANDSAT) and other sources and entered into a GIS
- Predicted species distributions are based on existing range maps and other distributional data, combined with information on the habitat affinities of each species

**Populations: variation in demography across landscapes**

Two general approaches:

1) Testing for effects of landscape structure on fecundity and/or survival

**Using it as a tool**

Decision support tool: an interactive tool designed to organize existing data for better management

Simulated landscape attributes or changes in the environment

Predicted ecological consequences

Scenario A

Scenario B

**Interpreting wildlife responses to landscape structure**

- Individuals
  - Dispersal and movement behavior
- Populations
  - Species distributions
  - Demographic variation with landscape structure
Nest success and parasitism of migrants

Robinson et al. (1995)

Populations: variation in demography across landscapes

Two general approaches:
1) Testing for effects of landscape structure on fecundity and/or survival
2) Spatially explicit population models

Spatially explicit population models

- Models are spatially explicit when they combine: population simulator + landscape map
- Through the use of explicit maps, the effect of changing landscape features on population dynamics can be studied
- SEPMs are proving useful for interpreting potential management strategies

An example: BACHMAP
Pulliam et al. (1992)
Liu et al. (1995)

Results from the SEPM:
- Could compare different forest management regimes
- Sparrows will likely persist, but only after a substantial decline
- Model sensitive to survival, landscape structure

Summary of wildlife landscape ecology

Wildlife Landscape Ecology

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