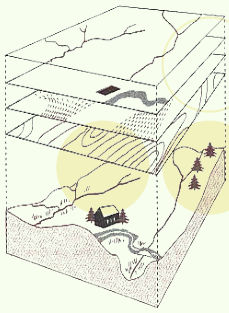
Landscape Ecology and Amphibians



WFS 533
Wyn Miller
March 26, 2009

Overview

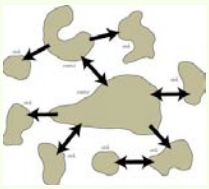
- Introduction to landscape ecology
  - Metapopulation dynamics
- Natural habitat fragmentation
- Anthropogenic habitat fragmentation
- Opportunities for landscape ecology

Introduction

- Landscape ecology (LE) "considers [the] influences of spatial heterogeneity on biotic and abiotic processes…" (Karr, 1985)
- LE themes:
  - the **spatial pattern or structure of landscapes**, ranging from wilderness to cities
  - the relationship between pattern and **process** in landscapes
  - the relationship of **human activity** to landscape pattern, process and change
  - the effect of **scale** and **disturbance** on the landscape (IALE 2009)

Metapopulation Dynamics

- Matrix, patches, corridors, landscapes
  - Patches of populations
  - Landscapes of metapopulations
  - Dispersal & migration take place through matrix



Metapopulation Dynamics

- Amphibians are adapted to fragmented habitats
  - Evolution of dispersal
  - Natural habitat fragmentation

Natural Habitat Fragmentation

- Mountains, water bodies, deserts, changes in elevation
- Variety of scale
- Absolute barriers = usually geologic (large scale)

Natural Habitat Fragmentation

- Quality of matrix affects likelihood of successful dispersal
- Hostile matrix:
  - less likely to attempt dispersal, more likely to experience mortality (Joly 2003)
  - Sensitivity to isolation and area of patches increased (Prugh 2008)

Anthropogenic Habitat Fragmentation

- Human land use alters landscape greatly
  - Increases habitat loss and fragmentation
  - Affects quality of matrix
  - Creates many small-scale absolute barriers

Landscape Alteration: Deforestation

- Effects:
  - Increases temperature,
  - reduces moisture and vegetative cover
- Variables:
  - frequency and intensity of timbering
  - second-growth vegetation

Landscape Alteration: Agriculture

- Effects:
  - Disturbs substrate
  - Decreases plant diversity
- Examples:
  - Row crops, vineyards
  - Livestock pasture
  - Forage production

Landscape Alteration: Hydrology

- Effects:
  - Affects habitat access
  - Affects water permanency and quality
- Examples:
  - Dams
  - Canals
  - Drained wetlands

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Landscape Alteration: Urban Development

- Effects:
  - Decreases overall habitat quality (water into sewage system, paved land, loss of vegetation, traffic, etc.)
  - Habitat is lost
  - Creation of many absolute barriers

Landscape Alteration: Roads

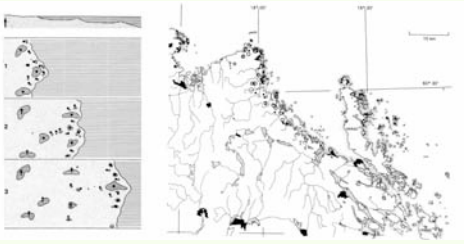
- Variables:
  - Traffic density
  - Width and direction of road
  - Proximity of road to habitat (Langen 2008)
- Effects:
  - Increase edge effects (predation)
  - Traffic: demographic sink
  - "Key factor limiting dispersal" (Ficetola 2008)
  - May be factor in decline (Elzanowski 2009)

Anthropogenic Habitat Fragmentation

- Interaction of different types of landscape alteration produces highly hostile matrices
- Greatly altered landscapes result in habitat loss and fragmentation

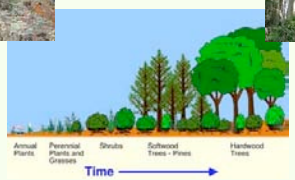
Temporal Aspects

- Landscapes naturally change over a long period of time
  - Geology's effect on populations (Gulve 1994)



Temporal Aspects

- Anthropogenic landscape change happens quickly
  - Seral continuum (Welsh 2005)
  - "Lag" in response to habitat degradation (Piha 2007)



Consequences of Fragmentation

- Altered landscapes may not be uninhabitable
  - However, they favor different species than before
  - Terrestrial eft stage's pros and cons (Gibbs 1998)

Notopthalmus viridescens

Consequences of Fragmentation

- Dispersal stage most sensitive to fragmentation (Gibbs 1998)
  - Red-spotted newts' threshold: 50%
  - Redbacked salamanders' threshold: 5-30%

Table 1. General comparison of life-history characteristics of the five woodland amphibian species surveyed along a forest fragmentation gradient in southern Connecticut, 1992–1994[1].

Characteristic	Red-spotted Newt	Redback salamander	Spotted salamander	Spring peeper	Wood frog
Relative density	Low	High	Low	Intermediate	Low
Dispersal tendency	High	Low	Intermediate	Intermediate	Intermediate
Life-cycle	Bi-phasic	Uni-phasic	Bi-phasic	Bi-phasic	Bi-phasic
Adult habitat	Forest	Forest	Forest	Mixed	Forest

[1] Based on Gill (1978), Healy (1978), Jaeger (1980), Wyman (1988), Berven (1990), Berven and Grudzien (1991), Conant and Collins (1991).

Consequences of Fragmentation

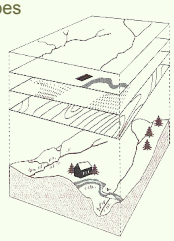
- However, landscapes greatly impacted by anthropogenic alteration often cannot serve as amphibian habitat
- Amphibians may be especially prone to local extinction from landscape alteration due to "the spatially and temporally dynamic nature of their populations." (Gibbs 1998)
- Urbanization is probably a major cause of global amphibian decline (Pillsbury 2008)

Red-legged Frog, *Rana aurora*

Israel Painted Frog, *Discoglossus nigriventer*

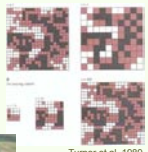
Opportunities for Landscape Ecology

- Landscape ecologists have devised tools for better conservation efforts
  - Genetic studies across landscapes
  - Landscape anisotropy
  - Resistance indexes
  - Connectivity maps
  - Wildlife bridges, ecoducts, and wildlife fences
  - Corridors and buffers

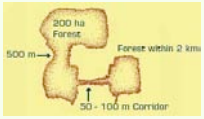


Opportunities for Landscape Ecology

- Common practices
  - Forested corridors
  - Multiple scales



Turner et al. 1989



Opportunities for Landscape Ecology

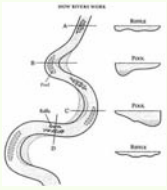
- Common practices
  - Riparian buffer zones
  - Ought to be 50-300m (Semlitsch 2003)
  - Usually only 5-25m
  - Does not provide for activities that take place away from the stream

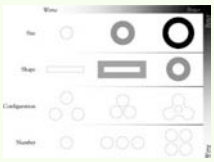
Opportunities for Landscape Ecology

- Common practices
  - Keep livestock out of streams
  - Partial timbering
  - Using permeable materials

Opportunities for Landscape Ecology

- Landscape anisotropy
  - Landscape has different qualities when measured along different axes (Ficetola 2008)
- Disproportionate use of landscape
  - Some spaces or directions more useful than others (Olson 2007)



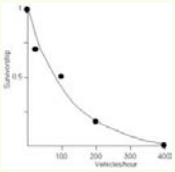


Opportunities for Landscape Ecology

- Assessing connectivity (Joly 2003)

Urbanised areas and vineyards	80
Cultivated fields	45
Pebble beds	45
Roads and railways	45
Meadows and marshes	25
Poplar growing fields	15
Forested areas	5

1. Each type of landscape given a "resistance coefficient" based on the friction provided by the landscape with regards to a given individual



2. Interaction with roads

Opportunities for Landscape Ecology

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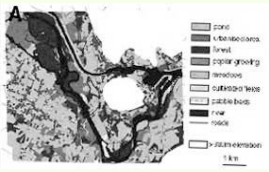
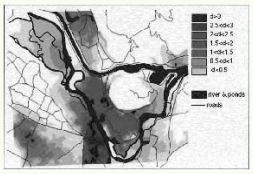


3. Habitat map



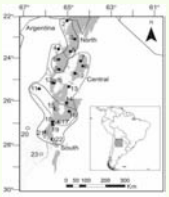
4. Connectivity map
(could be used in land use planning?)

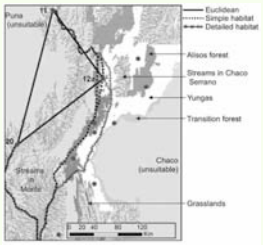
Opportunities for Landscape Ecology

- Predicting "hot spots" of road mortality (Langen 2008)
  - Causeway scenario
  - Allowing continued flow of amphibian movement

Opportunities for Landscape Ecology

- Genetic analysis as a method for generating routes (Koscinski 2009)
  - Gather DNA
  - Assess lineages
  - Generate routes





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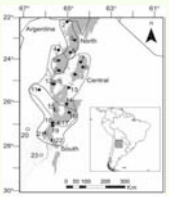

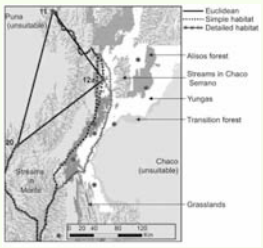

The end…on to “defragmentation” in Europe