Organisms and Landscape Pattern

What are the essential processes necessary for the persistence of a species?

Reading: Chapter 8

Recruitment: Essential for species persistence and/or species replacement (succession)

What are the important factors for recruitment of species in landscapes?

Conceptual development of organism-spatial interactions

- Theory of island biogeography (MacArthur and Wilson 1963, 1967, MacArthur 1972)

Conceptual development of organism-spatial interactions

- Theory of island biogeography (MacArthur and Wilson 1963, 1967, MacArthur 1972)

The number of species on an island is dependent upon: the size of the island and the distance to the mainland source populations.

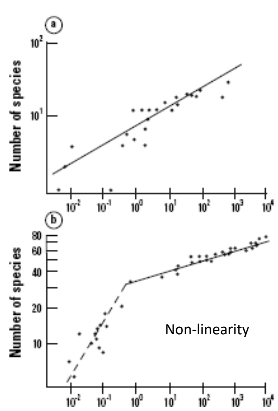
Immigration Rate is dependent upon: distance to mainland, and the size of the mainland source community (number of populations and size of populations)

Extinction Rate is dependent upon: available resources (island size)

Examples of species-area relationships

A: Species-area plot for 24 islands in the Sea of Cortez (Cody 1983)

B: Species-area plot for birds in the Solomon Islands (Diamond and Mayr 1976, Williamson 1981



Source: T,G & O 2001. Figure 2.3

Landscape connectivity and metapopulation dynamics

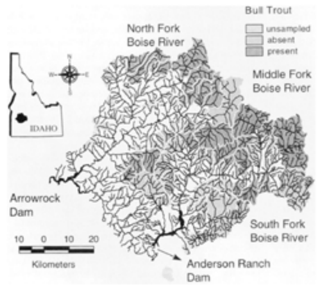
Pacific Northwest forests

What can you generalize about the primary factors influencing species dispersal in these two landscapes?

Habitat in which landscape is the most fragmented?

Dunham, J.B. and B. E. Rieman. 1999. Metapopulation structure of bull trout: Influences of physical, biotic, and geometrical landscape characteristics. Ecological Applications 9:642-655.

Studied the population structure of bull trout in the Boise River Basin.



Dunham, J.B. and B. E. Rieman. 1999. Metapopulation structure of bull trout: Influences of physical, biotic, and geometrical landscape characteristics. Ecological Applications 9:642-655.

Data collected:
Brook and bull trout occurrence (categorical data: 0-1)
Stream width (m)
Stream gradient (%)
Solar radiation (GJ/m^2/y)
Road density m/ha
Patch area of catchment (ha)
Distance to nearest occupied patch (m)

TABLE 3. Results of logistic regressions of patch-scale bull trout occurrence (transformed predictors, see *Methods*). Values in parentheses are lower and upper 95% confidence limits for parameter estimates.

Variable	df	Parameter estimate	SE	Wald chi-square	P
Intercept	1	−3.2	3.49	0.84	NS
Patch area	1	1.26 (0.61, 2.05)	0.36	12.05	0.0005
Distance to nearest occupied patch	1	−0.84 (−1.48, −0.30)	0.30	8.10	0.004
Road density†	1	1.59 (0.07, 3.19)	0.79	4.10	0.04

† Note that the sign of the slope parameter estimate for road density is for an inverse transformation, and thus the sign is reversed from that expected with untransformed data.

Most important predictor variables included:
- Patch area (catchment)
- Distance to nearest occupied patch

- Road density (significant but of lesser importance)

Dunham and Rieman 1999

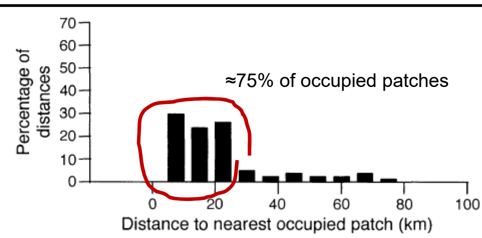


FIG. 5. Distribution of distances to nearest occupied patch for 81 patches of potentially occupied bull trout habitat in the Boise River basin.

Conclusions- Conservation of bull trout efforts should focus on large patches (catchments) of habitat (> 10^5 ha) that are close together (< 25km).

Dunham and Rieman 1999

Conceptual development of organism-spatial interactions

- Theory of island biogeography (MacArthur and Wilson 1963, 1967, MacArthur 1972)
- Metapopulation biology (Levins 1969, 1970)
  - Populations are locally dynamic but regionally stable
  - All patches are of equal quality, implying the same birth and death rates

What conditions contribute to local extinction?

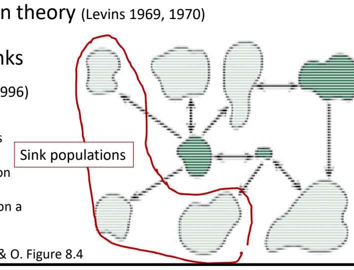
What conditions contribute to regional extinction?

Conceptual development of organism-spatial interactions

- Theory of island biogeography (MacArthur and Wilson 1963, 1967, MacArthur 1972)
- Metapopulation theory (Levins 1969, 1970)
- Sources and sinks

(Pulliam 1988, Dias 1996)

Source habitats- reproduction is greater than mortality.
Sink habitats where reproduction is less than mortality, producing habitats that without immigration a species would go locally extinct.



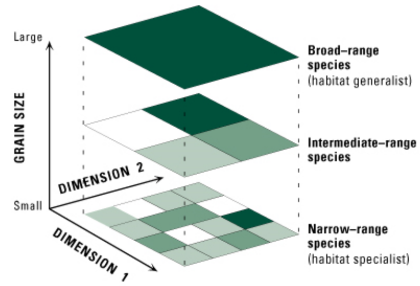
T,G & O. Figure 8.4

Organisms perceive habitat quality and fragmentation from different perspectives.

What are some factors that result in differences in how species perceive landscapes?

Species related factors	Environmental factors
•	•
•	•
•	•
•	•
•	•
•	•
•	•

Organisms perceive habitat quality and fragmentation from different scales

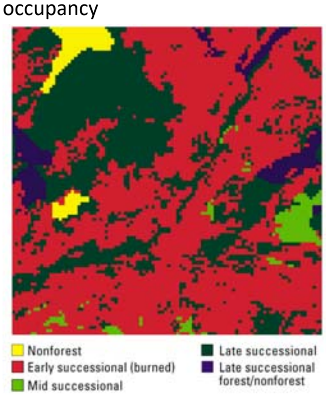


T,G & O. Figure 8.7

Identification of 'suitable habitat' through current occupancy

Landscape ecologists are frequently asked to classify habitat into areas of suitable habitat for a species.

What variables can we use to help identify (classify) suitable habitat for a given species?



Adapted from
T, G & O. Figure 5.5

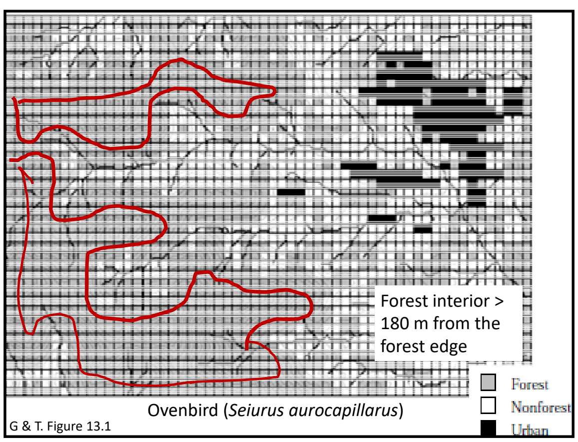
Identification of 'suitable habitat'

Rule-Based Approach

- When limited amounts of occurrence data is available
- Based on expert opinion
- Also called deductive models (based on deductive reasoning)

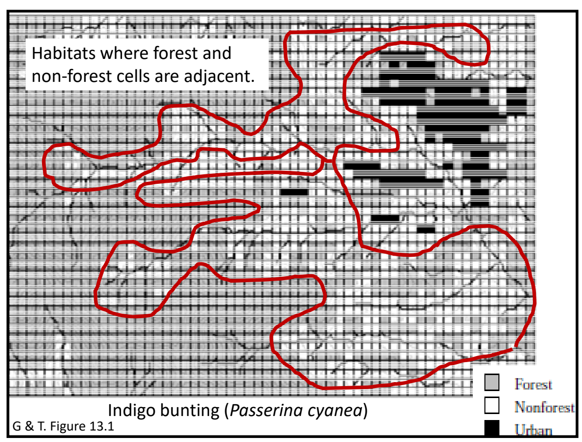
Probability-Based Approach

- When large amounts of well distributed occurrence data is available
- When the data accuracy is high
- Also called inductive models (statistics based)



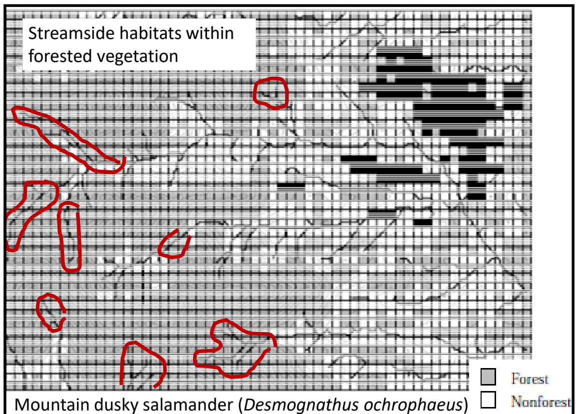
Ovenbird (*Seiurus aurocapillarus*)

G & T. Figure 13.1



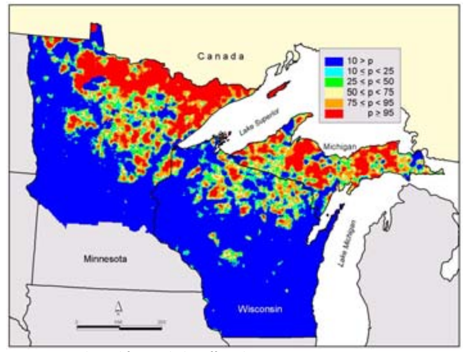
Indigo bunting (*Passerina cyanea*)

G & T. Figure 13.1



Mountain dusky salamander (*Desmognathus ochrophaeus*)
G & T. Figure 13.1

Probability of occurrence of suitable wolf habitat -probability based approach



T, G & O. Figure 8.5, Adapted from Mladenoff et al. 1995

Probability of occurrence of suitable wolf habitat

How did they develop the habitat map?

They had 15 years of wolf radio collar locations.

Spatial data utilized:
- Land cover (developed 6 landscape indices)
- Land ownership
- Road density
- Human-population density
- Deer density

Determined 14 areas used by wolf packs, and 14 randomly assigned areas not used by wolves

Mladenoff et al. 1995. Conservation Biology 9:279-294

Probability of occurrence of suitable wolf habitat

Landscape vegetation indices included:
- **Land cover mean patch area**
- **Total edge** between patches (normalized by area), a measure of the amount of juxtaposition between different land cover types
- **Fractal dimension**, an index of patch boundary complexity in relation to patch size scaled from 1-2 (simple to complex)
- Two indices based on the Shannon-Wiener Index: **landscape diversity** and **landscape dominance**
- **Landscape contagion**, an index of aggregation of cover types across the landscape

Mladenoff et al. 1995. Conservation Biology 9:279-294

Probability of occurrence of suitable wolf habitat

Finally, stepwise logistic regression analysis was used to derive a multivariate model that would predict the probability of the presence or absence of wolf packs.

Wolf packs utilized areas that had:

1) Low human influence (low road density, low human population density)

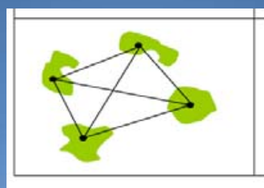
2) Larger patches of unfragmented forest vegetation

Mladenoff et al. 1995. Conservation Biology 9:279-294

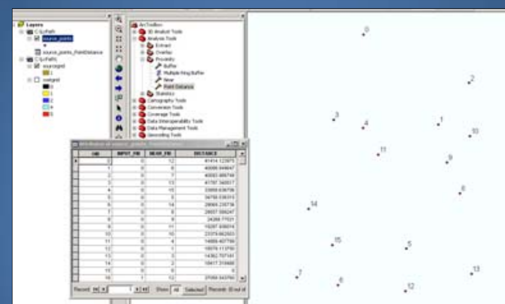
GAP Analysis Project

- State-wide or region-wide projects
- Landcover maps
- Species habitat models
- Protection status of species

Least Cost Path Analysis and Functional Connectivity

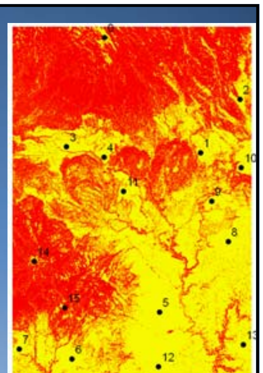


POINT DISTANCE in ArcToolbox



Least cost distance?

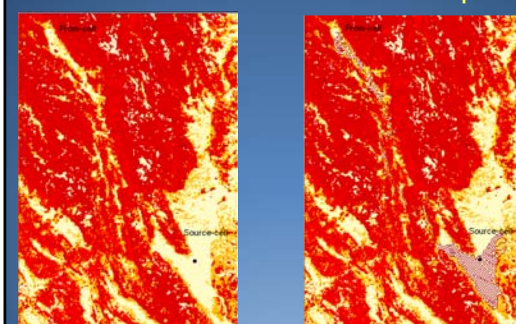
- A method to measure effective distance between habitat patches
- Measures connectivity between existing or potential reserves
- Least cost modeling has been enabled by GIS technology
- Requires two spatial data layers
  - ✓ A resistance/friction surface indicating travel cost
  - ✓ A source patch layer to which the cumulative travel cost fore each cell is measured



Difficult to traverse

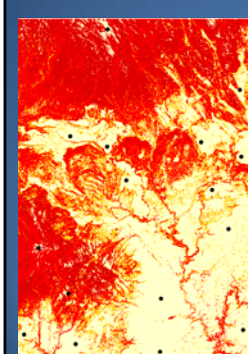
Easy to traverse

Resistance surface example



Darker color – more difficult habitat to traverse

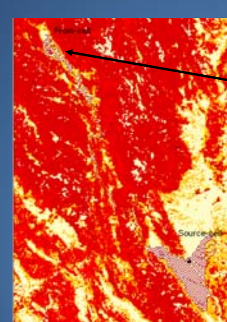
COSTDISTANCE



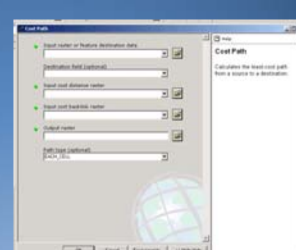
A resistance surface (cost grid) overlaid with points that make up the source grid

COSTDISTANCE in ArcToolbox

COSTPATH

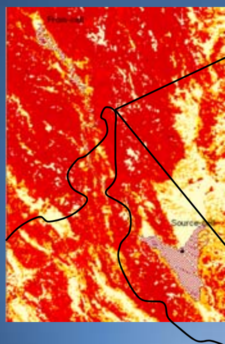


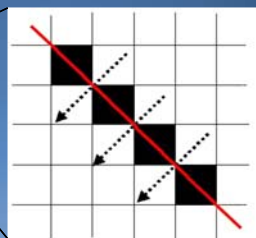
costpathgrd = COSTPATH(fromcell, costdist, backlinkgrd)



COSTPATH in ArcToolbox

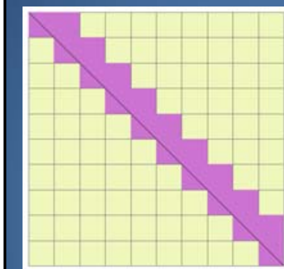
Linear features in the resistance surface??





- Cracks are created when linear features are converted to raster data
- The organism may find 'inexpensive' non-existing shortcuts

Solutions

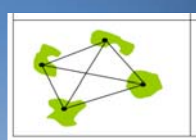


- Make buffer before converting to raster
- use the *linegrid* command
- the cell size should be no larger than half the width of the most narrow polygon feature
- Aggregate cost-weights to a coarser resolution using a moving window

Theobald 2005

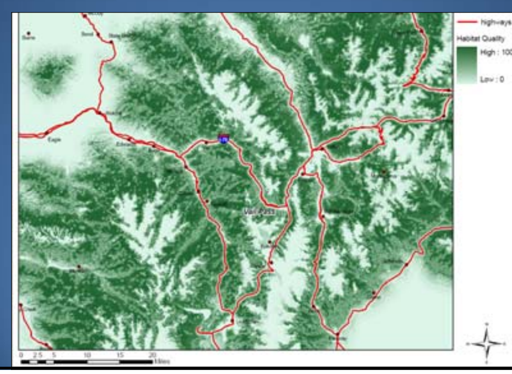
Functional Connectivity

- *FunConn* modeling tool in ArcGIS 9.x http://www.nrel.colostate.edu/projects/starmap/
- Developed by Dr. David Theobald, CSU
- Offers improvements over least-cost-path analysis
- Allow landscape connectivity to be examined from a functional perspective
- Based on graph theory

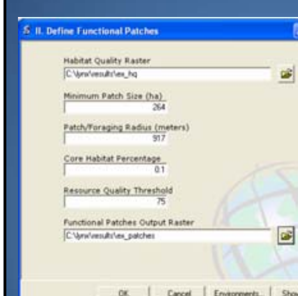


Citation: Theobald, D.M., J.L. Norman, and M.R. Sherburne. 2006. FunConn v1: Functional Connectivity tools for ArcGIS v9. Natural Resource Ecology Lab, Colorado State University.

Lynx Habitat Quality Map



Define Functional Patches



Minimum size

Max foraging radius

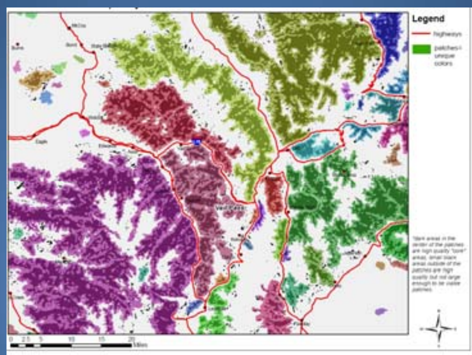
Core habitat

Quality threshold (based on habitat quality raster)

Define functional patches overview

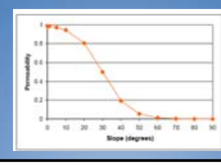
1) Areas greater than the quality threshold are kept and regiongrouped
2) Areas less than the minimum core habitat percentage times the area of the foraging radius are eliminated
3) A cost surface is created from the habitat quality raster, cells of high quality have a low cost and vise versa
4) The remaining patches are grown outwards across the cost surface to a distance equal to the foraging radius.
5) Patches less than the minimum patch size are eliminated.

Functional Patches of Lynx Habitat



Permeability raster

- Permeability is the inverse of resistance
- Is NOT the same as habitat quality, but rather describes how readily the organism can move through
- Permeability can be a function of for example habitat type or topography,



Lynx Landscape Network

Summary of ideas covered

Three major ecological theories related to the conceptual development of organism-spatial interactions

- Theory of island biogeography
- Metapopulation theory
- Source and sink theory

Approaches to classifying suitable habitat

- Rule-based approach- bird habitat example
- Probabilistic analysis- wolf habitat example

•Least-cost-path analysis
•Functional connectivity