ENV761 Geospatial Analysis for Conservation & Management

Landscape Prioritization:
Connectivity Analysis

NICHOLAS SCHOOL OF THE
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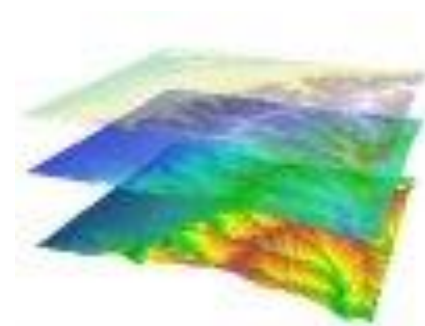


Patch attributes

- Patch size, shape, and distribution
  - Area, compactness, core:area ratio
- Patch corridors and connectivity
  - Least cost paths; corridors; and effective proximity
- Patch sensitivity and proximity to threats/stresses
  - Mapping threat density and magnitude

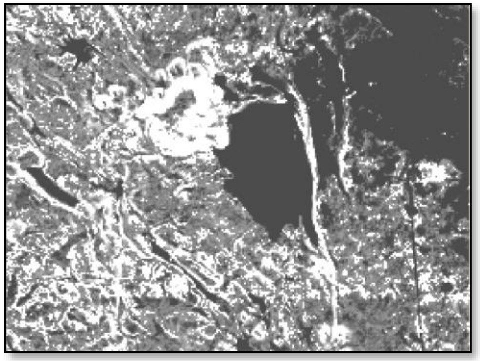
Habitat and *Habitat Patch* maps

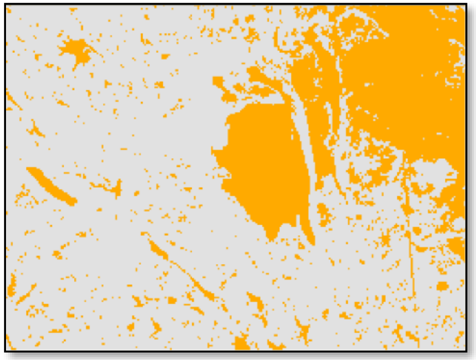
Pronghorn distribution model → **Pronghorn habitat map** → **Pronghorn habitat-patch map**

Continuous:
Pronghorn habitat suitability (0.0-1.0)

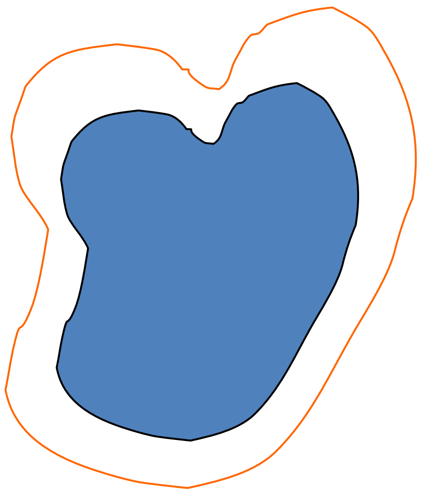
Binary:
Separates pixels into suitable and non-suitable classes

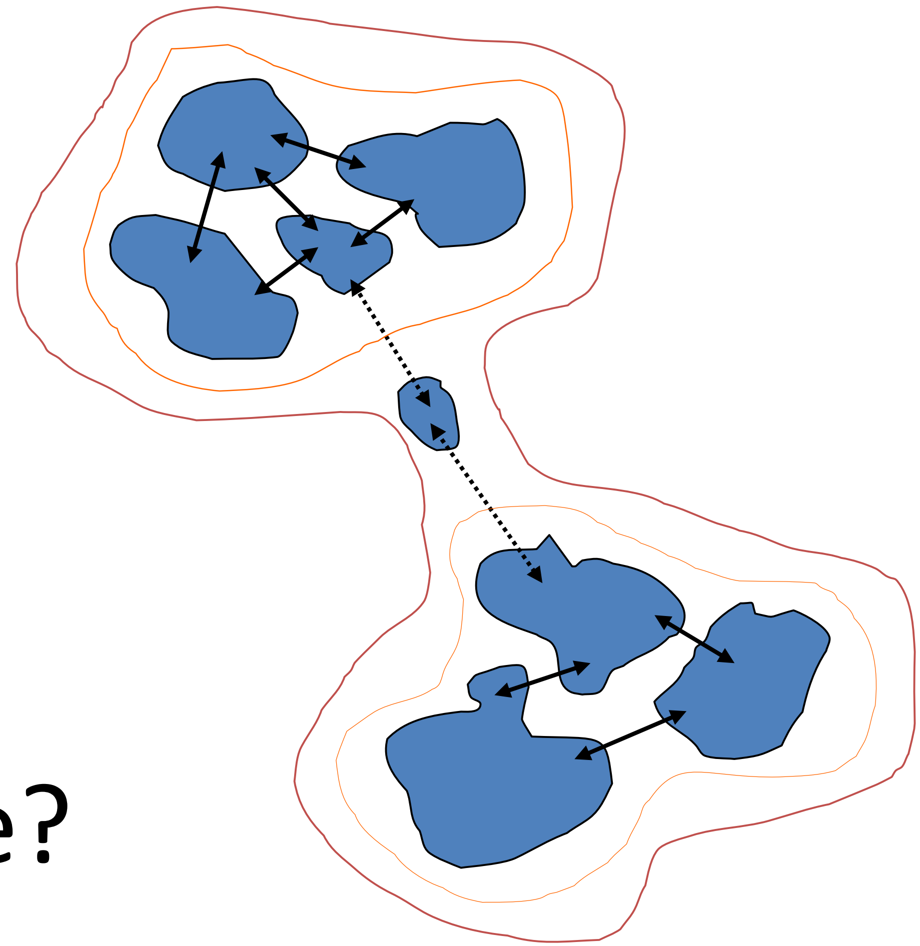
Nominal:
Clusters of connected habitat cells are grouped and given a unique ID





Landscape Prioritization: Connectivity





How to prioritize?

Connectivity

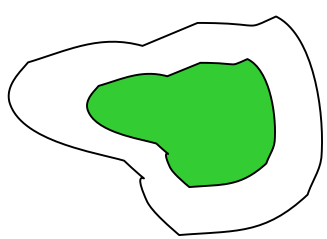
- Individuals may migrate beyond habitat boundaries.

- Habitat patches within the distance an individual is likely to travel are functionally connected.

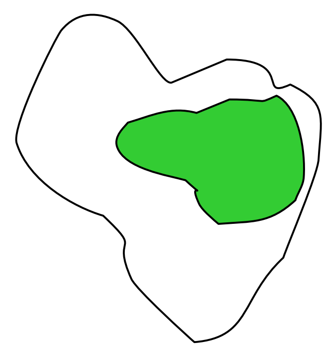
- The set of functionally connected patches make up a patch subnetwork.

Connectivity Analysis: Requirements

- Habitat patch dataset…
- Data on how far individuals are likely to venture outside of habitat…



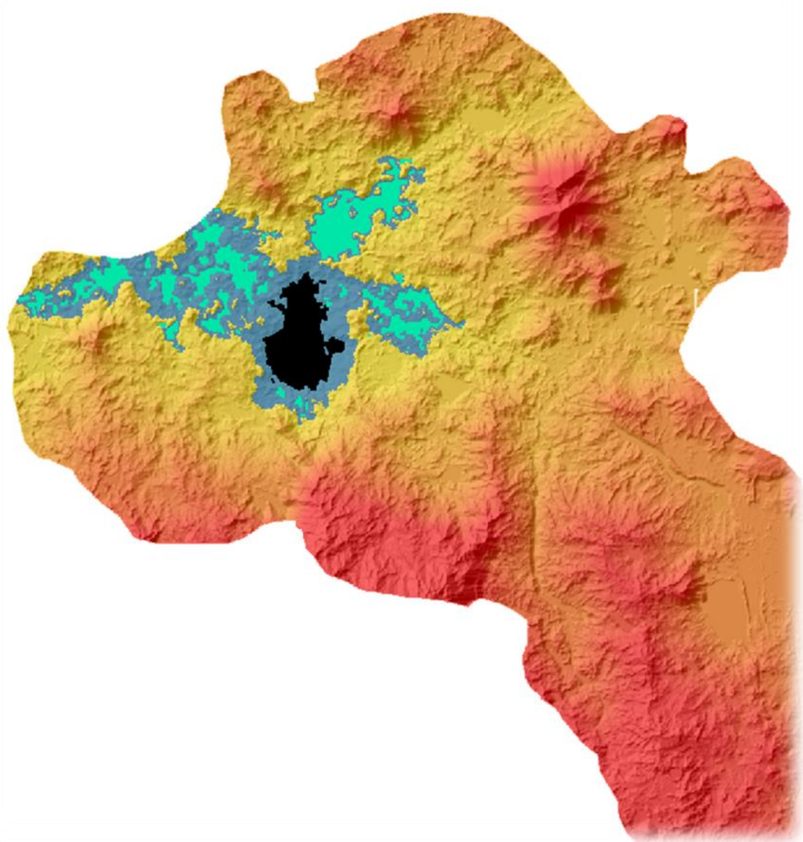
Euclidean



Cost-weighted

I. Distance to Source Patch

What patches are connected to an area of particular importance*?

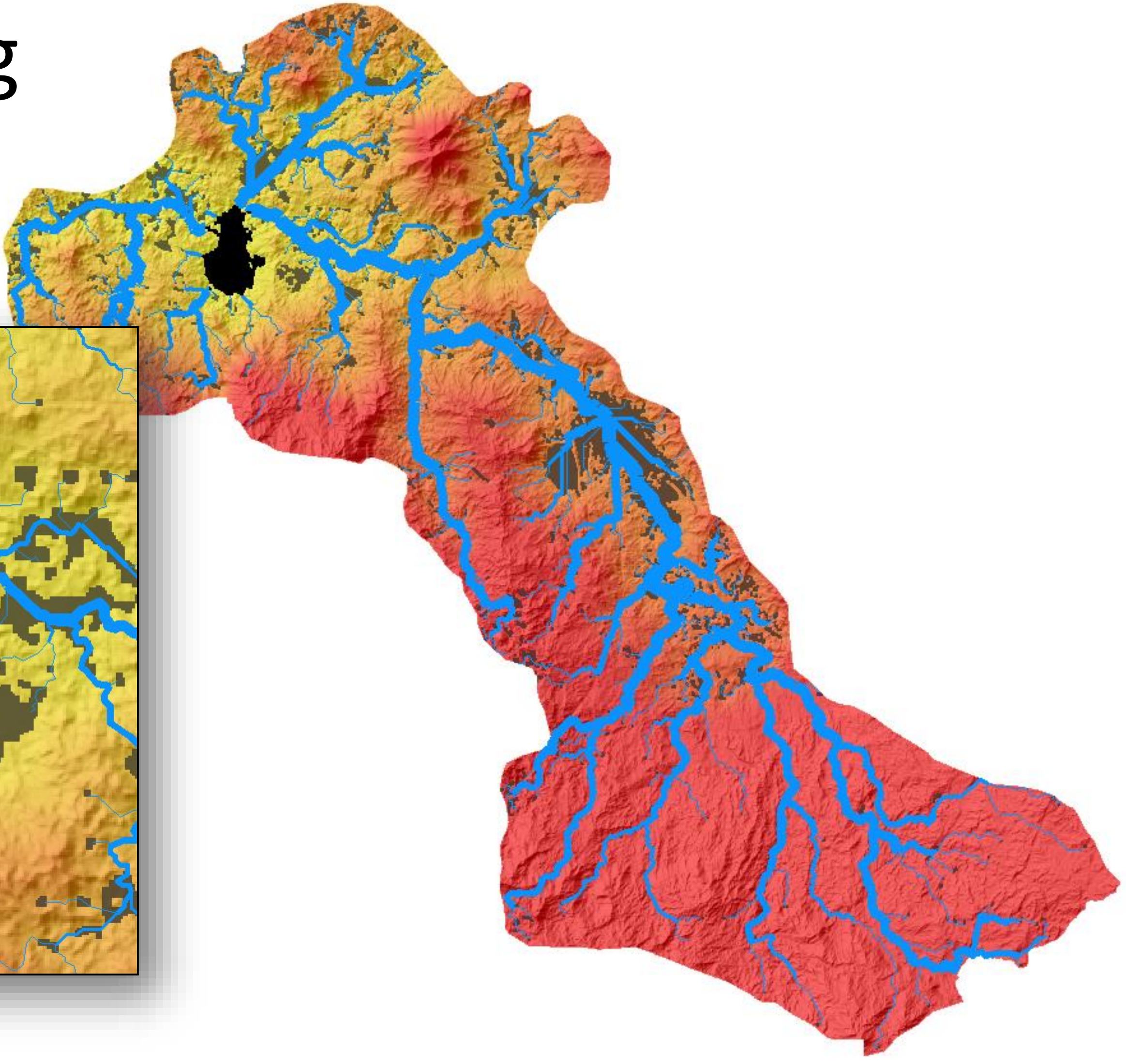


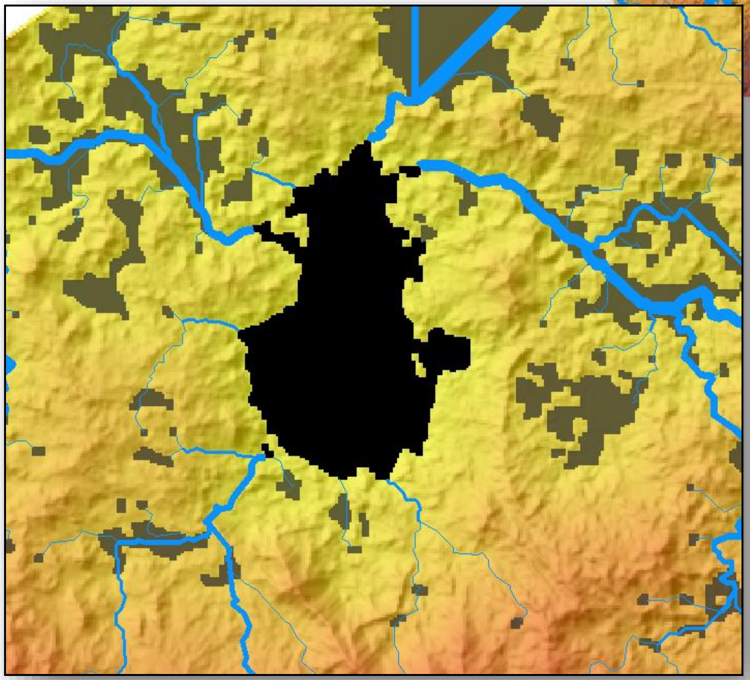
* *Existing protected area…*

* *Known breeding ground…*

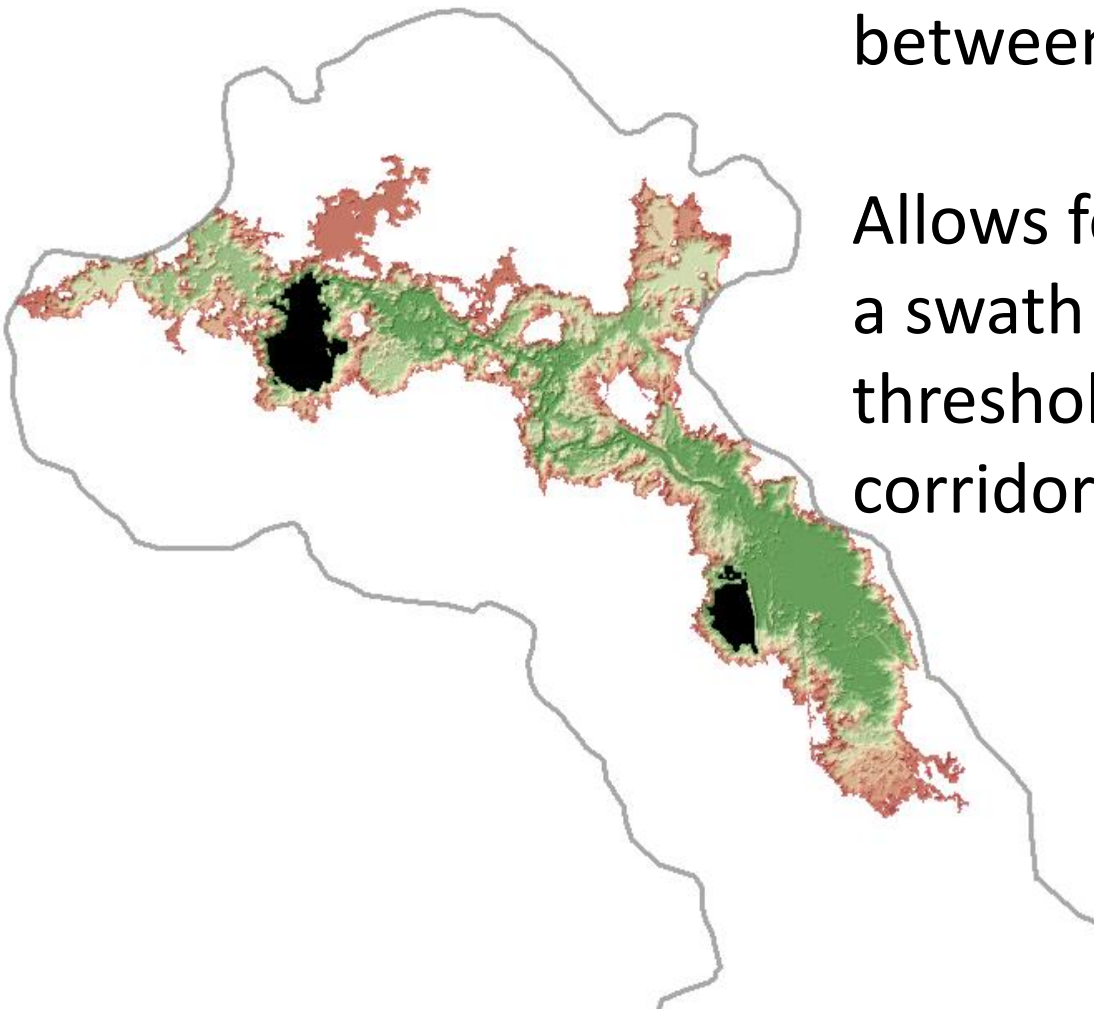
II. Least-Cost Paths to Source Patch

Useful for ranking *non*-habitat…





III. Corridors



Range of accumulative cost between two patches…

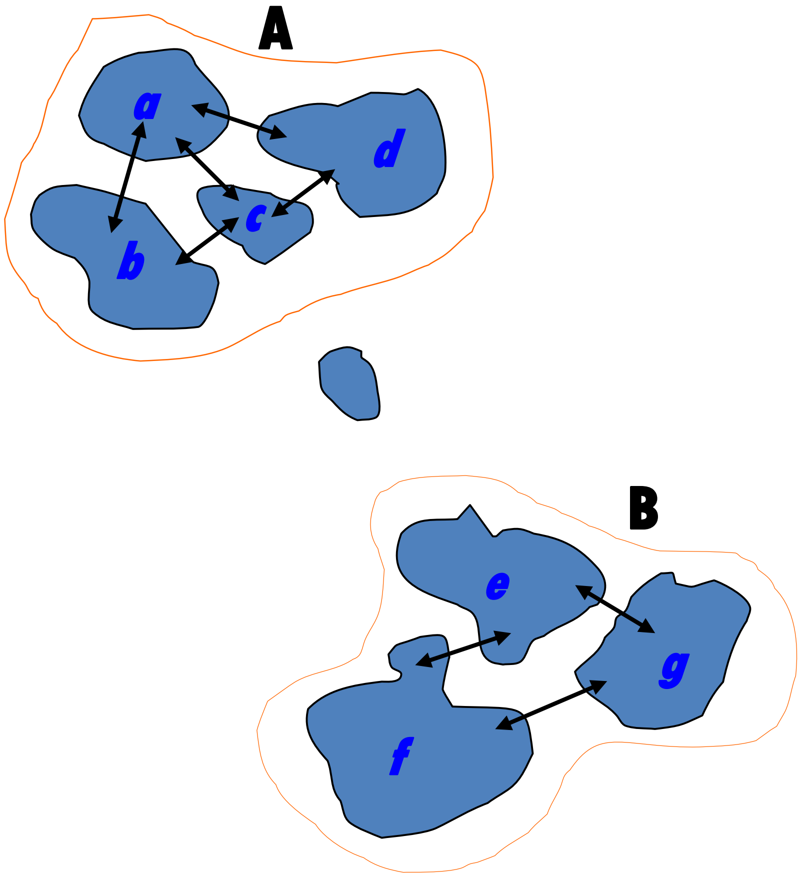
Allows for the determination of a swath of cells below a threshold cost distance – i.e. a corridor…

IV. Patch Subnetworks – Resource pools

Resource pools

Subnetwork A = a + b + c + d

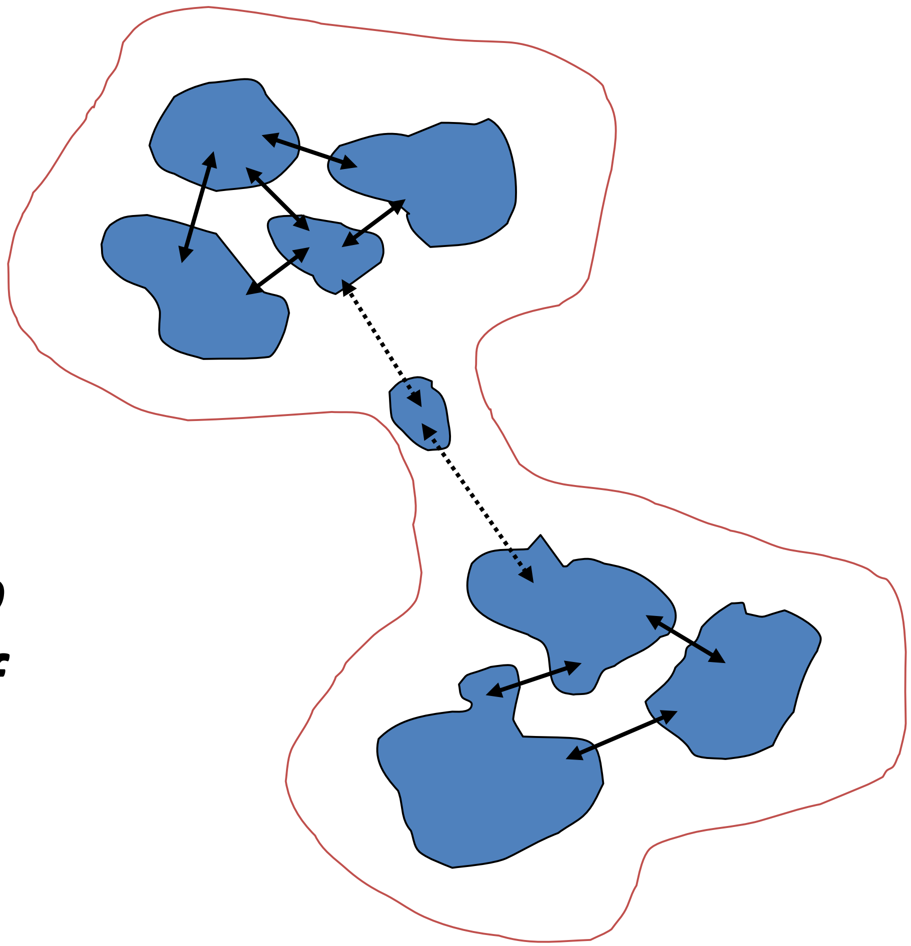
Subnetwork B = e + f + g



IV. Patch Subnetworks - Centrality

Subnetwork Patch Attributes

- ***Which patch gets the most traffic?***
- ***Which patch is most vital to maintaining the integrity of the patch subnetwork?***



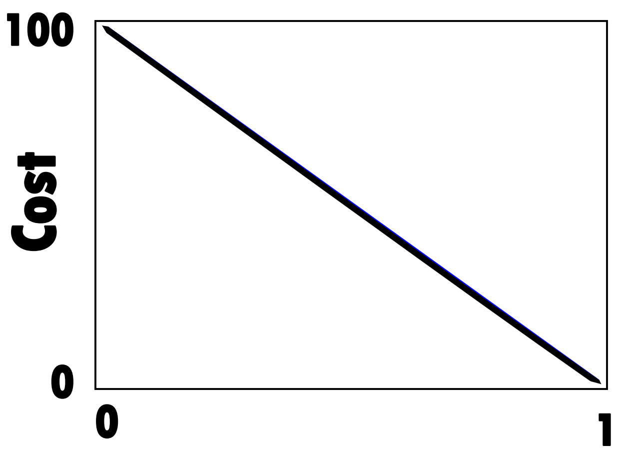
Connectivity Analyses

1. Connectivity to source patch
2. Least cost paths to source patch
3. Patch Corridors
4. Patch Sub-Networks
   - Resource pools
   - Patch centrality

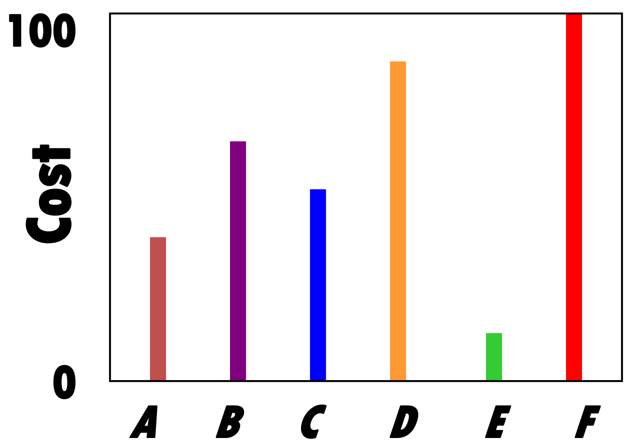
In class demonstration… (too complicated!)

Step 2: Resistance Surfaces

- How far might an antelope travel outside its habitat?
  - Uniform cost → Euclidean Distance
  - Variable cost → **Cost Distance**

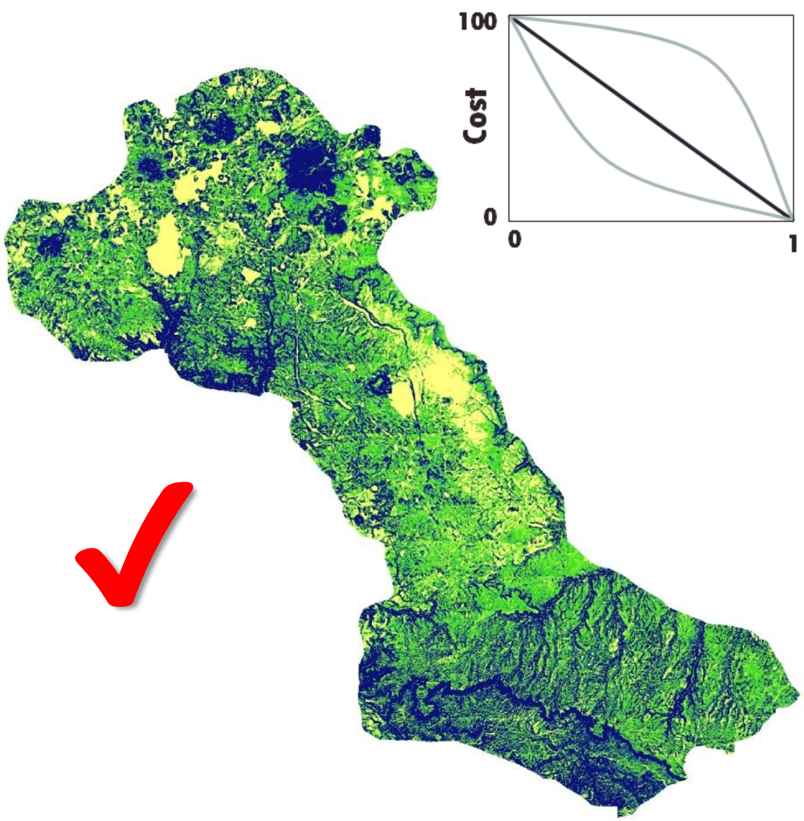


Habitat Suitability Based



Classification Based (Vegetation Overstory)

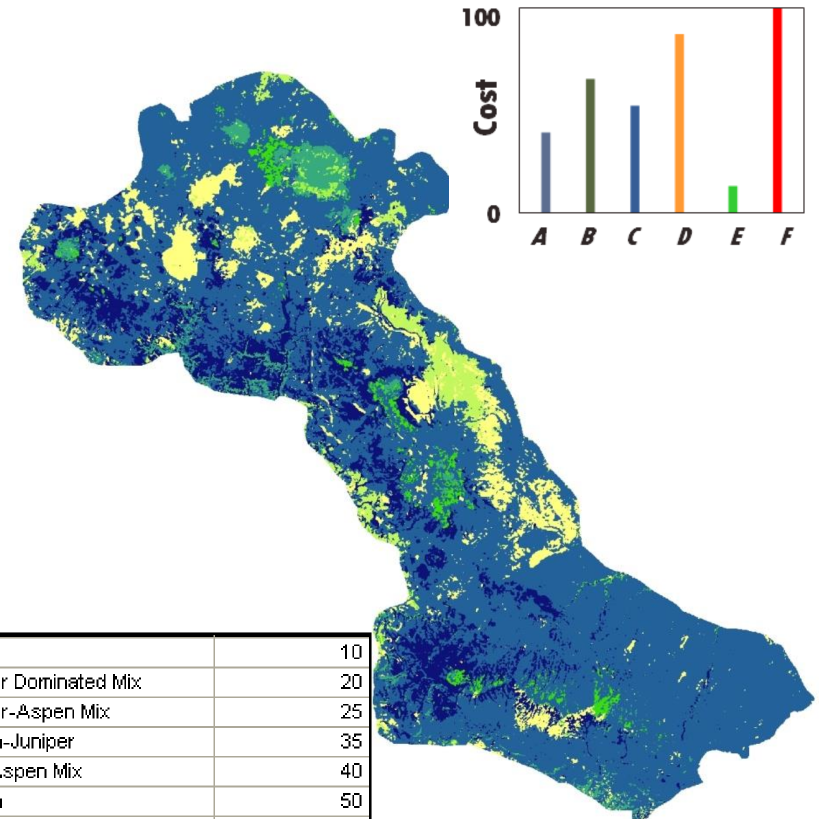
Step 2: Resistance Surfaces



(1.0 - Pronghorn Habitat Suitability)

(1.0 / Pronghorn Habitat Suitability)

Habitat Suitability Based

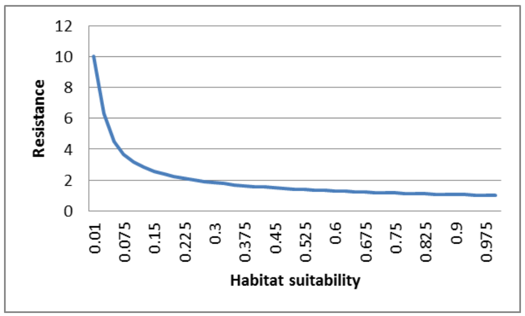


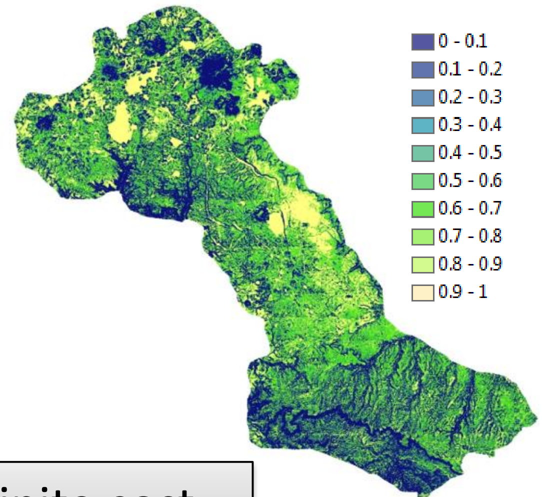
Open	10
Juniper Dominated Mix	20
Conifer-Aspen Mix	25
Pinyon-Juniper	35
Pine-Aspen Mix	40
Aspen	50
Mixed Conifer	60
Ponderosa Pine	80
Pine-Oak Mix	100

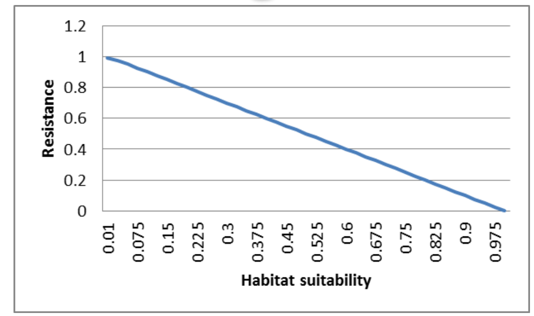
Classification Based (Vegetation Overstory)

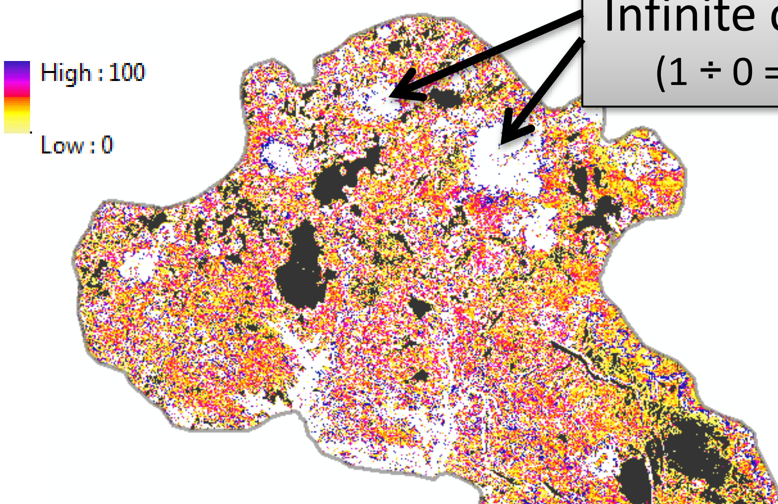
Step 2: Resistance Surfaces

"Inverse" of Habitat Suitability



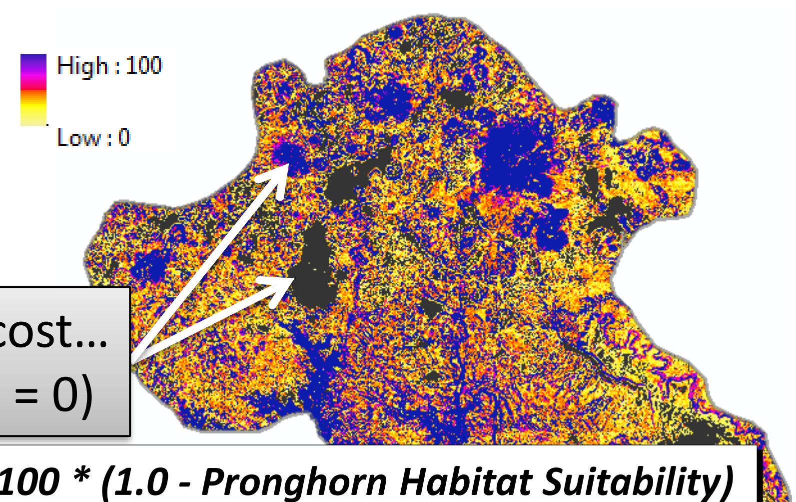






Infinite cost…
(1 ÷ 0 = ∞)

(1.0 / Pronghorn Habitat Suitability)



Zero cost…
(1 - 1 = 0)

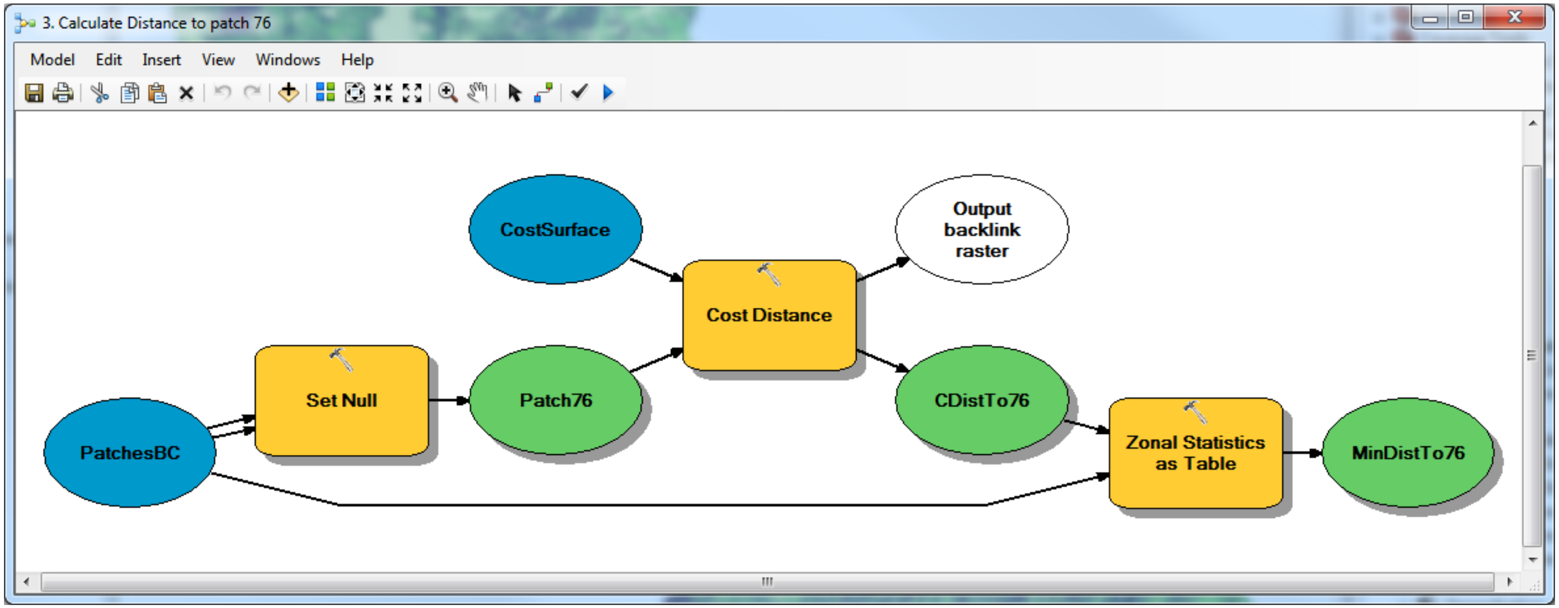
100 * (1.0 - Pronghorn Habitat Suitability)

→ If zero, set to 0.001 ←

Cost Distance to Source Patch

- Isolate source patch (Con or Set Null)
- Euclidean/Cost distance from source
- Zonal statistics on other patches
  - *Which zonal statistic??*
- Identify patches below threshold as connected to source patch…

Cost Distance to Source Patch



MinDistTo76

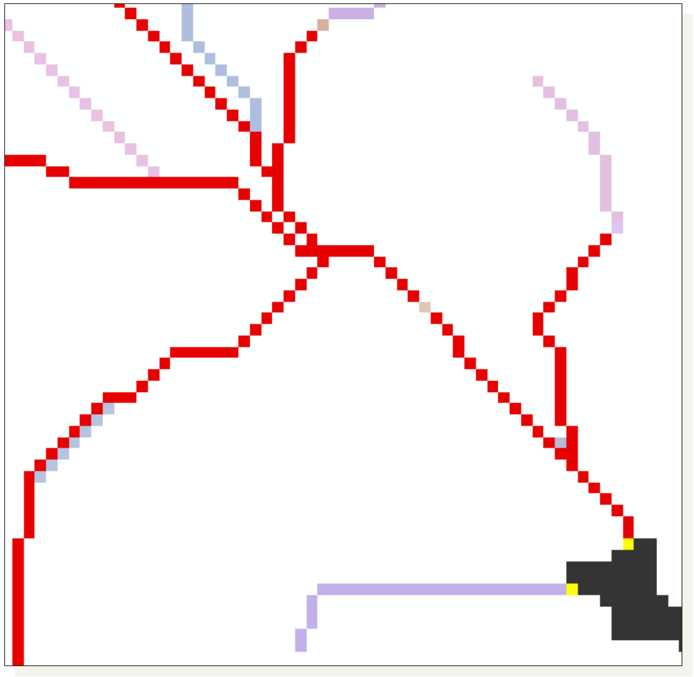
Field: Add Delete Calculate Selection:

OBJECTID	VALUE	COUNT	AREA	MIN
332	332	40	324000	1899872.125
324	324	55	445500	1766626.375
339	339	43	348300	1736740
331	331	40	324000	1731779.625
345	345	43	348300	1615113.875
340	340	55	445500	1568470.375

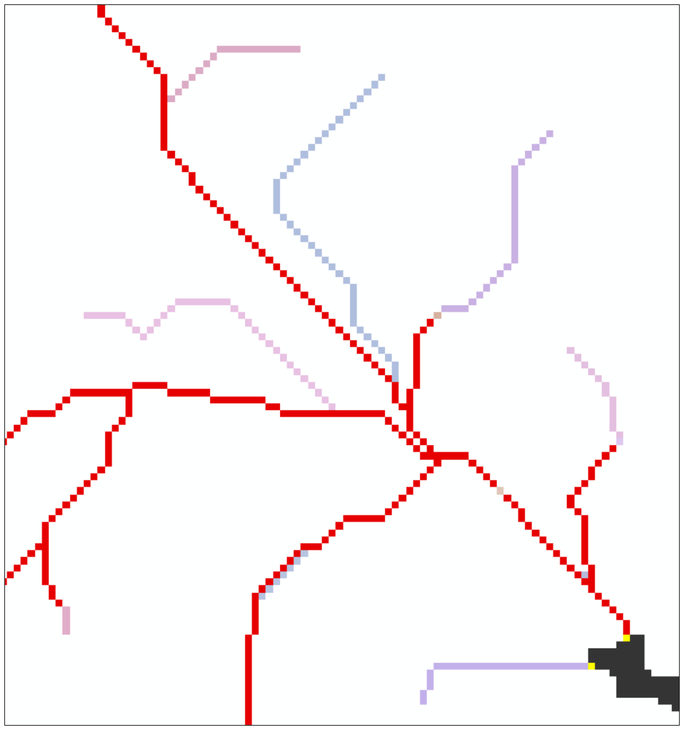
Patch 332 is furthest from patch 76 (~190k cost units)

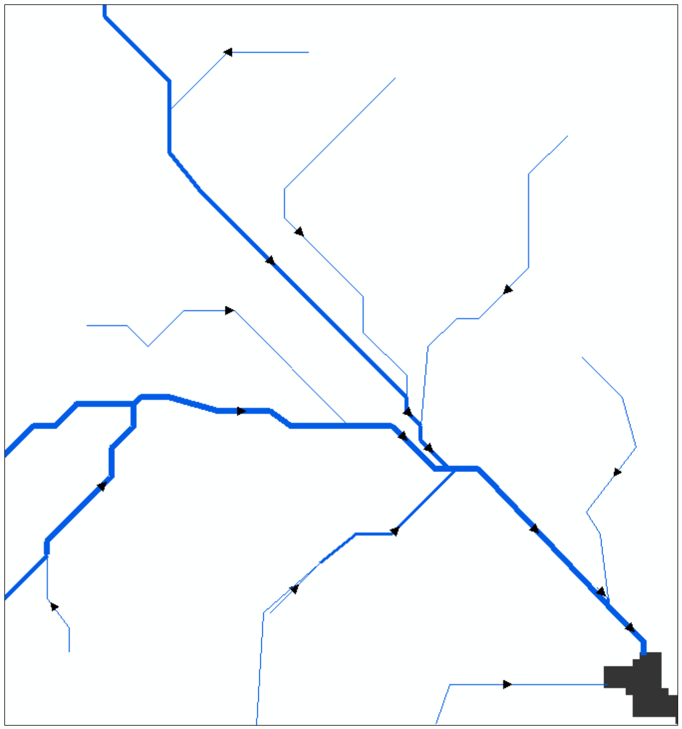
Least-Cost Path to Source: Cost Path Tool

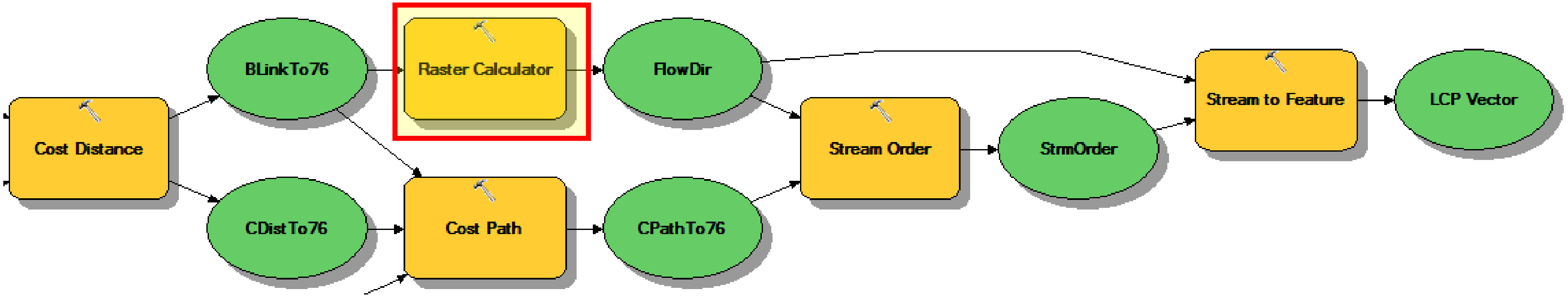
- Uses cost distance and cost backlink layers to find least cost paths from patch to source
- Results (cell values):
  - 1 → LCP at Source
  - 2 → Shared LCP
  - 3+ → Individual LCP



Least-Cost Paths to Source: Raster to Vector

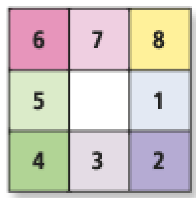




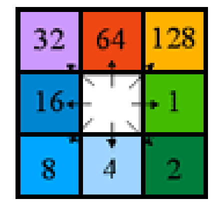


Least-Cost Paths to Source: Raster to Vector

Cost backlink → Flow Direction

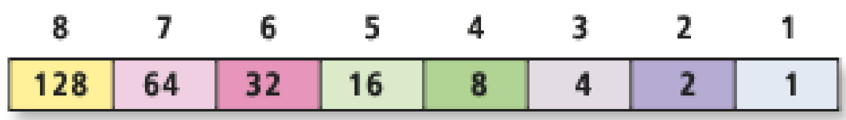


Neighborhood cell positions

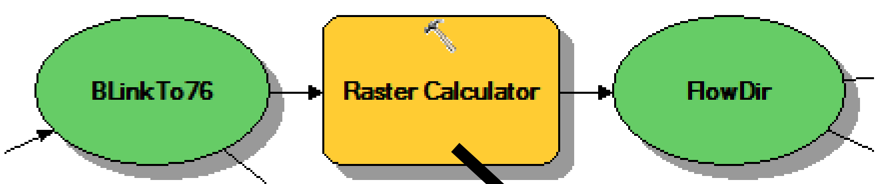


Direction Coding

Corresponding bit positon



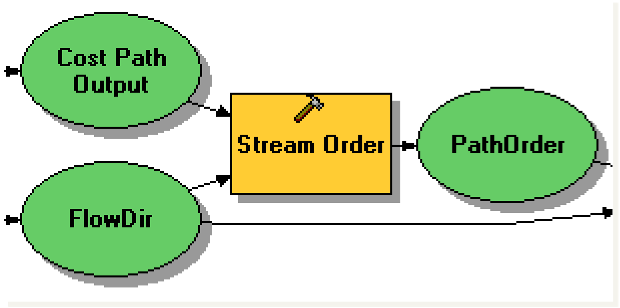
Base$_{10}$ bit values

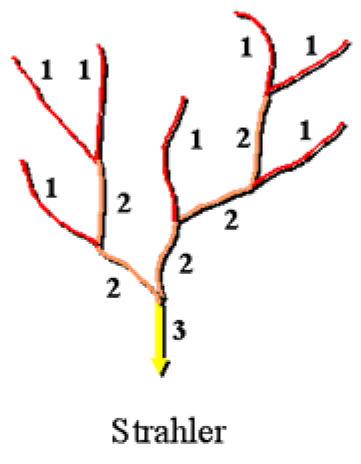


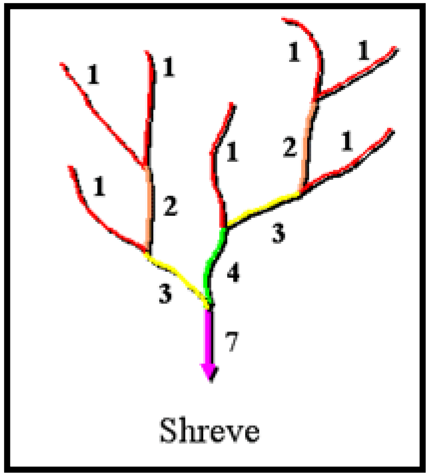
Int(Exp2("*%CostBackLink%*") / 2)

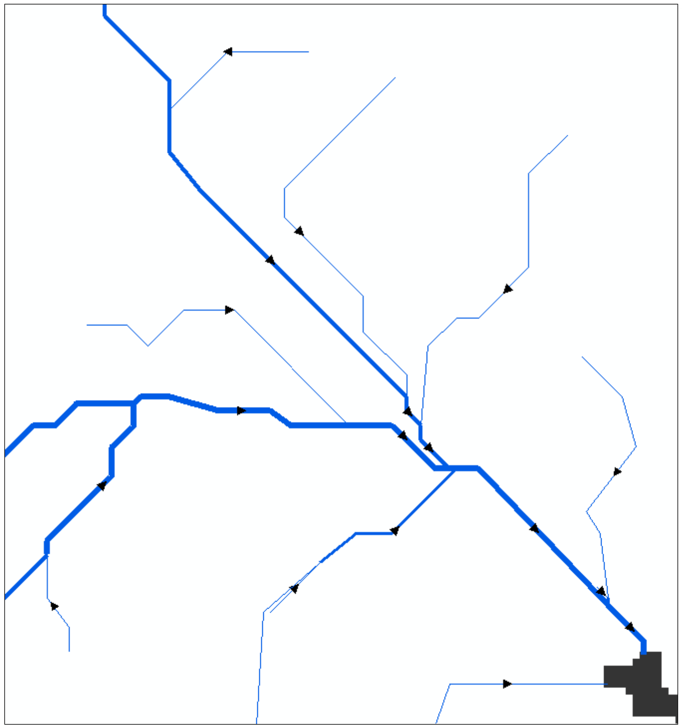
Least-Cost Paths to Source: Raster to Vector

Using Stream Order to classify how much 'traffic' a least-cost path might get…

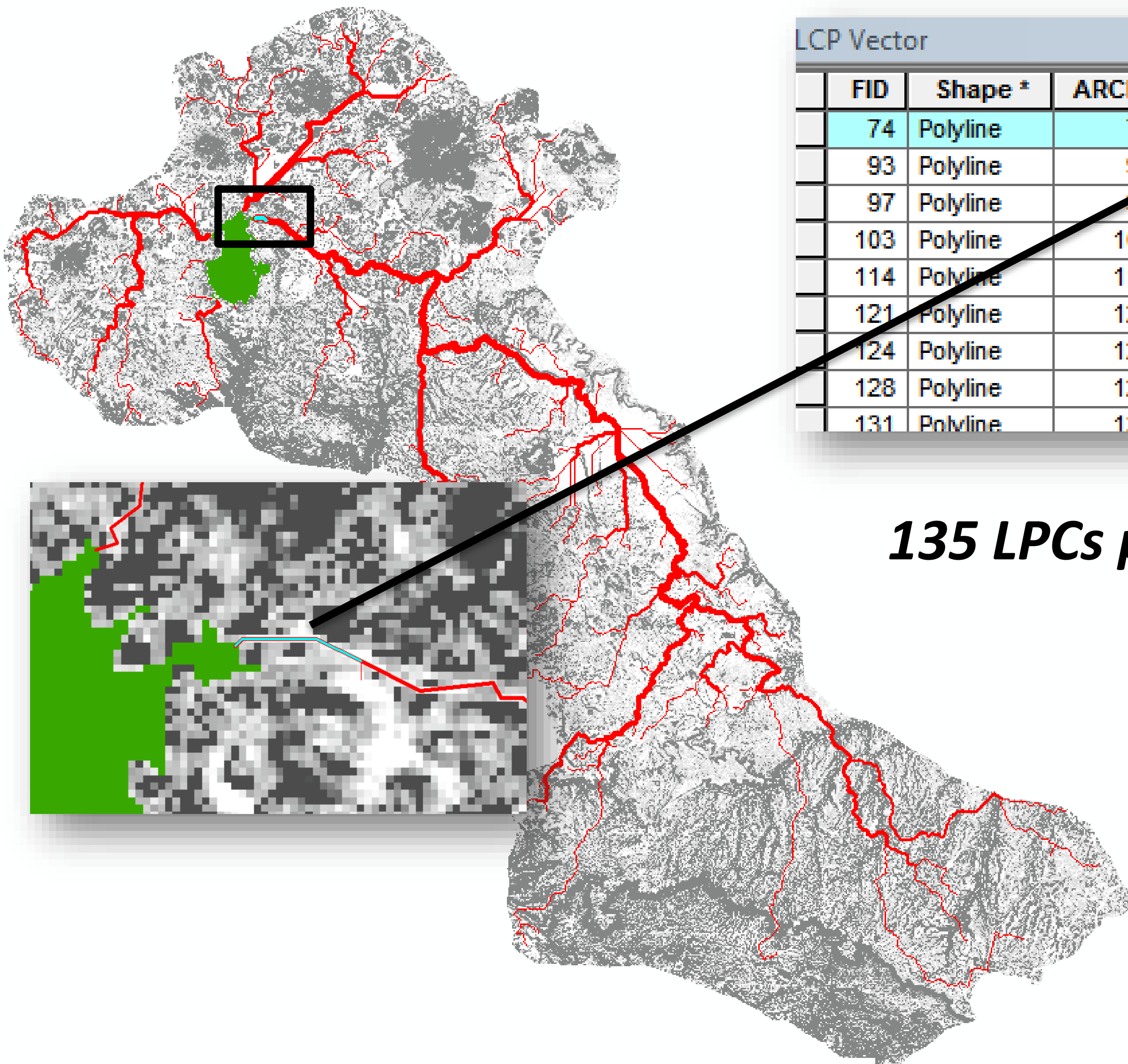








Least-Cost Paths to Source: Raster to Vector



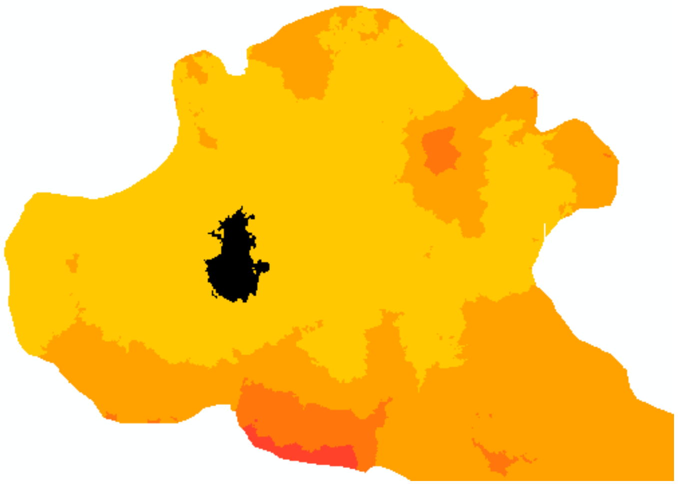
LCP Vector

FID	Shape *	ARCID	GRID_CODE	FROM_NODE	TO_NODE
74	Polyline	75	135	85	80
93	Polyline	94	134	104	85
97	Polyline	98	133	107	104
103	Polyline	104	132	112	107
114	Polyline	115	129	123	112
121	Polyline	122	123	127	123
124	Polyline	125	122	133	127
128	Polyline	129	121	132	133
131	Polyline	132	106	139	132

135 LPCs pass thru this segment

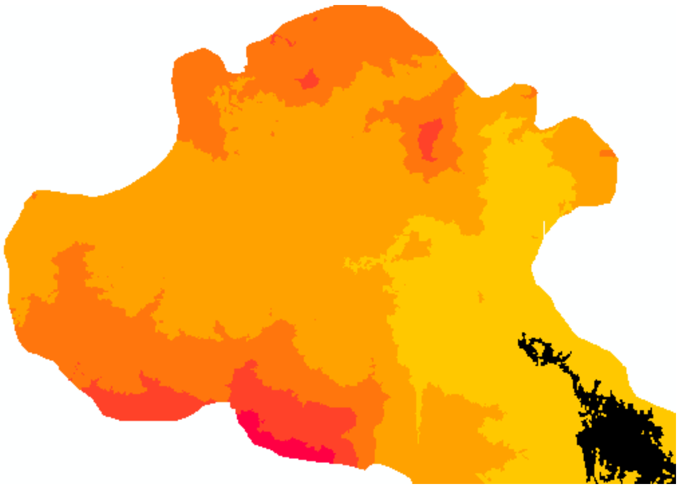
Patch Corridors

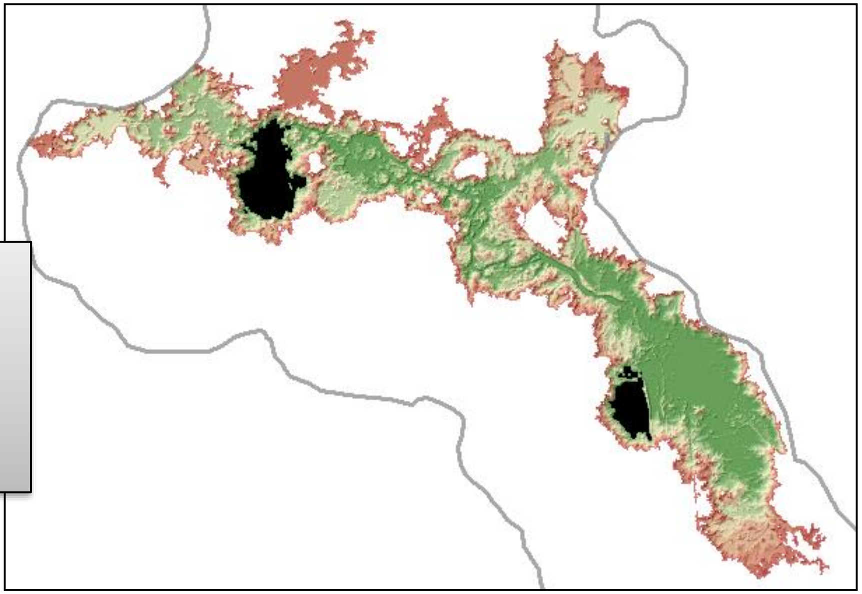
Cost distance to patch 76



+

Cost distance to patch 156



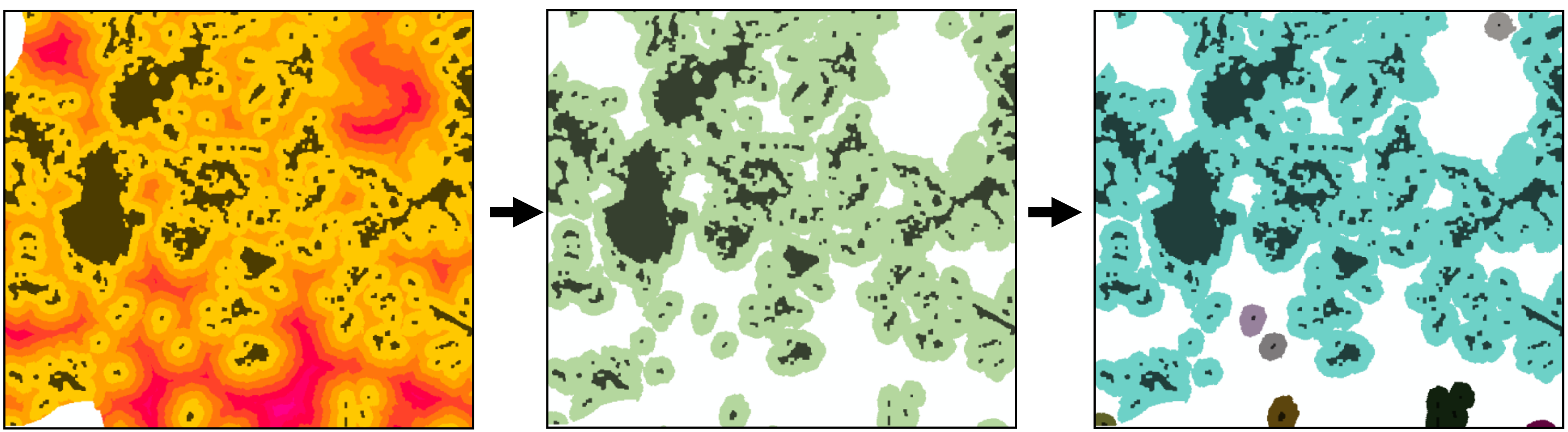


Resulting values, thresholded at 30,000* cost units

** Use 40,000 in assignment*

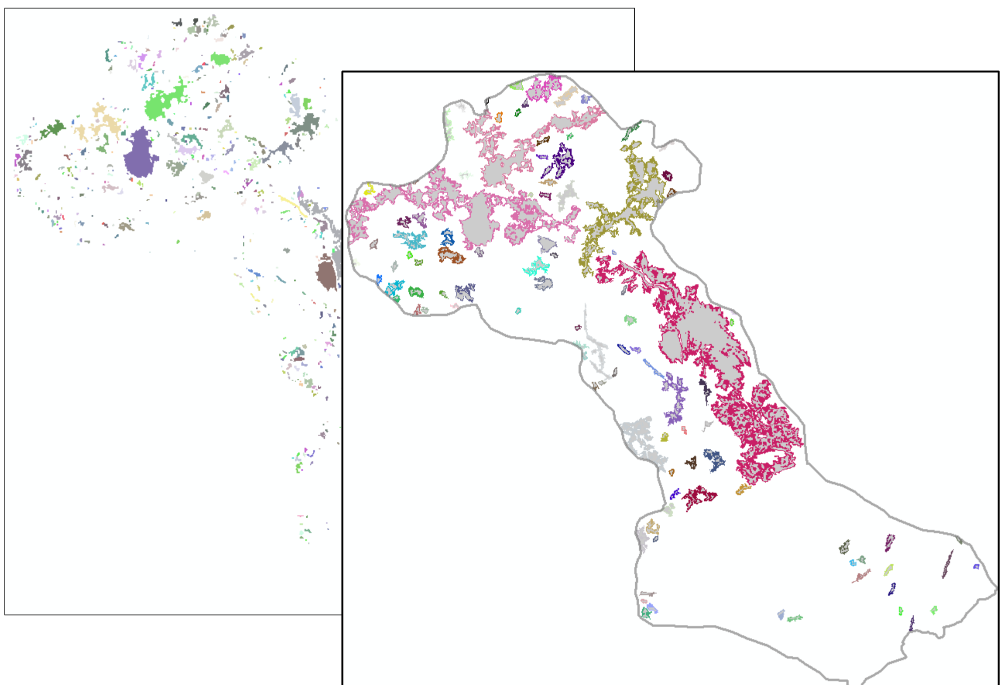
Patch Subnetworks

- Calculate distances to all cleaned patches
  - Euclidean or cost-weighted
- Apply threshold to cost distance
  - <u>One-half</u> the distance an individual can travel
- Region group result into sub-networks



Patch Subnetworks

- Combine subnetworks with patches to create a look-up table listing which patches belong to which subnetwork…



Subnet ID
Patch ID

PatchSubnet

Rowid	VALUE	COUNT	SUBNETS	PATCHESBC
0	1	559	1	1
1	2	301	2	2
2	3	176	1	3
3	4	49	1	4
4	5	308	1	5
5	6	181	3	6
6	7	429	1	8
7	8	59	1	7

Assignment

SHORT LAB: Connectivity analysis		
NetID		
Score:		
		1. Enter the number of boundary cleaned patches within 100k cost units of patch 195.
		2a. Which patch is furthest, cost-wise, from patch 195?
		2b. What is the cost to get from this patch back to patch 195? (Round to the nearest thousand cost unit)
		3a. Create a map showing least cost paths (vector) to patch 195. Indicate the segment with the "highest traffic".
		3b. How many least cost paths to patch 195 travel through the segment with the highest traffic?
		4a. Create a map of the corridor between patch 76 and patch 195 thresholded at 300,000 cost units. Be sure to include a legend.
		4b. How many patches occur within the corridor (defined as cost < 300,000) between patch 76 and 195.
		5a. Create a map of functionally connected patch subnetworks (40,000 cost unit threshold)
		5b. How many distinct subnetworks are created at a cost distance threshold of 40,000?
		5c. How many square km of habitat is in the subnetwork with the most habitat?
		5d. How many patches does this subnetwork contain?

Maps are to check answers only; no need to make them "fancy"…

Demonstration: Patch Centrality

Ranking patches based on their importance at keeping the network intact…