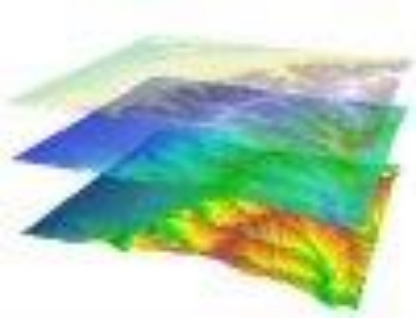
ENV761 Geospatial Analysis for Conservation & Management

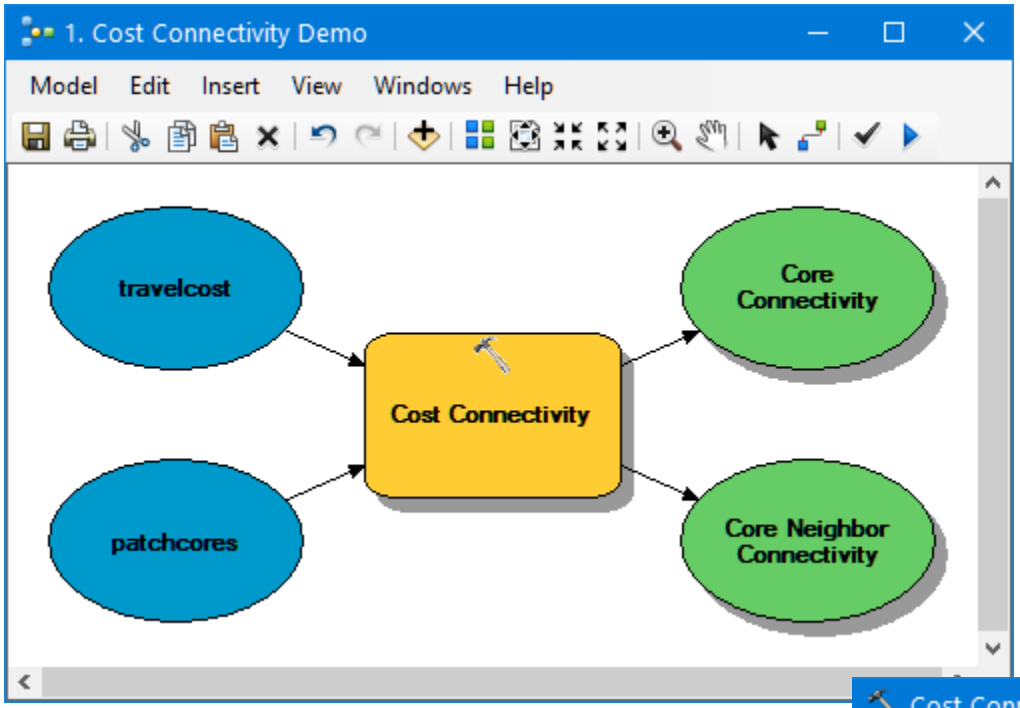
Connectivity Demos

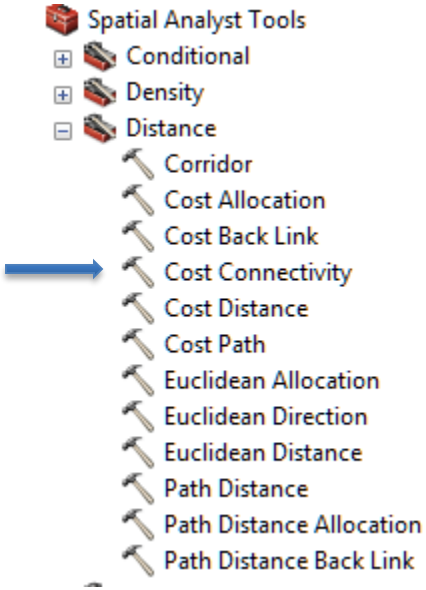
NICHOLAS SCHOOL OF THE ENVIRONMENT AND EARTH SCIENCES

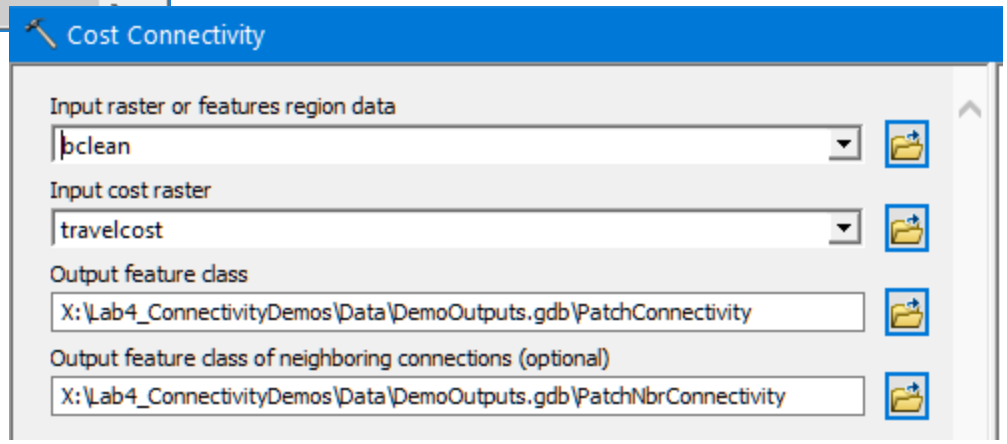
DUKE UNIVERSITY



Cost Connectivity







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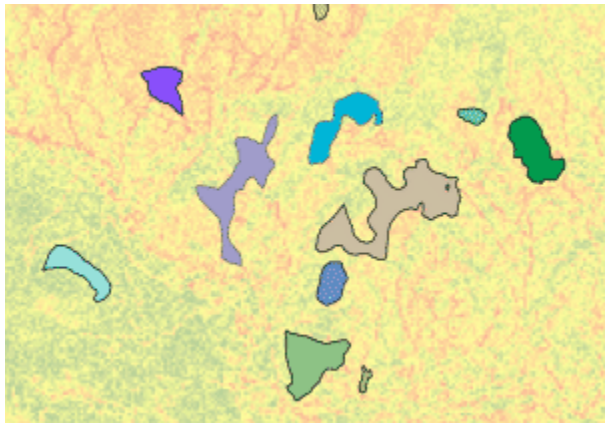
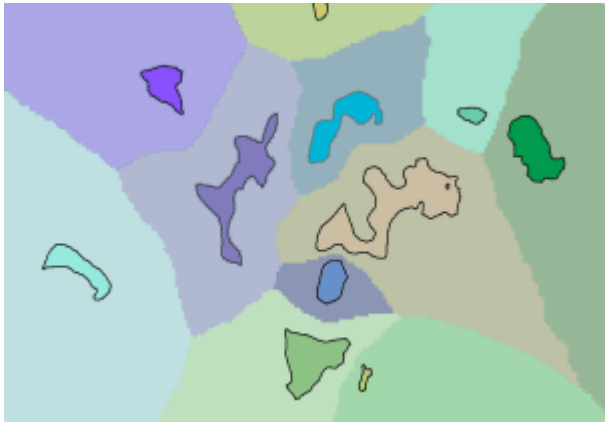
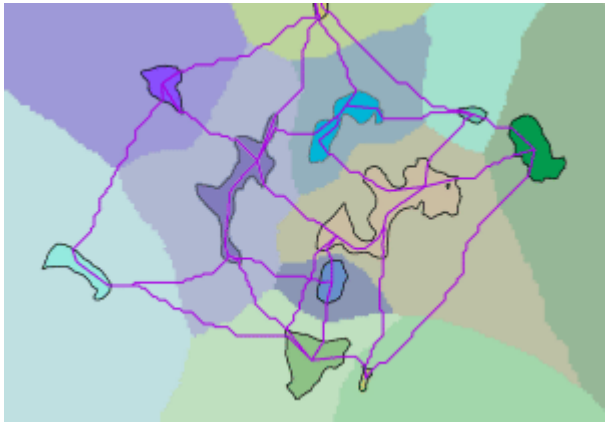
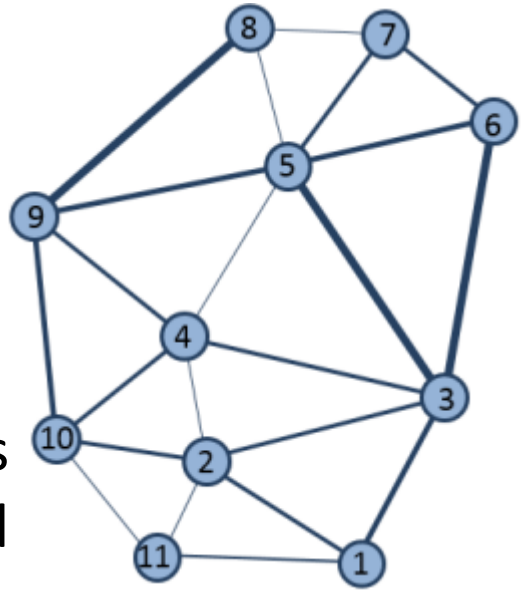




Cost Allocation

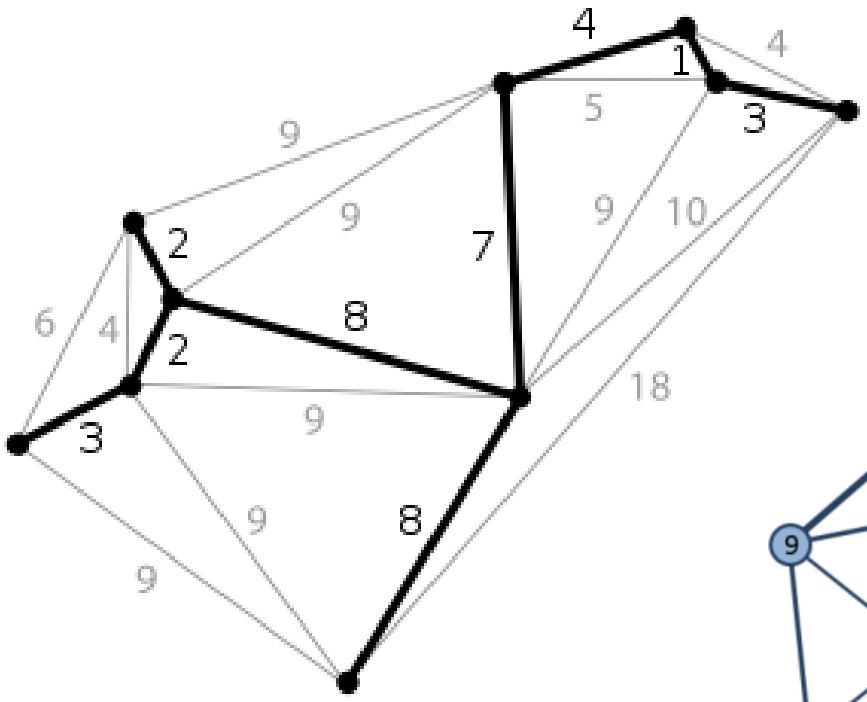


LCPs created among neighboring patches

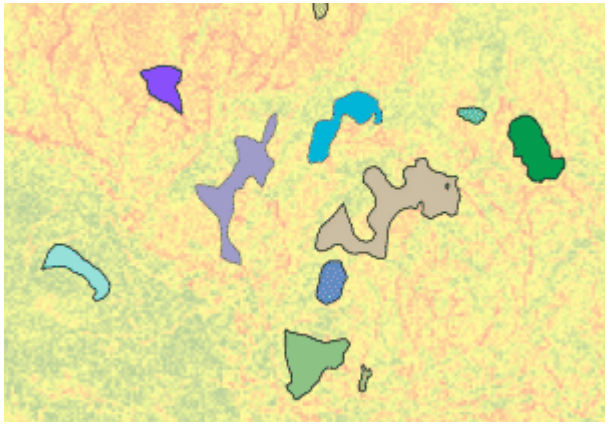


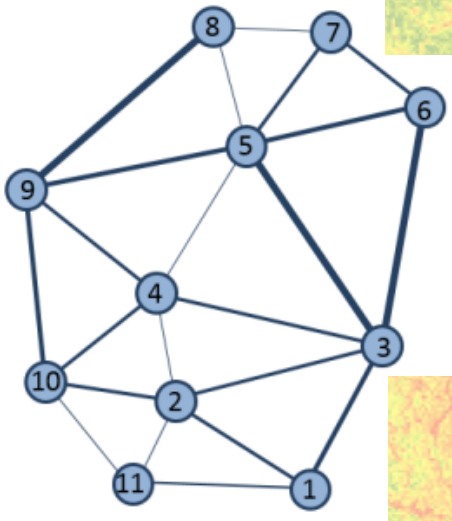
Graph of LCPs created

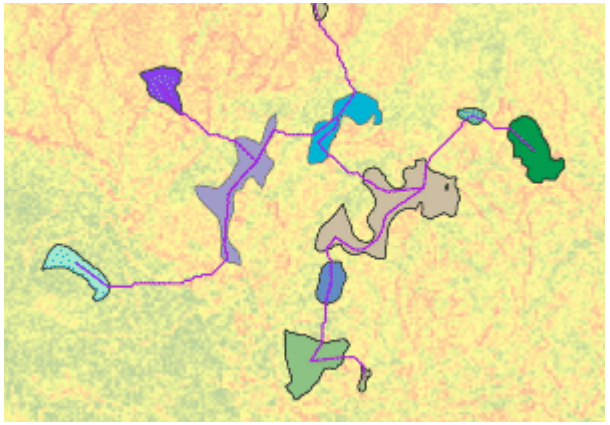
Cost Connectivity



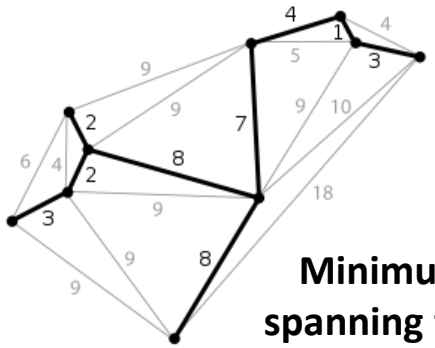
Minimum spanning tree







Cost Connectivity



Minimum spanning tree

Table

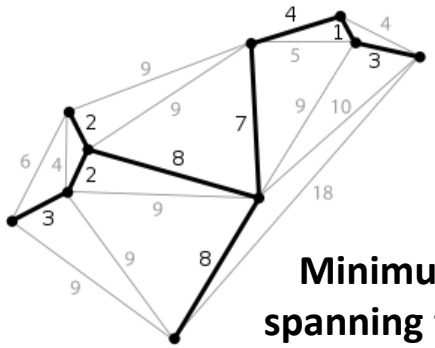
Patch Connectivity

Shape *	PATHID	PATHCOST	REGION1	REGION2	Shape_Length
Polyline	72	656.294861	99	115	4948.042498
Polyline	247	1157.951172	114	115	1925.548558
Polyline	248	37287.609375	114	117	7778.069128
Polyline	821	20251.677734	109	117	5421.323093
Polyline	632	17718.037109	103	118	4184.859299
Polyline	730	26646.068359	113	118	5600.659415
Polyline	731	848.591675	116	118	1557.868007
Polyline	73	10267.245117	99	119	6147.762848
Polyline	633	68457.632813	87	120	5693.207457

0 (3 out of 343 Selected)

Patch Connectivity

Cost Connectivity



Minimum spanning tree

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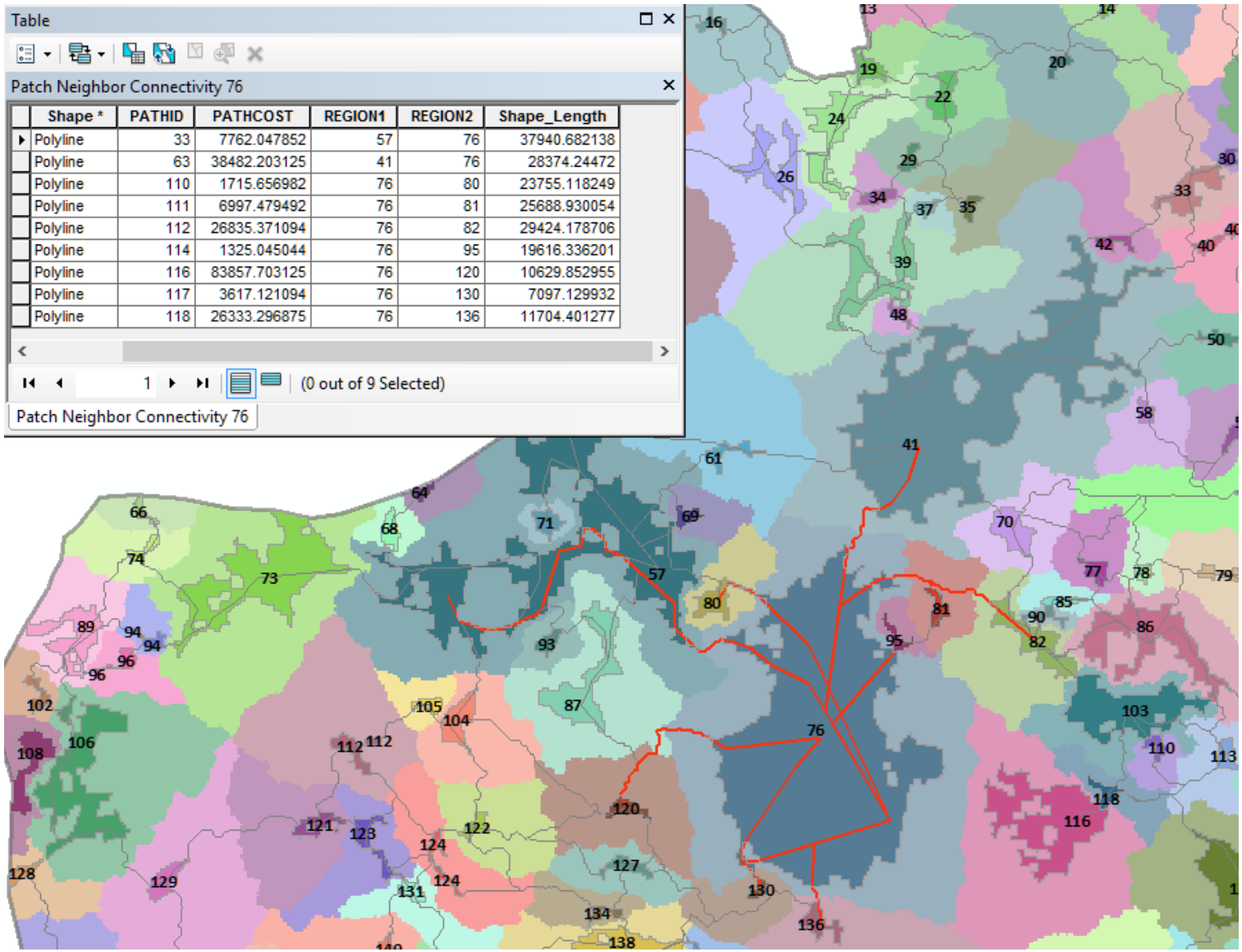
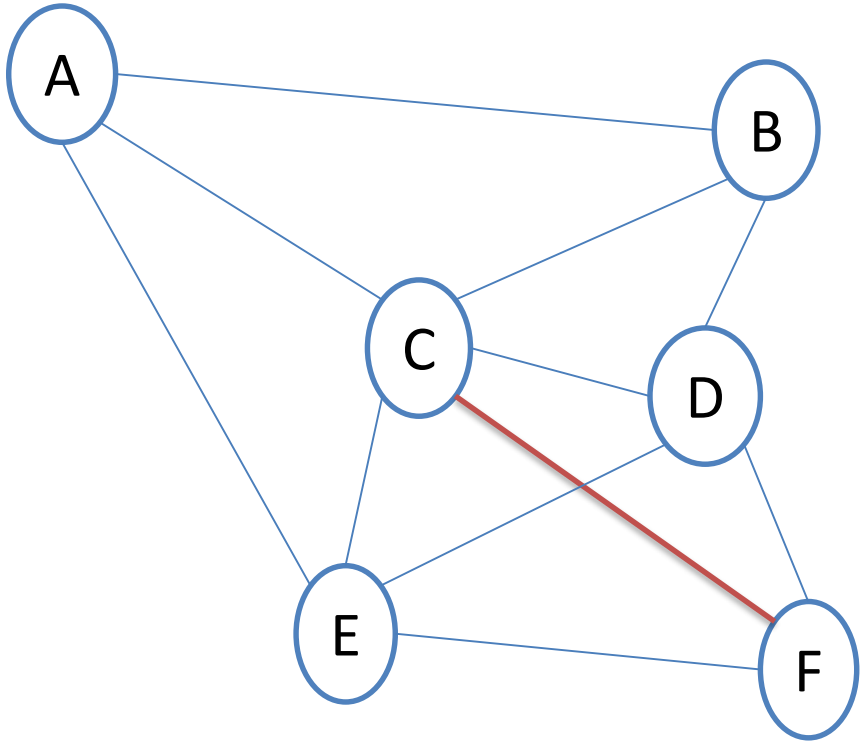
Patch Connectivity

Cost Connectivity



Cost Connectivity

Shortcoming of cost connectivity…



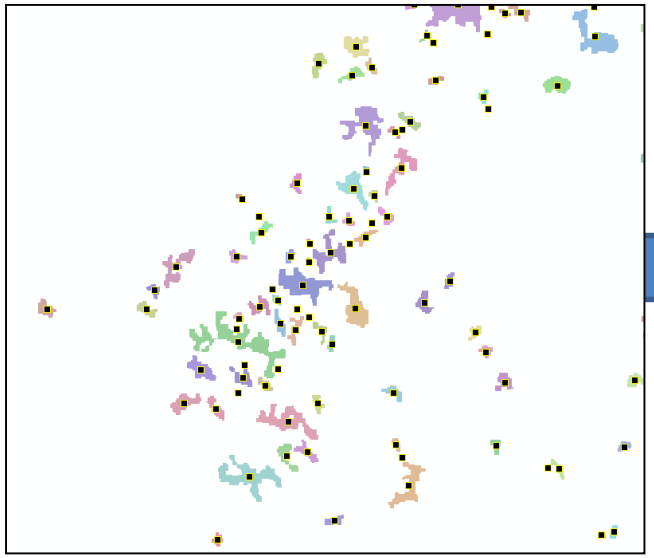
…it only considers neighbors when LCP might be beyond neighbor

GeoHAT - Workflow

- Create an **edge list** (Euclidean or Cost distance)
  - Create cost raster if using the cost distance approach
- Draw **edges/least cost paths** between patches
- Summarize graph to determine **connectivity distance**:
  - Plot graph diameter at threshold distance intervals
- Calculate **centrality metrics**:
  - *Degree* (number of patches within the distance threshold)
  - *Betweenness* (frequency in least cost paths among patch pairs)
  - *Closeness* (avg. distance to neighbors relative to other patches)
- Calculate **connected habitat area**:
  - Total area within the distance threshold
  - Inverse distance weighted area set to $d_{0.01}$ at distance threshold

GeoHAT – Creating an edge list

- Euclidean distance method:
  - Measures straight-line distance between patch centroids
  - Very fast and does not require data on travel costs
  - Hope to improve by measuring distances between patch *edges*

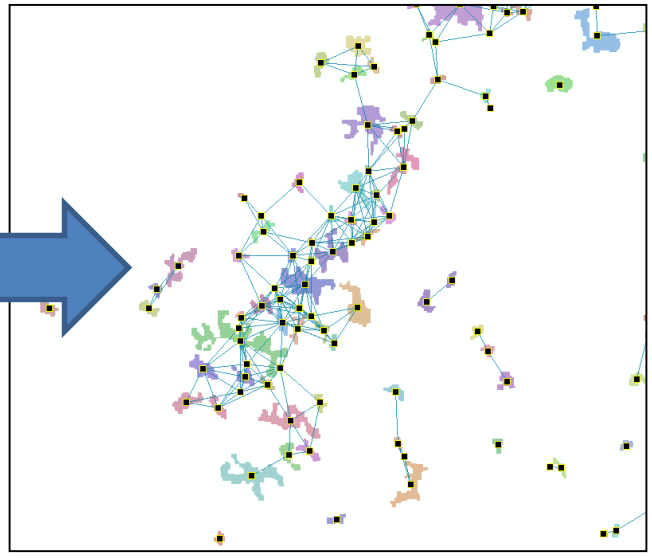


Patch Centroids

SalEdgeList

FromID	ToID	Distance
1	493	62362
1	490	62084
1	497	64481
1	496	64131
1	495	64144
1	494	63006
1	492	62937
1	491	63165
1	489	62427
1	487	60493
1	482	59525
1	484	59690

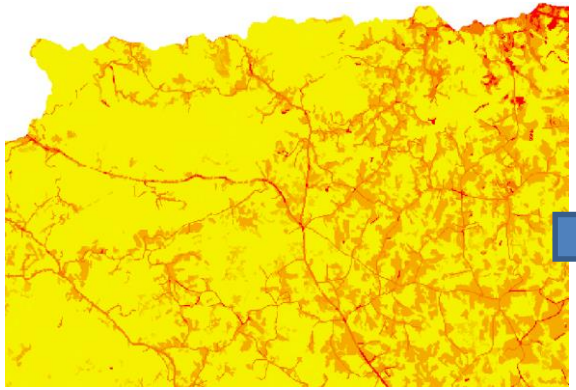
Edge list



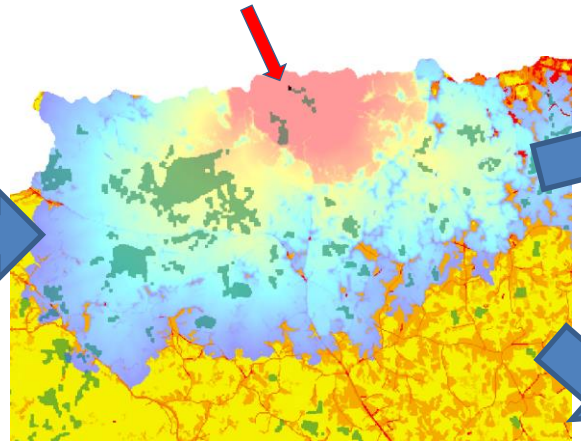
Patch Edges

GeoHAT – Creating an edge list

- Cost distance method:
  - Requires a travel cost raster (information on resistances)
  - Takes significantly longer to calculate, but potentially more precise
  - Requires recalculation whenever costs change



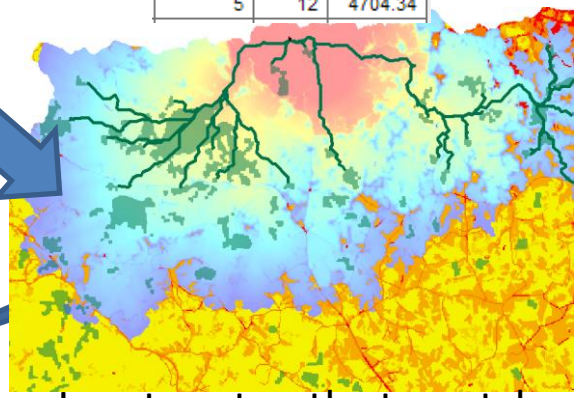
Cost raster



Cost distance from patch

FromID	ToID	Cost
1	2	68245.9
3	4	4498.6
3	19	56962.52
3	39	57742.26
4	19	50529
4	39	52522.3
5	6	300
5	7	60474.01
5	8	59961.88
5	9	2849.48
5	11	63101.07
5	12	4704.34

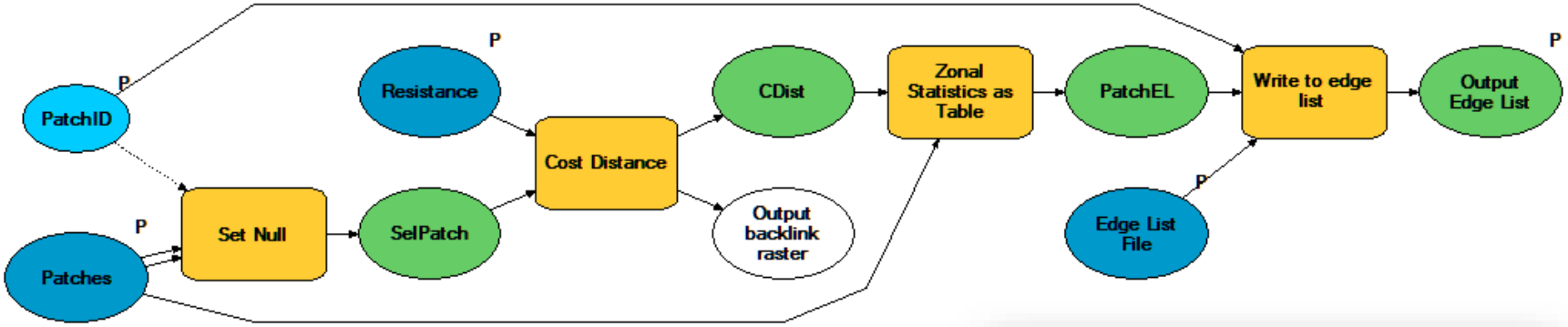
Edge list

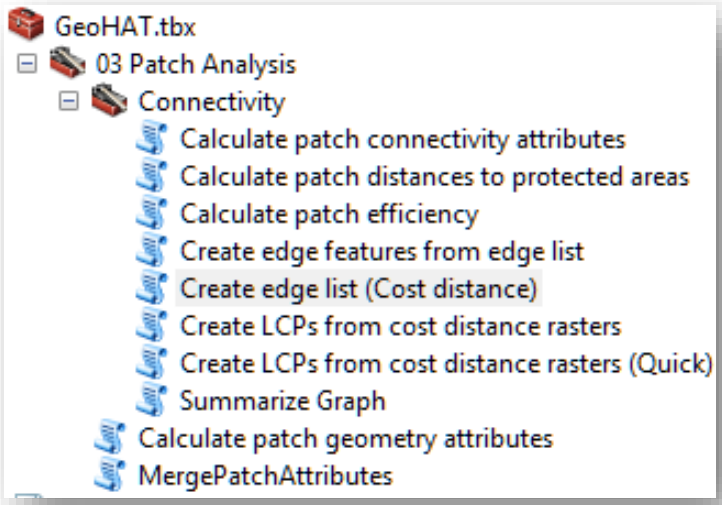


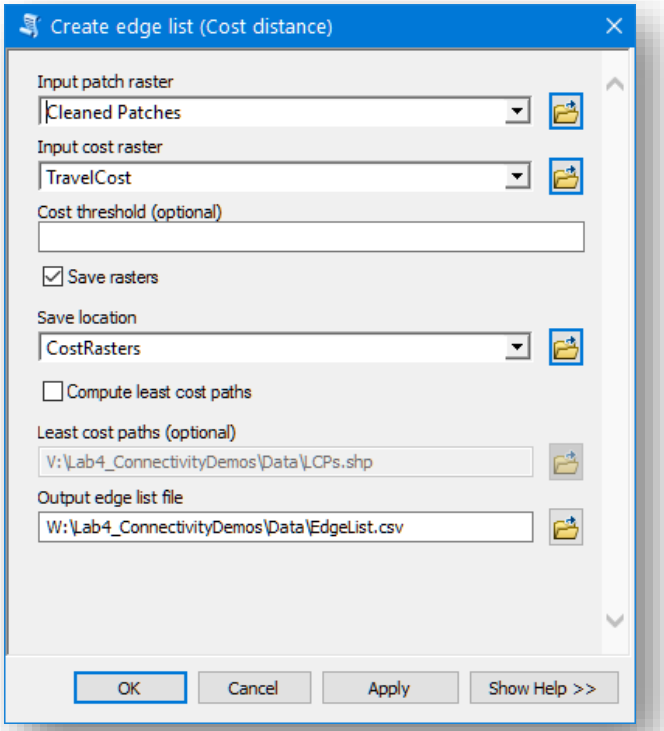
Least cost paths to patch

Iterate through all patches

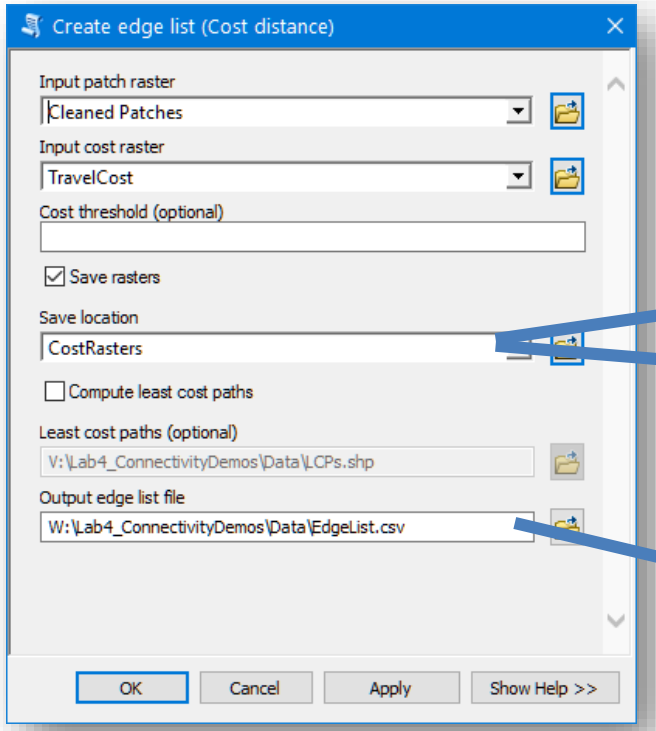
GeoHAT

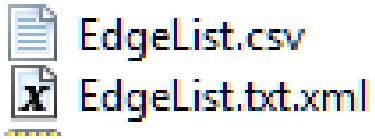

P
PatchID
P
Patches
Set Null
P
Resistance
SelPatch
Cost Distance
CDist
Output backlink raster
Zonal Statistics as Table
PatchEL
P
Edge List File
Write to edge list
P
Output Edge List

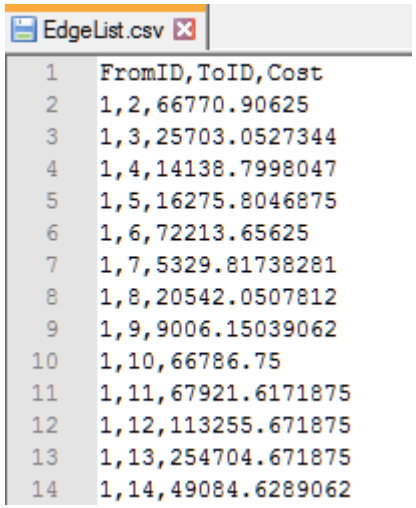

GeoHAT.tbx
03 Patch Analysis
Connectivity
Calculate patch connectivity attributes
Calculate patch distances to protected areas
Calculate patch efficiency
Create edge features from edge list
Create edge list (Cost distance)
Create LCPs from cost distance rasters
Create LCPs from cost distance rasters (Quick)
Summarize Graph
Calculate patch geometry attributes
MergePatchAttributes

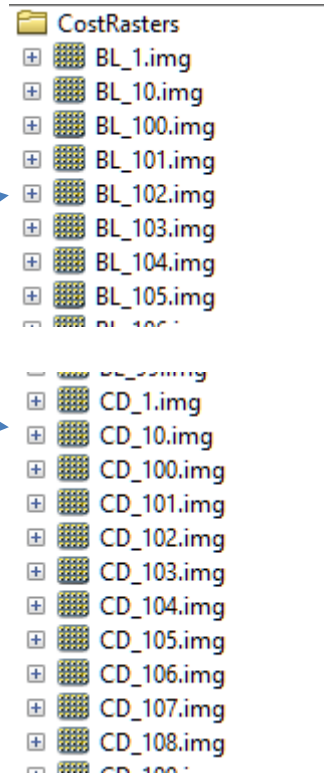

Create edge list (Cost distance)
Input patch raster
Cleaned Patches
Input cost raster
TravelCost
Cost threshold (optional)
Save rasters
Save location
CostRasters
Compute least cost paths
Least cost paths (optional)
V:\Lab4_ConnectivityDemos\Data\LCPs.shp
Output edge list file
W:\Lab4_ConnectivityDemos\Data\EdgeList.csv
OK
Cancel
Apply
Show Help >>

GeoHAT – Edge list

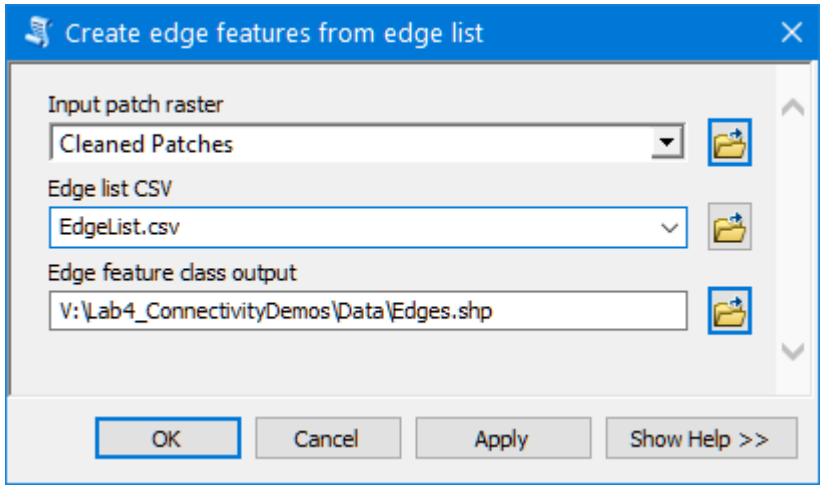


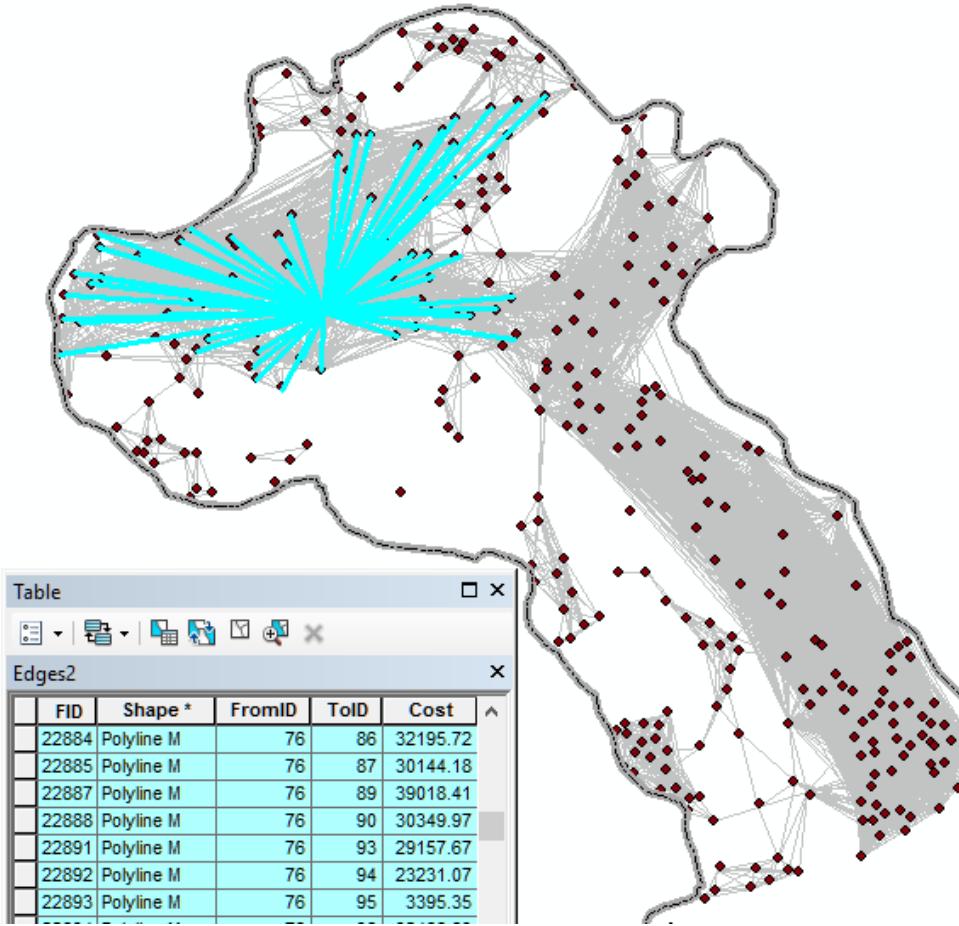






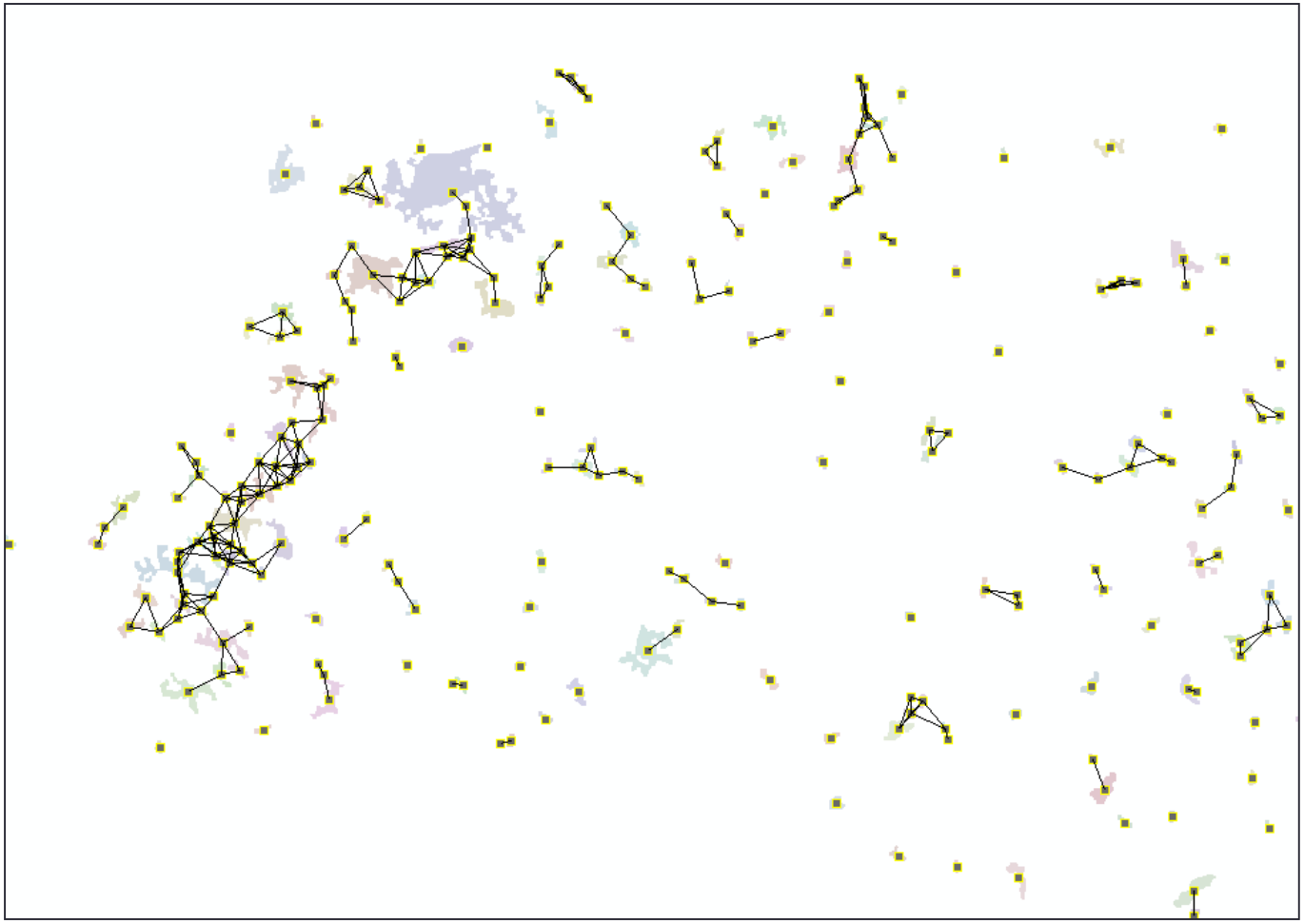
GeoHAT – Create Edge Features





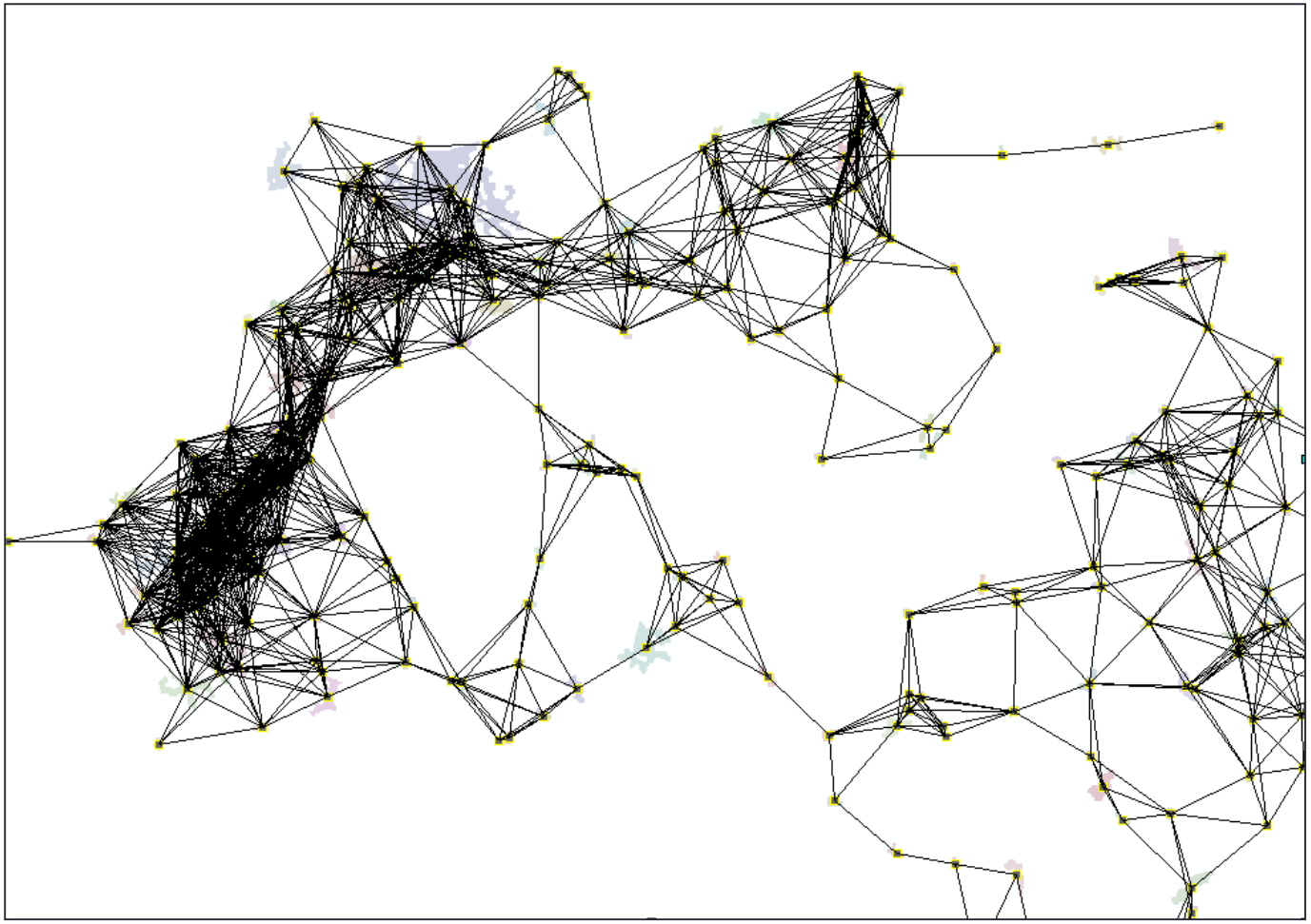
FID	Shape *	FromID	ToID	Cost
22884	Polyline M	76	86	32195.72
22885	Polyline M	76	87	30144.18
22887	Polyline M	76	89	39018.41
22888	Polyline M	76	90	30349.97
22891	Polyline M	76	93	29157.67
22892	Polyline M	76	94	23231.07
22893	Polyline M	76	95	3395.35

GeoHAT – Summarize graph



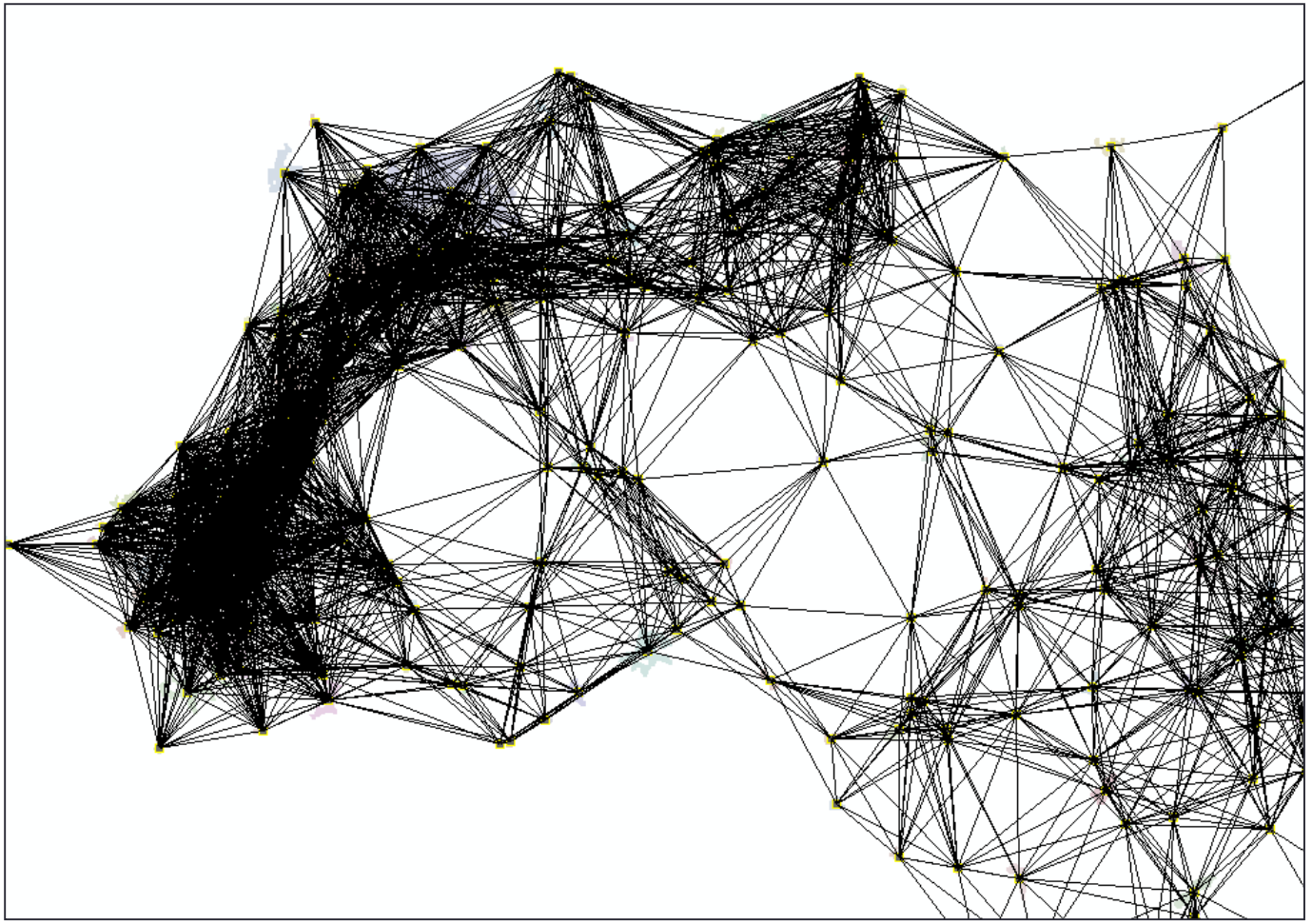
Threshold = 1 km; Diameter = 13; # Components = 110

GeoHAT – Summarize graph



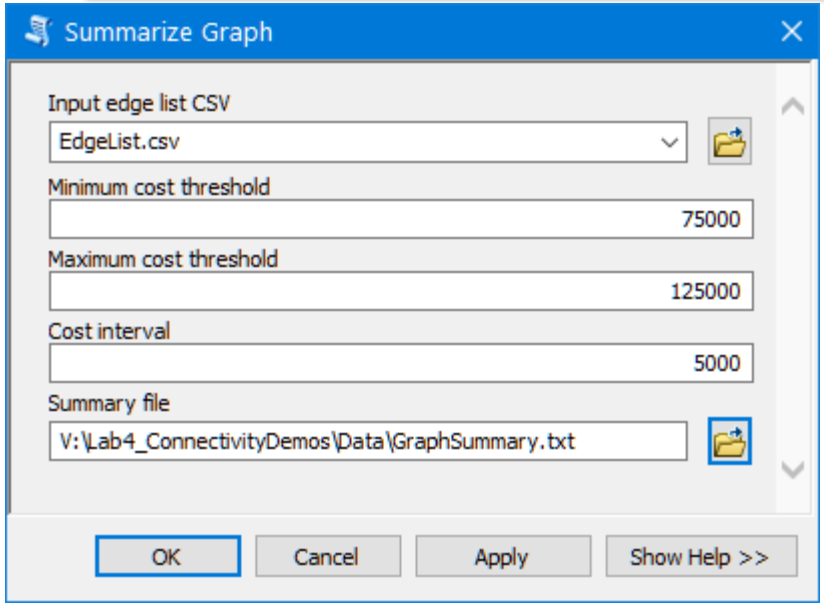
Threshold = 3 km; Diameter = 40; # Components = 10

GeoHAT – Summarize graph



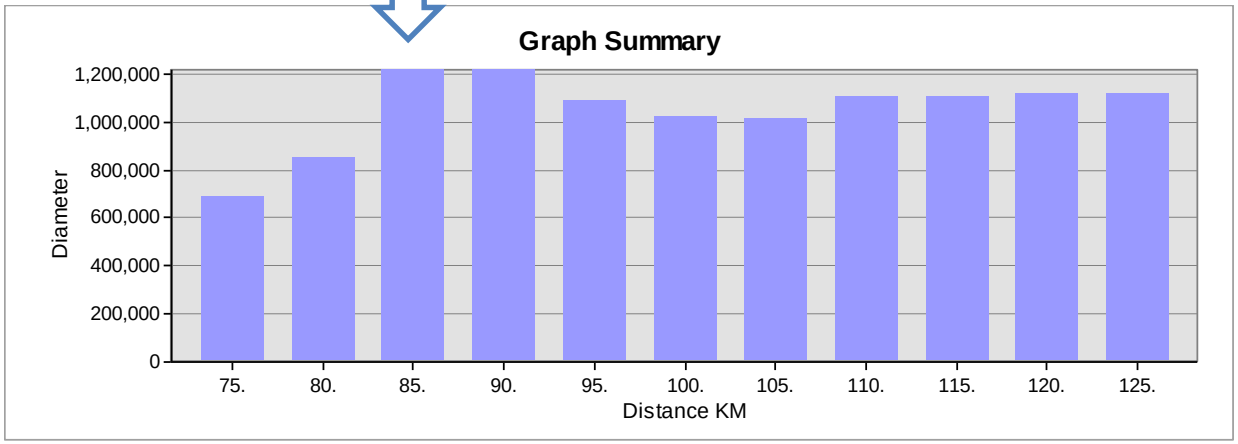
Threshold = 5 km; Diameter = 20; # Components = 1

GeoHAT – Summarize graph

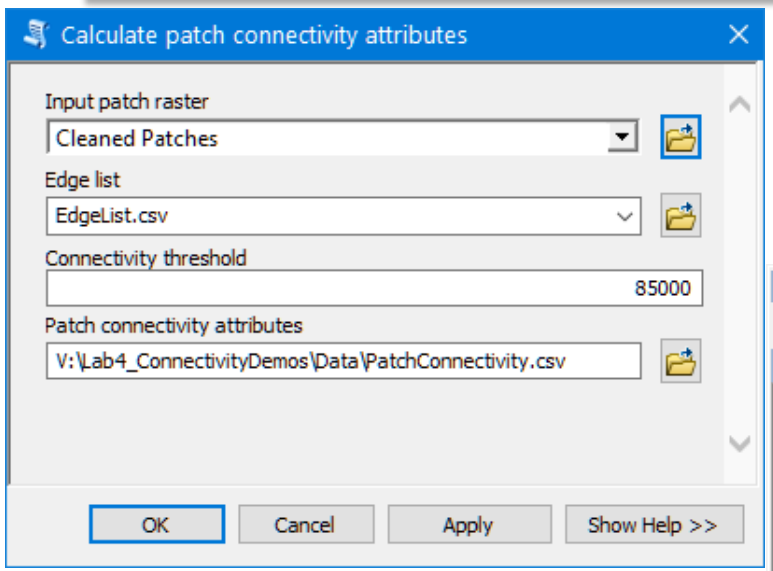


Graph Summary

Distance	NComps	Diameter
75000	23	685984
80000	19	847898
85000	16	1213111
90000	16	1213111
95000	15	1084976
100000	14	1017705
105000	13	1010177
110000	12	1099164
115000	11	1099164
120000	9	1115760
125000	8	1115760



GeoHAT – Calculate connectivity



Table

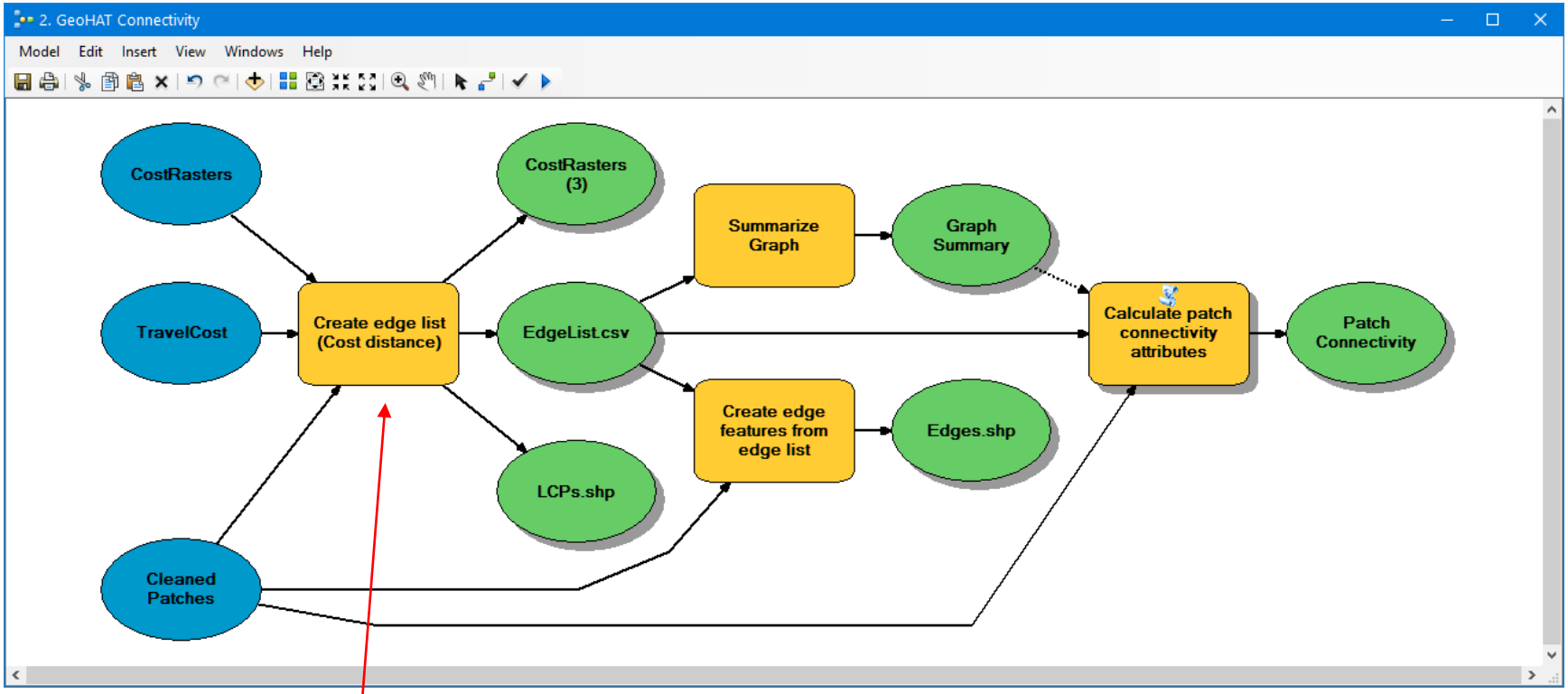
Patch Connectivity

patchID	closeness	betweenness	connectedArea	idwArea	degree	eigenvector
73	0.0004	11.0631	20742	9434	43	0.0046
74	0.0005	0	13415	2741	20	0.0342
75	0.0005	9.9773	6509	1093	20	0.8767
76	0.0004	11.0631	17575	7439	56	0.0046
77	0.0005	0.6897	20241	4814	34	0.0311
78	0.0005	0.6897	13625	2382	22	0.0311
79	0.0005	1.5297	4050	824	15	0.0345
80	0.0004	11.5308	23014	12735	51	0.0084
81	0.0004	11.5308	23008	11456	49	0.0084
82	0.0004	3.4005	21329	8152	40	0.0265
83	0.0005	0	7548	4491	30	0.7547
84	0.0005	0	8172	5499	36	0.215
85	0.0005	0.6897	20698	6545	35	0.0311
86	0.0004	3.4005	20881	7025	39	0.0265
87	0.0004	11.5308	19954	6794	37	0.0084
88	0.0005	0	7598	5086	32	0.7547
89	0.0005	42.3768	19842	6367	33	0.0312
90	0.0004	3.4005	21592	7891	40	0.0265
91	0.0005	0	7601	5240	32	0.7547
92	0.0005	0	8484	3230	34	0.7547
93	0.0004	11.5308	21256	7334	37	0.0084
94	0.0004	11.5308	21365	9440	39	0.0084
95	0.0004	11.5308	23079	13113	51	0.0084
96	0.0005	0.6897	20224	7436	35	0.0311

0 (1 out of 345 Selected)

Patch Connectivity

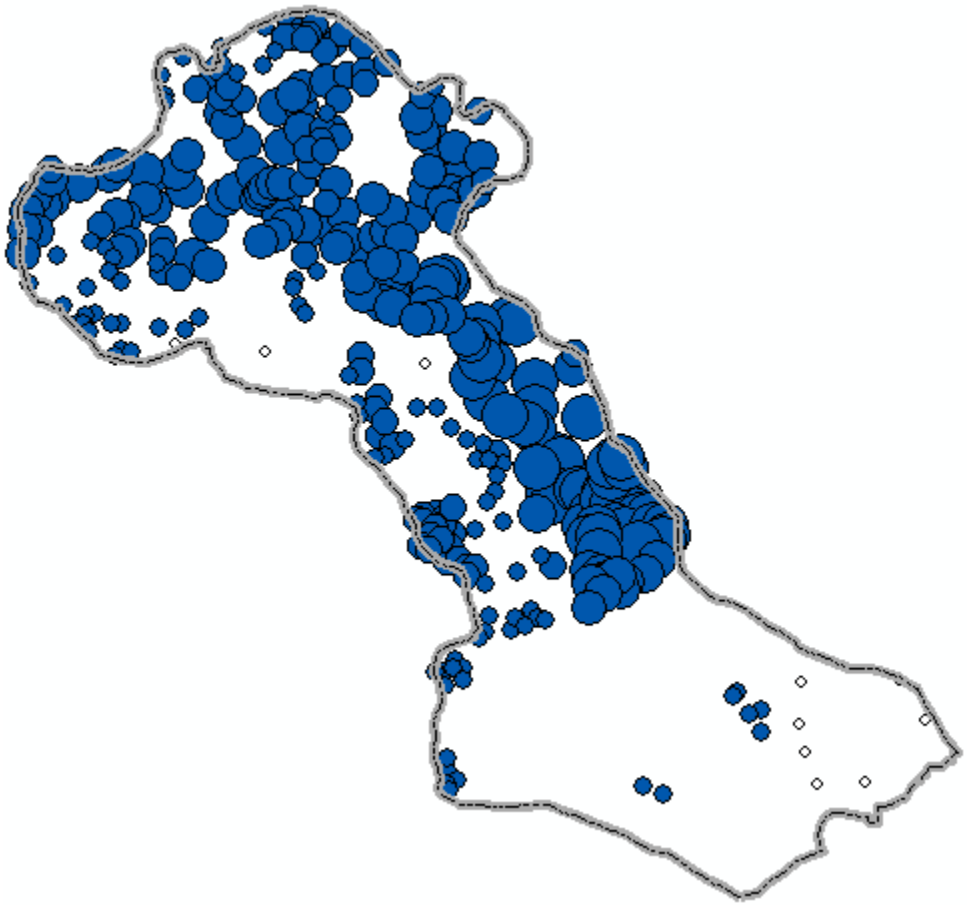
GeoHAT



1hr 24min

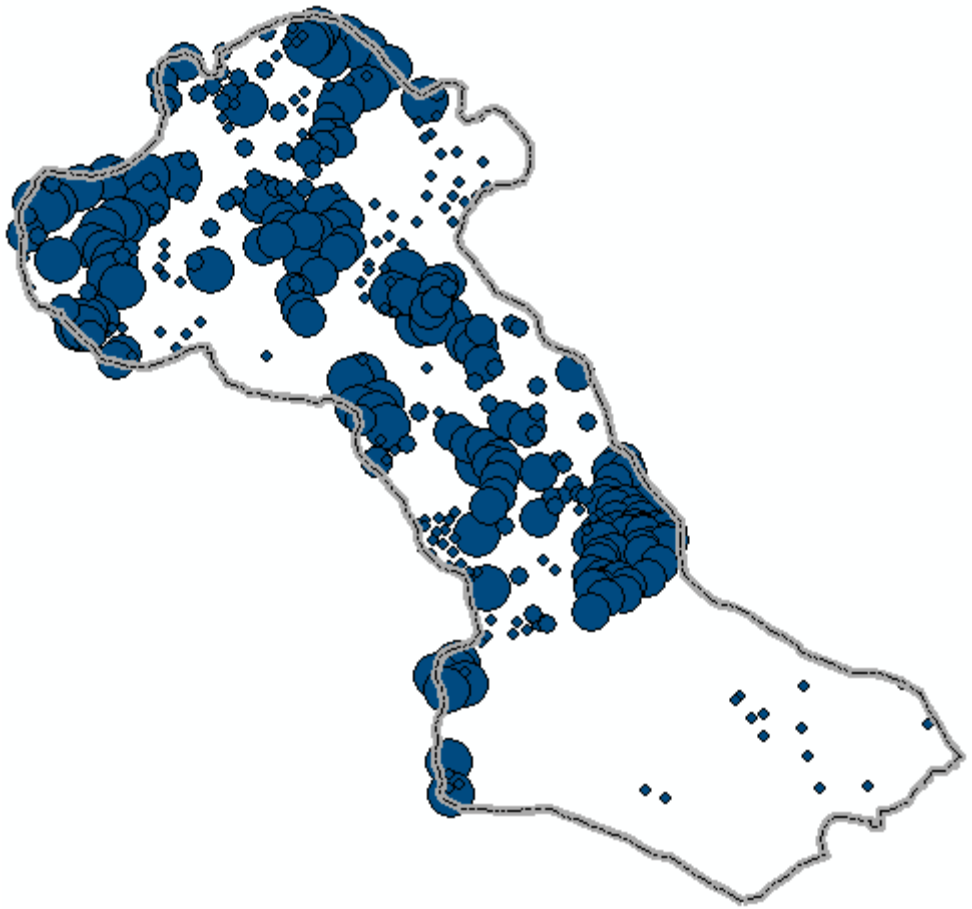
GeoHAT Connectivity Metrics

- **Degree centrality:**
  # connected patches within a connectivity threshold



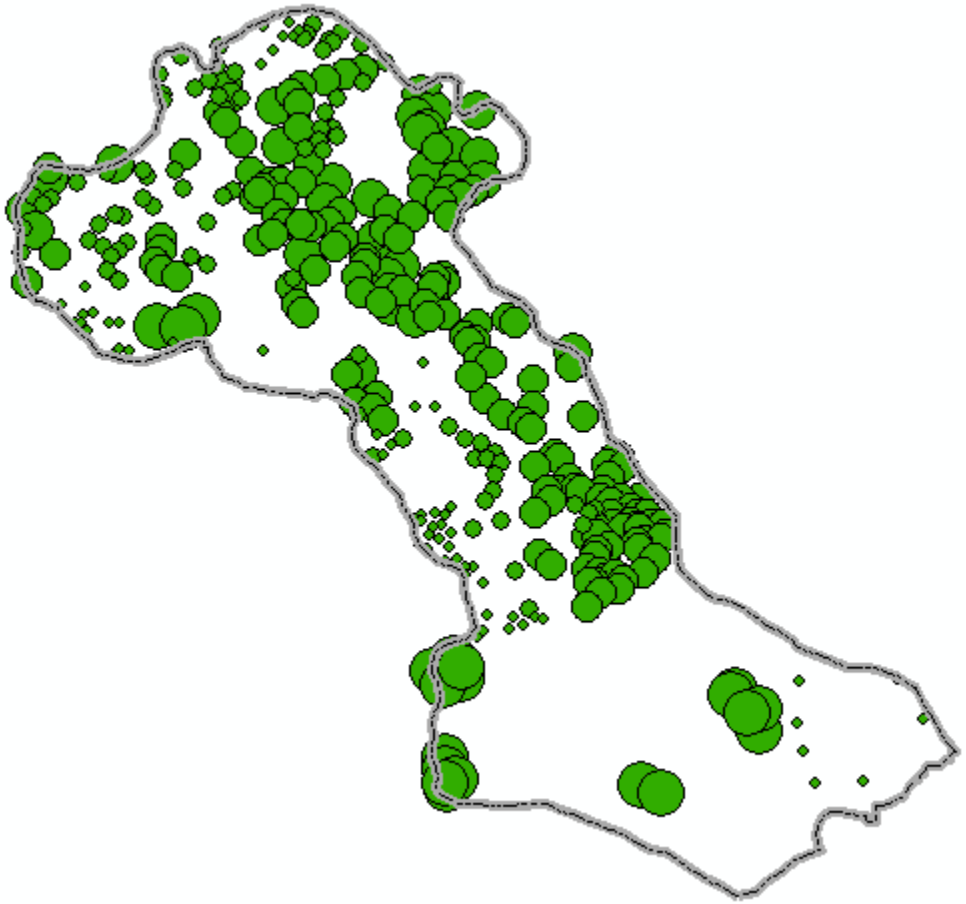
GeoHAT Connectivity Metrics

- **Betweenness centrality:**
  Frequency a patch is found in the LCP of other patch pairs



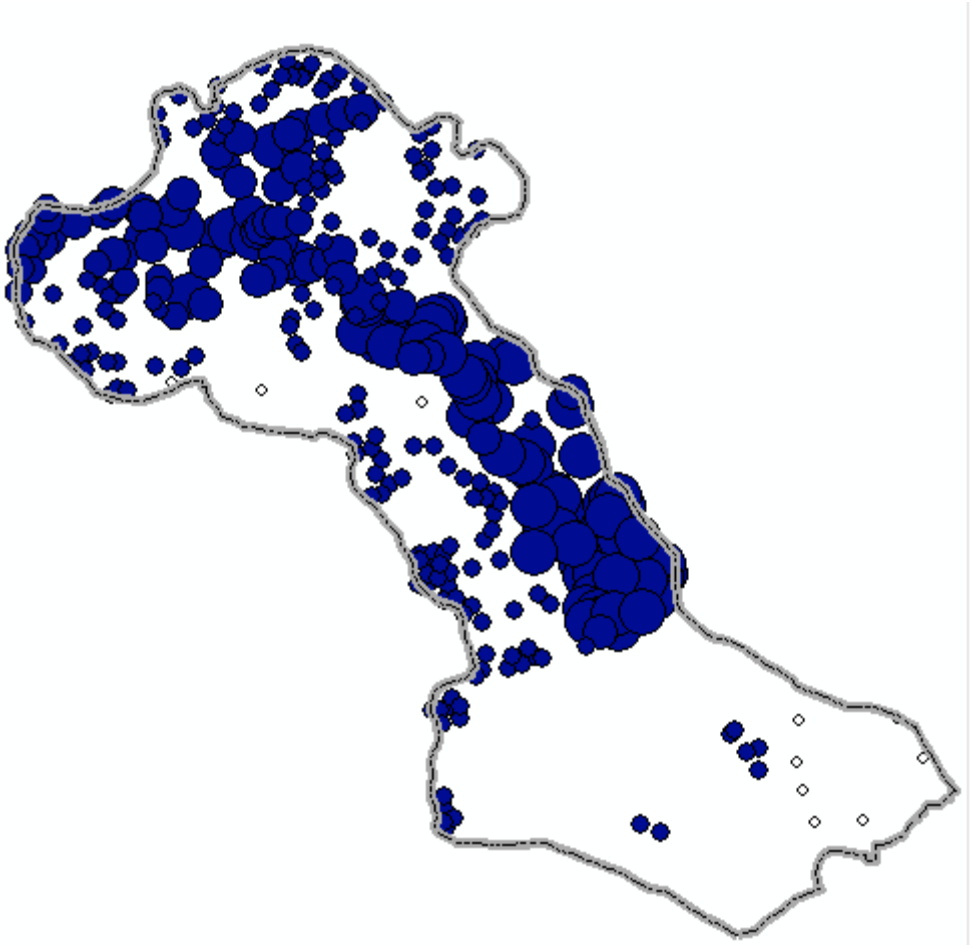
GeoHAT Connectivity Metrics

- **Closeness centrality:**
  Avg. distance to neighbors relative to other patches



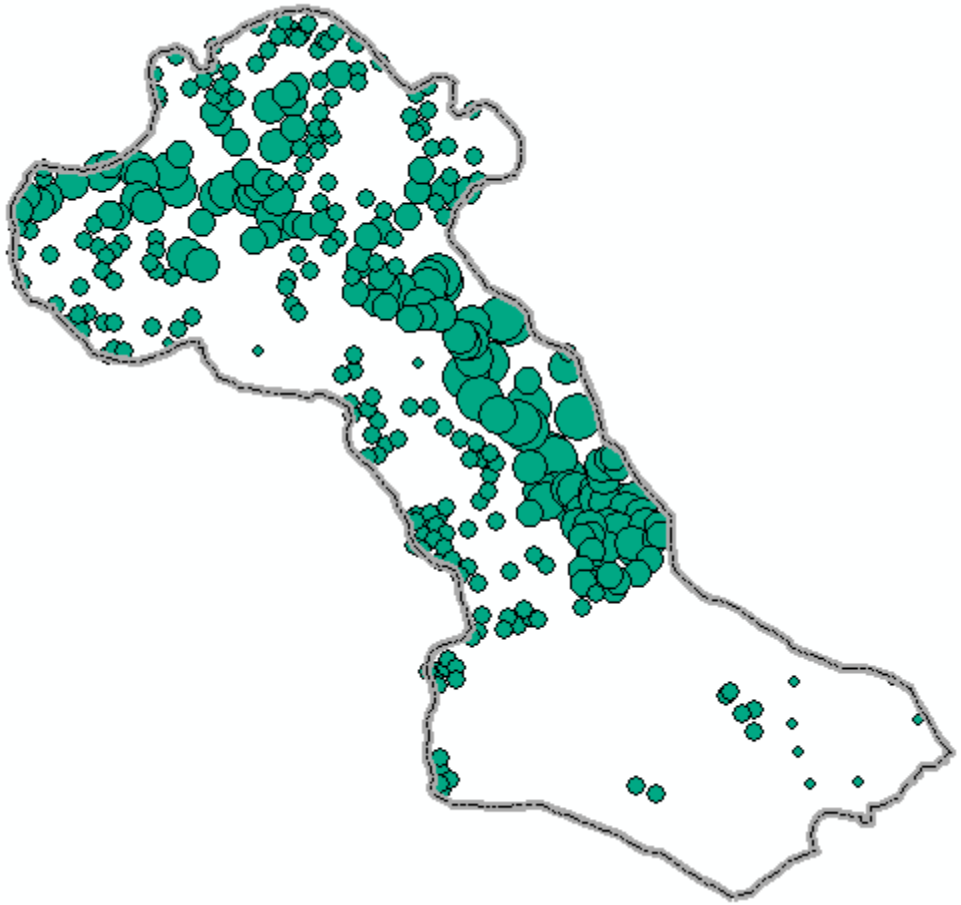
GeoHAT Connectivity Metrics

- **Connected Area:**
  Total patch area within the connectivity threshold



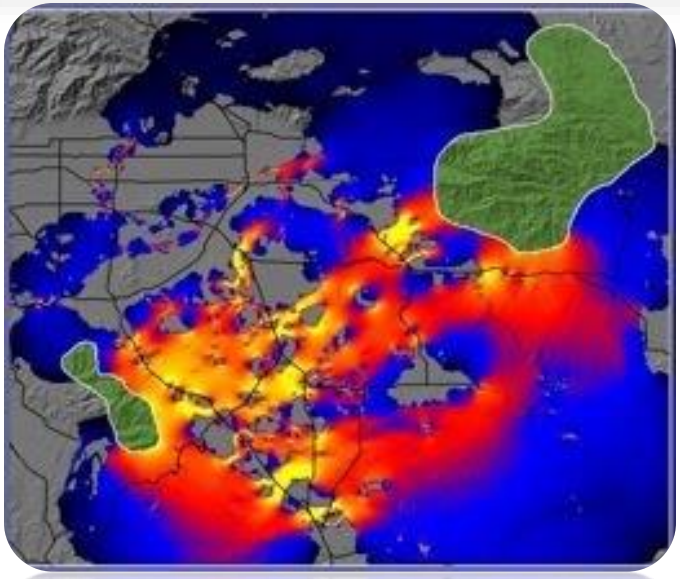
GeoHAT Connectivity Metrics

- **Probable Connected Area:**
  Inverse distance weighted area within connectivity threshold

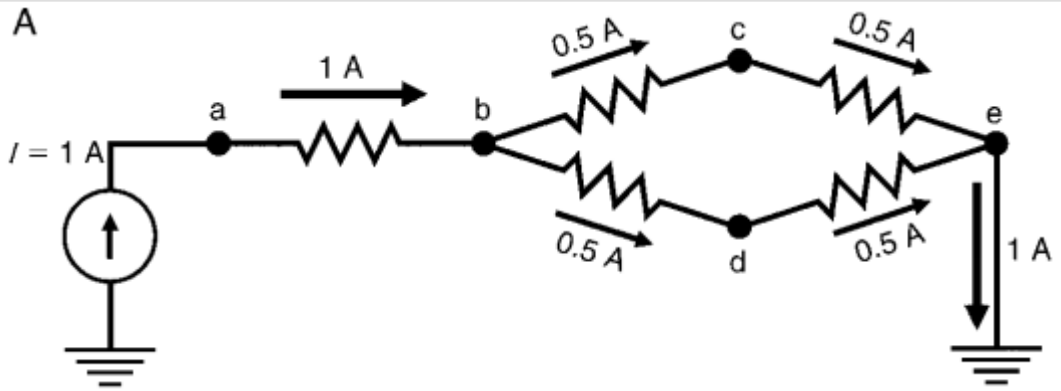


CircuitScape

CIRCUITSCAPE.ORG

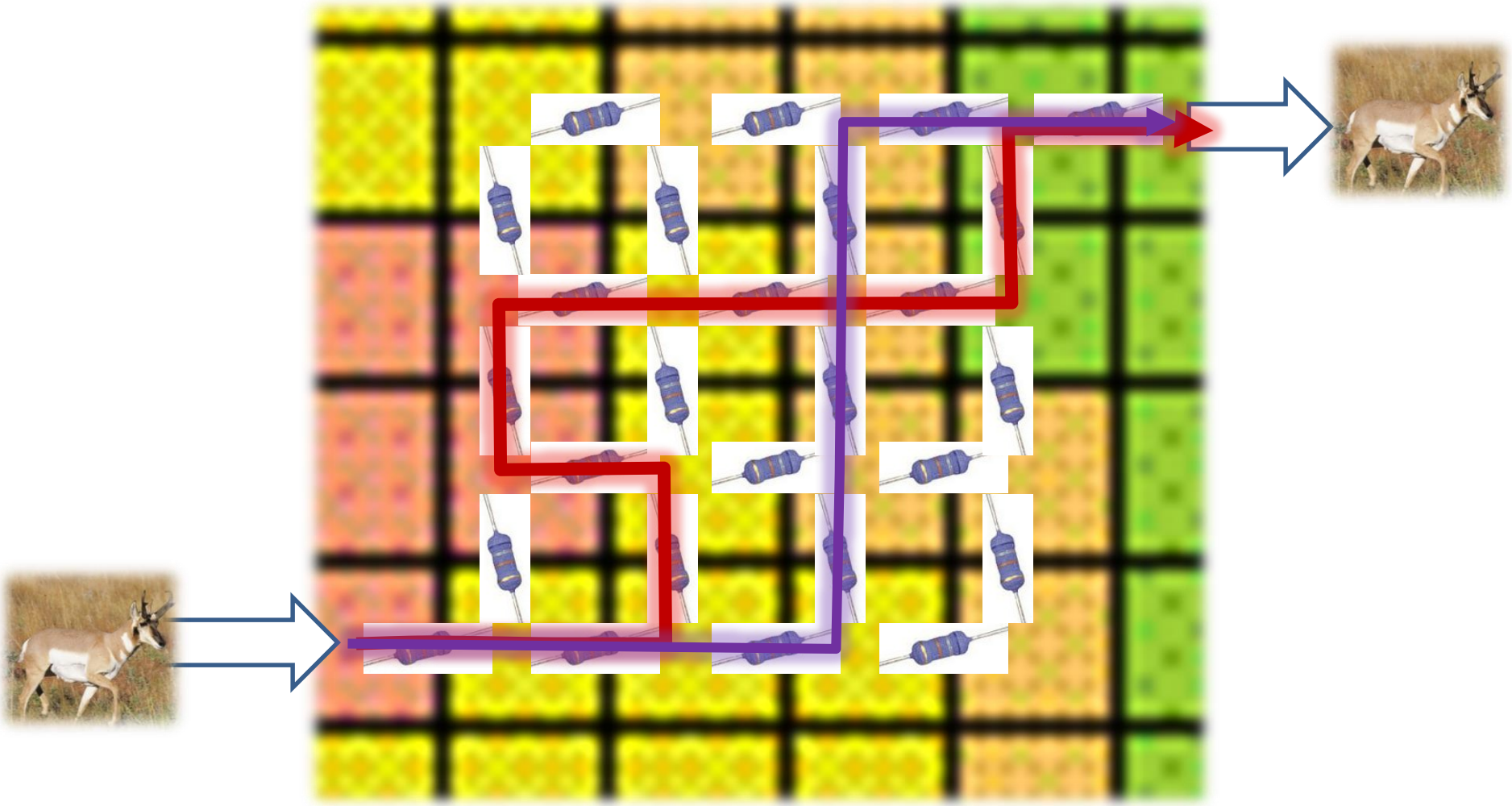


Circuit Theory and Circuitscape

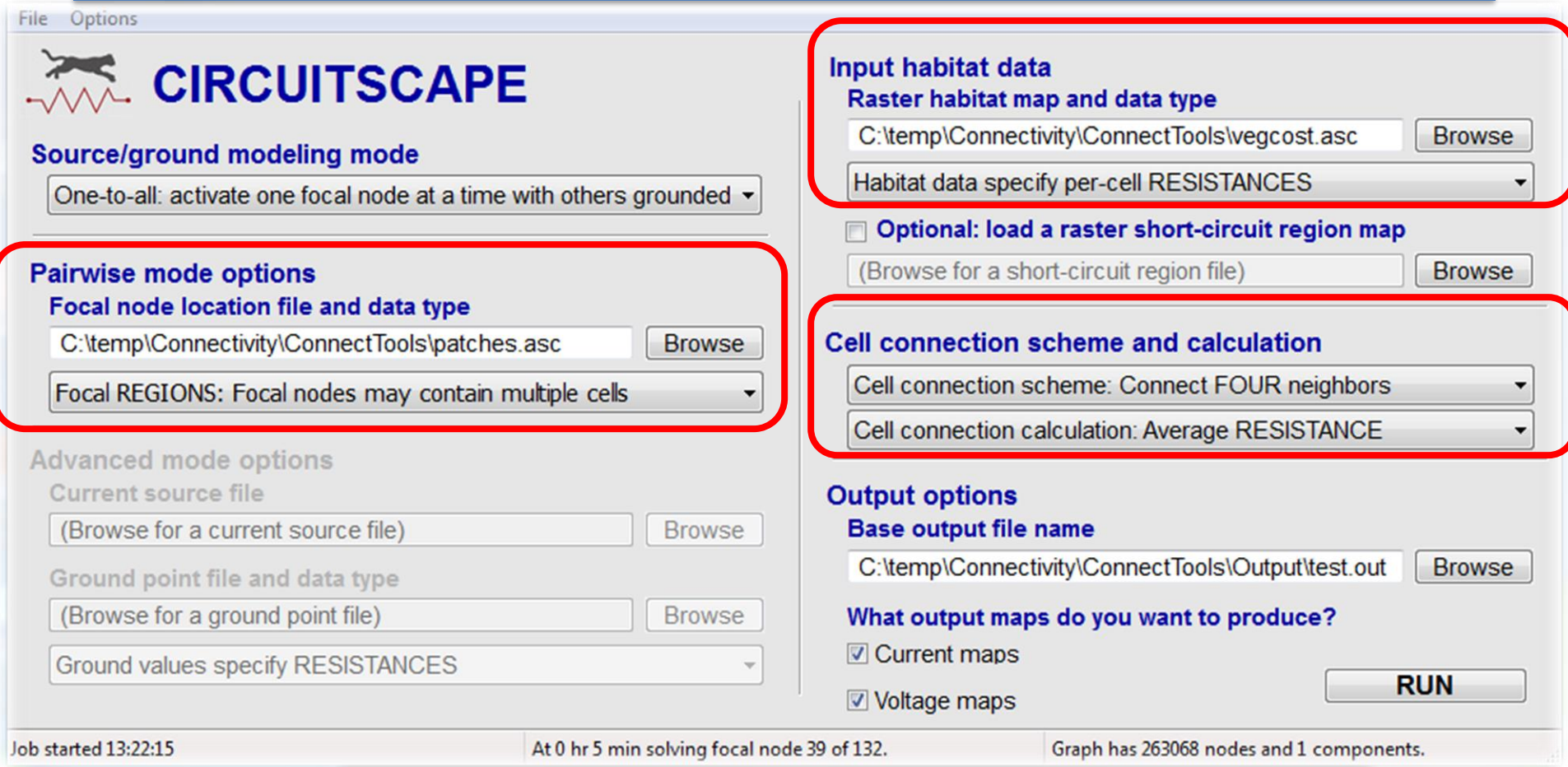


- Antelope (random walker) = electron
- Source patch = source of current (1 amp)
- Destination patch = grounding of current
- Cost raster = network of resistors
- Random walks = circuit

Cost raster = network of resistors



Circuitscape inputs



Features to connect:

- Patches → regions
- **Centroids → nodes**

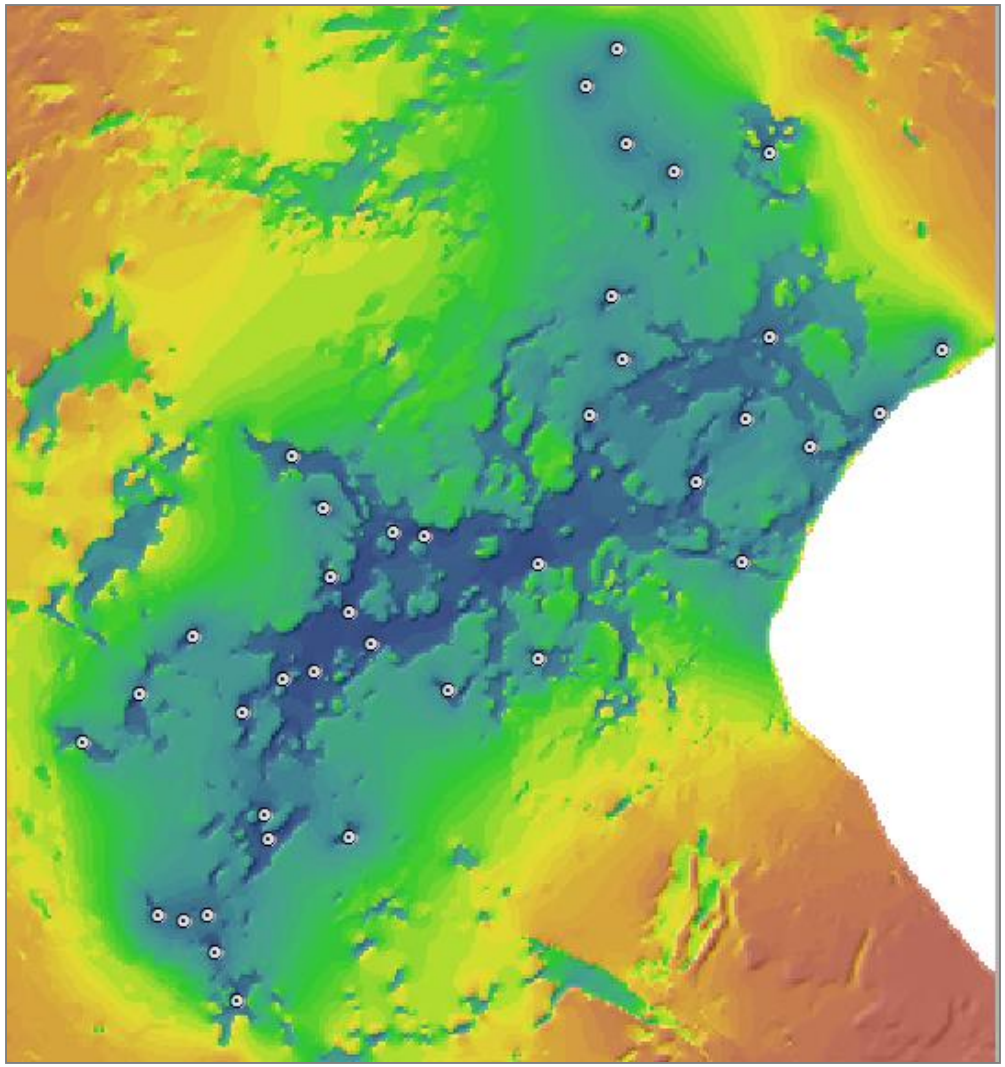
Habitat data:

- Resistance -or-
- **Conductance**

Connectivity rules:

- 4 or 8 cell
- **Resistance or conductance**

Pairwise mode: Cumulative Current



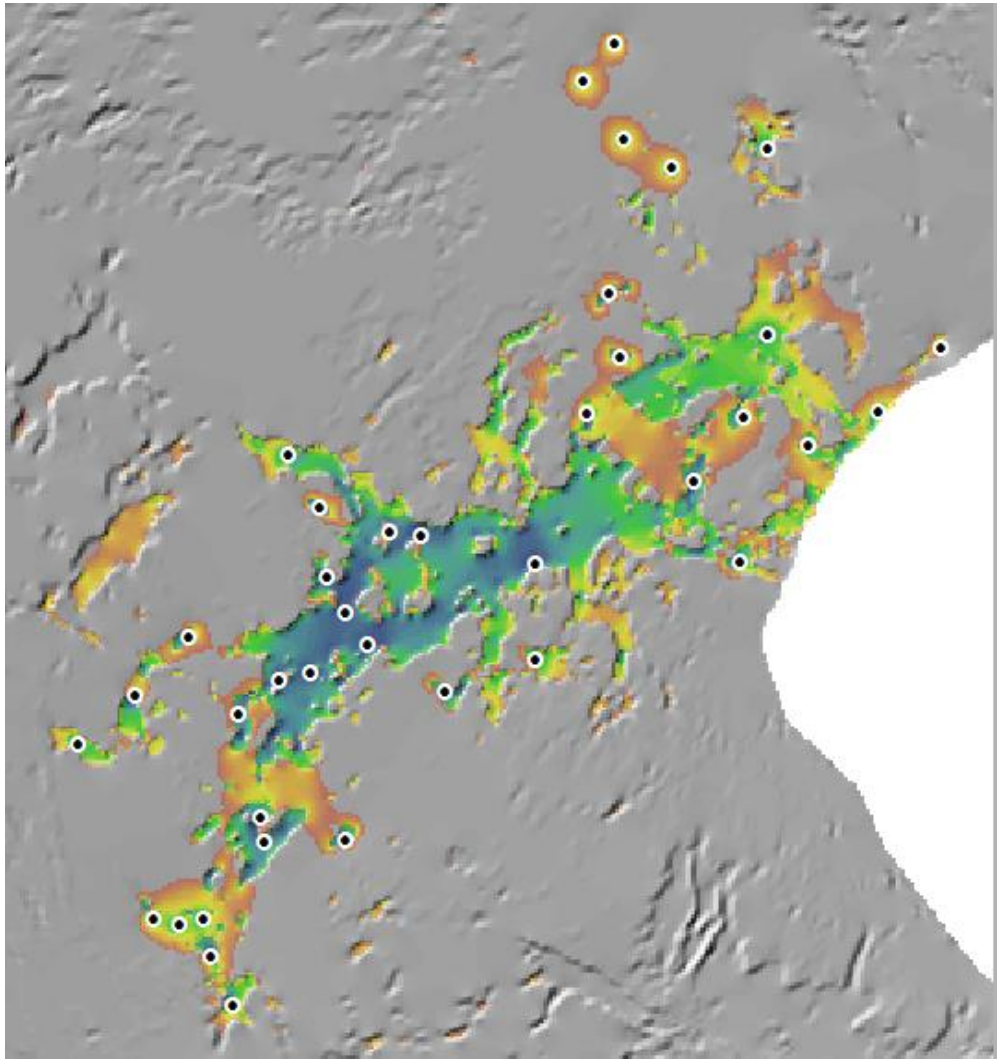
Blues: high current

Oranges: low current

Calculated by summing together all pairwise current maps.

Results are a lot like betweenness centrality as a deeper blue indicates that the pixel is used in many pathways among patch pairs.

Pairwise mode: Corridor



All cumulative pairwise currents below a threshold

Isolates all areas with "significant" betweenness centrality, i.e. high connectivity relevance.

Could be interpreted as areas of priority conservation for connectivity…