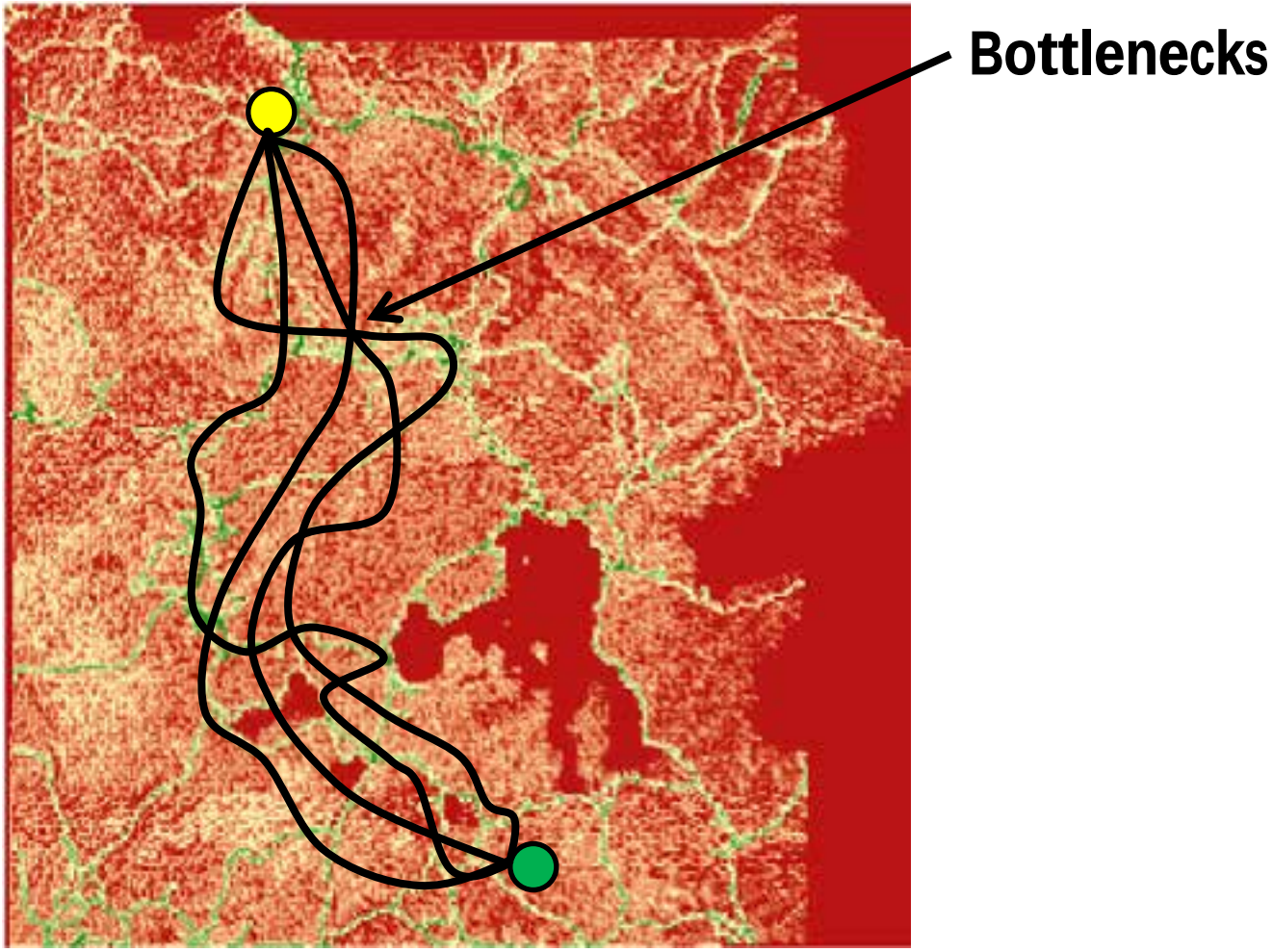
Vector-based Mobility Modeling

Shreyas Shinde
Dr. Douglas Flewelling
University of Redlands
Master of Science in GIS Program

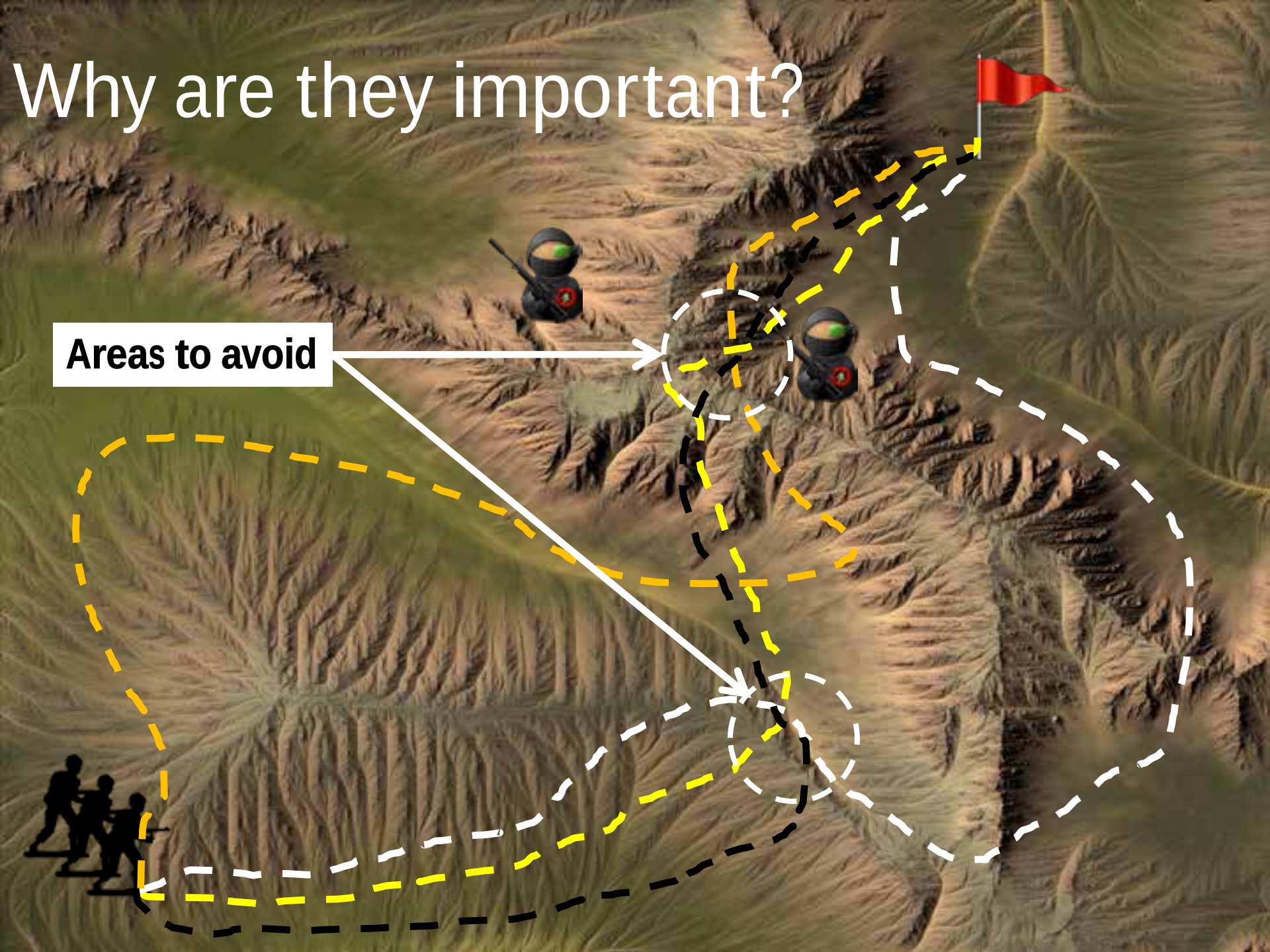
The problem

- To find areas on a terrain that could become potential bottlenecks for people moving across the terrain

What are bottlenecks?



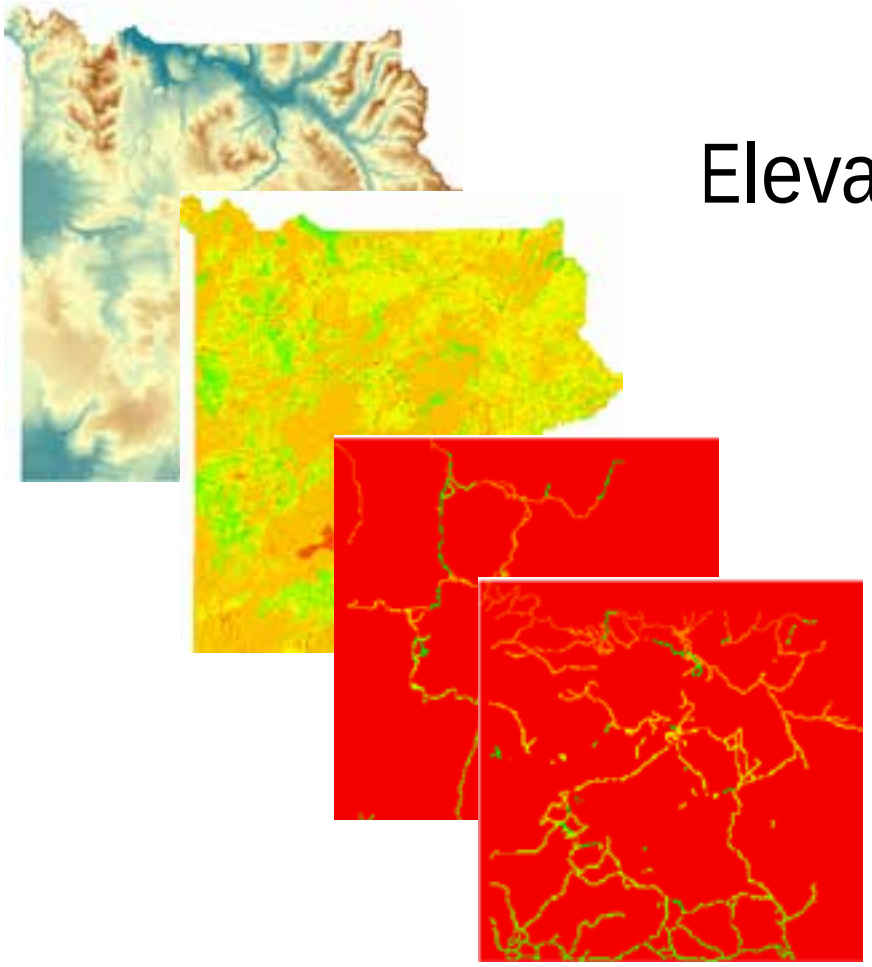
Why are they important?



The approach

- Consider many possible routes between points
  - Optimal (least cost path analysis)
  - Sub-optimal
    1. Build a cost surface
    2. Iteratively vary the cost surface
    3. Least cost path
    4. Repeat
    5. Visualize

Step 1: Building the cost surface (pre-processing)



Elevation model
Land Cover
Roads
Trails
Posts

Reclassification

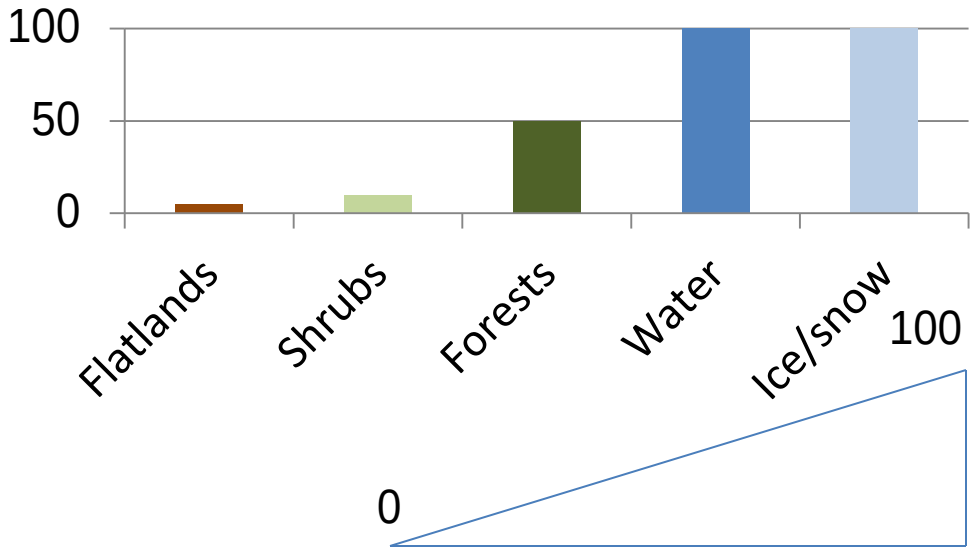
Trails and posts

0 if present, else 100

Roads and highways

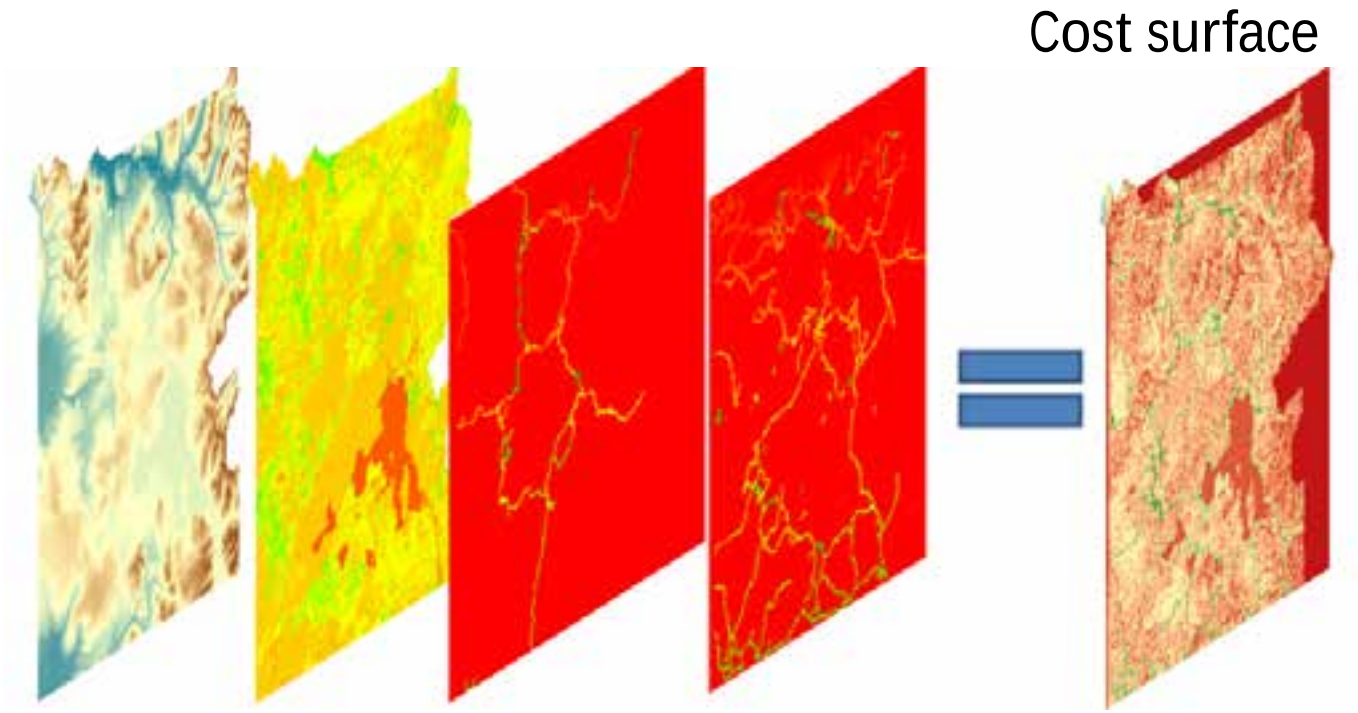
0 if present, else 100

Land Cover



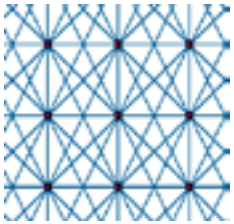
Elevation profile è Slope

Reclassification and weighted overlay

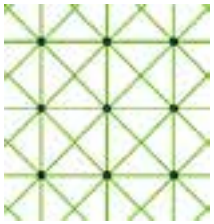


Step 2: Vector based re-sampling

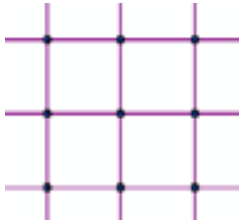
- To speed up simulation
- Consider a regular grid of points connected by edges



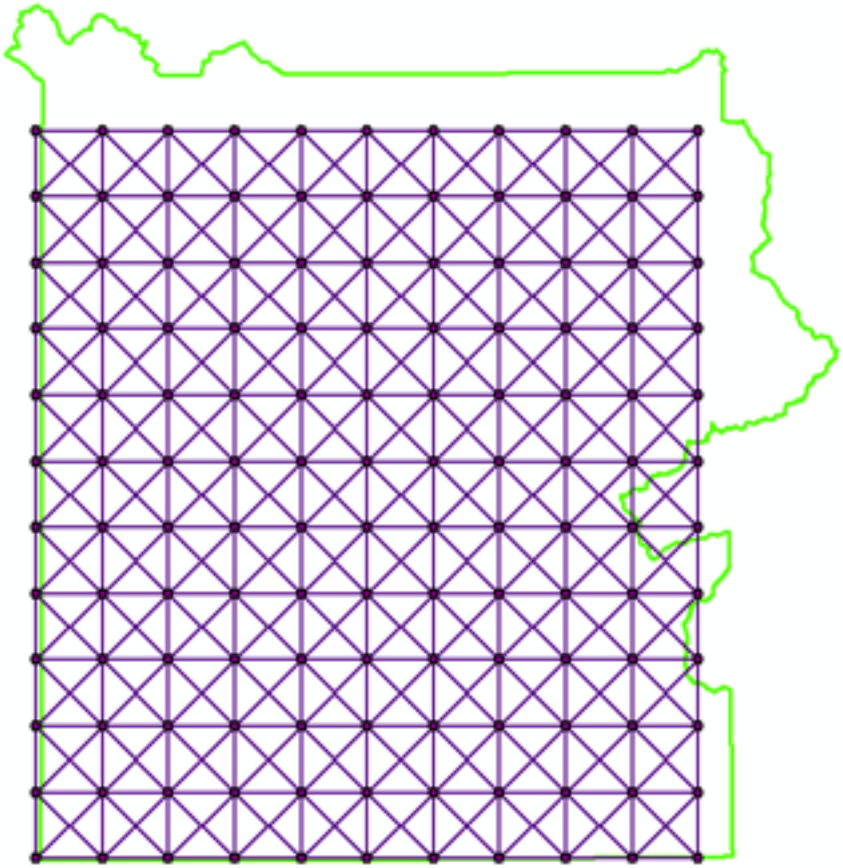
Knight



Queen



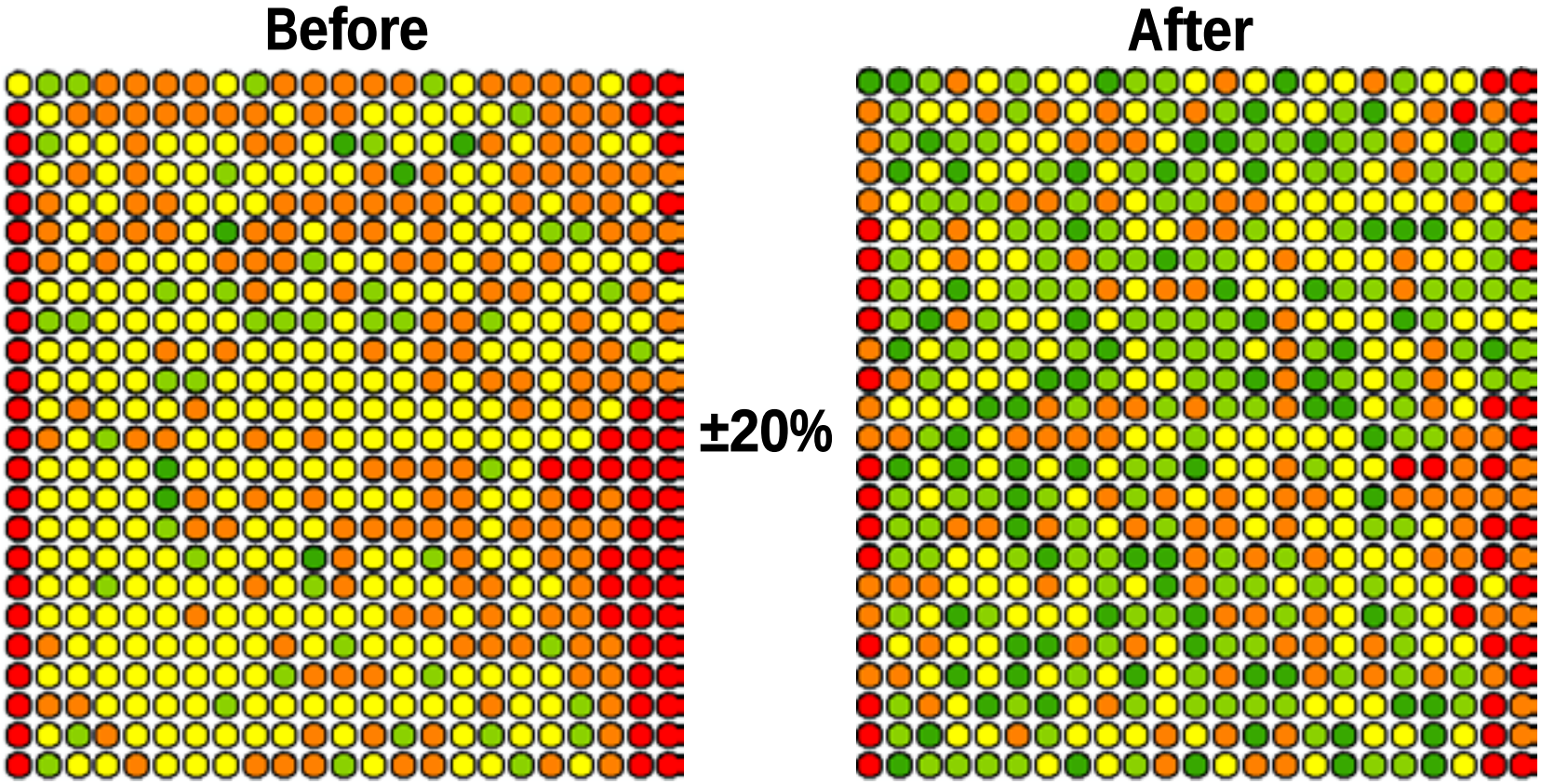
Rook



Step 3: Least cost path analysis

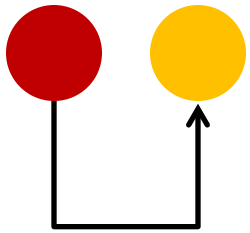
- Faster when run on a lower resolution vector model instead of a raster
- Ability to record every traversed edge and node
- Ability to model complex constraints
  - With the use of ArcGIS Network Analyst Extension

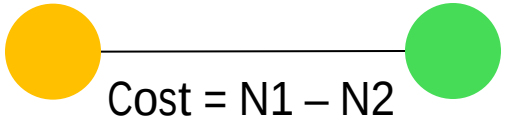
Step 4: Apply noise to vary the surface

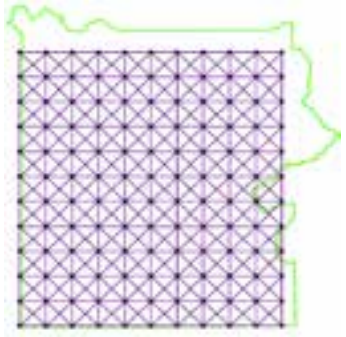


Step 5: Re-compute edge & repeat LCPA

- Cost of traversing an edge is the difference in costs of the adjoining nodes
- When noise is added to the node value the cost of the edge varies
- Re-build the network dataset







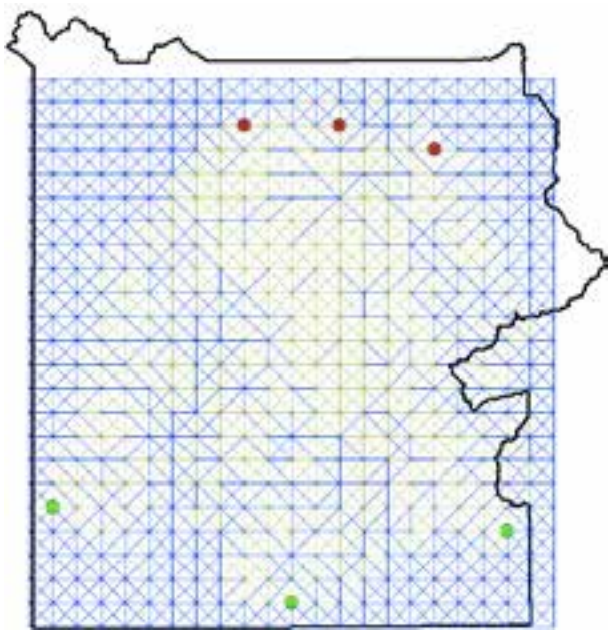
Step 6: Store traversed edges

- Track the occurrence of each edge in all the traversed routes

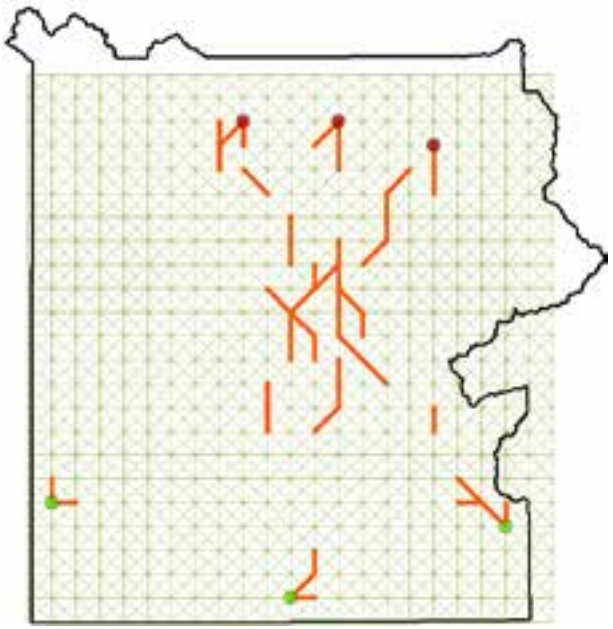
edges

OBJECTID *	SHAPE *	Id	SRC_ID	DES_ID	COST	REPEATED	ETYPE	SHAPE_Length
64	Polyline M	0	34	10	0	0	2	5939.696962
65	Polyline M	0	35	34	10	300	1	4200
66	Polyline M	0	35	12	115	0	1	4200
67	Polyline M	0	35	13	0	3	2	5939.696962
68	Polyline M	0	35	11	28.28	0	2	5939.696962
69	Polyline M	0	36	35	20	56	1	4200

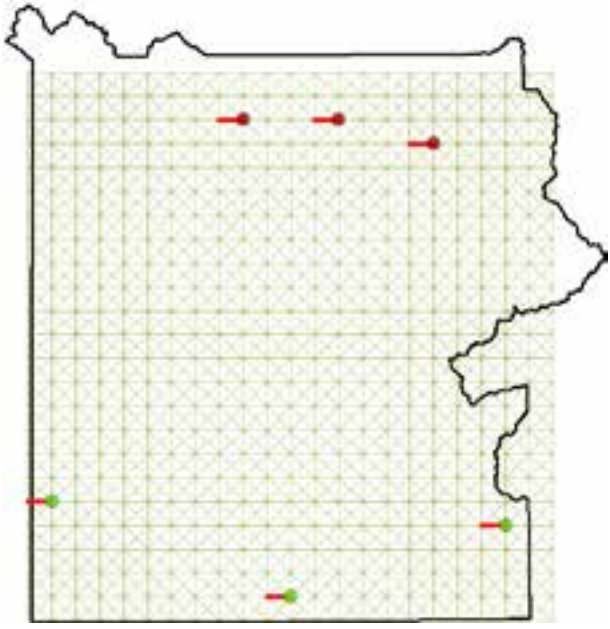
Step 7: Visualize result



Edges not traversed at all



Edges with high traversal



Edges with highest traversal

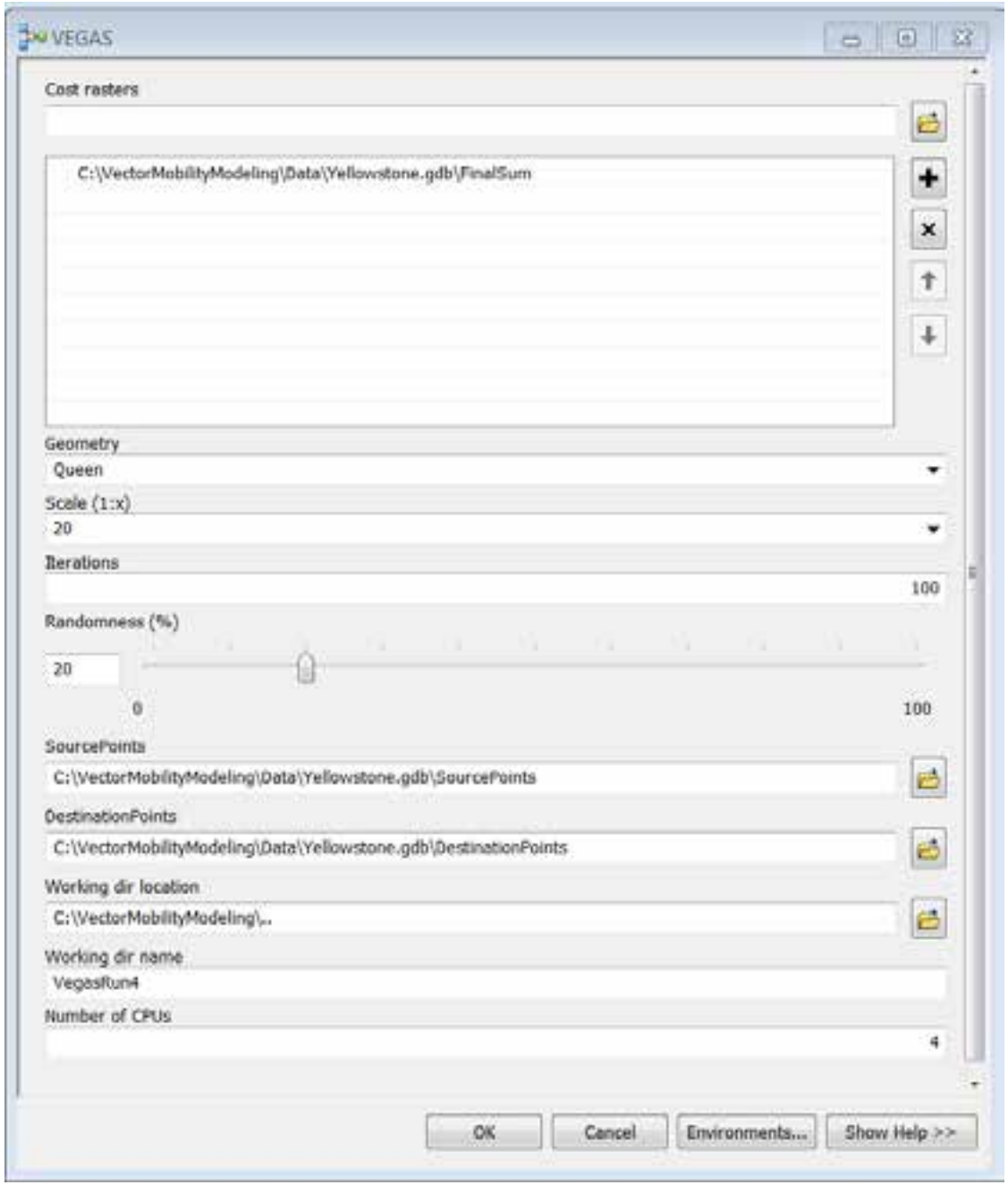
The model

Raster surfaces

Geometry, Scale, Iterations, Noise

Source and Destination

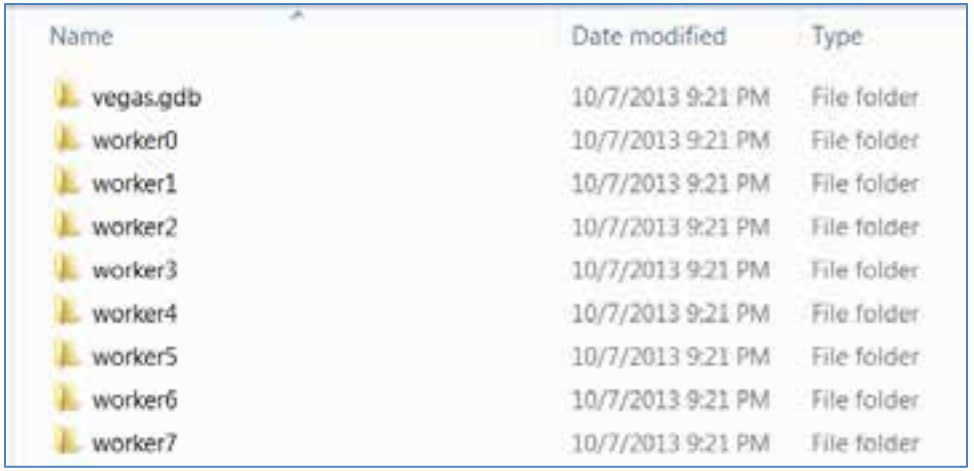
Working dir., Cores

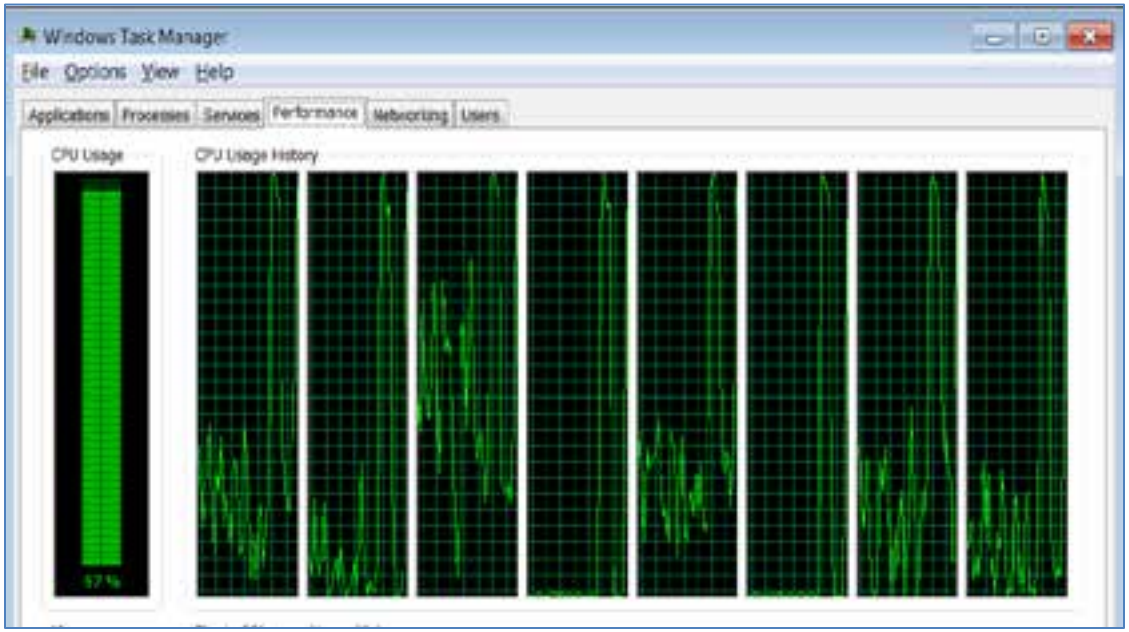


About the tools

- Python scripts
  - Using arcpy and Network Analyst Extension
  - Run be run within ArcMap as a Model
  - Python API
- Runs simulation of routes in multi-processing manner for efficiency

Multi-processing



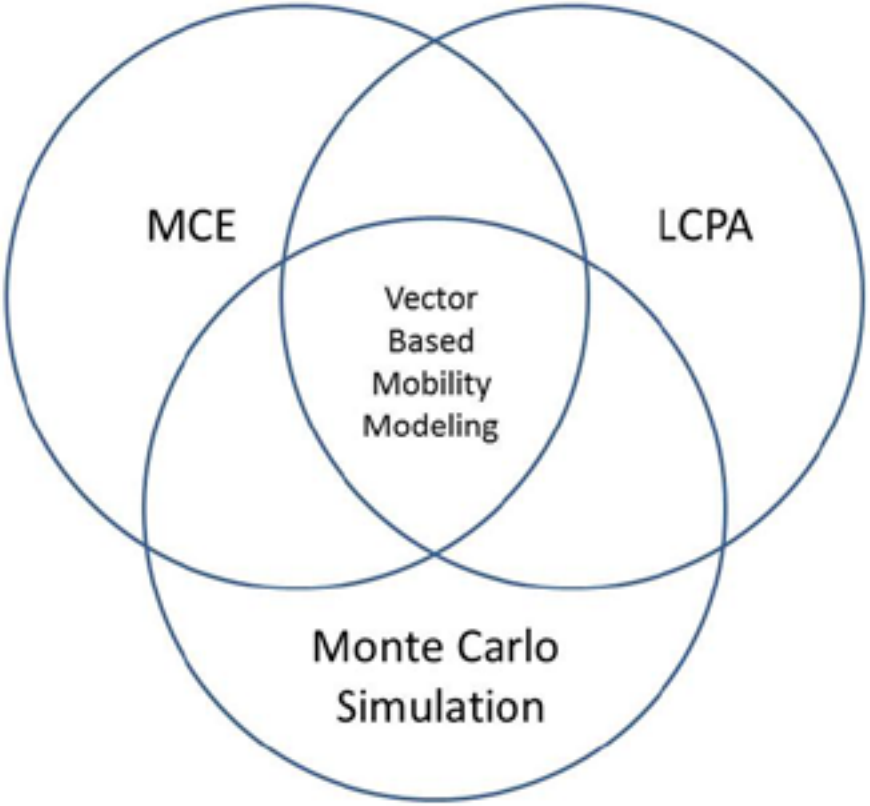


~100% CPU

Applications

- Troop mobility
- Congestion mapping in transportation
- Troop positioning in guarding facilities
- Rescue mission planning
- ...

Thank you



Shreyas Shinde - shreyasshinde@gmail.com
Dr. Douglas Flewelling - douglas_flewelling@spatial.redlands.edu