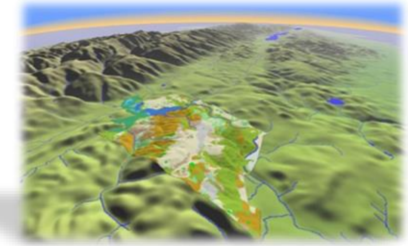
NICHOLAS SCHOOL OF THE ENVIRONMENT AND EARTH SCIENCES
DUKE UNIVERSITY



ENVIRON 761:
Threat Mapping

Instructor: John Fay

Lab Exercise: Overview

- **Distance to threat/stress**
  - Euclidean distance (linear) to developed areas
  - Euclidean distance (exponential) to power lines
- **Density of threats/stresses**
  - Point density of human conflict points
  - Kernel density of human conflict points
  - Kernel density of roads
  - Focal density of developed lands
- **Mapping urban expansion**
- **Assessing patch threat levels**
  - Weighted overlay of threats
  - Zonal statistics

Lab Exercise: Data

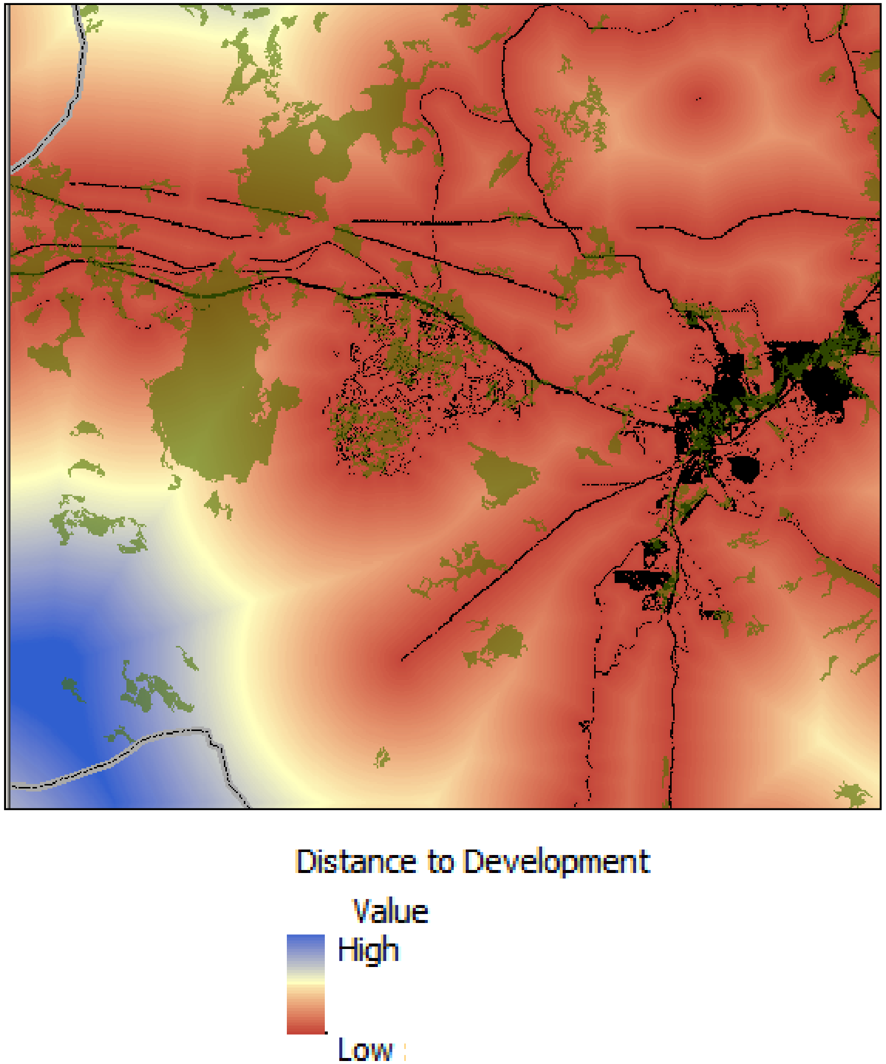
- 2011 NLCD → Developed areas…
- Geog. Names Information System (GNIS) → Human conflict points
- TIGER Transmission lines
- TIGER Roads

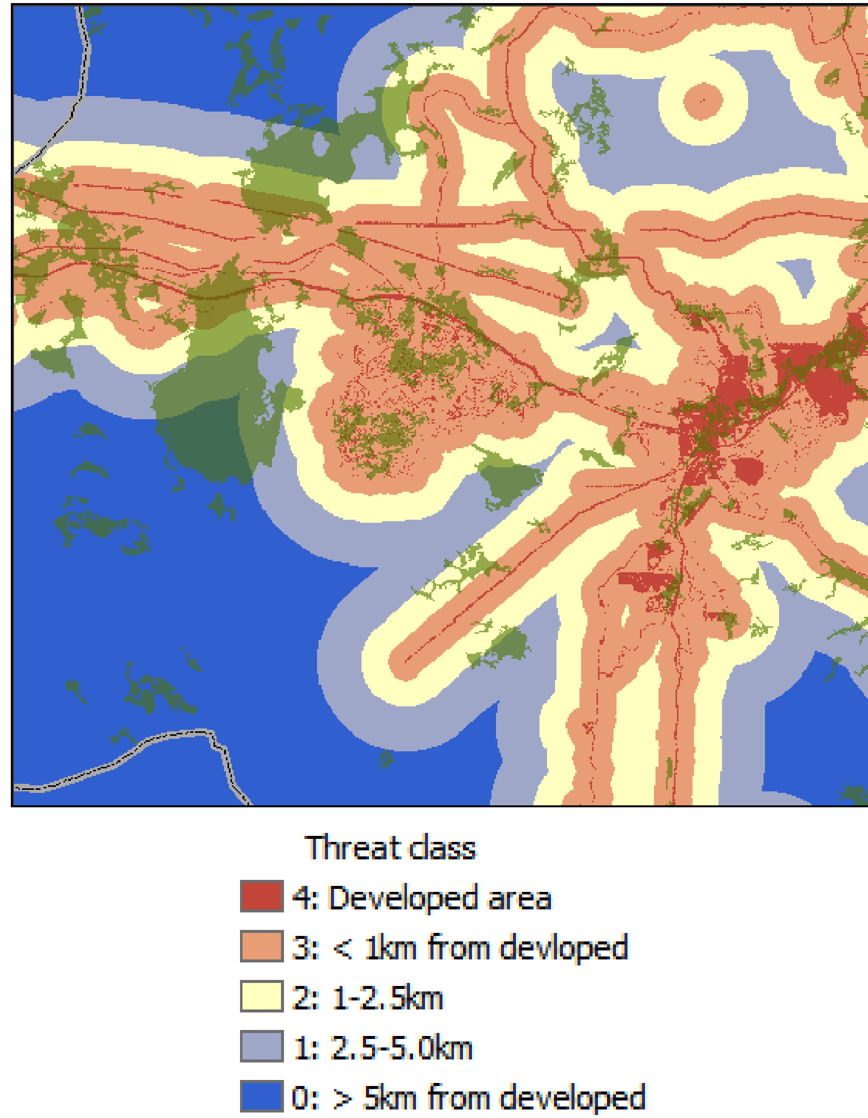
1. Linear distance from developed areas

"Pronghorn generally don't like to wander in or near developed areas. A recent study noted that the pronghorn will outright avoid developed areas and are only seldom seen in viable habitat areas within 1 km of developed areas. Areas within 1-2.5 km are somewhat stressful to the antelope and less so in areas 2.5 to 5km from developed areas. Beyond 5km, developed areas have no impact."

- Isolate developed classes from NLCD…
- Calculate Euclidean distance…
- Reclassify into threat classes…

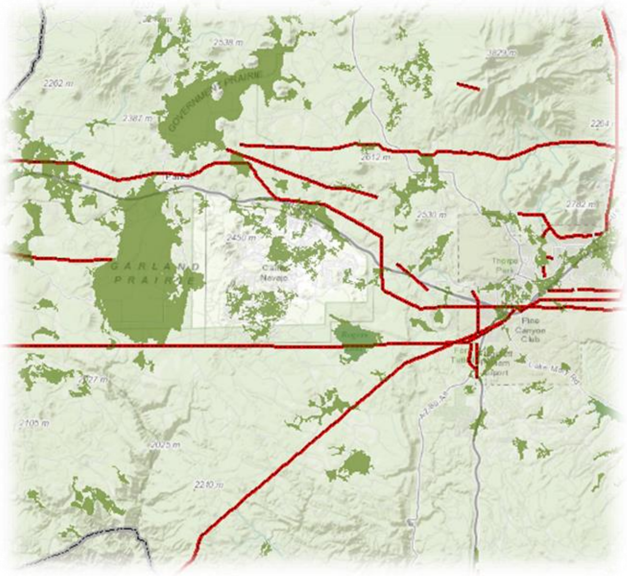
1. Linear distance from developed areas

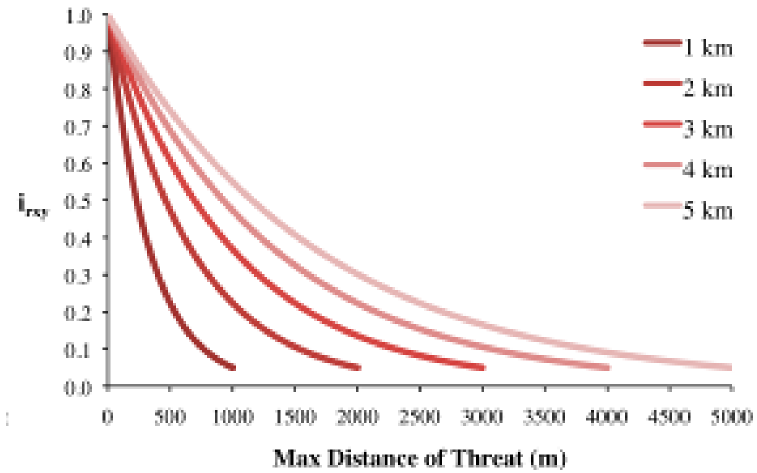




2. (Decayed) distance from power lines

"Pronghorn antelope are stressed out by the magnetic fields generated by transmission lines. The magnetic fields are strongest directly under the transmission lines but the field strength (and effect on the antelope) decays exponentially. At 6000 meters away, the impacts are negligible (about 0.1% of original strength)."





2. Exponential distance to power lines

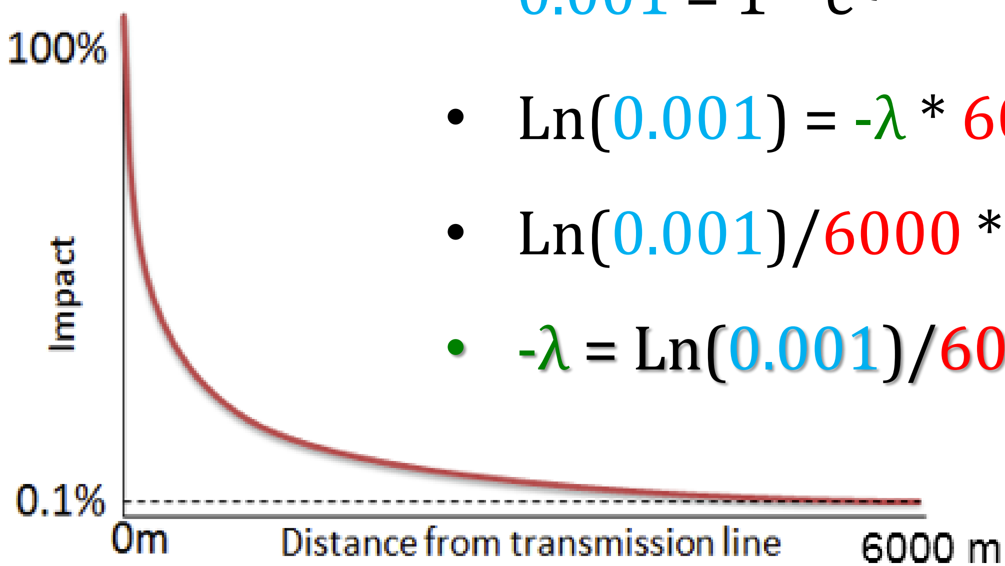
At 6000 meters away, the impacts are negligible (about 0.1% of original strength)."

$$N(t) = N_0 e^{-\lambda t}$$

Exponential decay function

- $0.001 = 1 * e^{(-\lambda * 6000)}$
- $\mathrm{Ln}(0.001) = -\lambda * 6000$
- $\mathrm{Ln}(0.001)/6000 * = -\lambda$
- $-\lambda = \mathrm{Ln}(0.001)/6000 = -0.001151293$

Solve for λ...



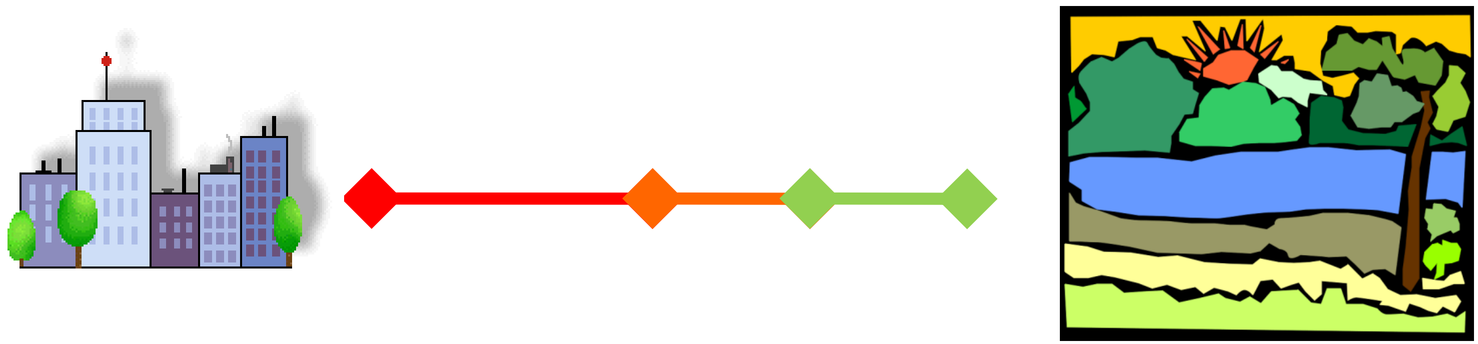
2. Exponential distance to power lines

- Calculate Euclidean (linear) distance from power lines
- Transform linear distances into exponential decay distances

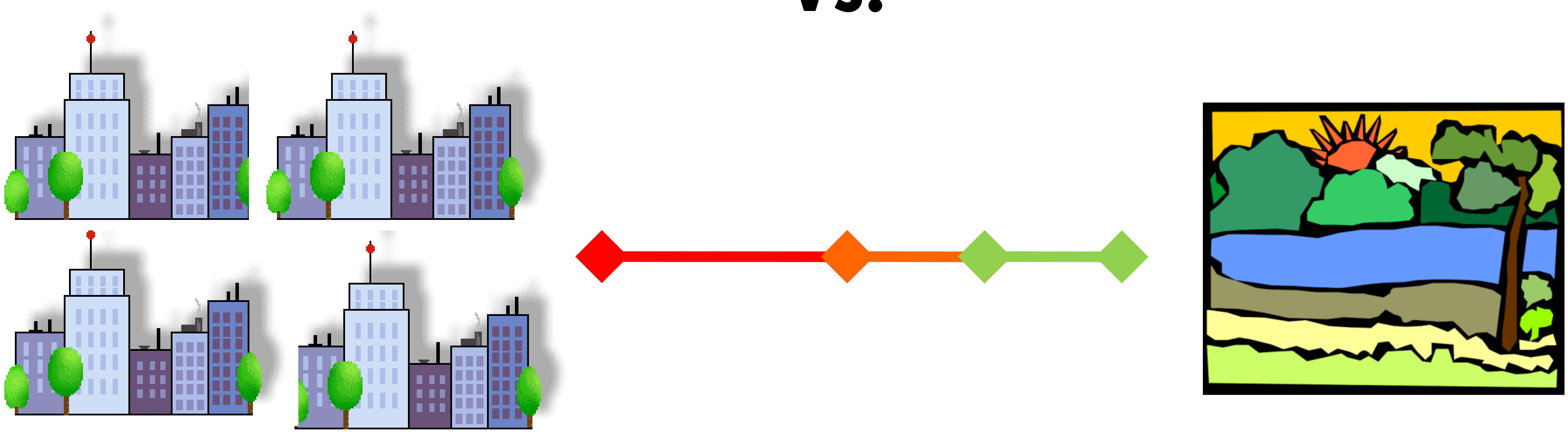
$$N(t) = N_0 e^{-\lambda t}$$

Decayed Impact Raster = Exp**(-0.001151293** * *Euclidean Distance Raster***)**

Threat density analysis

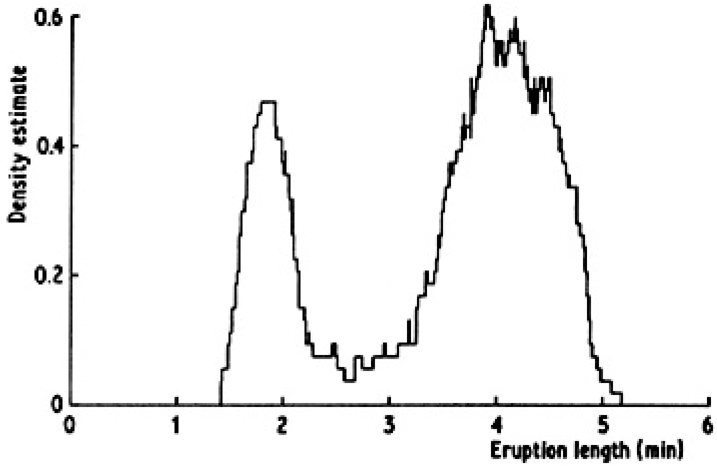


Vs.

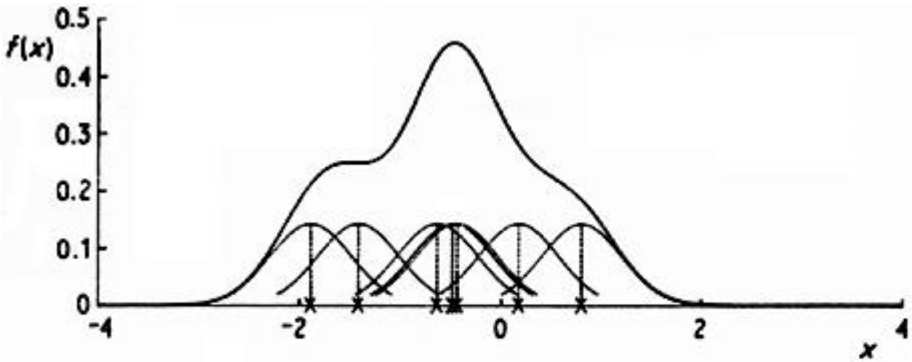


Threat density analysis

Point distance
Number of features within a set radius of a given raster cell



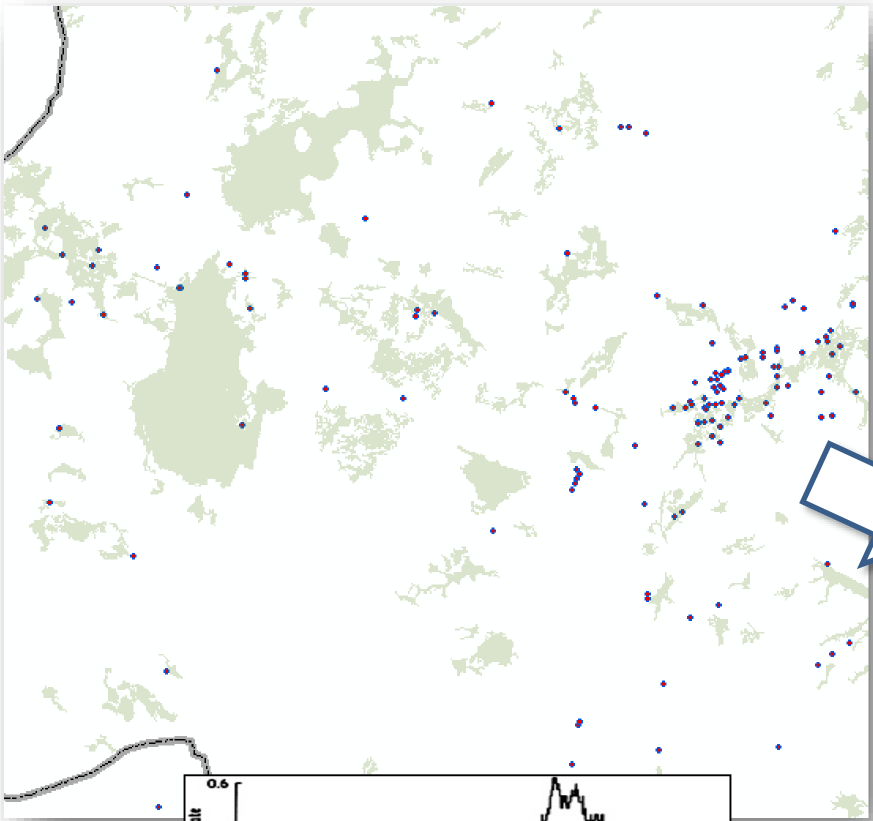
Kernel distance
Uses a distribution around a point (i.e., a kernel) rather than the point itself to measure density. Result is the sum of the distributions.

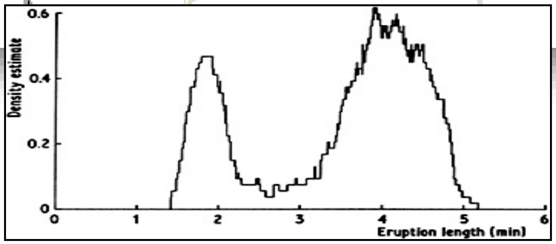


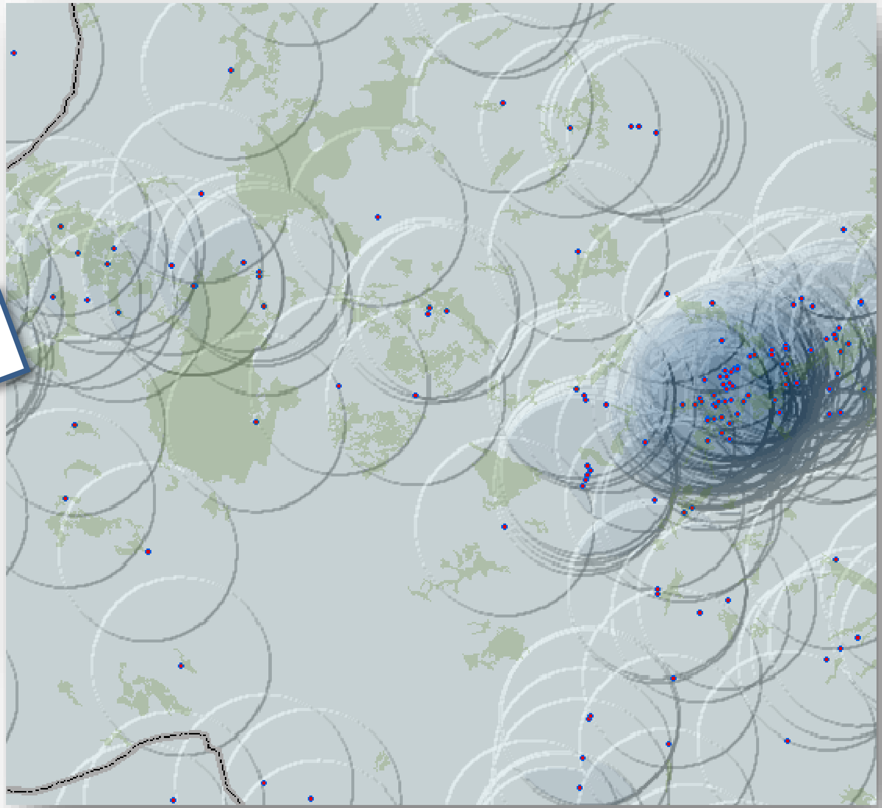
http://nedwww.ipac.caltech.edu/level5/March02/Silverman/paper.pdf

3. Density of Human Conflict Points

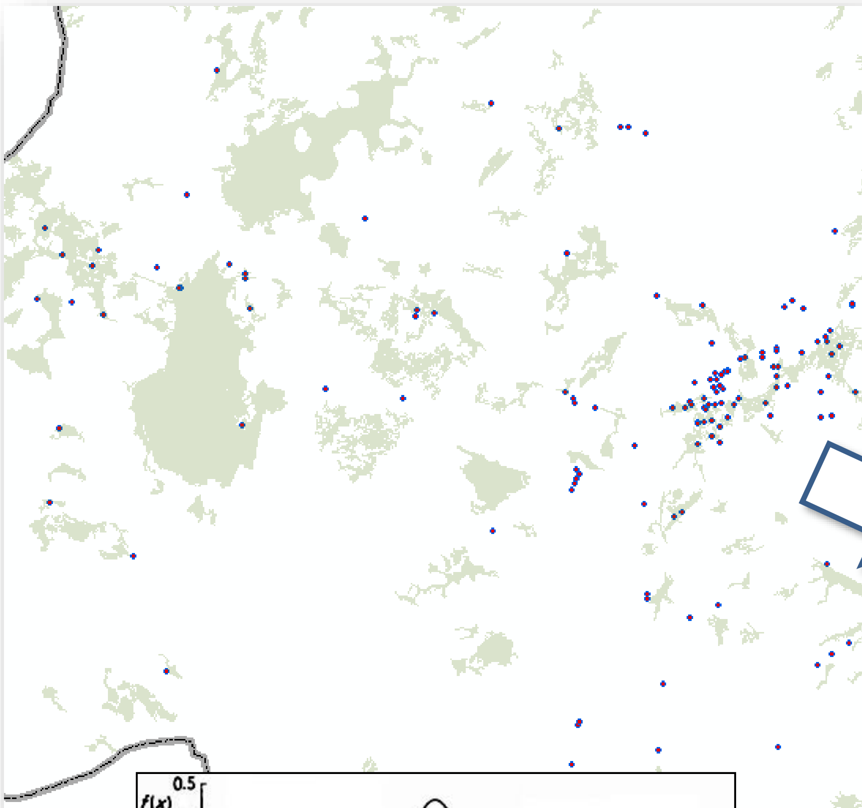
- Point density:
  # of points w/in 5km

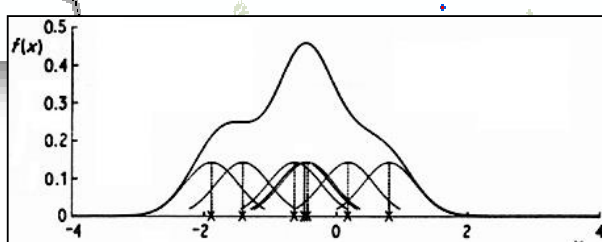




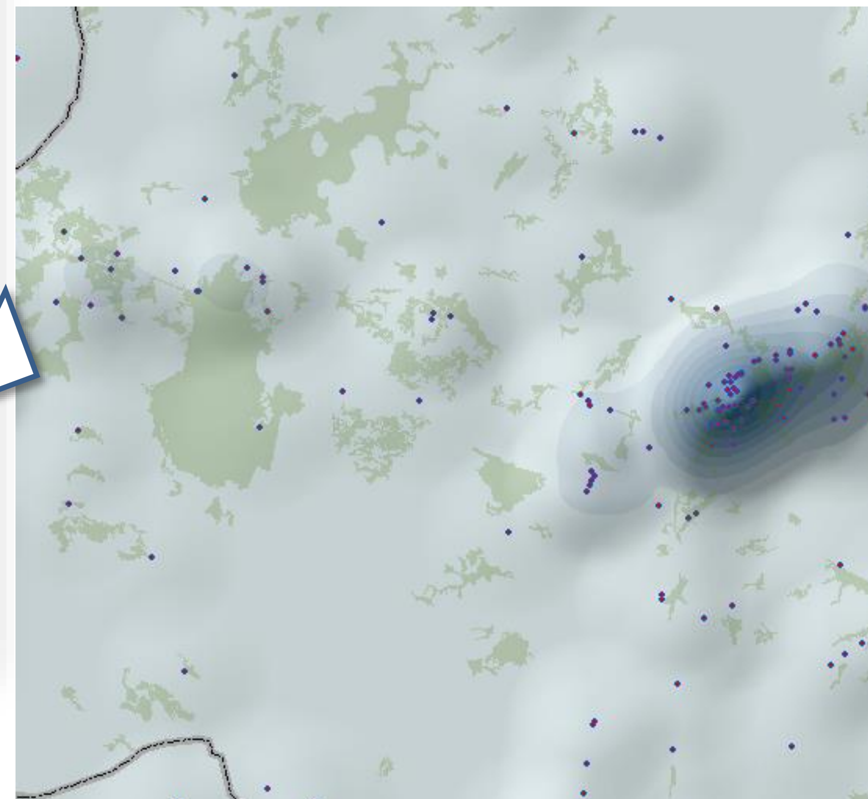


3. Density of Human Conflict Points



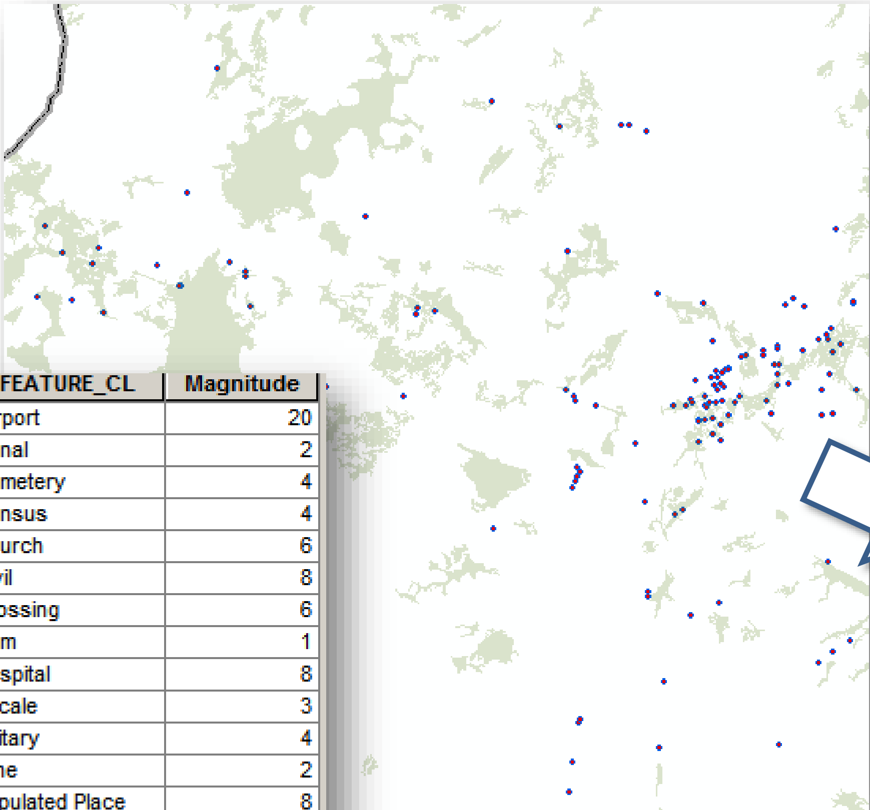


- <u>Kernel density</u>:
  Influence of points w/in 5km

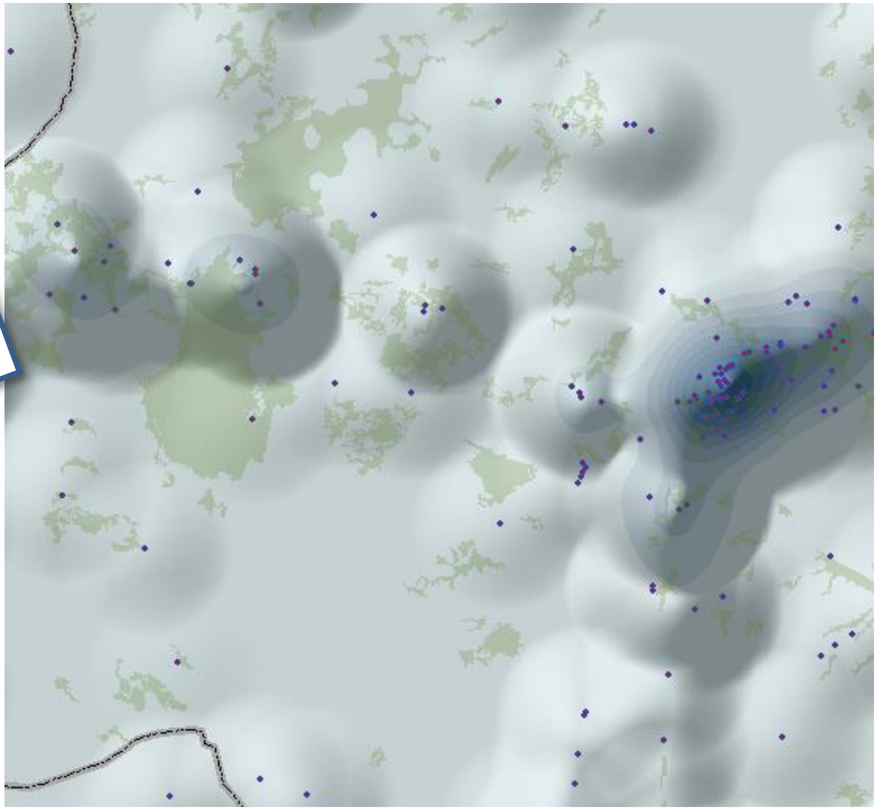


3. Density of Human Conflict Points

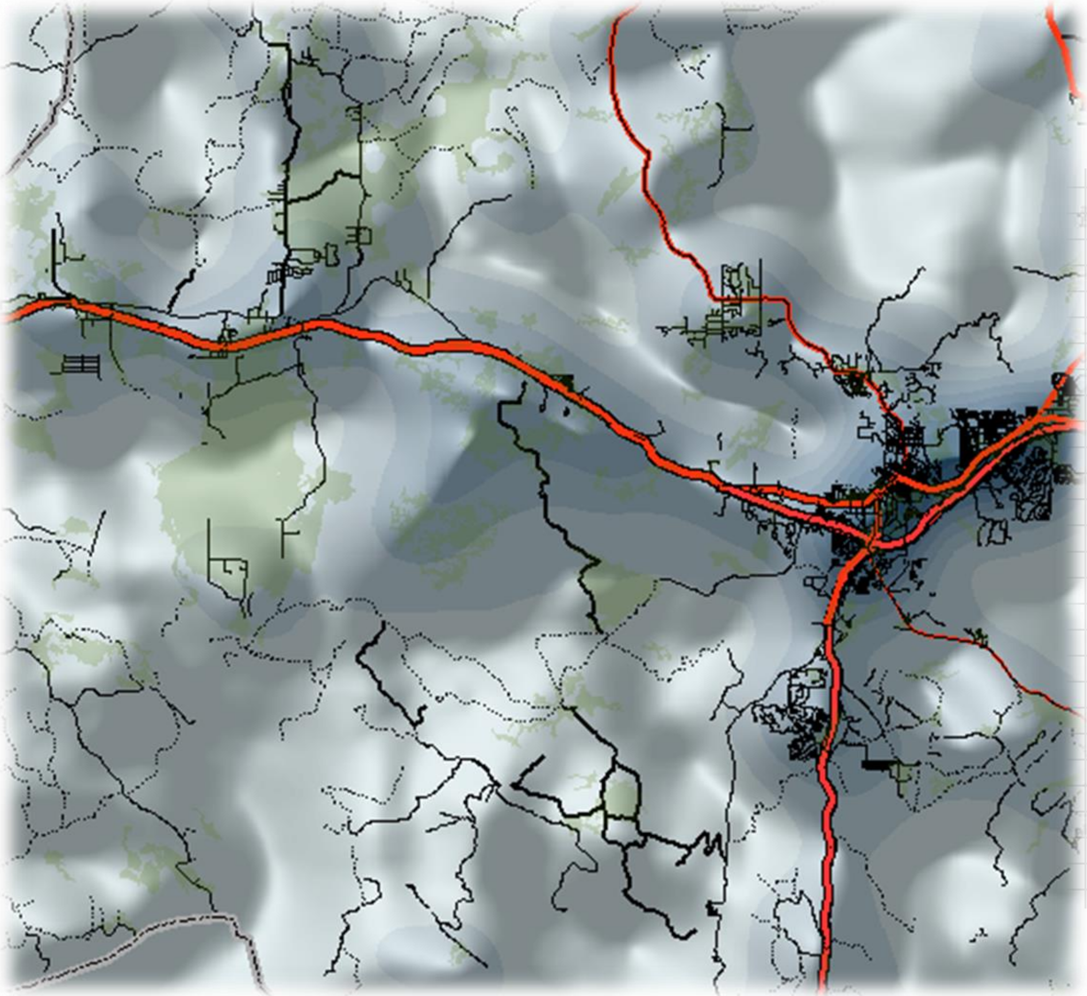
- *Weighted* Kernel density: *Influence* of points w/in 5km

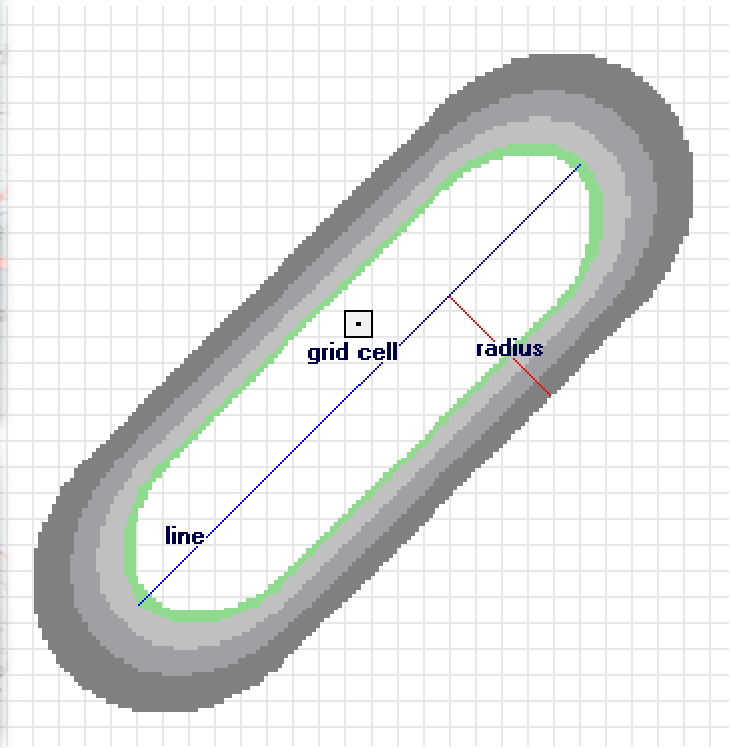


FEATURE_CL	Magnitude
Airport	20
Canal	2
Cemetery	4
Census	4
Church	6
Civil	8
Crossing	6
Dam	1
Hospital	8
Locale	3
Military	4
Mine	2
Populated Place	8
Post Office	6
School	6
Tower	2
Well	1



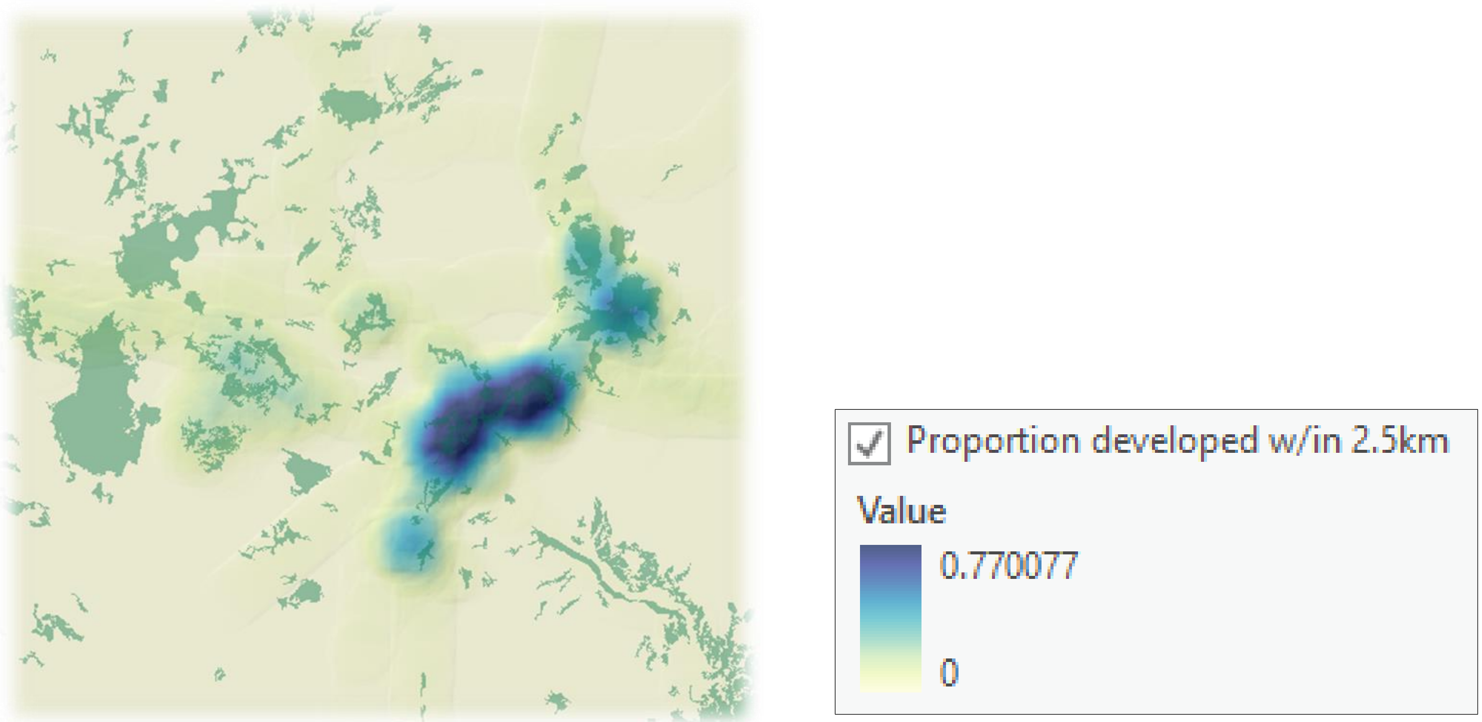
4. Road kernel density





5. Focal density of development

- How much development within 2.5 km of a pixel?
  - Create binary map of development
  - Calculate focal mean w/2.5km radius

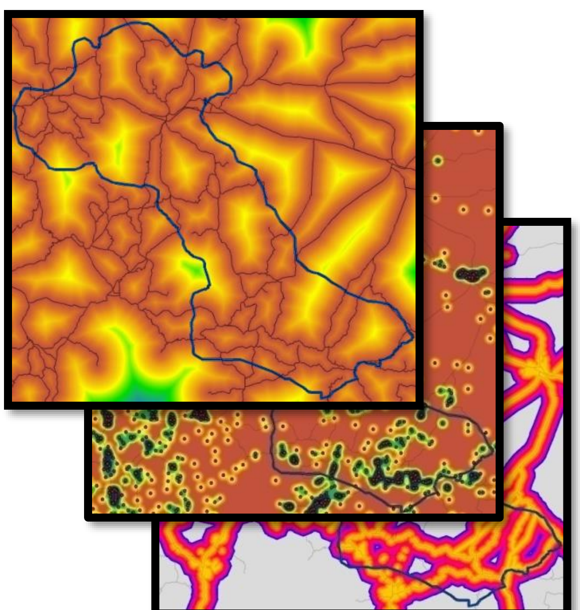


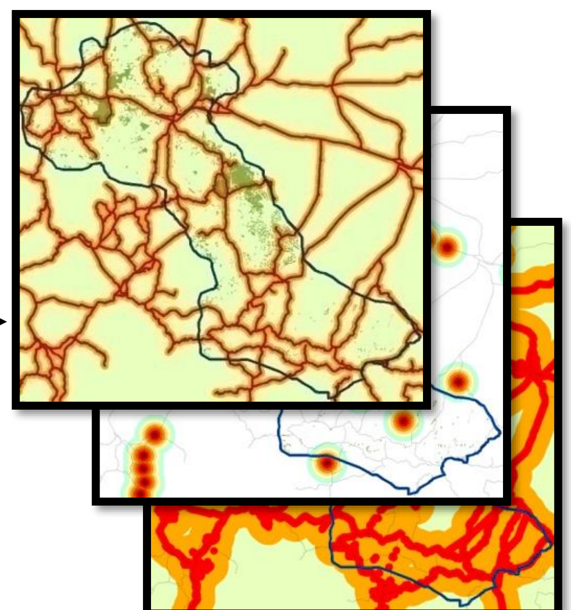
Synthesizing results: Threat maps

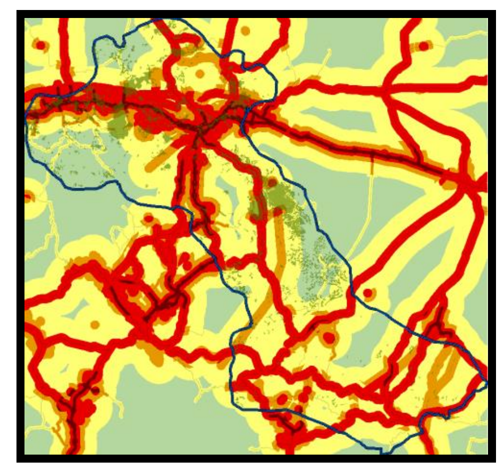
Continuous single threat maps

Categorical single threat maps

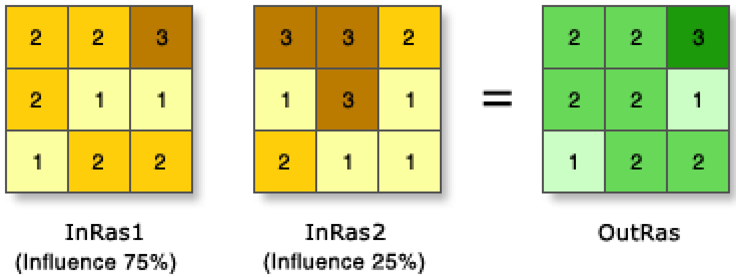
Weighted overlay threat maps

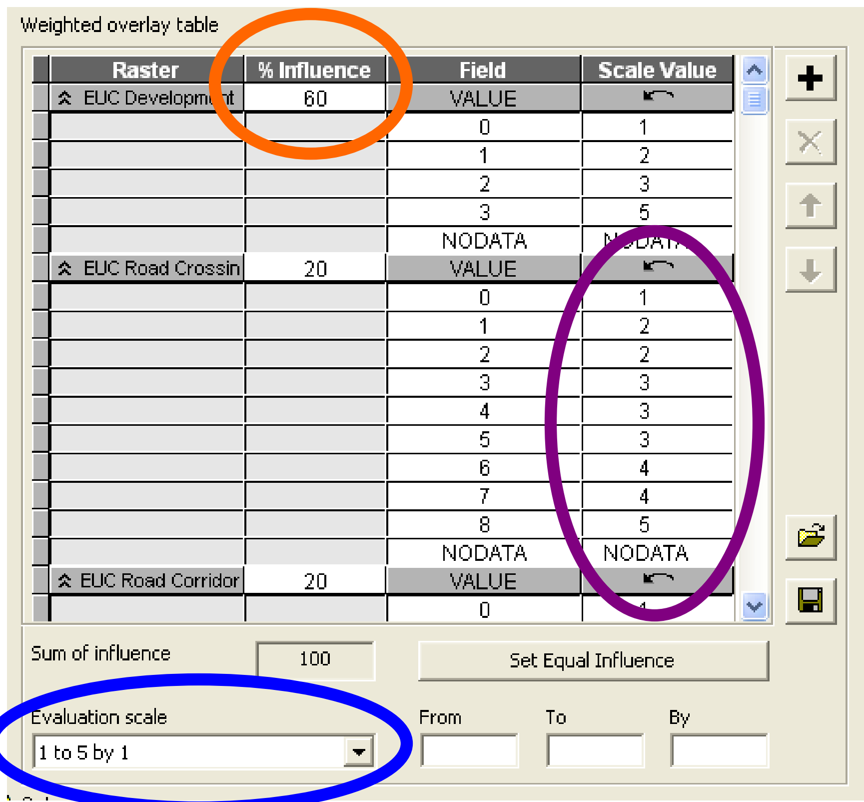






Synthesizing results: Threat maps





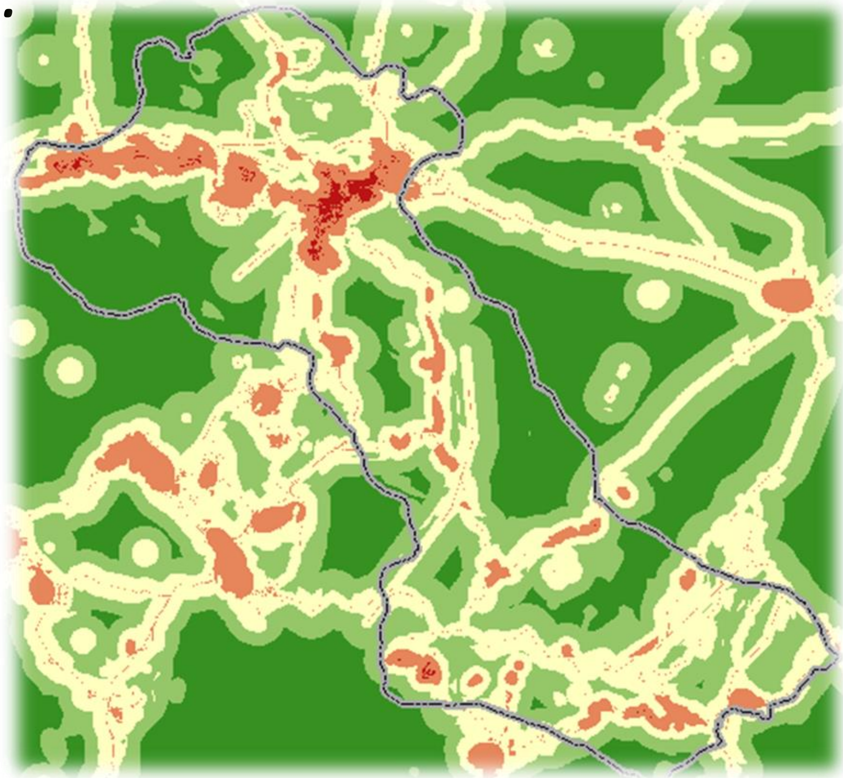
- Number of output classes
- % influence of each input
  - Development = 3x others
- Scale values
  - Extreme impact = 5
  - Minimal impact = 1

Synthesizing results: Weighted overlay

Objective:

- *Combine threat from GNIS points, road density, and proximity to developed areas into a single threat map of 5 levels (1=lowest threat; 5=highest threat).*

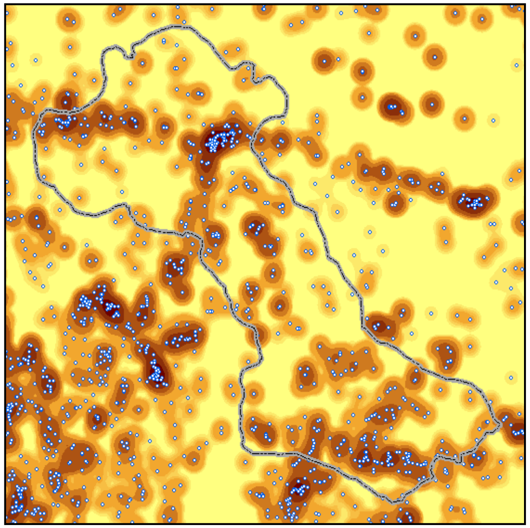
  - *Threat from proximity to development is 3x more potent than threats from other two sources.*



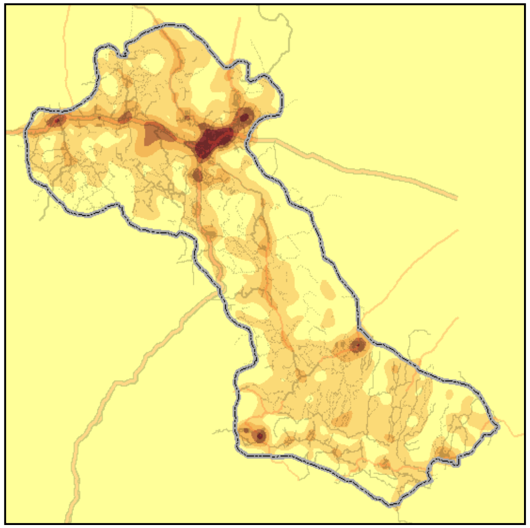
Synthesizing results: Weighted overlay

- *<u>Step 1</u>: Reclassify continuous layers into a manageable number of classes*

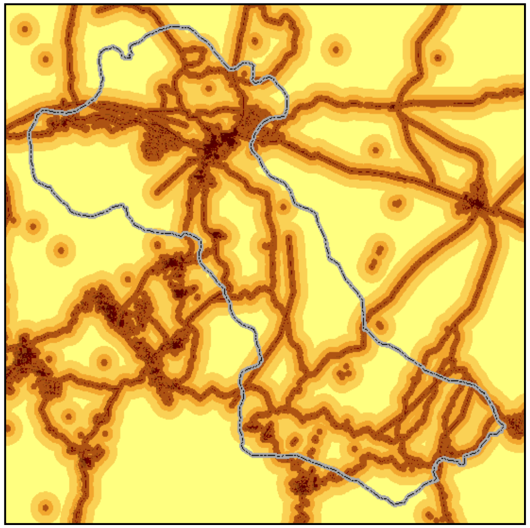
Low – Least threat
High – Highest threat



Conflict point density
9 classes



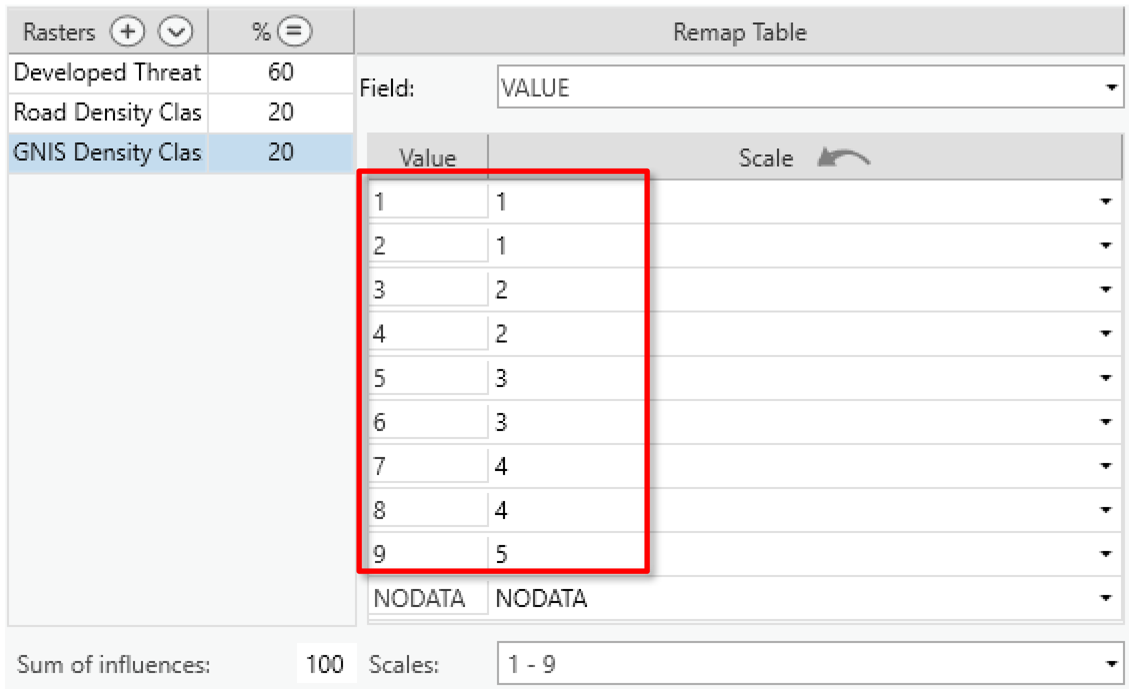
Road density
5 classes



Proximity to developed
5 classes
3x importance

Synthesizing results: Weighted overlay

- *<u>Step 2</u>: Rescale class values into number of threat classes desired (in our case 5)*

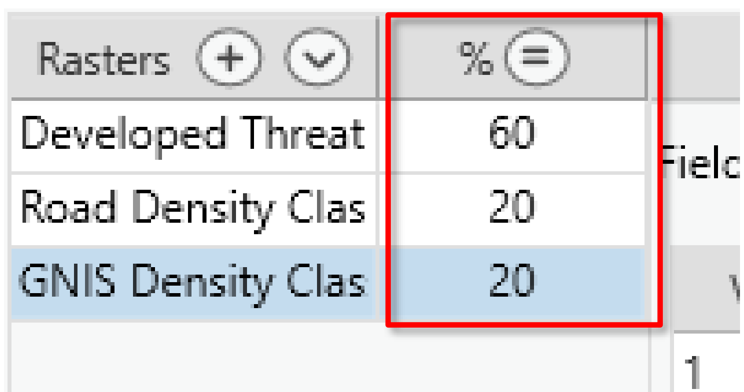


Rescaling 9 GNIS classes into 5; done in Weighted Overlay tool

Synthesizing results: Weighted overlay

- *<u>Step 3</u>: Assign relative weighting for each threat component*

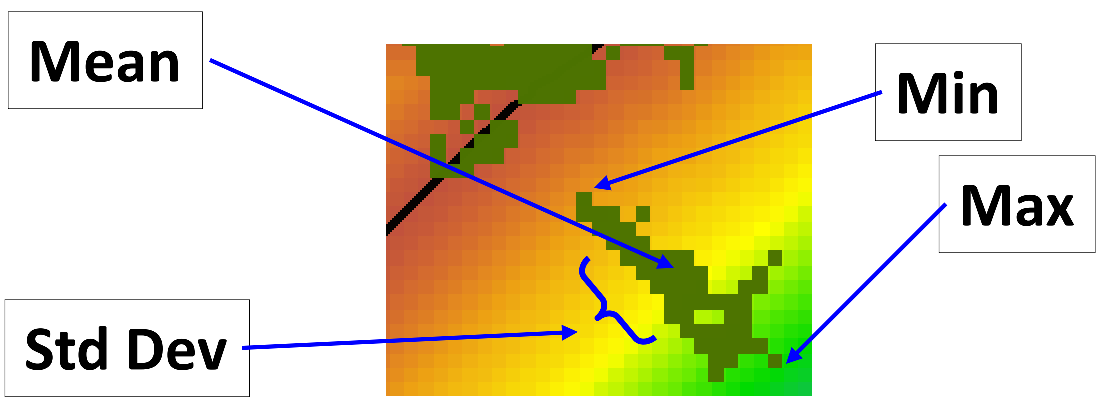
Weightings must add to 100



Synthesizing results: Patch attribution

Zonal statistics on:

- Euclidean distance from developed
- Decayed distance from transmission lines
- Kernel density of GNIS points
- Cost distance from developed



Attributes of ZS_KDensGNIS

PATCH ID	MIN	MAX	MEAN	STD
1	0	0	0	0
2	0	0.021114	0.007935	0.005717
3	0.001513	0.050003	0.026541	0.012387
4	0.013418	0.057084	0.032146	0.011155
5	0.005603	0.022057	0.014979	0.00522
6	0.029427	0.049639	0.038795	0.006463

Record: 0 Show: All

Summary

- Threat mapping is not (yet?) an exact science…
- Many ways of representing threats…
- Many ways of combining threats…
- Assumptions are necessary, but…
  - Be clear & transparent about them
  - Be aware of their implications
  - Enable users to modify them