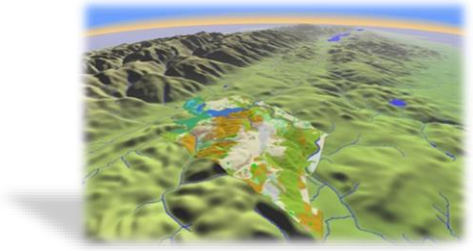
NICHOLAS SCHOOL OF THE ENVIRONMENT AND EARTH SCIENCES
DUKE UNIVERSITY



ENVIRON 761:
Threat Mapping

Instructor: John Fay

Review…

- *Threats* as yet another attribute for prioritization…
- Describe threats in terms of **scope** and **severity**…
- Address threat's **source** or the **stress** they cause…
  - Sources (root causes) can be quite complex…
  - Stresses can vary by conservation target…

WWF Threat ranking example

WWF for a living planet®

Step 1.4 Threat Ranking

DIRECT THREAT	TARGET: Sharks					TARGET: Coral Reefs					TARGET: Intertidal Systems					TARGET: Seabirds					SITE RANKING	
	SCOPE	SEVERITY	IRREVERSIBILITY	TOTAL	CLASSIFICATION	SCOPE	SEVERITY	IRREVERSIBILITY	TOTAL	CLASSIFICATION	SCOPE	SEVERITY	IRREVERSIBILITY	TOTAL	CLASSIFICATION	SCOPE	SEVERITY	IRREVERSIBILITY	TOTAL	CLASSIFICATION	TOTAL	CLASSIFICATION
Illegal shark fishing by boats from mainland	4	3	3	17	Very High																17	High
Global warming						4	3	3	17	Very High											17	High
Diver & anchor damage						1	2	1	7	Low											7	Low
Legal but unsustainable fishing by local fishermen						3	3	3	15	High	3	2	3	13	Medium						28	Very High
Sewage											1	1	1	5	Low						5	Low
Potential oil spills											1	2	2	8	Low	2	3	2	12	Medium	20	High
Introduced predators (rats)																2	3	2	12	Medium	12	Medium

Note: Total = 2(scope + severity) + Irreversibility*

Threat ranking & GIS

What role does spatial analysis play?

- Threat identification
- Estimating threat scope/extent
- Estimating threat severity
- Combining and ranking threats

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

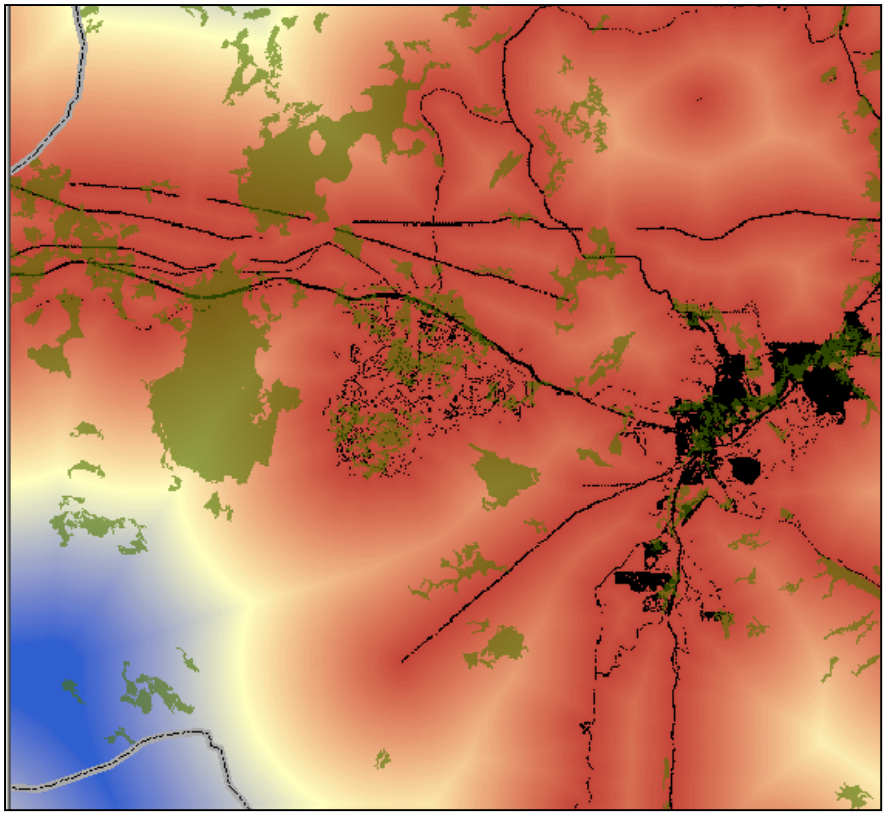
- 2011 NLCD → Developed areas…
- Geog. Names Information System (GNIS) → Human conflict points
- TIGER Transmission lines
- TIGER Roads

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

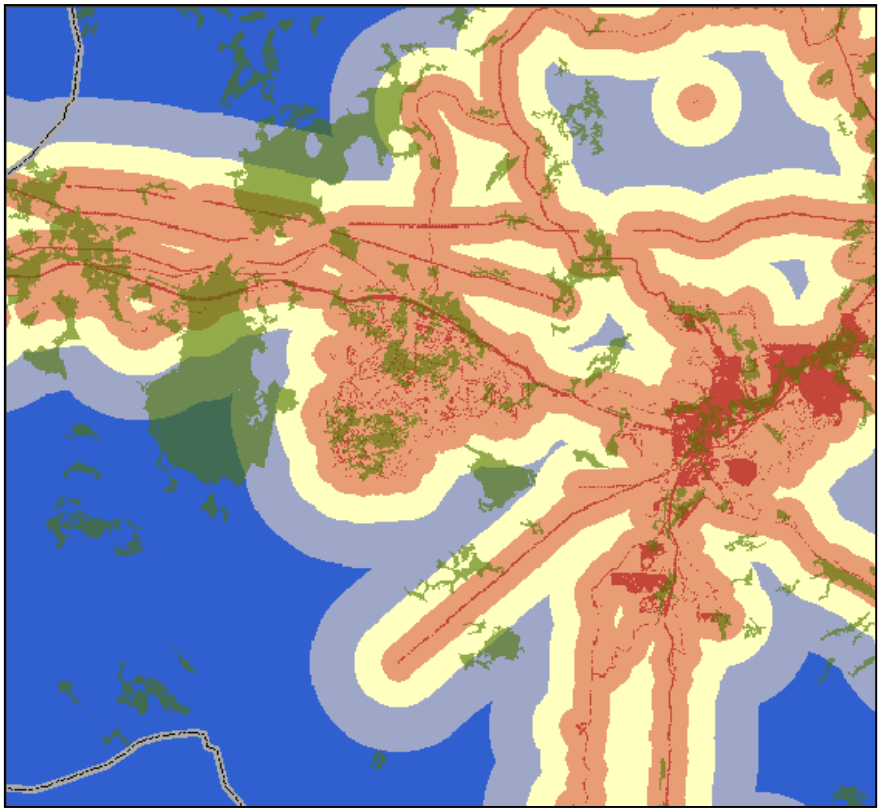


Distance to Development

Value

High

Low



Threat class

4: Developed area

3: < 1km from devloped

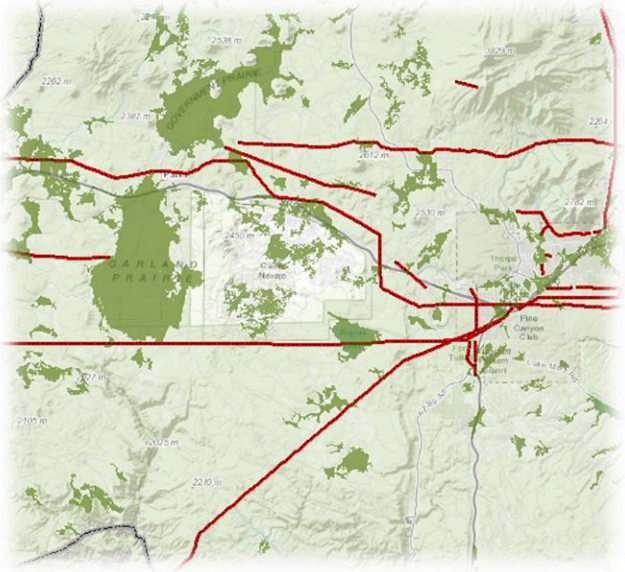
2: 1-2.5km

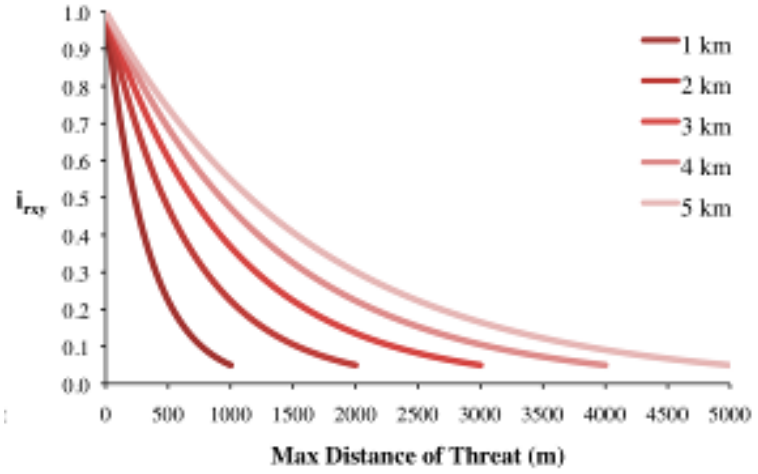
1: 2.5-5.0km

0: > 5km from developed

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

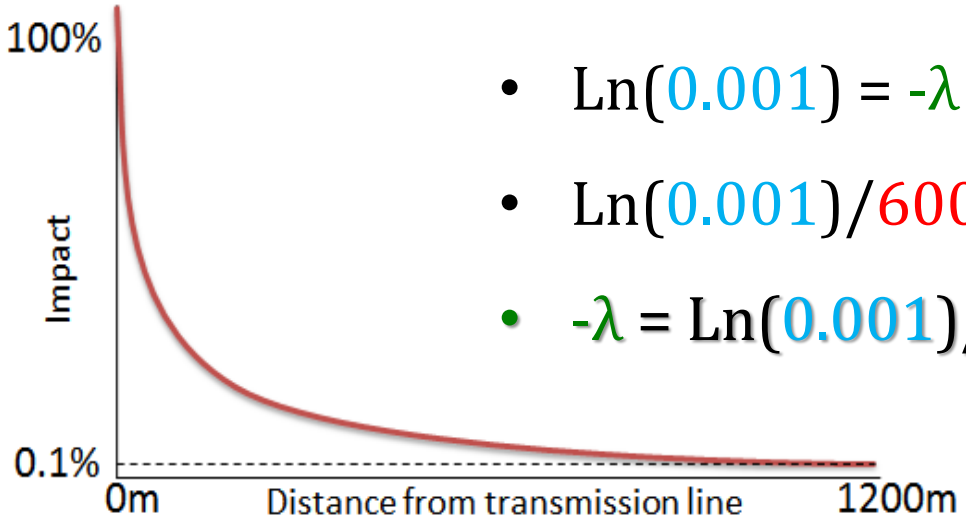
At 6000 meters away, the impacts are negligible (about 0.1% of original strength)."

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

Exponential decay function

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

Solve for λ…



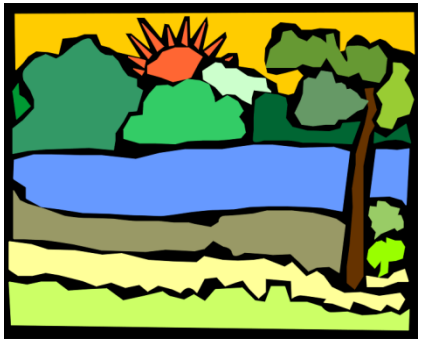
2. Exponential distance to power lines

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

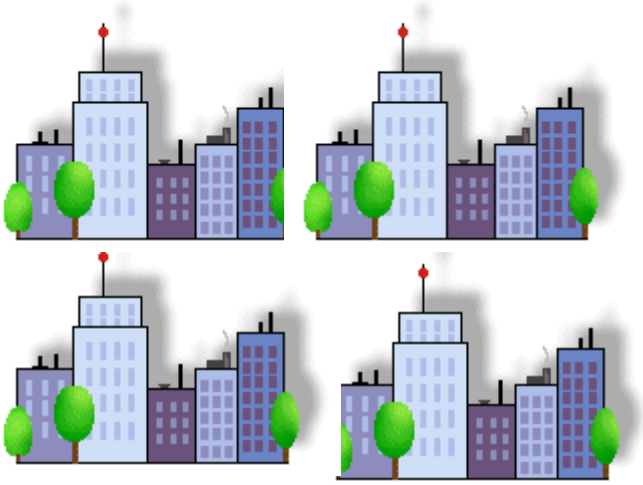
$$N(t) = N_0 e^{-\lambda t}$$

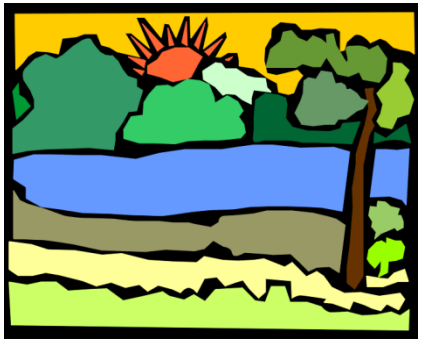
Decayed Impact Raster = Exp**(-0.001151293** * *Euclidean Distance Raster***)**

Threat density analysis



Vs.

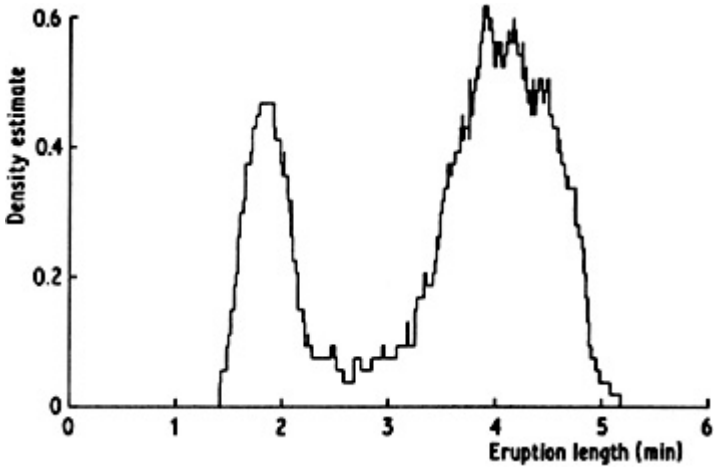




Threat density analysis

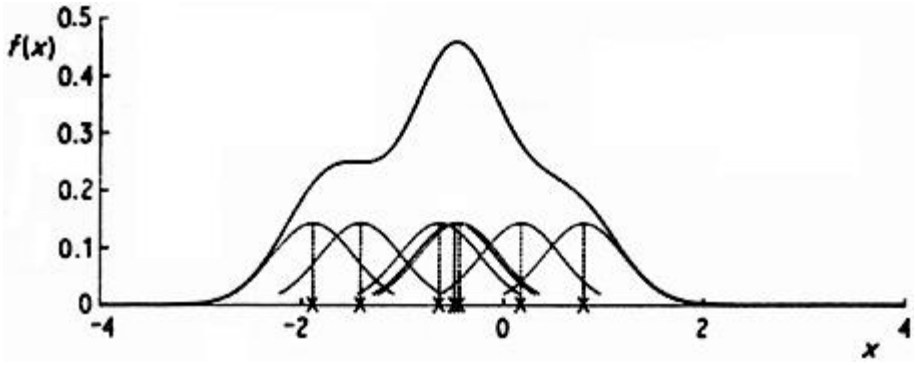
Point distance

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



Kernel distance

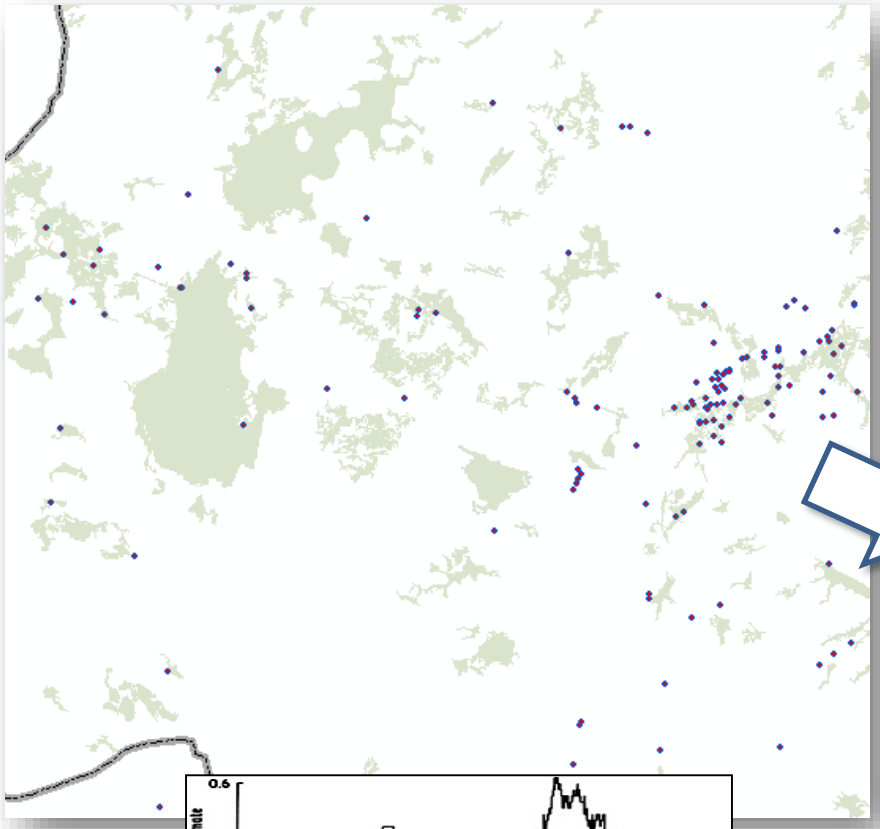
Uses a distribution around a point (i.e., a kernel) rather than the point itself to measure density. Result is the sum of the distributions.

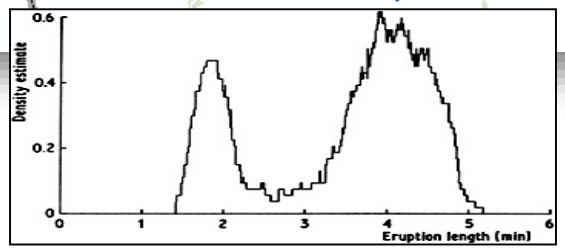


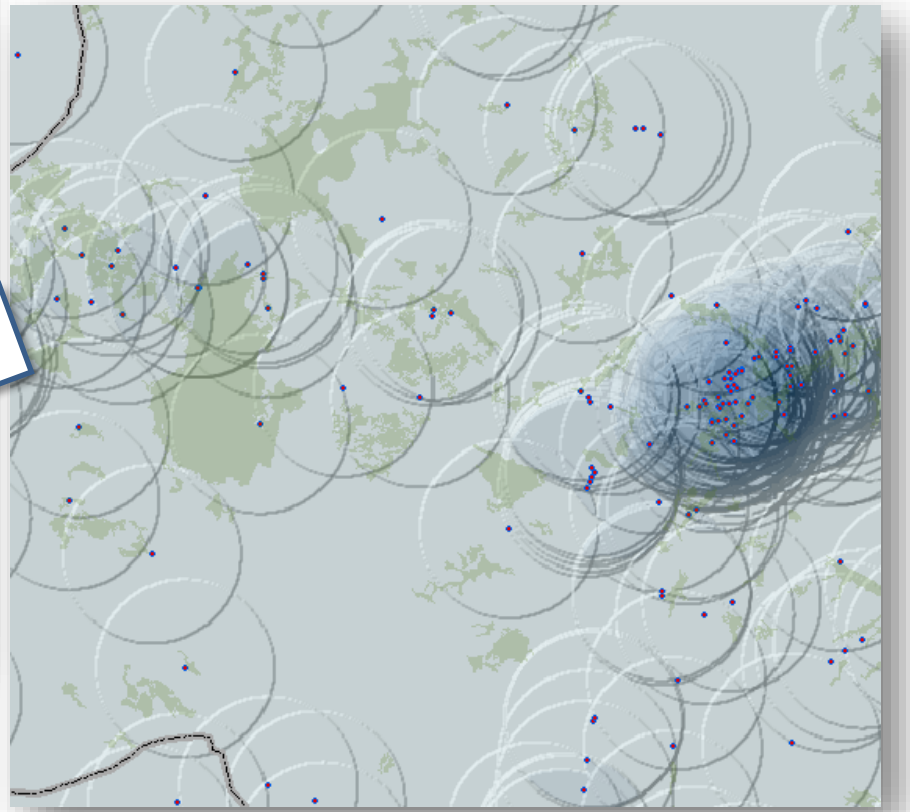
http://nedwww.ipac.caltech.edu/level5/March02/Silverman/paper.pdf

3. Density of Human Conflict Points

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

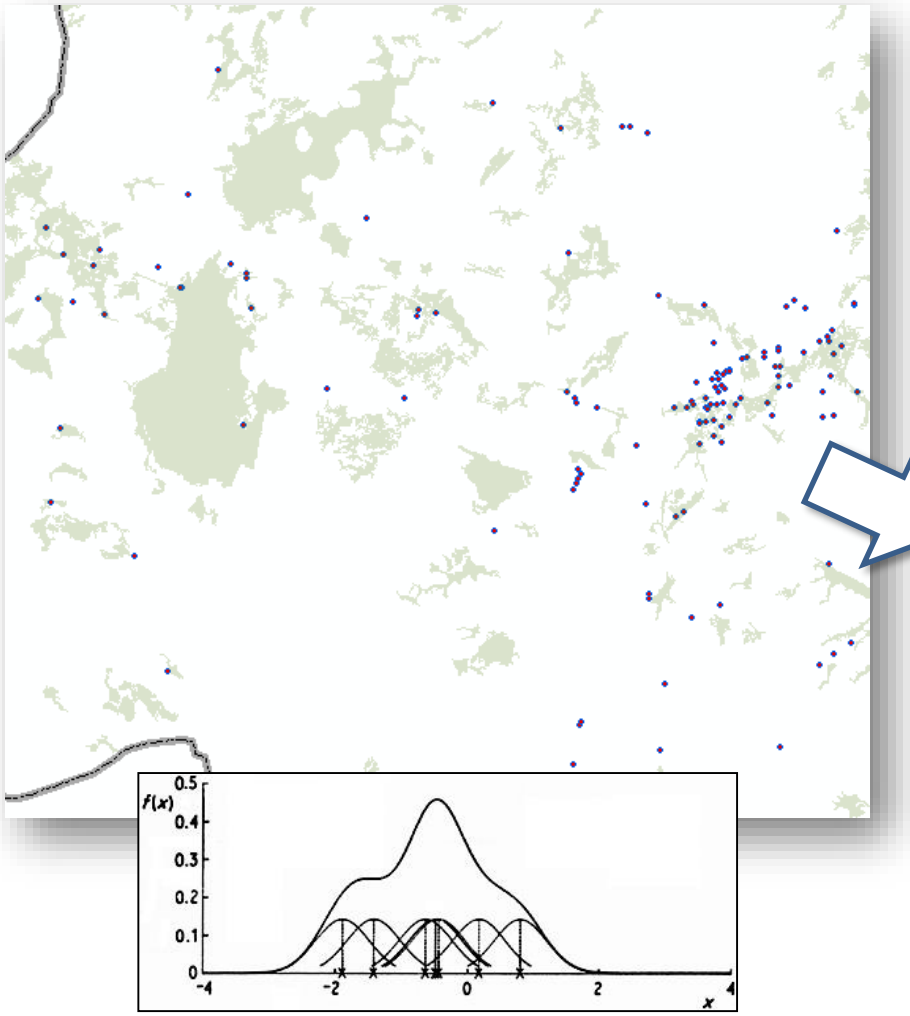


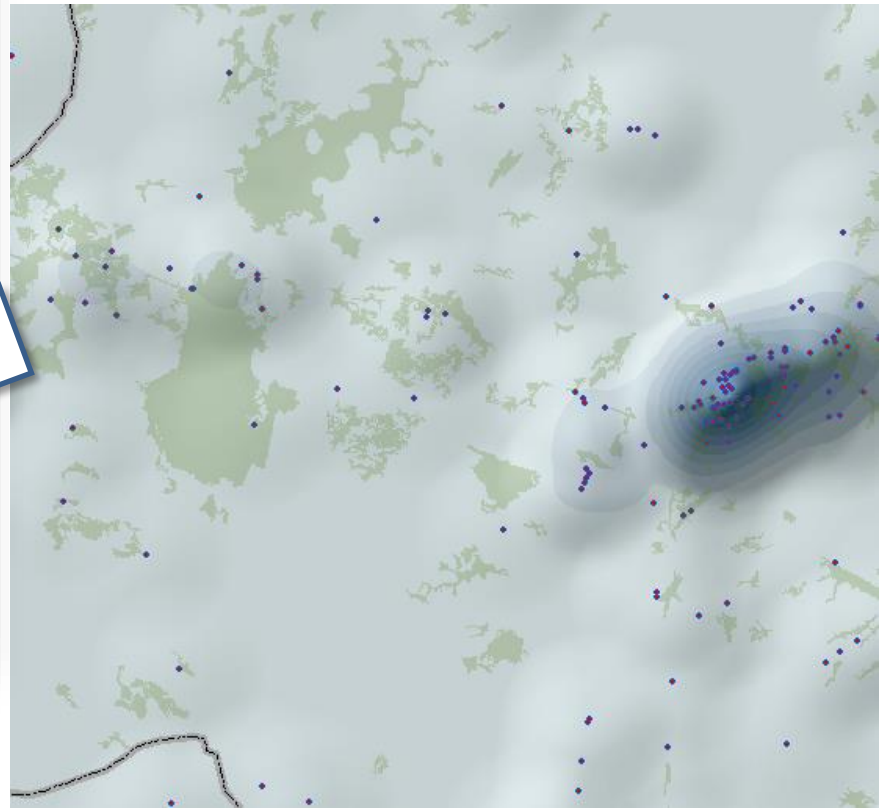




3. Density of Human Conflict Points

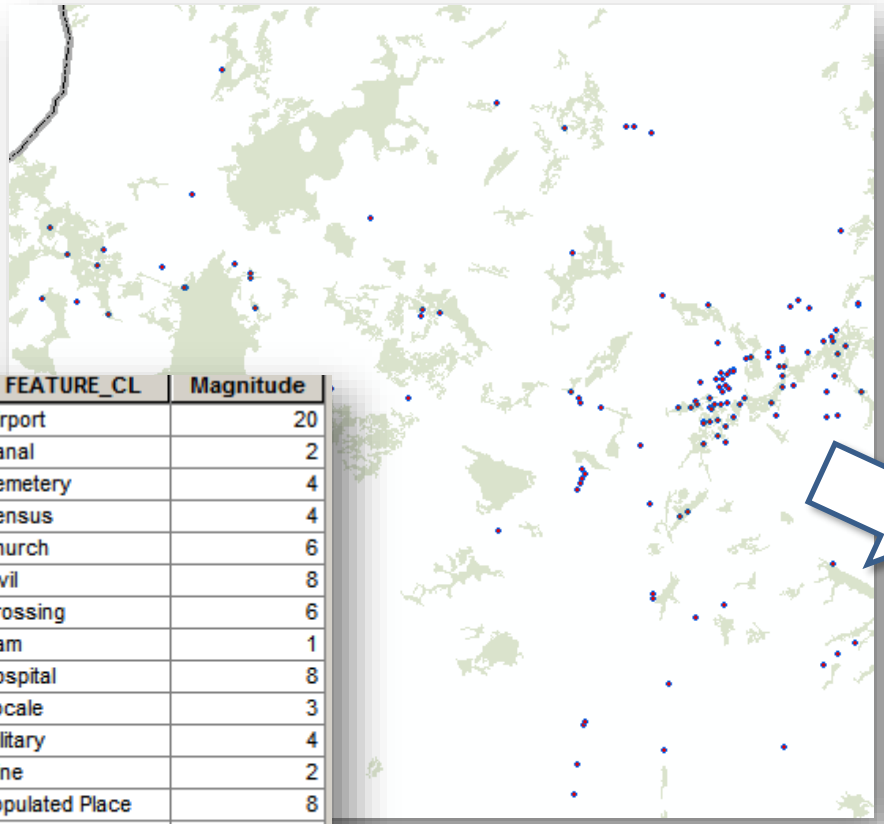
- Kernel density:
  Influence of points w/in 5km



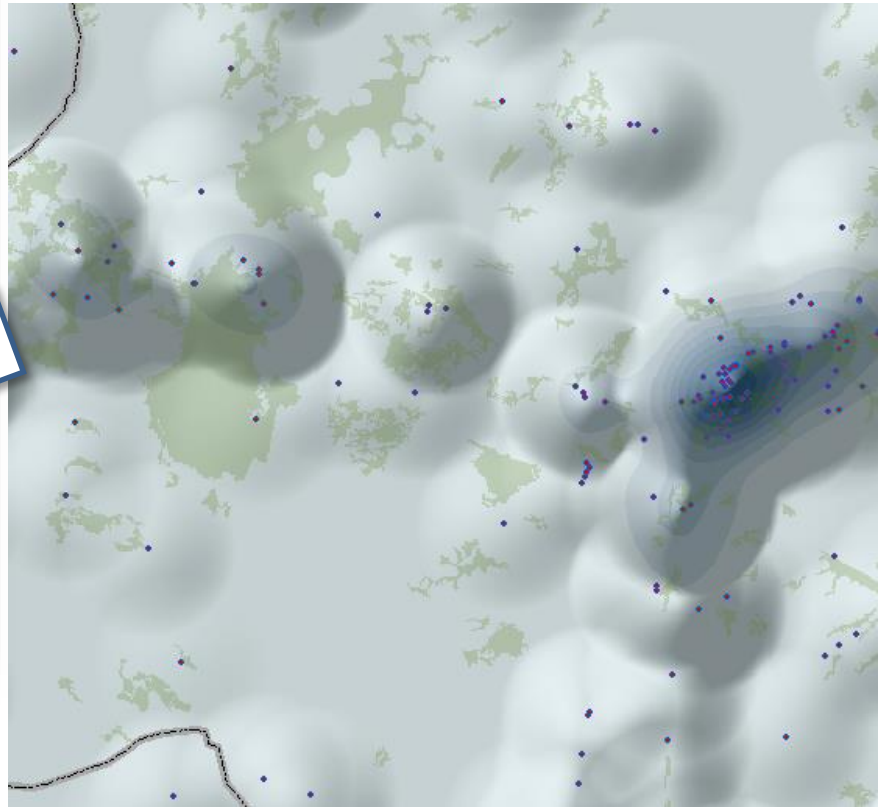


3. Density of Human Conflict Points

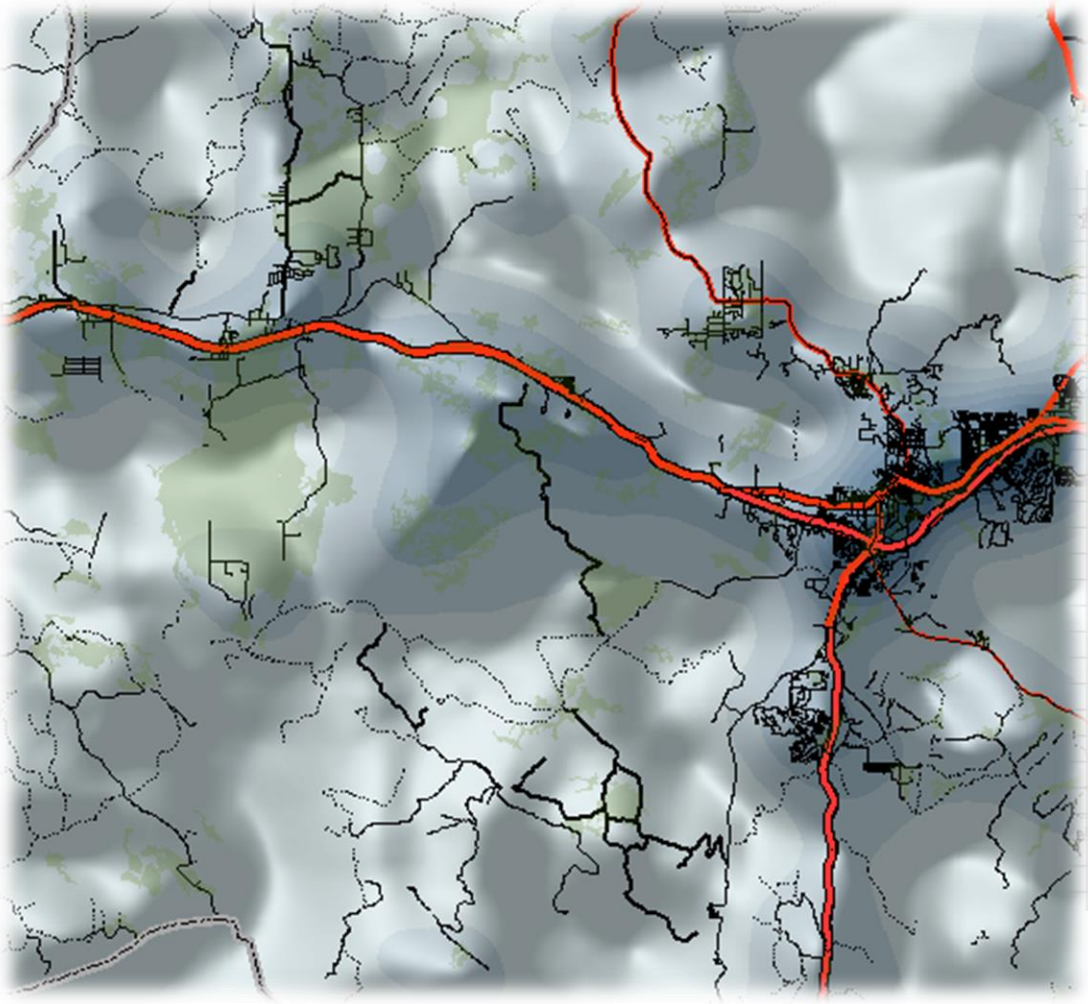
- *Weighted* Kernel density:
  Influence of points w/in 5km

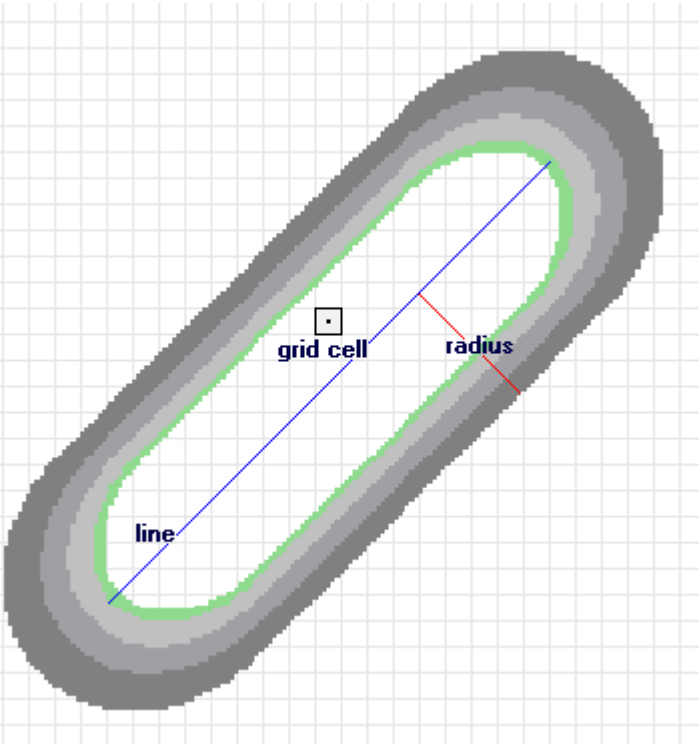


FEATURE_CL	Magnitude
Airport	20
Canal	2
Cemetery	4
Census	4
Church	6
Civil	8
Crossing	6
Dam	1
Hospital	8
Locale	3
Military	4
Mine	2
Populated Place	8
Post Office	6
School	6
Tower	2
Well	1



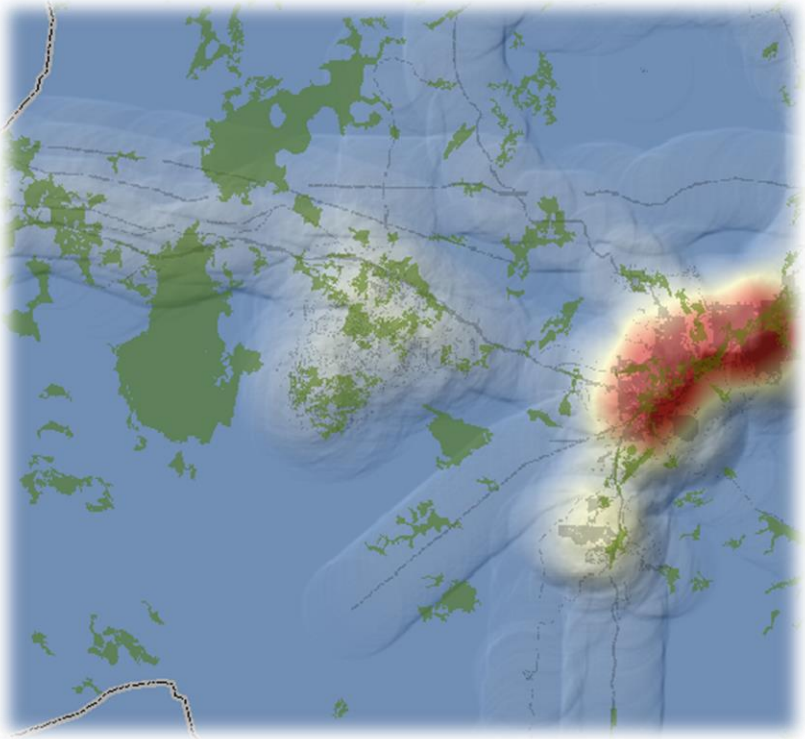
4. Road kernel density





5. Focal density of development

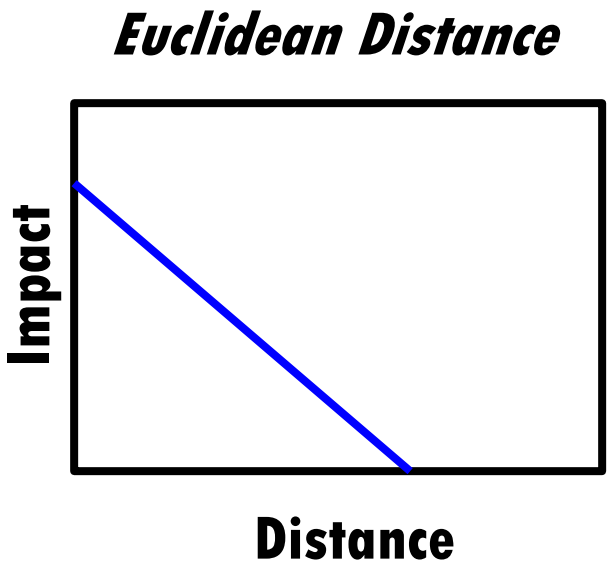
- How much development within 3 km of a pixel?
  - Create binary map of development
  - Calculate focal mean w/3km radius

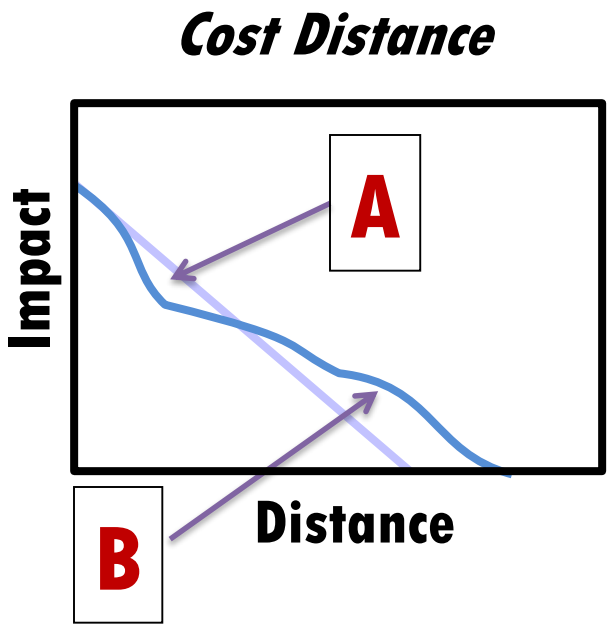


Cost distance approaches

Proximity/Density isn't always the whole story…

Cost distance approaches



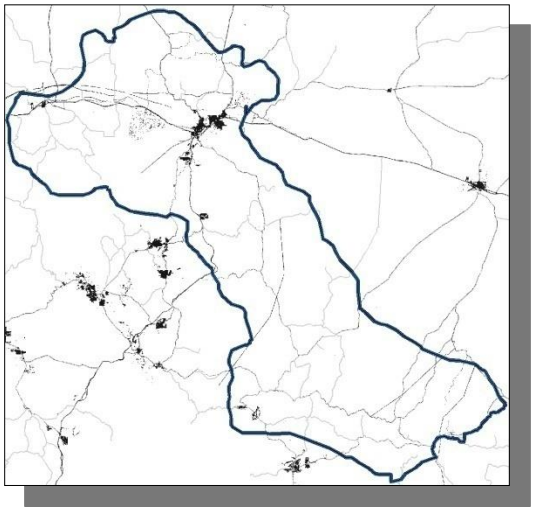


A Extent of threat is dampened by resisting factors (e.g. water)

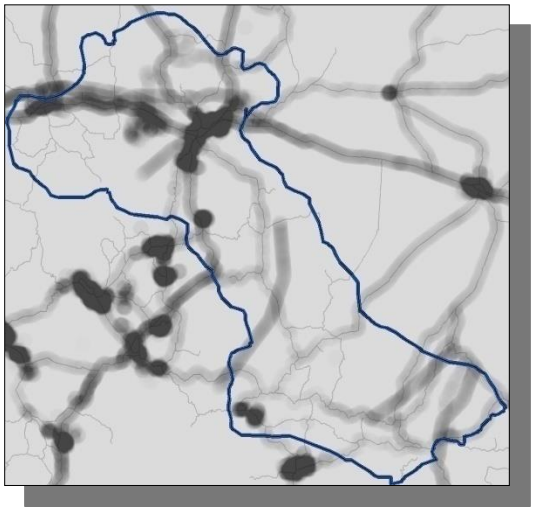
B Extent of threat is increased by enhancing factors (e.g. roads)

Cost distance approaches

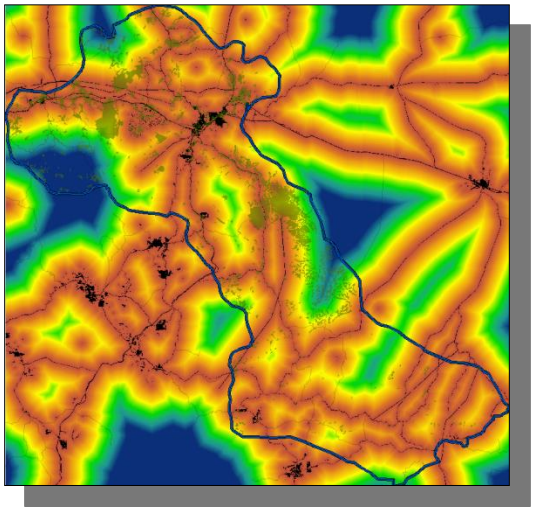
Development more likely in areas with more existing development…



Threat source:
Developed areas



Cost surface:
(1 - Density of Dev.)



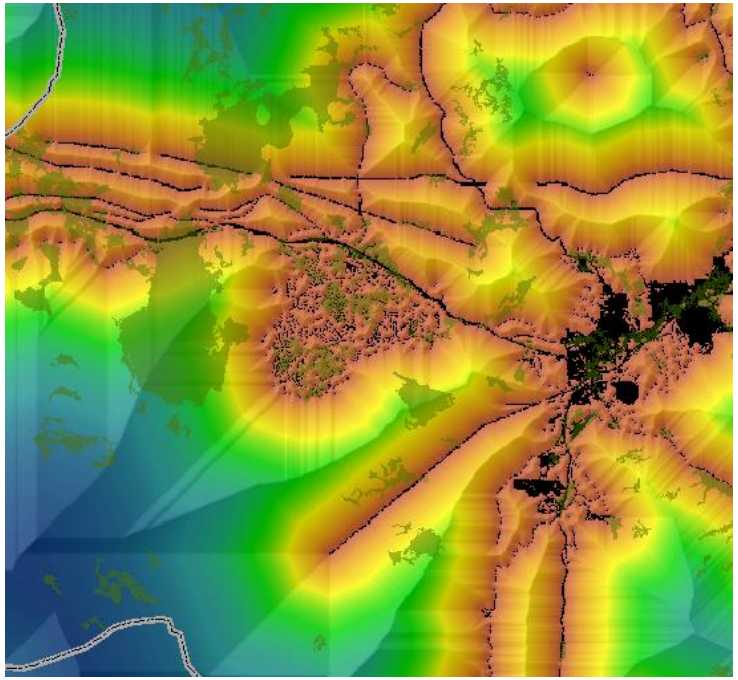
Cost distance:
Variable threat extent

Alter function to alter relationship

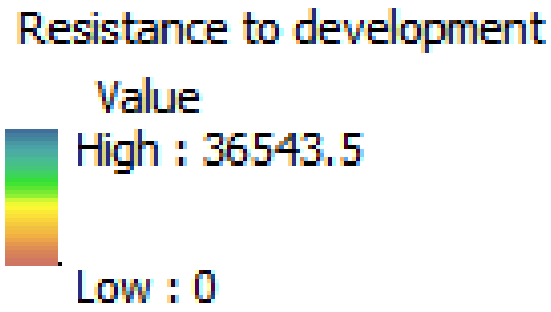
Cost is higher in areas with less development, so development doesn't extend as outward…

Cost distance approaches

- Invert focal density of developed (1 – [Focal Mean])
- Calculate cost distance from developed, using the inverted focal density as the cost raster



- Low values = likely development
- High values = less likely



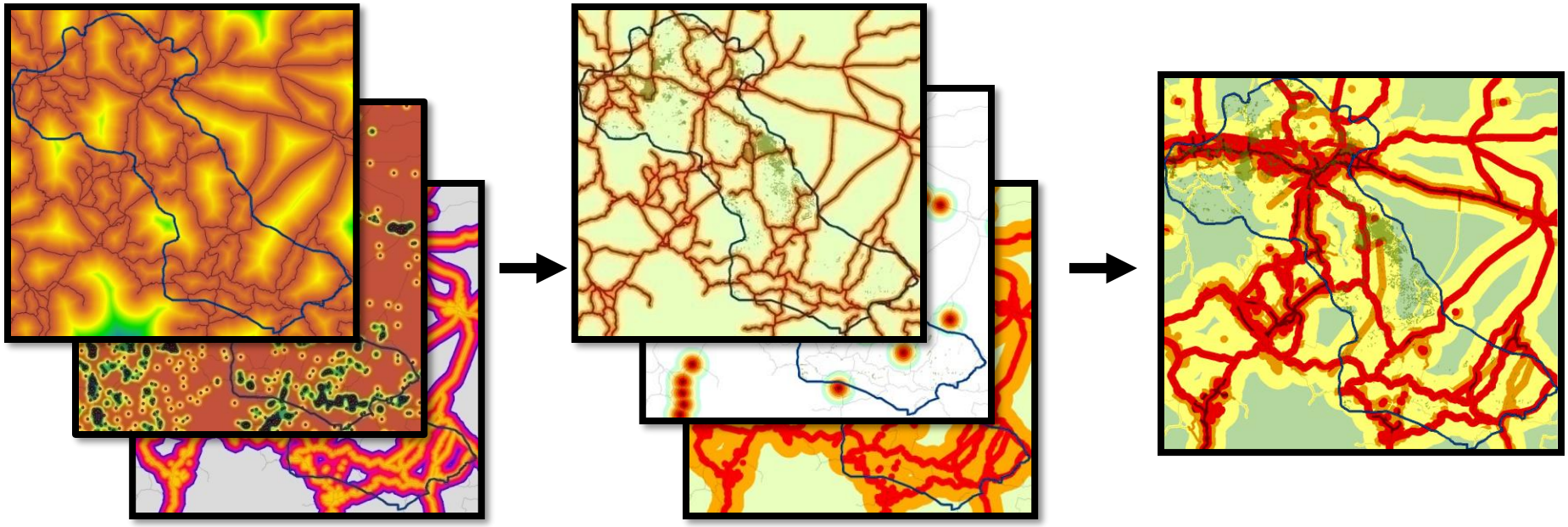
Show as stretched using “Histogram Equalize

Synthesizing results: Threat maps

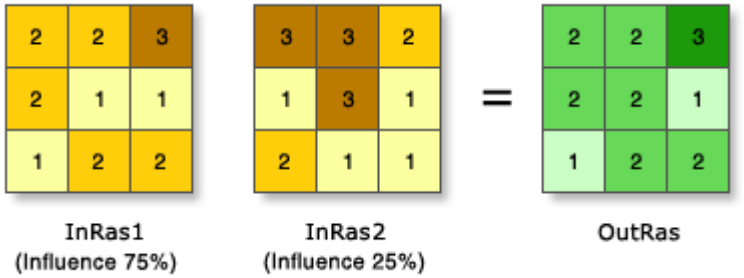
Continuous single threat maps

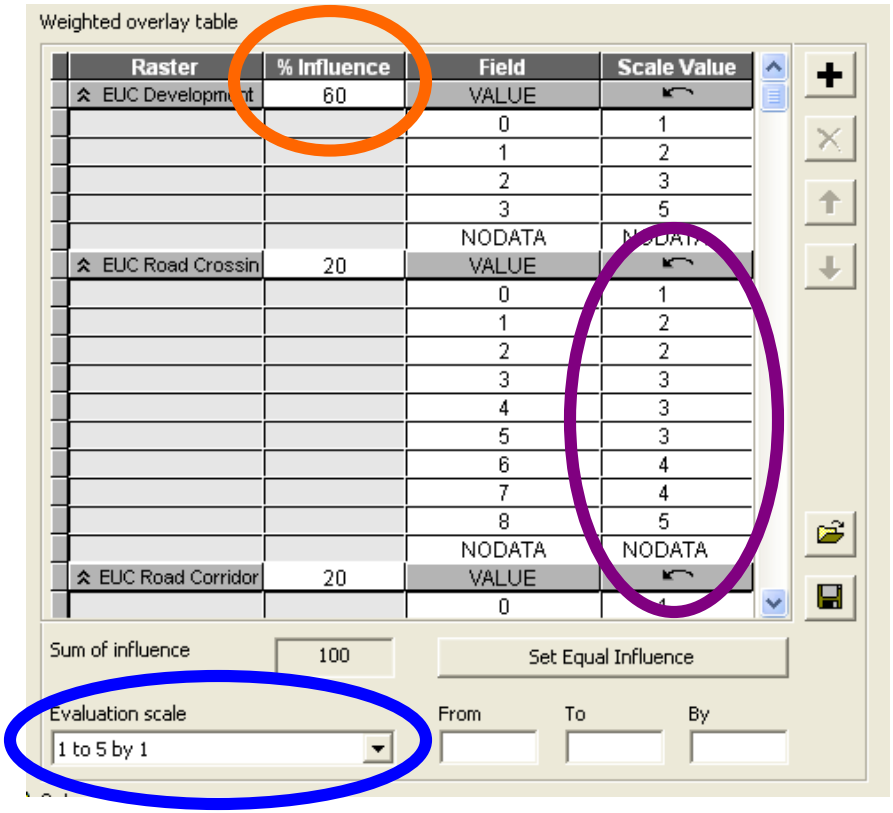
Categorical single threat maps

Weighted overlay threat maps



Synthesizing results: Threat maps





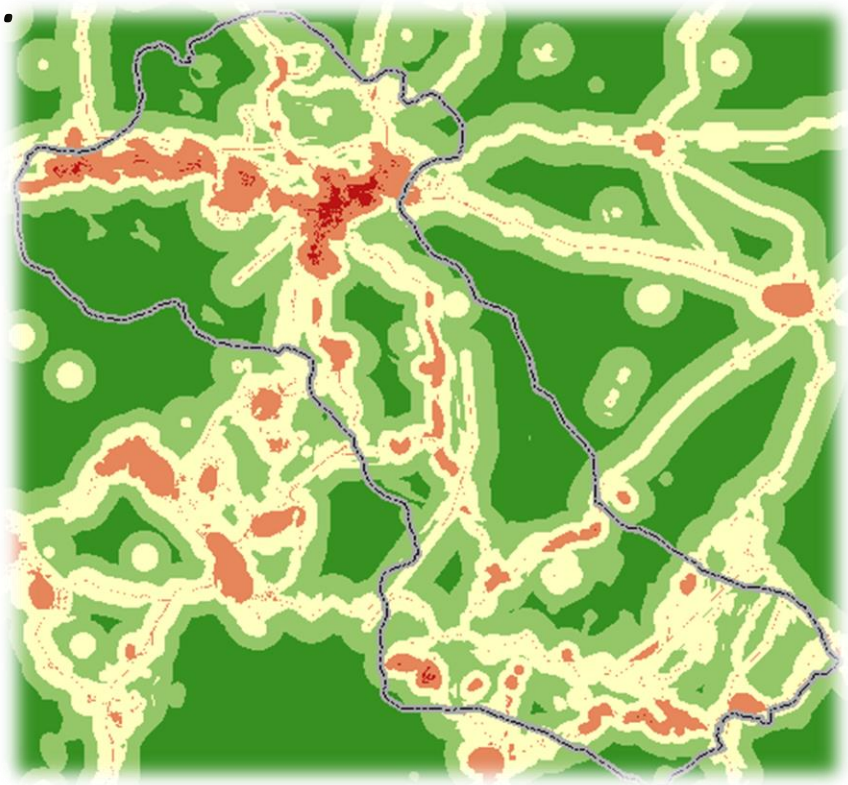
- Number of output classes
- % influence of each input
  - Development = 3x others
- Scale values
  - Extreme impact = 5
  - Minimal impact = 1

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.*

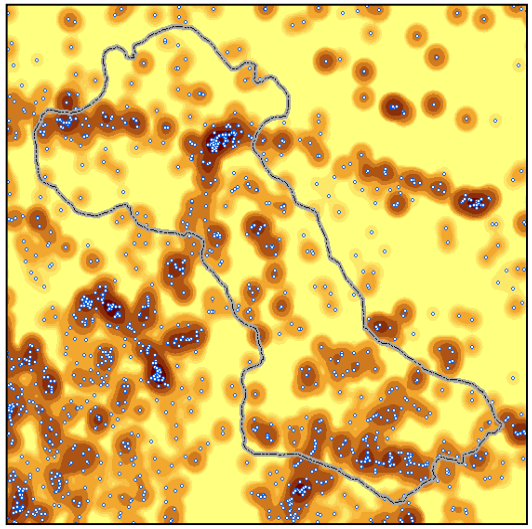


Synthesizing results: Weighted overlay

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

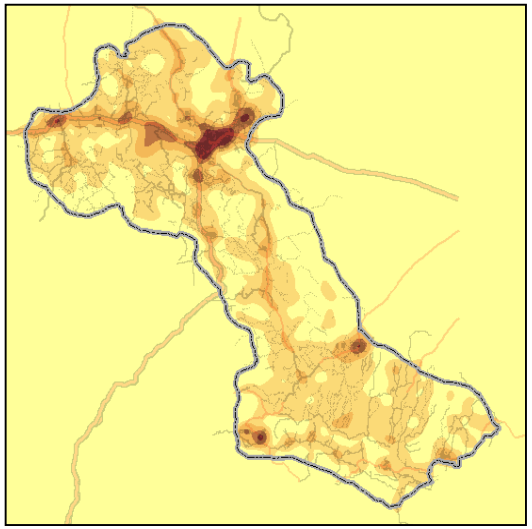
Low – Least threat

High – Highest threat



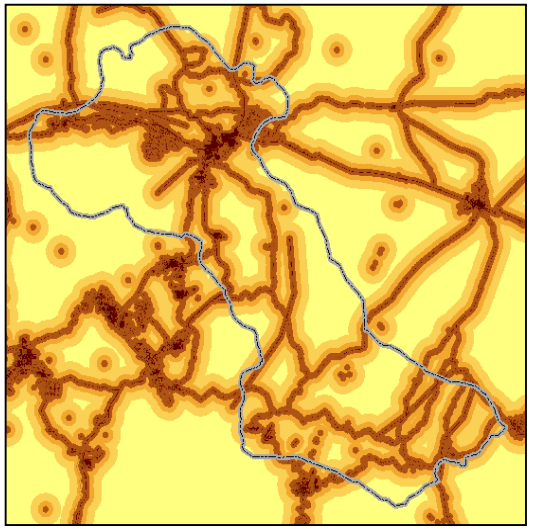
Conflict point density

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)*

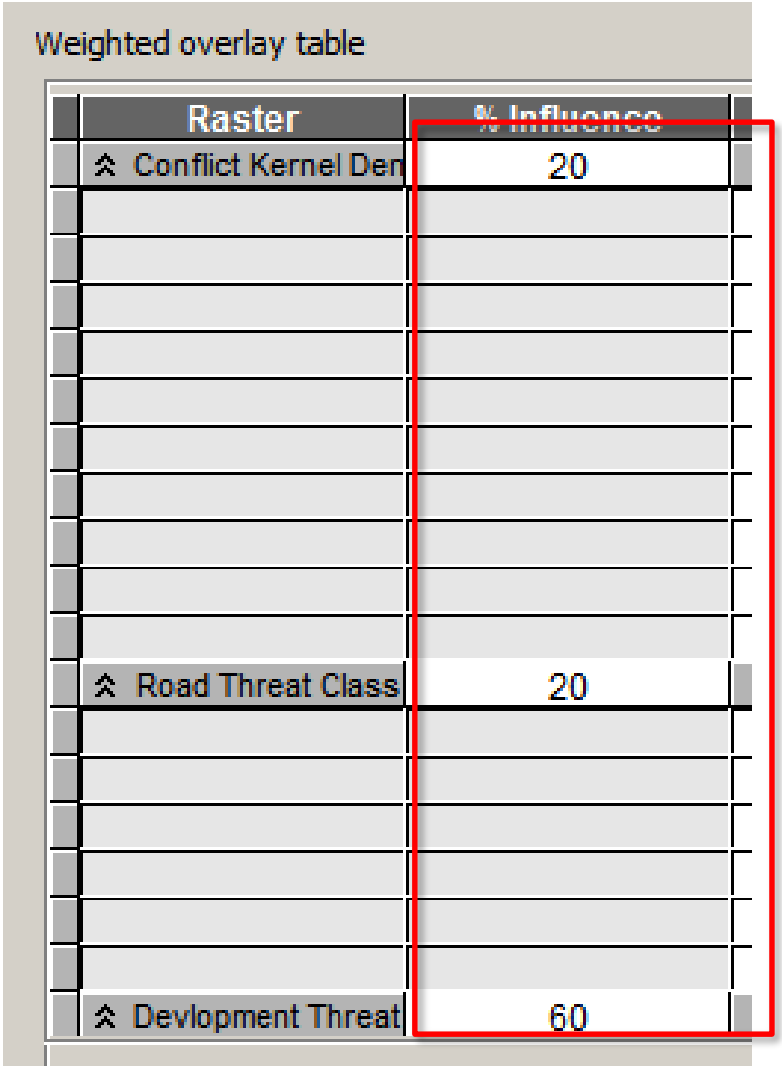
Raster	% Influence	Field	Scale Value
GNISDensityClasse	0	VALUE	
		1	1
		2	1
		3	2
		4	2
		5	3
		6	3
		7	4
		8	4
		9	5
		NODATA	NODATA
RoadDensityClass	0	VALUE	

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*

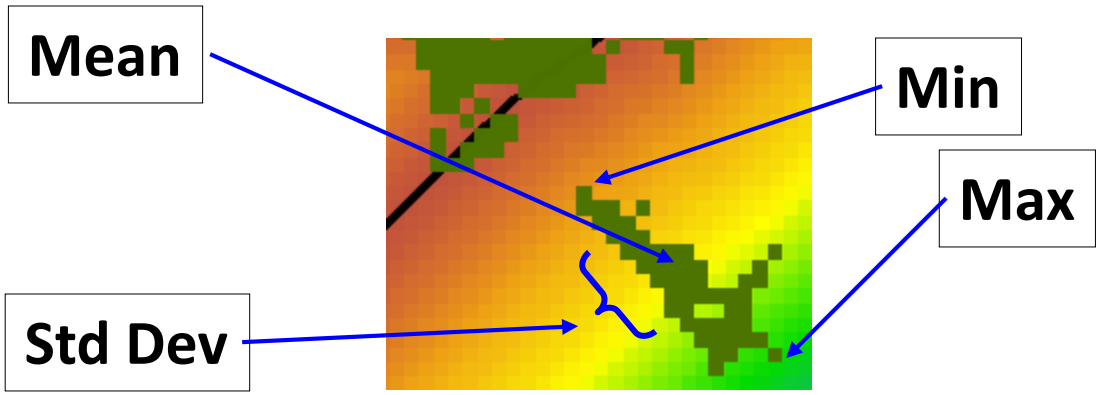
Weightings must add to 100



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