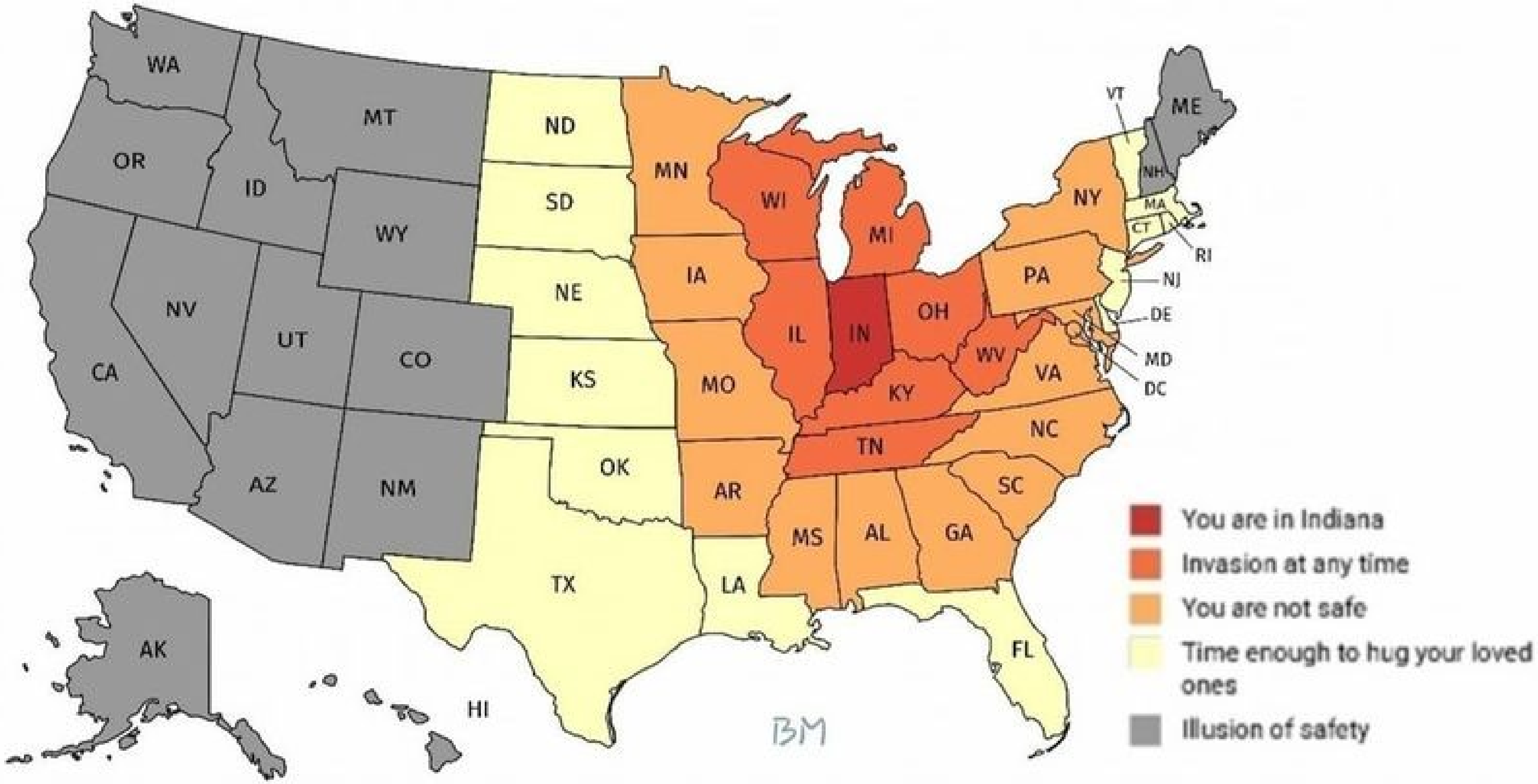
Deck 8: Raster Data And Analysis

Intro to GIS – UMass Amherst – Michael F. Nelson

Overview

- Raster Data Overview
- Revisiting data creation
- Scale

DANGER PRESENTED BY INDIANA



Final Project Poster Examples

Mapping the Changing Honeybee Insecticide Threat Landscape

Alex Low
NRC 585

Introduction:

For many plants, pollination is necessary for their growth and reproduction. Among species which perform this valuable service, Honeybees are some of the most prevalent and widely used, especially in large-scale agricultural operations. In light of their valuable pollination services, large observed declines in their populations are especially worrying. Land cover changes, agricultural intensification, parasites, and pesticide use are thought to be main drivers of this decline, though the exact extent of their impacts are yet to be determined. The purpose of this project is to determine the threat landscape posed by pesticide usage, as a way to identify areas where Honeybees may be particularly vulnerable.

Methods:

- Publicly available USDA Data used for county-level pesticide application weights from 2005 and 2010
- Application weights cross-referenced with EPA Ecotox studies of each pesticide on Honeybees to quantify the number of applied toxic doses of each substance
- Sum of applied toxic doses per county then normalized by county size and plotted using ggplot in R (Figures 2, 3)
- Measuring applied toxic doses gives a better sense of pesticide threat than just looking at application weights alone
- Observing the ratio of applied toxic doses in 2010 to 2005 shows the proportional change in insecticide threat (Figure 1)
- Graphs are displayed in a logarithmic scale to show the full breadth of distributions
- Gray counties = no data

Discussion:

- Gaps in available application data (i.e. Louisiana) could obfuscate important trends
- Limited Ecotox studies on Honeybees means that some pesticides do not have appropriate toxicity data for this study and could not be considered
- Additional study needed to determine whether toxic dose changes are the result of agricultural intensification/deintensification or use of different pesticides

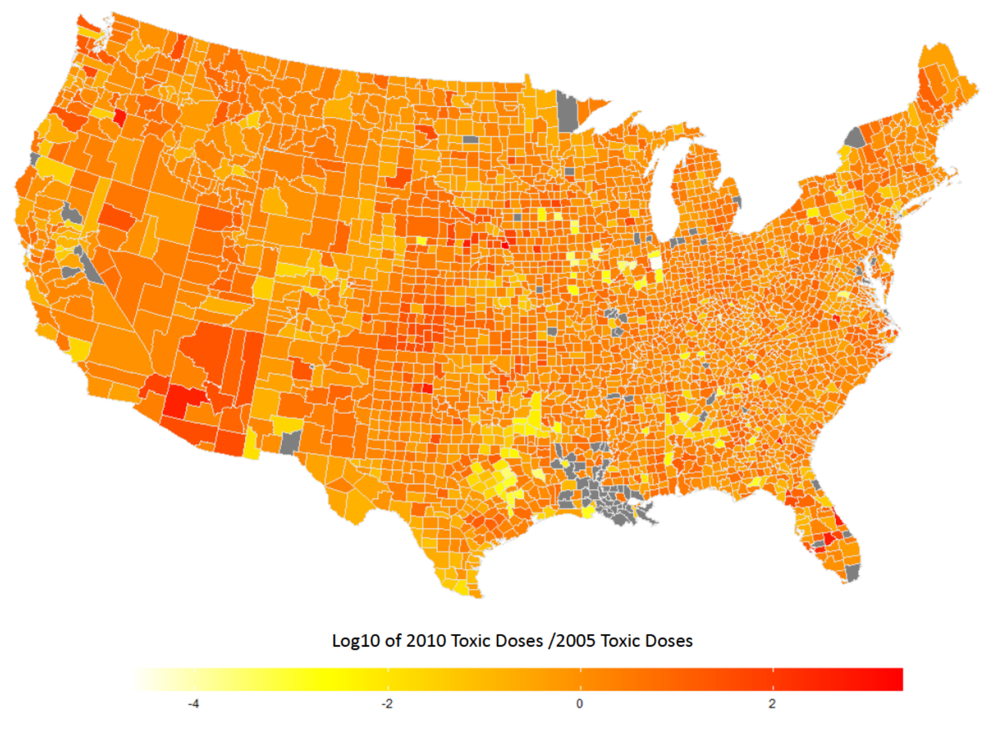


Figure 1: County-level toxic load ratio from 2005 to 2010. Each successive value represents one order-of-magnitude change.

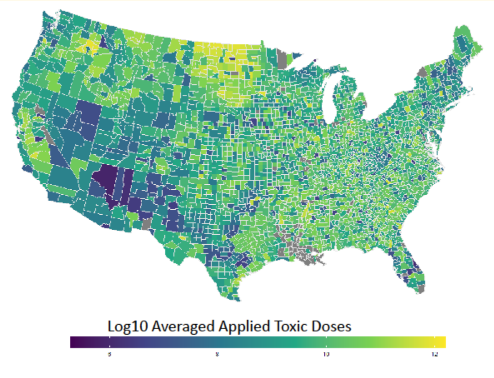


Figure 2: County-level toxic load applications, 2005. Each successive value represents one order-of-magnitude change.

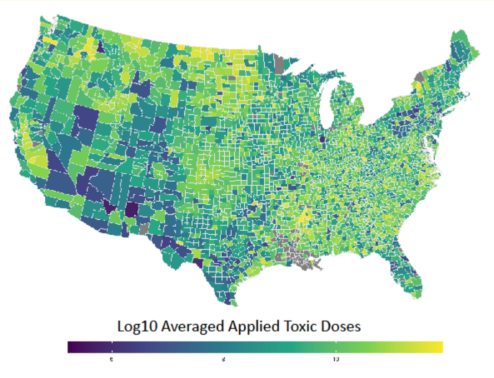


Figure 3: County-level toxic dose applications, 2010. Each successive value represents one order-of-magnitude change.

Results:

- Overall patchy distribution of toxic doses
- Comparatively high toxic doses in Pacific Northwest, North and South Dakota, Heartland, and parts of the South
- Comparatively low toxic doses in desert regions like Arizona, Nevada, and West Texas
- Heavily urbanized regions did not seem to have lower toxic dose applications than average
- Most counties stayed relatively consistent in toxic dose applications over the 5 year period
- Large toxic load increases in Arizona, Southern Florida, and select counties in the Heartlands and Pacific Northwest
- Large toxic load decreases in northeastern Texas and select parts of the South and Midwest
- Large toxic doses in North and South Dakota are especially problematic, as they are commonly used as wintering grounds for managed Honeybees
- Though the pesticide landscape has remained consistent for the most part, major changes in particular regions may call for direct preventative measures from state and county officials.

Mapping Household Income Distribution in Hampden County, Massachusetts:

Inequality and Clustering from a visual standpoint

Alvaro J. Castro Rivadeneira
NRC 585 – Intro to GIS

INTRO

- Springfield is the poorest city in Massachusetts, with over 25% of the population below the poverty line, yet it is surrounded by wealthy towns.

METHODS

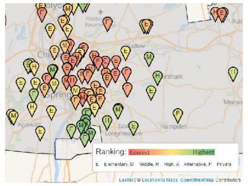
1. Data and maps were all obtained from the US Census Bureau
2. Numerical estimates were drawn from the American Community Survey 5-year estimates for 2019
3. **Data and statistical analyses were conducted with ArcMap 10.8.1**

RESULTS

- Contrast/inequality is most evident in comparing Springfield and Longmeadow – adjacent municipalities
- Longmeadow: pop. 16,000 (7% Hispanic)
- Springfield: pop: 154,000 (45% Hispanic)
- Wealthiest census tract in Longmeadow: $150,000 annual median household income, poorest census tract in Springfield: $13,000.
- Richest and poorest areas in county concentrated around urban areas

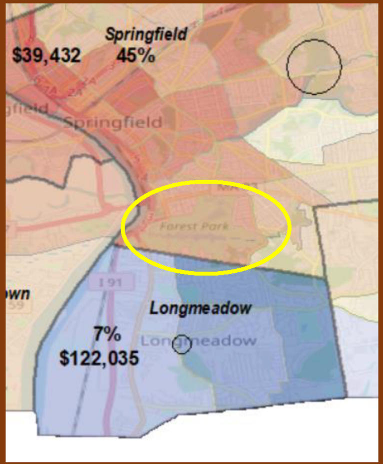
DISCUSSION

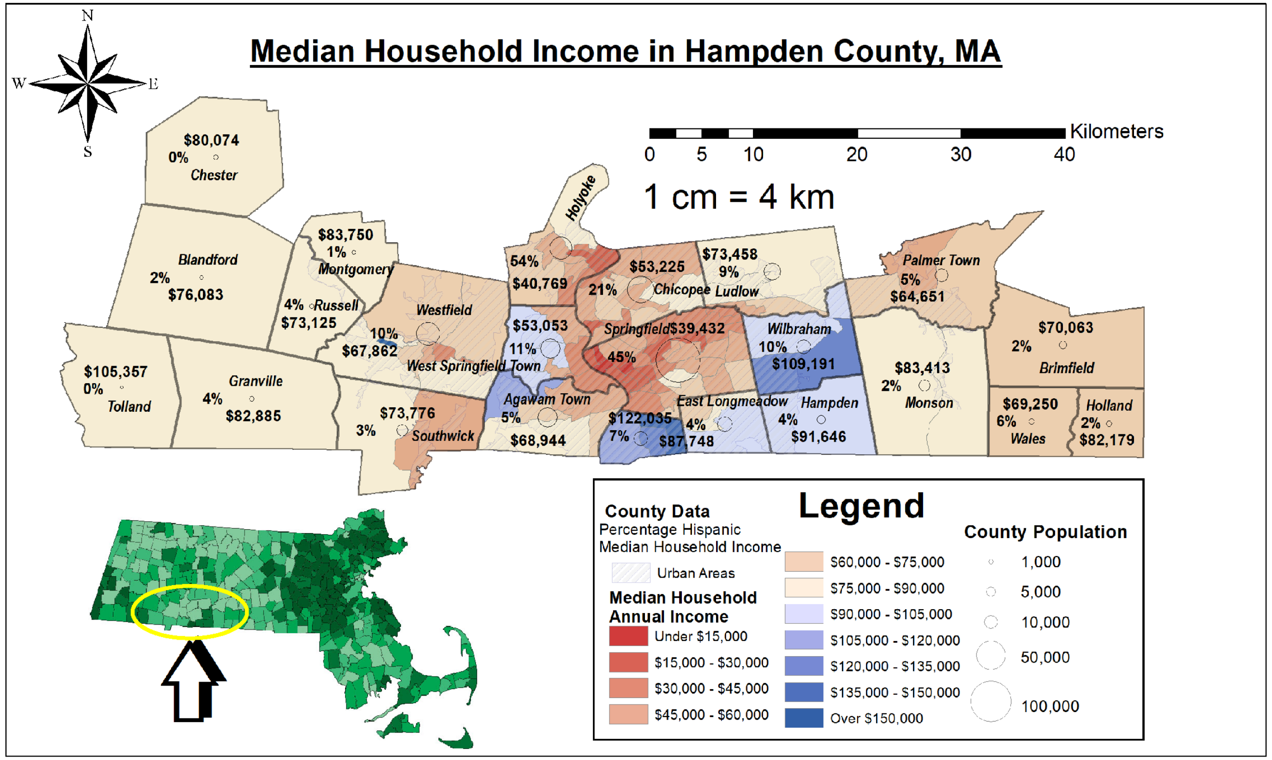
- Visually, clustering is evident, with poverty, minorities, and lower rated public schools clustered in specific municipalities
- Worth considering how neighboring municipalities can redistribute resources



Source: SchoolDigger.com
https://www.schooldigger.com/

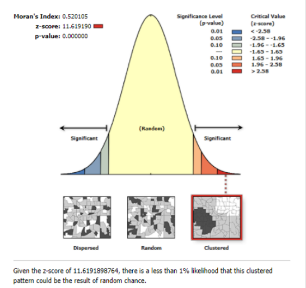
Household income is clustered in white, suburban towns around Springfield





Moran's I

Clustering within Census Tract



Given the z-score of 11.6191898764, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

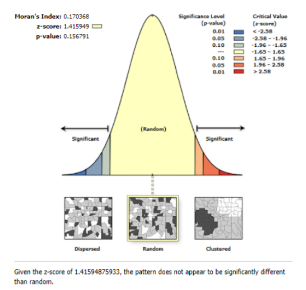
Global Moran's I Summary

Moran's Index:	0.520105
Expected Index:	-0.009804
Variance:	0.002080
z-score:	11.619190
p-value:	0.000000

Dataset Information

Input Feature Class:	hampdentract
Input Field:	HAMPDENTRACT.MHHI_TRACT
Conceptualization:	INVERSE_DISTANCE
Distance Method:	EUCLIDEAN
Row Standardization:	False
Distance Threshold:	11746.4546 Meters
Weights Matrix File:	None
Selection Set:	False

Clustering within Towns



Given the z-score of 1.41594875933, the pattern does not appear to be significantly different than random.

Global Moran's I Summary

Moran's Index:	0.170368
Expected Index:	-0.045455
Variance:	0.023233
z-score:	1.415949
p-value:	0.156791

Dataset Information

Input Feature Class:	hamptowns
Input Field:	HAMPTOWNS.MHHI_TWN
Conceptualization:	INVERSE_DISTANCE
Distance Method:	EUCLIDEAN
Row Standardization:	False
Distance Threshold:	11624.9619 Meters
Weights Matrix File:	None
Selection Set:	False

Digitizing Historical Salt Marshes of Massachusetts

Kayla Clark, '14, Smith College Sociology Department

Background

Coastal salt marshes are ecosystems that prevent erosion, maintain water quality and provide storm protection and are habitat and nurseries for many species. Salt marshes are an integral part of Massachusetts coastline. Baseline information of historic marshland aids in understanding coastal change over centuries and could aid in designing restoration sites and conservation plans. The most extensive map of coastal Massachusetts for the 18th century was created with watercolor, pen and ink by the British Royal Navy in 1750 (Fig 2). Their current paper format, however, limits spatial analysis.

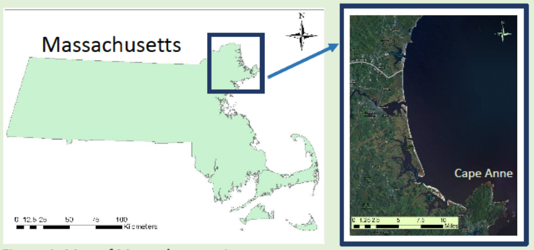


Figure 1: Map of Massachusetts, inset shows study area covering rom Salisbury to Cape Anne

Goals:

1. Geo-reference and digitize marsh and shallow water along the Massachusetts coast from Ipswich Bay to Cape Anne(Fig 1).
2. . Preliminary comparison of current a marsh with historic data to test the hypothesis that increased population has led to decreasing marshland.

Figure 2: Photographs of the British Royal Navy maps drawn in 1750

Figure 3: Image of Salt marsh

Methods

Geo-referenced photographs of historical paper maps

- Re-projected ArcGIS online base map "*Images with References*" from Mercator transverse to NAD_1983_StatePlane_Massachussuttes FIPS 2001
- Identified and snapped reference point locations including road junctions, towns, coastline shape, and islands found in both historical and current maps

Digitized marshland

- Created polygon shape-file
- Used freehand tool to draw over marshland and shallow water on historical maps

Figure 4: Examples of historical symbology of marsh(green outline) and shallow water (blue)

Comparison with current marsh

- Overlaid and took intersect of digitized historic marsh on current marshland shown in Wetlandsdep_poly.exe
- Intersected town census data from Census_Towns_2010 with current marsh and with historic to form new feature classes
- Calculate geometry for area of both feature classes

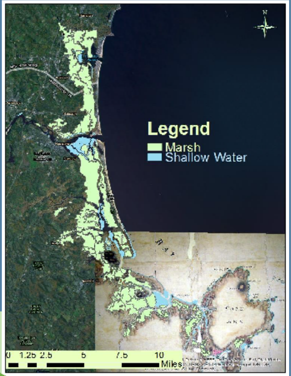


Figure 5: Marsh and shallow water shapefile digitized from 1750 British Navy paper map, a portion of which is visible here on top of base map

Results

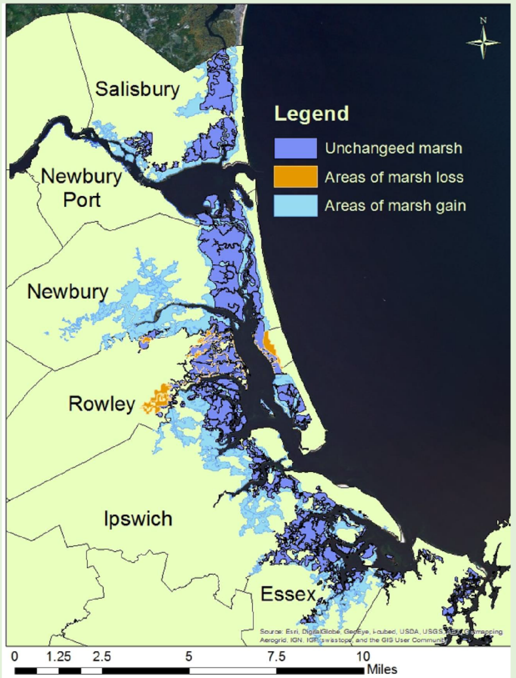


Figure 5: Map of coastal change in salt marshes between 1750 and 2010

Figure 6: Square miles of marsh by town. Towns arranged in order of population size starting with Essex as smallest.

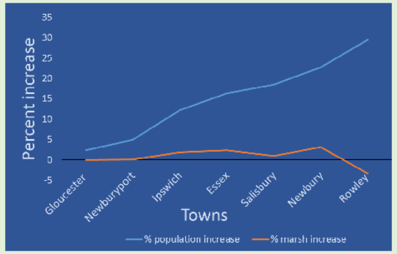


Figure 7: percentage of Eastern Massachusetts population and marsh increase 1750-2010

Discussion & Conclusion

Comparison of Historical and Current Marsh

- Overall 16 square miles of marsh in 1750
- 24 square miles present in 2010
- Rowley was only town with marsh loss (Fig 5.
- No clear relationship between population size and marsh loss or gain (fig 6) or between percent of population increase and marsh loss(fig 7)

This lack of relationship could be due to:

1. **Population may not be a good proxy for development**
2. **Restoration sites located in area could counteract loss**
3. **Limitations in accuracy historical data set:**

- Few geographical features on edges of maps, leading to poorly distributed snapping points and thus warping..
- The RMS error 396 meters between maps, features available included mostly river and coastline, aspects that could have changed location over the last 200 years

The geo-referencing still needs to be fine tuned further, however the digitized spatial data layer for marsh in 1750 is an opportunity to better understand historic marsh .

Acknowledgements

Thank you to Karen Alexander for the project idea and providing the historic maps & Steven Mattocks for teaching me how to geo-reference, T A s & Bethany Bradley

Food Web Interactions in the Isla Bastimentos Marine Park, Panama

Austin Peek

Department of Environmental Conservation, University of Massachusetts

Introduction

Carribean coral reefs have **declined by 80%** over the last five decades (Gardener et al. 2003). **Macroalgal dominance** deters the settlement of coral larvae and overgrow young coral colonies (Mcclanahan 1999). Sea urchins (e.g. Echinometra spp.) may afford some level of functional **redundancy in herbivory**. **Marine Protected Areas** and fisheries closures have been implemented as a means to restore biodiversity and ecosystem function, however, these reserves may promote predator populations and subsequent **suppression** of sea urchin herbivory **(Fig. 1)**.

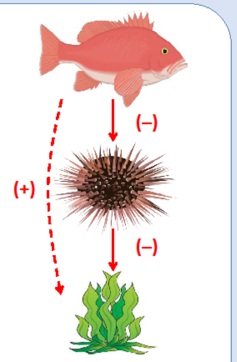


Figure 1. Caribbean Food web. Predatory fish consume *Echinometra*, resulting in a positive effect on algal abundance.

Questions + Hypothesis

1. How does abundance for Black Margate (predatory fish), *Echinometra*, and algae populations differ within protected and fished sites?

Hypothesis: There will be a higher abundance of Black Margate and algae within protected areas. *Echinometra* populations will be higher outside MPAs.

2. Does the distance away from park boundaries have an effect on these abundances?

Hypothesis: Distance away from the MPA has an affect on all species' populations.

Isla Bastimentos National Marine Park

The **Isla Bastimentos National Marine Park (IBNMP) is a 13,360 hectare marine reserve** on the Caribbean north end of Panama within the Bocas Del Toro **(Fig.2)**. The main goal of the park is to conserve a **"representative sample of the marine and coastal ecosystems"** of the region and prohibits extraction of resources within the park borders.

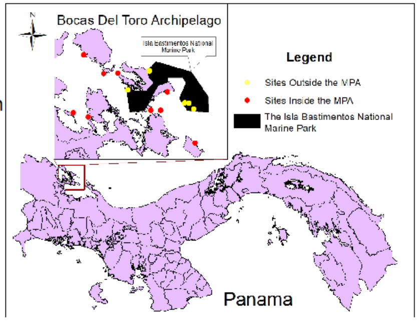


Figure 2. Study sites throughout the Bocas Del Toro Archipelago. The IMNMP is represented by the black polygon

Methods

1. Create MPA Boundaries - Use georeferencing tool bar and create polygon shapefile.

2. Convert MPA Boundary Polygon to Raster - Use polygon to raster conversion tool

3. Create Land Mask - Make land raster equal no data in reclassify tool. Reclassify water as 1. Extract value to points

4. Calculate Distance from Boundaries to Sites – Cost distance spatial analysis tool **(Fig. 3)**. Add distance column to attribute table

5. Data Analysis – Generalized Linear mixed models were used to test for differences in abundance and distances using the R Computing Environment

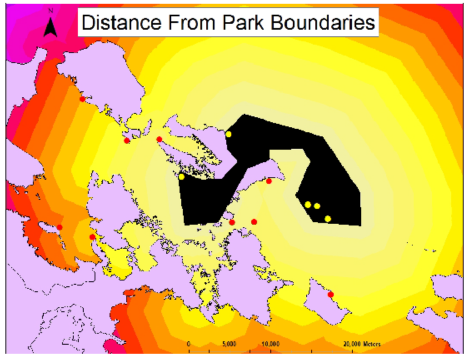


Figure 3. Distance of Sites from MPA borders using Cost Distance Spatial Analysis Tool The darker the color, the further a site is (ignoring land).

Results

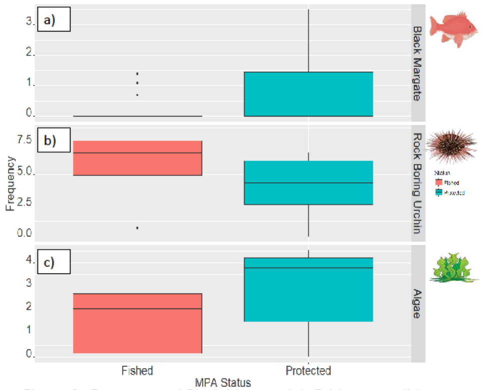


Figure 4. Frequency of Black Margate **(a)**, *Echinometra* **(b)**, and percent coverage of algae **(c)**.

Black Margate (*Anisotremus surinamensis*) were **more abundant** within MPA as opposed to fished sites **(p<0.001). (Fig.4a)**

There were **fewer urchins** (*Echinometra*) inside than there are outside the MPA **(p=0.0377). (Fig.4b)**

There was **more algae** present within the MPA **(p=0.007). (Fig.4c)**

Distance has a significant effect on the abundance of Algae **(p=0.05)** and Urchins **(p=0.007).** However, distance does not have a substantial effect on Black Margate **(p=0.09). (Fig. 5)**

Conclusions

The data support the hypothesis that **Black Margate and Algae abundance increases** in protected areas, while ***Echinometra*** abundance **decreases**.

The protection of fish appears to have a **negative** impact on the region's food web by decreasing urchin abundance in the park.

Protected areas may be providing benefits to some species, but may be detrimental to others.

Distance does not appear to have an affect on Black Margate Abundance. This may be due to the lack of Black Margate outside the MPA.

More research must be performed to understand the food webs of marine protected areas.

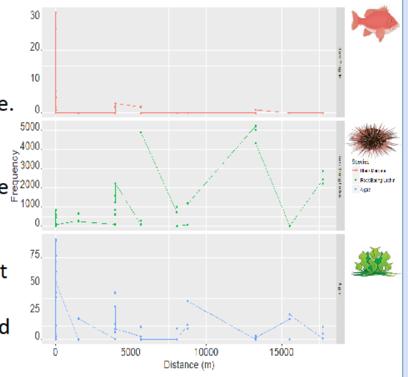


Figure 5. Graph comparing Frequency of Species Vs. Distance.

References

Gardner, T. A., Côté, I. M., Gill, J. A., Grant, A., & Watkinson, A. R. (2003). Long-term region-wide declines in Caribbean corals. *Science*, *301*(5635), 958-960.

Guerrón-Montero, C. (2005). marine Protected areas in Panama: grassroots activism and advocacy. *Human organization*, *64*(4), 360-373.

McClanahan, T. R. (1999). Predation and the control of the sea urchin Echinometra viridisand fleshy algae in the patch reefs of Glovers Reef, Belize. Ecosystems, 2(6), 511-523.

McClanahan, T. R., Muthiga, N. A., & Coleman, R. A. (2011). Testing for top-down control: can post-disturbance fisheries closures reverse algal dominance?. Aquatic Conservation: Marine and freshwater ecosystems, 21(7), 658-675.

Randall, J. E. (1967). Food habits of reef fishes of the West Indies.

Acknowledgements

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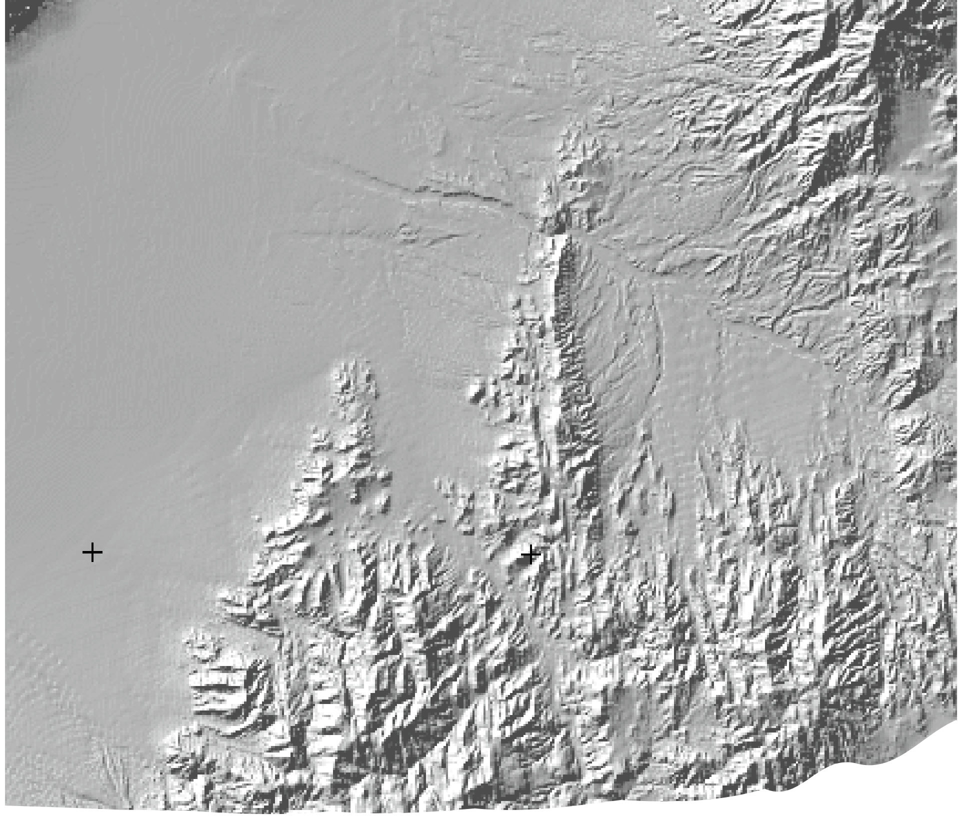
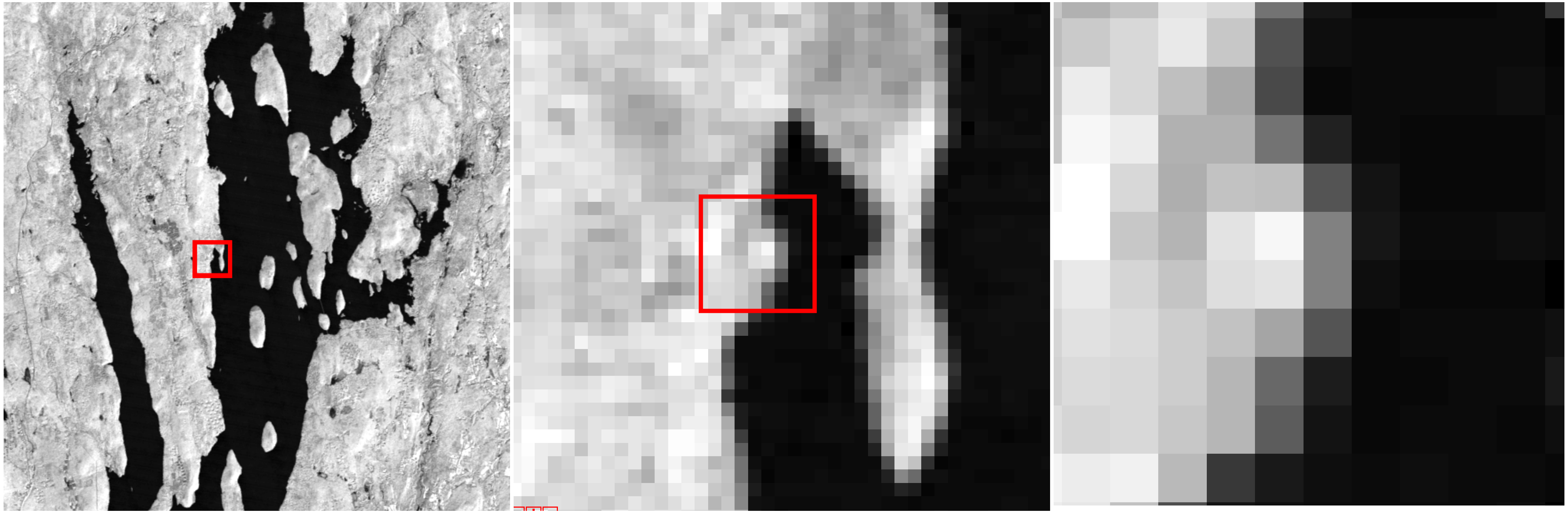


Spatial Analyst
Introduction to Raster Processing

Raster Data

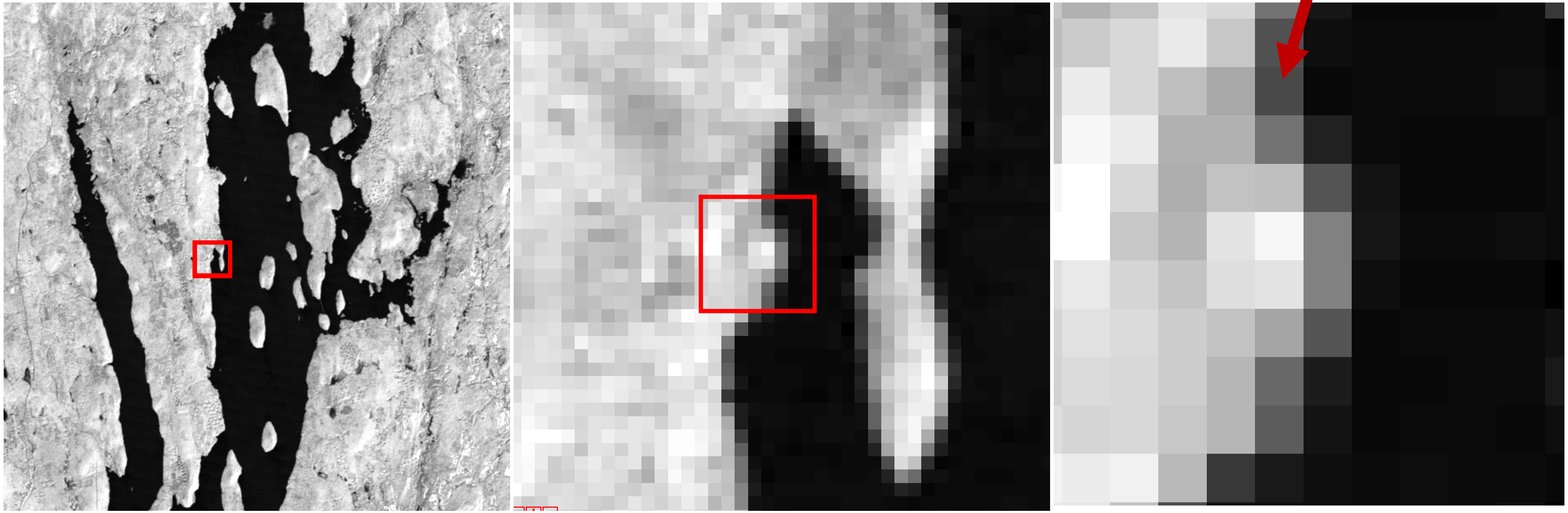
What do the pixel values represent??



Raster Data

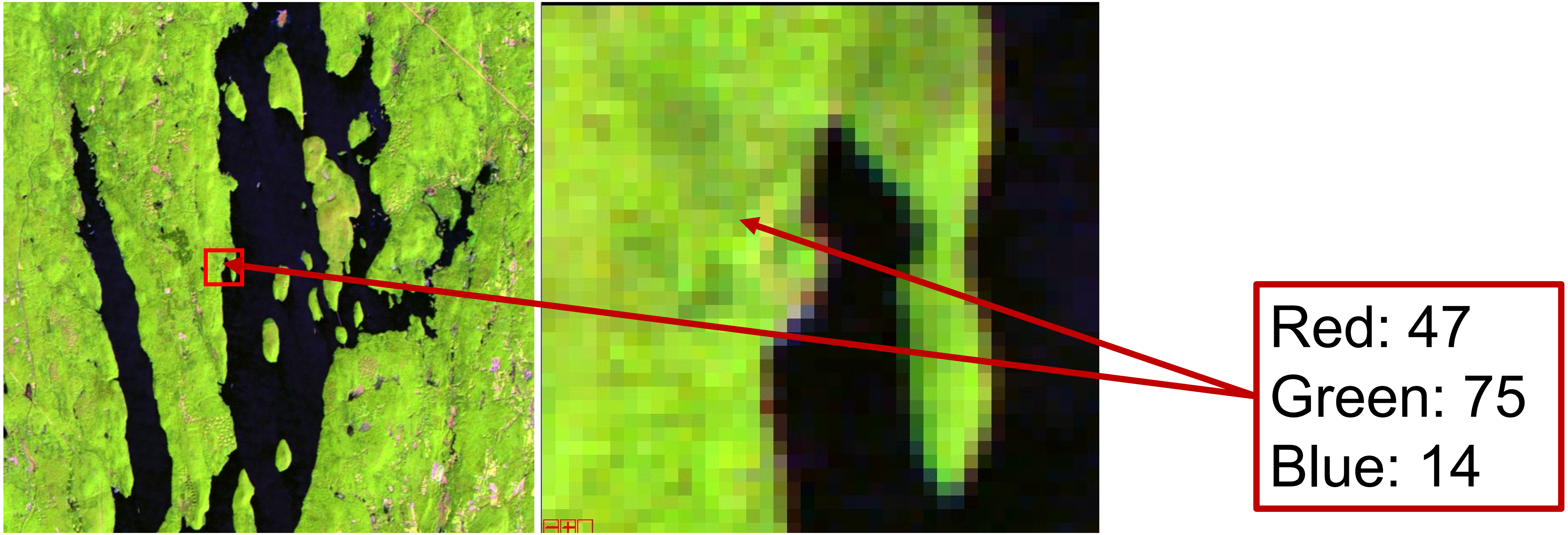
What do the pixel values represent?

The answer is 42



Raster Data

What do the color channels represent?

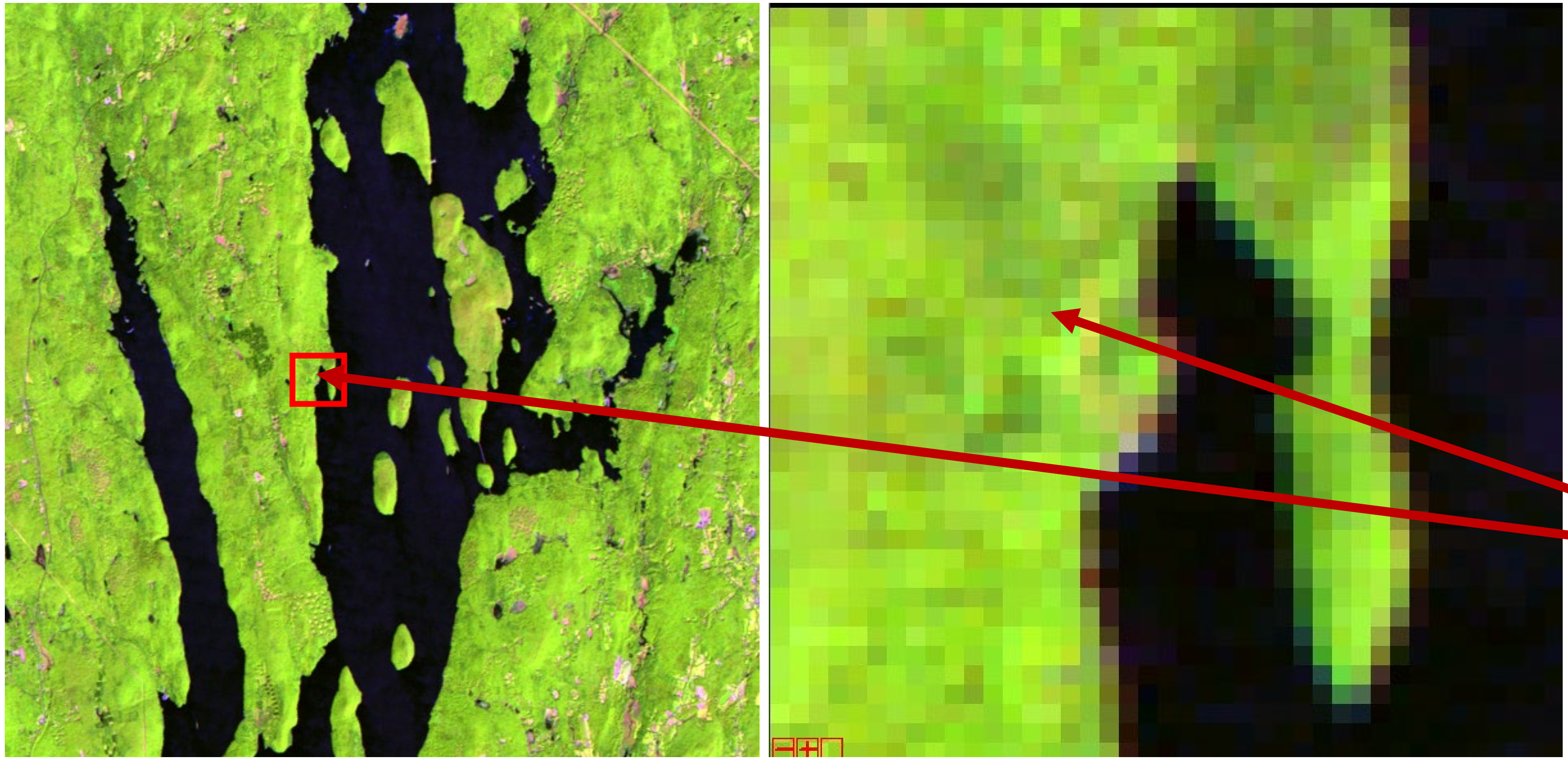


Raster Data

- We can think of rasters as image files.
- They can store 1 or more layers:
  - Grayscale
  - RGB color

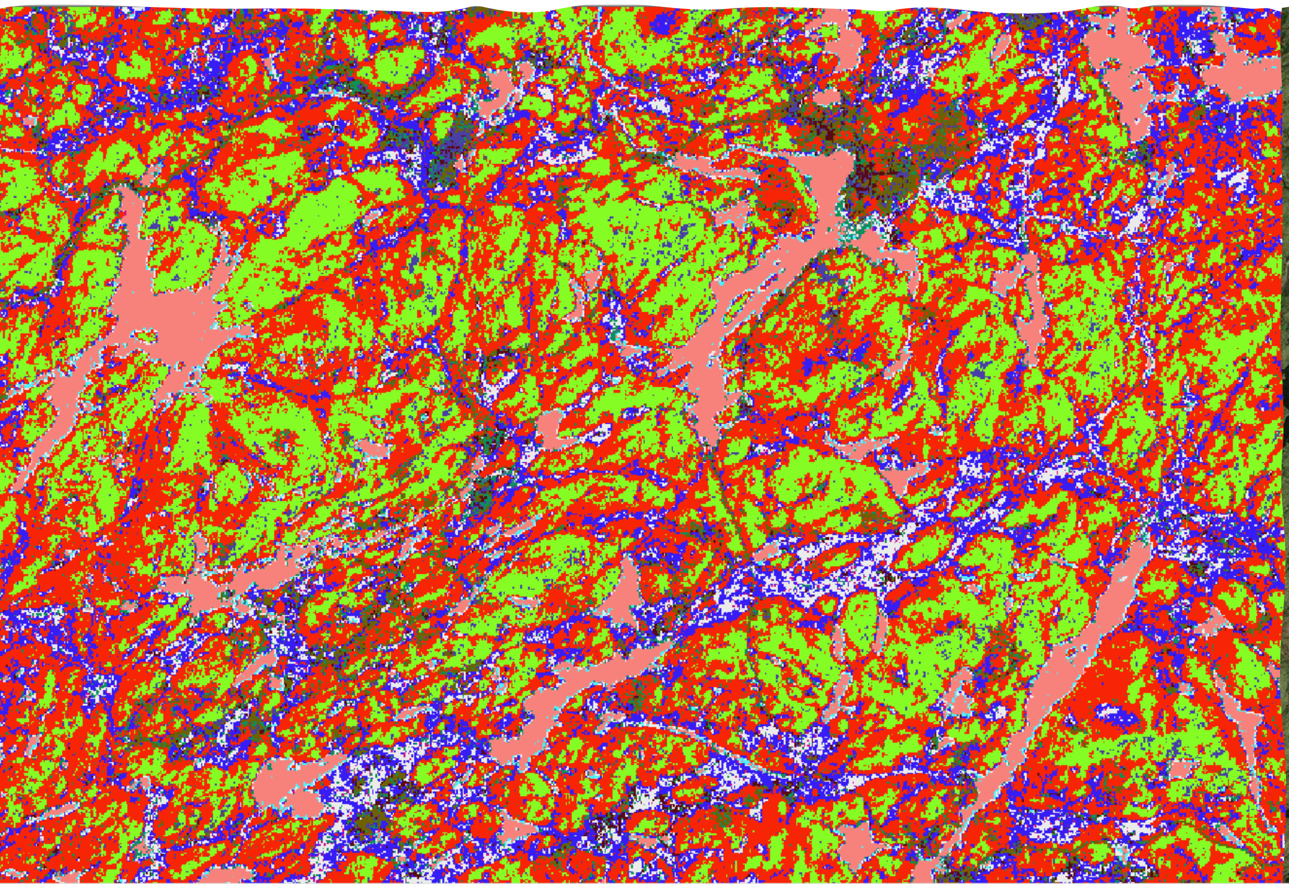
What do the color channels represent?

Remember the RGB model?



Red: 47
Green: 75
Blue: 14

True and False-Color Imagery



Raster Data

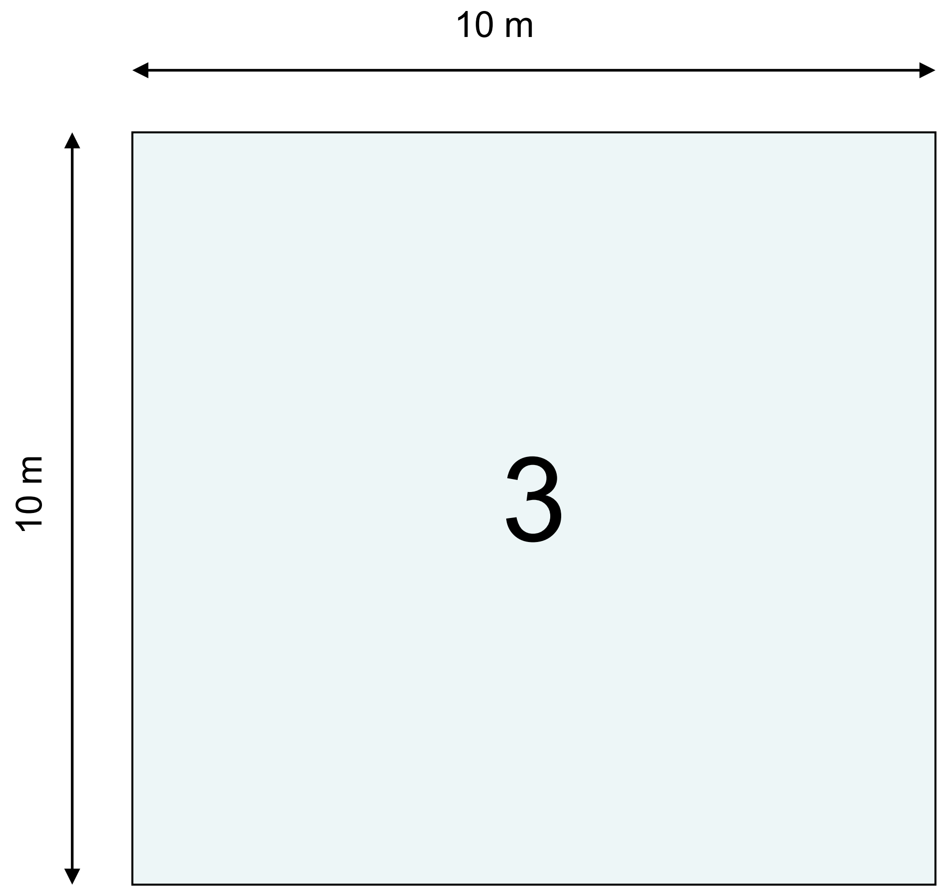
Surface of values composed of square **pixels (or cells)** each with a specific **value**

2	2	5	3	3
2	2	5	3	3
2	5	5	3	3
4	5	4	4	3
4	4	5	4	6
1	1	4	5	6
1	1	1	1	5

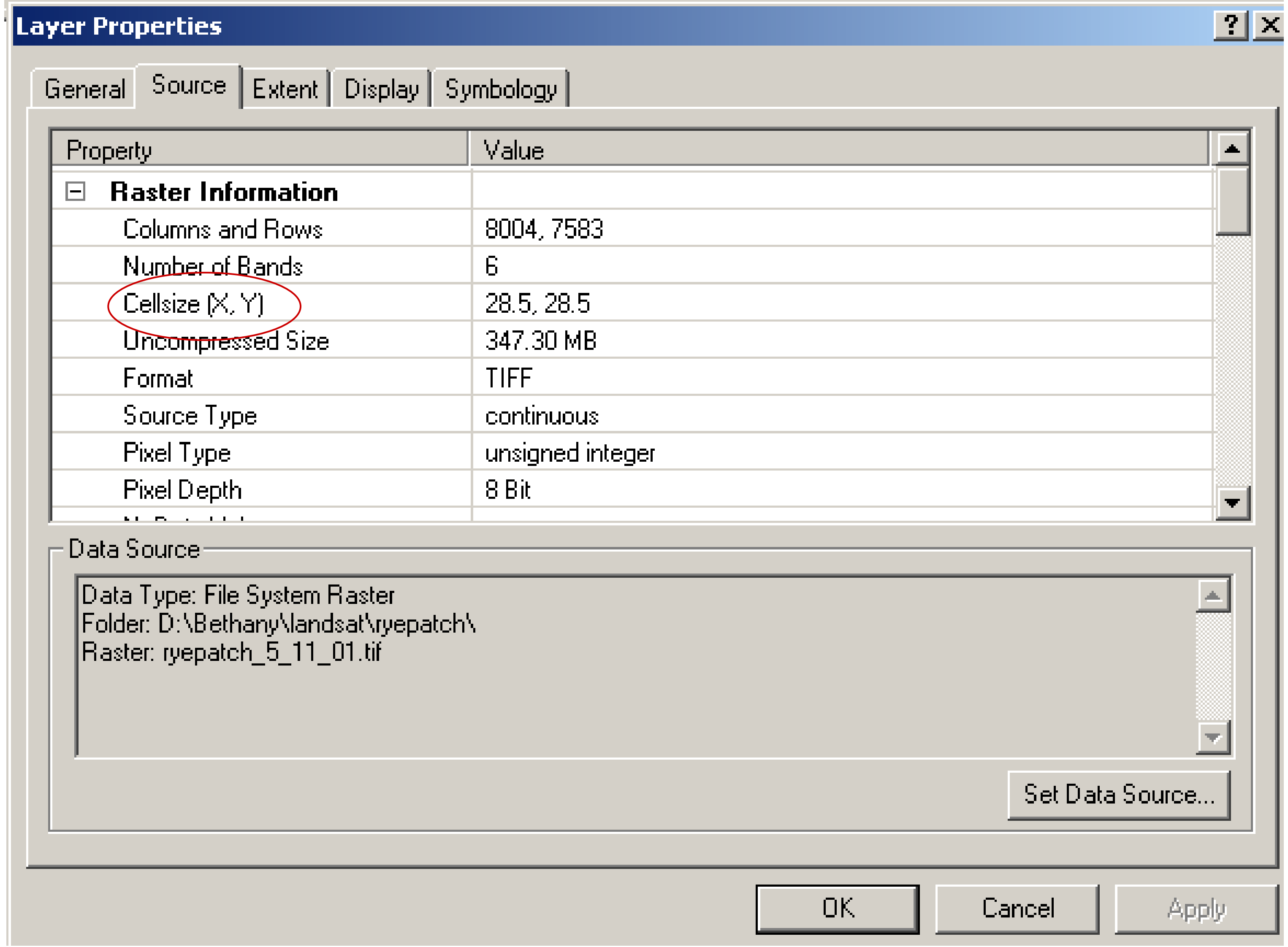
cnty_grid_v2
cnty_grid_v3
county_grid
dens2
dist_roads

A raster layer is composed of pixels

- Surface of values composed of [usually] **square** pixels each with a specific value
- Pixels have a specific length/width size (ex. 10 m).
- Pixels may only hold **one *value.***
  - Compare to vector **attributes**

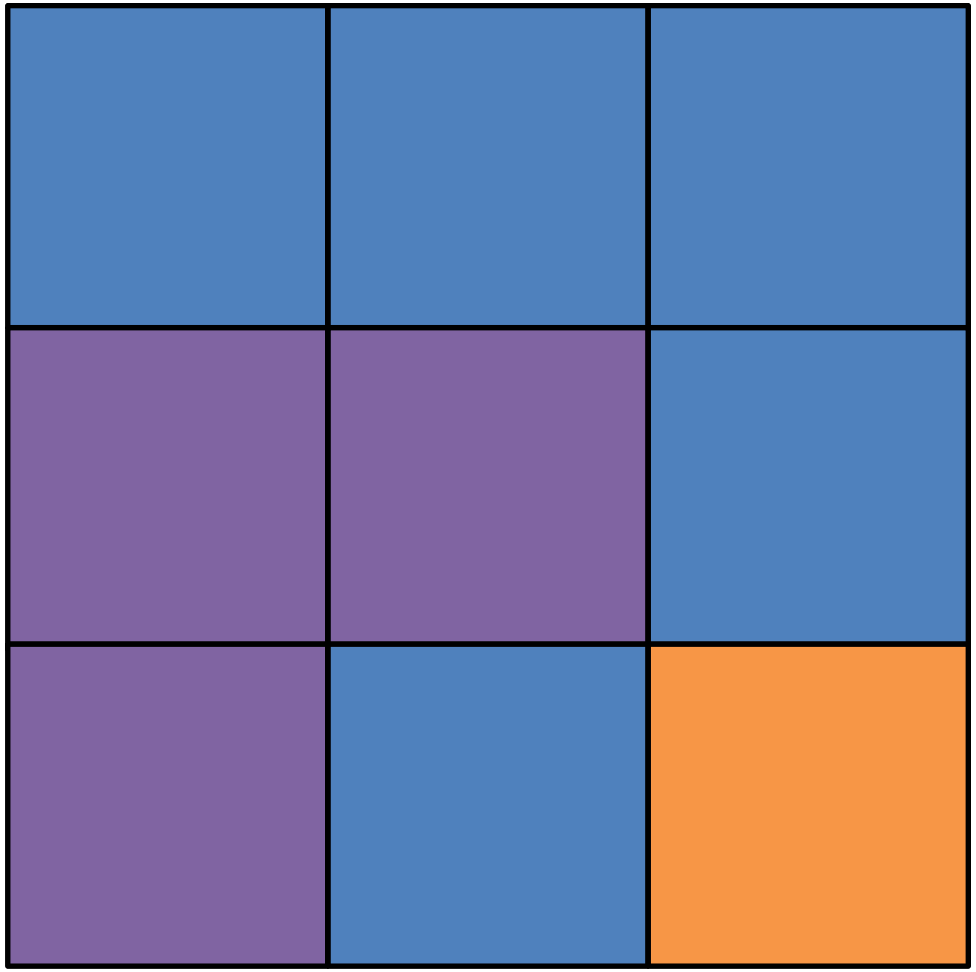


Pixel Size = Spatial Resolution



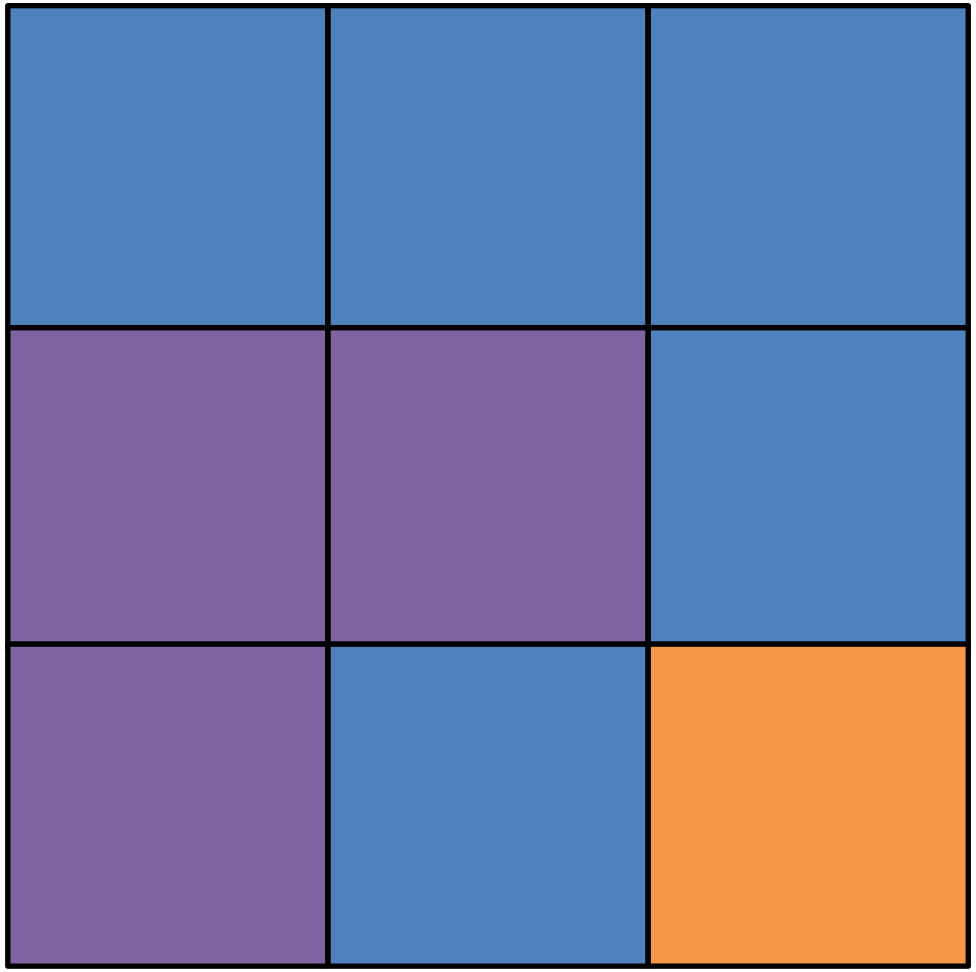
Rasters Make Math Easy

- Vector math can be computationally intensive.
- How do we calculate areas with vector data?
- How do we calculate vector overlap?

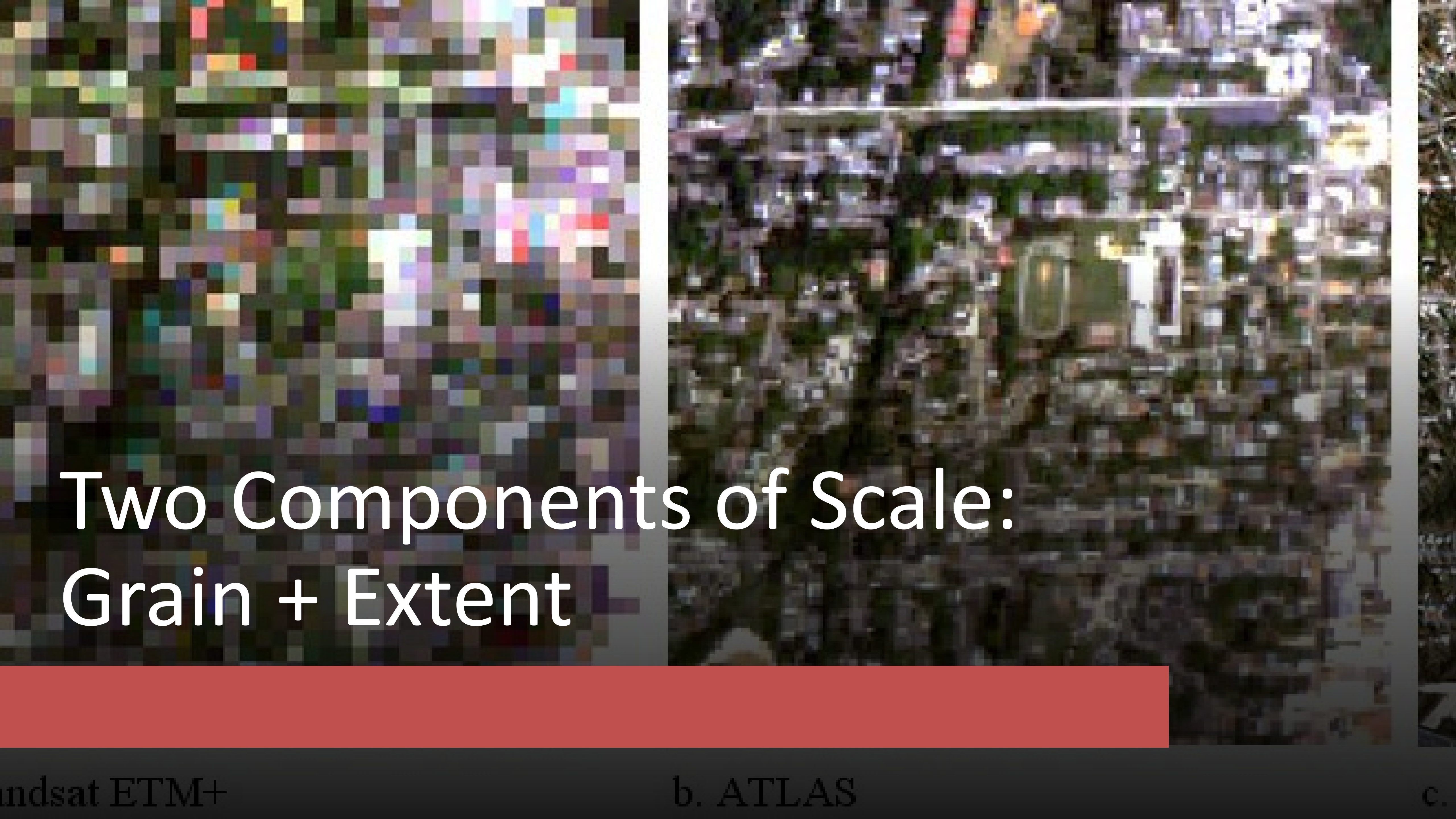


Rasters Make Math Easy

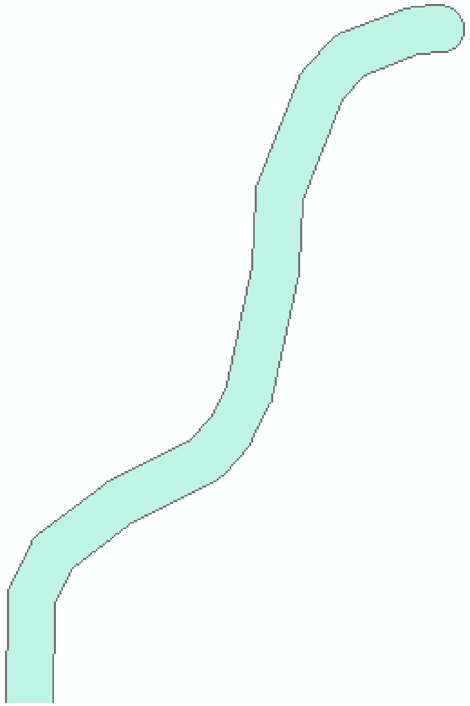
- If our cells are 10m by 10m, what is the area of a cell?
- What is the combined area of each color cell?
- Raster math usually reduces to simple operations of cell values.



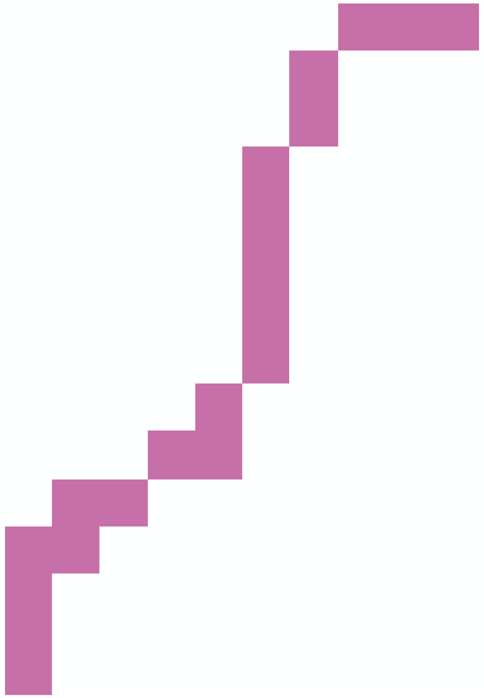
Two Components of Scale: Grain + Extent



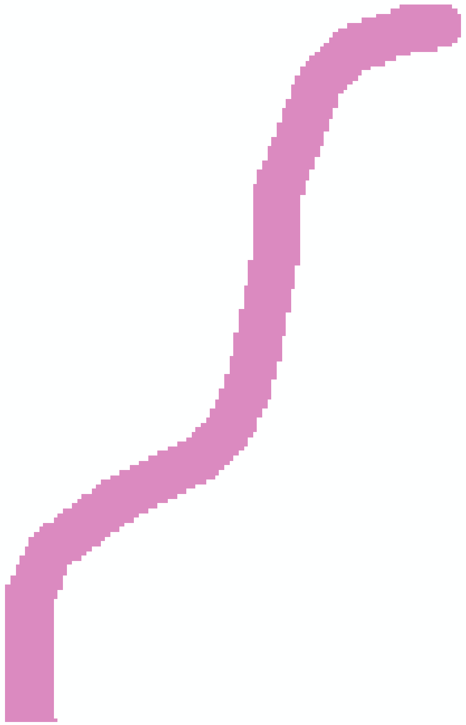
Raster vs. Vector I: pixel size is important



vs.



vs.



Scale: Grain and Extent
All of these rasters have the same extent

a. Landsat ETM+

b. ATLAS

c. QuickBird

a. Landsat ETM+ b. ATLAS c. QuickBird

Grain (or resolution): Pixel (cell) size

Extent: Area covered by raster

The Scale's the Thing for Questions, Answers, Representation

- "As resolution increases, objects tend to differentiate from classes. For example, objects might be represented by buildings, which taken collectively, might be classified as a commercial district. At even higher resolution, objects dissolve into materials with different spectral properties. Although this scale may appear more "realistic" to the human brain, the resolution may be too high to obtain meaningful objective interpretation through image processing.
  - https://weather.msfc.nasa.gov/land/ncrst/multiclas.html

Vector vs. Raster: Rasterizing a Vector

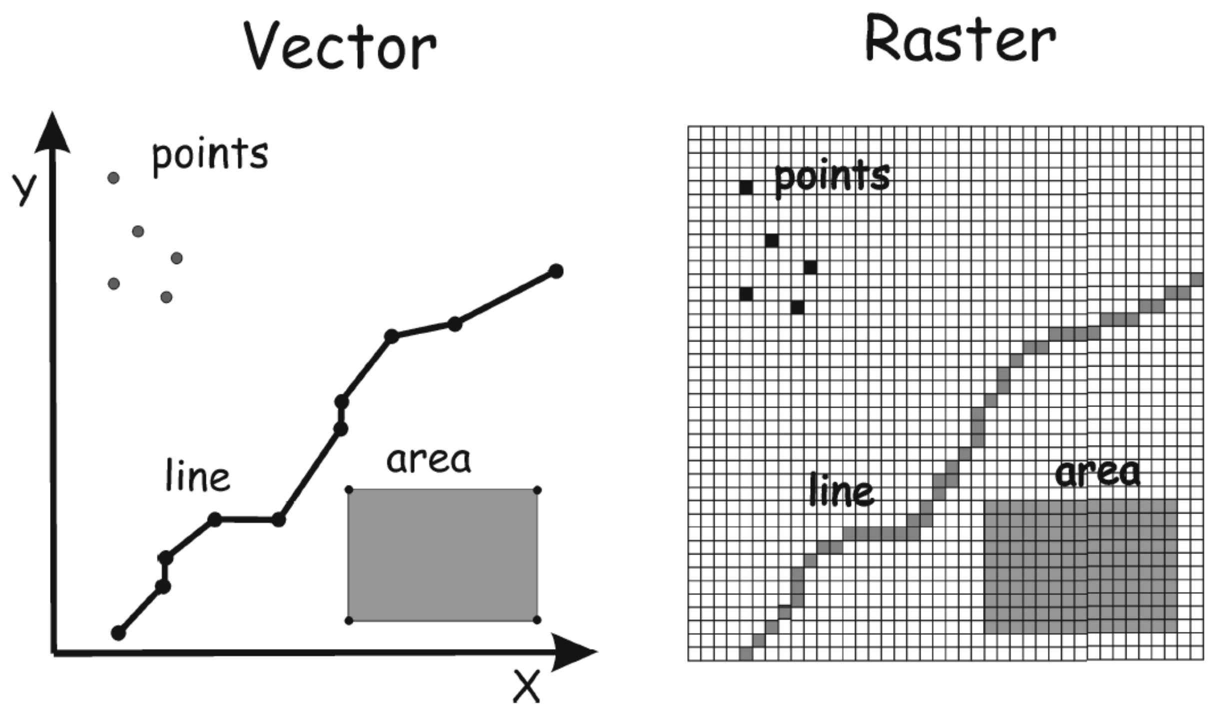


Figure 2-8: Vector and raster data models.

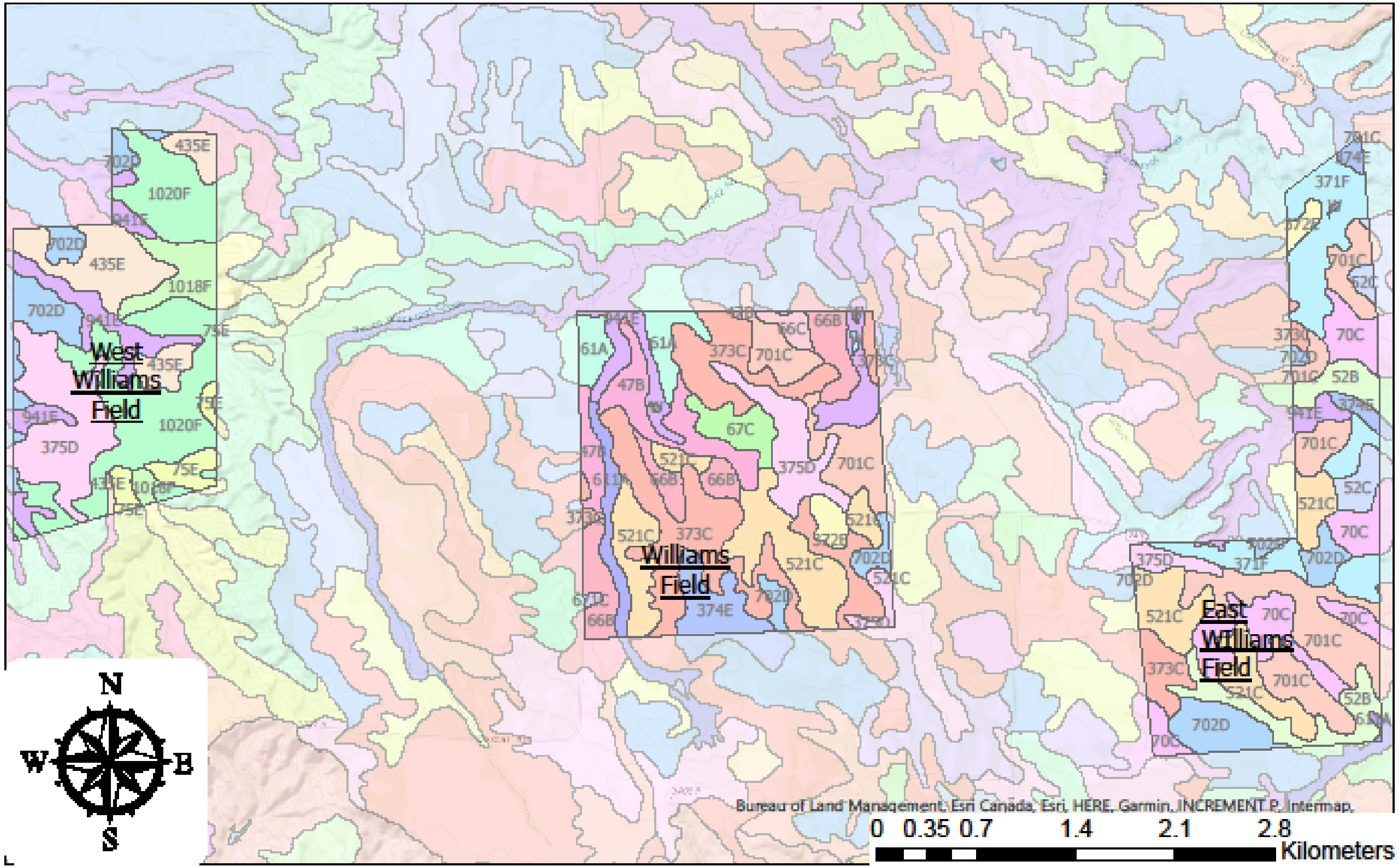
Vector vs. Raster

Table 2-2: A comparison of raster and vector data models.

Characteristic	Raster	Vector
data structure	usually simple	usually complex
storage requirements	large for most data sets without compression	small for most data sets
coordinate conversion	may be slow due to data volumes, and require resampling	simple
analysis	easy for continuous data, simple for many layer combinations	preferred for network analyses, many other spatial operations more complex
positional precision	floor set by cell size	limited only by positional measurements
accessibility	easy to modify or program, due to simple data structure	often complex
display and output	good for images, but discrete features may show "stairstep" edges	map-like, with continuous curves, poor for images

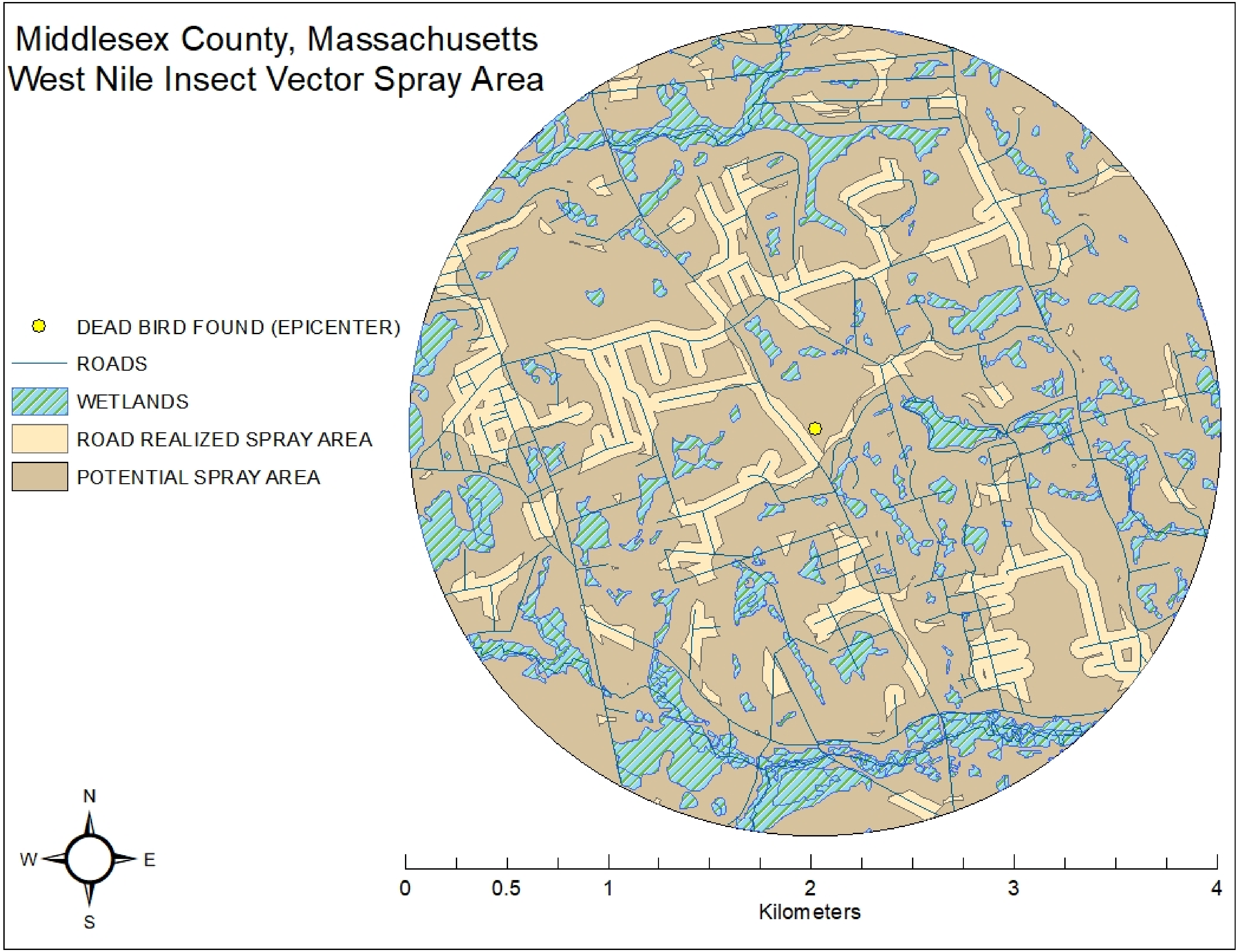
Source: Paul Bolstad. 2012. GIS Fundamentals – A first text on Geographic Information Systems. 4th ed.

Williams Field Soil Types

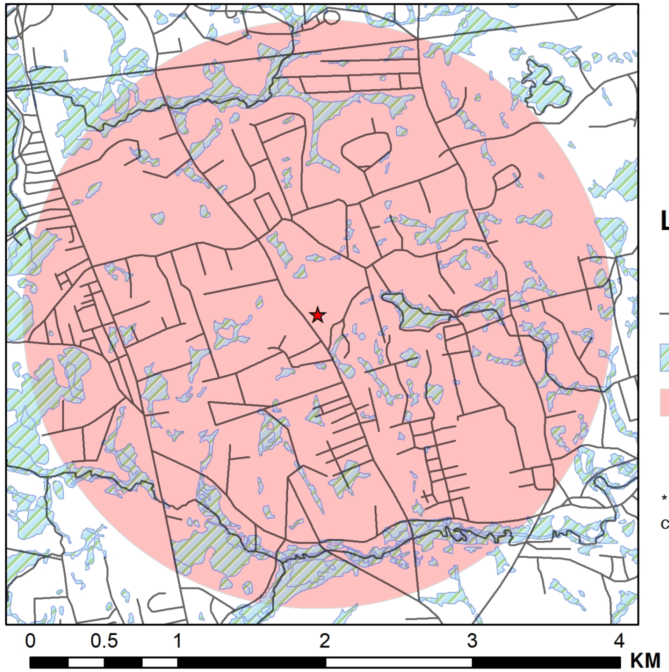


Soil Types

- Cabbart, wooded-Blacksheep-Delpoint complex, 6 to 60 percent slopes,75E
- Cabbart-Havre loams, 0 to 35 percent slopes,941E
- Cambeth, noncalcareous-Megonot complex, 2 to 8 percent slopes,373C
- Cambeth-Cabbart-Rock outcrop, soft, complex, 8 to 45 percent slopes,371F
- Cambeth-Cabbart-Yawdim complex, 15 to 25 percent slopes,374E
- Cambeth-Rock outcrop, soft-Yawdim association, 25 to 70 percent slopes,1020F
- Cambeth-Twilight-Cabbart complex, 4 to 15 percent slopes,375D
- Delpoint-Cabbart-Yawdim complex, 4 to 25 percent slopes,435E
- Ethridge silty clay loam, 0 to 4 percent slopes,47B
- Floweree silt loam, 0 to 4 percent slopes,52B
- Floweree silt loam, 4 to 8 percent slopes,52C
- Floweree-Cambeth silt loams, 2 to 8 percent slopes,521C
- Havre loam, 0 to 2 percent slopes, occasionally flooded,611A
- Havre loam, 0 to 2 percent slopes, rarely flooded,61A
- Kobase silty clay loam, 0 to 4 percent slopes,66B
- Kobase silty clay loam, 4 to 8 percent slopes,66C
- Kremlin loam, 2 to 8 percent slopes,67C
- Kremlin-Delpoint loams, 2 to 8 percent slopes,671C
- Lonna silt loam, 4 to 8 percent slopes,70C
- Lonna-Cambeth silt loams, 2 to 8 percent slopes,701C
- Lonna-Cambeth-Cabbart silt loams, 12 to 25 percent slopes,372E
- Lonna-Cambeth-Cabbart silt loams, 4 to 12 percent slopes,702D
- Neldore-Cabbart-Blacksheep association, 15 to 60 percent slopes,1018F
- Water,W


Middlesex County, Massachusetts
West Nile Insect Vector Spray Area
DEAD BIRD FOUND (EPICENTER)
ROADS
WETLANDS
ROAD REALIZED SPRAY AREA
POTENTIAL SPRAY AREA
N
W
E
S
0
0.5
1
2
3
4
Kilometers

CDC West Nile Mosquito Spray Analysis Middlesex County, MA



Legend

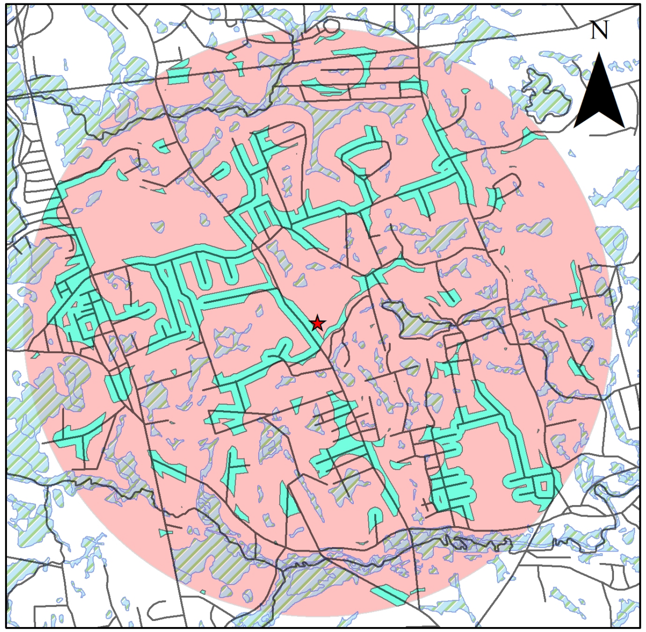
★ Infected Dead Bird

Roads

Wetlands

2km Recommended Spray Area*

*Layer does not take into consideration CDC constraints



Legend

★ Infected Dead Bird

Roads

wetlands

Realized Spray Area **

2km Recommended Spray Area

**CDC constraints: pesticides cannot be applied within 100m of wetland; Pesticides sprayed from road will only reach 50m on either side of road.

Where do rasters come from?

Raster files are abstractions of landscape features.

How do we decide what a pixel should contain?

Making Raster Decisions

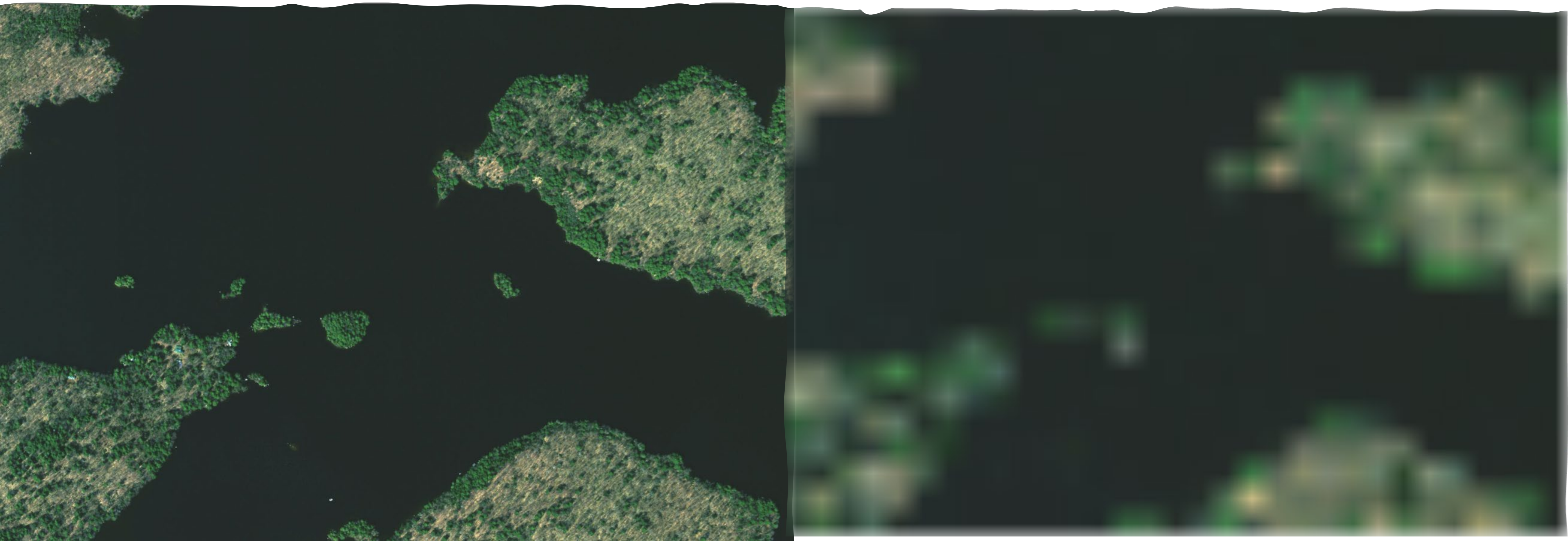
What's in a cell?

- Quantities?
- Categories?
- Remote-sensed imagery?
- Landcover type?

Making Raster Decisions

Our goal determines the file format/contents.

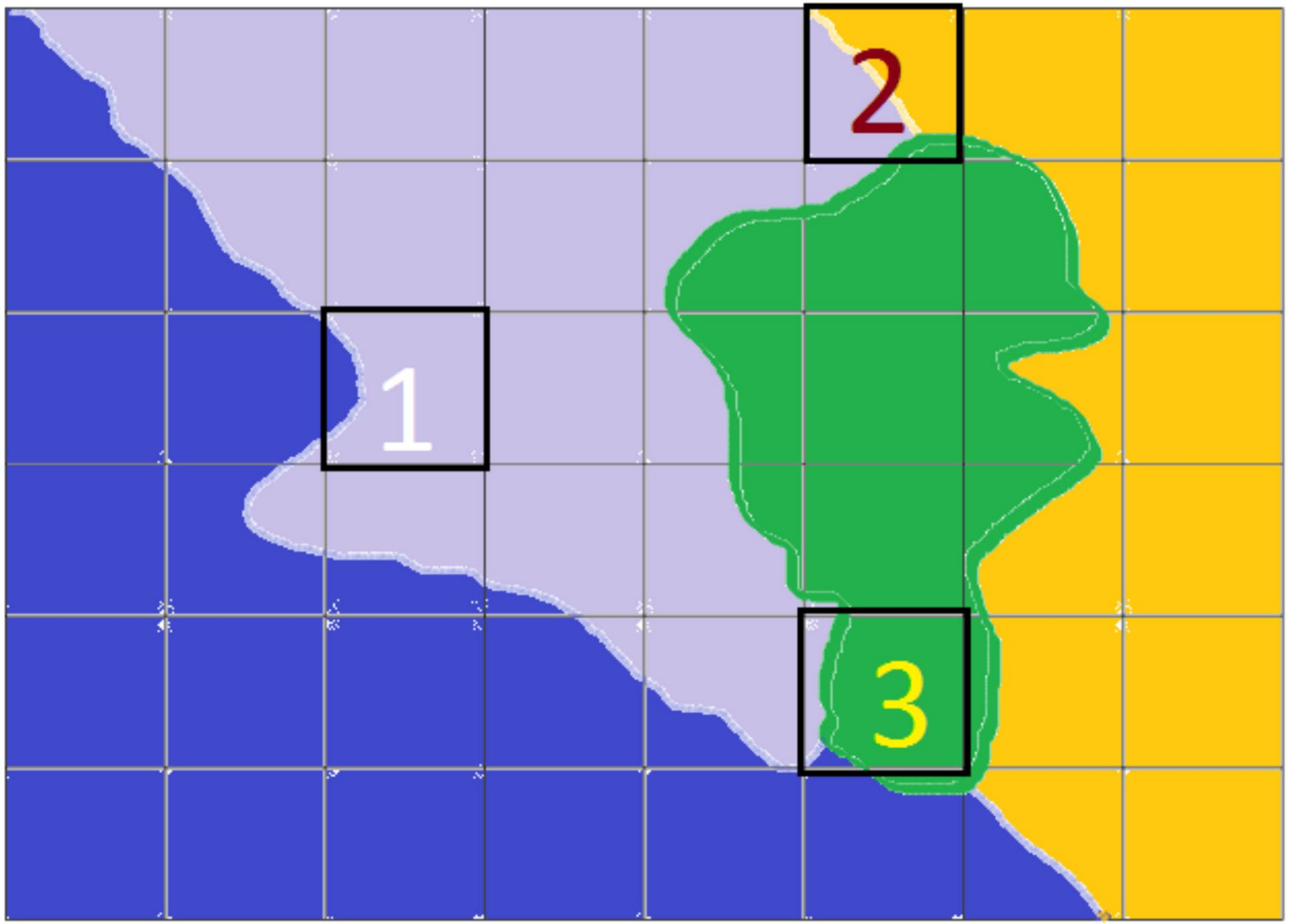
Changing Grain



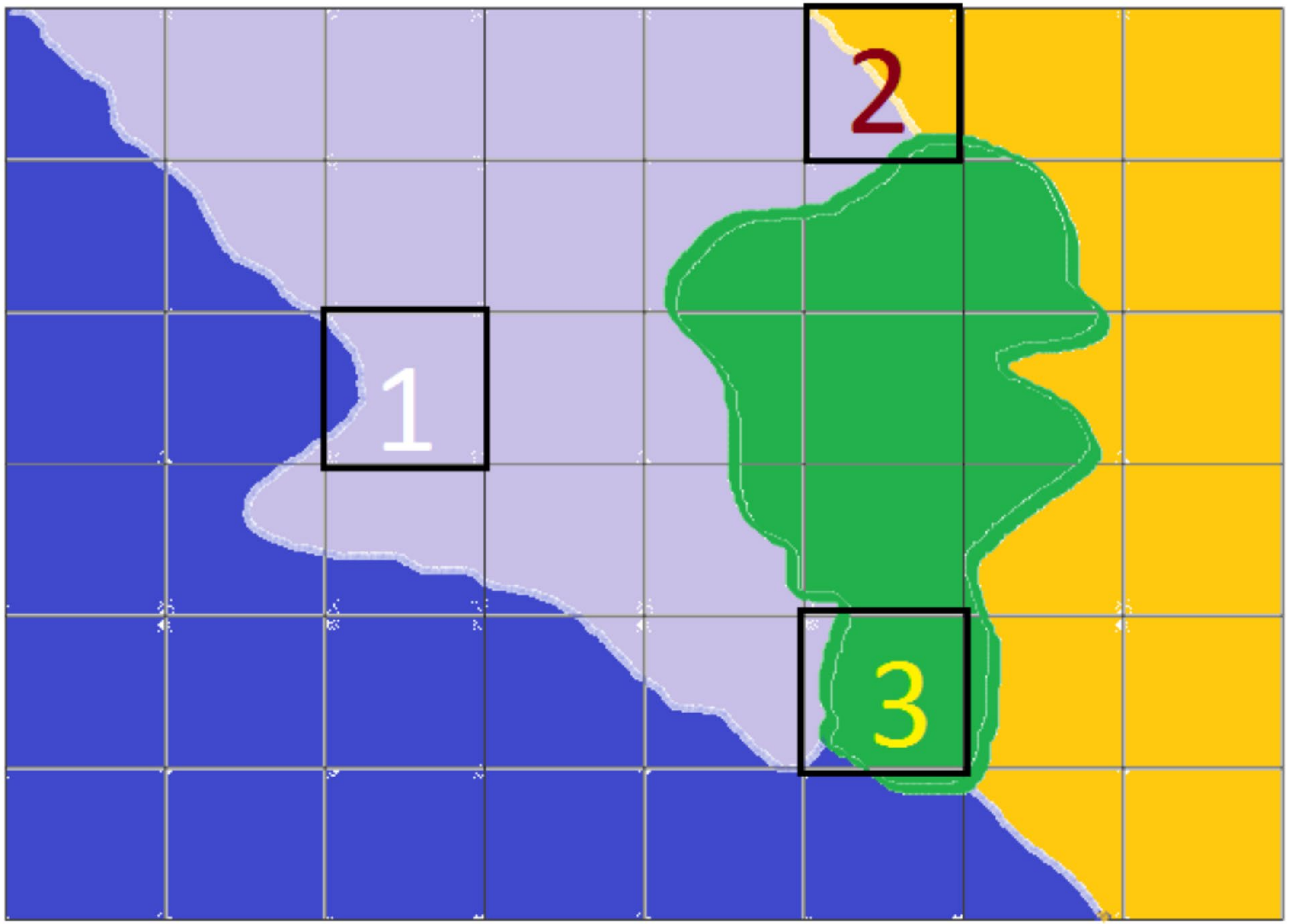
Rules for changing grain

- Where does the cell value apply within the cell?
  - (Mixed Pixel Problem)
  - Centroid method: Assigns each cell the value of the feature at the center of the cell;
  - Winner takes all: Whichever feature has the highest percentage of coverage in the cell ‘wins’;
  - Dominant: Whatever that most important ‘type’ of feature wins, when present.

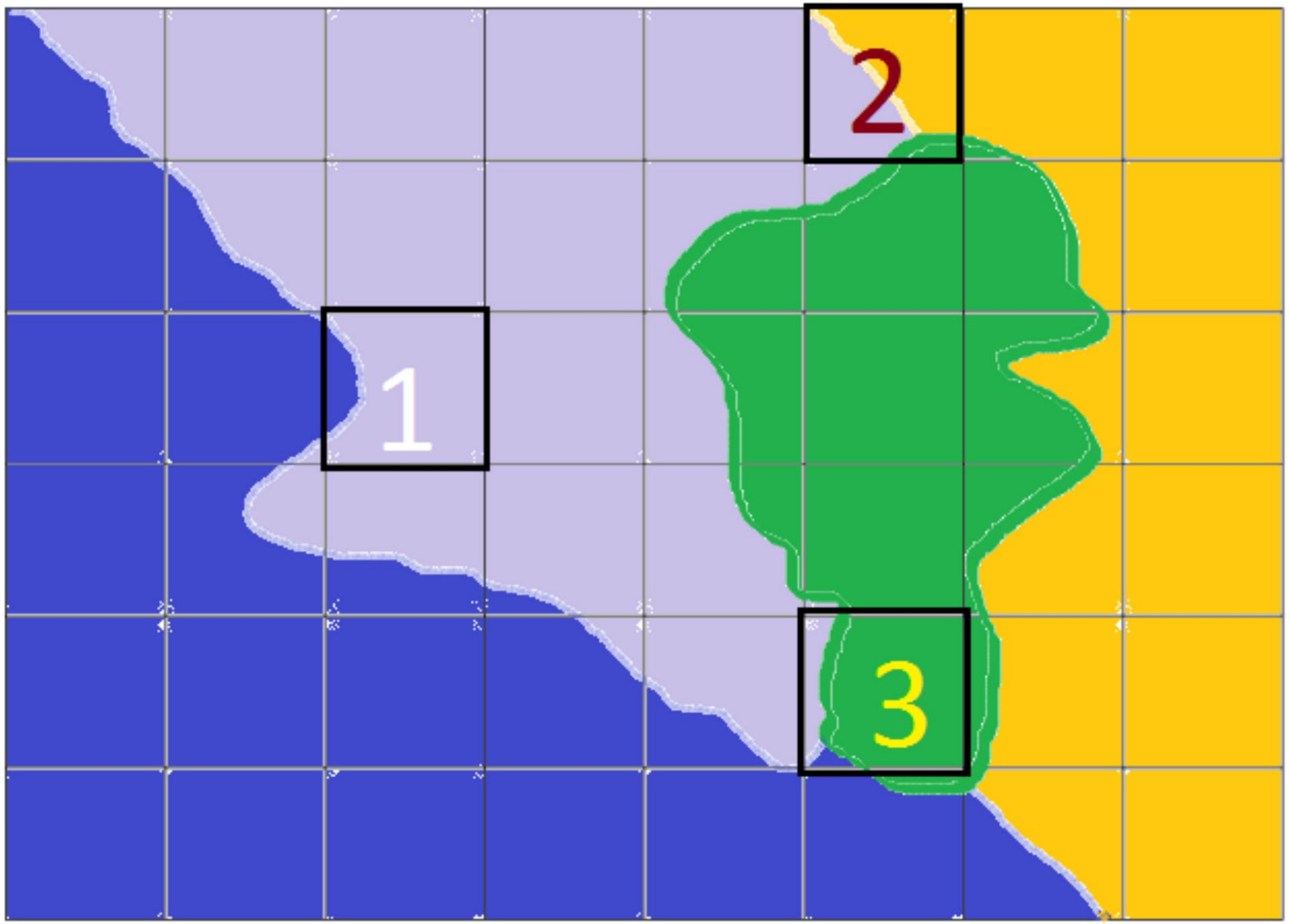
For 'Winner Takes All' coverage, what colour should cell 1 be?



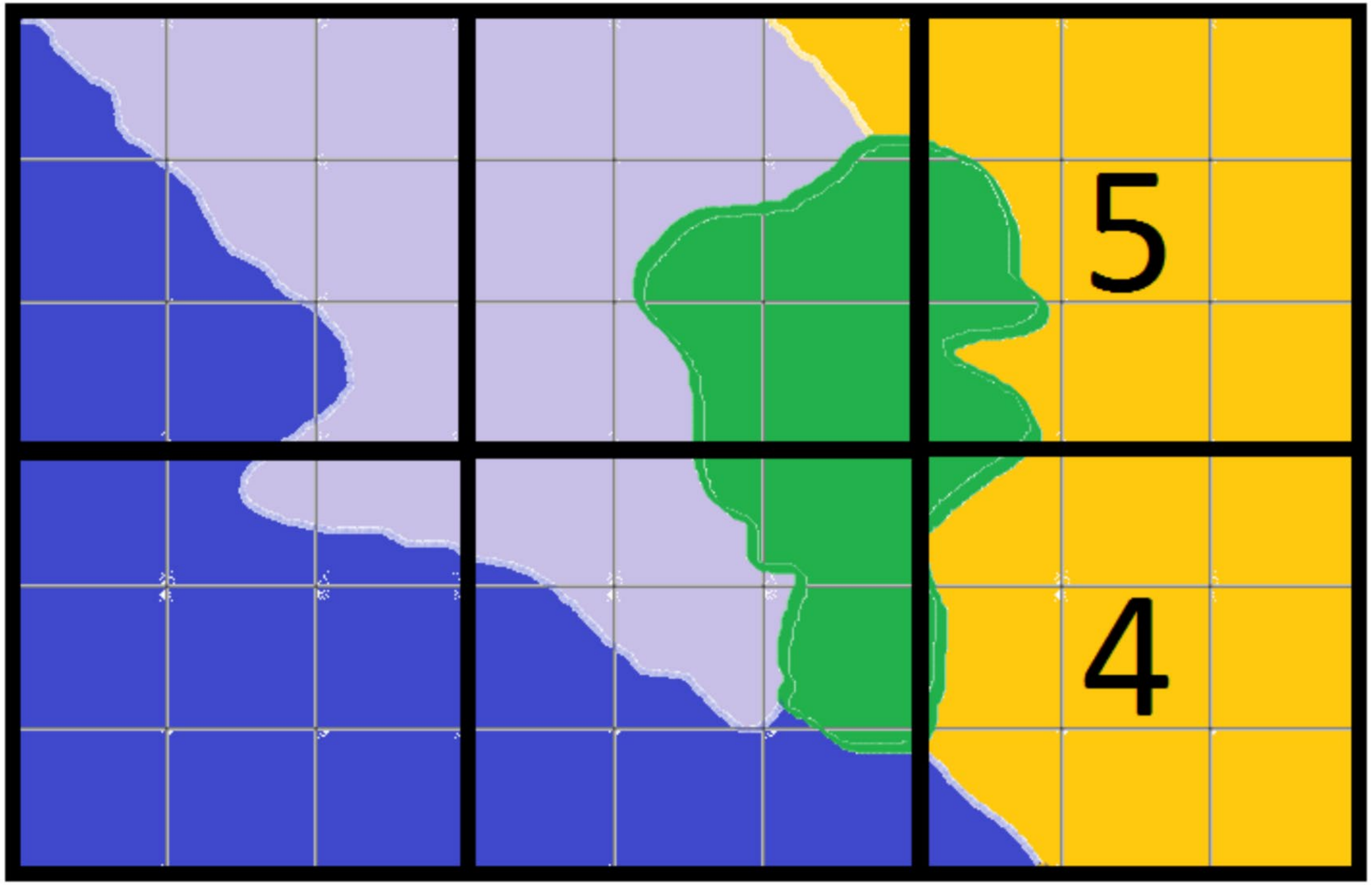
For 'Winner Takes All' coverage, what colour should cell 2 be?



For 'Blue Dominates' coverage, what colour should cell 3 be?



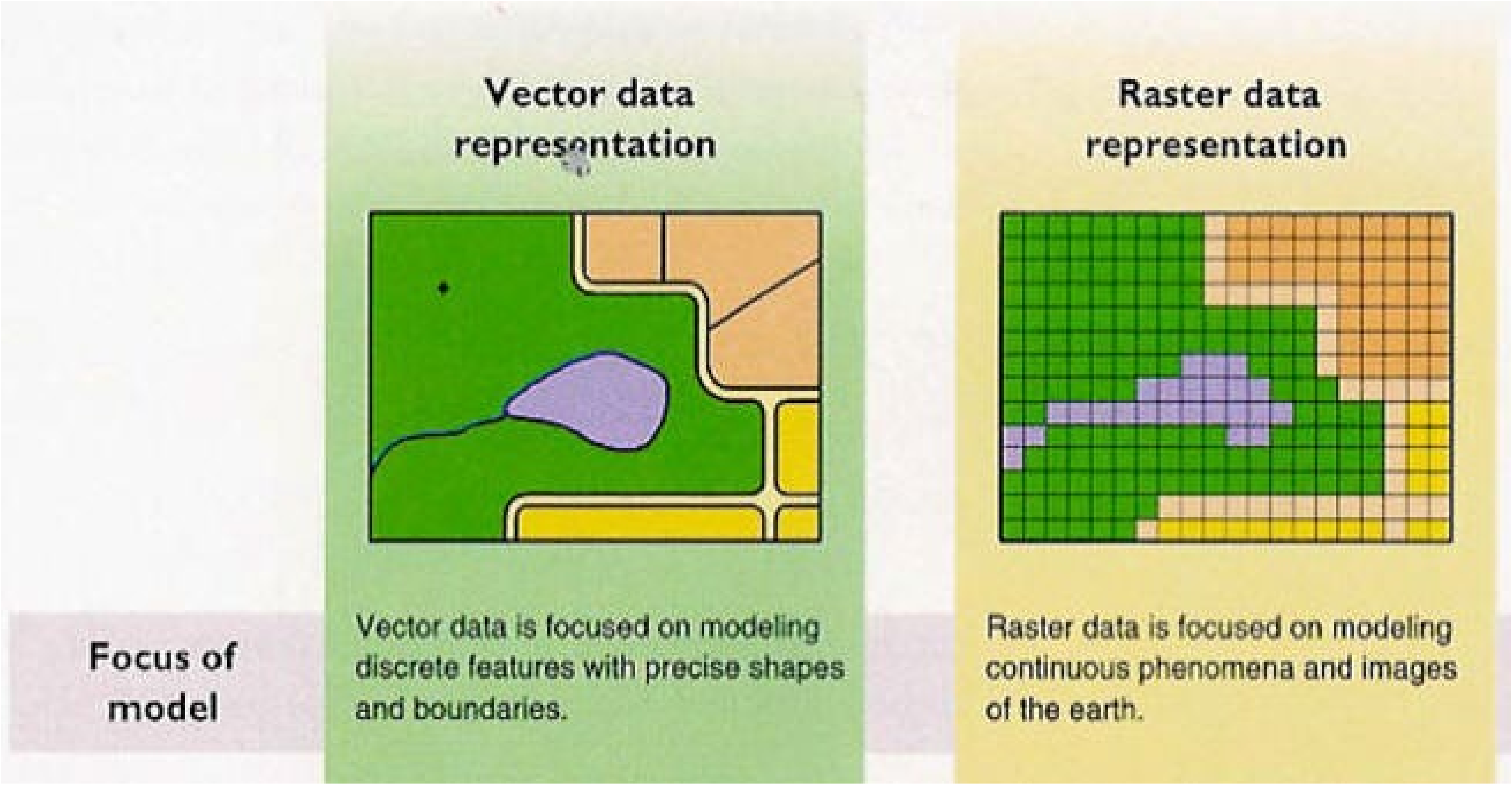
For 'Blue Dominates' coverage, what colour should cell 4 be?



The blue dominate rule seems weird.

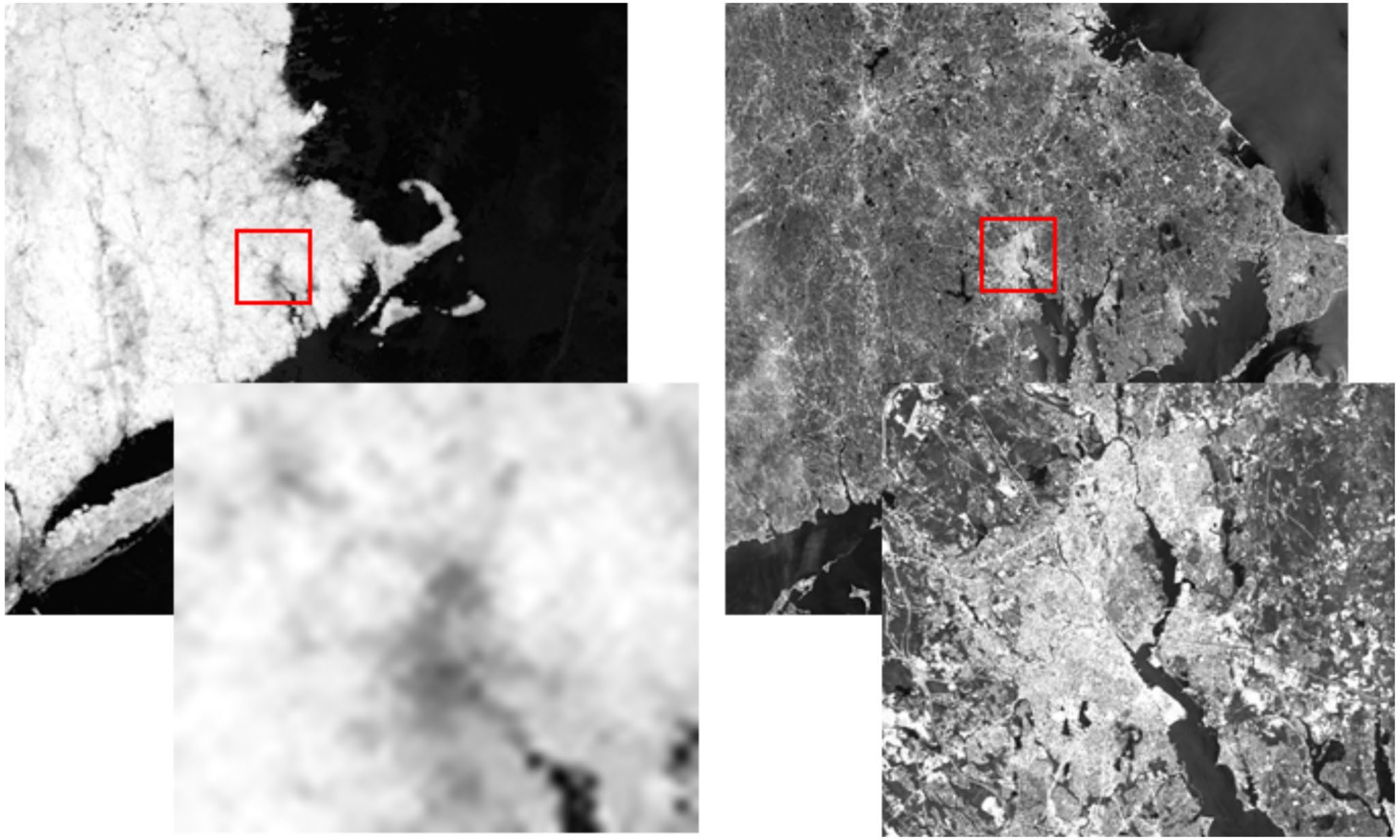
When would you actually use it?

Choice of Vector vs. Raster



http://map.sdsu.edu/geog104/lecture/unit-2.htm

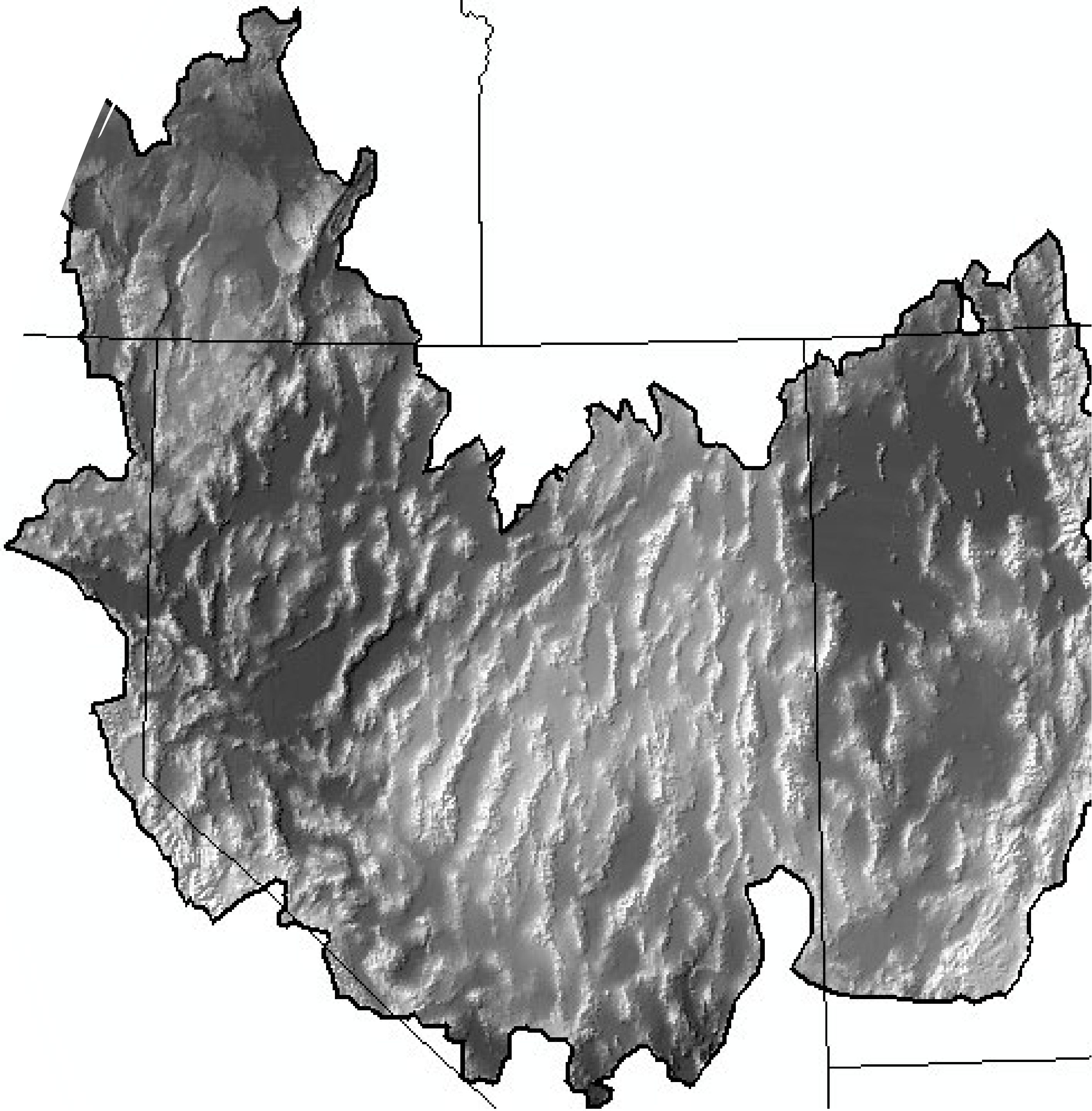
Why Don’t We Use 1 m (or finer) Resolution for Every Raster Dataset?



Advantages of Raster Data

- Represents a data surface - every location within the raster extents has a value.
- Sometimes smaller file size than shapefiles containing the same amount of data.
- Looks good on a map…

  if you're not close to the raster resolution.

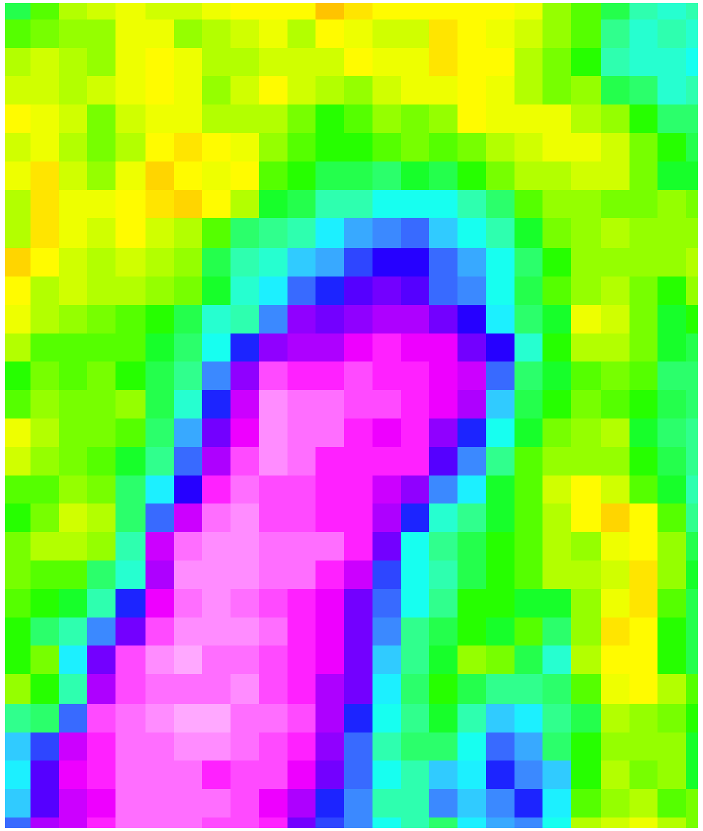


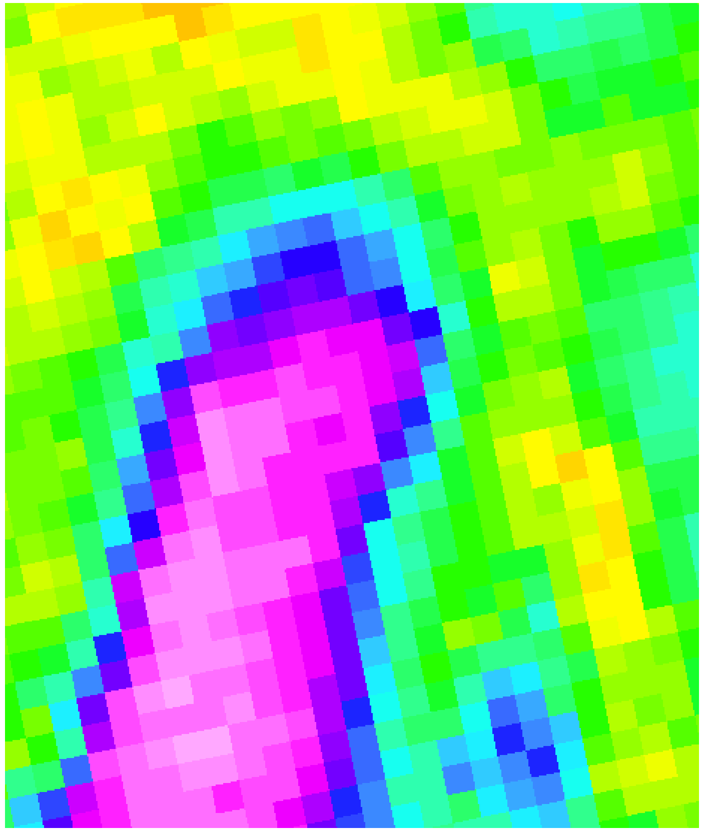
[Possible] Disadvantages of Raster Data

What shape is a pixel?

- Why is this important when converting between coordinate systems?

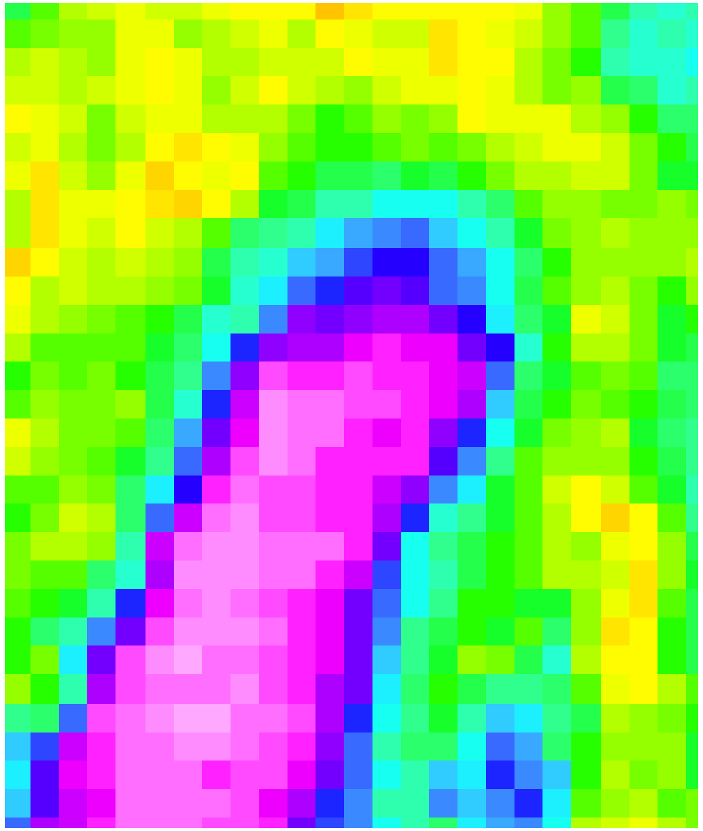
Transformations are destructive (irreversible)

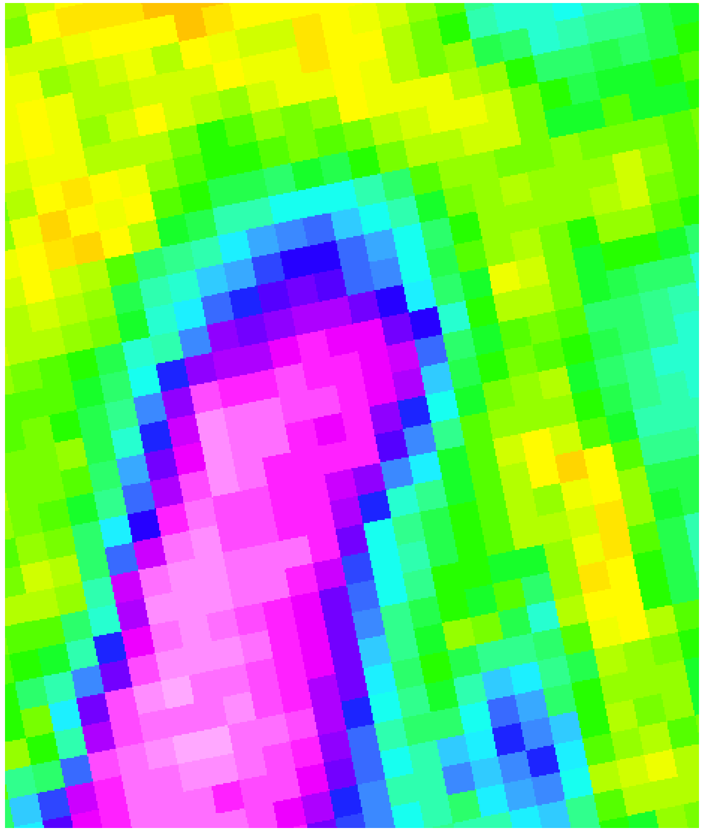




Disadvantages of Raster Data

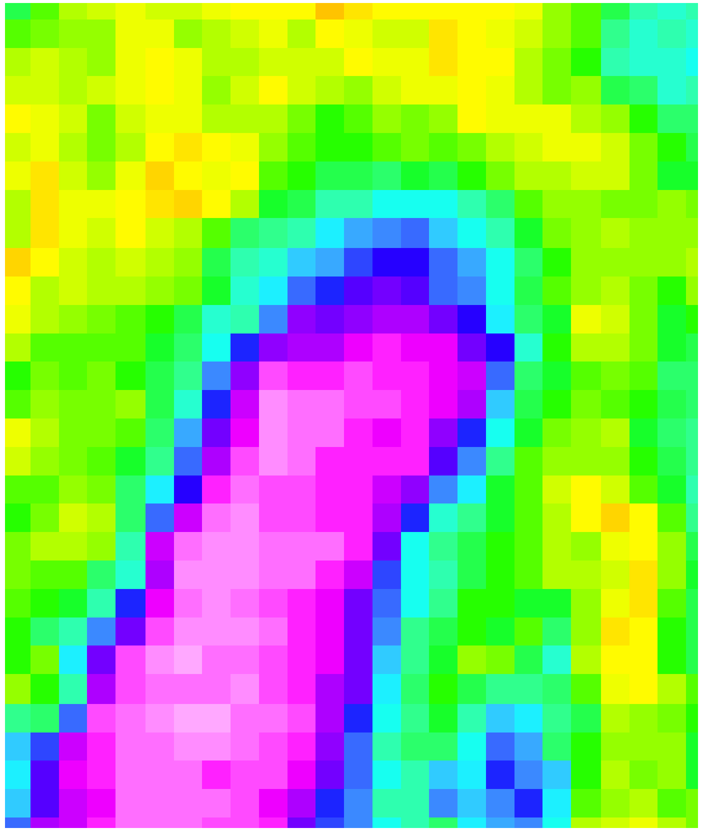
- Changing coordinate system alters the data

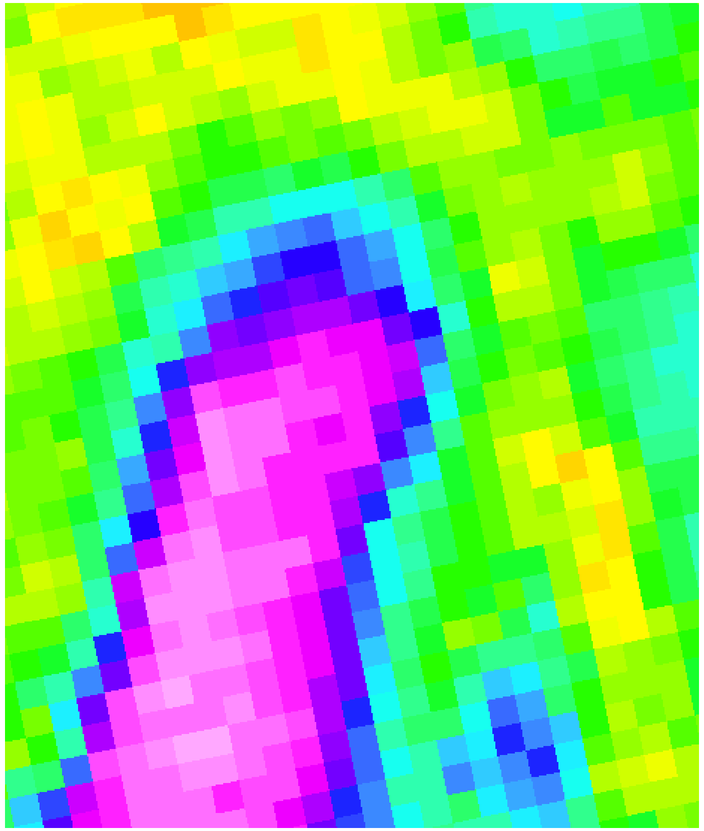




Disadvantages of Raster Data

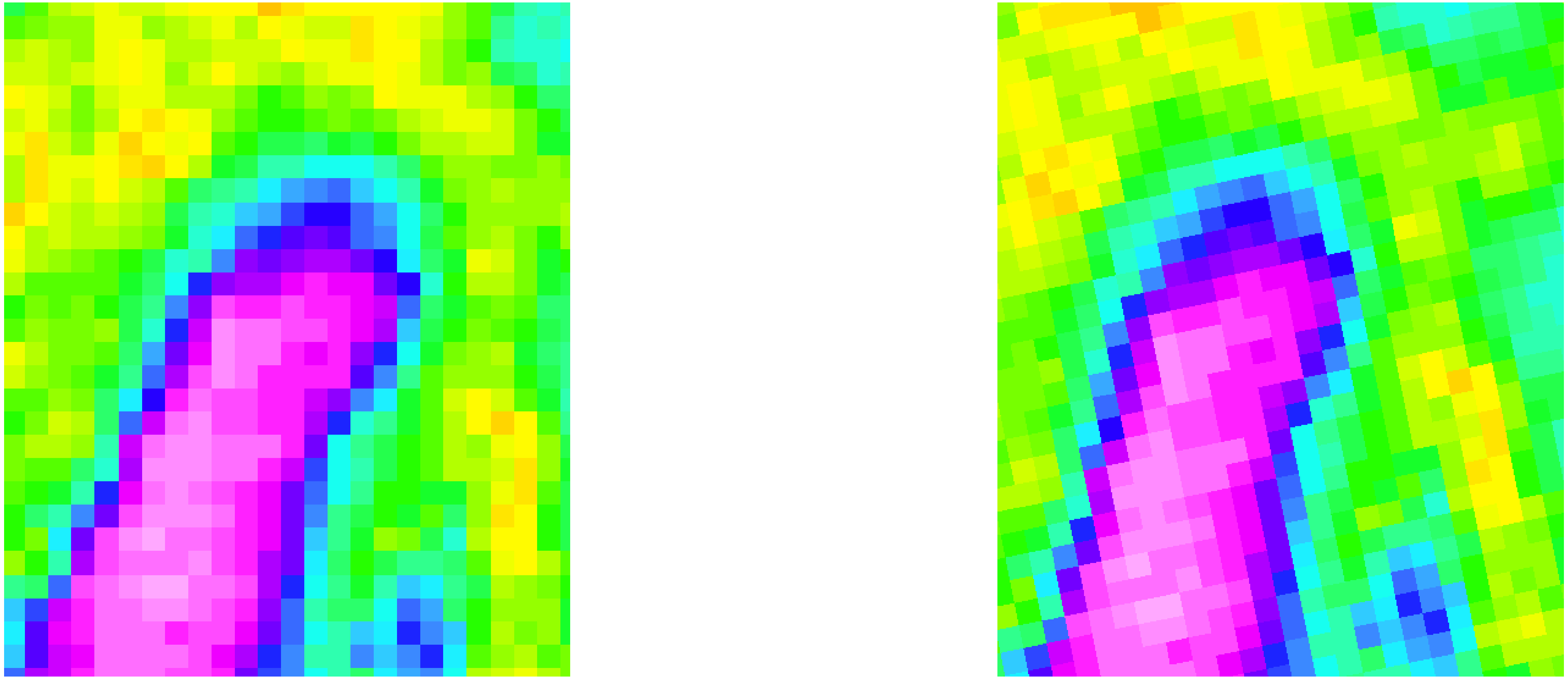
- Zooming can accentuate pixelation





Disadvantages of Raster Data

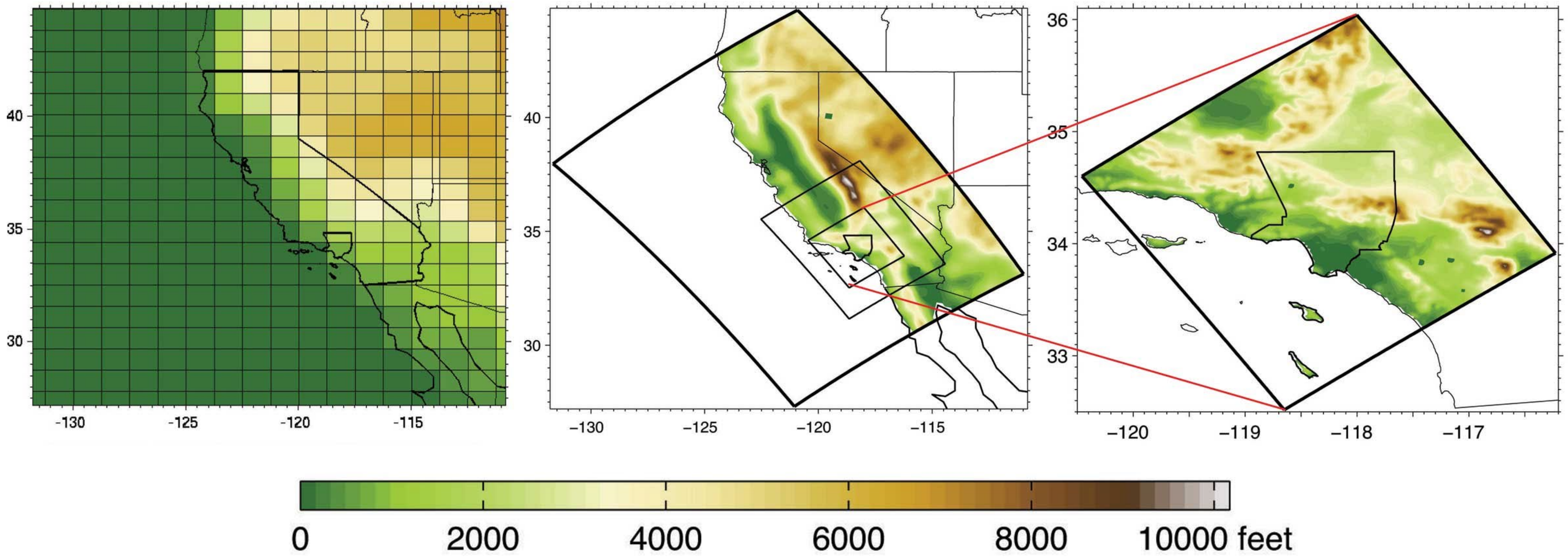
- Decreasing or increasing cell size requires interpolation



Disadvantages of Raster Data

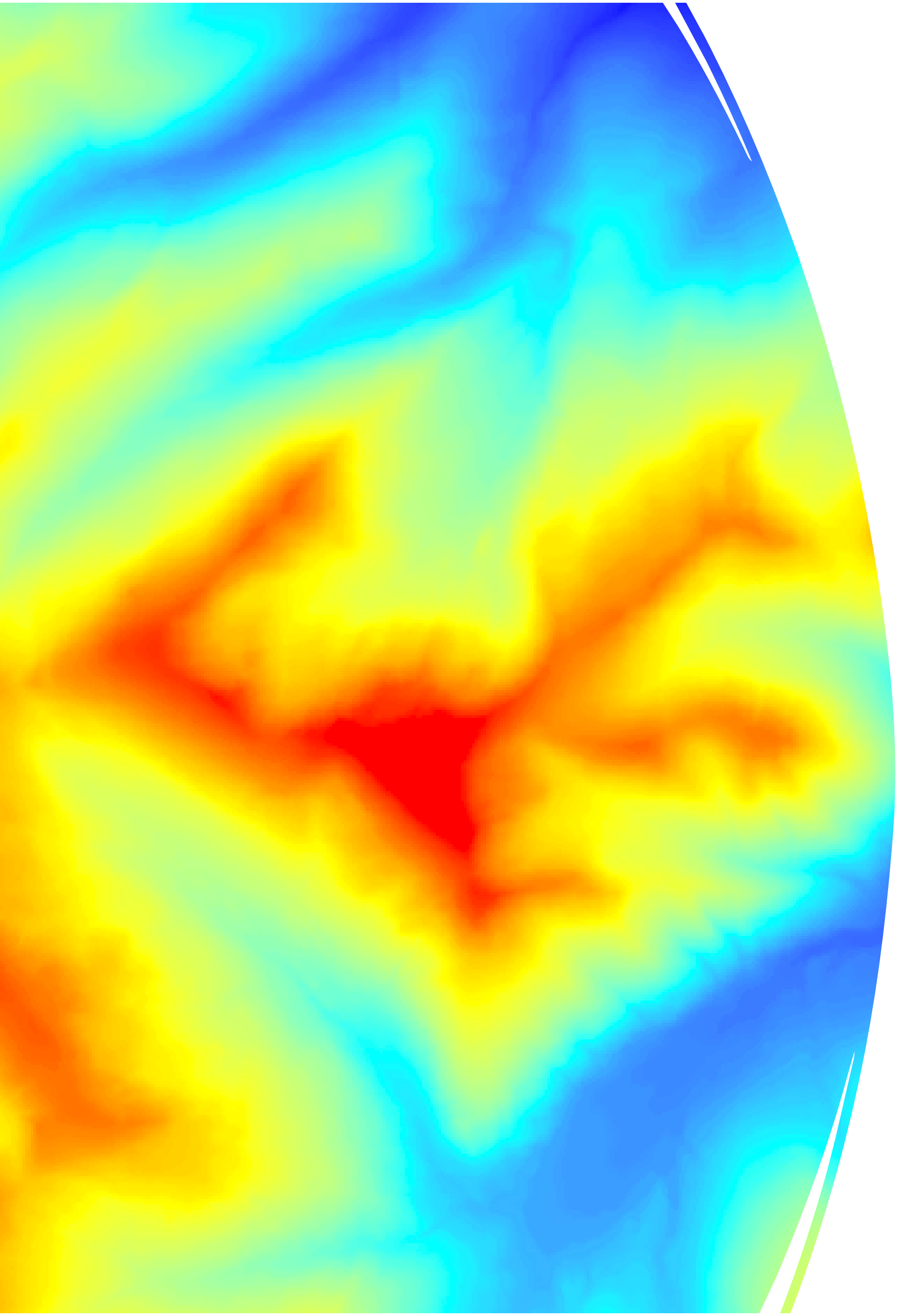
- Increasing cell size (aggregating) is lossy.
- Remember our rasterizing rules?

Grain is important



What impact would these different considerations of elevation have on a model being run at these different extents?

https://www.youtube.com/watch?v=vTgP3o4-UCM



Types of Raster Data

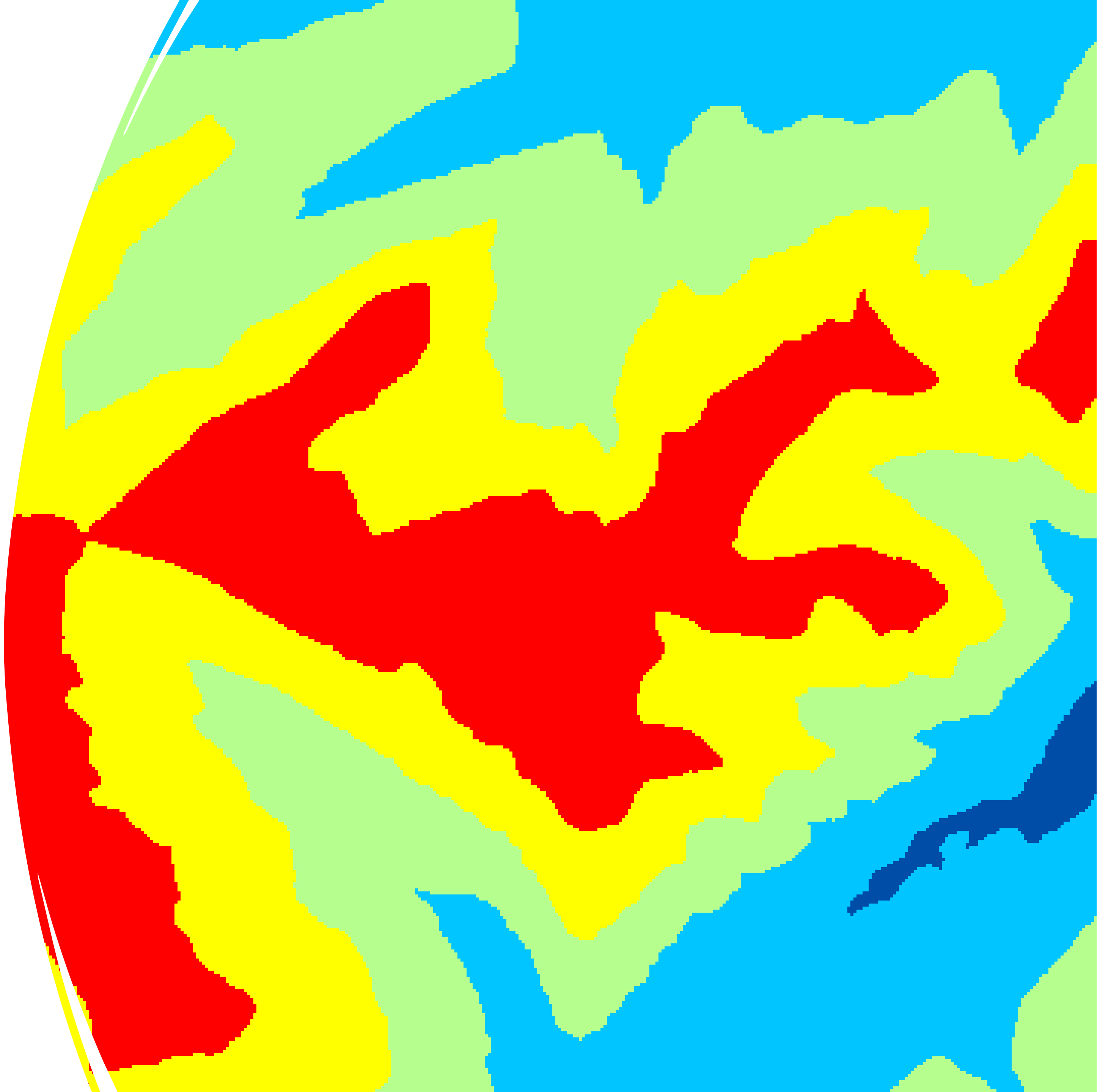
Continuous

- Represents a surface or data that is constant
- Floating point or Integer
- Examples:
  - Topography,
  - Satellite Imagery,
  - Proximity

Types of Raster Data

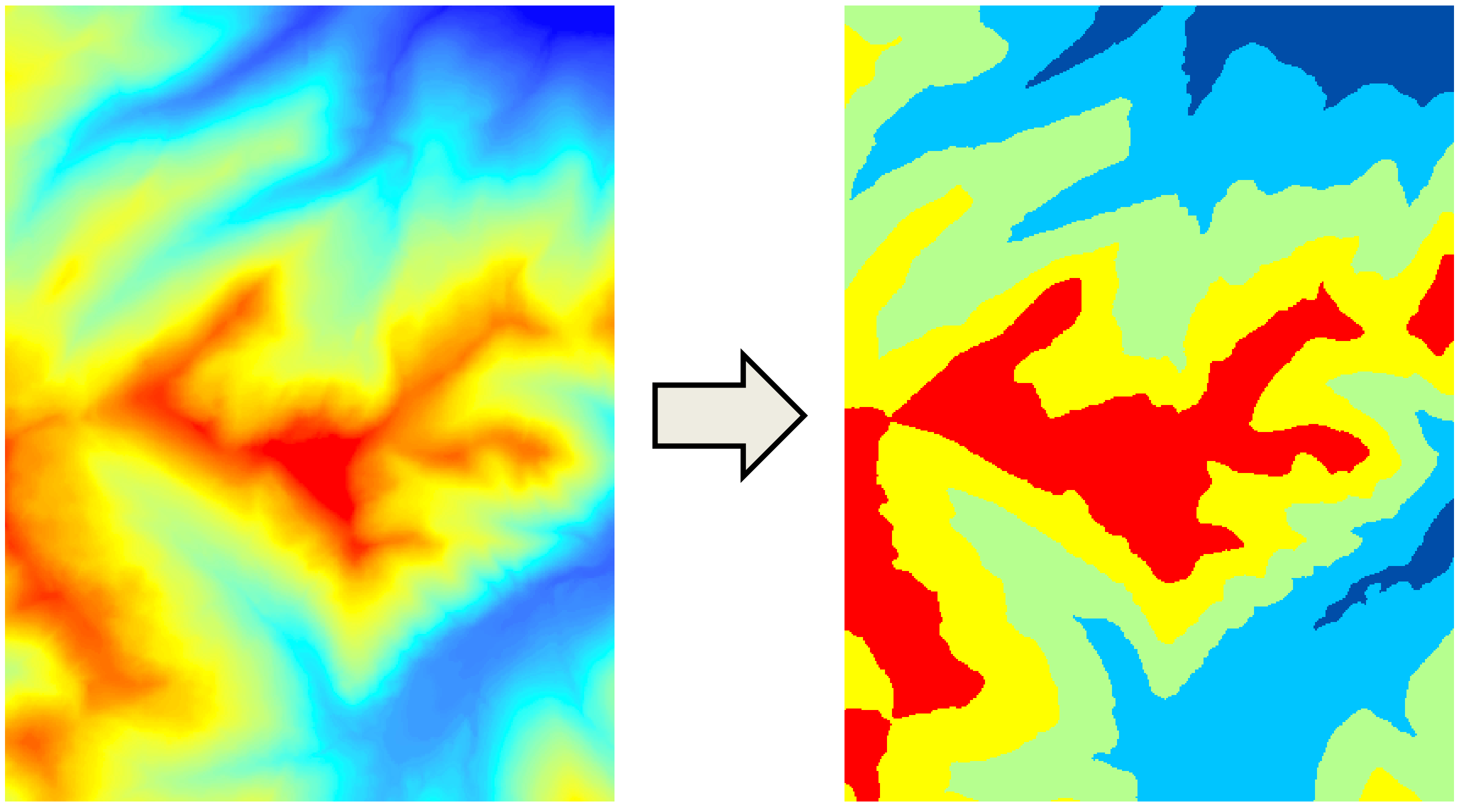
Discrete

- Could be binary (1,0)
- Could be limited number of unique values
- Examples:
  - Land cover classification,
  - Suitability,
  - Presence/absence



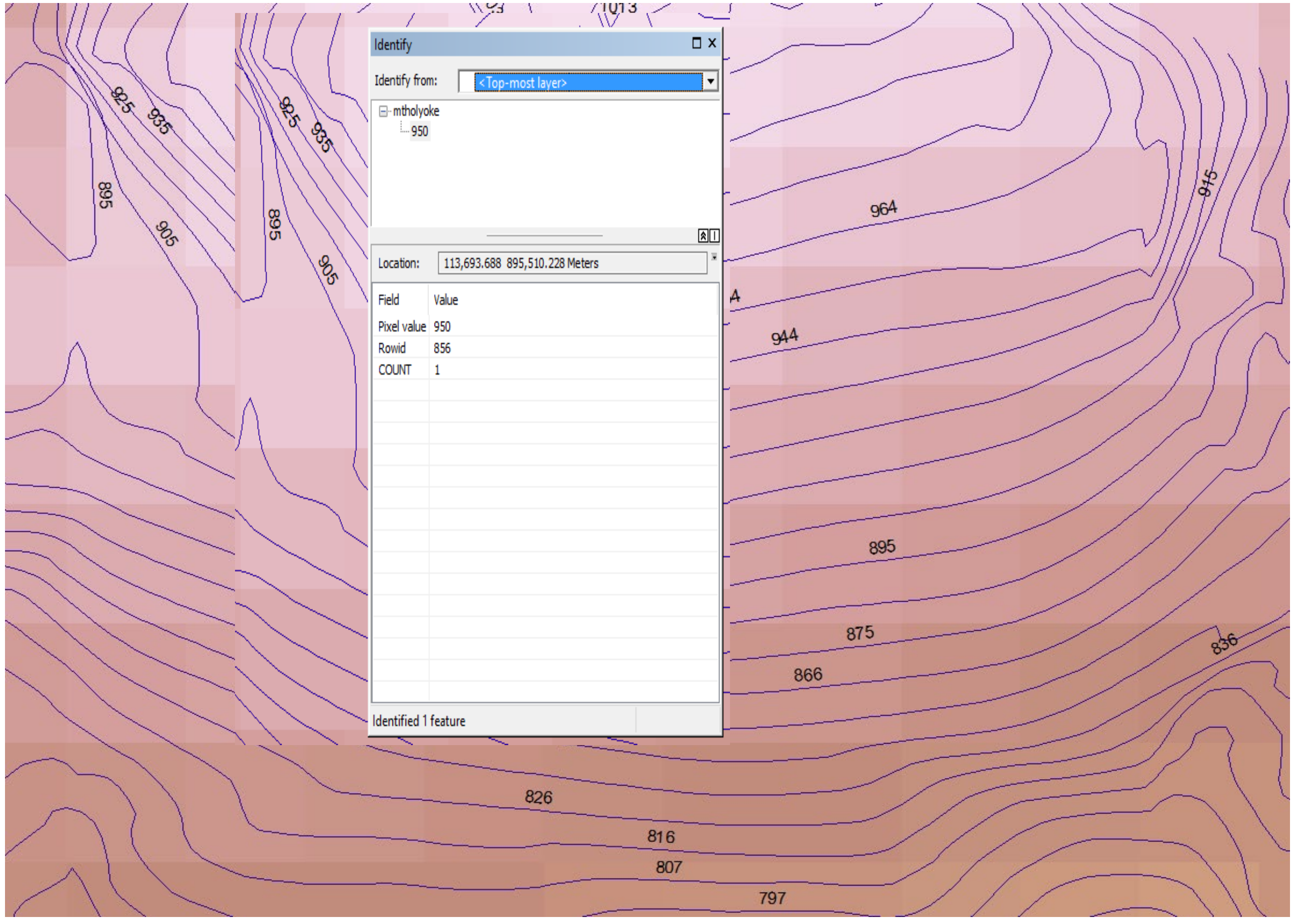
Reclassifying continuous to discrete results in loss of information.

It is non-reversible



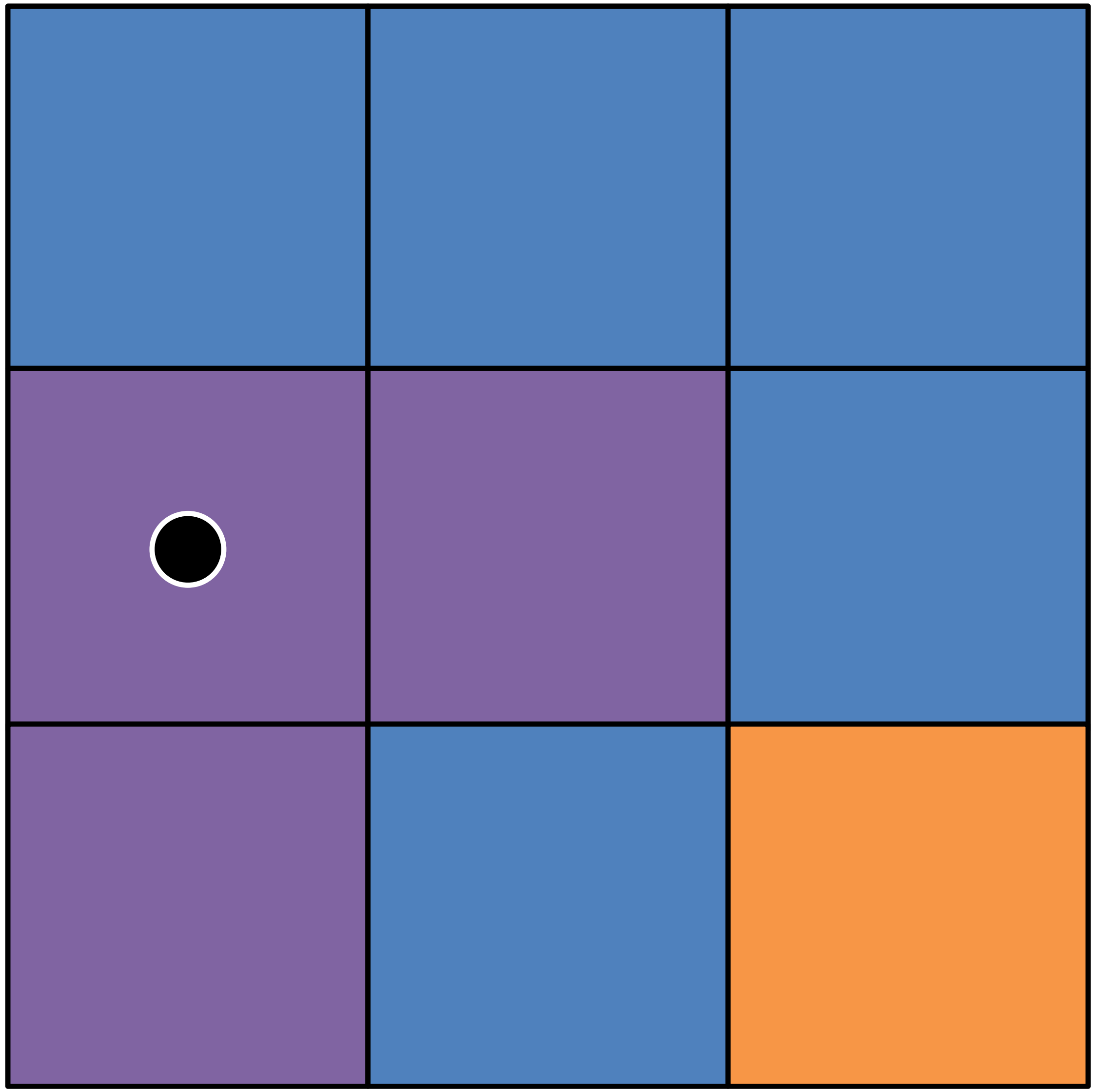
Working With Rasters

Identify cell values



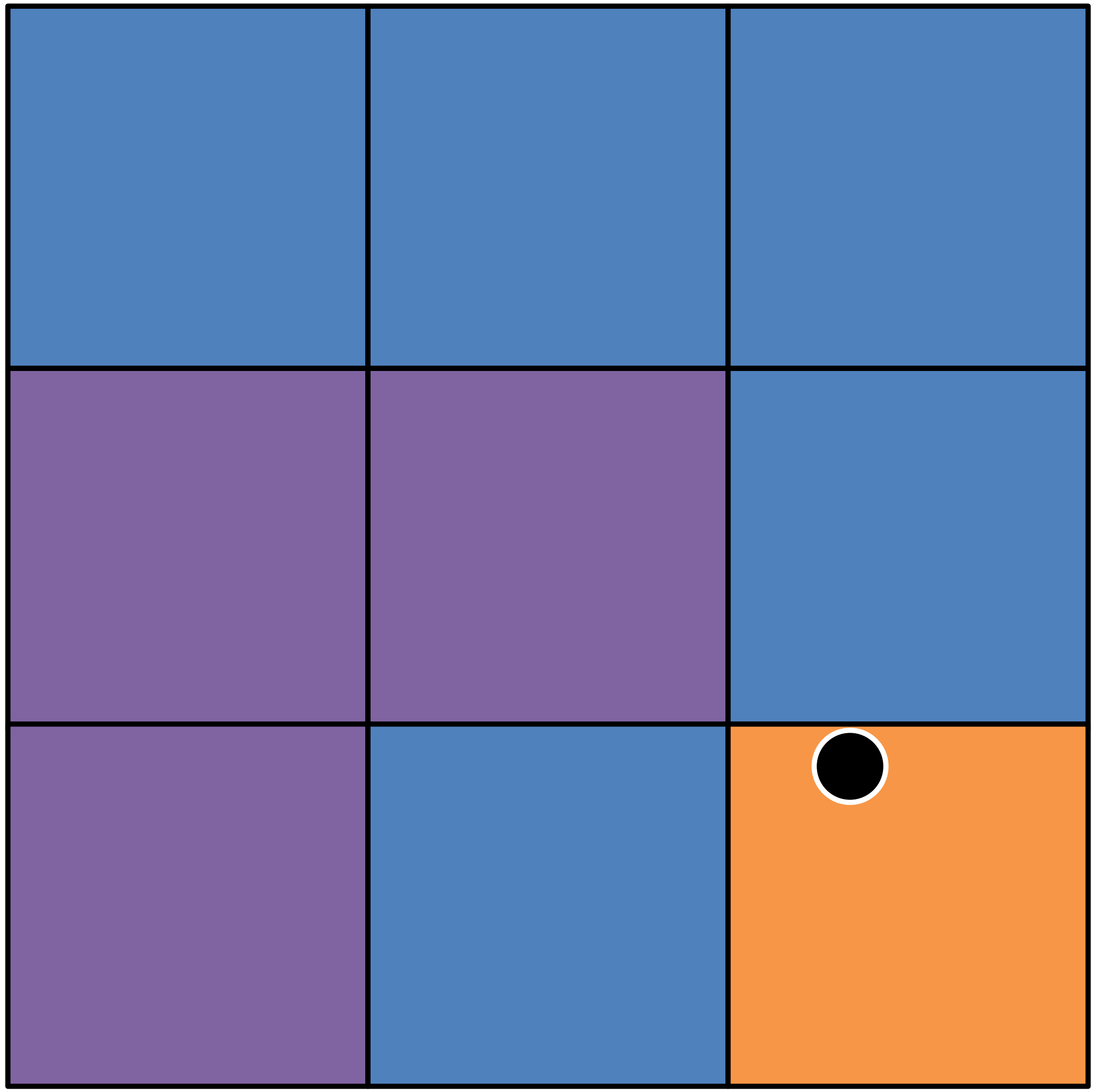
Querying a Cell Value: By Cell Index

What is the value of the cell at (1, 2)?

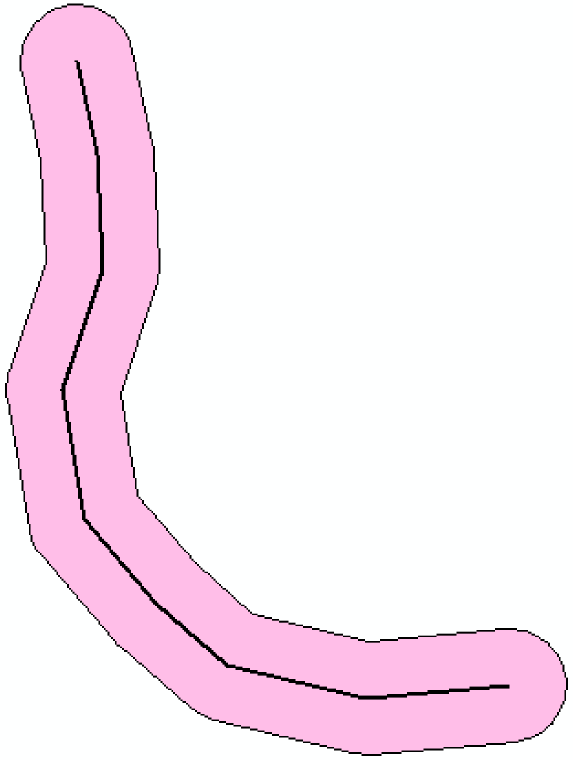


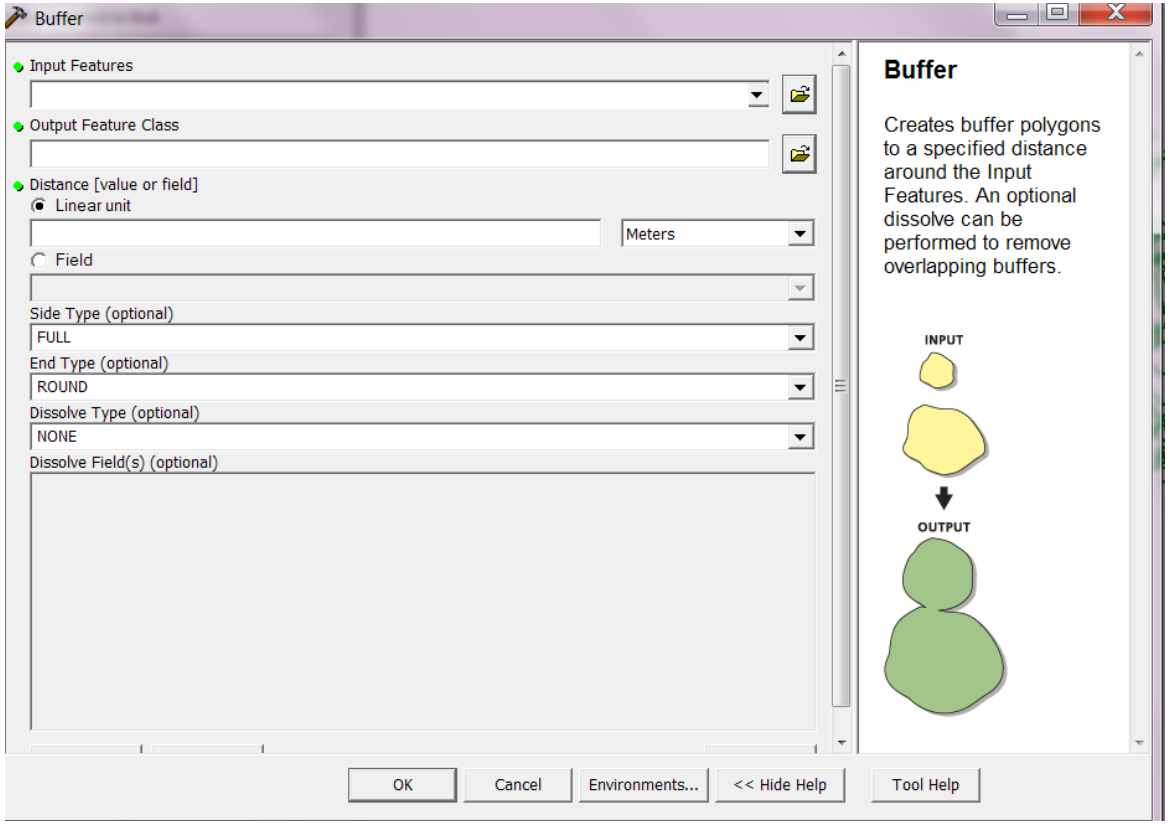
Querying a Cell Value: By Coordinate

What is the value of the cell at (253.112, 67.435)?

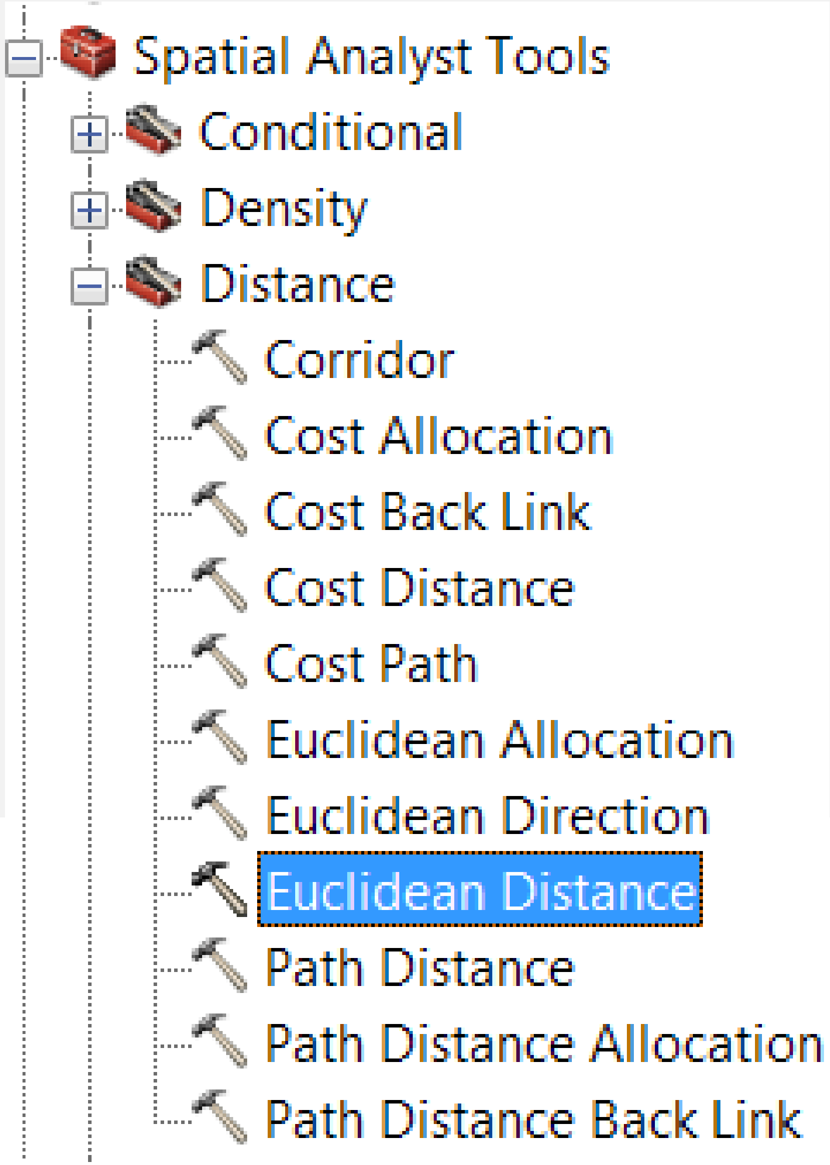


Distances: Vector and Raster





Vector Analysis: Buffers



Raster Analysis: computing distance

Distances and Buffers

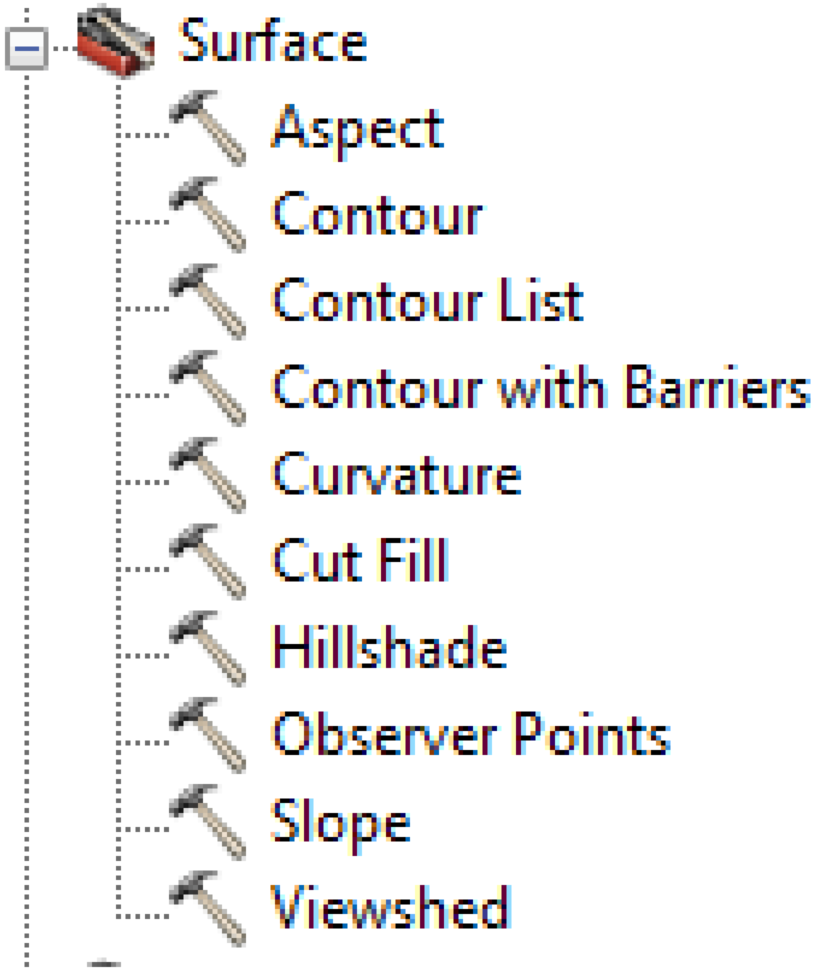
Vector Data

- Polygons are spatially discrete objects.
  - There can be empty space between polygons.
- **Buffering**
  - The boundary of the region within a specified distance.
  - Divides the surface into areas that are inside/outside the critical distance.
    - This is like a mask

Raster Data

- Rasters cover an entire surface
  - Cells completely tile the surface.
- **Distance**
  - Calculates a value of the (usually) Euclidean distance from the feature to the center of each cell.
- **Mask**
  - Cells have value TRUE if they are within the critical distance

Topographic (Surface) Analysis



Hillshade

- Creates a shaded relief map from a DEM

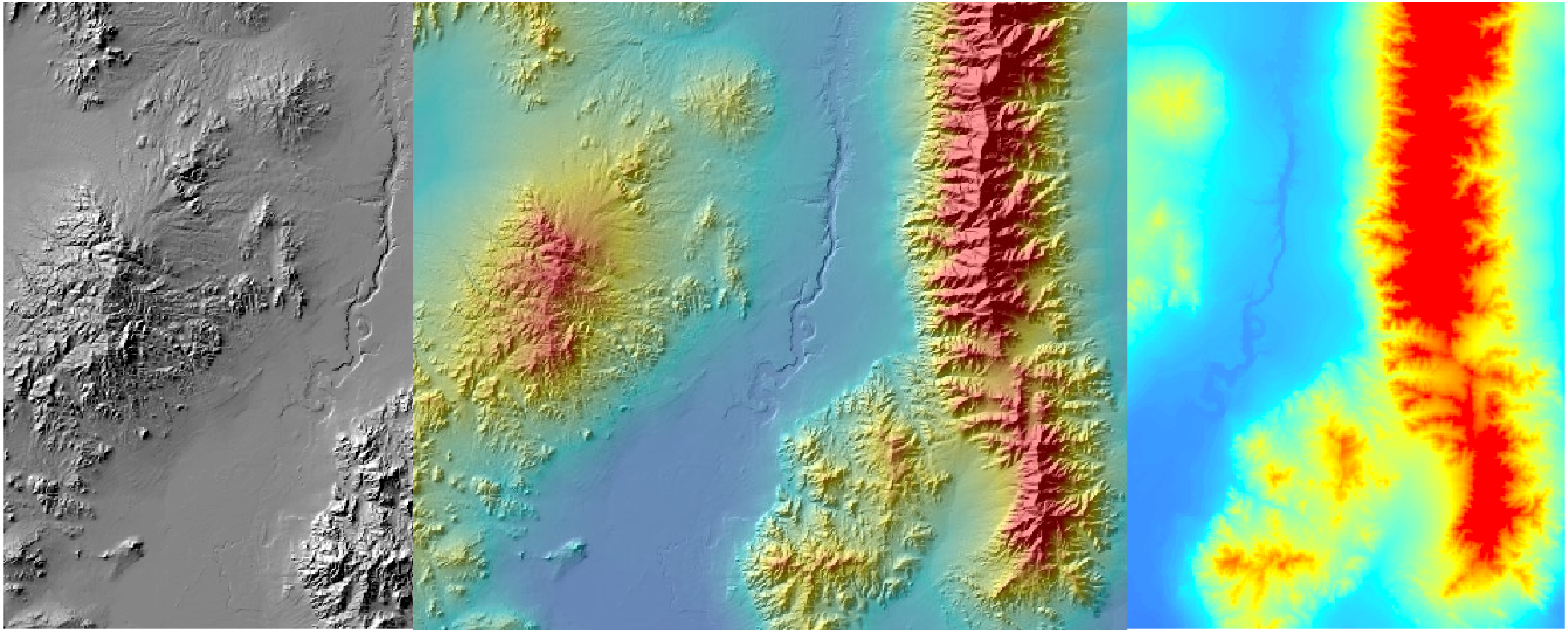
Slope

- Creates a slope map (degree or percent) from a DEM

Aspect

- Creates a slope direction (0-360˚) from a DEM
- Can also be in radians

Hillshade + DEM



Boolean Algebra and Raster Calculations

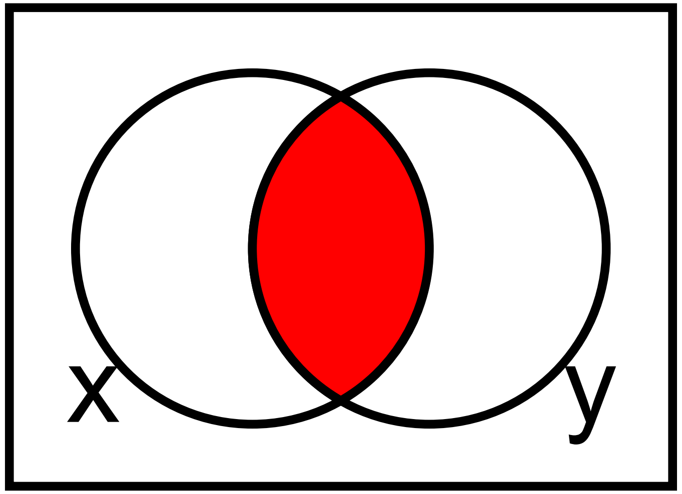
TABLE 1-1 Basic Identities of Boolean Algebra

(1) $x + 0 = x$	(2) $x \cdot 0 = 0$
(3) $x + 1 = 1$	(4) $x \cdot 1 = x$
(5) $x + x = x$	(6) $x \cdot x = x$
(7) $x + x' = 1$	(8) $x \cdot x' = 0$
(9) $x + y = y + x$	(10) $xy = yx$
(11) $x + (y + z) = (x + y) + z$	(12) $x(yz) = (xy)z$
(13) $x(y + z) = xy + xz$	(14) $x + yx = (x + y)(x + z)$
(15) $(x + y)' = x'y'$	(16) $(xy)' = x' + y'$
(17) $(x')' = x$	

http://www.cs.science.cmu.ac.th/person/chumphol/204231/Basic%20Identities%20of%20Boolean%20Algebra.jpg

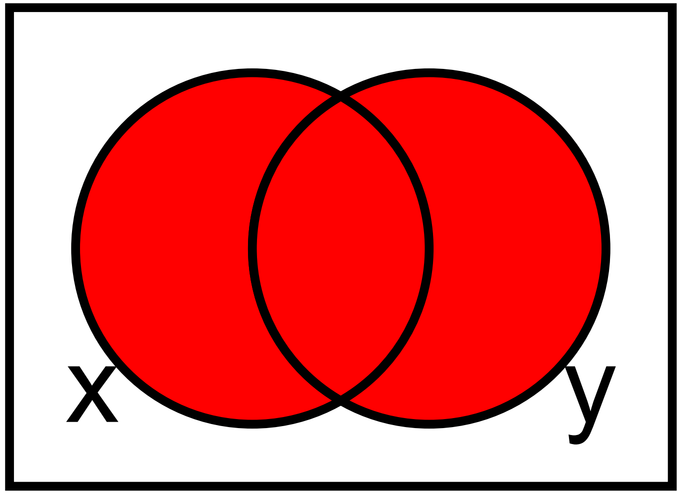
Boolean Algebra: Set Theory Perspective

x AND y



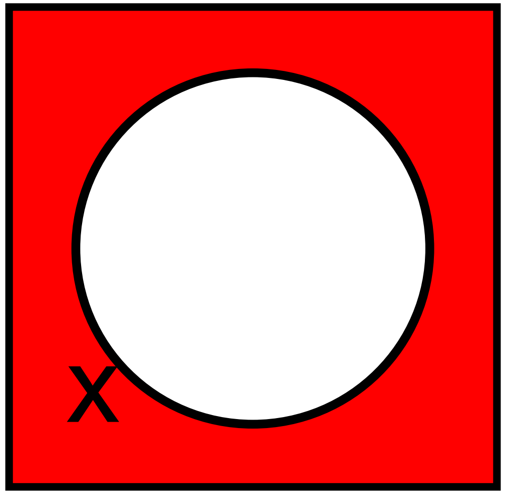
$x \wedge y$

x OR y



$x \vee y$

NOT x

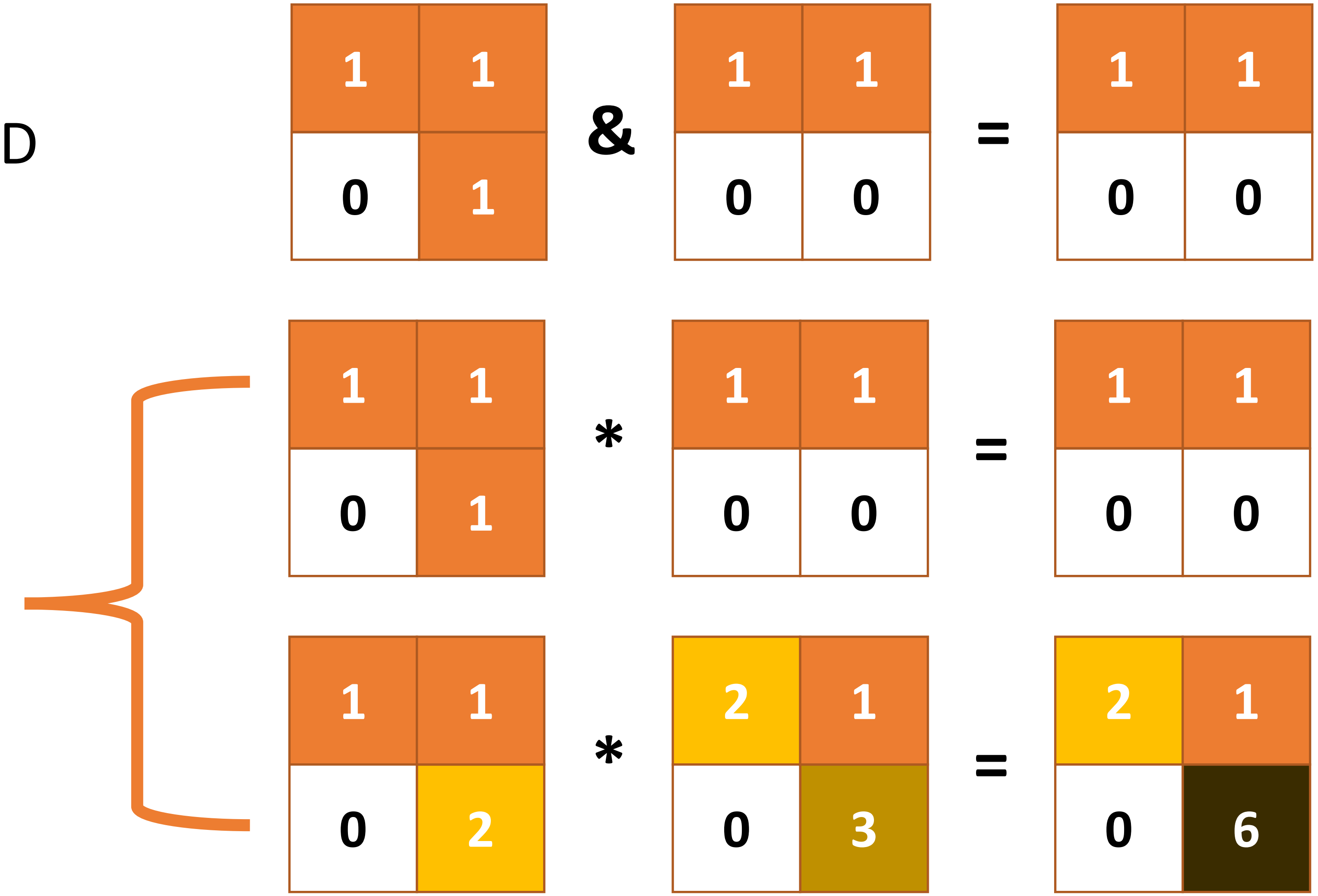


$\neg x$

Boolean AND vs. Raster Calculator Multiply

Boolean AND

Raster Multiply



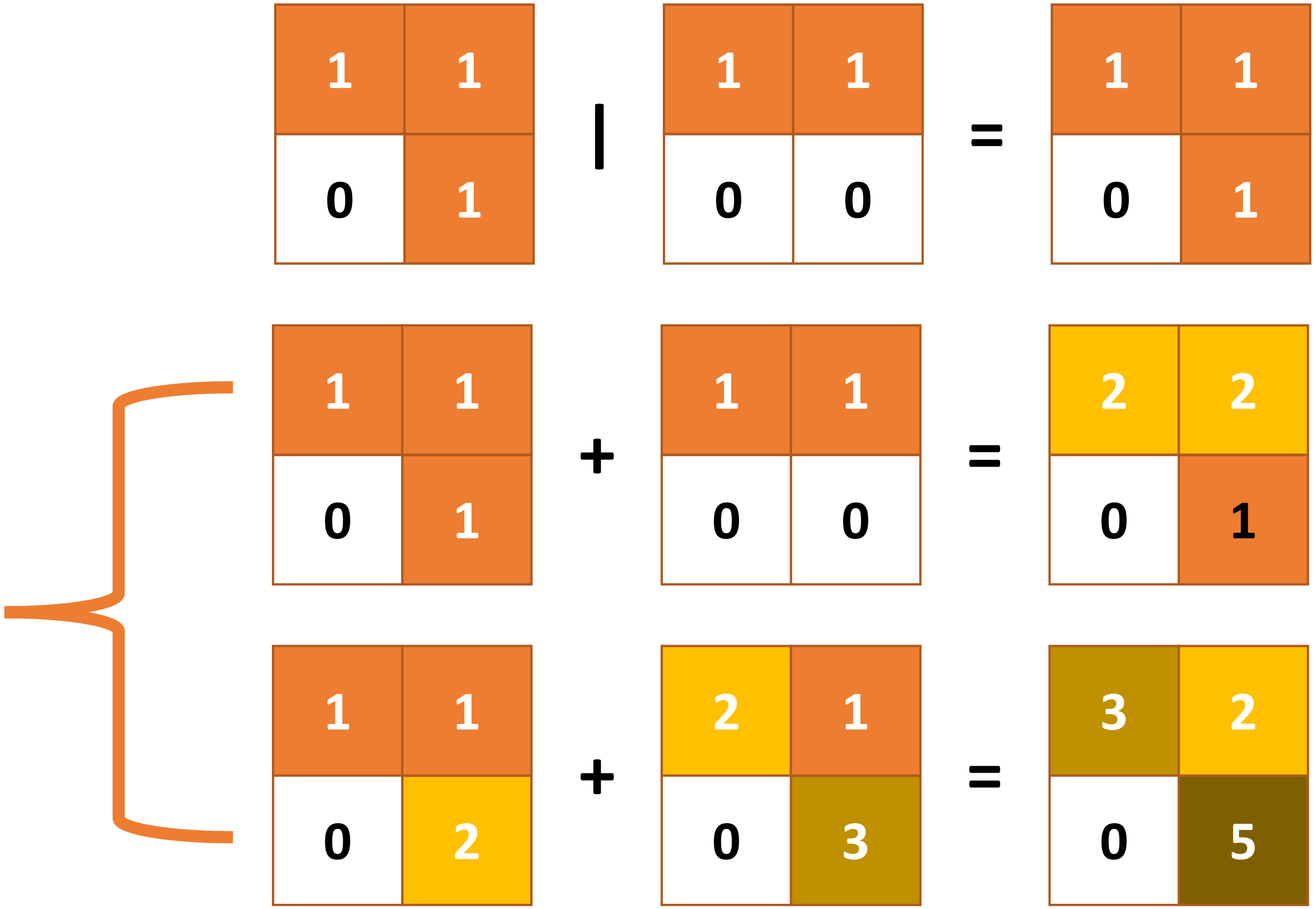
Boolean values are binary

Boolean OR vs. Raster Calculator Add

Boolean OR

Boolean values are binary

Raster Add



Watch out for Missing Data

$$\begin{bmatrix}1 & \text{NA}\\ 0 & 1\end{bmatrix} \;|\; \begin{bmatrix}1 & 1\\ 0 & 0\end{bmatrix} = \begin{bmatrix}1 & \text{NA}\\ 0 & 1\end{bmatrix}$$

$$\begin{bmatrix}1 & \text{NA}\\ 0 & 1\end{bmatrix} \;\&\; \begin{bmatrix}1 & 1\\ 0 & \text{NA}\end{bmatrix} = \begin{bmatrix}1 & \text{NA}\\ 0 & \text{NA}\end{bmatrix}$$

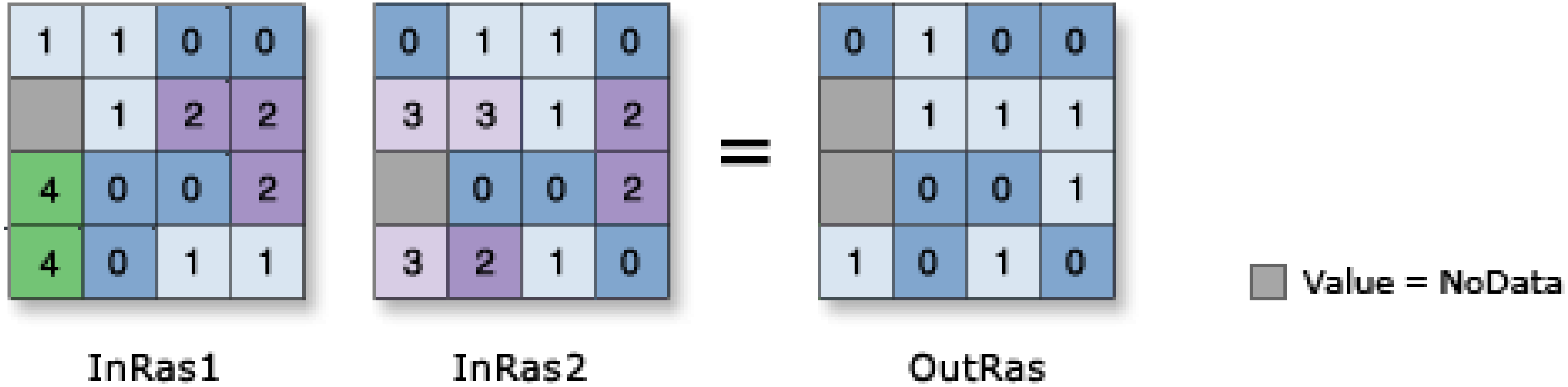
$$\begin{bmatrix}1 & 1\\ 0 & 2\end{bmatrix} + \begin{bmatrix}\text{NA} & 1\\ 0 & \text{NA}\end{bmatrix} = \begin{bmatrix}\text{NA} & 2\\ 0 & \text{NA}\end{bmatrix}$$

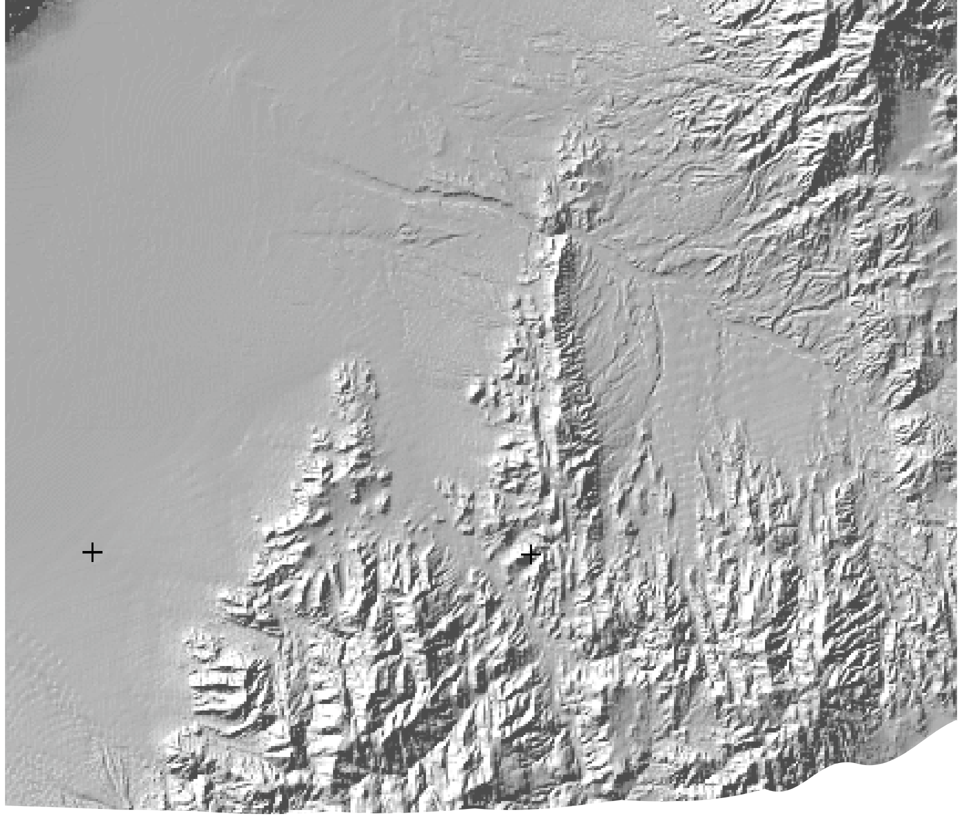
& (Boolean And)

Summary

Performs a Boolean And operation on the cell values of two input rasters.

Illustration



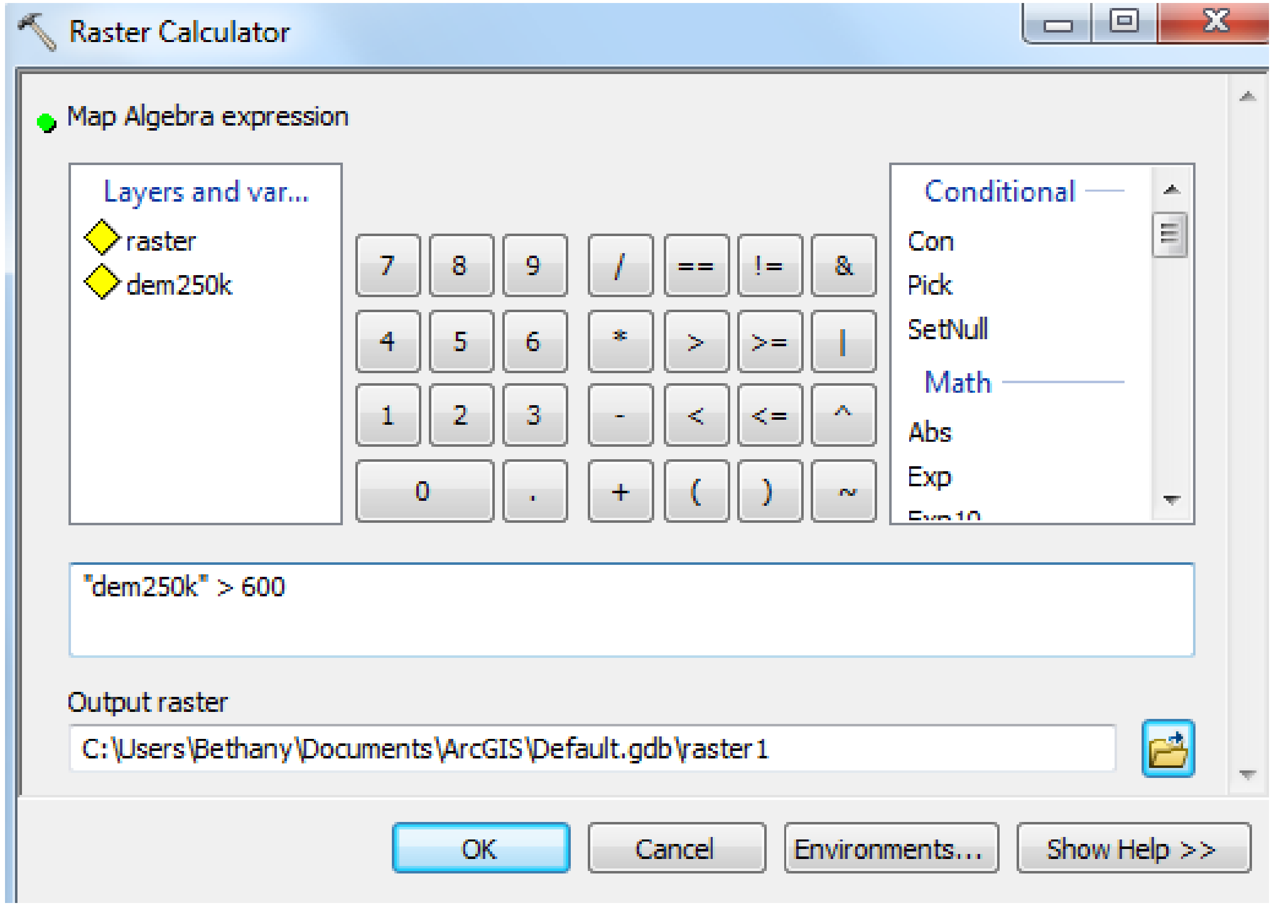


ArcGIS’s Raster Calculator

Raster Calculator

Raster grid algebra (e.g., create a new grid of elevation greater than 600 m)

Combine suitability layers using ‘AND’ or ‘OR’ statements

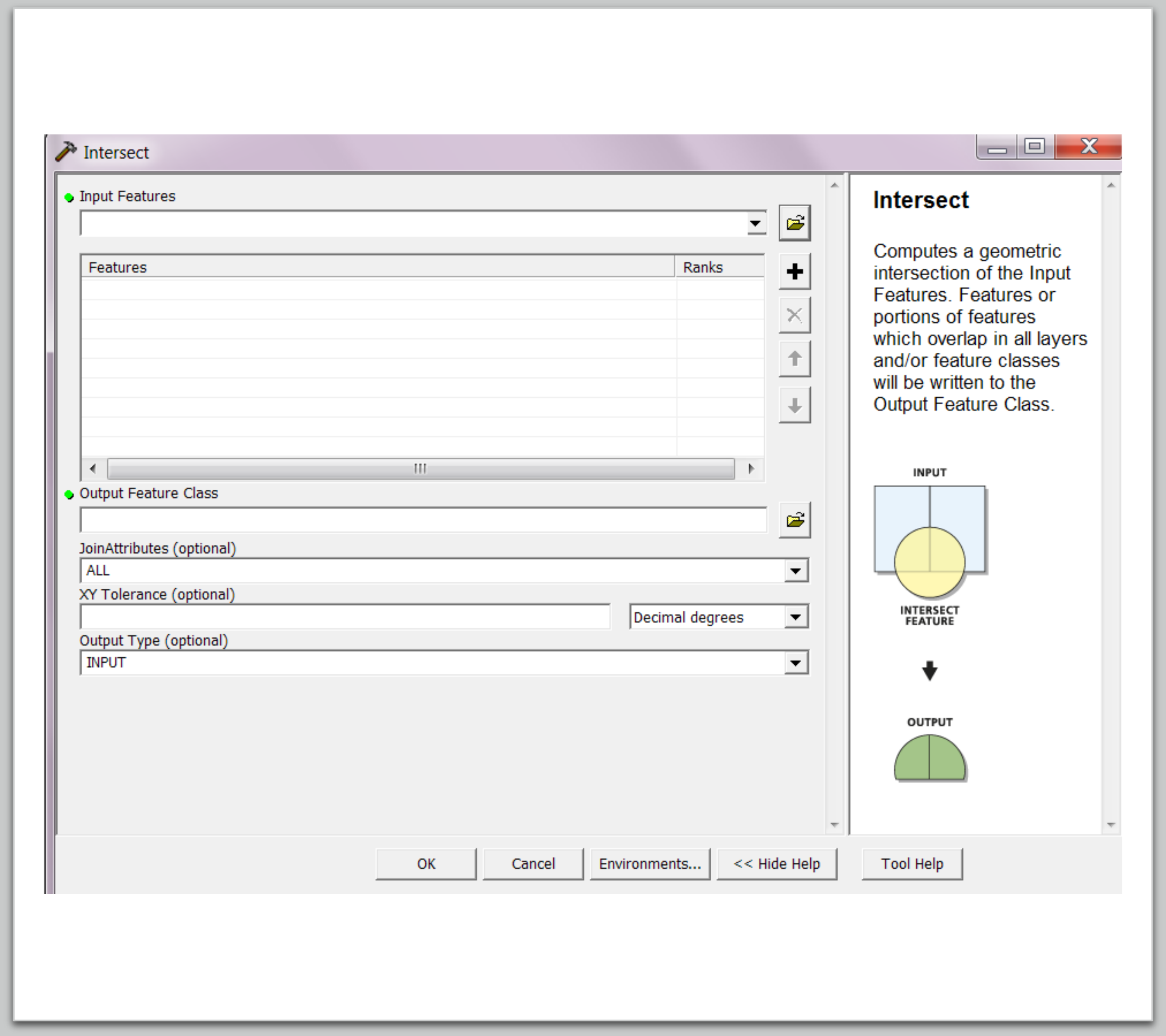


Spatial Data Operators, Set Theory, Boolean Algebra

Vector Operator	Set Theory	Boolean	ArcMap	English
Union	AUB	OR A|B	Dissolve	Elements that are in at least one of A or B
Intersection	A∩B	AND A&B	Clip	Elements are on both A and B
Symmetric Difference	AUB - A∩B	Exclusive OR, XOR A|B – A&B	Erase	Elements are in A or B, but not both

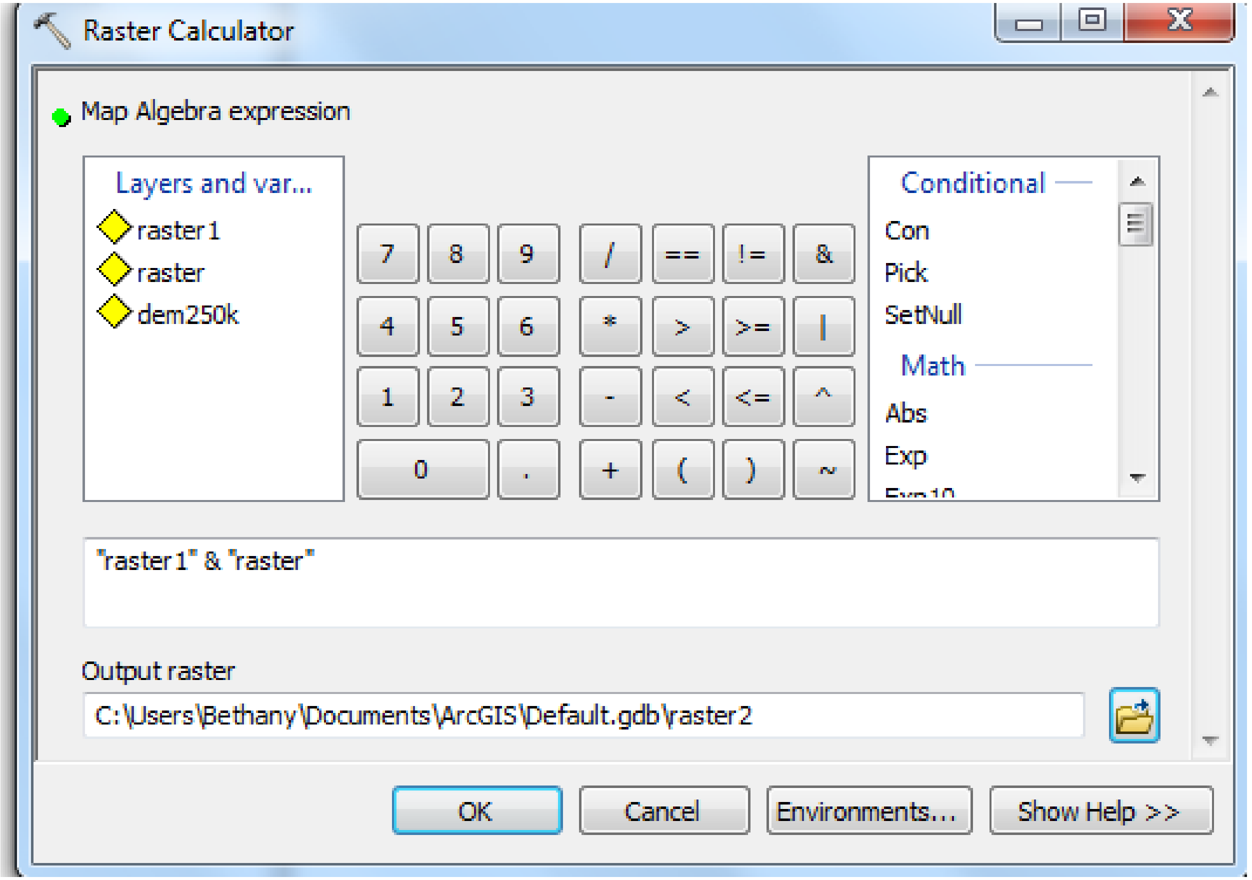
Vector Analysis: Intersect or Clip

Keep, or discard, overlapping regions.

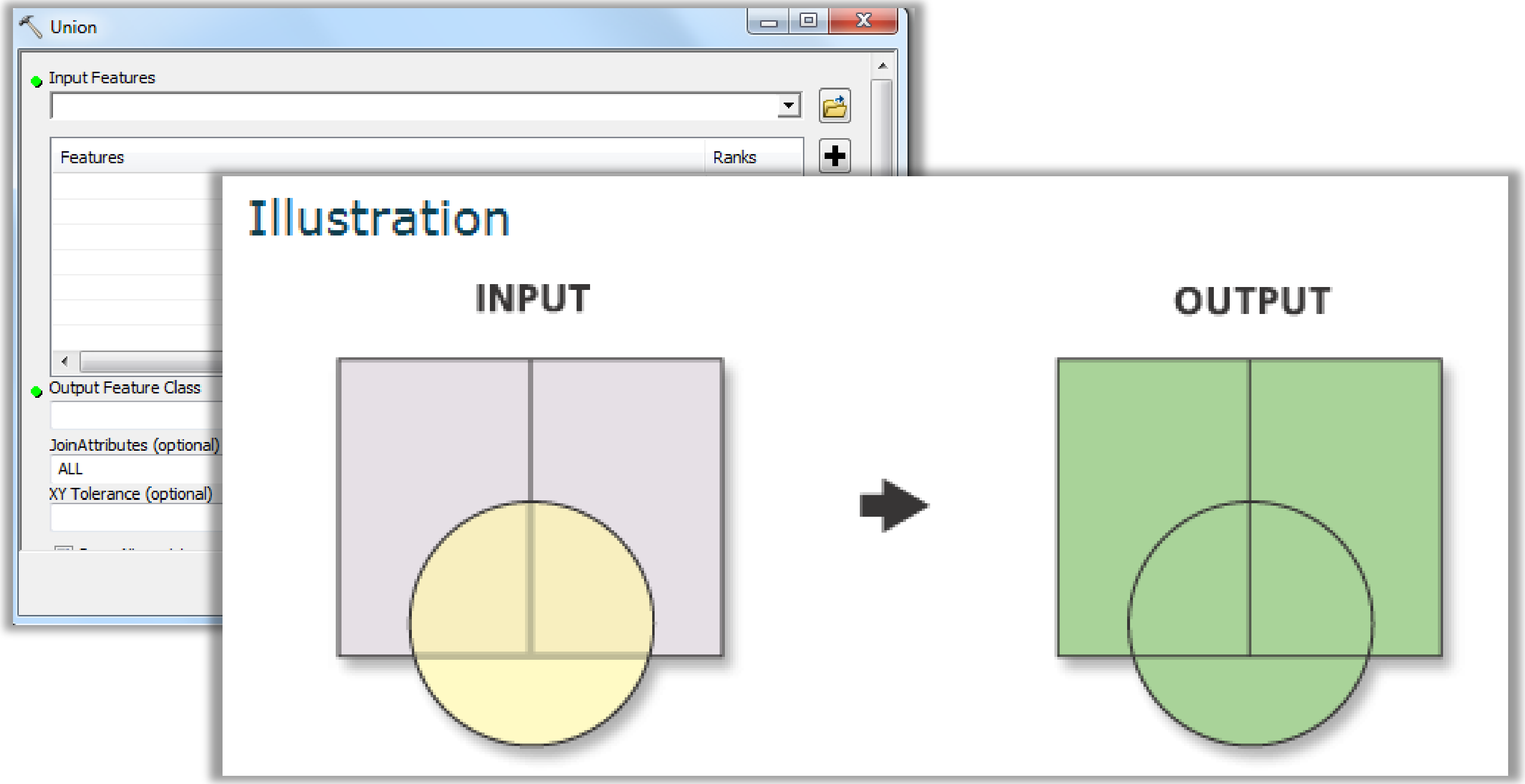


Raster Analysis: ‘AND’ statements

Multiply two raster layers (*usually one is binary)* to achieve a raster “intersect” or “erase”

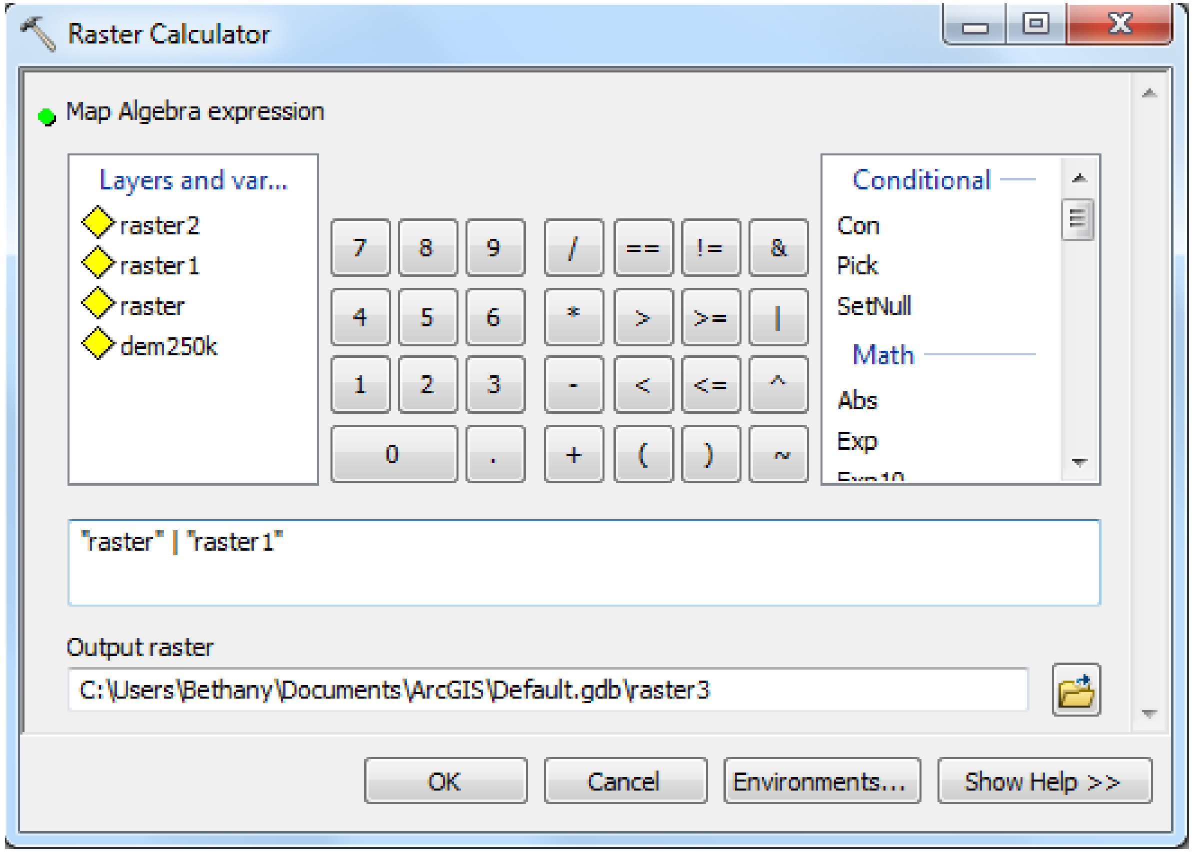


Vector Analysis: Union



Raster Analysis: Or

The | symbol ('OR') achieves a raster 'union'. All non-zero values get an output value of 1 = true

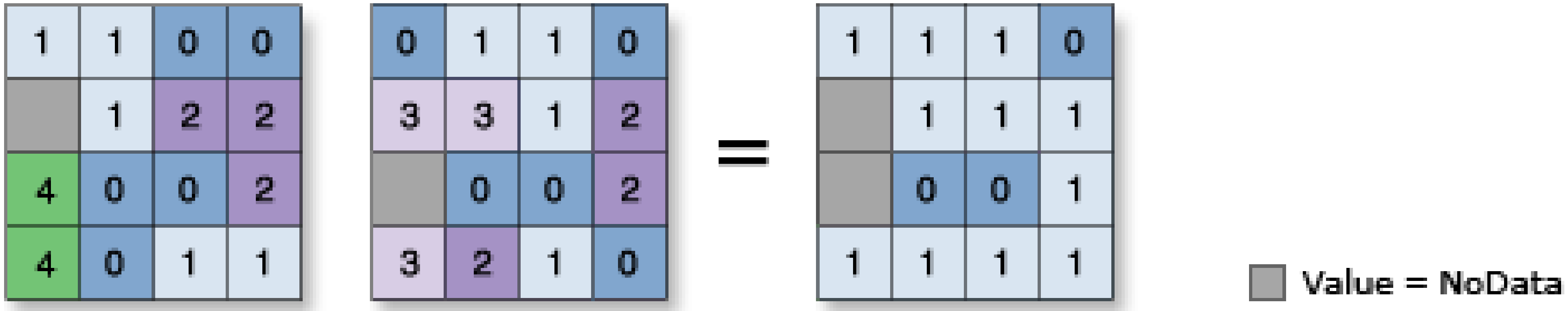


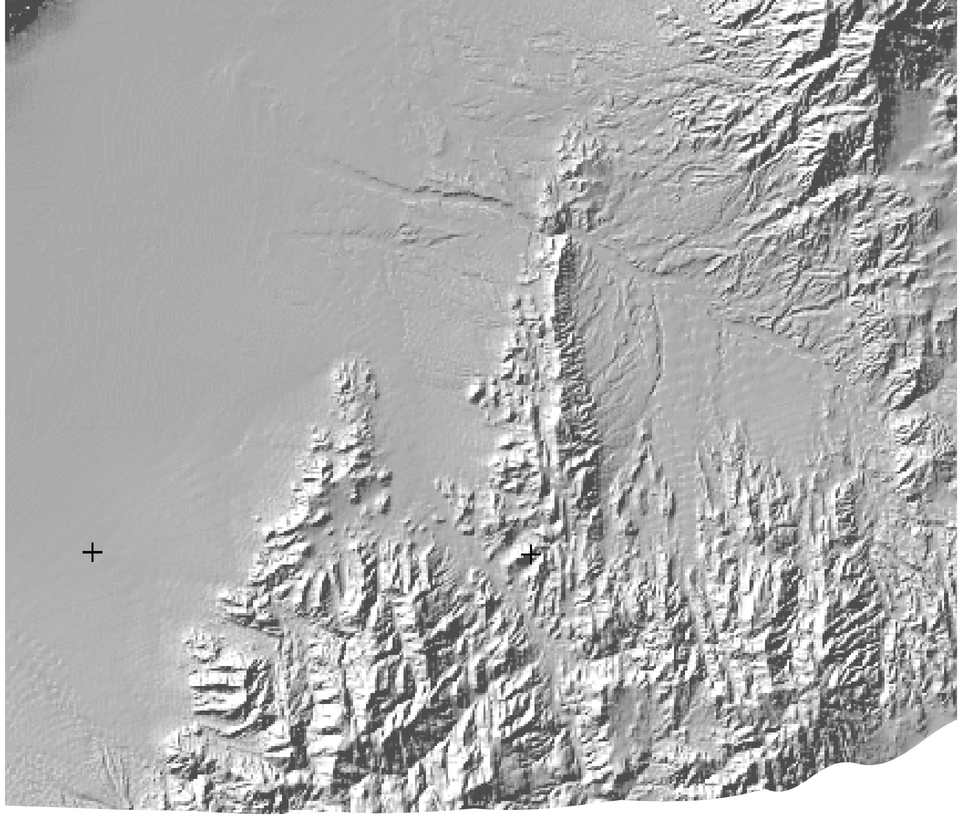
| (Boolean Or)

Summary

Performs a Boolean Or operation on the cell values of two input rasters.

Illustration



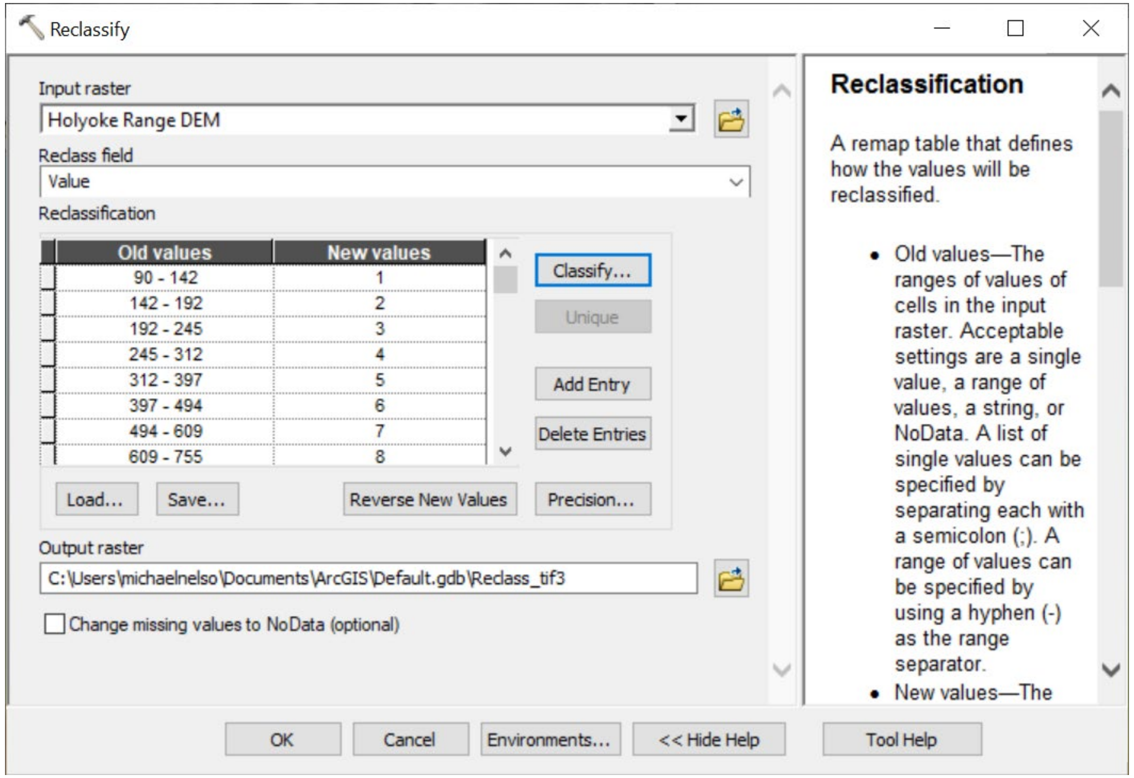


Arc’s Raster Reclass

Raster Reclass Tool

Creates categories:

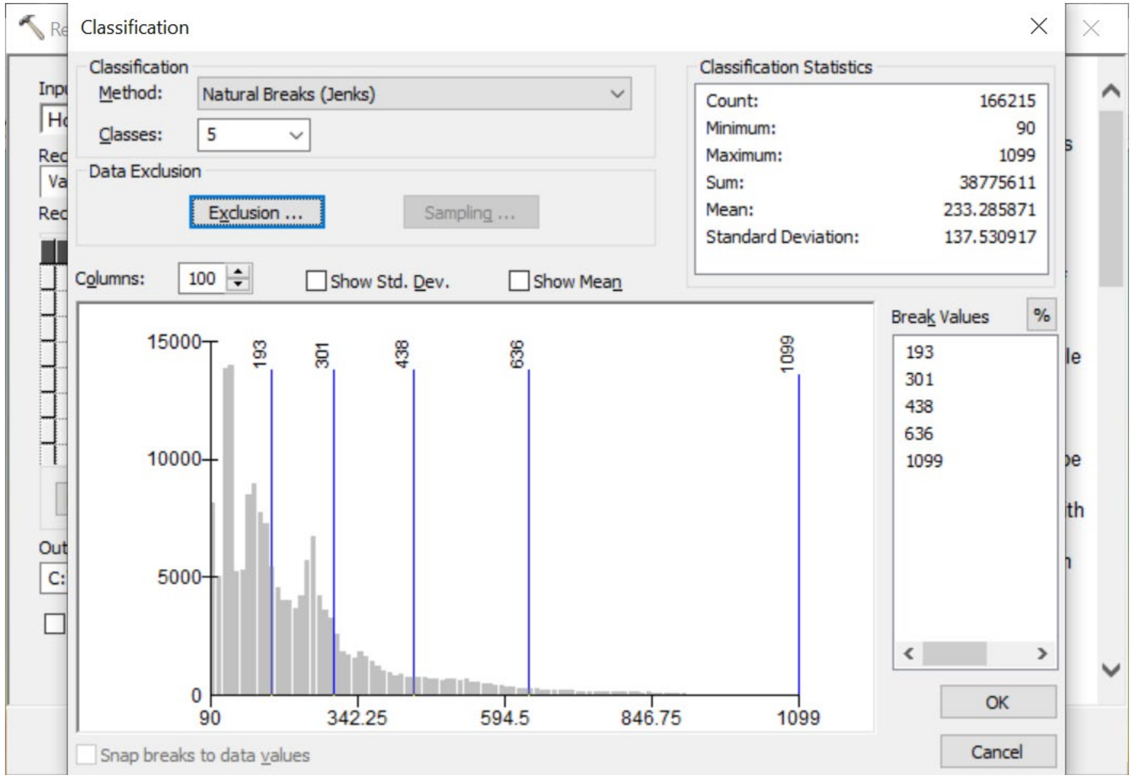
- Numerical ranges to category.
- Combine several categories into 1



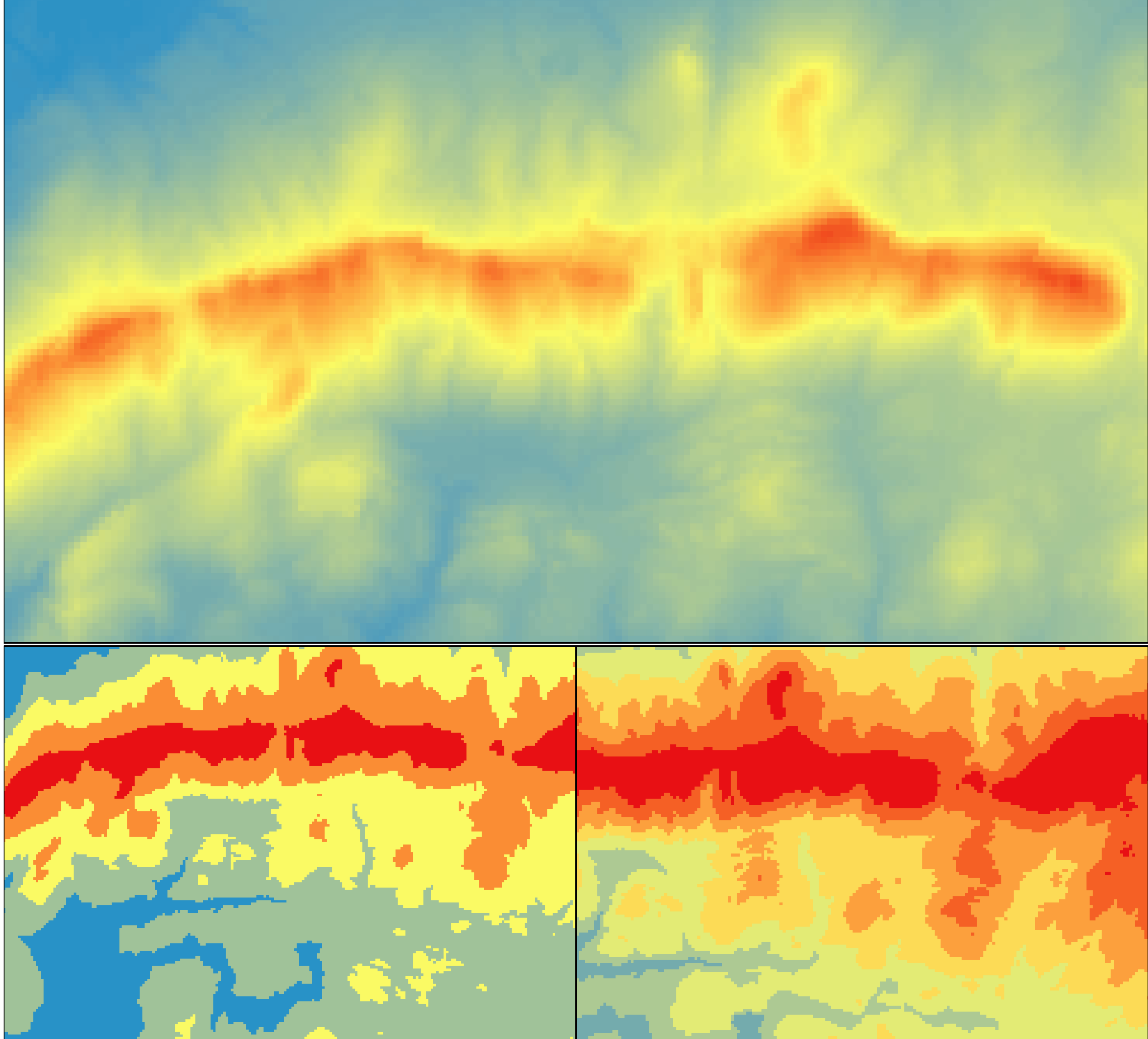
Reclassification Methods

Creates breaks. You need to consider:

- Number of classes
- Break Values
- Quantiles



Elevation to altitude categories



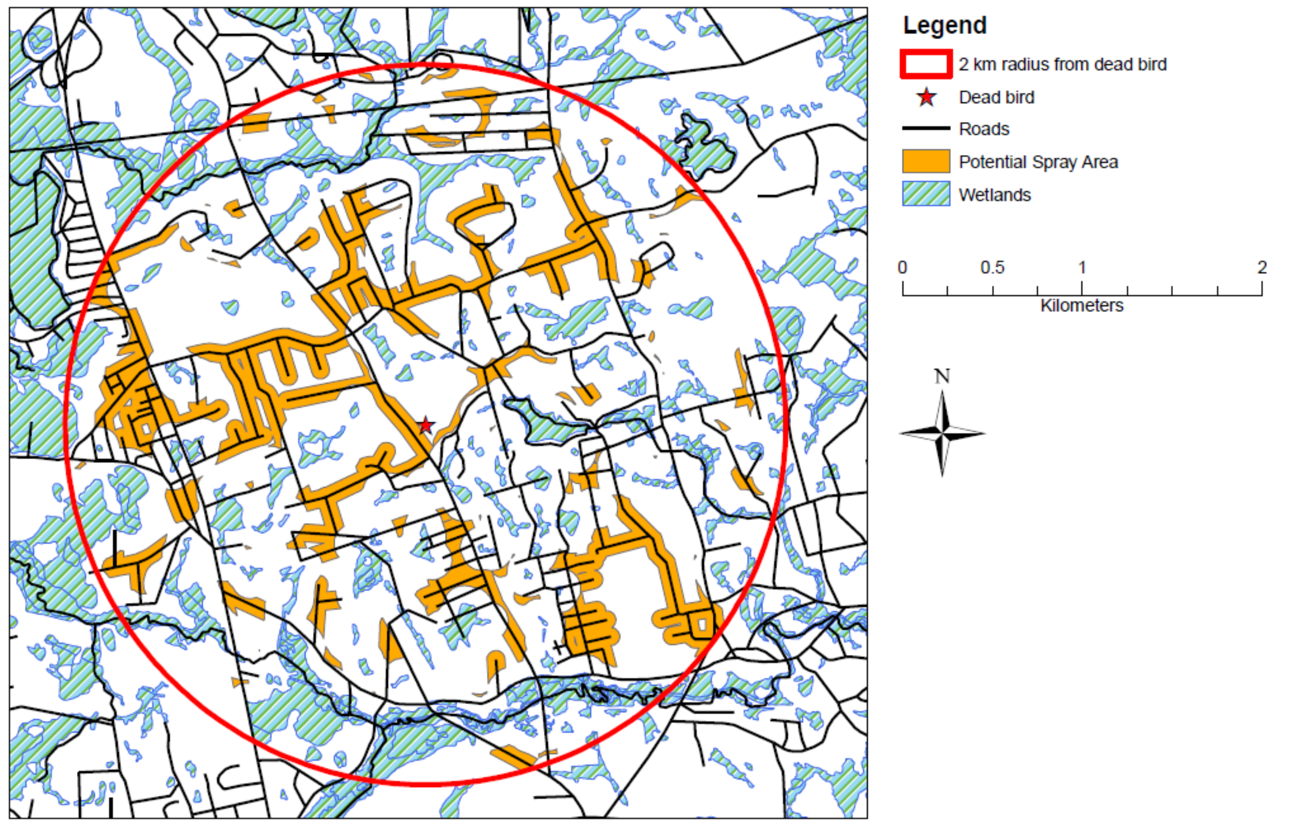
Dead Birds Reimagined

A.K.A. the dead bird lab…

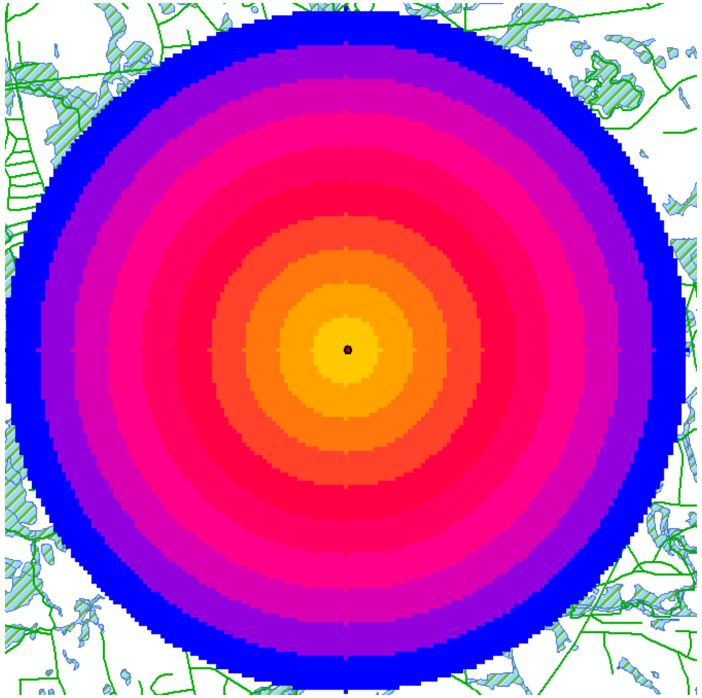
Dead Bird Analysis with Vector

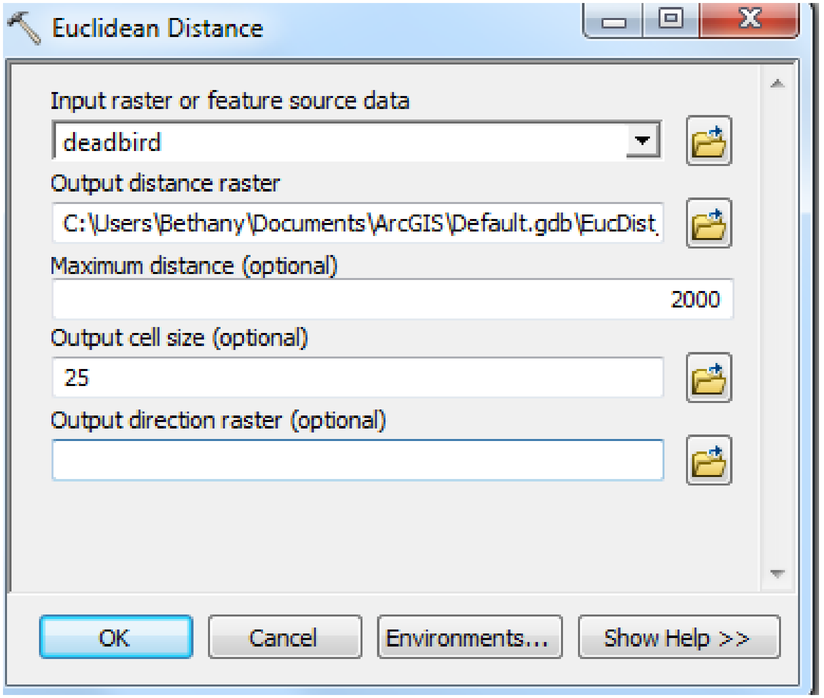
Vector operations (geoprocessing):

- Buffer
- Clip
- Erase

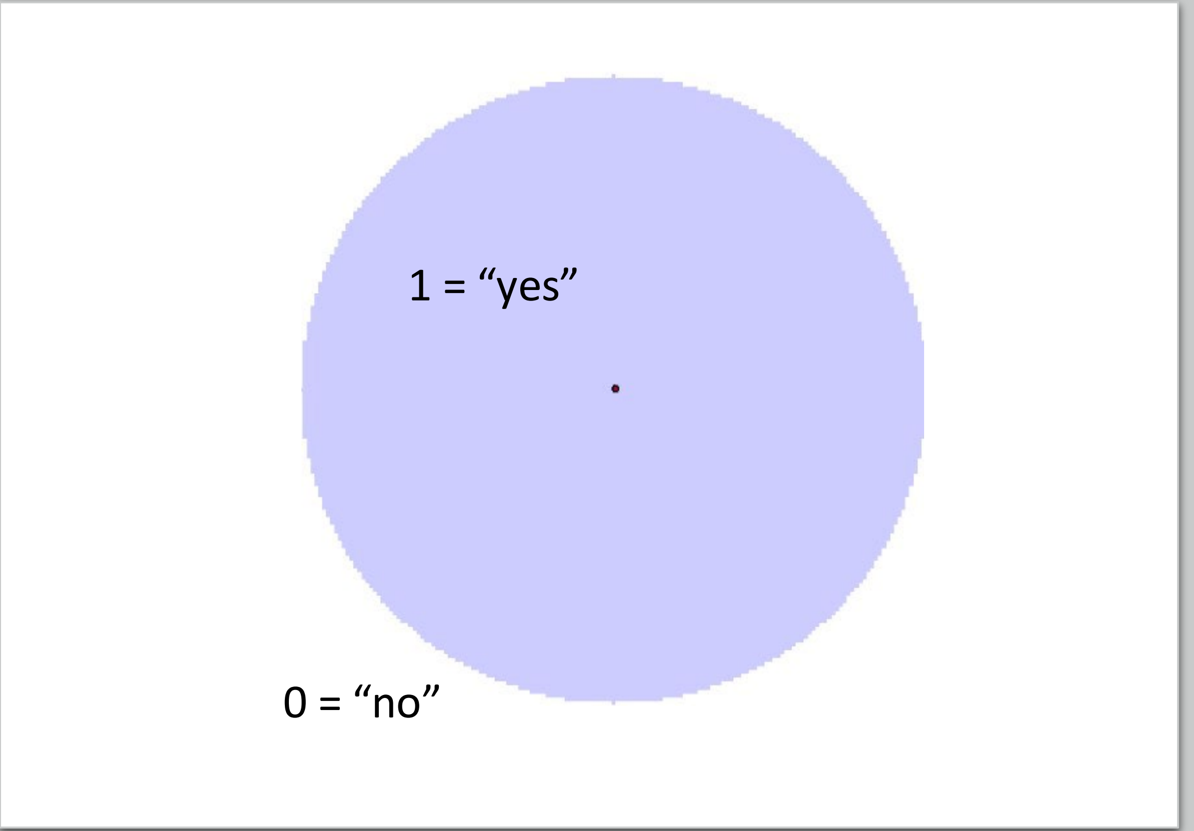


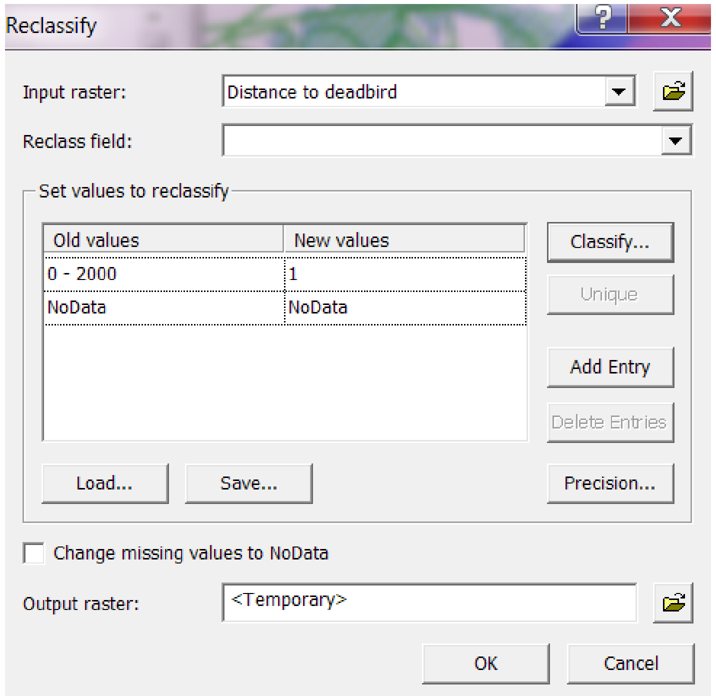
Dead Bird Analysis with Raster: Euclidean Distance Raster



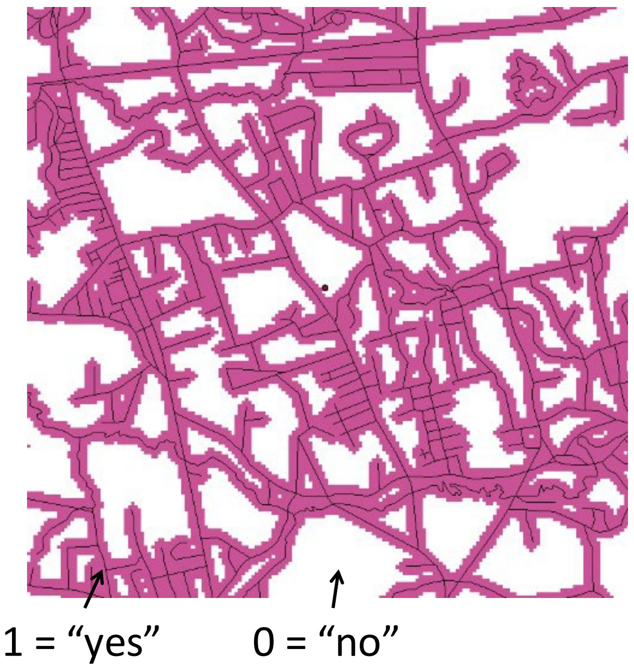


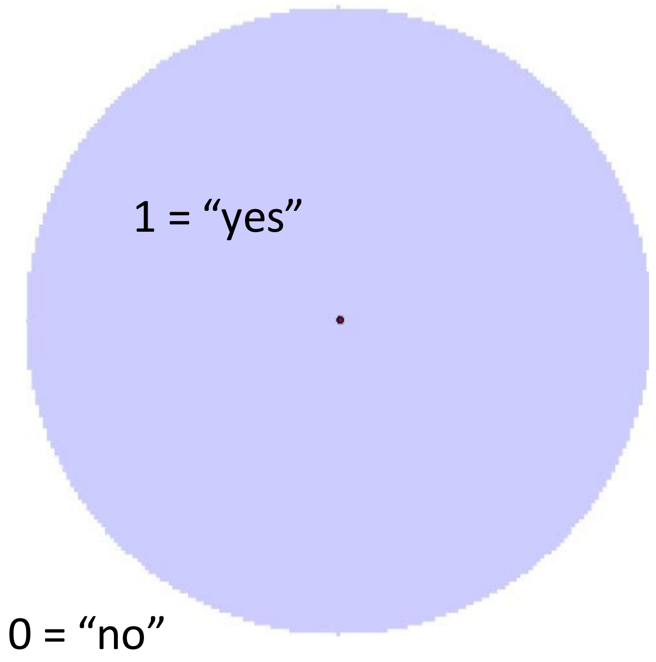
Dead Bird Analysis with Raster: Reclassify Tool



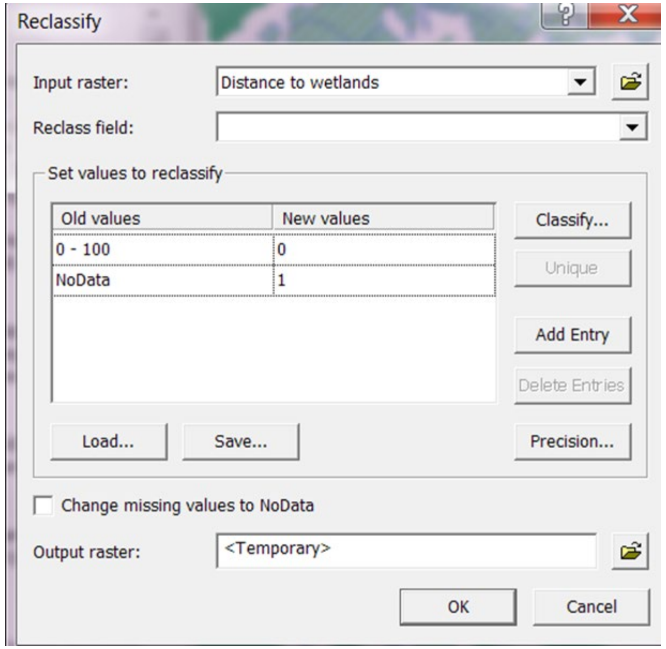


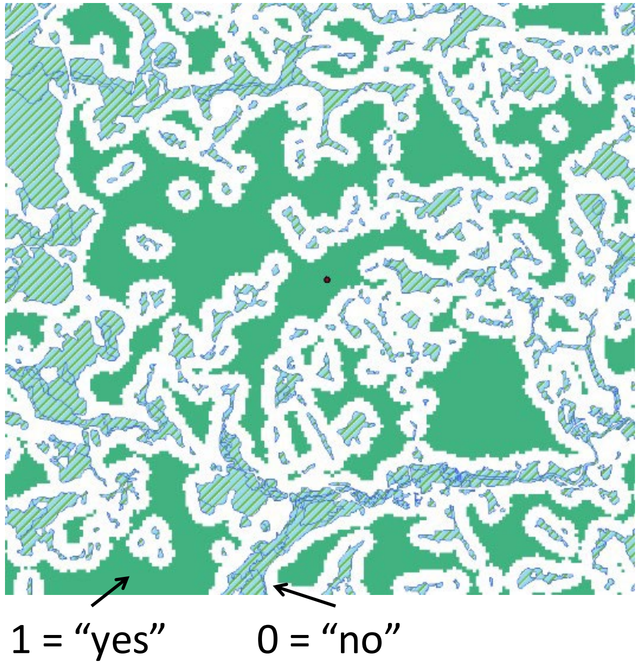
Dead Bird Analysis with Raster: Reclassify Tool





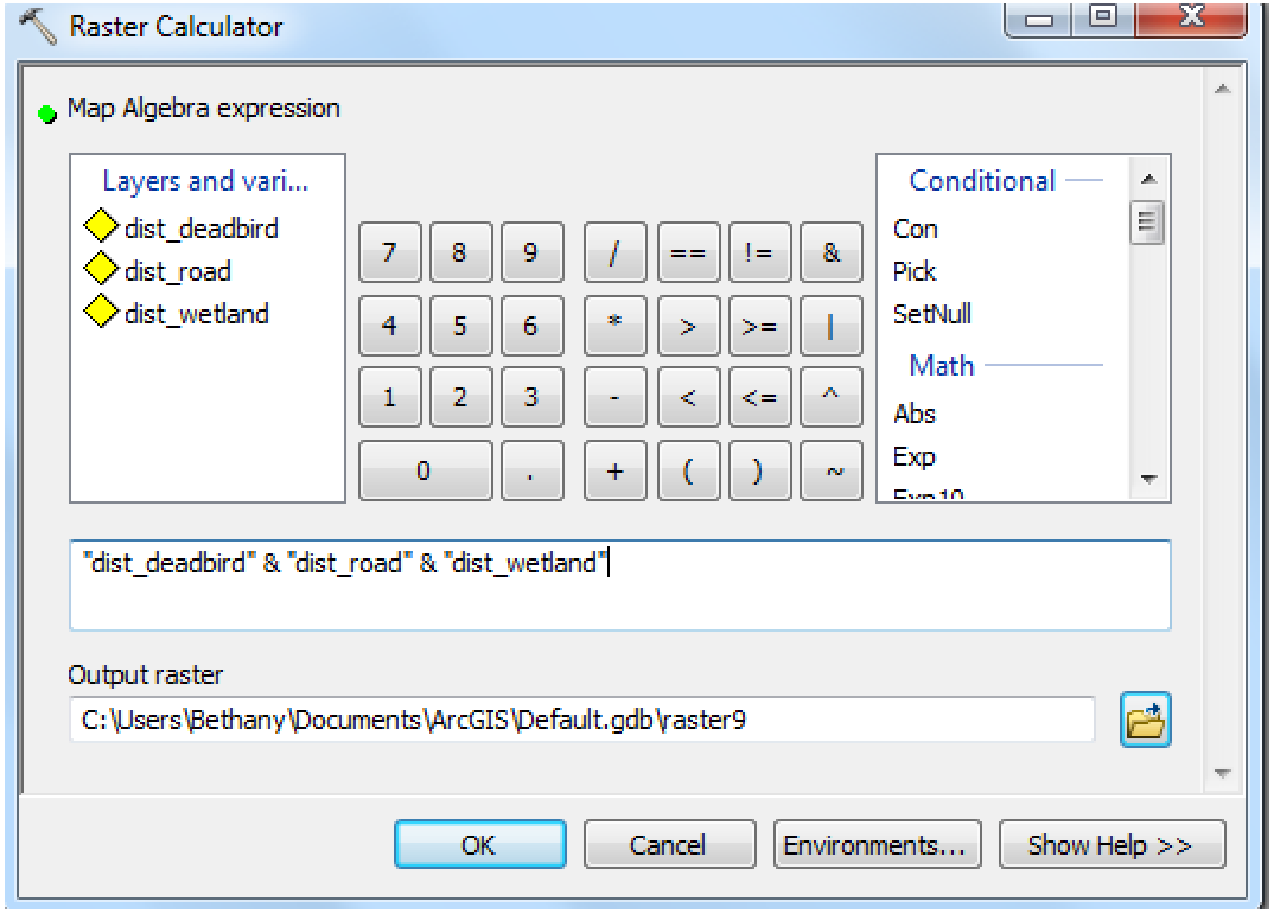
Dead Bird Analysis with Raster

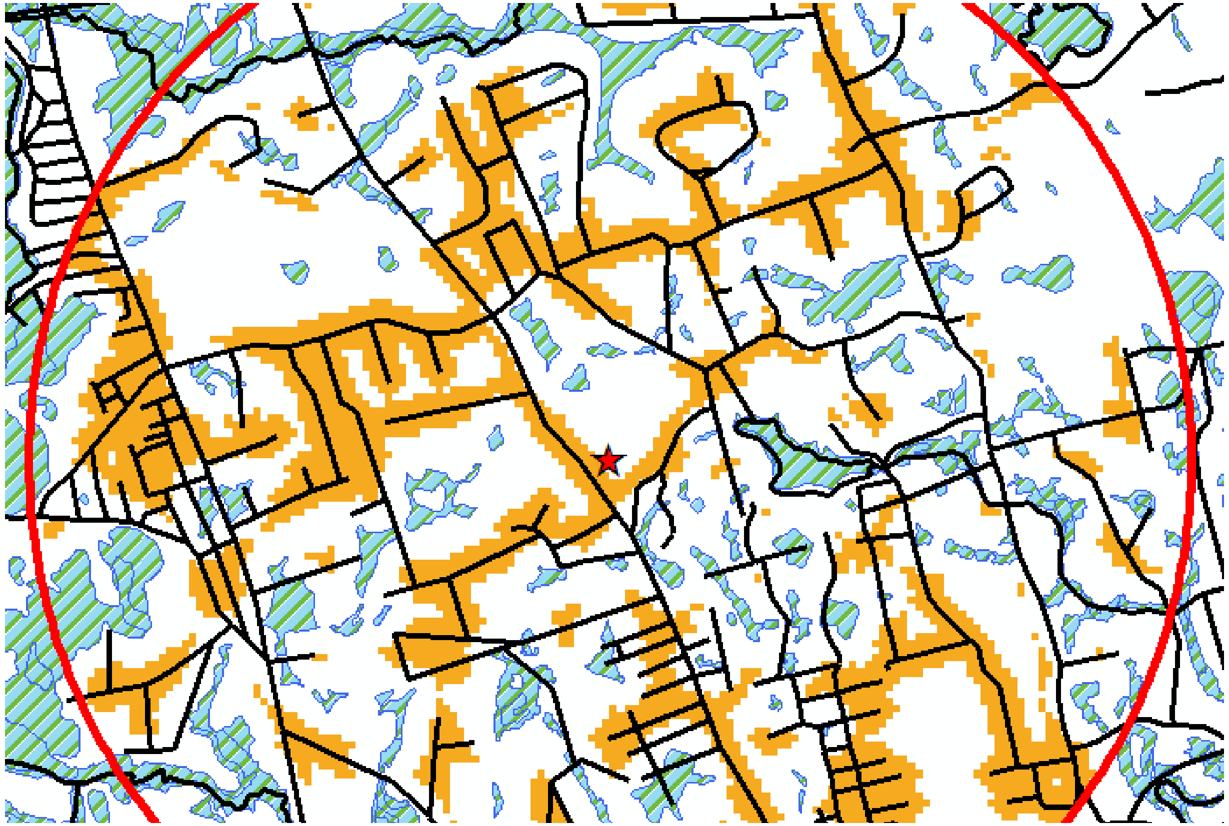




Dead Bird Analysis with Raster: binary rasters are awesome!

- Raster 'AND' identifies all pixels with a value of
- 1 = "true"





Dead Bird Analysis with Raster: Different Grains