Raster Data

Vector Data Review

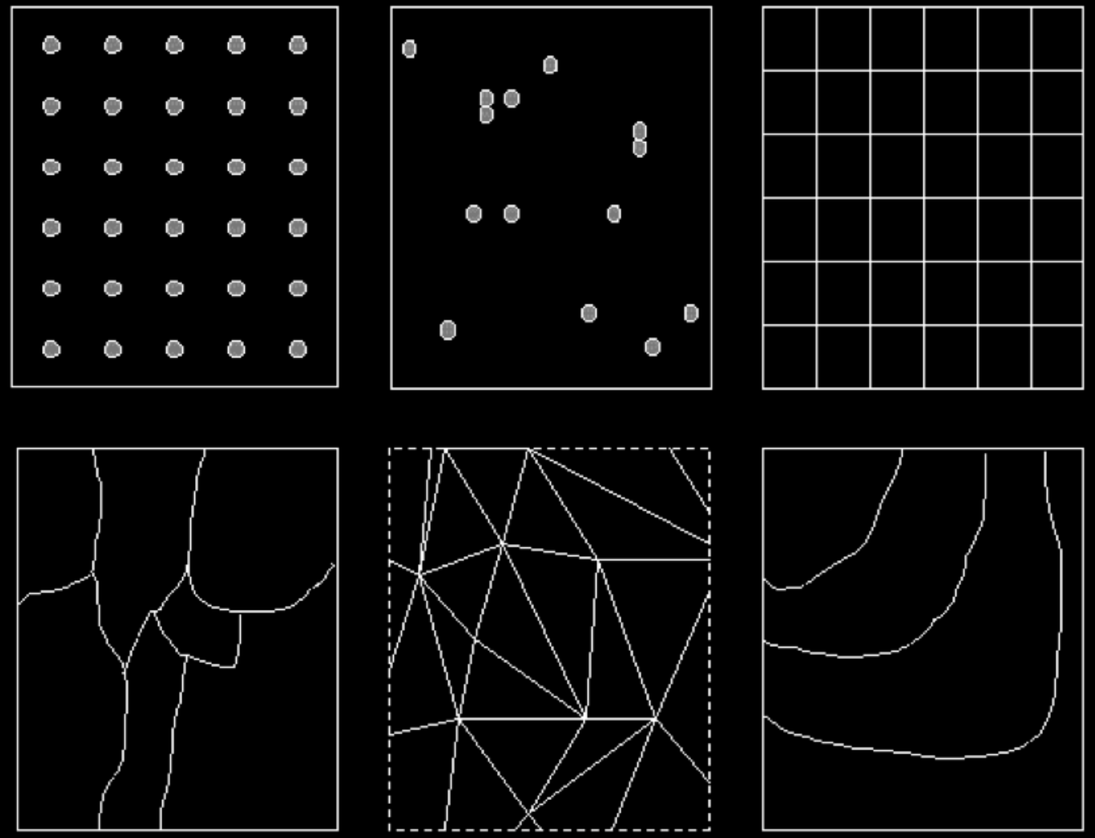
- discrete objects
- geometry = **points**
  - by themselves
  - connected → **lines**
  - closed → **polygons**
- attributes linked to **feature ID**
- explicit location
  - every point has coordinates

Fields in GIS

- continuous f(x, y)
- so how represent
  - geometry?
  - attributes?
  - location?

Approximating Fields

- Point set
  - regular
  - irregular
- Grid
- Polygons
- TIN
- Contours

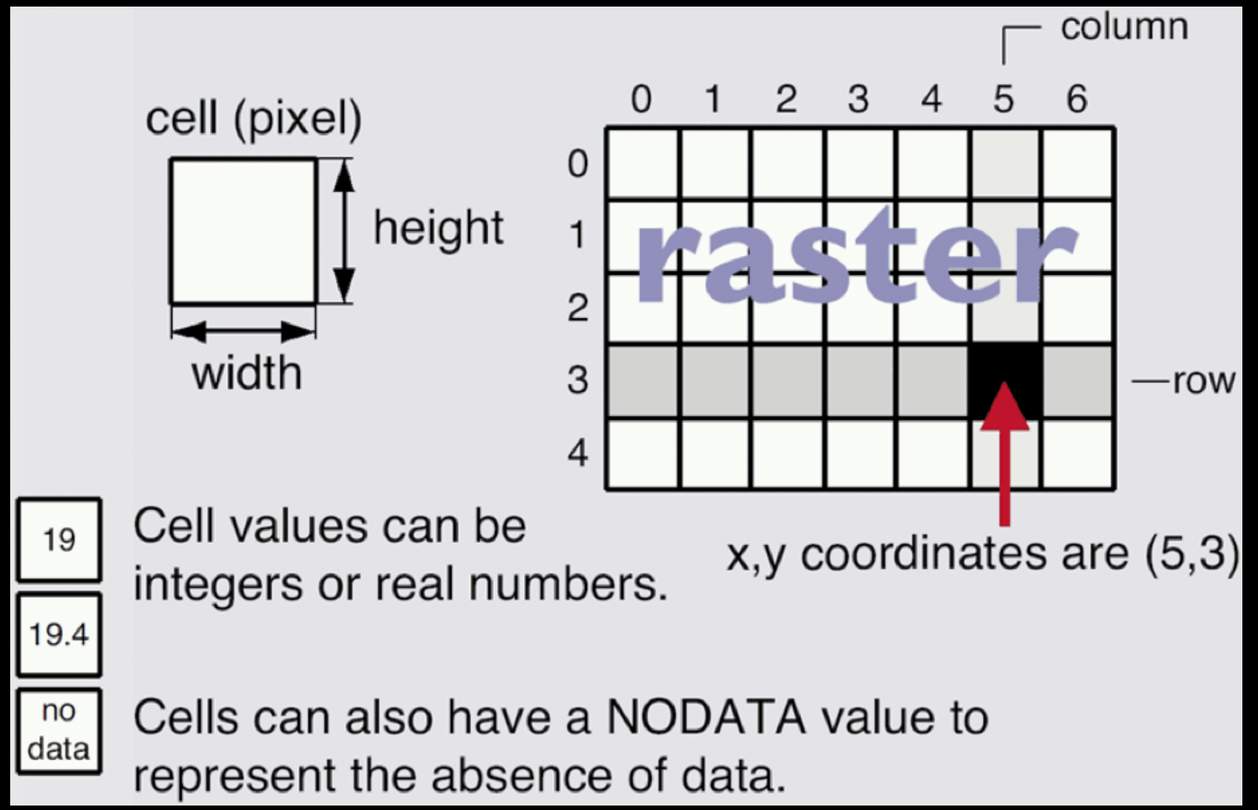


Sampled Fields: Rasters

- Divide (part of) the world into square **cells** (aka **pixels**)
- Register the corners to the Earth
- Represent **fields**
  by assigning field values to cells
- Represent **discrete objects**
  as collections of one or more cells
- More commonly used to represent fields
  than discrete objects

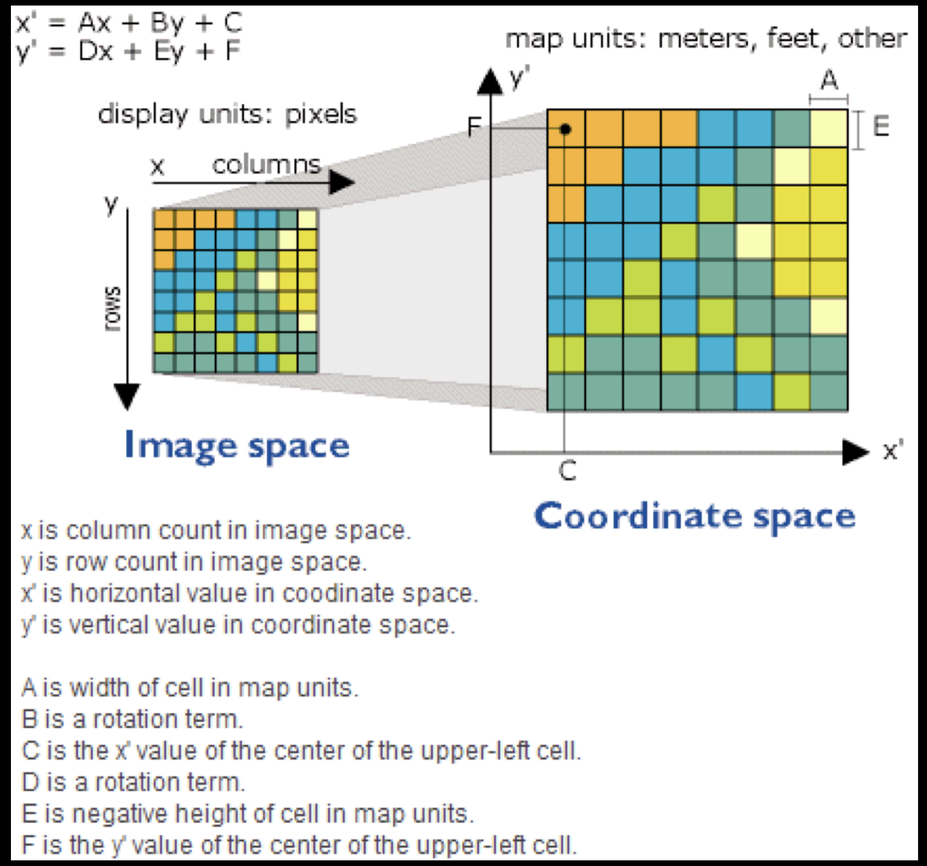
Raster Data Model

- Cell size defines level of spatial detail
  - all variation **within** cells is lost
  - ↓ → ↑#cells → ↑data volume
- Cell value
  - field value w/in cell
    - average? total? modal?
    - central point?
- Implicit geometry
  - grid cell (pixel) coordinates



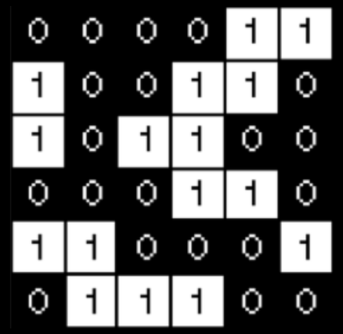
Raster Coordinates

- convert
  raster (row, column)
  to
  map (x, y)
  using affine transform
- transform parameters
  may be saved in "world file"
  – or embedded in raster formats
    like GeoTIFF

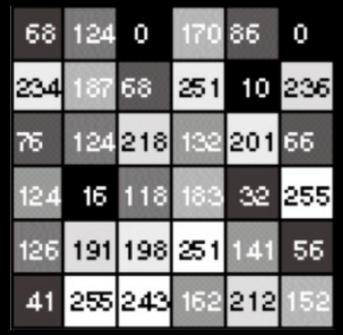


Characteristics of Rasters (cont'd)

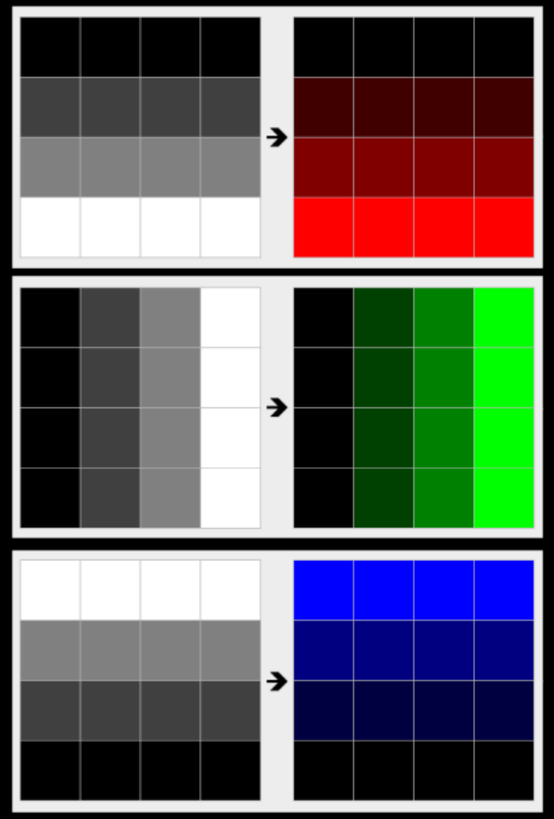
- Bands (channels)
  - single ("binary")



  - single ("grayscale")



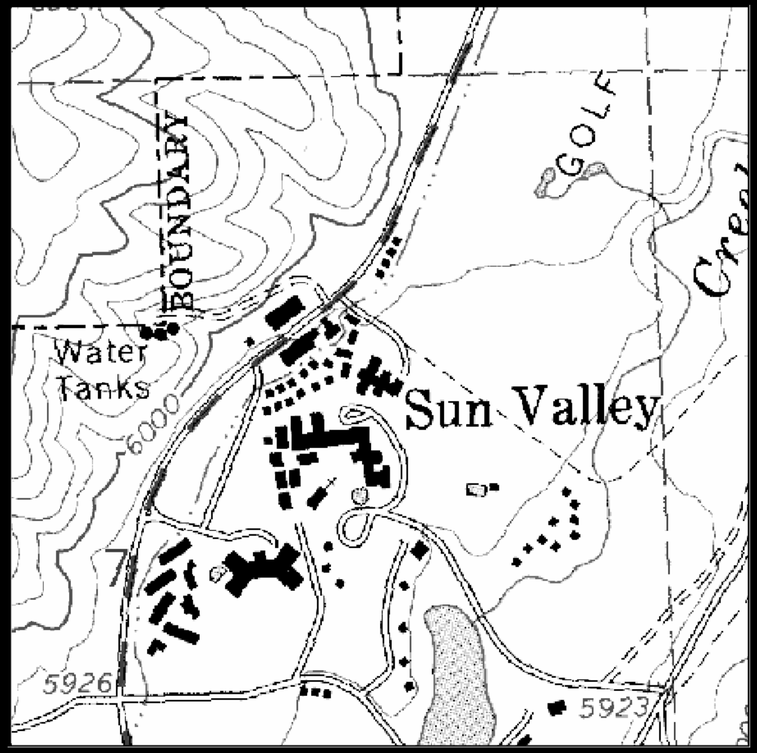
  - multiple ("color composite")



Raster Examples

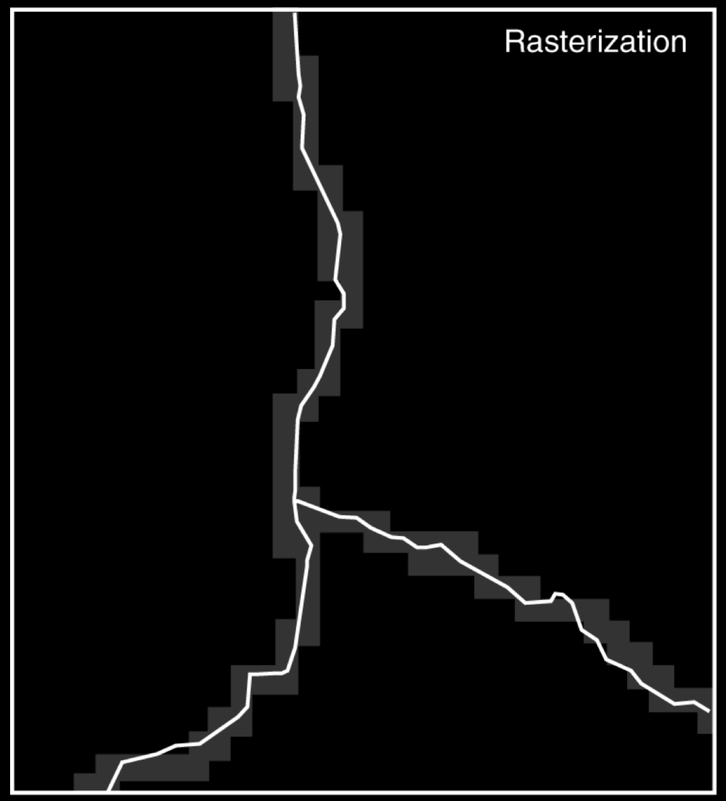
- aerial image

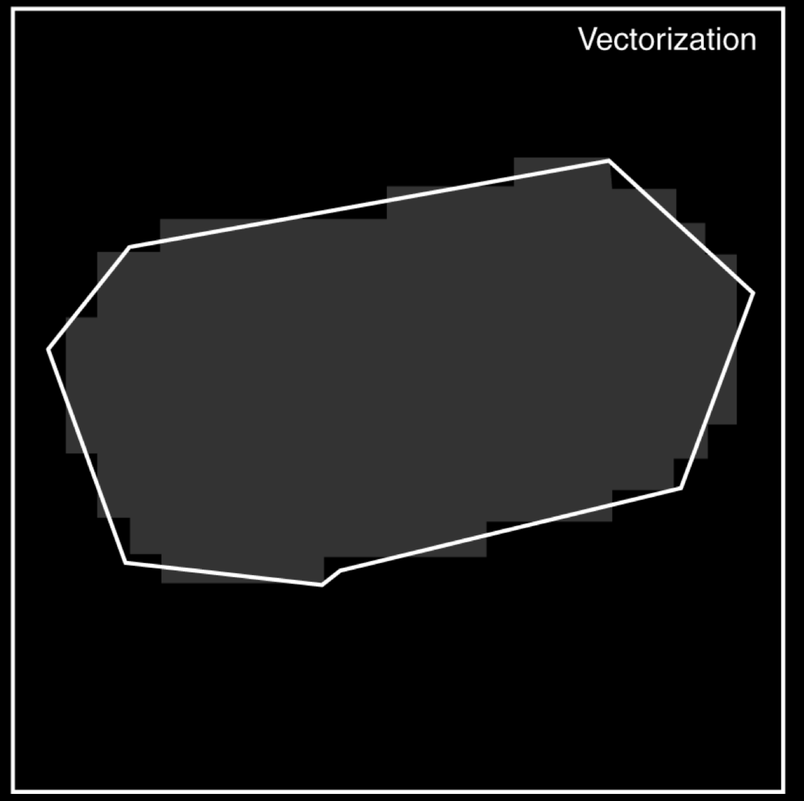
- scanned topo map



Vector ↔ Raster Conversion

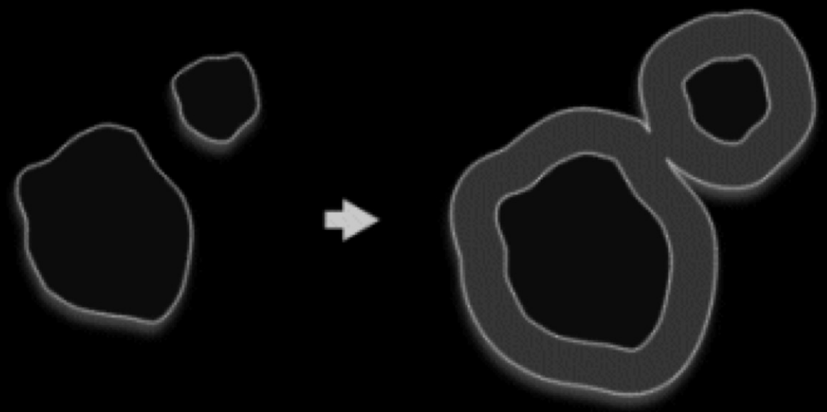
- Rasterize = cells that intersect feature
- Vectorize = outline contiguous region



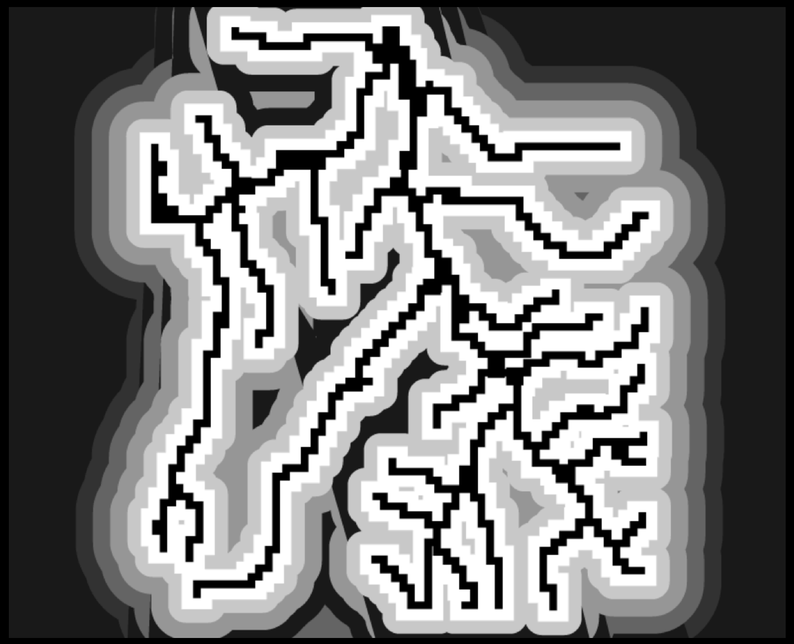


Note: Distance vs Buffering

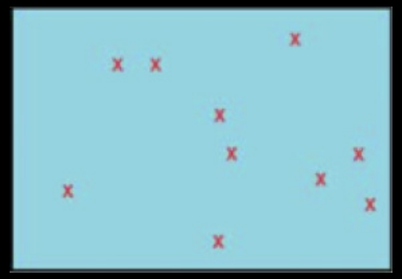
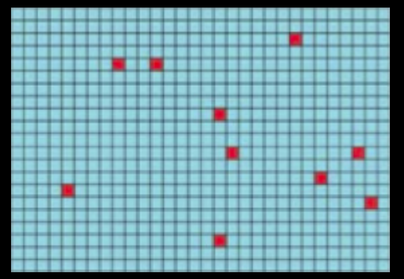
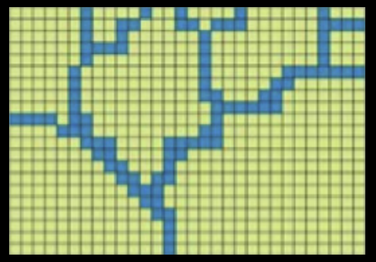
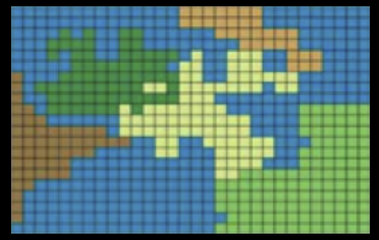
- Buffer: discrete



- Distance: continuous

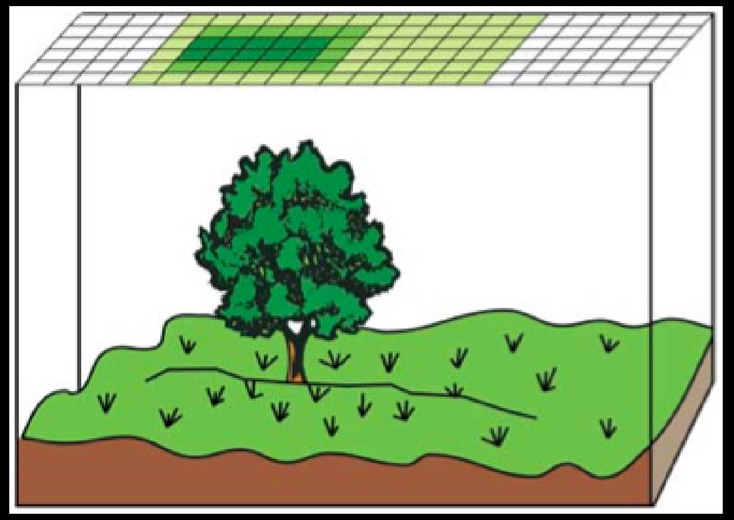


Feature Representation in Rasters: Sub-pixel Features Coarsened

	• vector	• raster
• points		
• lines		
• polygons		

Feature Representation in Rasters: Large Features Blurred

- Tree represented as varying values of “treeness”, instead of as a crisp feature



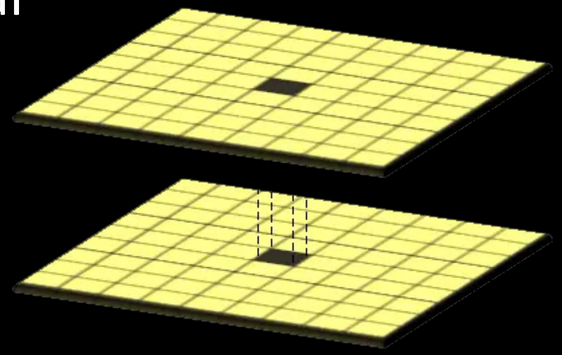
Raster Operations

in order of increasing #input cells contributing to 1 output cell

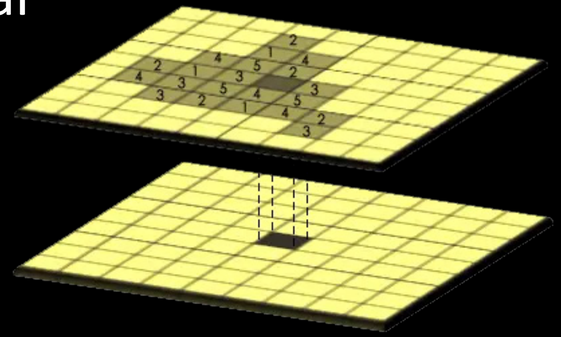
- Local
- Focal
  - aka neighborhood
- Zonal
- Global

Raster Operations

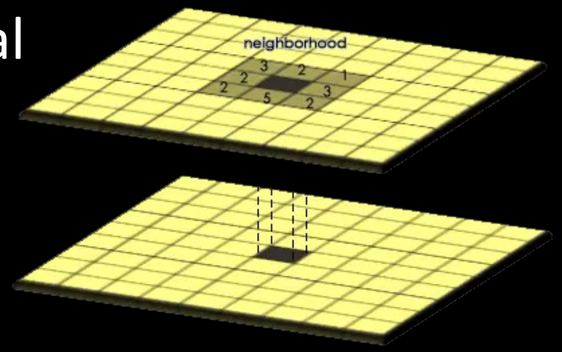
- Local



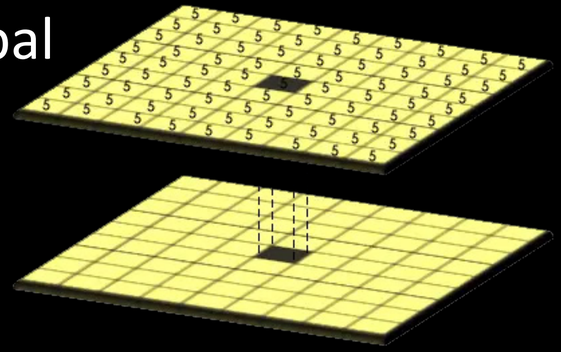
- Zonal



- Focal

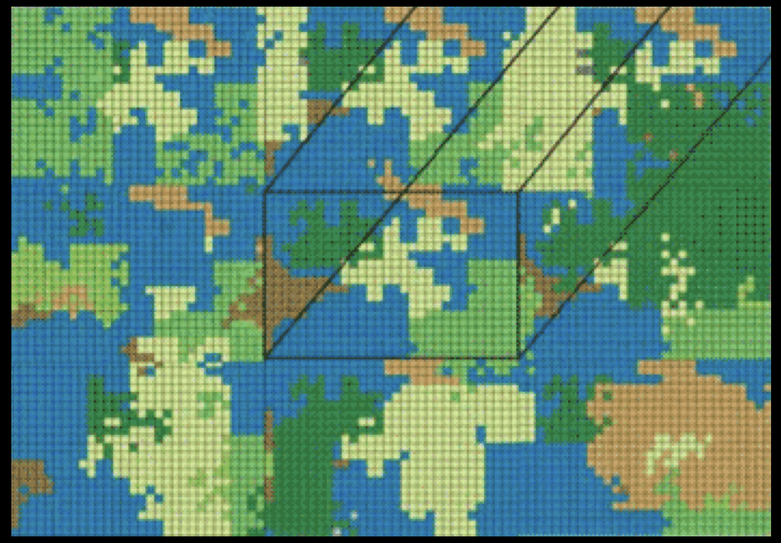


- Global



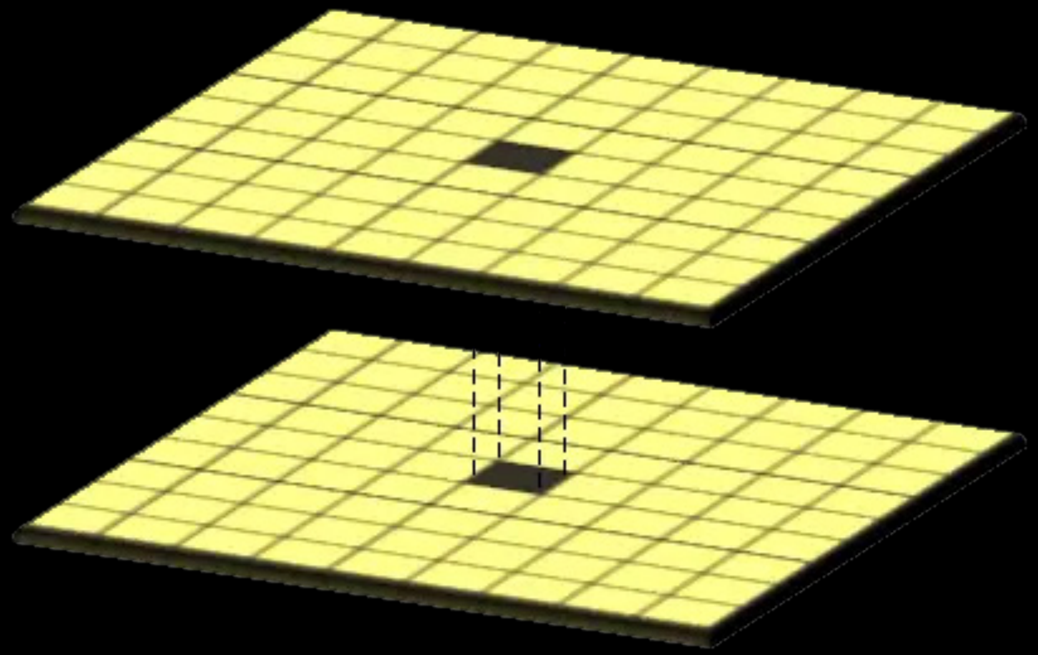
Extent

- restrict processing to rectangular subset
  - explicit: (x_{min}, y_{min}, x_{max}, y_{max})
  - default: bounding box of inputs



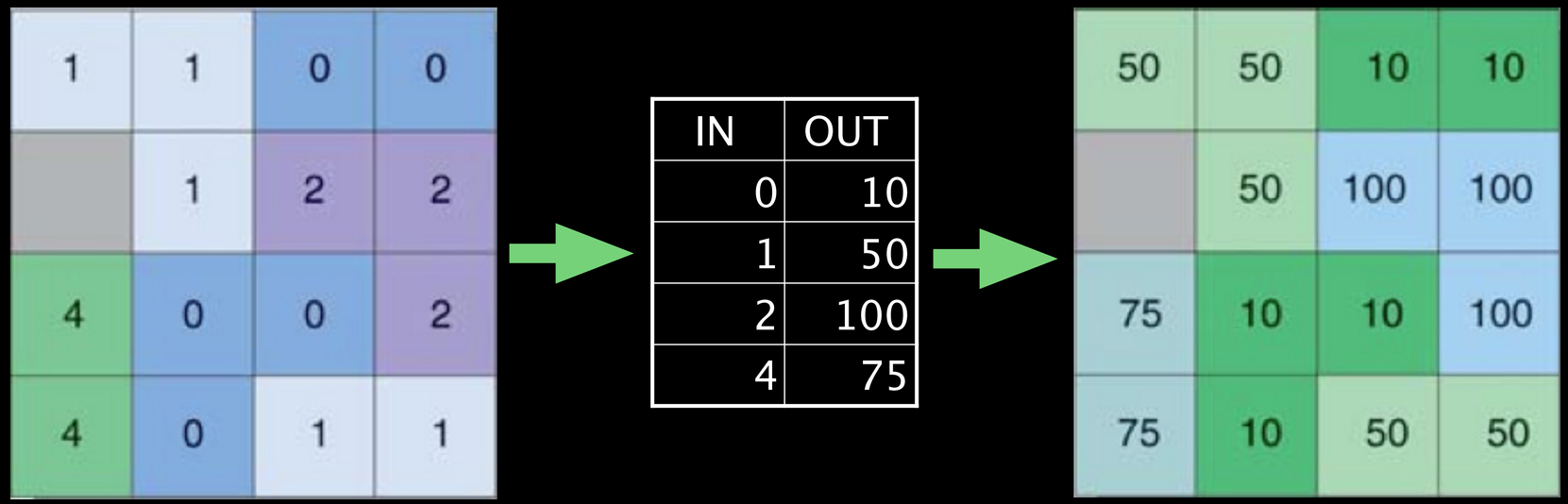
Local Operations

- $out(x_i, y_j) = f(in(x_i, y_j))$
  - Neighbors don't influence
- Examples
  - reclassify
  - select
  - min/max
- Think of as:
  - Solve for all unique cell values; then
  - Reclassify

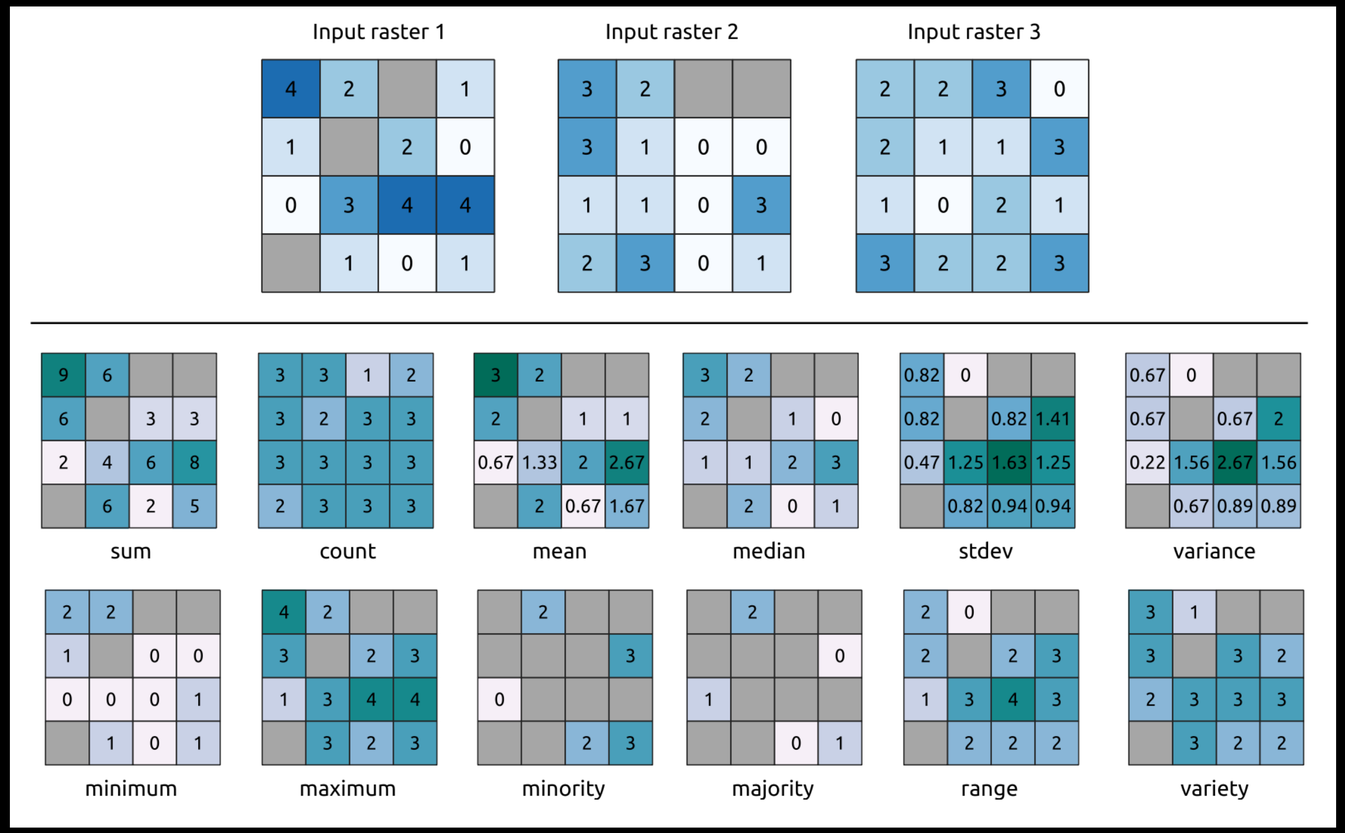


Local Operation Example: 1 Input

- Reclassify (change values using lookup table)

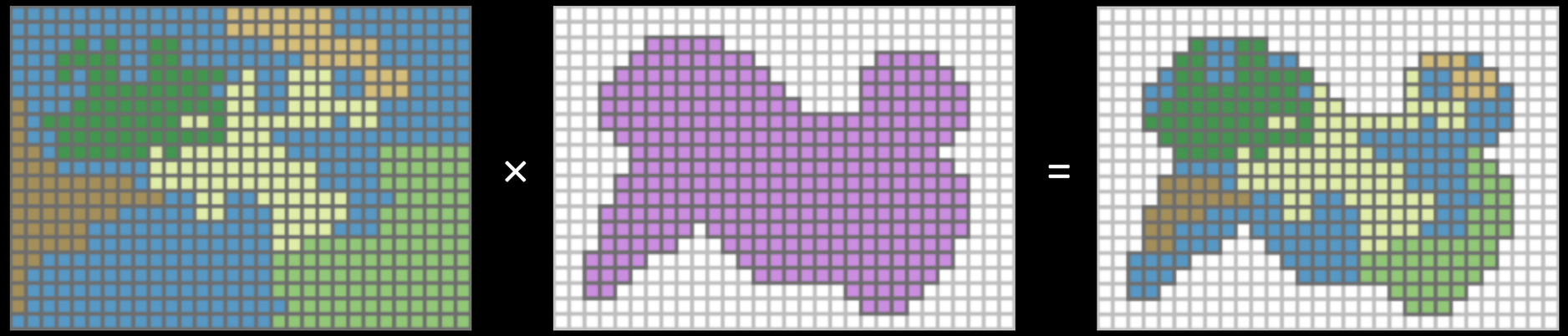


Local Operation Example: Multiple Inputs



- shaded = NoData
  - NB: NoData in **any** input → NoData in output

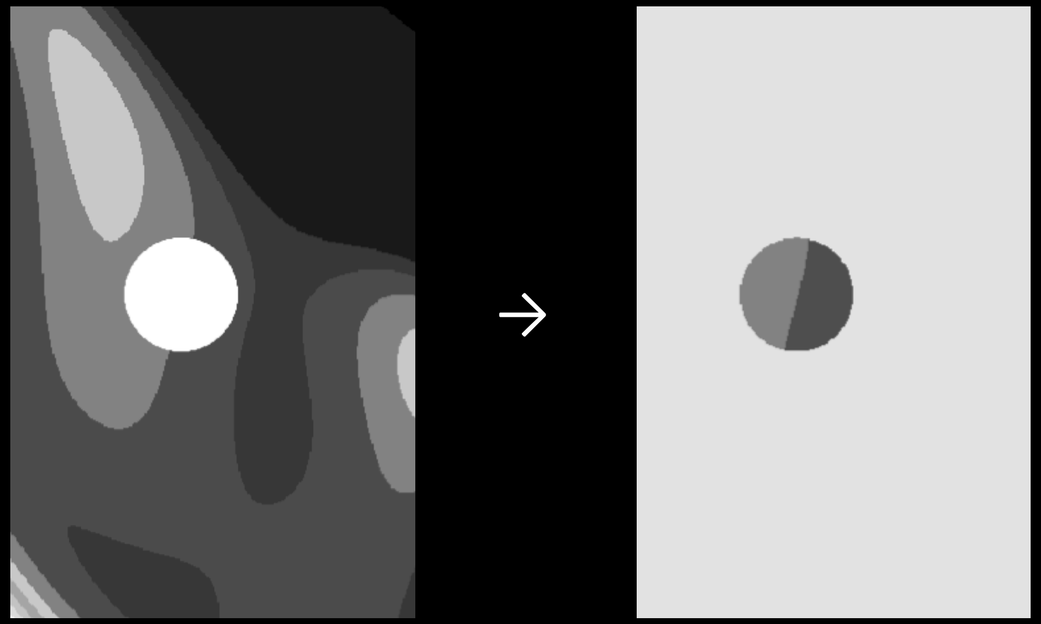
Local Operation Example: Mask



1 → pass
0 → 0
NoData → NoData

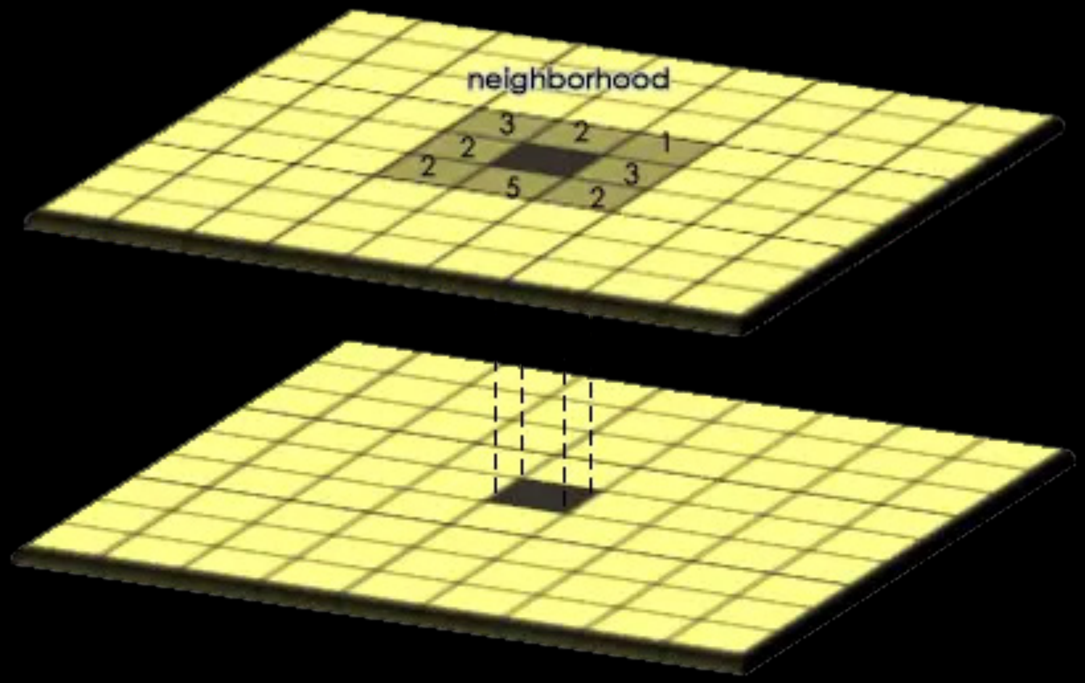
Extract

- Clip raster by mask layer (vector)



Focal (Neighborhood) Operations

- out(x_i, y_j) = f(in(x_k, y_m) ∀ k,m **near** i,j)
  - single cell
    and its neighbors
- Examples
  - smooth
    - sharpen
  - noise suppresion
- Think of as
  - weighted sum
    or
  - sort and pick



Focal Operation Example: Mean

- b = 3x3 mean (a)
  - e.g. 2.11 = (2+2+2+2+1+3+2+2+3) / 9

(a)

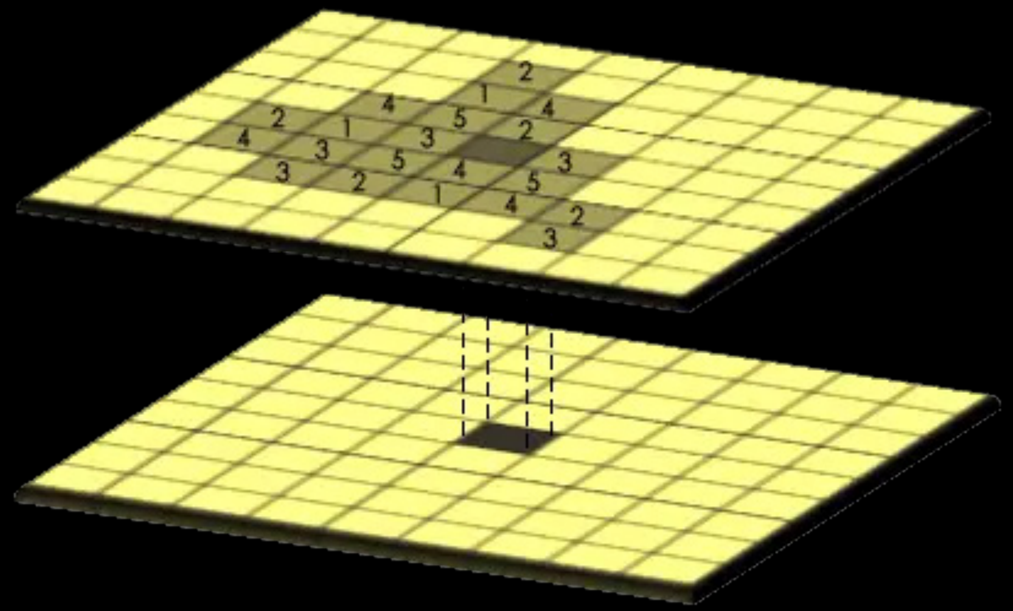
1	2	2	2	2
1	2	2	2	3
1	2	1	3	3
2	2	2	3	3
2	2	2	2	3

(b)

1.56	2.00	2.22
1.67	2.11	2.44
1.67	2.11	2.44

Zonal Operations

- out(x_i, y_j) =
  f(in(x_k, y_m) ∀ k,m ∃ zone(x_k, y_m) = zone(x_i, y_j))
  - like focal, but uses **zone** for neighborhood
  - replace cell value
    with some property
    of its neighbors
    in zone it overlaps



Zonal Operation Example:
Zonal Mean

1	2	2	1
1	4	5	1
2	3	7	6
1	3	4	4

input

1	1	2	2
1	1	2	2
1	1	3	3
3	3	3	3

zones

2.17	2.17	2.25	2.25
2.17	2.17	2.25	2.25
2.17	2.17	4.17	4.17
4.17	4.17	4.17	4.17

zonal mean (input,zones)

e.g. 2.17 = mean(zone 1: {1, 2, 1, 4, 2, 3})

Zones Can Be Discontiguous

- Zone = **all** cells with same value

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

Zonal Operations in QGIS

- supported statistics
  - majority, median, minority
  - maximum, range, minimum
  - sum, mean, standard deviation
  - count, variety (# distinct values)

- zonal operations produce **tables**, not rasters
  - row = zone
  - column = statistic

- input zones can be a **vector** layer
  - output is a vector layer with zonal stats added to attribute table

Global Operations

- $out(x_i, y_j) = f(in(x_k, y_m)\ \forall\ k,m)$
- each output cell depends on ≤ **all** input cells
  – can be “computationally intensive”
- Examples
  – distance
  – variogram

Global Operation Example:
Proximity

Euclidean distance to nearest target value(s)

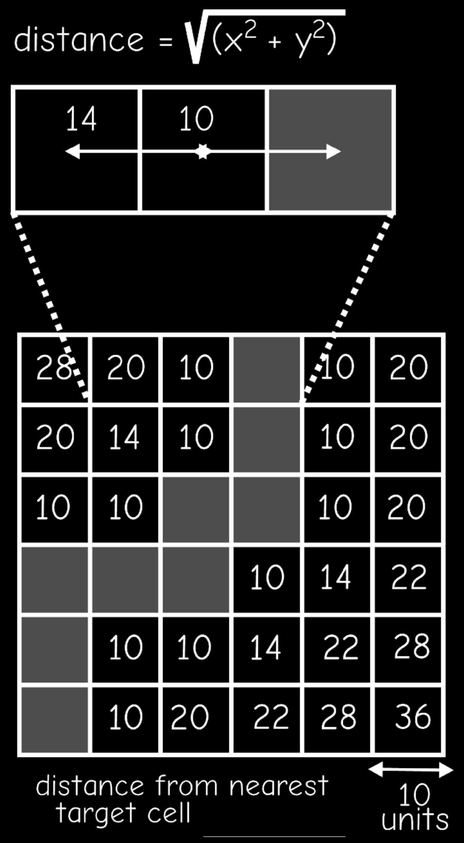


Figure Credits

- ArcGIS 9: Using ArcGIS Spatial Analyst
- ArcMap Help
- Geographic Information Systems and Science, 2nd ed. ISBN 978-0470870013
- GIS Fundamentals, 6th ed. ISBN 978-1-59399-552-2
- GISGeography.com
- Introduction to Geographic Information Systems, 4th ed. ISBN 978-0-07-305115-2
- Modeling Our World. ISBN 1-879102-62-5