Geographic Information Systems

ESM 263 - Winter 2023

Raster Data

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Vector Data Review

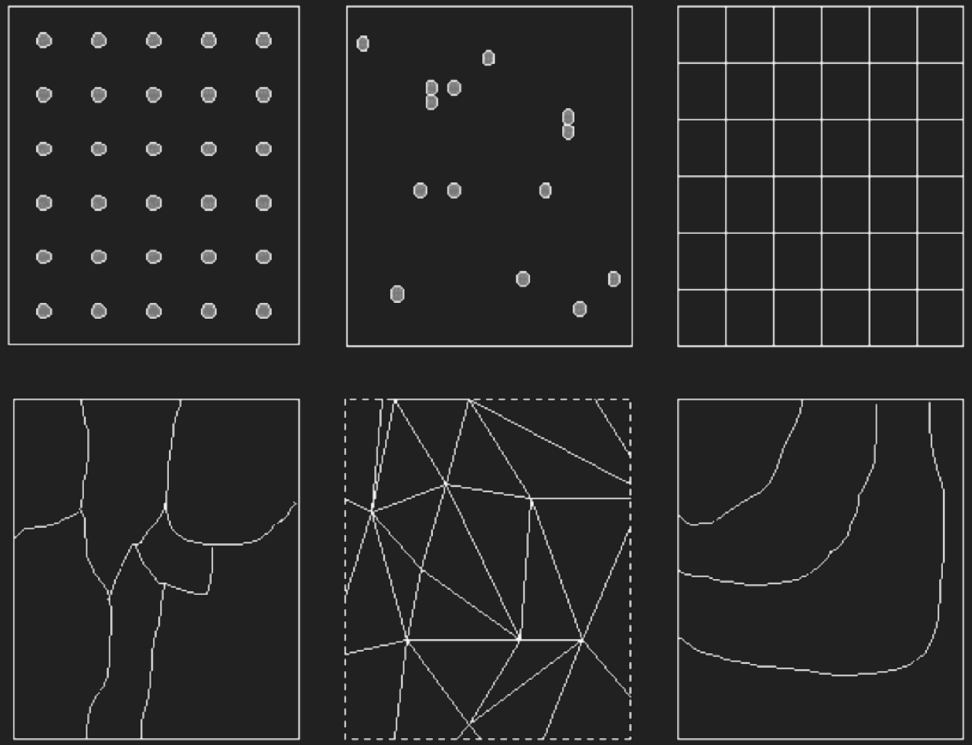
- discrete objects
- geometry = points
  - by themselves
  - connected → lines
  - closed → polygons
- attributes linked to feature ID
- explicit location
  - every point has coordinates

Fields in GIS

- continuous f(x, y)
- so how represent
  - Geometry?
  - Attributes?
  - Location?

Approximating Fields

- Point set
  - Regular
  - Irregular
  - Grid
- Polygons
- TIN
- Contours

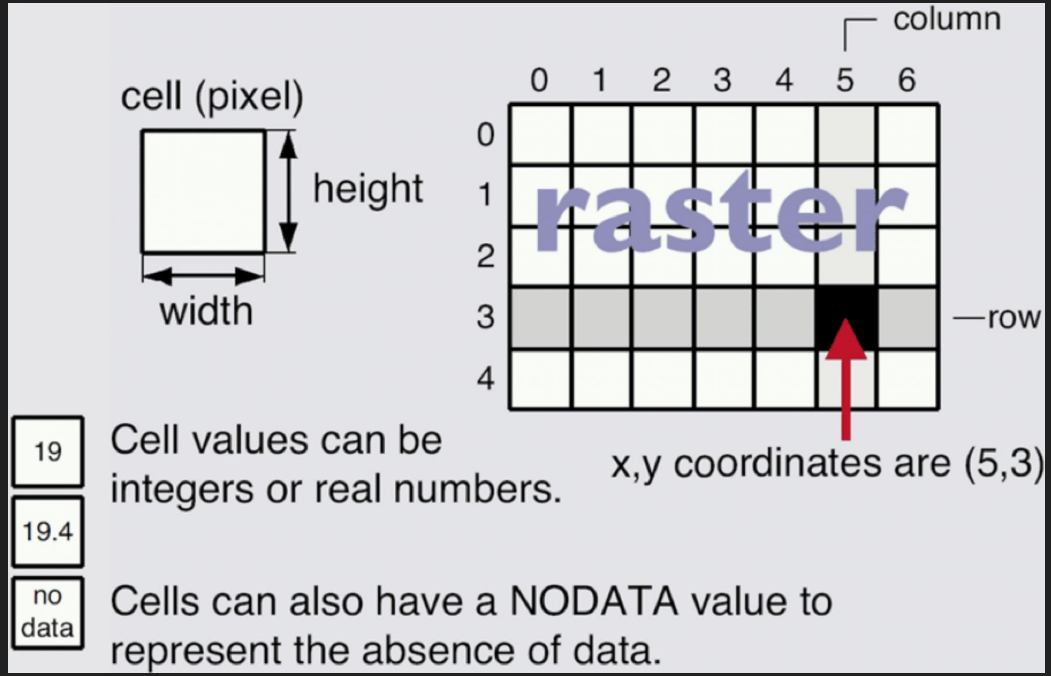


Sampled Fields: Rasters

- 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

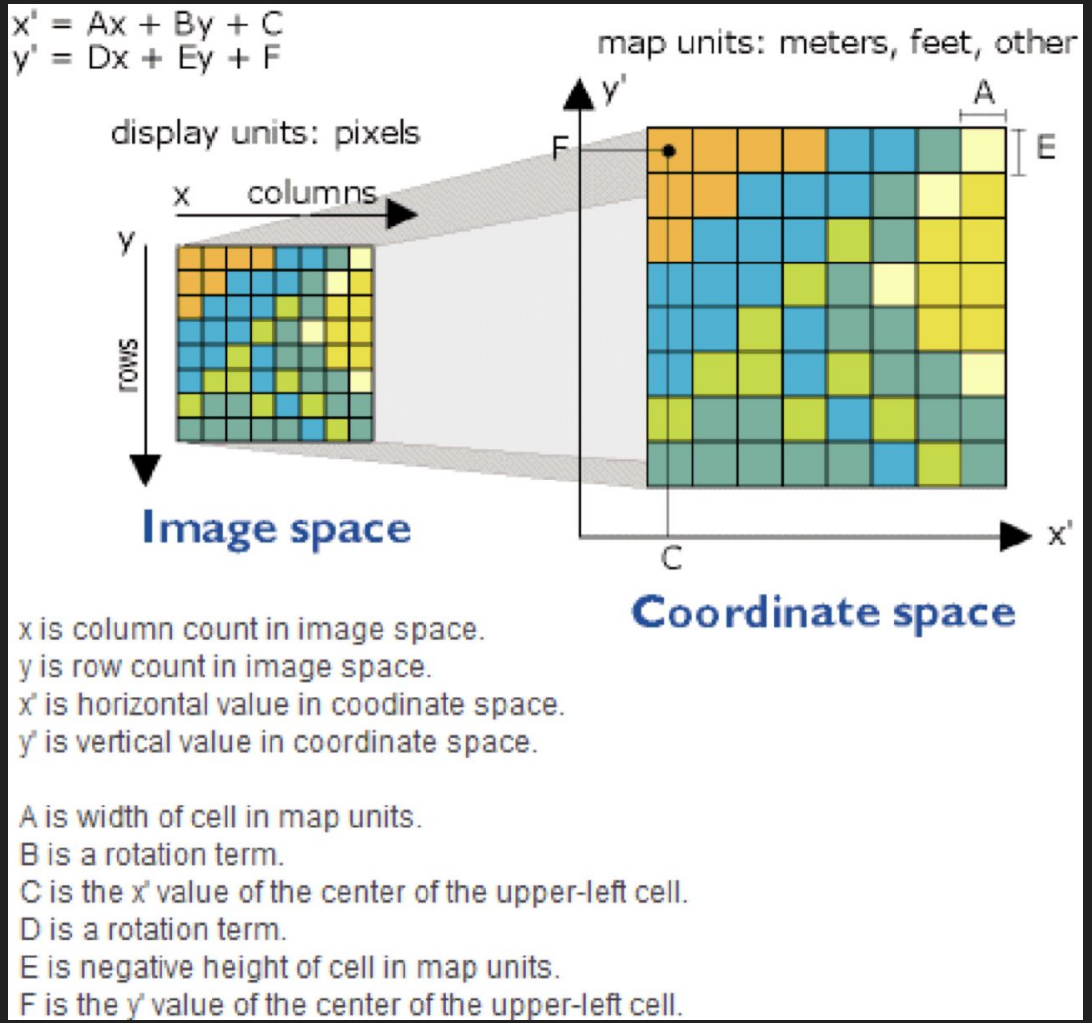
- Cell size defines level of spatial detail
  - all variation within cells is lost
  - ↓ → ↑#cells → ↑data volume
- Cell value (field value w/in cell)
  - average? total? Modal?
  - central point?
- Implicit geometry
  - grid cell (pixel) coordinates



Raster Coordinates

- Convert
  raster (row, column)
  to
  map (x, y)
  using affine transform

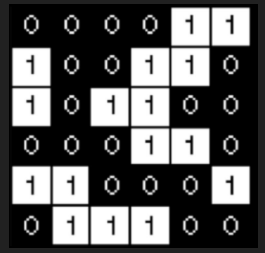
- transform parameters may be saved in “world file”
  - or embedded in raster formats like GeoTIFF



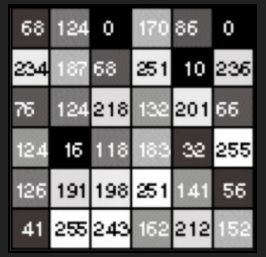
Characteristics of Rasters (cont'd)

Bands (channels)

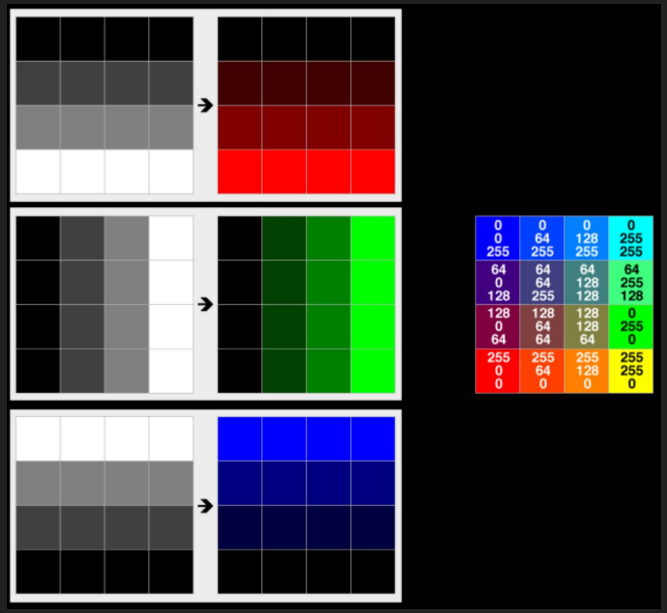
- single ("binary")



- single ("grayscale")



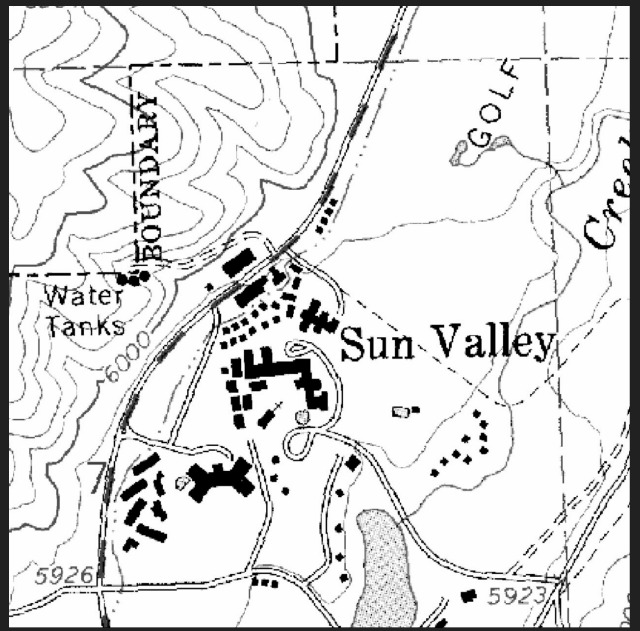
- multiple



Raster Examples

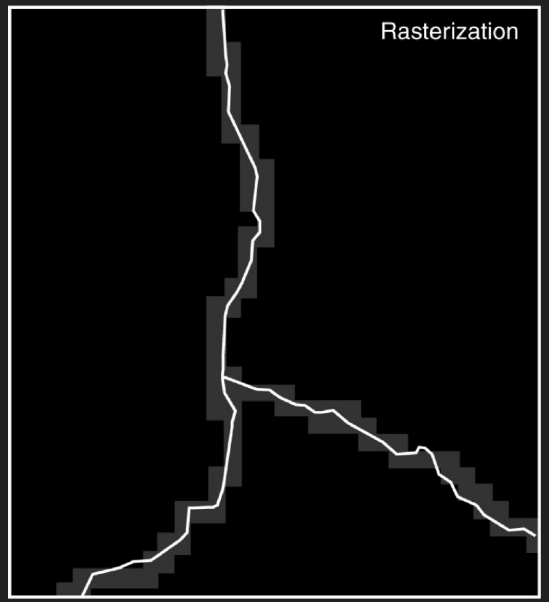
aerial image

scanned topo map

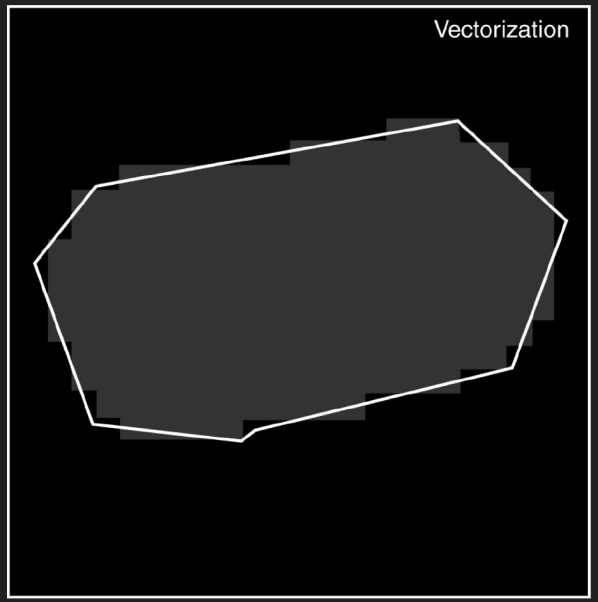


Vector ↔ Raster Conversion

Rasterize = cells that intersect feature

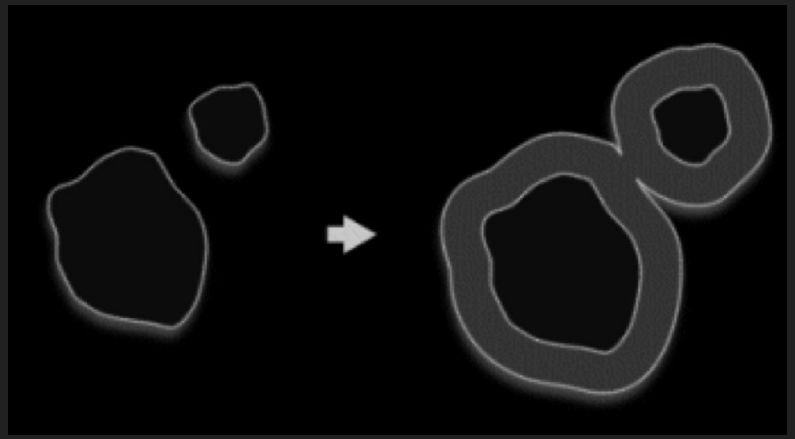


Vectorize = outline contiguous region

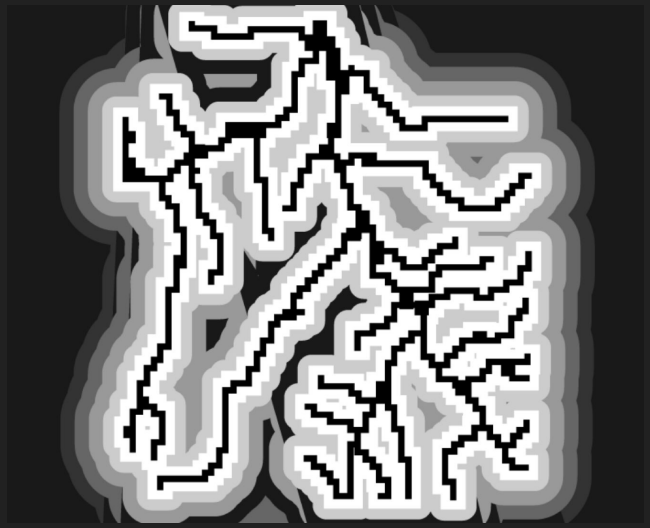


Note: Distance vs Buffering

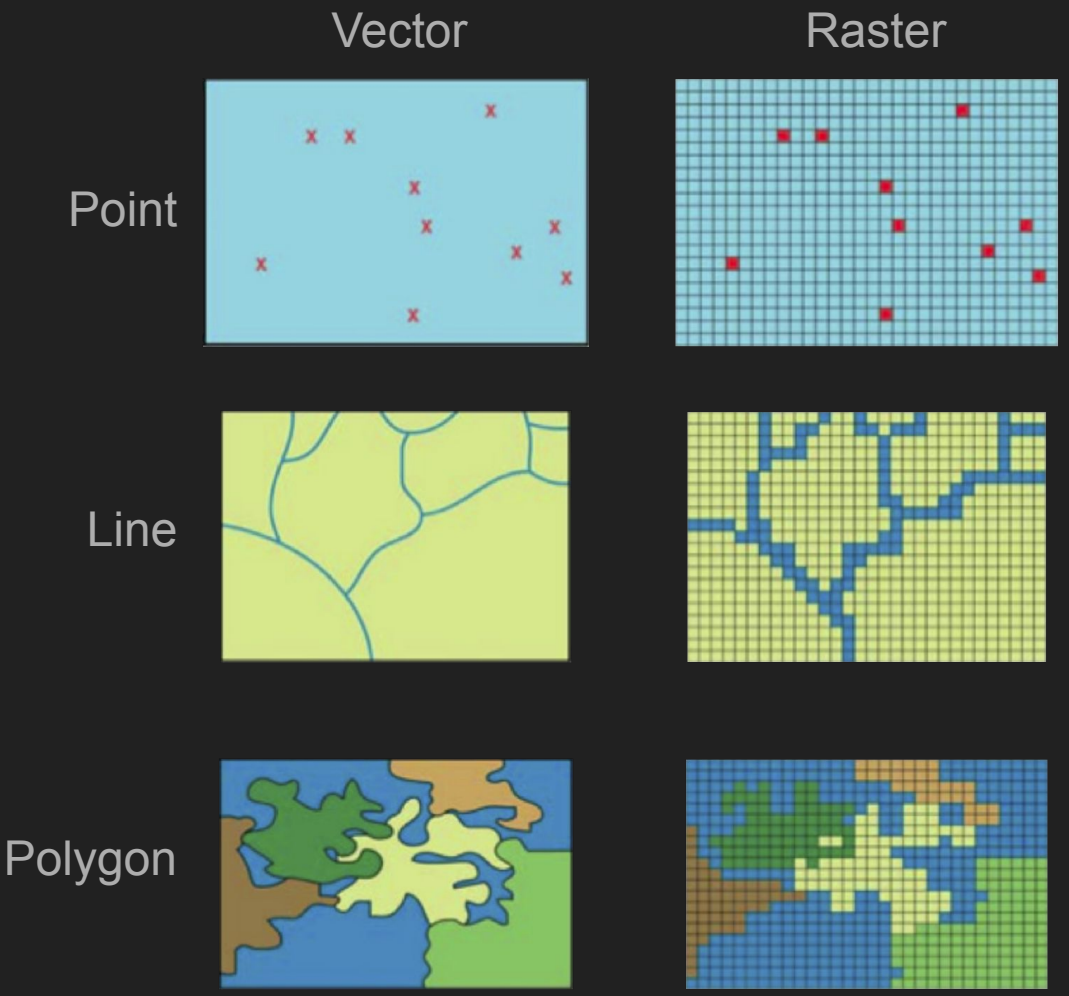
Buffer: discrete



Distance: continuous

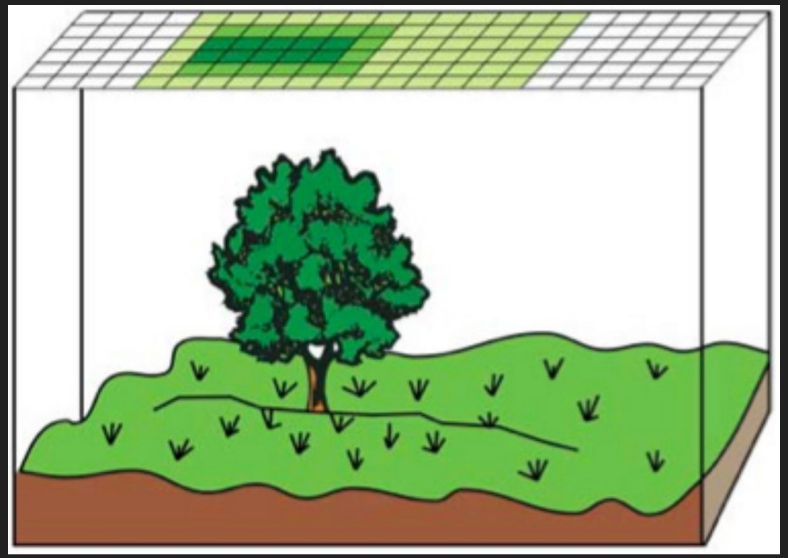


Feature Representation in Rasters: Sub-pixel Features Coarsened



Feature Representation in Rasters: Large Features Blurred

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



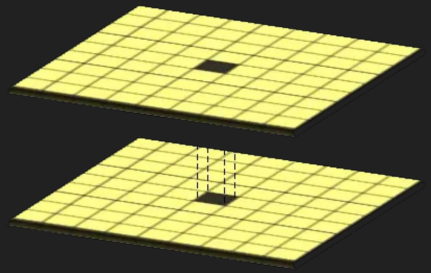
Raster Operations

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

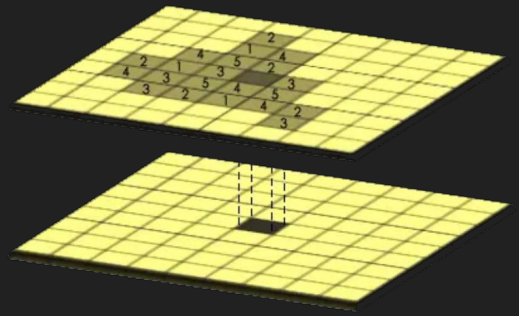
- Local
- Focal
  - aka neighborhood
- Zonal
- Global

Raster Operations

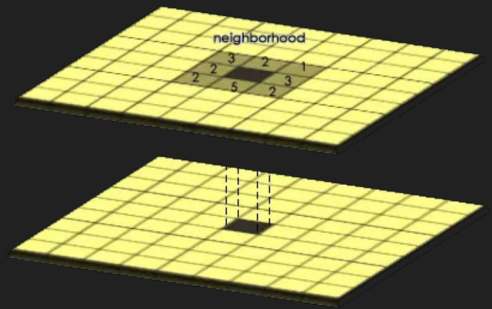
Local



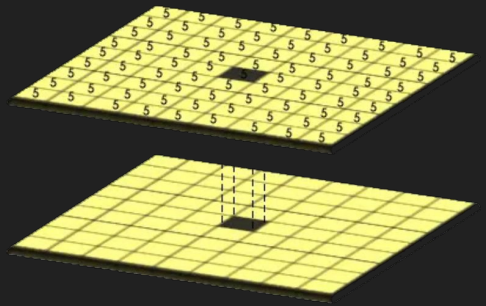
Zonal



Focal



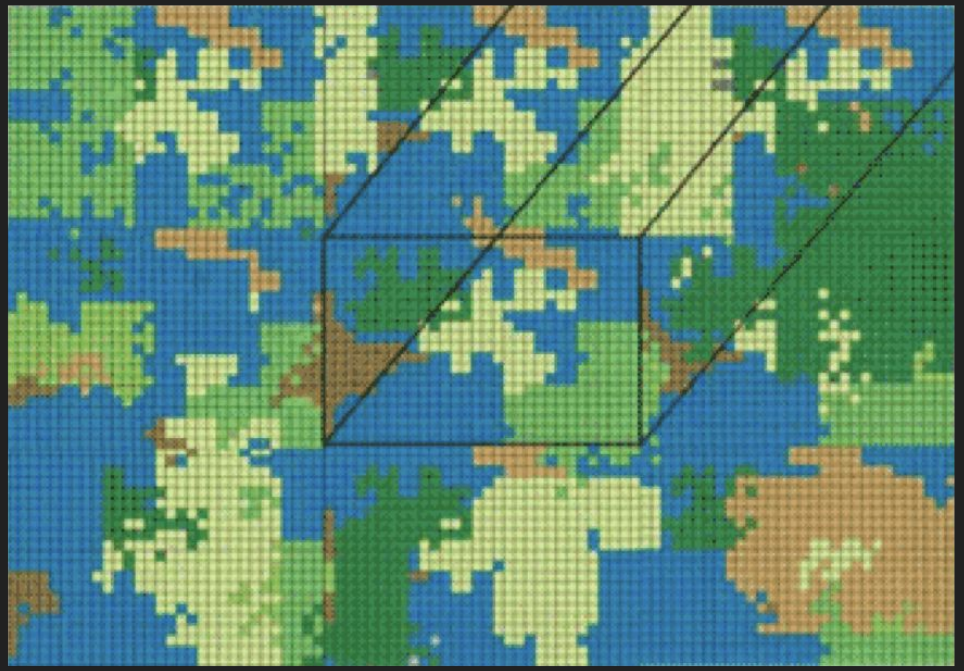
Global



Extent

restrict processing to rectangular subset

- explicit:
  (xmin, ymin, xmax, ymax)
- default: bounding box of inputs



Local Operation Example: 1 Input

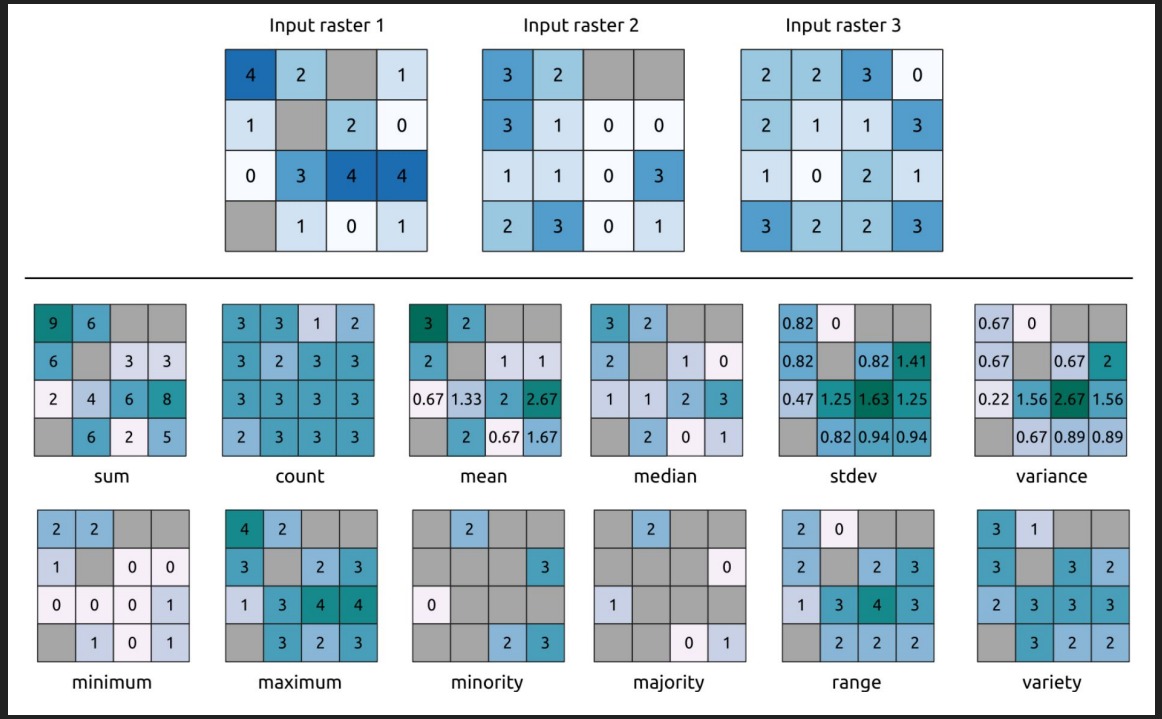
Reclassify (change values using lookup table)

1	1	0	0
	1	2	2
4	0	0	2
4	0	1	1

IN	OUT
0	10
1	50
2	100
4	75

50	50	10	10
	50	100	100
75	10	10	100
75	10	50	50

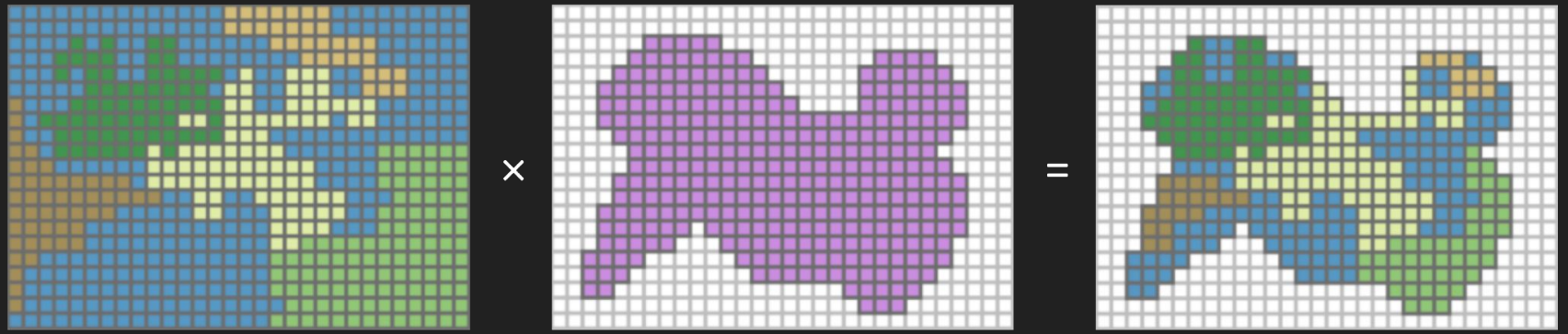
Local Operation Example: Multiple Inputs



shaded = NoData

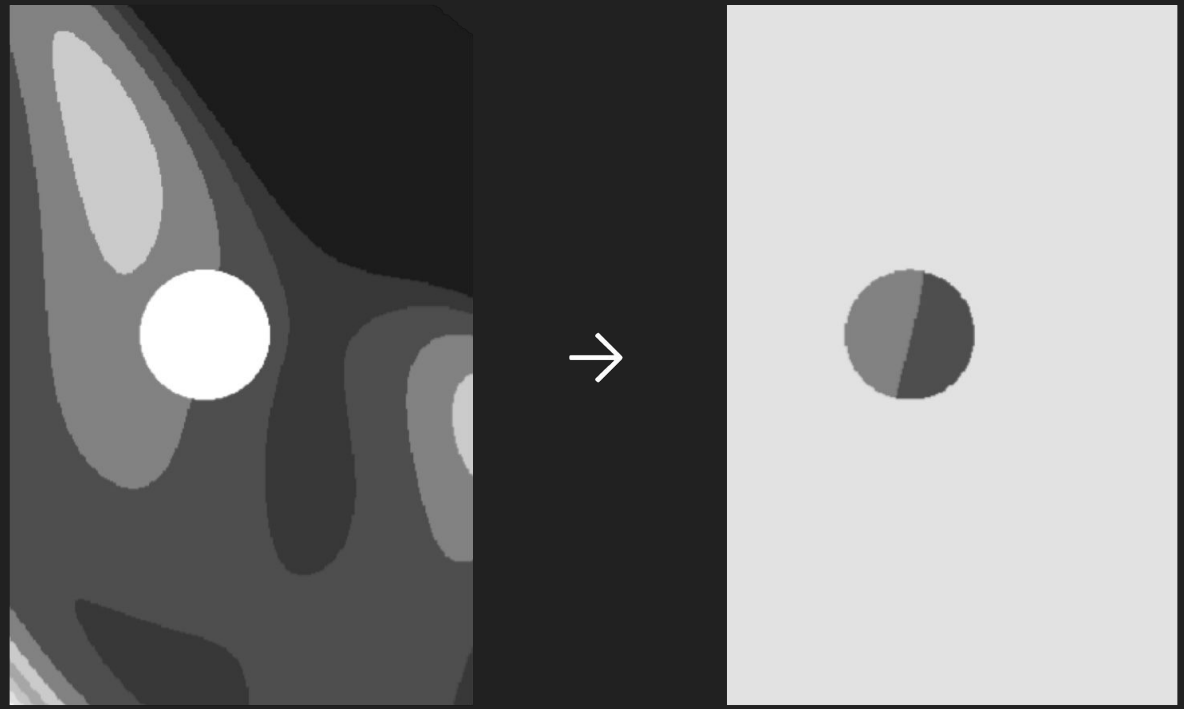
NB: NoData in any input
→ NoData in output

Local Operation Example: Mask



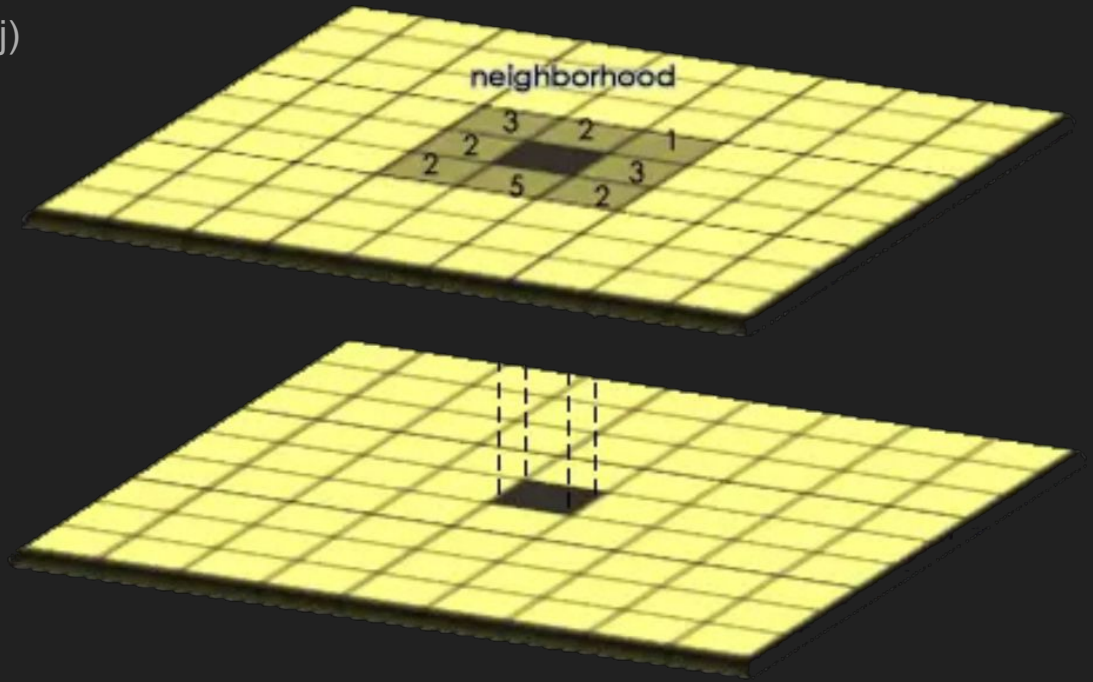
- 1 → pass
- 0 → 0
- NoData → NoData

Extract (Clip raster by mask layer (vector))



Focal (Neighborhood) Operations

- out(xi, yj) = f(in(xk, 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+2+2+2+1+3+2+2+3) / 9 = 2.11

(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

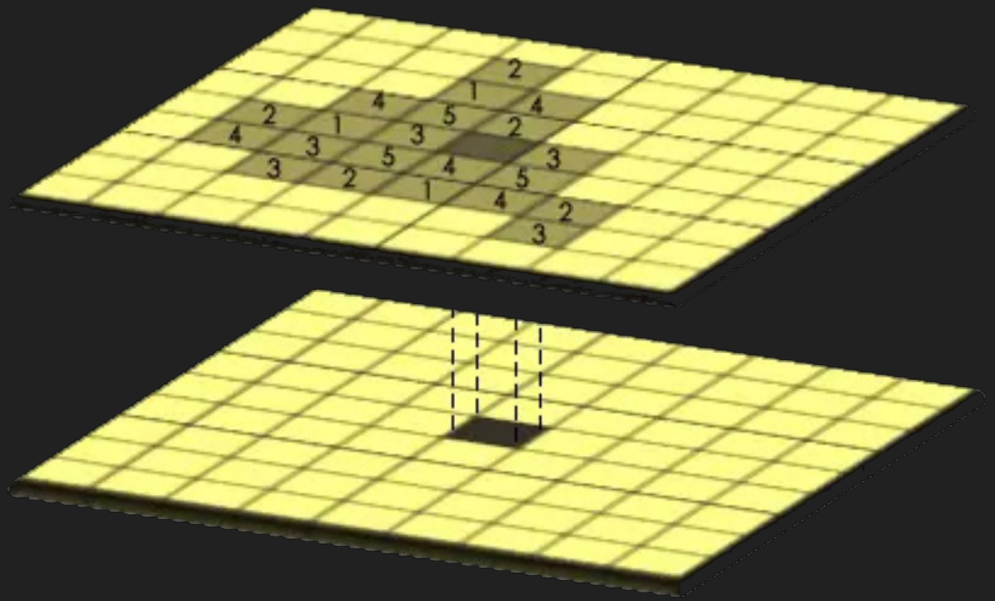
(b)

1.56	2.00	2.22
1.67	2.11	2.44
1.67	2.11	2.44

Zonal Operations

out(xi, yj) =
f(in(xk, ym) ∀ k,m ∃ zone(xk, ym) = zone(xi, yj))

- 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: Proximity

Euclidean distance to nearest target value(s)

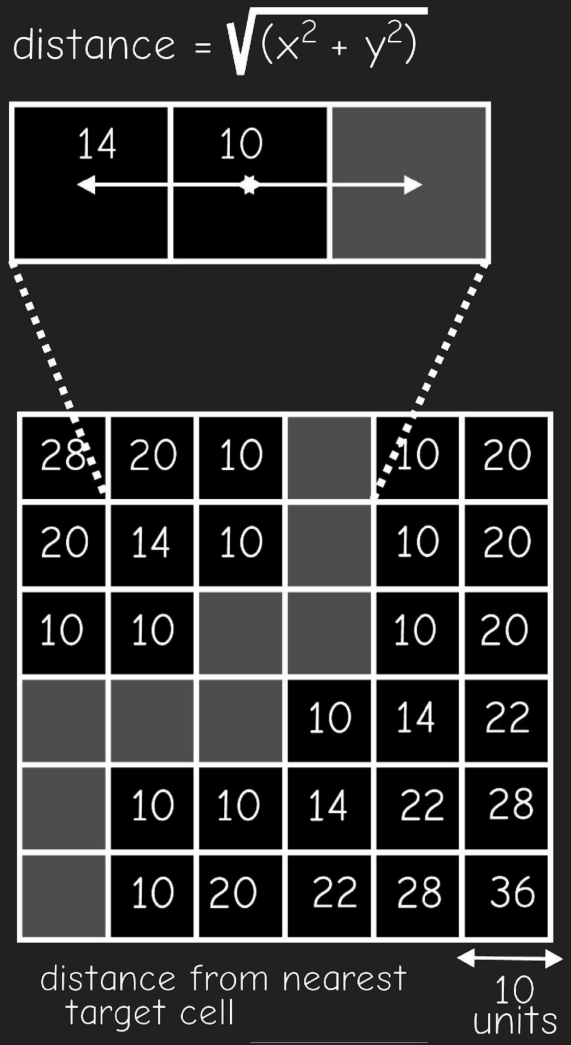


Figure Credits

- 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