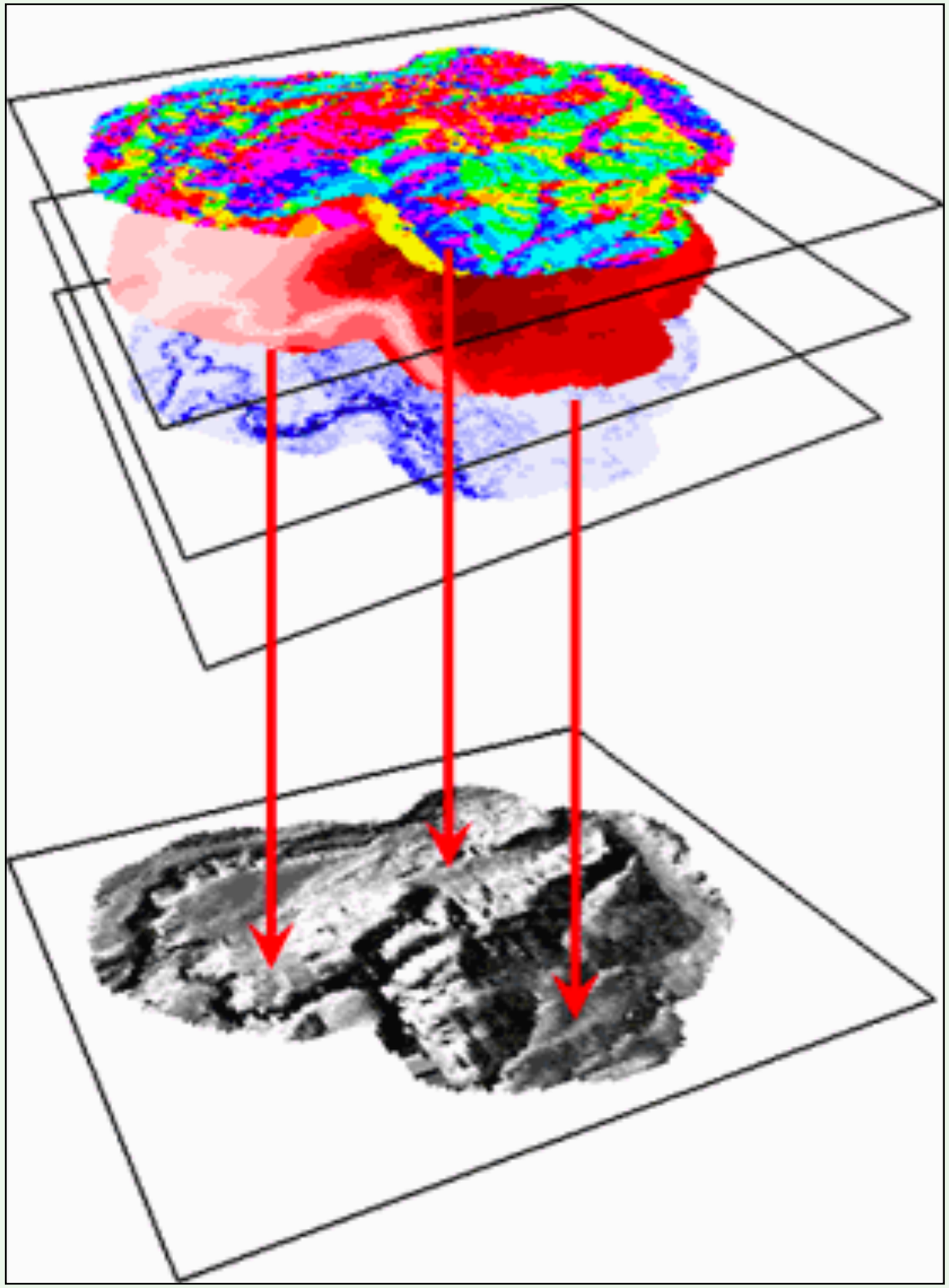
GEOG 358: Introduction to Geographic Information Systems

Raster Analysis

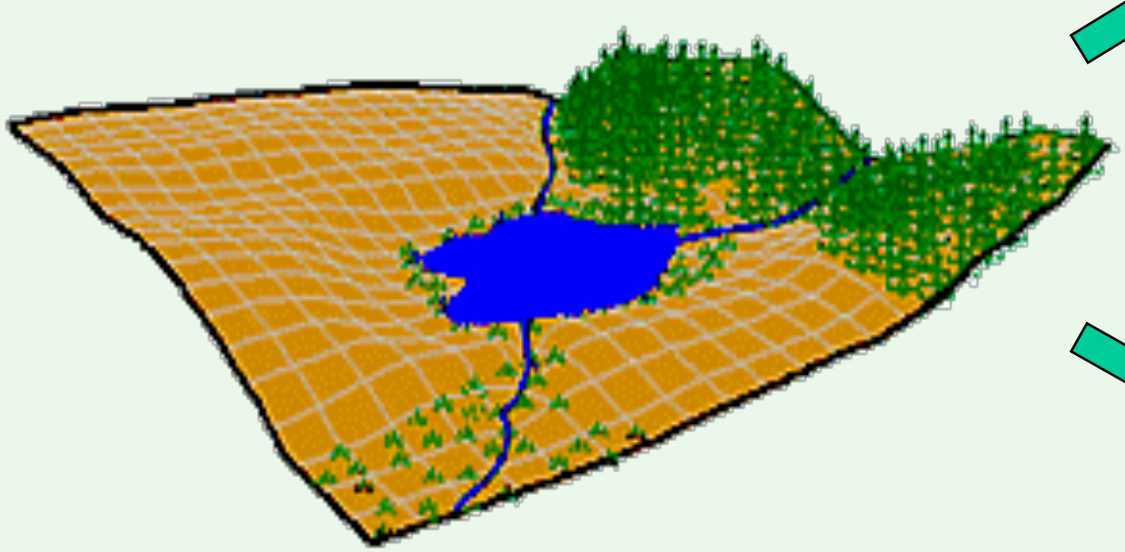


Topics

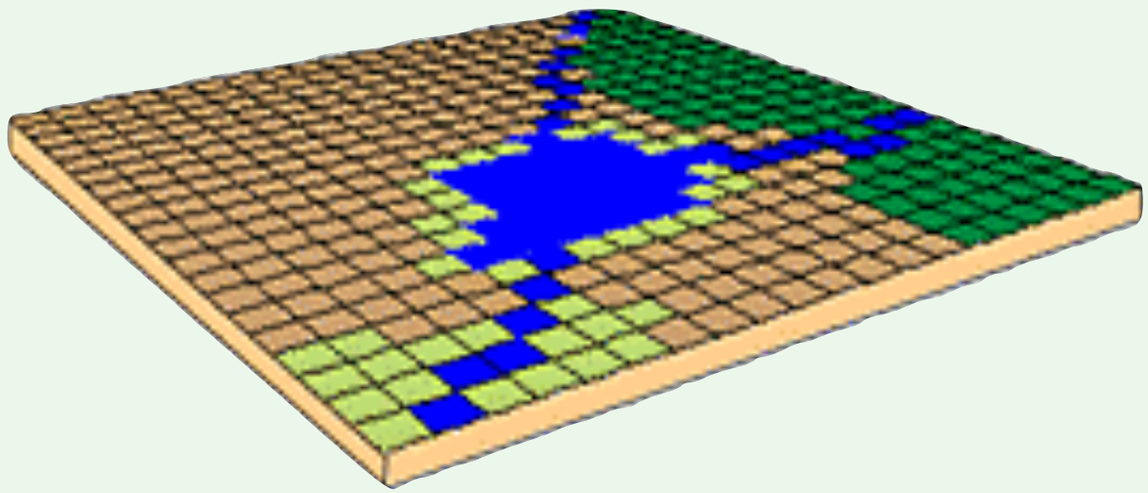
- Raster data model
- Map algebra/Cartographic modeling
- Readings
  - Chapter 10
  - Chapter 13: Cartographic modeling

Multiple Representations

vector data model



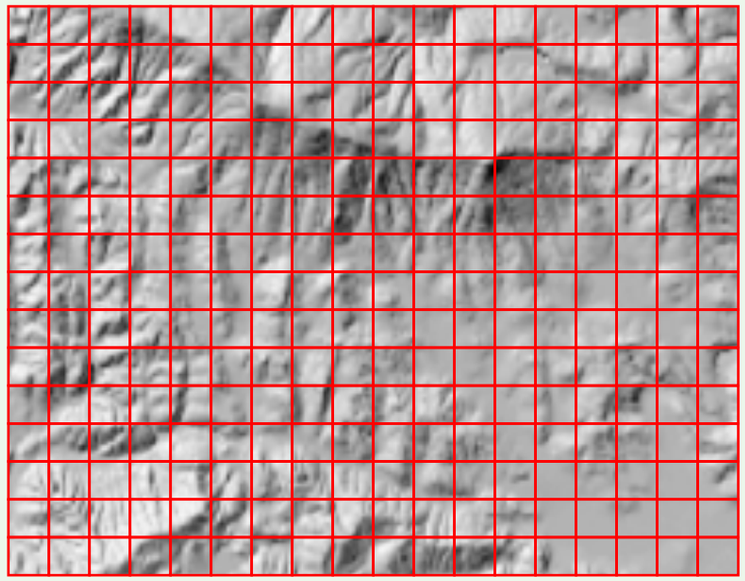
real world

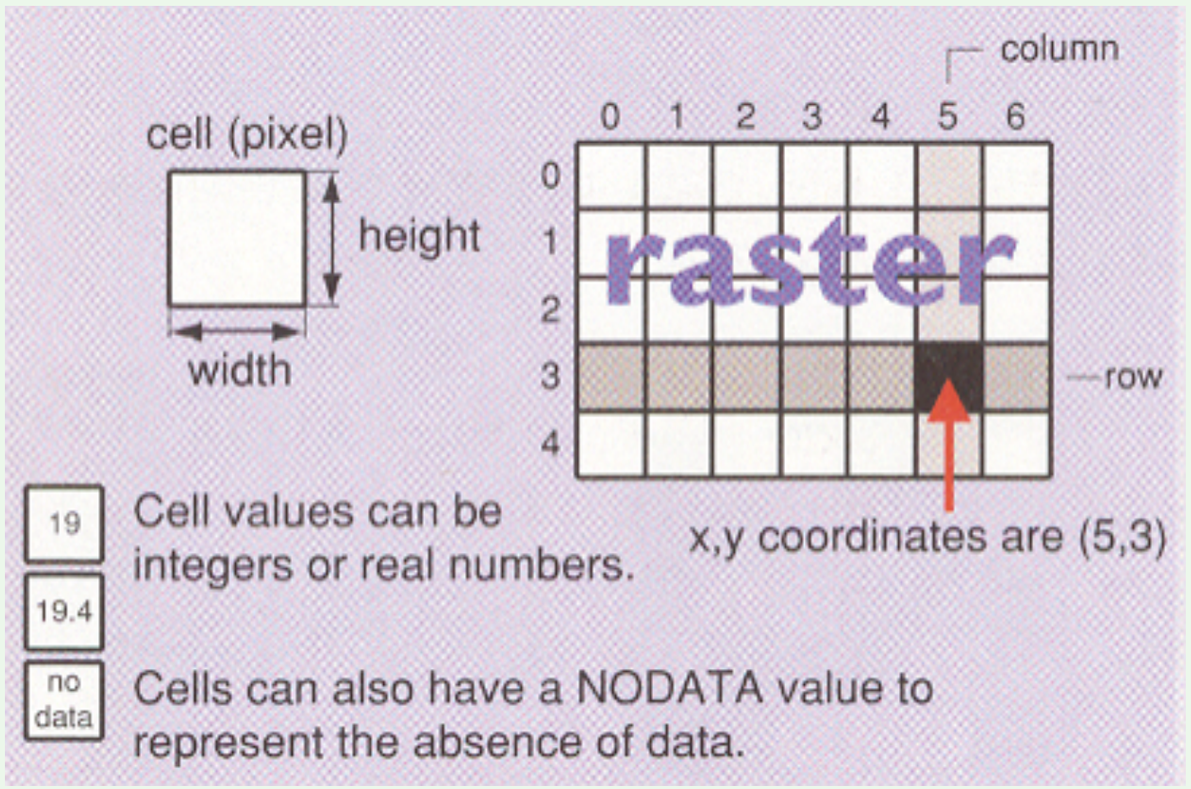


raster data model

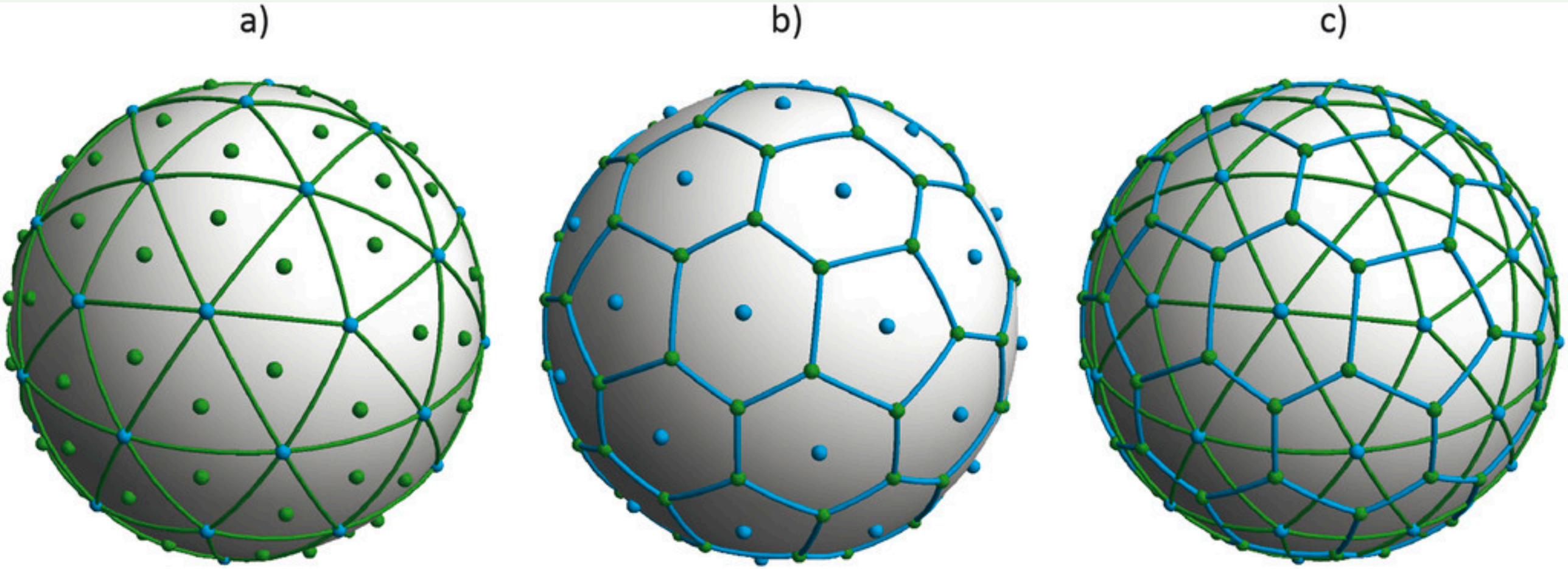
Elements of the Raster Data Model

- Space is tessellated into **cells** or **pixels**
- Raster layer
  - Matrix of cells
  - Rectangular region
  - Aligned with coordinate axes
- Georeferenced
  - Geospatial coordinates of anchor cell
  - Cell size
- Rasters involved in an analysis often resampled to the same grid system

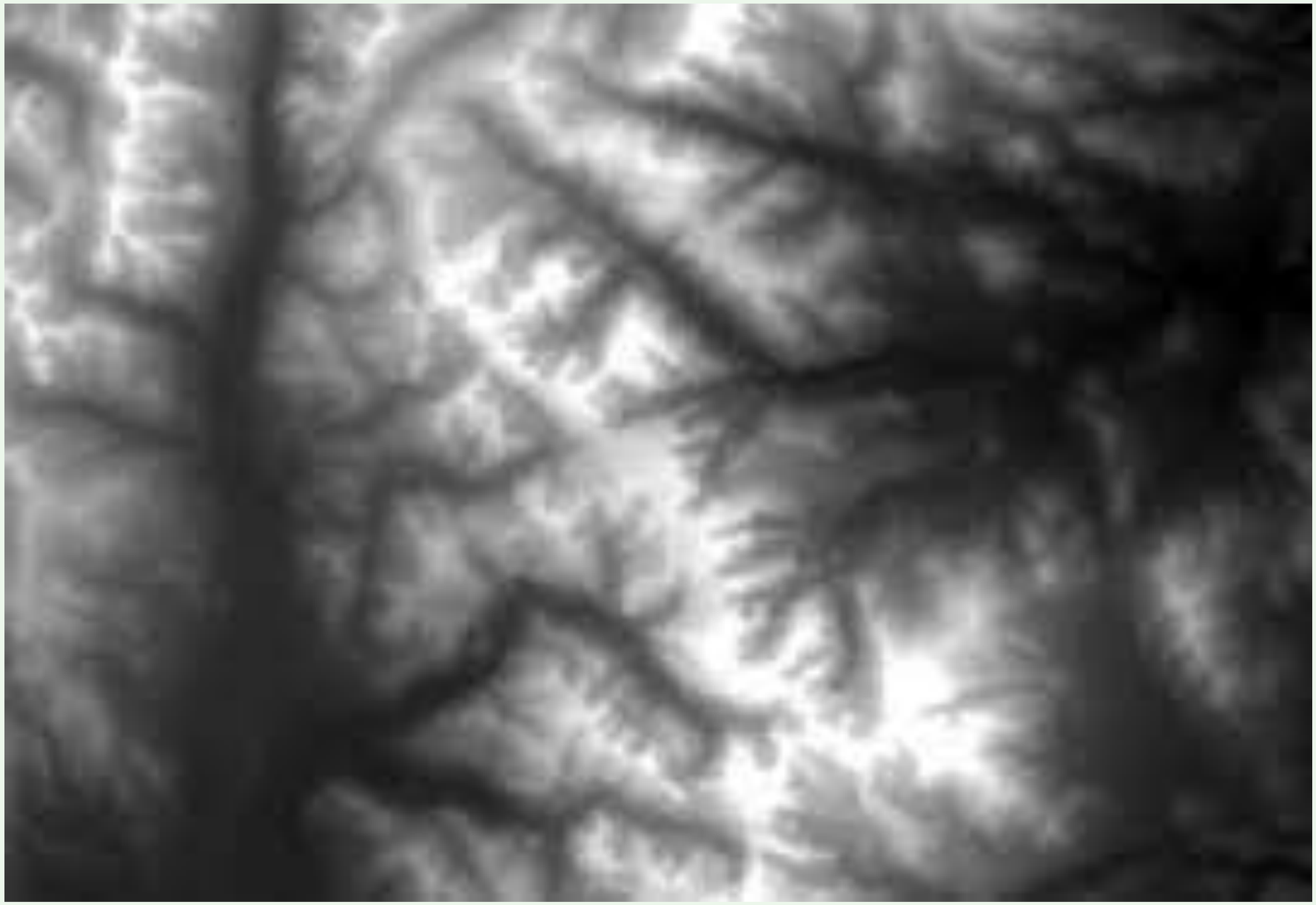




- Other spatial tessellations are available (hexagons)

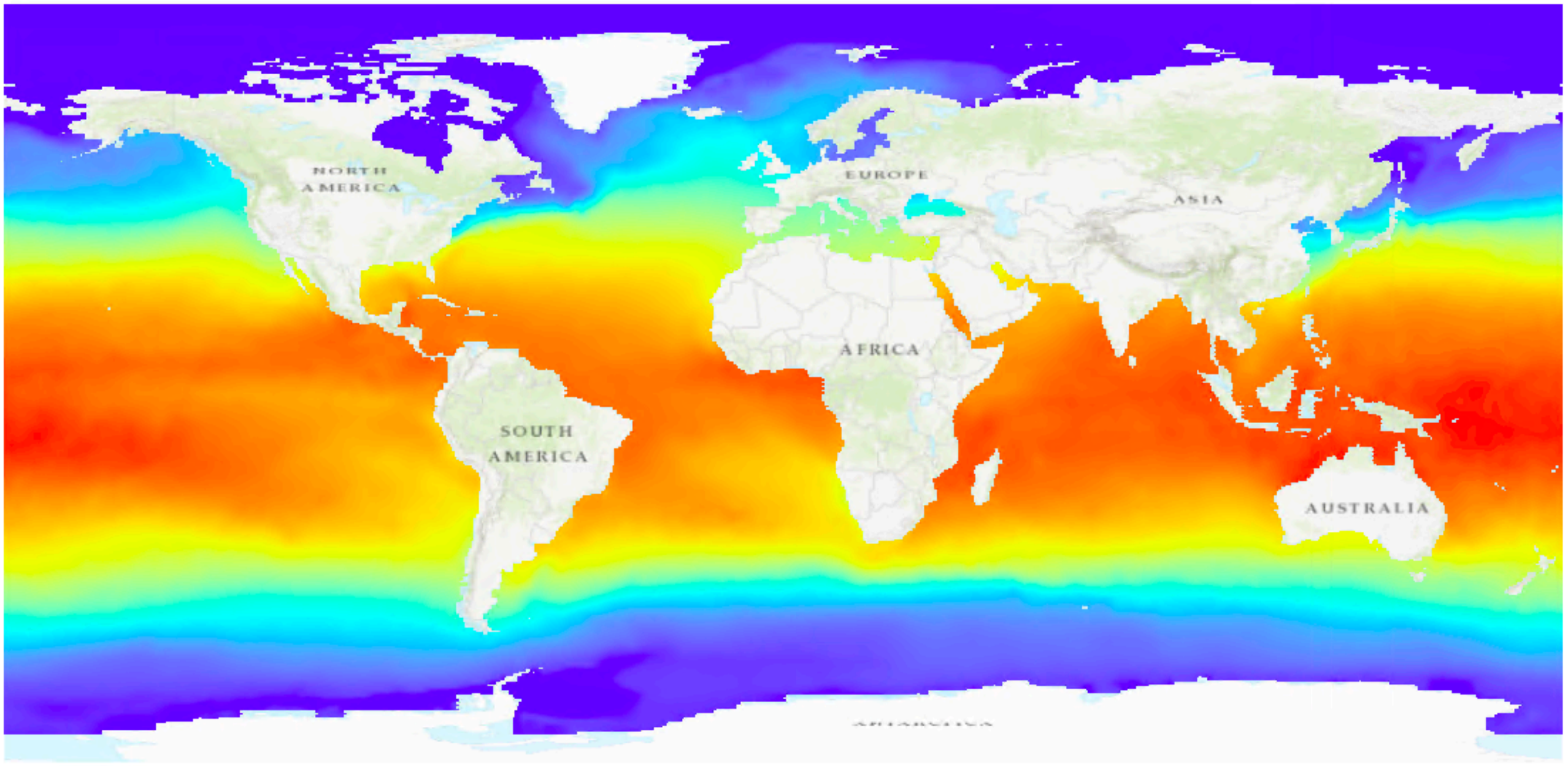


Example Raster Layers



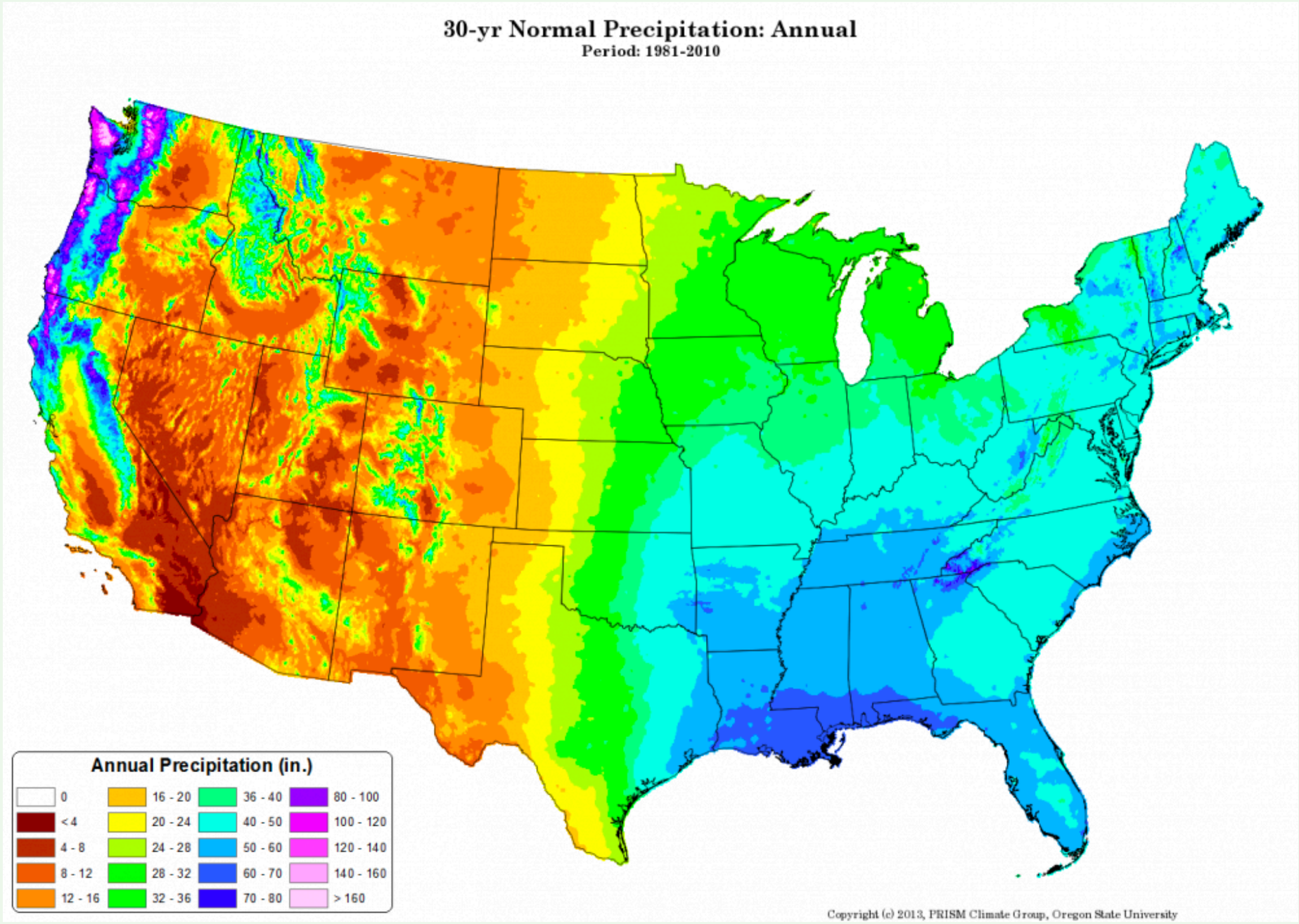
Digital elevation model (DEM)

Example Raster Layers



Climate Forecast System Reanalysis (CFSR)
Sea Surface Temperature (SST)

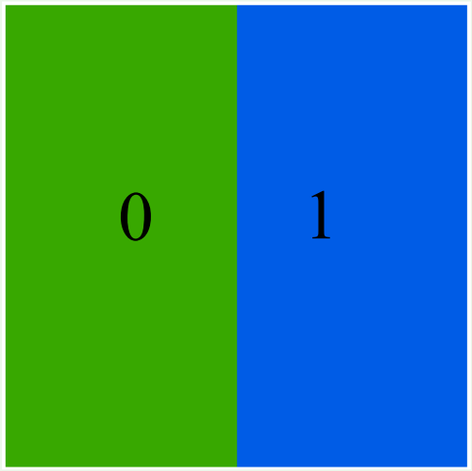
Example Raster Layers



PRISM Precipitation

Zone Raster and Raster Attribute Table

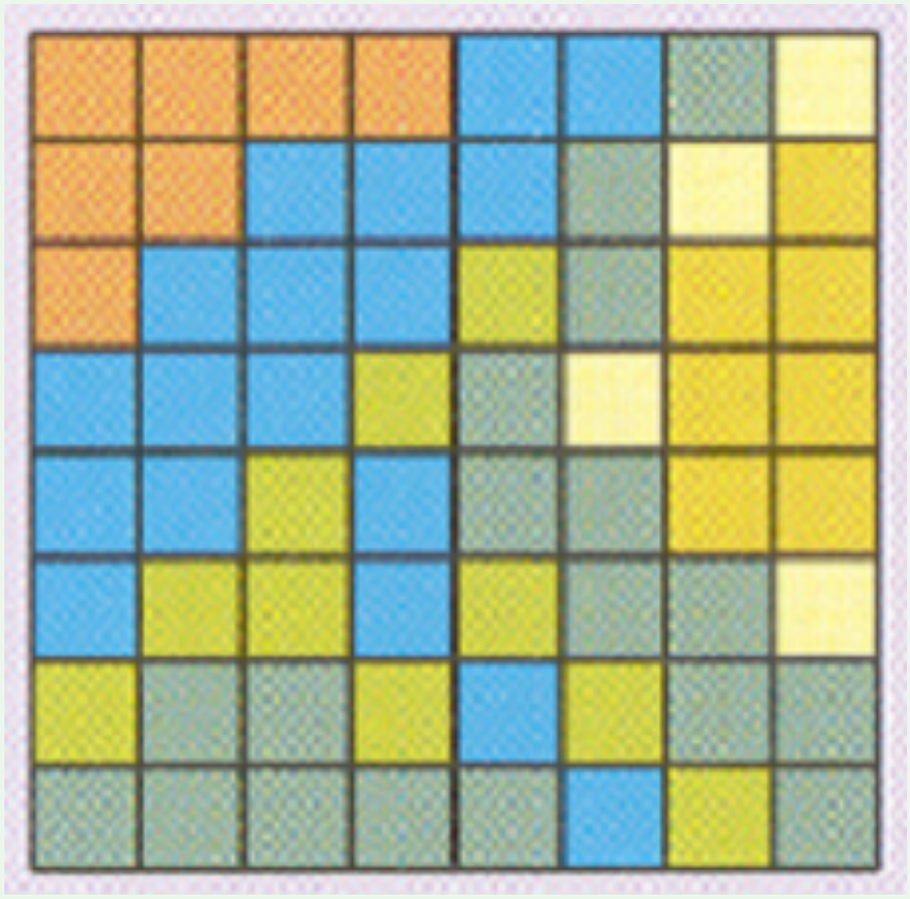
- Raster with many cells having the same value
  - akin to polygon features
- Each unique value forms a zone
  - All cells in a zone have the same value
  - Cells can be disjoint
- Typically has an attribute table
  - Frequency of the unique values (Value & Count fields)
  - May save storage space by storing zone IDs instead of zone attributes at each cell



Zone ID	Count	Value
0	50	200
1	50	325.6

Raster Attribute Table (RAT/VAT)

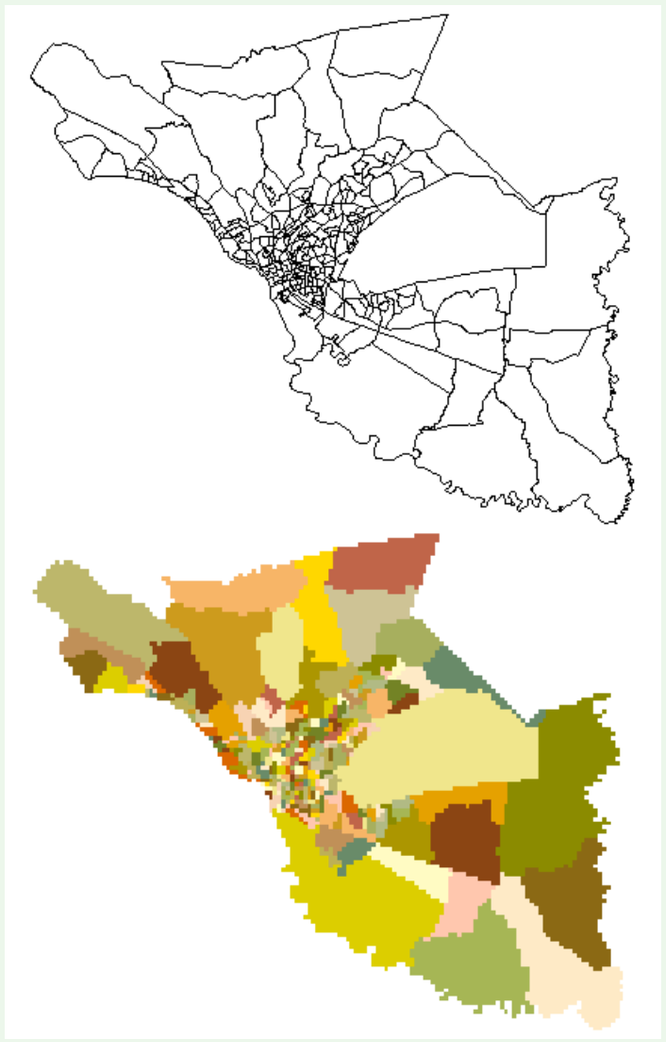
- An integer raster layer may have an attribute table
  - if the number of unique cell values is less than 1024
- Has the Value and Count fields

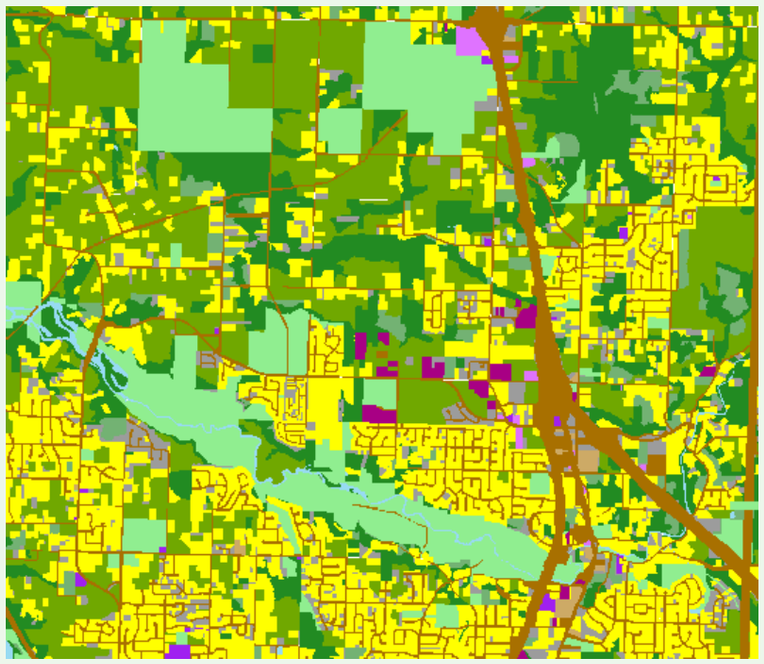


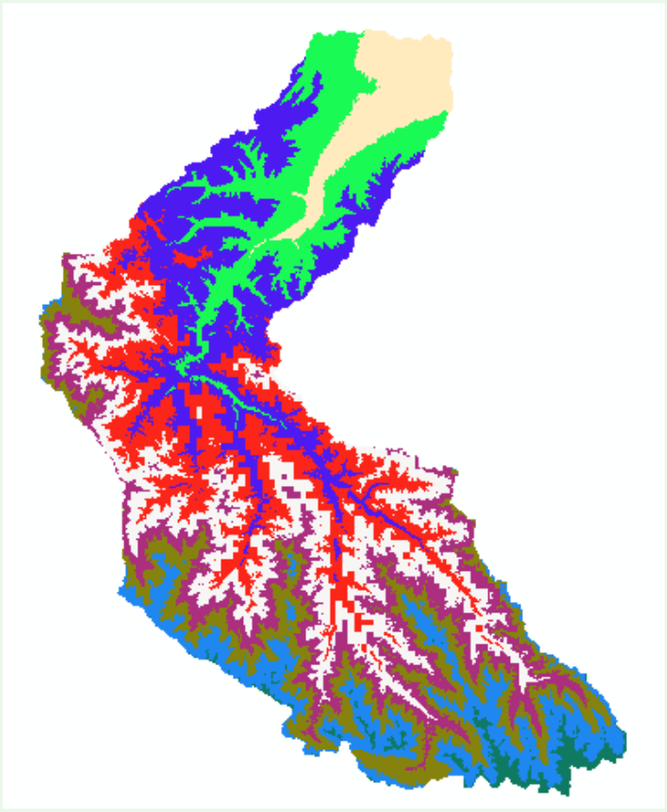
Value	Count
23	7
29	18
31	10
37	18
41	4
43	7

Zone Rasters

- Vector to raster conversion
- Image classification results
- Continuous raster can be converted into a zone raster by classifying the attribute





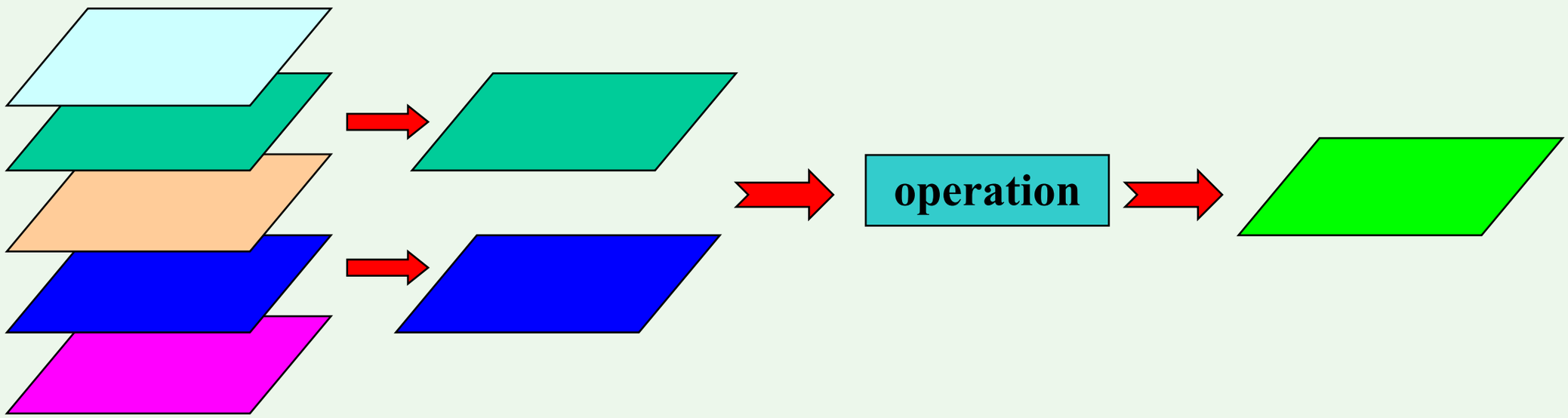


ESRI Raster--GRID

- Integer grid
  - Store values as 32-bit signed integer
    - (–2147483648 to 21474836487)
  - Represent continuous & discrete cell values
  - Uses compression (run-length coding) if applicable
  - Can have value attribute table (VAT)
- Floating point grid
  - Store values as 32-bit floating point numbers
  - Represent continuous field
  - Don’t have value attribute table (VAT)
  - No data compression
- GRIDs can be converted to each other

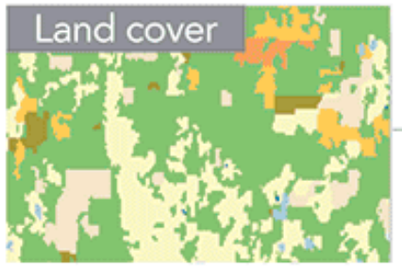
Spatial Analysis in the Raster Data Model

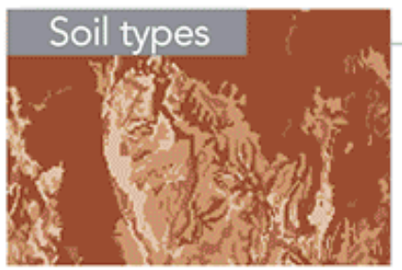
- New raster layers are created by applying an operation to input raster layer(s)
- Complex analysis can be performed by applying a sequence of operations

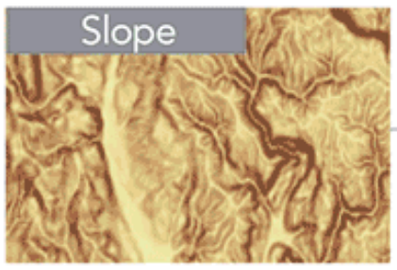


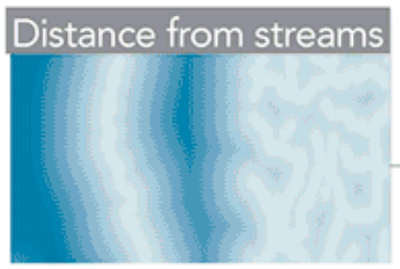
Collect source layers

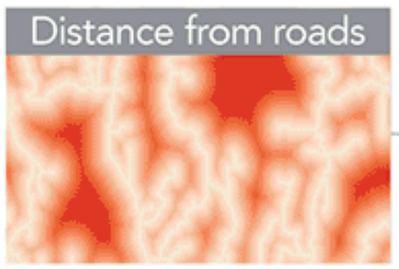
Data is first digitized into either polygon or raster layers. This housing suitability data is raster.

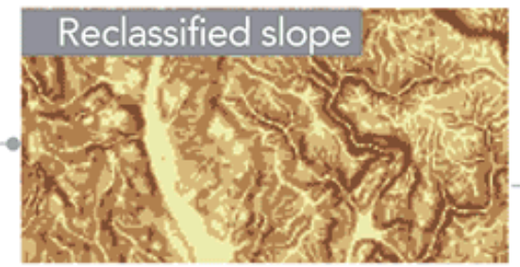










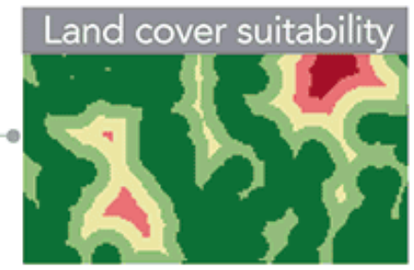


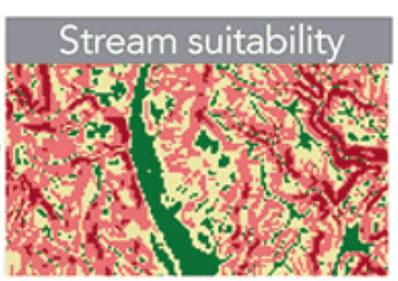
Reclassification

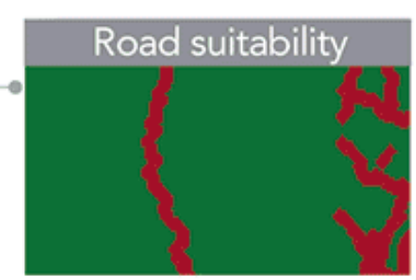
Source layers composed of continuous values (such as slope and distance layers) are first reclassified into meaningful ranges of values.

Create suitability layers

Each layer is now classified to use a common suitability scale: for example, low suitability could be assigned a value of 1 (dark red) and high suitabilty a value of 5 (dark green).

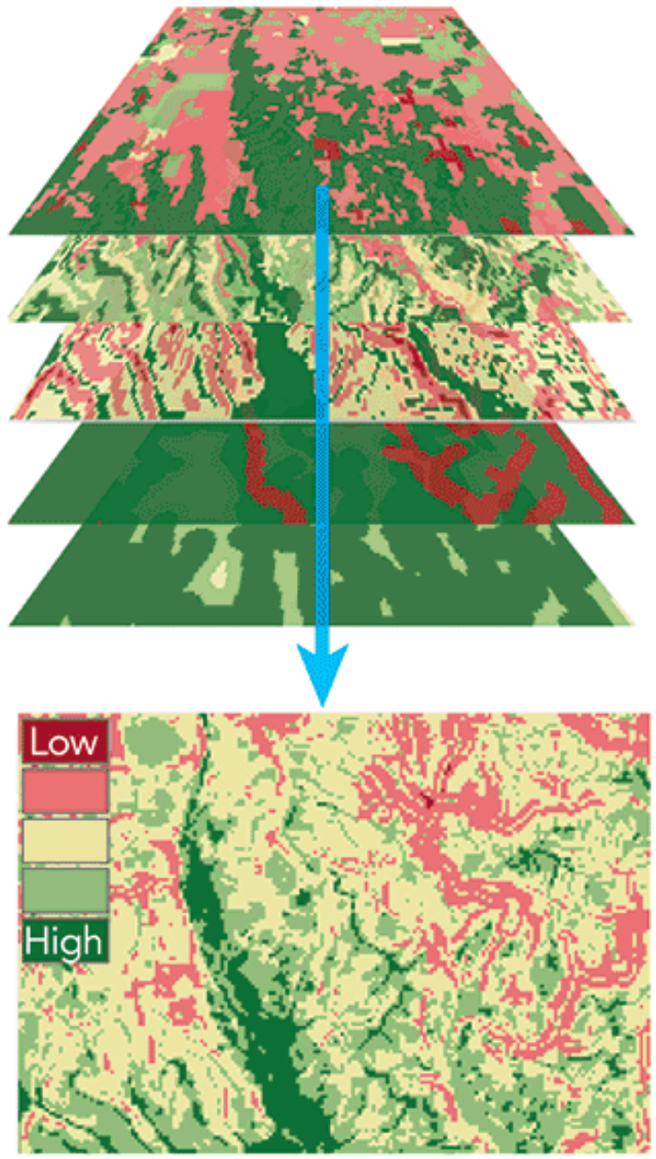






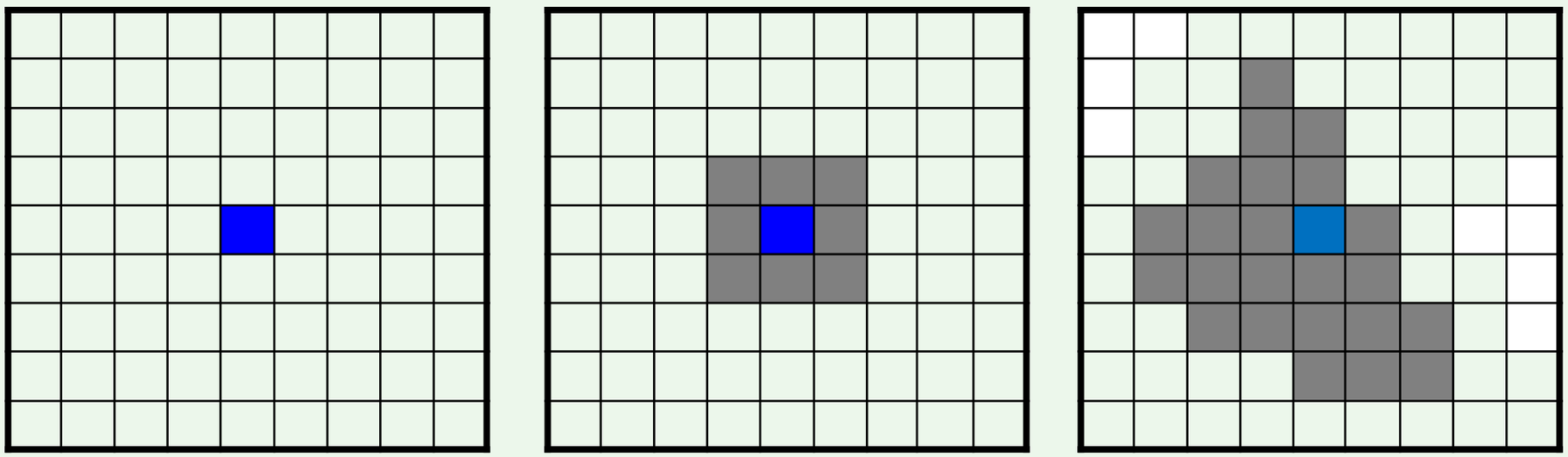
Calculate weighted overlay

Suitability layers are overlaid so that each cell gets an overall suitability rating. Weights of relative importance are assigned to each layer.

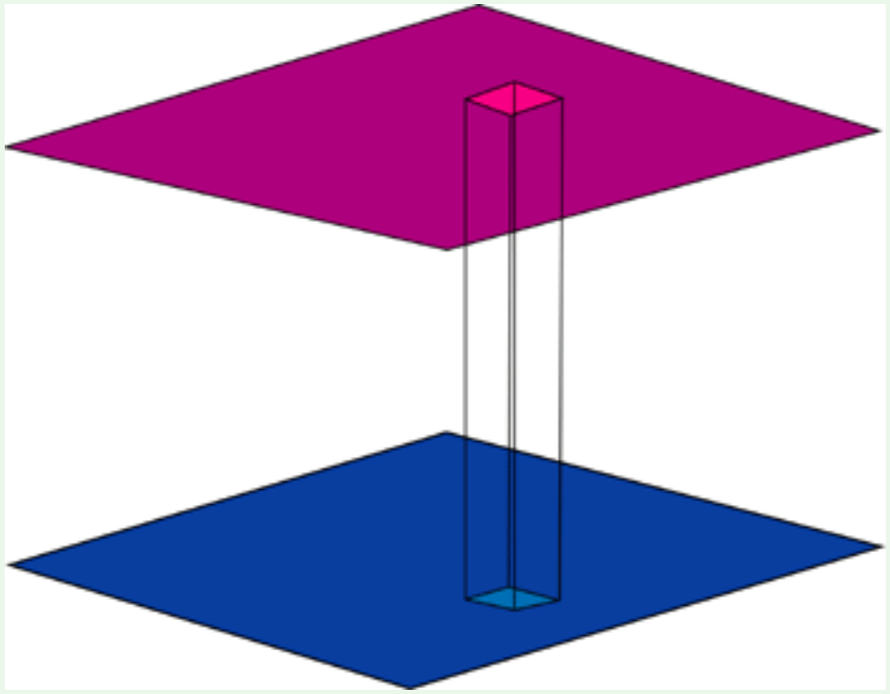


Map Algebra / Cartographic Modeling

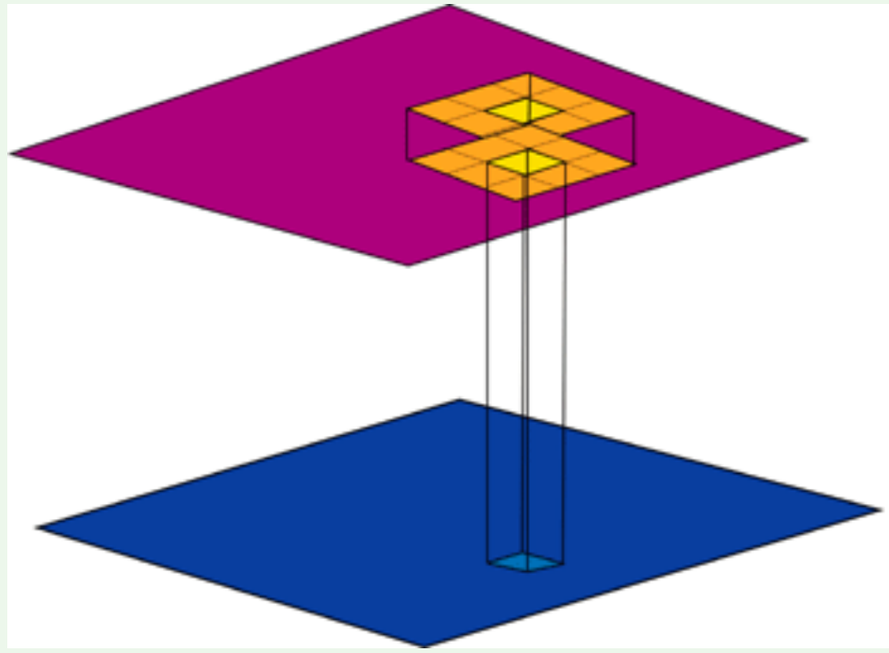
- Cartographic modeling / Map algebra
  - Invented around 1980 by Tomlin
  - A framework that defines and organizes operations on the raster data
- Operations are grouped as **local**, **focal**, and **zonal** according to the **spatial scope** of the operations.



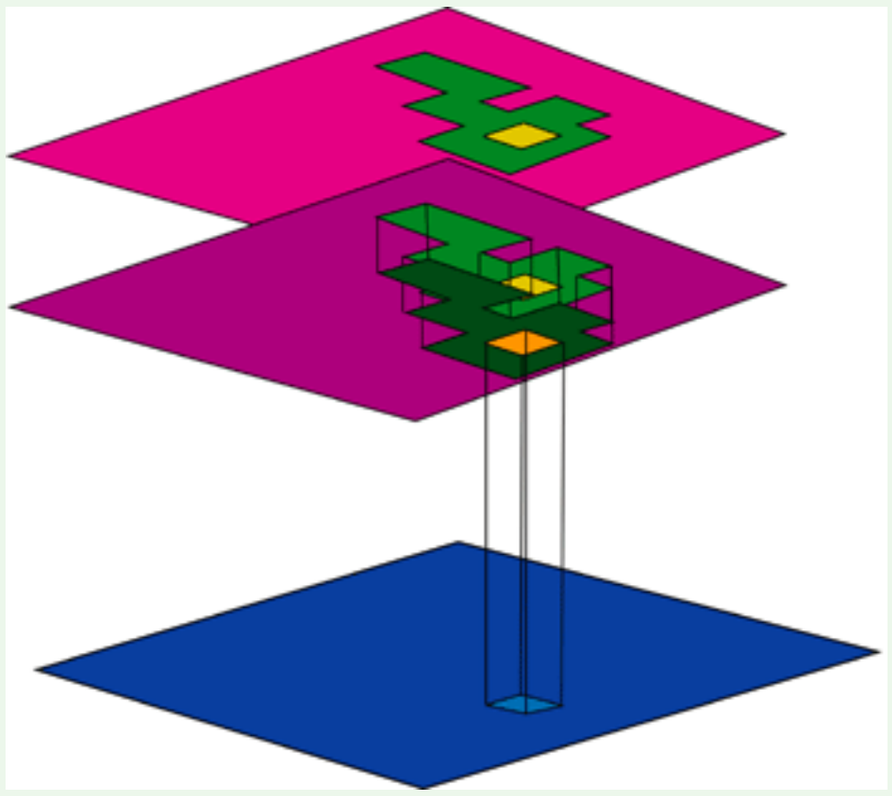
Local



Focal

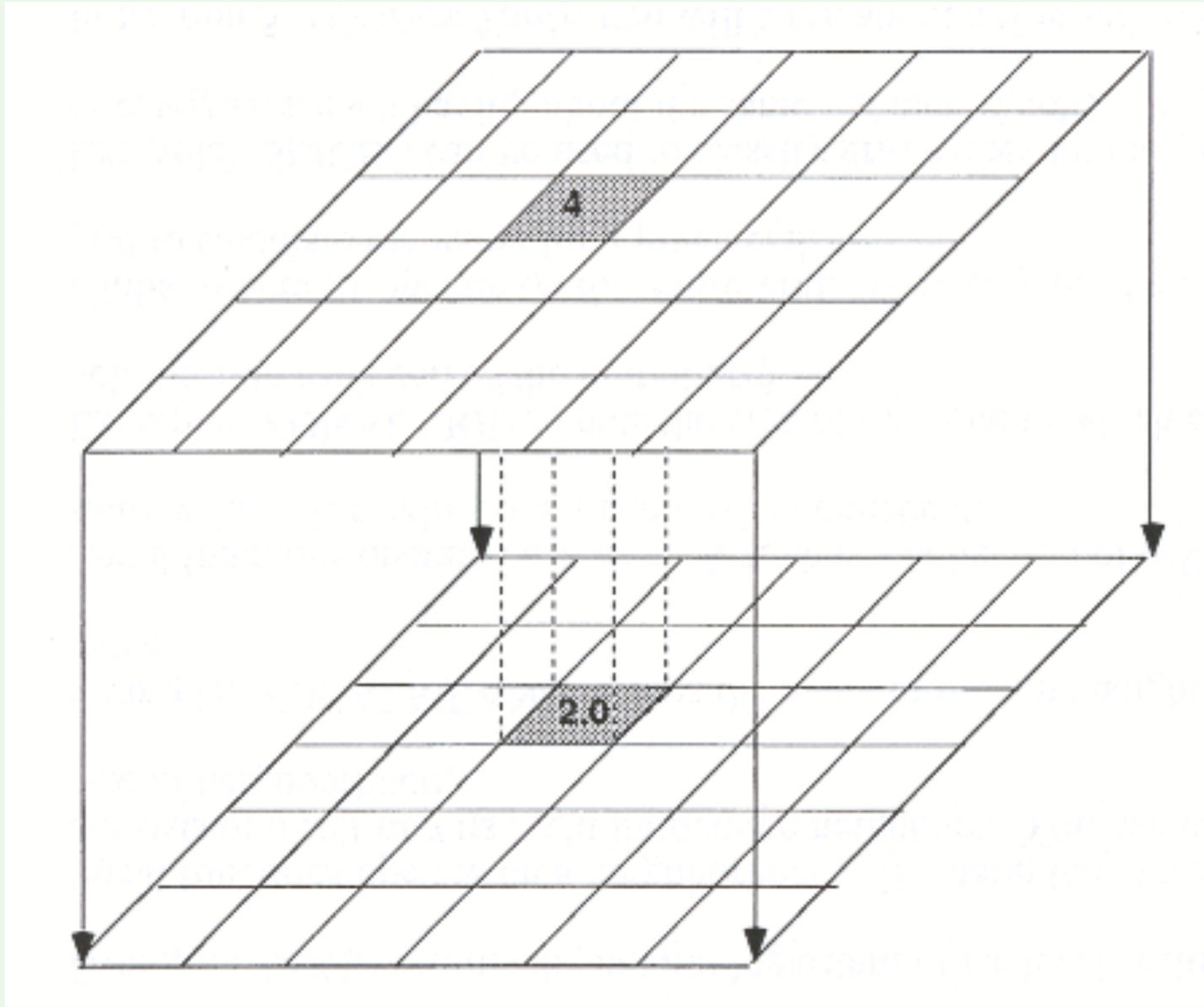


Zonal



Local Operations

- Compute a new value for each cell on the output raster layer as a function of one or more existing cell values ***at the same location/cell*** on the input raster layer(s)
- Example
  - Square root or divide by 2



Local Operations

- Arithmetic operations

  +, -, *, /, abs, …

- Relational operators

  >, <, …

- Statistic operations

  Min, Max, Mean, Majority, …

- Trigonometric operations

  Sine, Cosine, Tan, Arcsine, Arccosine, …

- Exponential and logarithmic operations

  Sqr, sqrt, exp, exp2, …

Local Operation Examples

LocalSum

9	9	7
9	8	5
6	3	0

+

0	0	2
0	0	1
0	0	0

=

9	9	9
9	8	6
6	3	0

LocalMax

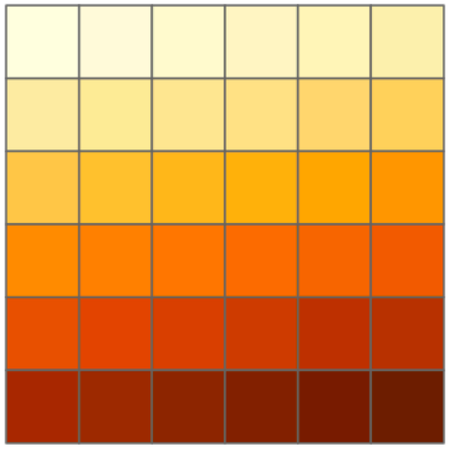
1	1	7
9	8	5
6	1	4

5	8	1
9	8	1
6	5	4

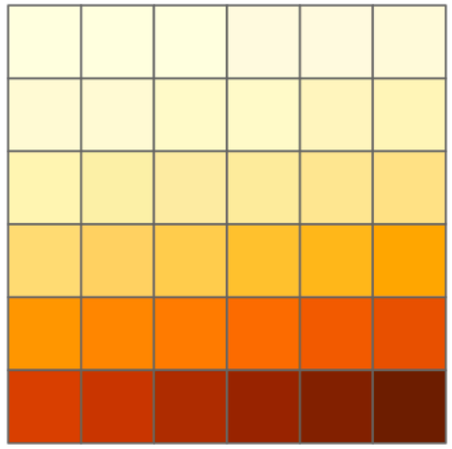
=

5	8	7
9	8	5
6	5	4

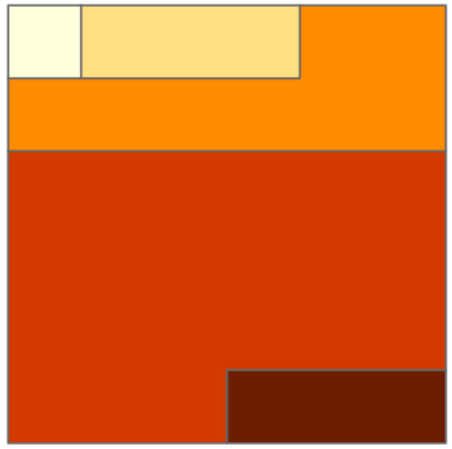
elev + elev



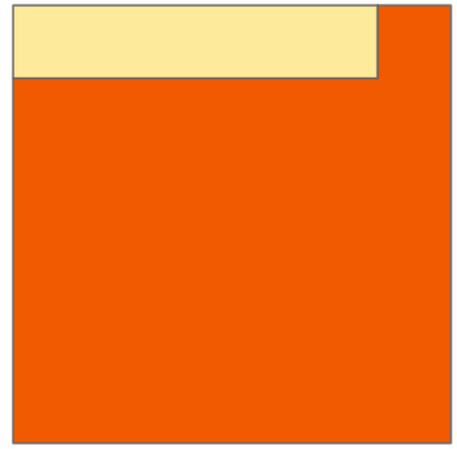
elev^2



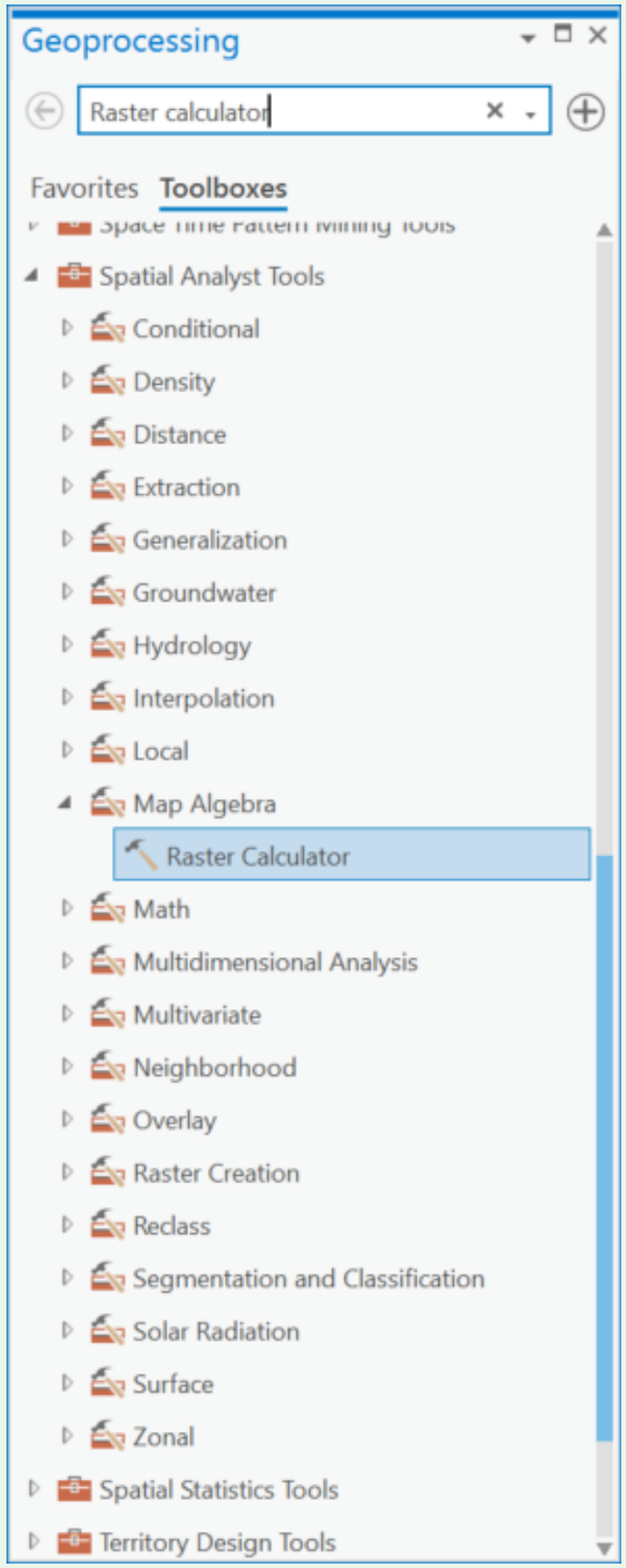
log(elev)

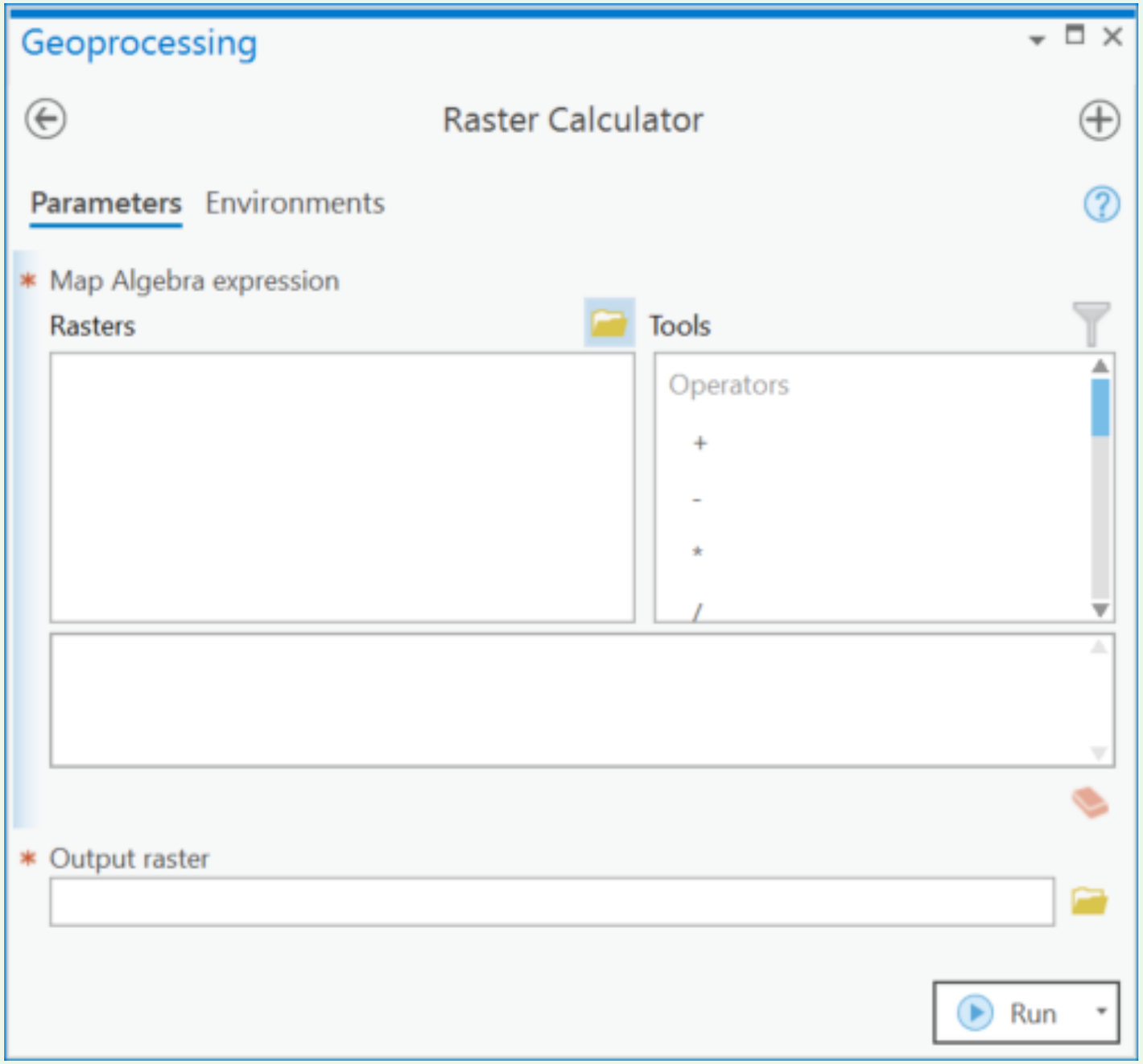


elev > 5

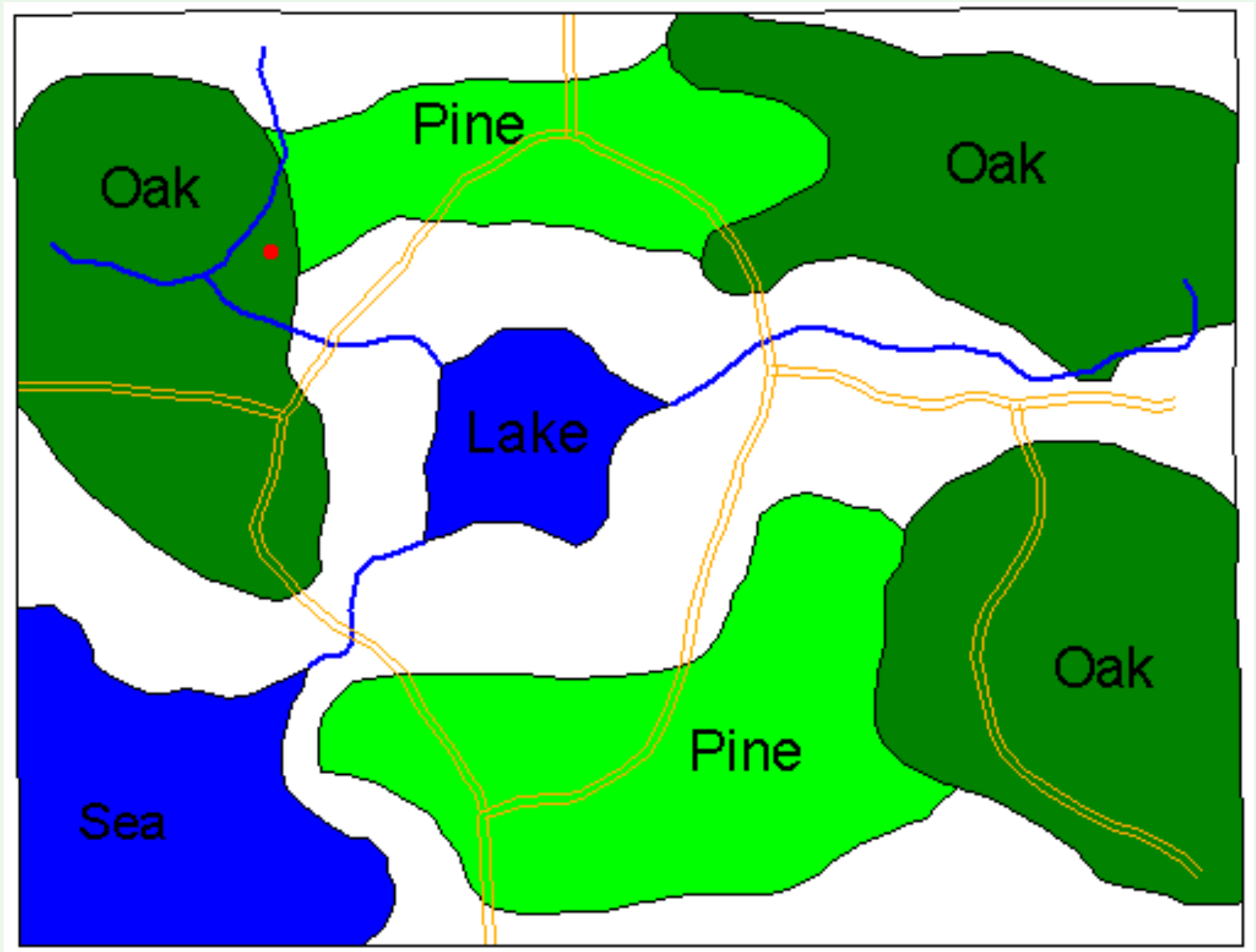


Raster Analysis in ArcGIS Pro—the Spatial Analyst Toolbox





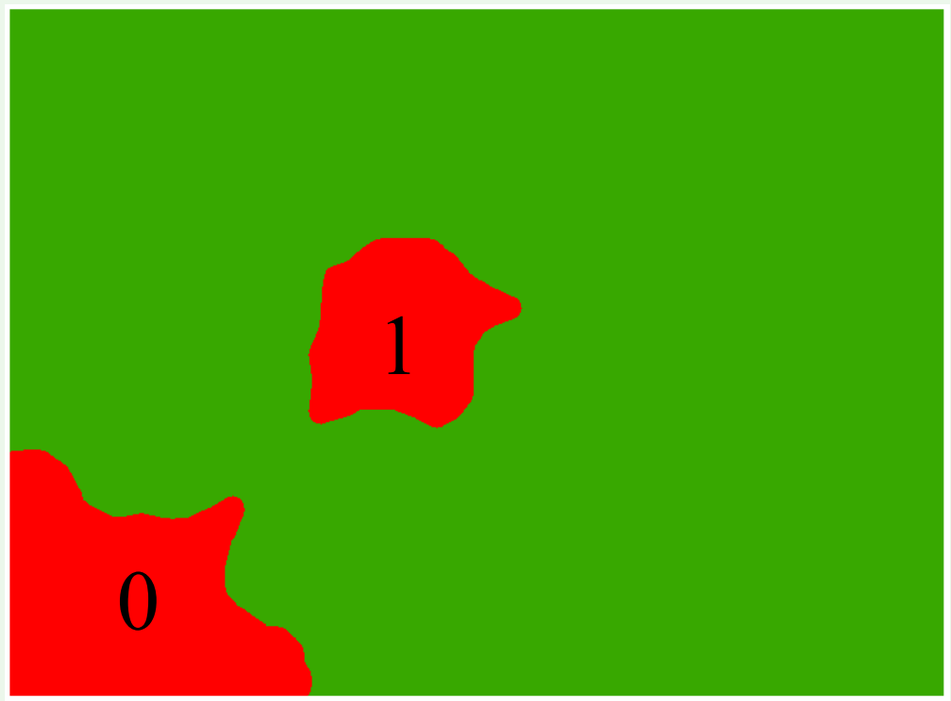
Logging Application

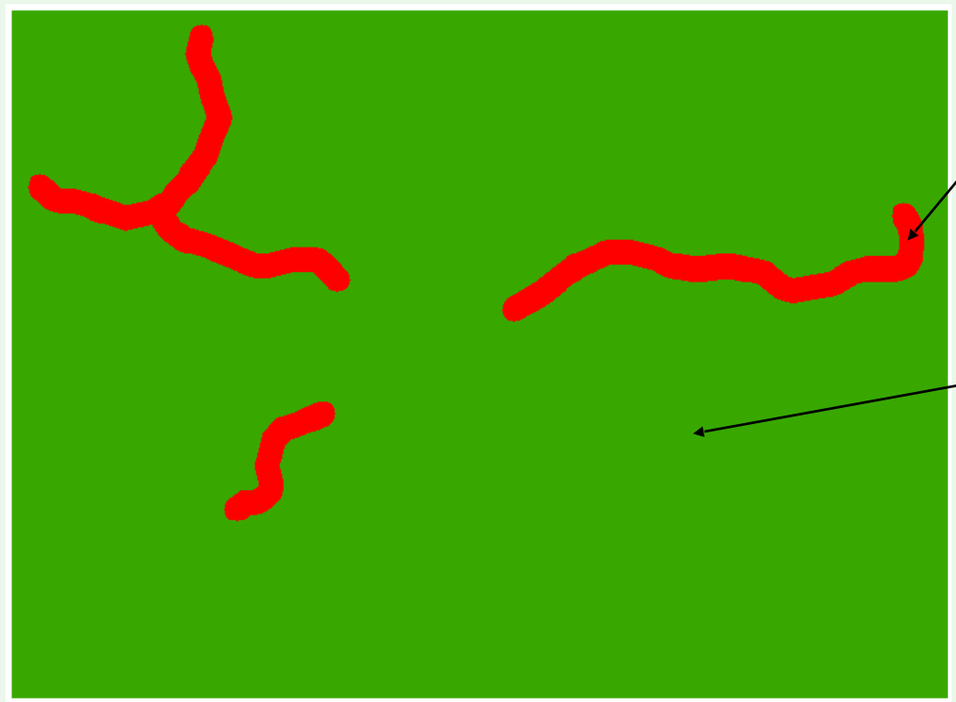


License Restrictions

- No trees may be cut down within 1 km of the sea, the lake or any rivers to help prevent land erosion.
- No trees may be cut down within 10 km of the shrine.
- The logging sites must be within 5 km of existing roads for easy access by heavy logging equipment.

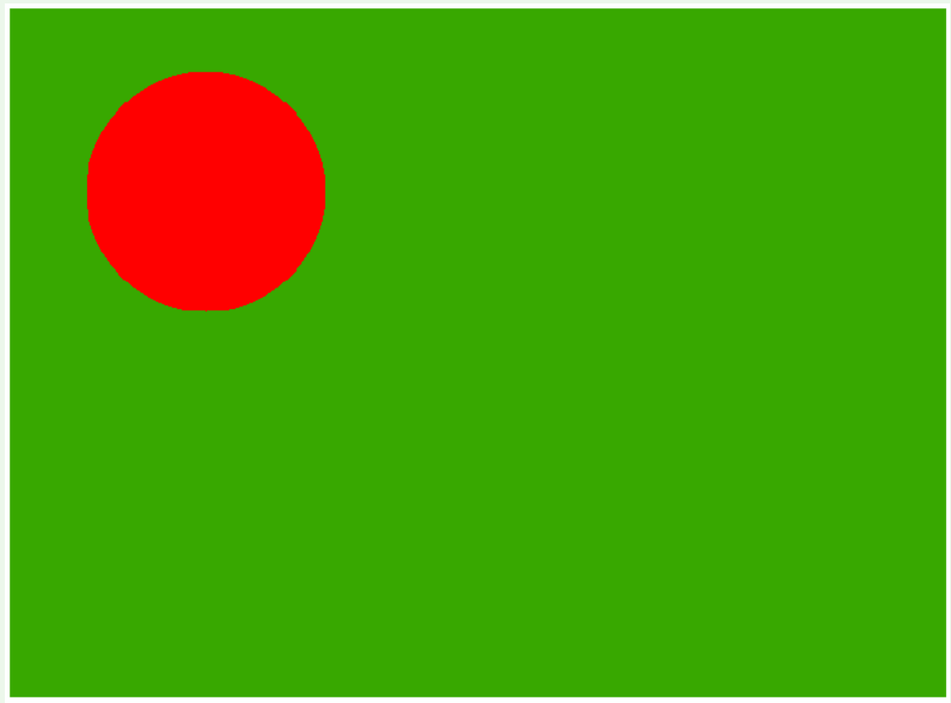
Logging Application





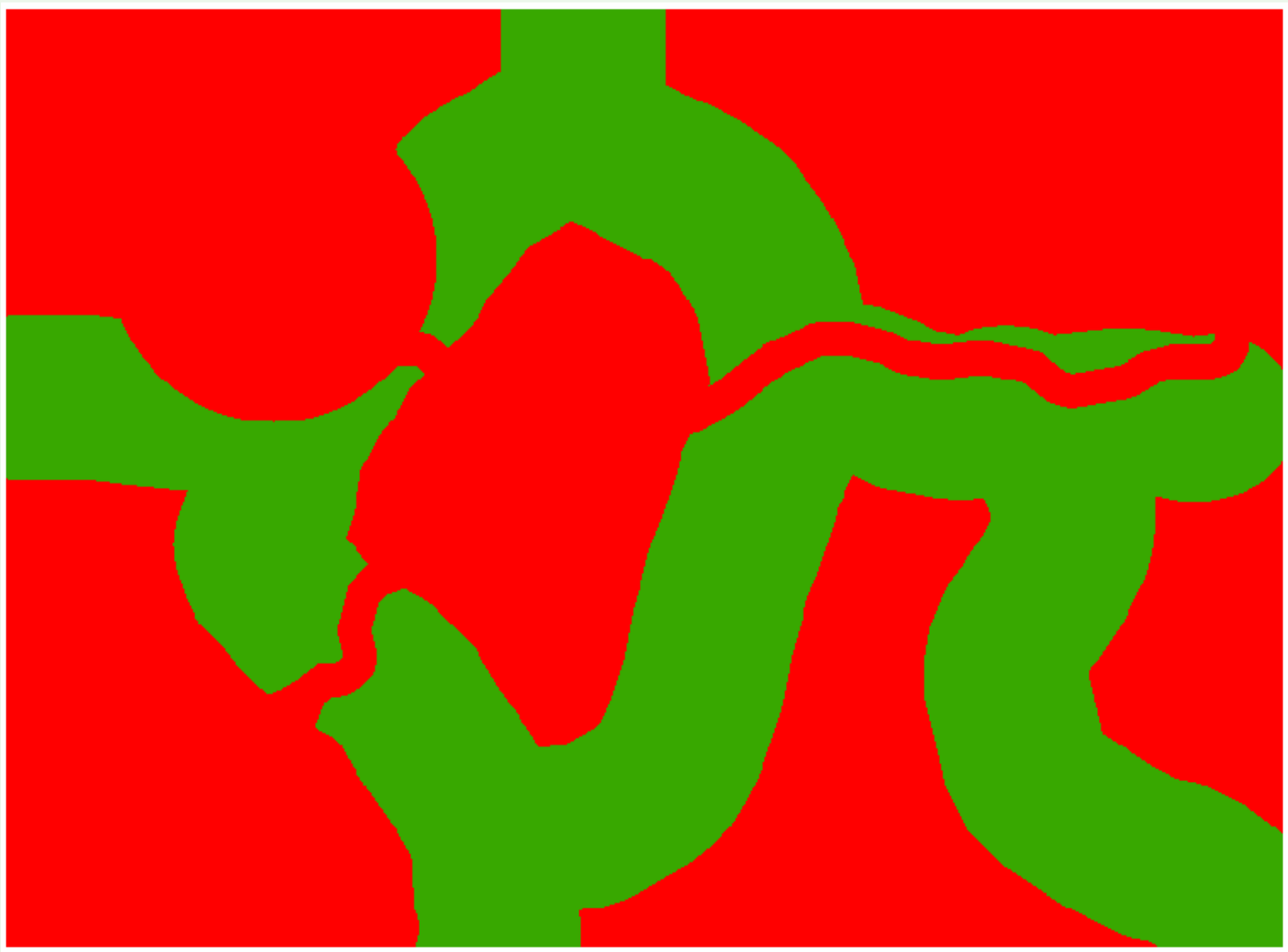
Red: no Logging ~ 0

Green: OK for Logging ~ 1

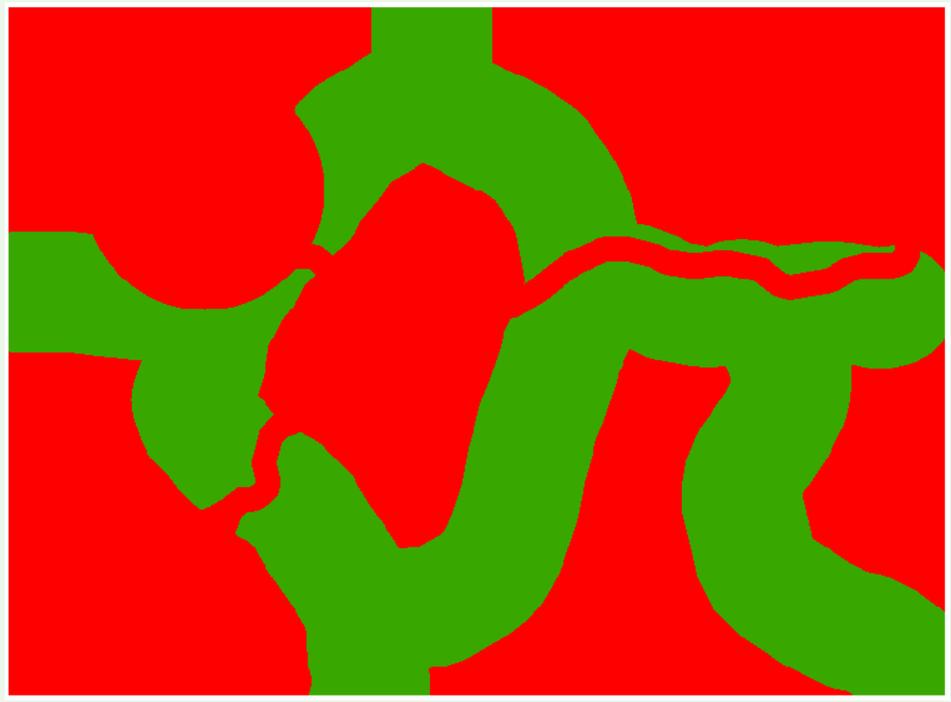


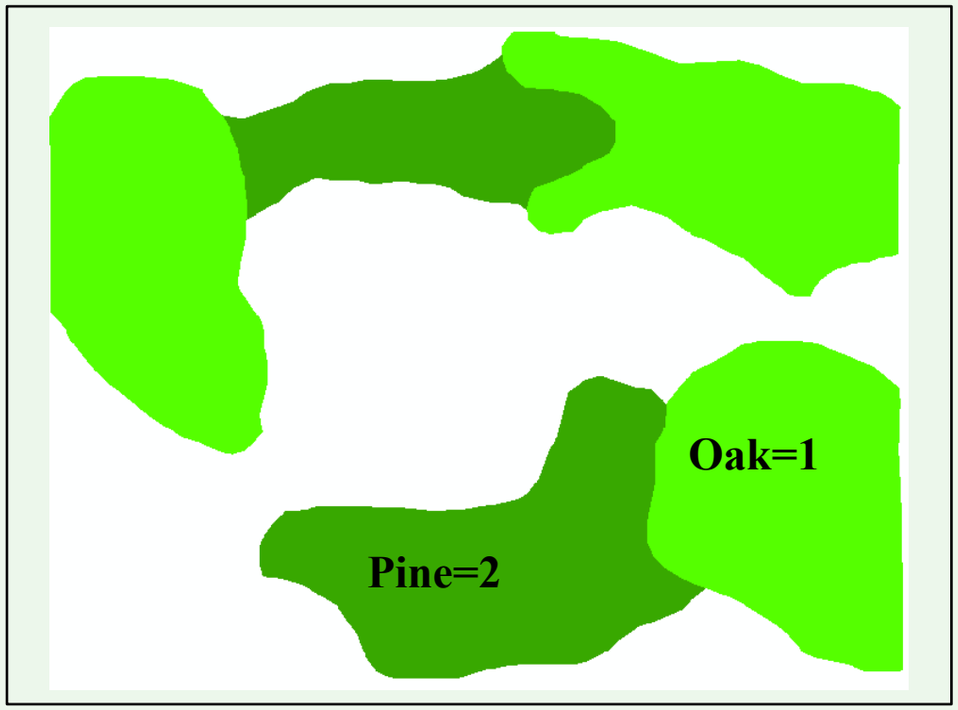
Logging Application

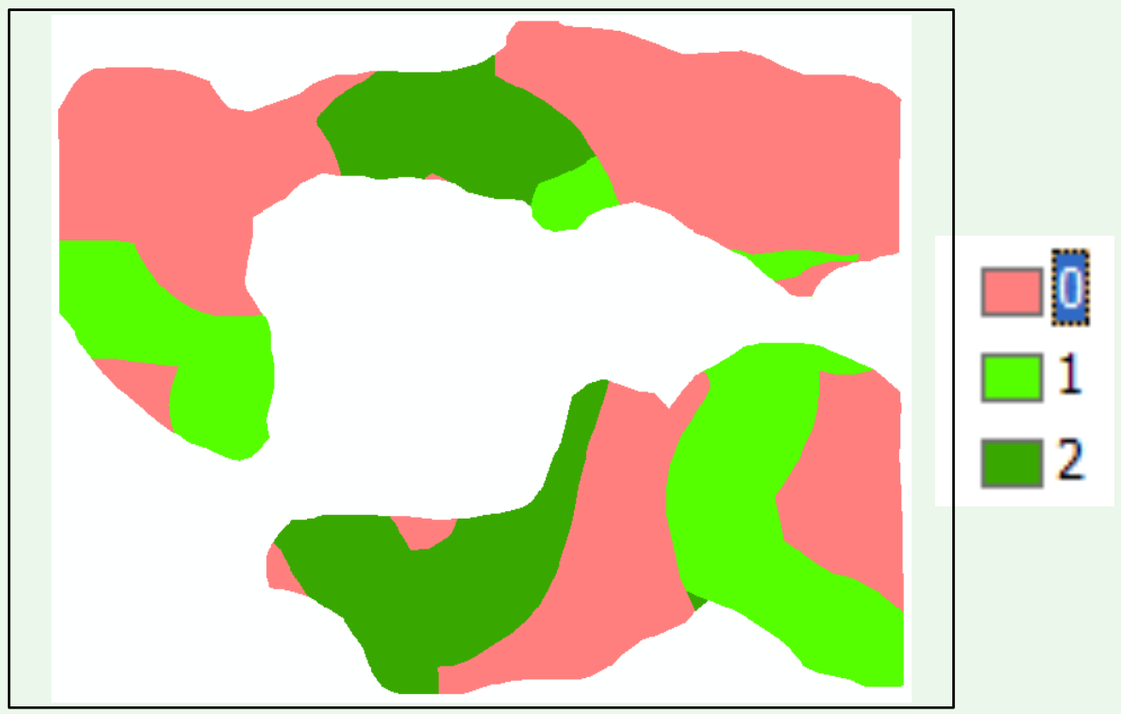
How to create the maximum logging raster map?



Logging Application—Suitable Forest Stands

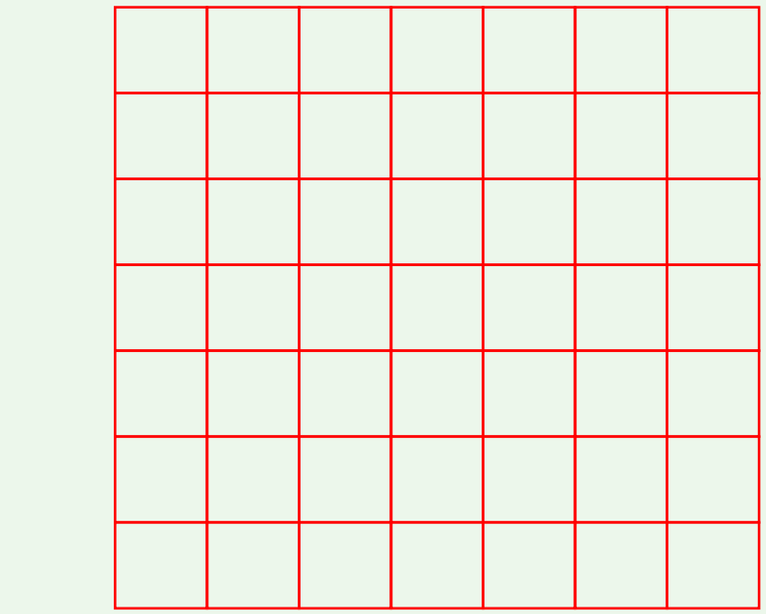


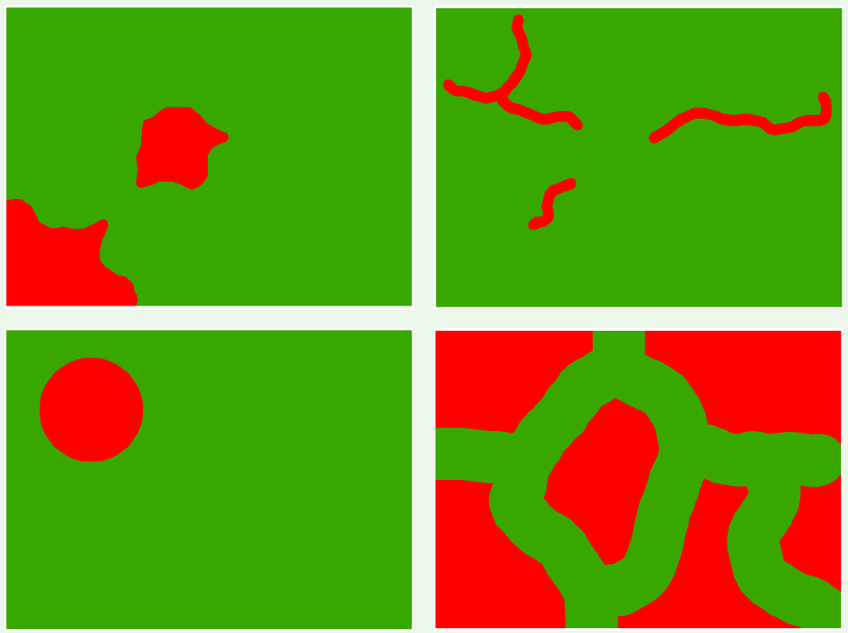




Suitability Analysis (Site Selection) *in the Raster Data Model*

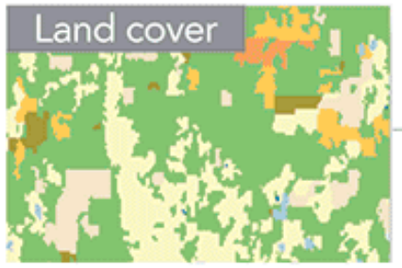
- Multi-criteria evaluation
  - Evaluates a number of alternatives in the light of multiple factors
- Suitability analysis in the raster data model
  - Cells are alternatives
  - Each factor is a raster layer
  - Binary or continuous factors
  - Combining factor layers
    - Multiplication, summation …

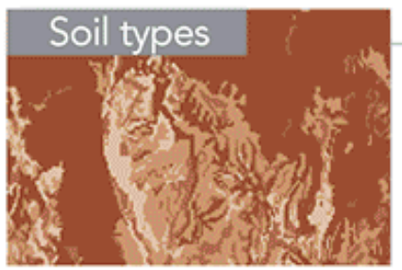


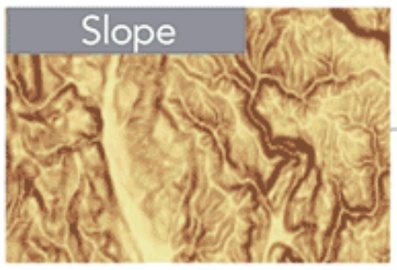


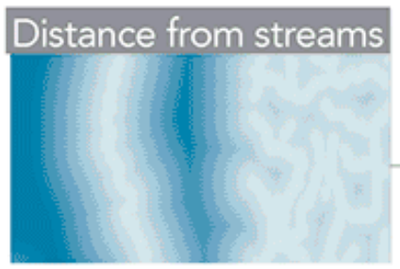
Collect source layers

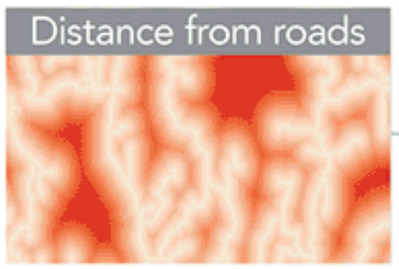
Data is first digitized into either polygon or raster layers. This housing suitability data is raster.

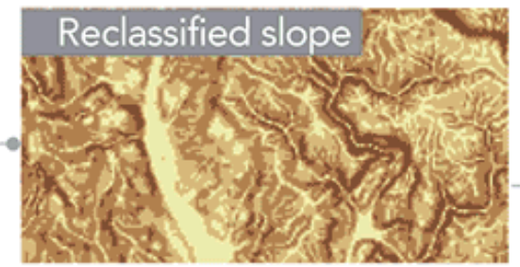










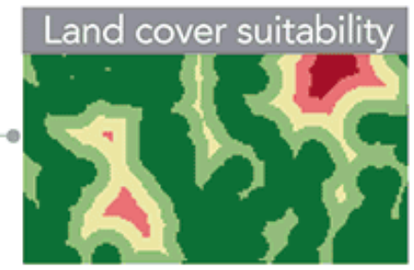


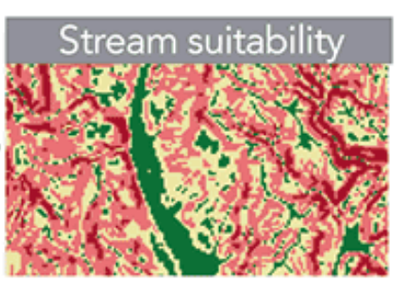
Reclassification

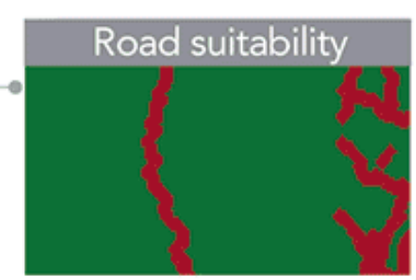
Source layers composed of continuous values (such as slope and distance layers) are first reclassified into meaningful ranges of values.

Create suitability layers

Each layer is now classified to use a common suitability scale: for example, low suitability could be assigned a value of 1 (dark red) and high suitabilty a value of 5 (dark green).

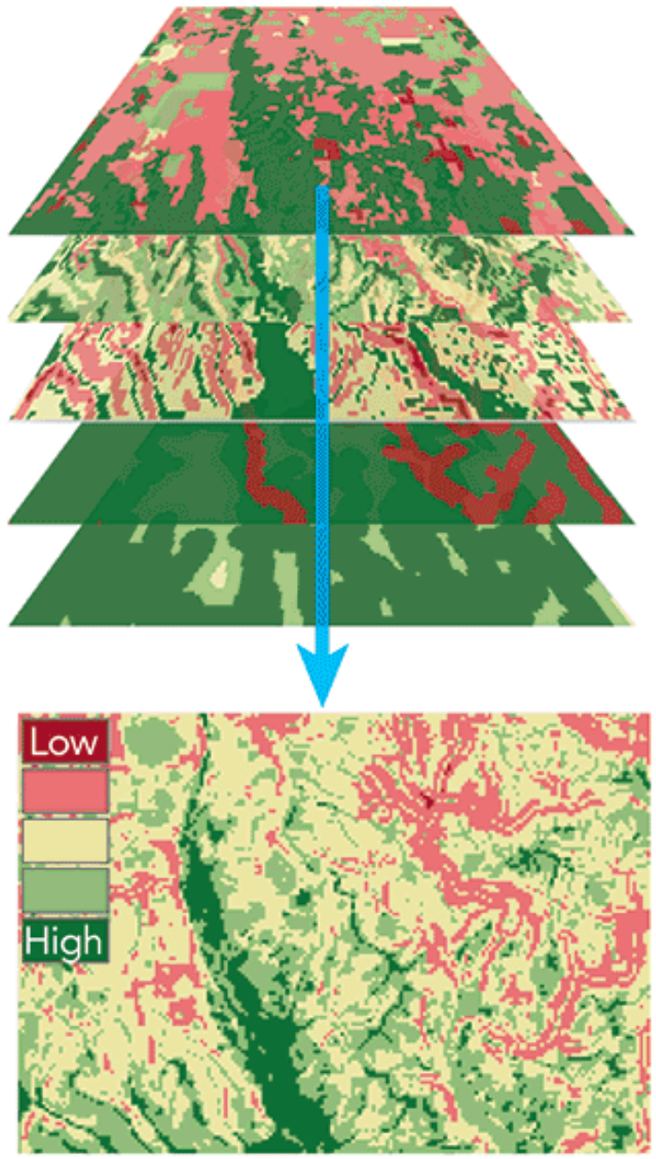






Calculate weighted overlay

Suitability layers are overlaid so that each cell gets an overall suitability rating. Weights of relative importance are assigned to each layer.

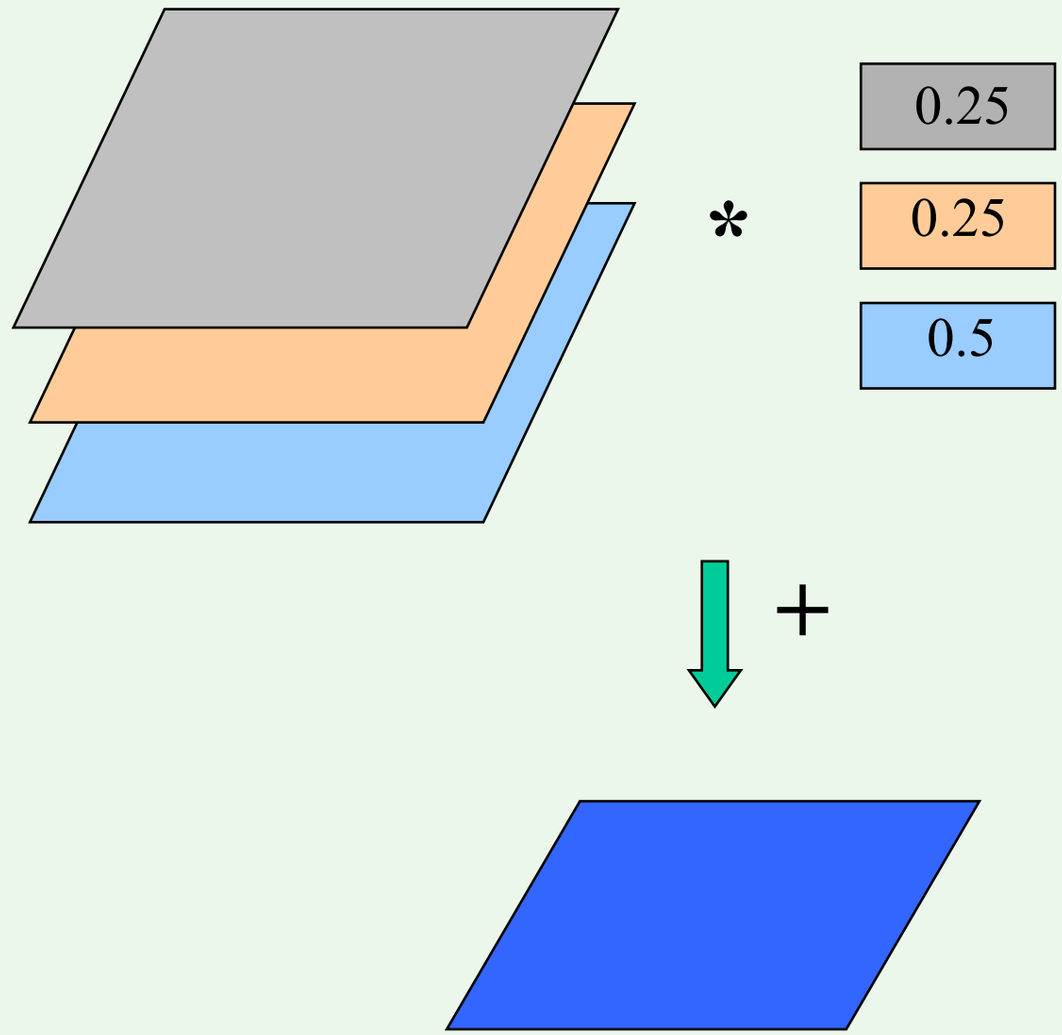


Combining Factors

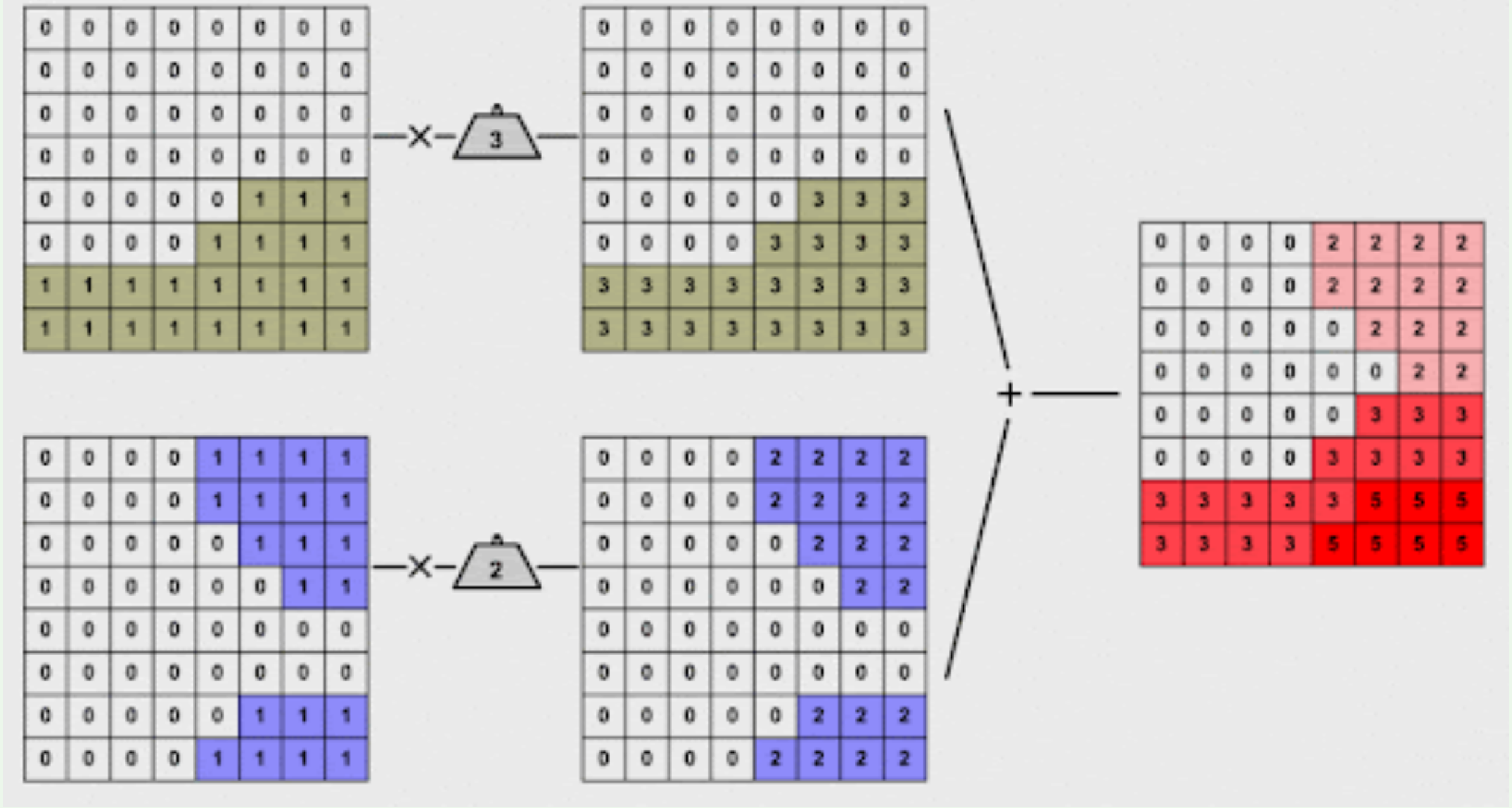
- Binary combination
  - Each cell can take two values (0 or 1, suitable or not suitable, a binary vision of the world)
  - Suitable cells must satisfy **all** the factors
  - Factors cannot balance each other out
- Summation of factors
  - One factor could mitigate other factors
  - Factors have to be in a common scale (standardized)
  - All the factors have the same importance

Weighted Linear Combination

- All the factors should be in a common scale (factor standardization)
- Each factor could be assigned a different weight
- Factors are combined after weight adjustment



$$V_j = \sum_{i=1}^{k} w_i \times v_i$$


0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 0 1 1 1
0 0 0 0 1 1 1 1
1 1 1 1 1 1 1 1
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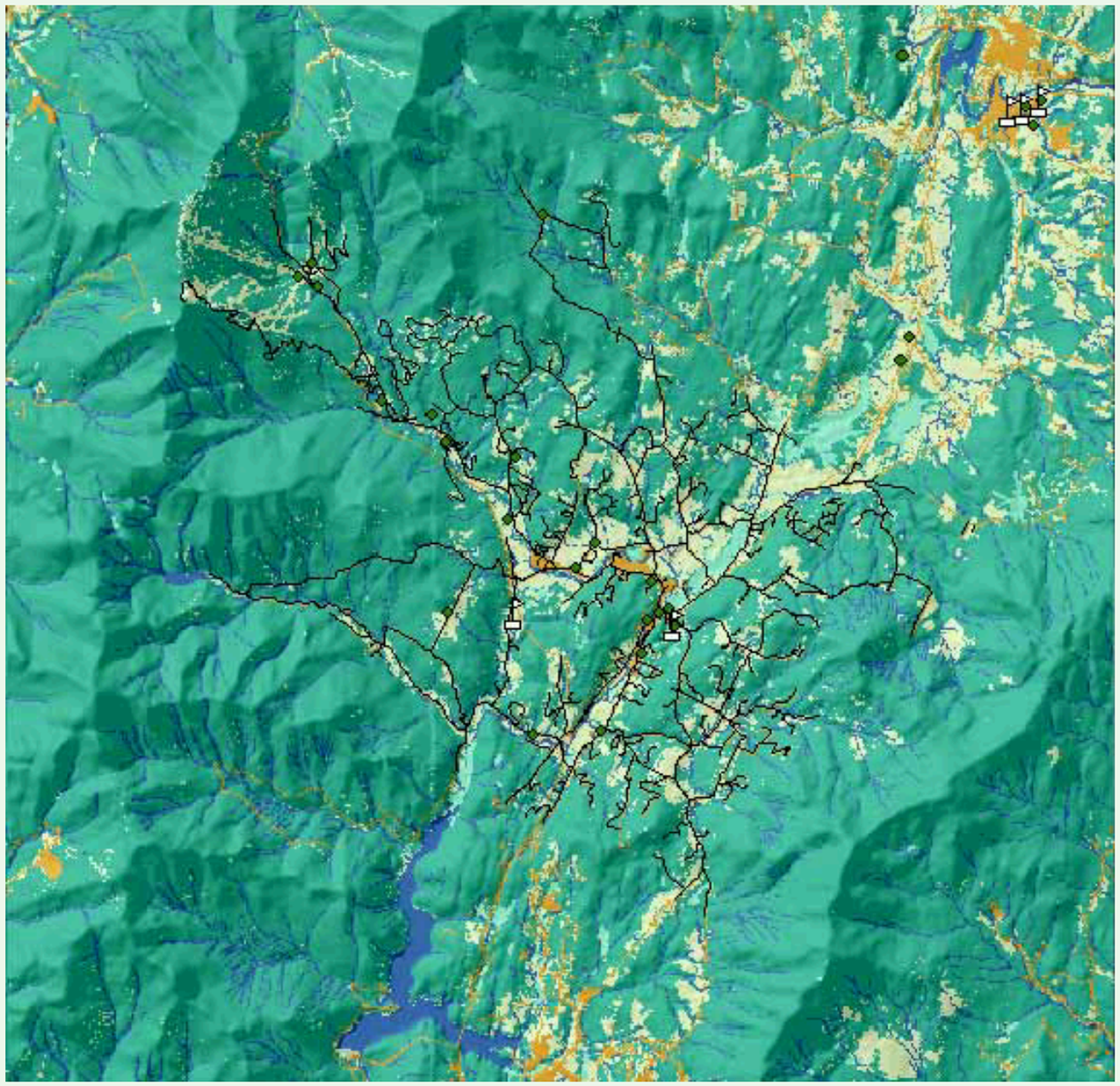
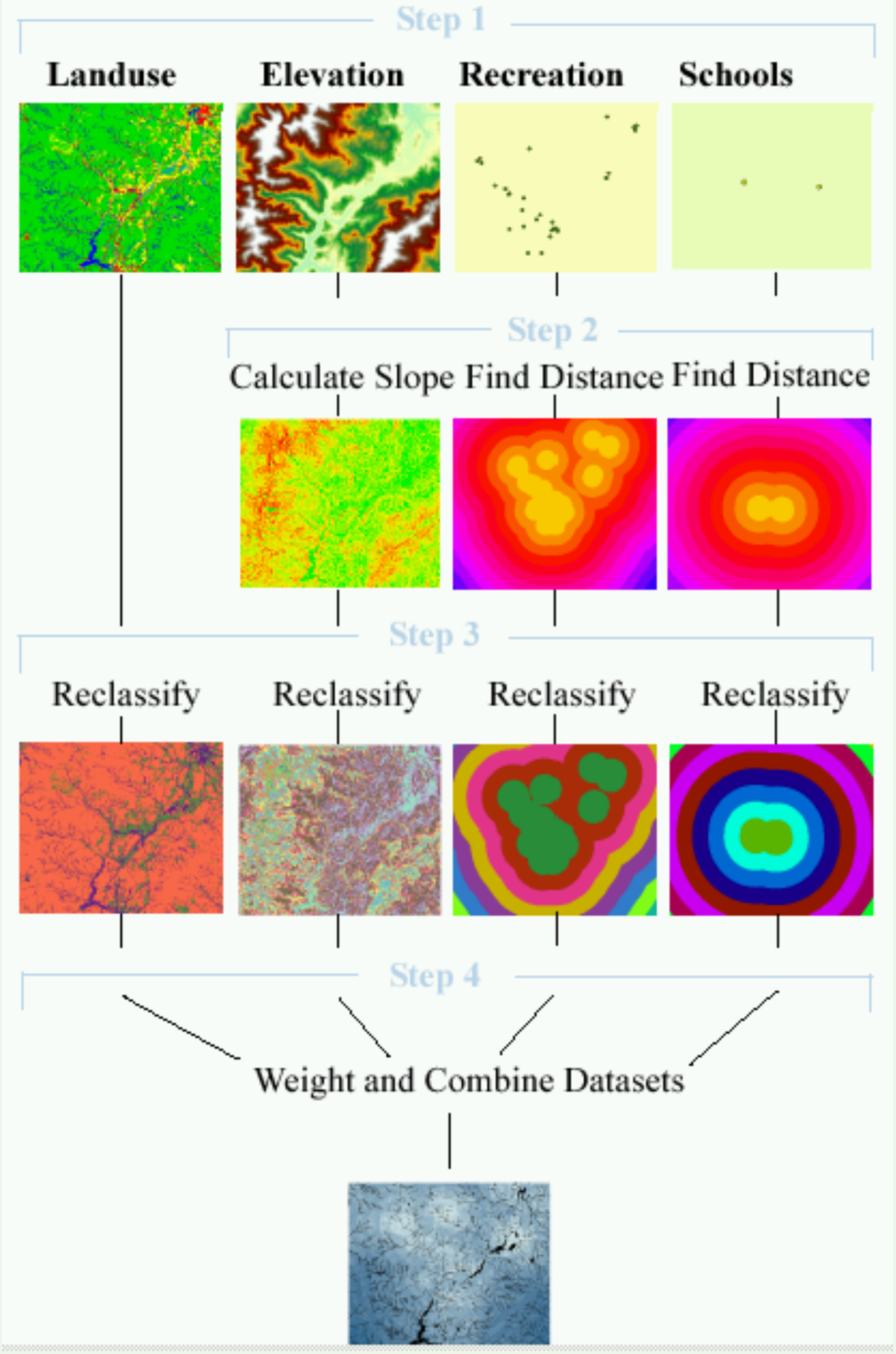
0 0 0 0 0 3 3 3
0 0 0 0 3 3 3 3
3 3 3 3 3 5 5 5
3 3 3 3 5 5 5 5

Siting A New School

- Close to recreational facilities
- Away from existing schools
- Avoid steep slopes and certain landuse types



Raster Analysis



Reclassify Operations

- Assign the value at a cell to a new value based on certain conditions
- Simple conditions can be stored as condition-value pairs in a table

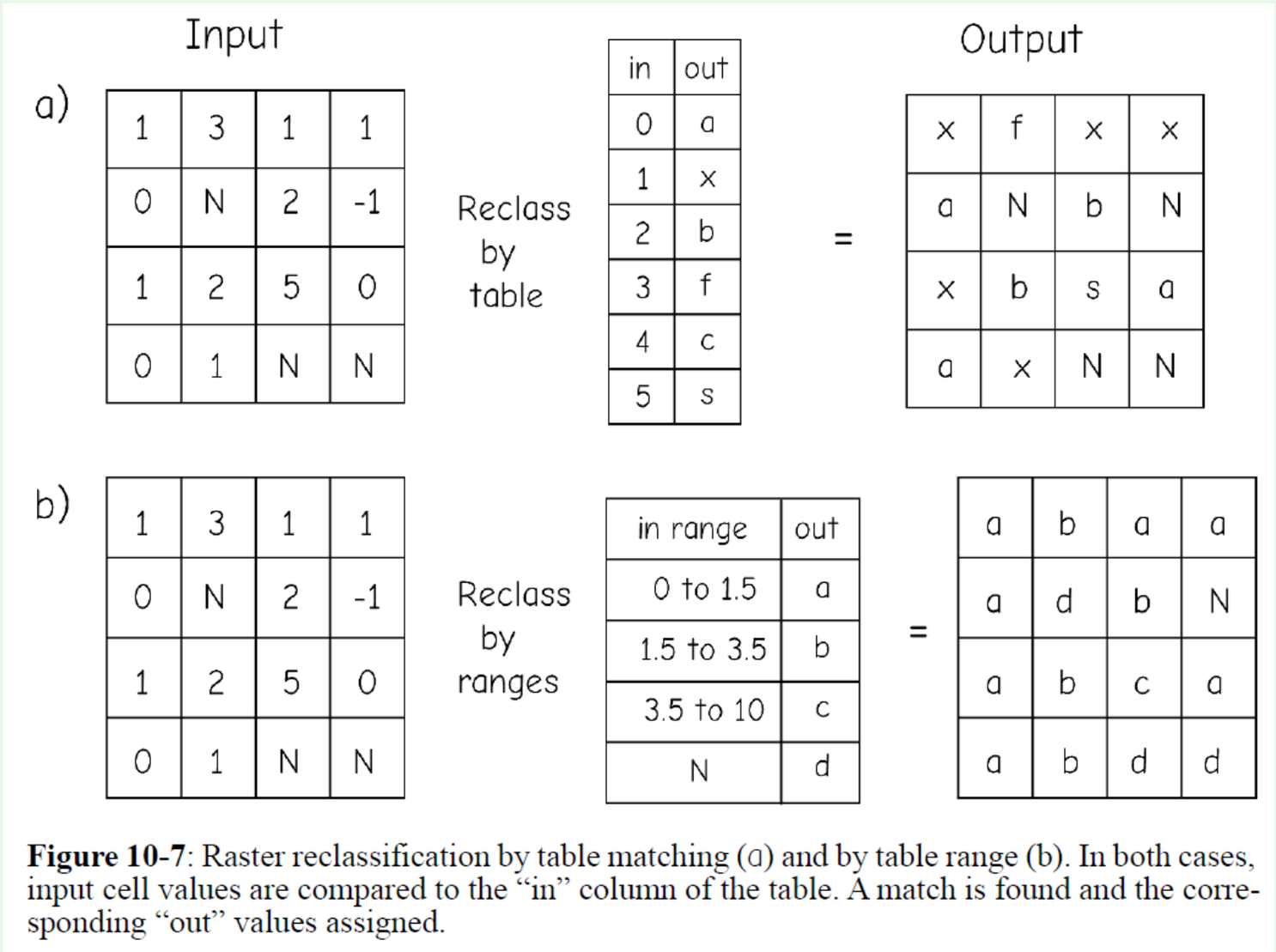


Figure 10-7: Raster reclassification by table matching (a) and by table range (b). In both cases, input cell values are compared to the "in" column of the table. A match is found and the corresponding "out" values assigned.

"equal to"-value mapping table

"within"-value mapping table

Reclassify Operations

- Most generic form
  - Conditions and values can both be rasters
- Each cell is tested for a condition
- Different values for True and False condition
- The value may vary at different cells
- "Con" operation in ArcGIS

(Condition, Value if TRUE, Value if FALSE)

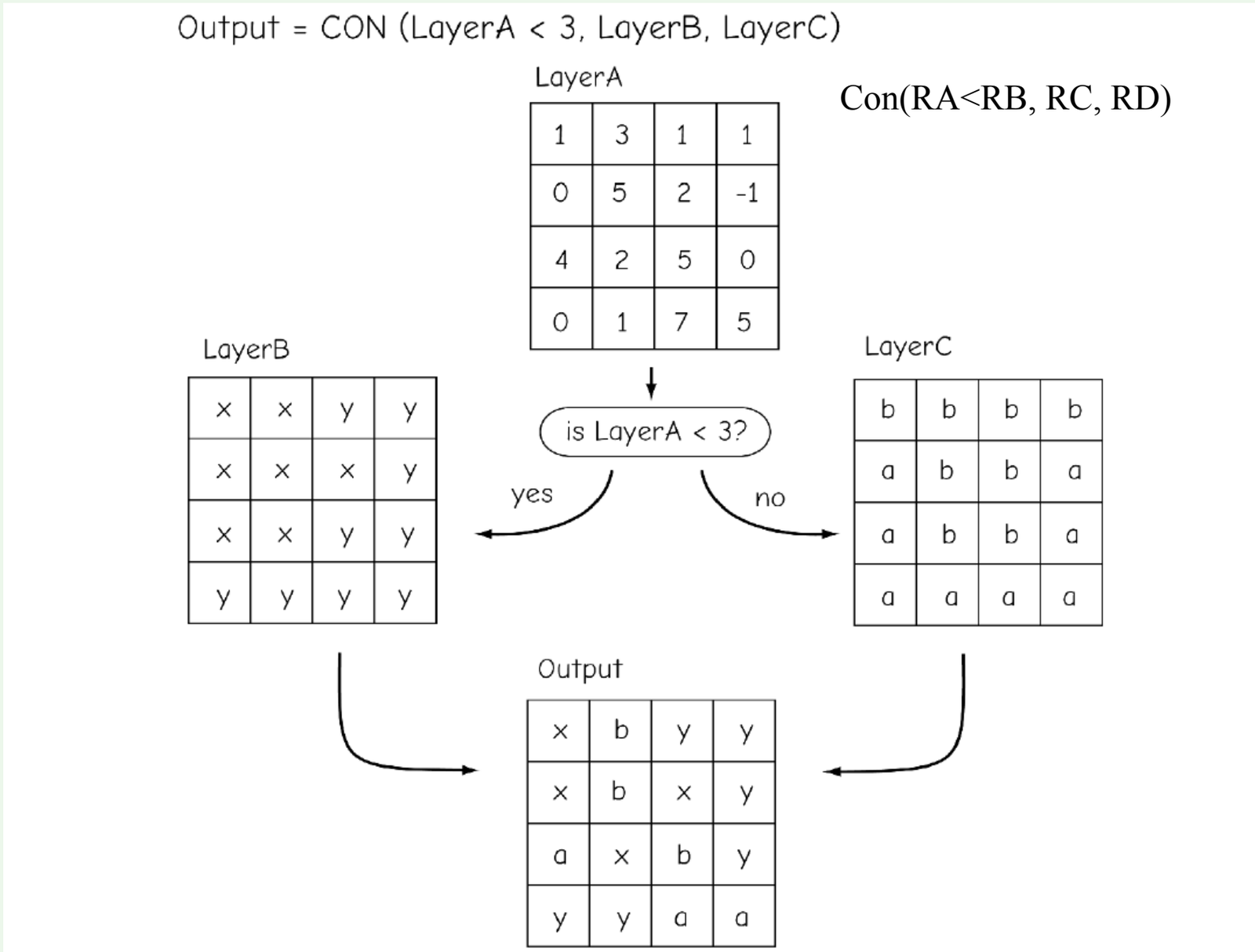


Figure 10-8: Reclassification by condition assigns an output based on a conditional test. In this example,

Geoprocessing

Reclassify

Parameters Environments

Input raster

Elevation

Reclass field

VALUE

Reclassification

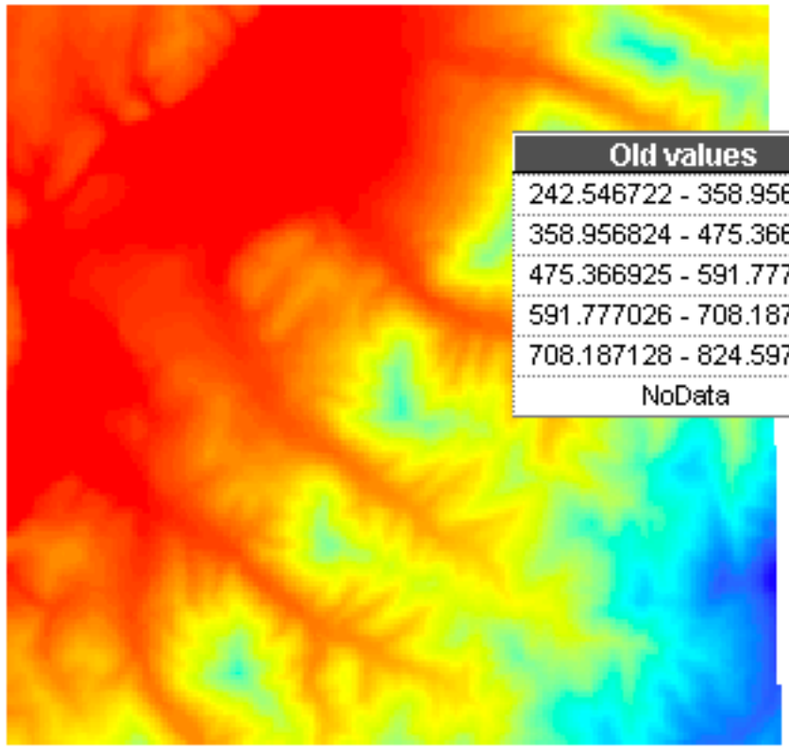
Start	End
124.415001	174.240869
174.240869	212.289713
212.289713	246.714858
246.714858	282.045928
282.045928	355.425842
NODATA	NODATA

Unique Classify

Output raster

Reclass_elev1

Change missing values to NoData



Old values	New values
242.546722 - 358.956824	1
358.956824 - 475.366925	2
475.366925 - 591.777026	3
591.777026 - 708.187128	4
708.187128 - 824.597229	5
NoData	NoData