

# UC Santa Barbara

## Core Curriculum-Geographic Information Systems (1990)

### Title

Unit 05 - Raster GIS Capabilities

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# UNIT 5 - RASTER GIS CAPABILITIES

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Compiled with assistance from Micha Pazner, University of Manitoba

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### **For Information that Supplements the Contents of this Unit:**

*[Links to the following resources have been omitted.]*

- [Buffers: Distance Transformations \(Chrisman/U of Washington\)](#)
  - [Comprehensive Operations: Incremental Operations \(Chrisman/U of Washington\)](#) -- Iterative operations; viewshed; influencing viewsheds; accumulated cost surfaces.
  - [Map Overlay \(Chrisman/U of Washington\)](#) -- Integrating information from diverse sources; steps to carry out overlay; discover relationships from geometry; assumption of uniformity.
  - [Map Overlay: Some Examples \(Chrisman/U of Washington\)](#) -- Numerous GRASS applications.
  - [Surfaces \(Chrisman/U of Washington\)](#) -- Types of surfaces; slope; slope gradient and aspect in a grid; convergence/divergence; computing properties of a surface.
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This unit continues the overview of raster GIS. If possible, we suggest that you replace and/or supplement the graphics provided with this unit with graphics generated by the raster program your students will be using in their labs. Alternatively, the best way to illustrate this unit may be through the use of a laboratory demonstration.

Consider providing handouts to the students that summarize the commands for the raster GIS program you will be using in labs. Check your program's manual for a command summary or do a screen dump of the appropriate help screen if there is one.

## UNIT 5 - RASTER GIS CAPABILITIES

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### [A. INTRODUCTION](#)

- a raster GIS must have capabilities for:
  - input of data
  - various housekeeping functions
  - operations on layers, like those encountered in the previous unit - recode, overlay and spread
  - output of data and results
- the range of possible functions is enormous, current raster GISs only scratch the surface
  - because the range is so large, some have tried to organize functions into a consistent scheme, but no scheme has been widely accepted yet
  - the unit covers a selection of the most useful and common
- each raster GIS uses different names for the functions

### [B. DISPLAYING LAYERS](#)

#### [Basic display](#)

- the simplest type of values to display are integers
  - on a color display each integer value can be assigned a unique color
  - there must be as many colors as integers

- if the values have a natural order we will want the sequence of colors to make sense
  - e.g. elevation is often shown on a map using the sequence blue-green-yellow-brown-white for increasing elevation
- there should be a legend explaining the meaning of each color
  - the system should generate the legend automatically based on the descriptions of each value stored with the data layer

overhead - Simple display (IDRISI)

- on a dot matrix printer shades of grey can be generated by varying the density of dots
- if there are too many values for the number of colors, may have to recode the layer before display

### Other types of display

- it may be appropriate to display the data as a surface
- contours can be "threaded" through the pixels along lines of constant value
  - the searching operation for finding contours is computer-intensive so may be slow
- the surface can be shown in an oblique, perspective view
  - this can be done by drawing profiles across the raster with each profile offset and hidden lines removed
  - the surface might be colored using the values in a second layer (a second layer can be "draped" over the surface defined by the first layer)
  - the result can be very effective
    - "LA The Movie" was produced by Jet Propulsion Lab by draping a Landsat image of Los Angeles over a layer of elevations, then simulating the view from a moving aircraft
  - these operations are also computer-intensive because of the calculations necessary to simulate perspective and remove hidden lines

### C. LOCAL OPERATIONS

- produce a new layer from one or more input layers
- the value of each new pixel is defined by the values of the same pixel on the input layer(s)
  - neighboring or distant pixels have no effect
- note: arithmetic operations make no sense unless the values have appropriate scales of measurement (see Unit 6)
  - you cannot find the "average" of soils types 3 and 5, nor is soil 5 "greater than" soil 3

### Recoding

- using only one input layer
- examples:
  1. assign a new value to each unique value on the input layer
    - useful when the number of unique input values is small

2. assign new values by assigning pixels to classes or ranges based on their old values
  - e.g. 0-499 becomes 1, 500-999 becomes 2, >1000 becomes 3
  - useful when the old layer has different values in each cell, e.g. elevation or satellite images
3. sort the unique values found on the input layer and replace by the rank of the value
  - e.g. 0, 1, 4, 6 on input layer become 1, 2, 3, 4 respectively
  - applications: assigning ranks to computed scores of capability, suitability etc.
- some systems allow a full range of mathematical operations
  - e.g.  $\text{newvalue} = (2 * \text{oldvalue} + 3)2$

### Overlaying layers

- an overlay occurs when the output value depends on two or more input layers
  - many systems restrict overlay to two input layers only
- examples:
  1. output value equals arithmetic average of input values
  2. output value equals the greatest (or least) of the input values
  3. layers can be combined using arithmetic operations
    - x and y are the input layers, z is the output
    - some examples:  $z = x + y$   $z = xy$   $z = x / y$
  4. combination using logical conditions
    - e.g. if  $y > 0$ , then  $z = y$ , otherwise  $z = x$
    - note: in many raster packages logical conditions cannot be done directly from input layers
      - must first create reclassified input images so that cells have 0 if they do not meet the condition and 1 if they do
  5. assign a new value to every unique combination of input values
    - e.g. LAYER 1 LAYER 2 OUTPUT LAYER 1 A 1 1 B 2 2 A 3 2 B 4

### D. OPERATIONS ON LOCAL NEIGHBORHOODS

- the value of a pixel on the new layer is determined by the local neighborhood of the pixel on the old layer

### Filtering

- a filter operates by moving a "window" across the entire raster
  - e.g. many windows are 3x3 cells

- the new value for the cell at the middle of the window is a weighted average of the values in the window
- by changing the weights we can produce two major effects:
  - smoothing (a "low pass" filter, removes or reduces local detail)
  - edge enhancement (a "high pass" filter, exaggerates local detail)
- weights should add to 1
- example filters:

1. .11 .11 .11 .11 .11 .11 .11 .11 .11

- replaces each value by the simple unweighted average of it and its eight neighboring values
- severely smooths the spatial variation on the layer

2. .05 .05 .05 .05 .60 .05 .05 .05 .05

- gives the pixel's old value 12 times the weight of its neighboring values
- slightly smooths the layer

3. -.1 -.1 -.1 -.1 1.8 -.1 -.1 -.1 -.1

- slightly enhances local detail by giving neighbors negative weights
- filters can be useful in enhancing detail on images for input to GIS, or smoothing layers to expose general trends

### Slopes and aspects

- if the values in a layer are elevations, we can compute the steepness of slopes by looking at the difference between a pixel's value and those of its adjacent neighbors
- the direction of steepest slope, or the direction in which the surface is locally "facing", is called its aspect
  - aspect can be measured in degrees from North or by compass points - N, NE, E etc.
- slope and aspect are useful in analyzing vegetation patterns, computing energy balances and modeling erosion or runoff
  - aspect determines the direction of runoff
    - this can be used to sketch drainage paths for runoff

## E. OPERATIONS ON EXTENDED NEIGHBORHOODS

### Distance

- calculate the distance of each cell from a cell or the nearest of several cells
  - each pixel's value in the new layer is its distance from the given cell(s)

### Buffer zones

- buffers around objects and features are very useful GIS capabilities
  - e.g. build a logging buffer 500 m wide around all lakes and watercourses

- buffer operations can be visualized as spreading the object spatially by a given distance
- the result could be a layer with values: 1 if in original selected object 2 if in buffer 0 if outside object and buffer
- applications include noise buffers around roads, safety buffers around hazardous facilities
- in many programs the buffer operation requires the user to first do a distance operation, then a reclassification of the distance layer
- the rate of spreading may be modified by another layer representing "friction"
  - e.g. the friction layer could represent varying cost of travel
  - this will affect the width of the buffer - narrow in areas of high friction, etc.

### Visible area or "viewshed"

- given a layer of elevations, and one or more viewpoints, compute the area visible from at least one viewpoint
  - e.g. value = 1 if visible, 0 if not
  - useful for planning locations of unsightly facilities such as smokestacks, or surveillance facilities such as fire towers, or transmission facilities

## E. OPERATIONS ON ZONES (GROUPS OF PIXELS)

### Identifying zones

- by comparing adjacent pixels, identify all patches or zones having the same value
- give each such patch or zone a unique number
- set each pixel's value to the number of its patch or zone

### Areas of zones

- measure the area of each zone and assign this value to each pixel instead of the zone's number
  - alternatively output may be in the form of a summary table sent to the printer or a file

### Perimeter of zones

- measure the perimeter of each zone and assign this value to each pixel instead of the zone's number
  - alternatively output may be in the form of a summary table sent to the printer or a file
- length of perimeter is determined by summing the number of exterior cell edges in each zone
- note: the values calculated in both area and perimeter are highly dependent upon the orientation of objects (zones) with respect to the orientation of the grid
  - however, if boundaries in the study area do not have a dominant orientation such errors may cancel out

### Distance from zone boundary

- measure the distance from each pixel to the nearest part of its zone boundary, and assign this value to the pixel
  - boundary is defined as the pixels which are adjacent to pixels of different values

### Shape of zone

- measure the shape of the zone and assign this to each pixel in the zone
  - one of the most common ways to measure shape is by comparing the perimeter length of a zone to the square root of its area
  - by dividing this number by 3.54 we get a measure which ranges from 1 for a circle (the most compact shape possible) to 1.13 for a square to large numbers for long, thin, wiggly zones
- commands like this are important in landscape ecology
  - helpful in studying the effects of geometry and spatial arrangement of habitat
    - e.g. size and shape of woodlots on the animal species they can sustain
    - e.g. value of linear park corridors across urban areas in allowing migration of animal species

### G. COMMANDS TO DESCRIBE CONTENTS OF LAYERS

- it is important to have ways of describing a layer's contents
  - particularly new layers created by GIS operations
  - particularly in generating results of analysis

### One layer

- generate statistics on a layer
  - e.g. mean, median, most common value, other statistics

### More than one layer

- compare two maps statistically
  - e.g. is pattern on one map related to pattern on the other?
  - e.g. chi-square test, regression, analysis of variance

### Zones on one layer

- generate statistics for the zones on a layer
  - e.g. largest, smallest, number, mean area

### H. ESSENTIAL HOUSEKEEPING

- list available layers
- input, copy, rename layers
- import and export layers to and from other systems
  - other raster GIS
  - input of images from remote sensing system
  - other types of GIS
- identify resolution, orientation



- "resample"
  - changing cell size, orientation, portion of raster to analyze
- change colors
- provide help to the user
- exit from the GIS (the most important command of all!)

## REFERENCES

Berry, J.K., 1987. "Fundamental operations in computer- assisted map analysis," International Journal of Geographical Information Systems 1:119-136. Describes a logical and consistent way of classifying and grouping raster GIS functions.

Burrough, P.A., 1986. Principles of Geographical Information Systems for Land Resource Assessment, Clarendon, Oxford. Chapter 5 is a comprehensive review of raster GIS.

Star, J.L. and J.E. Estes, 1990. Geographic Information Systems: An Introduction, Prentice Hall. A comprehensive text on GIS, with excellent treatment of raster systems.

Tomlin, C.D., 1990. Geographic Information Systems and Cartographic Modeling, Prentice-Hall, Englewood Cliffs, NJ. A comprehensive approach to analysis and modeling using raster systems - an excellent introduction to GIS- based analysis.

User documentation for any raster GIS.

## EXAM AND DISCUSSION QUESTIONS

1. Discuss the classification scheme proposed by Berry in the article listed in the references. Is it logical and comprehensive? Can you suggest improvements based on the material in this unit or the functions of a specific raster GIS to which you have access?

2. A variety of user interfaces have been used in raster GISs, including typed commands, menus and responses to

questions. Discuss the advantages and disadvantages of each.

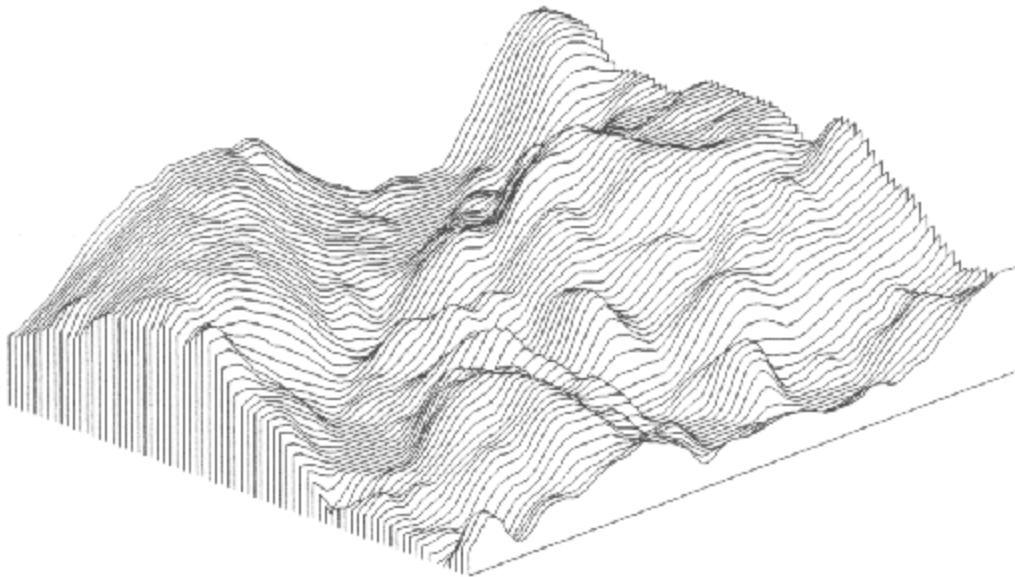
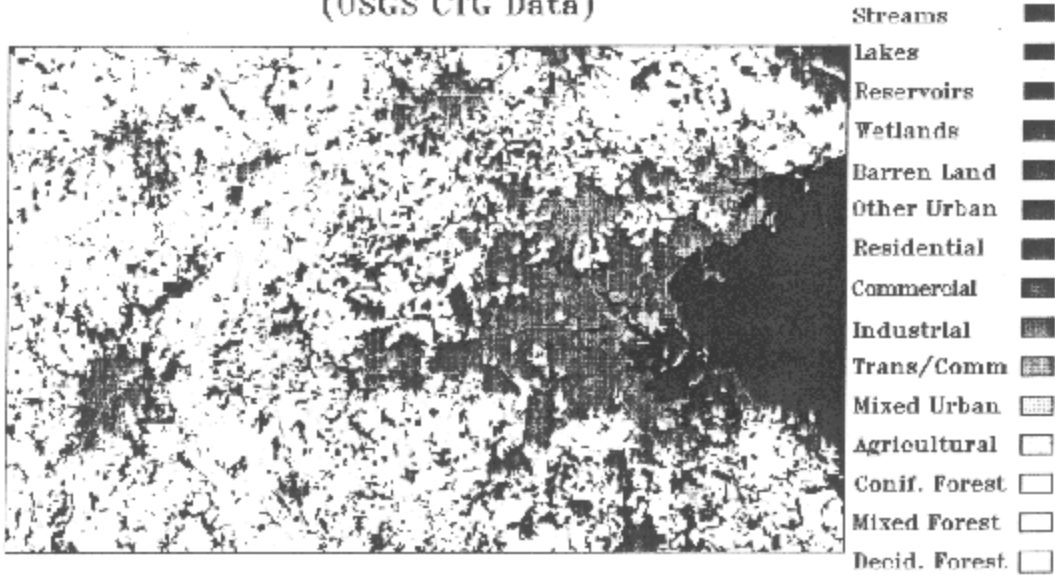
3. "The most valuable skill in GIS is the ability to take a real problem and convert it into a series of GIS operations". Discuss.

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*Last Updated: August 30, 1997.*

# UNIT 5 IMAGES

Eastern Massachusetts Land Use  
(USGS CTG Data)



WHAT CELLS ARE A OR 7?

A	A	B
A	A	B
C	C	B

6	7	7
6	7	7
8	8	7

RECLASSIFY

1	1	0
1	1	0
0	0	0

RECLASSIFY

0	1	1
0	1	1
0	0	1

ADD

1+0	1+1	0+1
1+0	1+1	0+1
0+0	0+0	0+1

1	2	1
1	2	1
0	0	1

RECLASSIFY

1	1	1
1	1	1
0	0	1

Original Mona Lisa



Mona Lisa with Mean Smoothing Filter



Mona Lisa with Edge Enhancement



