CHAPTER 12 RASTER DATA ANALYSIS

Raster Data Analysis

- Raster data analysis is based on cells and rasters.
- Raster data analysis can be performed at the level of individual cells, or groups of cells, or cells within an entire raster.
- Some raster data operations use a single raster; others use two or more rasters.
- Raster data analysis also depends on the type of cell value (numeric or categorical values).

Raster Analysis Environment

The analysis environment refers to the area for analysis and the output cell size.

Local Operations: Single Raster

Given a single raster as the input, a local operation computes each cell value in the output raster as a mathematical function of the cell value in the input raster.

Arithmetic	+, -, /, *, absolute,integer,floating-point
Logarithmic	exponentials, logarithms
Trigonometric	sin,cos, tan, arcsin, arccos, arctan
Power	square, square root, power

Figure 12.1
Arithmetic, logarithmic, trigonometric, and power functions for local operations.

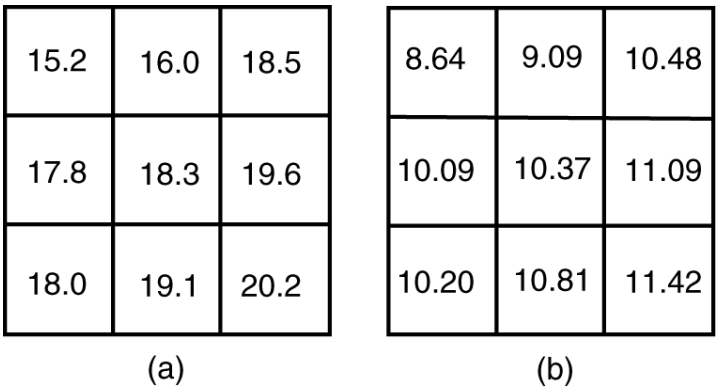


Figure 12.2
A local operation can convert a slope raster from percent (a) to degrees (b).

Local Operations: Multiple Rasters

- A common term for local operations with multiple input rasters is map algebra, a term that refers to algebraic operations with raster map layers.
- Besides mathematical functions that can be used on individual rasters, other measures that are based on the cell values or their frequencies in the input rasters can also be derived and stored on the output raster of a local operation with multiple rasters.

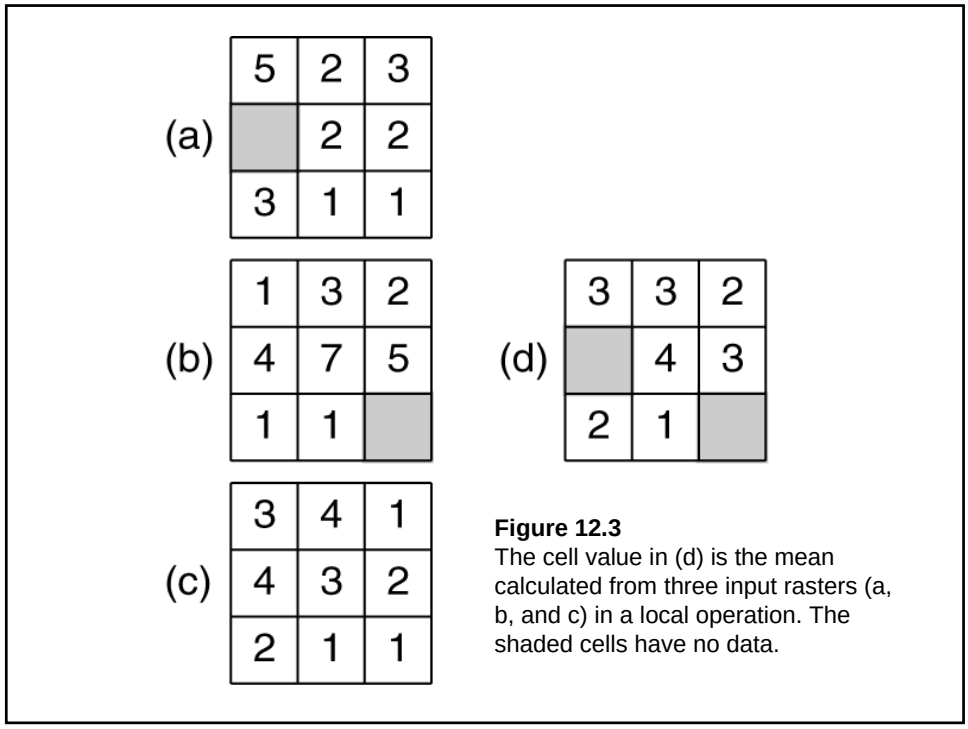


Figure 12.3
The cell value in (d) is the mean calculated from three input rasters (a, b, and c) in a local operation. The shaded cells have no data.

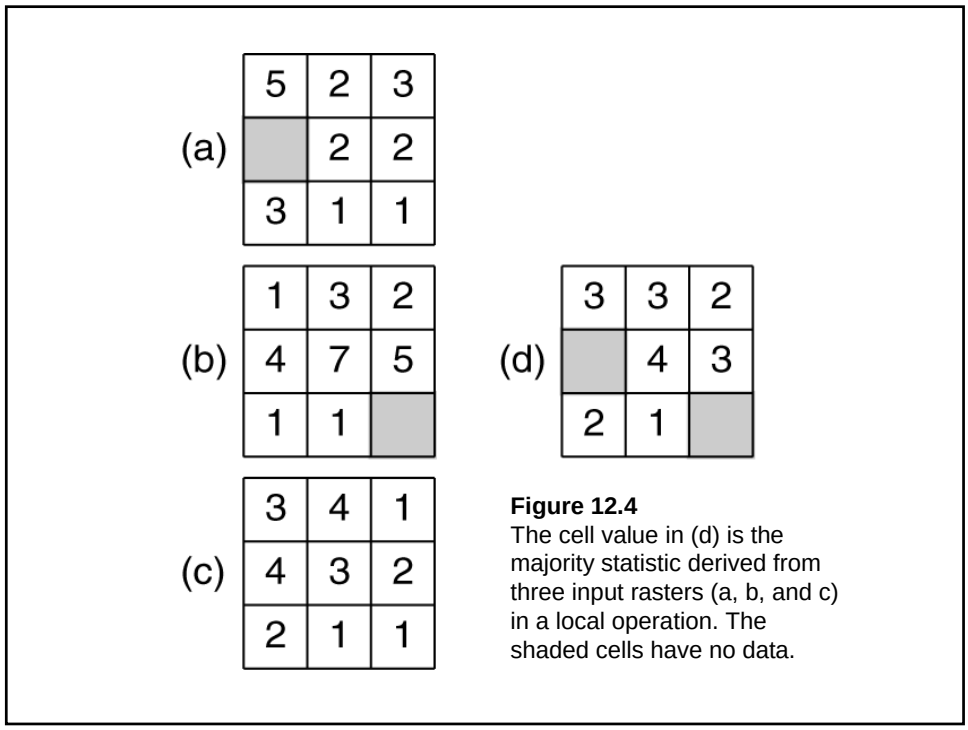
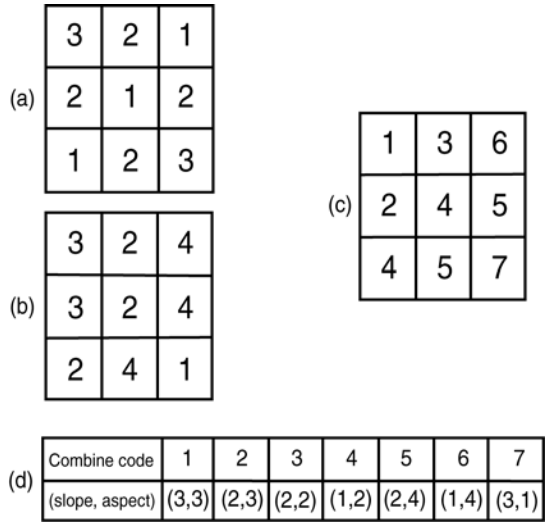


Figure 12.4
The cell value in (d) is the majority statistic derived from three input rasters (a, b, and c) in a local operation. The shaded cells have no data.



(a)

3	2	1
2	1	2
1	2	3

(b)

3	2	4
3	2	4
2	4	1

(c)

1	3	6
2	4	5
4	5	7

(d)

Combine code	1	2	3	4	5	6	7
(slope, aspect)	(3,3)	(2,3)	(2,2)	(1,2)	(2,4)	(1,4)	(3,1)

Figure 12.5
Each cell value in (c) represents a unique combination of cell values in (a) and (b). The combination codes and their representations are shown in (d).

Neighborhood Operations

- A neighborhood operation involves a focal cell and a set of its surrounding cells. The surrounding cells are chosen for their distance and/or directional relationship to the focal cell.
- Common neighborhoods include rectangles, circles, annuluses, and wedges.

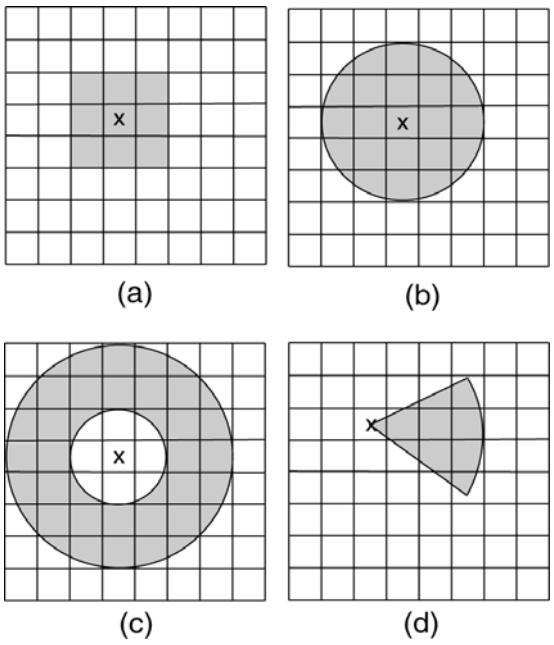


Figure 12.6
Four common neighborhood types: rectangle (a), circle (b), annulus (c), and wedge (d). The cell marked with an x is the focal cell.

(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

Figure 12.7
The cell values in (b) are the neighborhood means of the shaded cells in (a) using a 3 x 3 neighborhood. For example, 1.56 in the output raster is calculated from (1 +2 +2 +1 +2 +2 +1 +2 +1) / 9.

(a)

200	200	110	210	210
200	200	110	210	210
150	150	100	170	170
140	140	130	160	160
140	140	130	160	160

(b)

100	110	110
100	110	110
50	70	70

Figure 12.8
The cell values in (b) are the neighborhood range statistics of the shaded cells in (a) using a 3 x 3 neighborhood. For example, the upper-left cell in the output raster has a cell value of 100, which is calculated from (200 – 100).

(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)

2	2	2
2	2	3
2	2	3

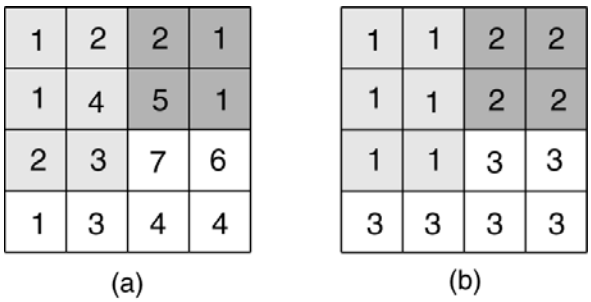
Figure 12.9
The cell values in (b) are the neighborhood majority statistics of the shaded cells in (a) using a 3 x 3 neighborhood. For example, the upper-left cell in the output raster has a cell value of 2 because there are five 2s and four 1s in its neighborhood.

Zonal Operations

- A zonal operation works with groups of cells of same values or like features. These groups are called zones. Zones may be contiguous or noncontiguous.
- A zonal operation may work with a single raster or two rasters.
- Given a single input raster, zonal operations measure the geometry of each zone in the raster, such as area, perimeter, thickness, and centroid.
- Given two rasters in a zonal operation, one input raster and one zonal raster, a zonal operation produces an output raster, which summarizes the cell values in the input raster for each zone in the zonal raster.

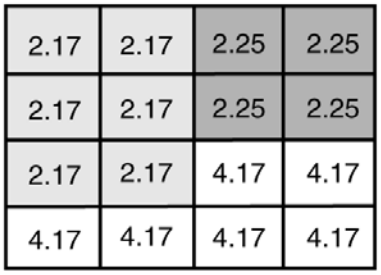
Zone	Area	Perimeter	Thickness
1	36,224	1,708	77.6
2	48,268	1,464	77.4

Figure 12.10
Thickness and centroid for two large watersheds (zones). Area is measured in square kilometers, and perimeter and thickness are measured in kilometers. The centroid of each zone is marked with an x.



(a)

(b)



(c)

Figure 12.11
The cell values in (c) are the zonal means derived from an input raster (a) and a zonal raster (b). For example, 2.17 is the mean of {1, 1, 2, 2, 4, 3} for zone 1.

Physical Distance Measure Operations

- The physical distance measures the straight-line or euclidean distance.
- Physical distance measure operations calculate straight-line distances away from cells designated as the source cells.

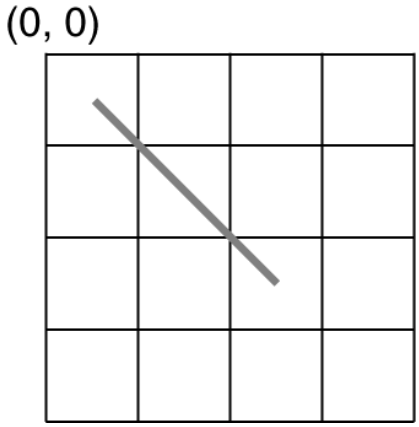


Figure 12.12
A straight-line distance is measured from a cell center to another cell center. This illustration shows the straight-line distance between cell (1,1) and cell (3,3).

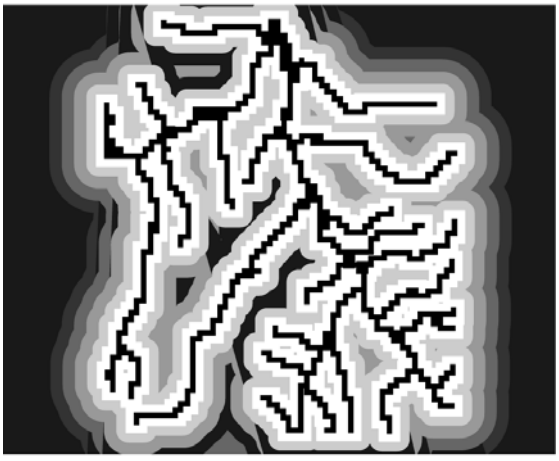


Figure 12.13
Continuous distance measures from a stream network.

Allocation and Direction

- Allocation produces a raster in which the cell value corresponds to the closest source cell for the cell.
- Direction produces a raster in which the cell value corresponds to the direction in degrees that the cell is from the closest source cell.

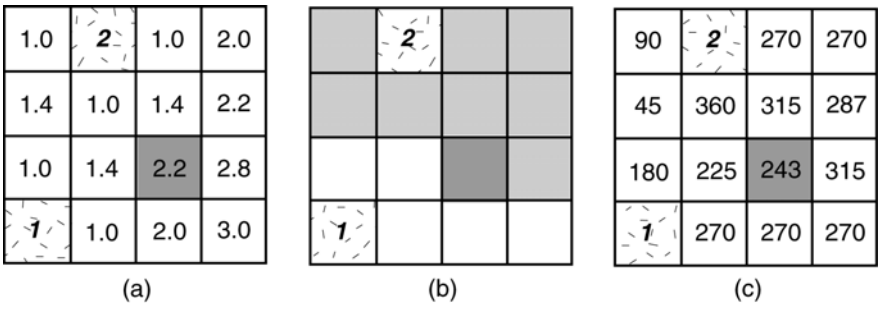


Figure 12.14
Based on the source cells denoted as 1 and 2, (a) shows the physical distance measures in cell units from each cell to the closest source cell; (b) shows the allocation of each cell to the closest source cell; and (c) shows the direction in degrees from each cell to the closest source cell. The cell in a dark shade (row 3, column 3) has the same distance to both source cells. Therefore, the cell can be allocated to either source cell. The direction of 243^0 is to the source cell 1.

Other Raster Data Operations

1. Operations for raster data management include Clip and Mosaic.
2. Operations for raster data extraction include use of a data set, a graphic object, or a query expression to create a new raster by extracting data from an existing raster.
3. Operations for raster data generalization include Aggregate and RegionGroup.

Figure 12.15
An analysis mask (*b*) is used to clip an input raster (*a*). The output raster is (*c*), which has the same area extent as the analysis mask.

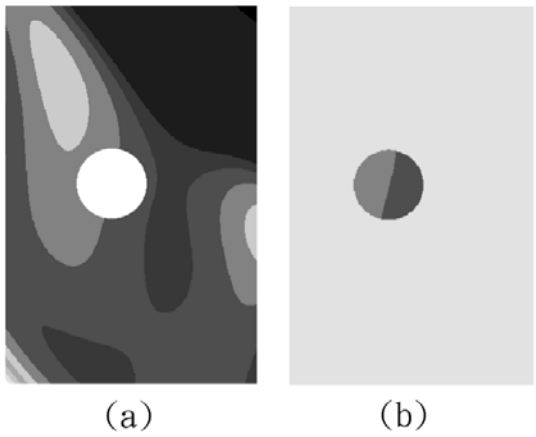


Figure 12.16
A circle, shown in white, is used to extract cell values from the input raster (*a*). The output (*b*) has the same area extent as the input raster but has no data outside the circular area.

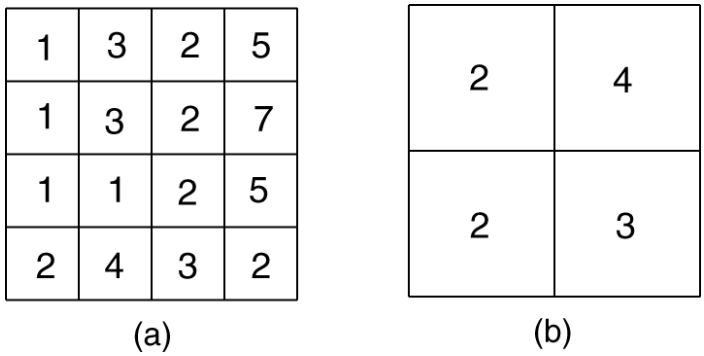


Figure 12.17
An Aggregate operation creates a lower-resolution raster (b) from the input (a). The operation uses the mean statistic and a factor of 2 (i.e., a cell in b covers 2 x2 cells in a). For example, the cell value of 4 in (b) is the mean of {2, 2, 5, 7} in (a).

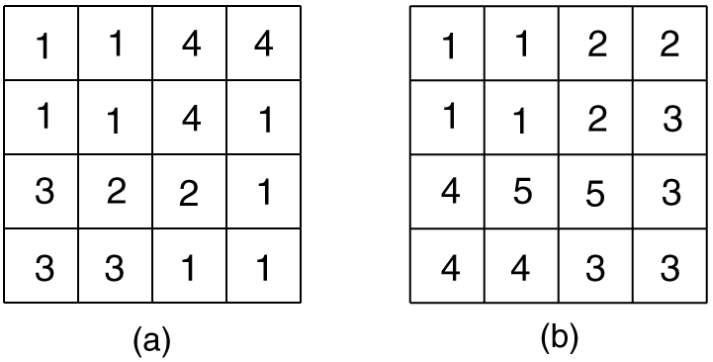


Figure 12.18
Each cell in the output (b) has a unique number that identifies the connected region to which it belongs in the input (a). For example, the connected region that has the same cell value of 3 in (a) has a unique number of 4 in (b).