

Chapter 14. VIEWSHEDS AND WATERSHEDS

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Key Concepts and Terms

Review Questions

Applications: Viewshed and Watershed

Task 1: Perform Viewshed Analysis

Task 2: Create a New Lookout Shapefile for Viewshed Analysis

Task 3: Delineate Areawide Watersheds

Task 4: Derive Upstream Contributing Areas at Pour Points

Challenge Question

References

Viewshed Analysis

A viewshed refers to the portion of the land surface that is visible from one or more viewpoints. The process for deriving viewsheds is called viewshed or visibility analysis.

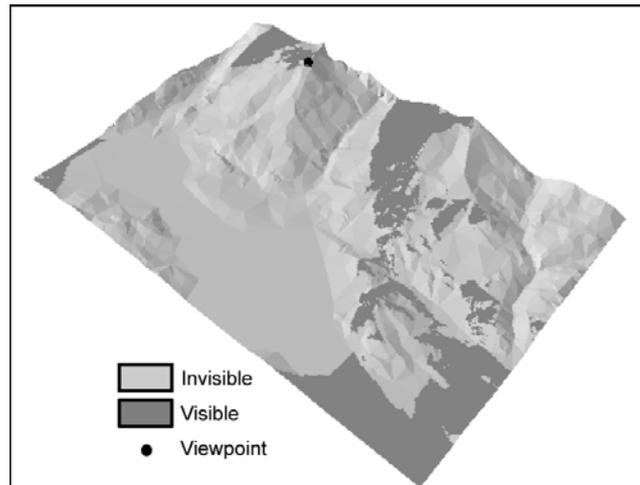
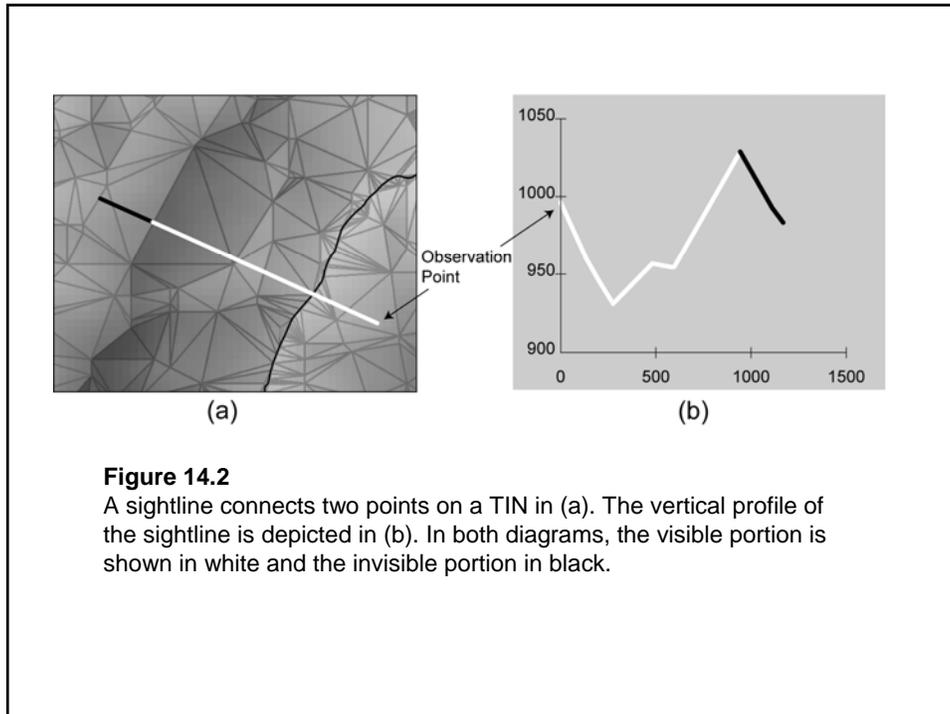
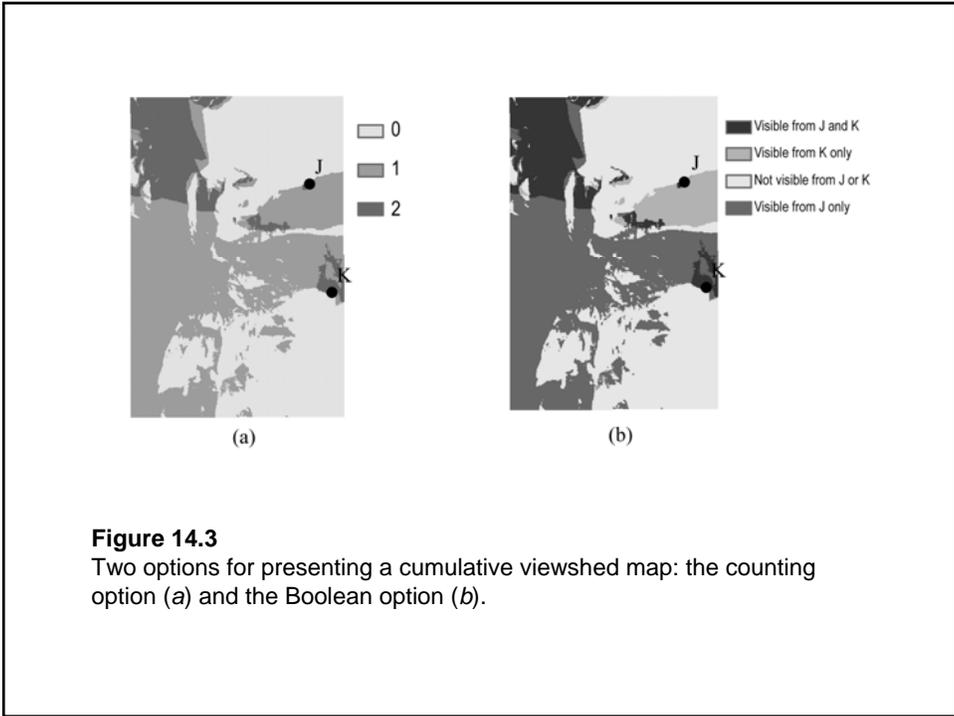


Figure 14.1
A viewshed example.



Output from Viewshed Analysis

- The output of a viewshed analysis is a binary map showing visible and not visible areas.
- Given one viewpoint, a viewshed map has the value of 1 for visible and 0 for not visible.
- Given two or more viewpoints, two options are common for presenting the output. The first option uses counting operations. The second option uses Boolean operations. A viewshed map based on two or more viewpoints is often called a cumulative viewshed map.



Parameters of Viewshed Analysis

A number of parameters can influence the result of a viewshed analysis including the viewpoint, the height of the observer, the viewing azimuth, the viewing radius, vertical viewing angle limits, the Earth's curvature, and tree height.

(a)

931	928	923	918	915	914
937	934	928	922	917	915
937	934	928	923	918	915
935	932	927	922	918	914

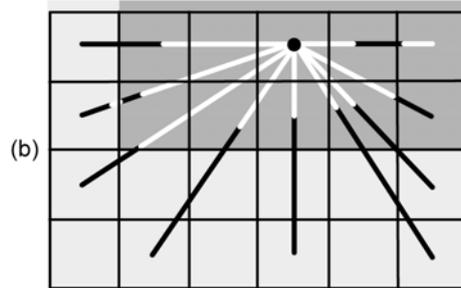


Figure 14.4

In (a), cells of an elevation raster are divided into visible (darker symbol) and invisible (lighter symbol) from the viewpoint located at the elevation of 918 in a viewshed analysis. The sightlines in (b) suggest that the viewshed analysis result can vary depending on where the target point is supposed to be located within the cell.



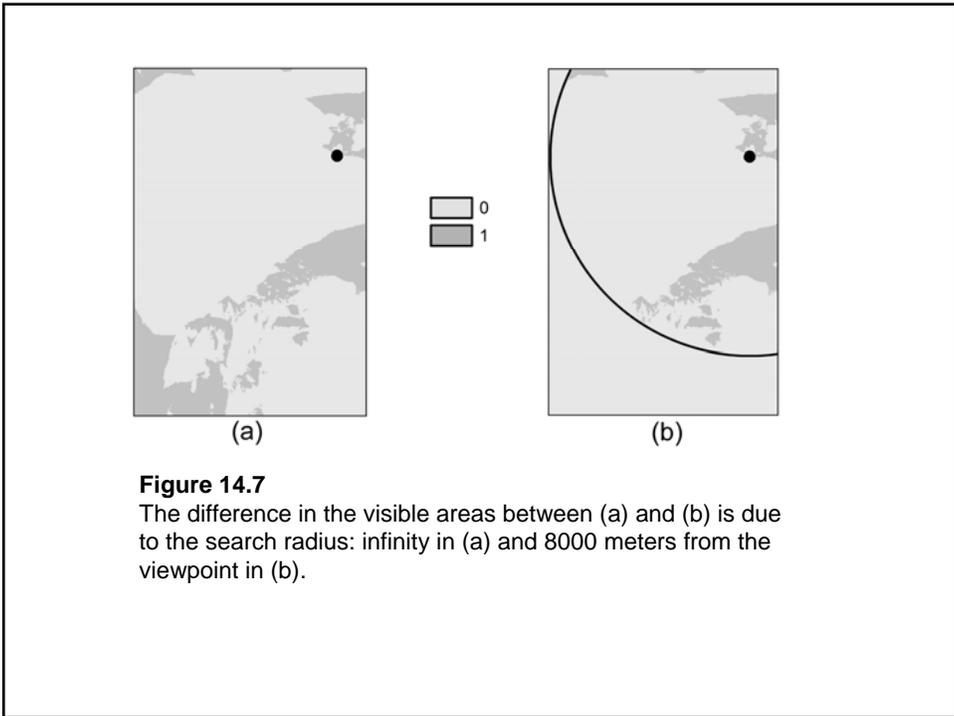
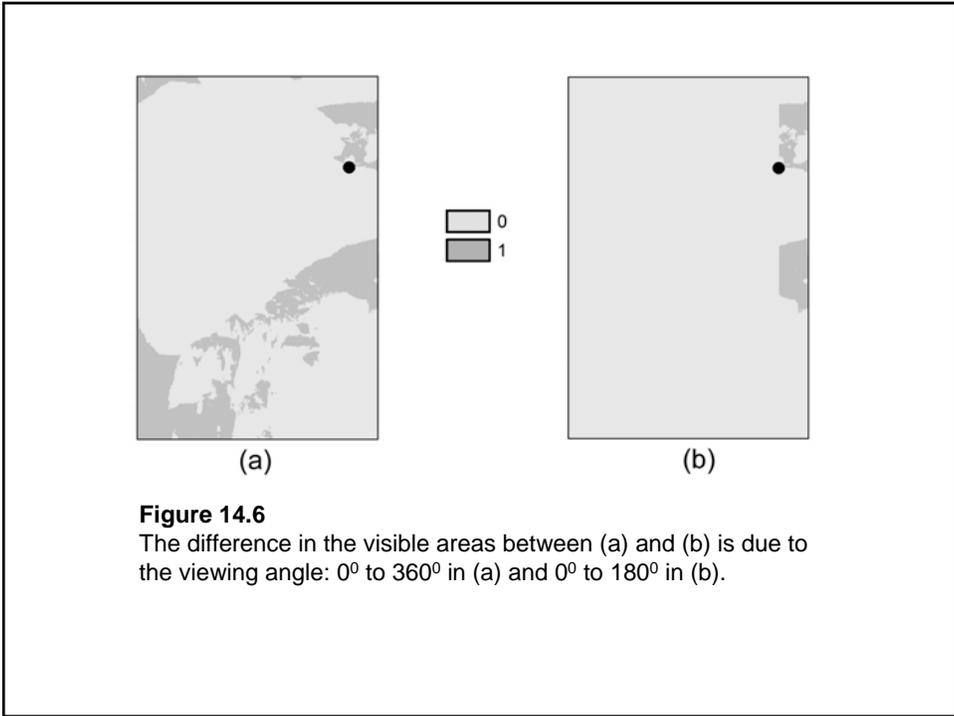
(a)



(b)

Figure 14.5

The increase of the visible areas from (a) to (b) is a direct result of adding 20 meters to the height of the viewpoint.



Watershed Analysis

Defined by topographic divides, a watershed is an area that drains surface water to a common outlet. Watershed analysis refers to the process of using DEMs and raster data operations to delineate watersheds and to derive topographic features such as stream networks.

Delineation of Watersheds

- Delineation of watersheds can take place at different spatial scales.
- Delineation of watersheds can also be area-based or point-based. An area-based method divides a study area into a series of watersheds, one for each stream section. A point-based method derives a watershed for each select point.

Steps for automated watershed Delineation

1. Make a filled DEM, a DEM void of depressions.
2. Derive a flow direction raster, which shows the direction water will flow out of each cell.
3. Derive a flow accumulation raster, which tabulates for each cell the number of cells that will flow to it.
4. Derive a stream network by applying a threshold value to a flow accumulation raster.
5. Derive stream links, with each link assigned a unique value and a flow direction.
6. Delineate watershed by using the flow direction raster and the stream link raster as the inputs.

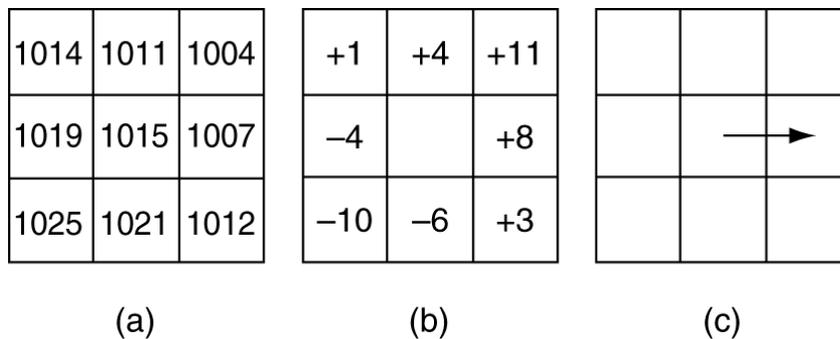


Figure 14.8

The flow direction of the center cell in (a) is determined by first calculating the distance-weighted gradient to each of its eight neighbors. For the four immediate neighbors, the gradient is calculated by dividing the elevation difference between the center cell and the neighbor by 1. For the four corner neighbors, the gradient is calculated by dividing the elevation difference by 1.414. The results in (b) show that the steepest gradient, and therefore the flow direction, is from the center cell to the right cell (+8).

(a)

1014	1011	1004	996
1019	1015	1007	999
1025	1021	1012	1003
1033	1029	1020	1003

(b)

↖	→	→	→
↖	→	→	↗
↖	↗	↗	↗
↖	↗	↗	↗

(c)

0	0	1	2
0	0	2	6
0	0	2	3
0	1	2	3

Figure 14.9

This illustration shows a filled elevation raster (a), a flow direction raster (b), and a flow accumulation raster (c). Both shaded cells in (c) have the same flow accumulation value of 2. The top cell receives its flow from its left and lower-left cells. The bottom cell receives its flow from its lower-left cell, which already has a flow accumulation value of 1.

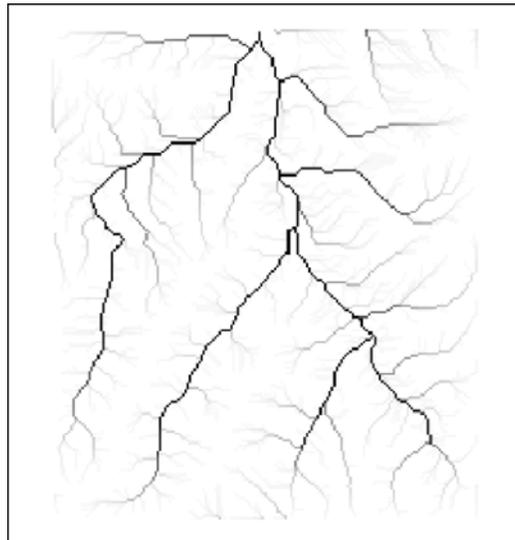


Figure 14.10

A flow accumulation raster, with darker symbols representing higher flow accumulation values.

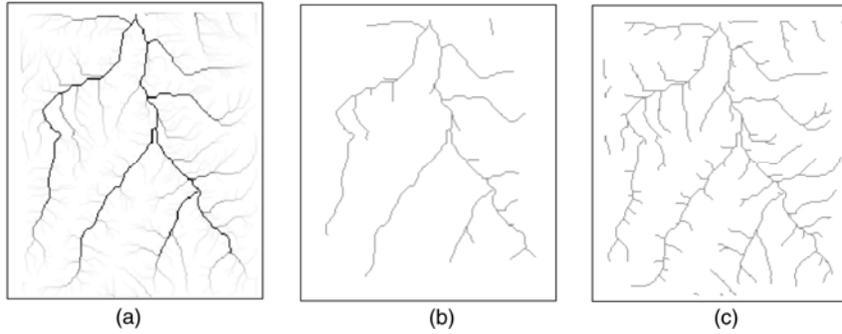


Figure 14.11
 (a) a flow accumulation raster; (b) a stream network based on a threshold value of 500 cells; and (c) a stream network based on a threshold value of 100 cells.

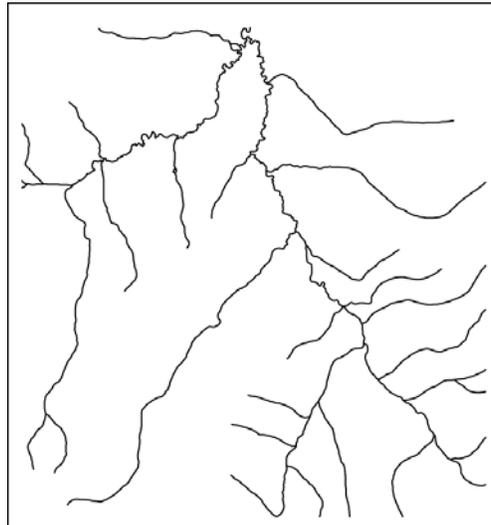


Figure 14.12
 The stream network from the 1:24,000-scale digital line graph for the same area as Figure 14.11.

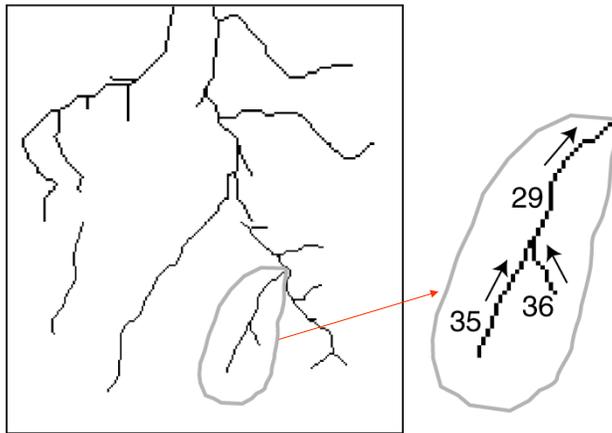


Figure 14.13

To derive the stream links, each section of the stream network is assigned a unique value and a flow direction. The inset map on the right shows three stream links.

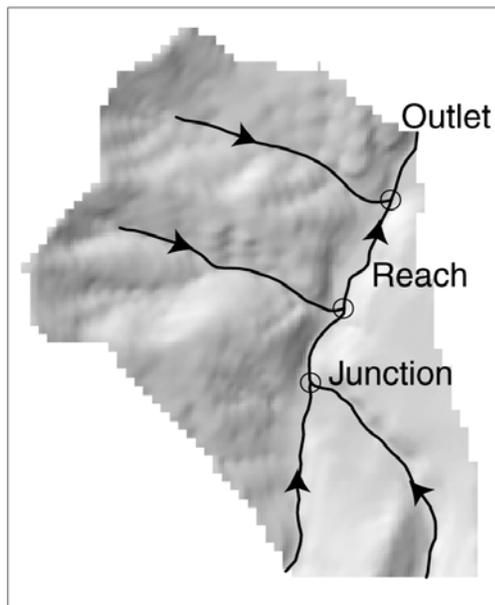


Figure 14.14

A stream link raster includes reaches, junctions, flow directions, and an outlet.

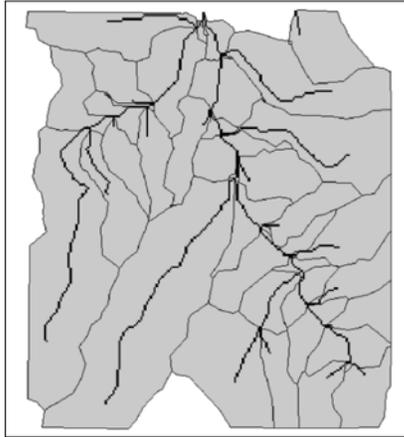
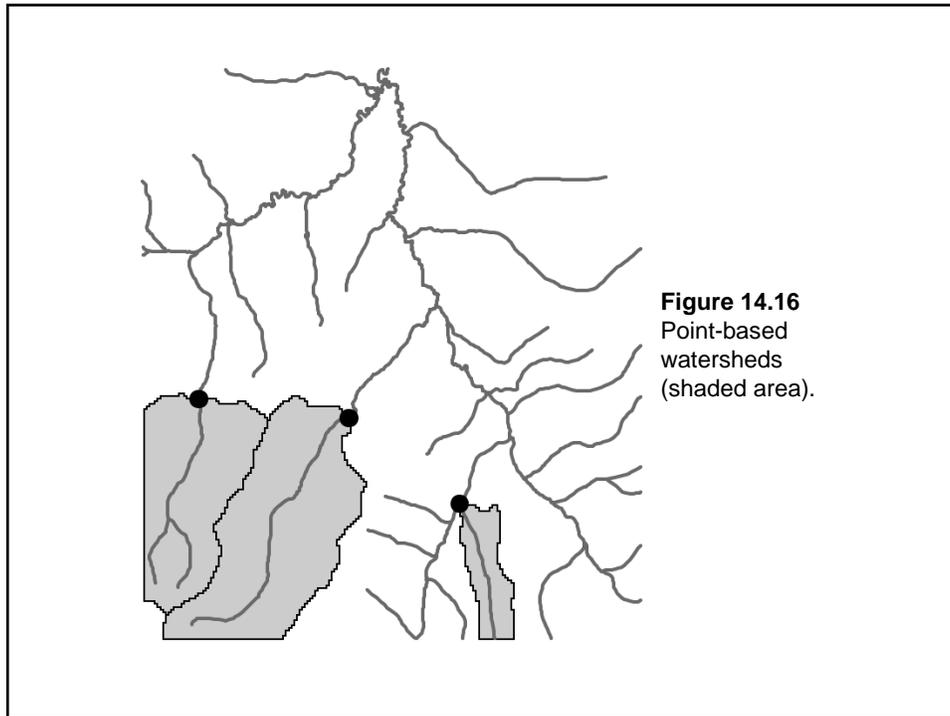


Figure 14.15
Area-wide watersheds.

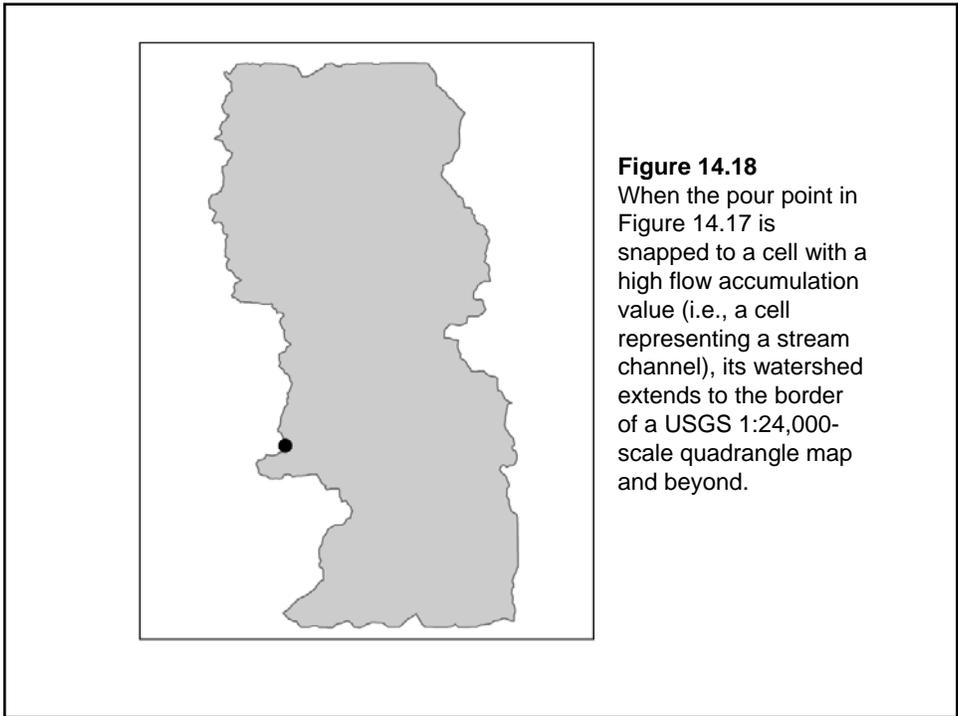
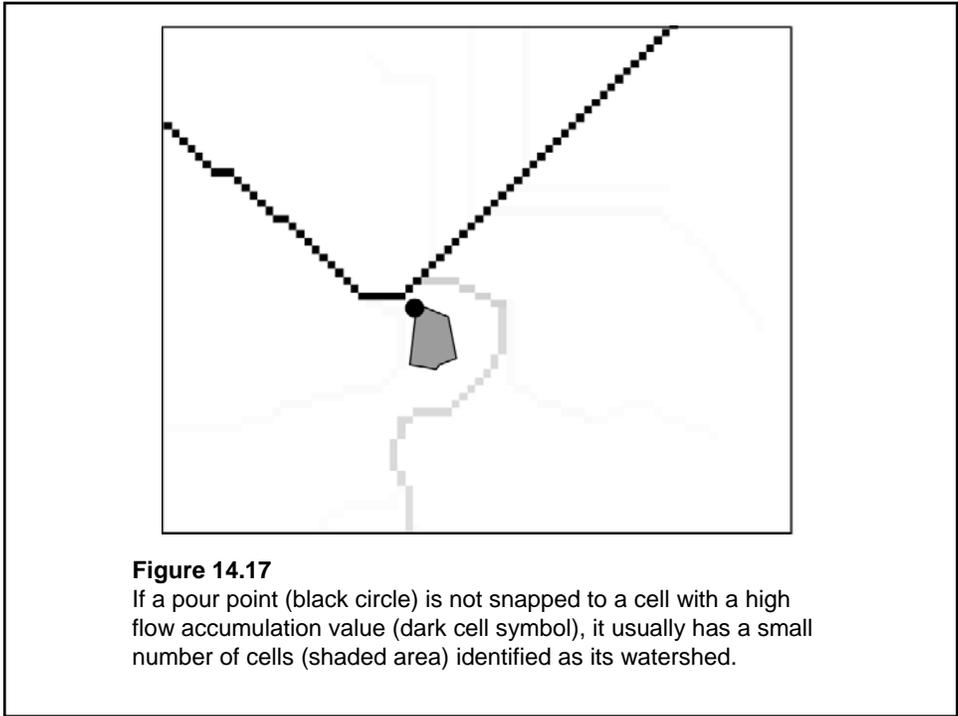
Point-Based Watersheds

Point-based watersheds have one watershed associated with each point, which may be a stream gage station, a dam, or a surface drinking water system intake location. In watershed analysis, these points of interest are called *pour points* or *outlets*.



Snap a Pour Point

- If a pour point is not located directly over a stream link, it will result in a small, incomplete watershed for the outlet.
- The solution is to use a command to snap a pour point to a stream cell within a user-defined search radius.



Algorithm for Deriving a Point-Based Watershed

- If the pour point is located at a junction, then the watersheds upstream from the junction are merged to form the watershed for the pour point.
- If the pour point is located between two junctions, then the watershed assigned to the stream section between the two junctions is divided into two, one upstream from the pour point and the other downstream. The upstream portion of the watershed is then merged with watersheds further upstream to form the watershed for the pour point.

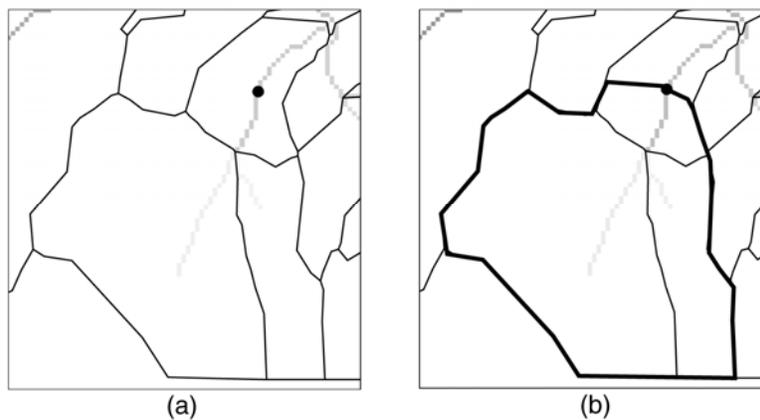
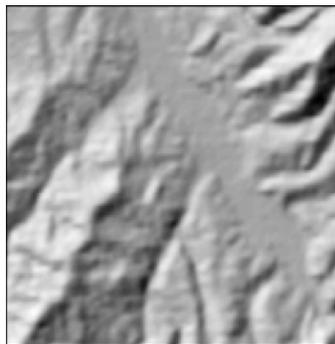


Figure 14.19

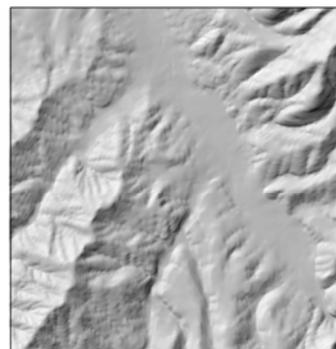
The pour point (black circle) in (a) is located along a stream section rather than at a junction. The watershed derived for the pour point is a merged watershed, shown in thick black line in (b), which represents the upstream contributing area at the pour point.

Factors Influencing Watershed Analysis

Factors influencing the outcome of a watershed analysis include the resolution and quality of DEM, the algorithm for deriving flow direction, and the threshold value for deriving the stream network.



(a)



(b)

Figure 14.20
DEMs at a 30-meter resolution (a) and a 10-meter resolution (b).

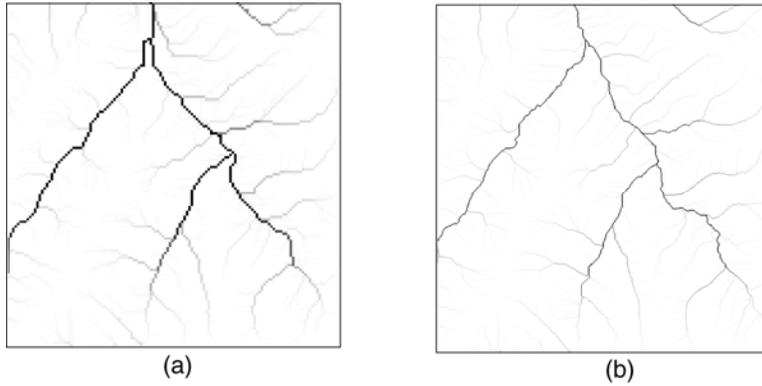


Figure 14.21
 Stream networks derived from the DEMs in Figure 14.20. The stream network derived from the 30-meter DEM (a) has fewer details than that from the 10-meter DEM (b).

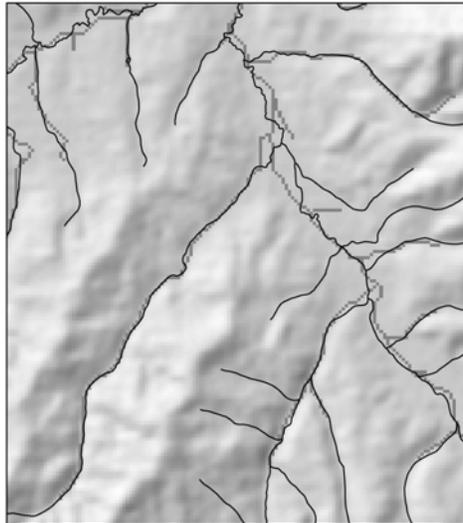


Figure 14.22
 The gray raster lines represent stream segments derived using the D8 method. The thin black lines are stream segments from the 1:24,000-scale DLG. The two types of lines correspond well in well-defined valleys but poorly on the bottomlands.

U.S. Clean Water Act

<http://water.usgs.gov/owq/cleanwater/ufp/>

Watershed Boundary Dataset

<http://www.ncgc.nrcs.usda.gov/branch/gdb/products/watershed/index.html>

Hydrologic Engineering Center (HEC) of the U.S. Army Corps of
Engineers: Hydrologic Modeling System (HMS)

<http://www.hec.usace.army.mil/>

USGS National Water Information System

<http://nwis.waterdata.usgs.gov/nwis>

GIS Data Depot

<http://www.geocomm.com>

Federal Standards for Delineation of Hydrologic Unit Boundaries

<http://water.usgs.gov/wicp/acwi/spatial/index.html>