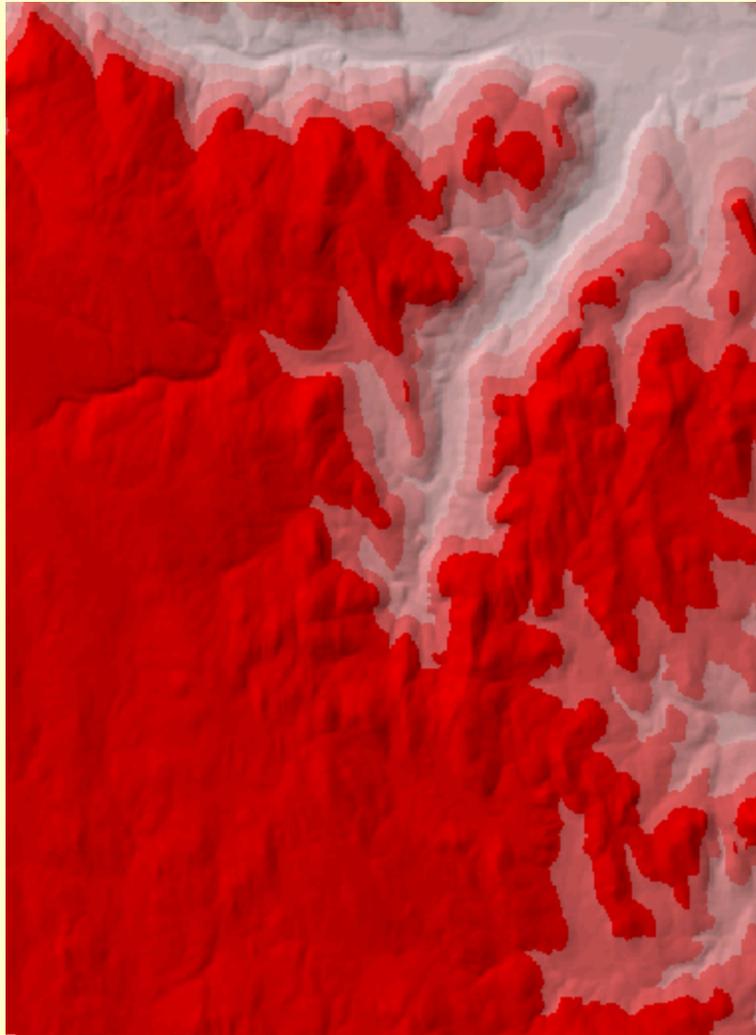


Digital Elevation Models



Using elevation data in raster format in a GIS

What is a Digital Elevation Model (DEM)?

- Digital representation of topography
 - Model based on scale of original data
- Commonly a raster dataset

Why use elevation data in a GIS?

- Easy to use
- Importance of terrain in hydrology and environmental modeling
- Visualization of landscapes

Creation of DEMs

- Conversion of paper maps
 - Scanned, vectorised contour lines
- From original photogrammetry
- From Space Shuttle topography mission (not available until 10/02)

Basic storage of data

340	335	330	340	345
337	332	330	335	340
330	328	320	330	335
328	326	310	320	328
320	318	305	312	315

DEM as matrix of elevations with a uniform cell size

Adding geography to data

Xmax, Ymax

340	335	330	340	345
337	332	330	335	340
330	328	320	330	335
328	326	310	320	328
320	318	305	312	315

Cell index
number x
cell size defines
position relative
to Xmin, Ymin
and Xmax,
Ymax and infers
An exact location

Xmin, Ymin – XY are in projected units

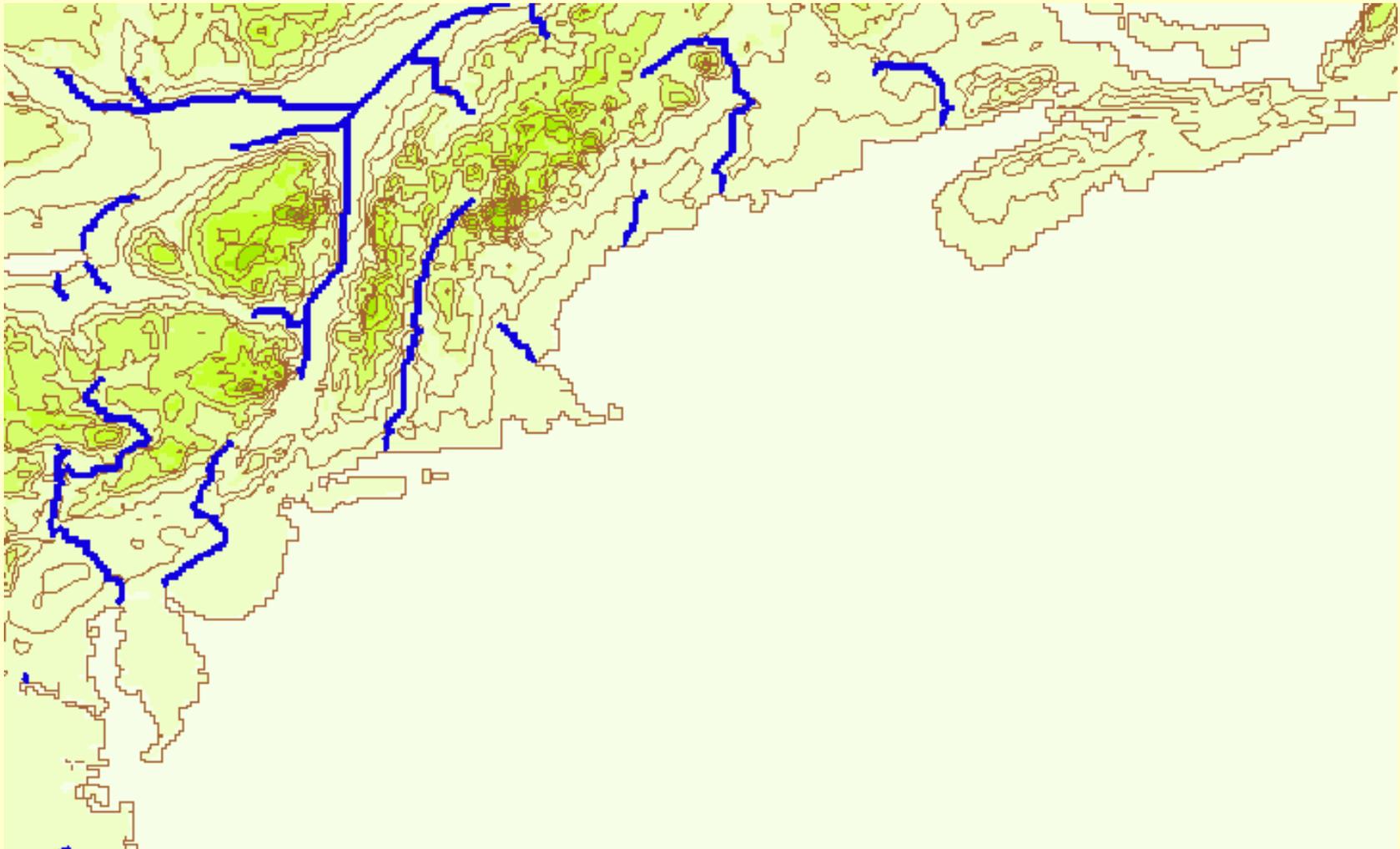
Uses of DEMs

- Determine aspects of terrain
 - Slope, aspect, spot elevations
 - Source for contour lines
- Finding terrain features
 - Watersheds, drainage networks, stream channels
- Modeling of hydrologic functions

Scale in DEMs

- Scale determines resolution (cell size)
- Depends on source data
- Resolution determines use of DEM and what features are visible

Scale ...



Errors in DEMs

- Typos occur frequently in DEMs
- Most common variety are “sinks” and “spires”.
 - Sinks occur when a very low elevation, relative to surrounding cells, is entered.
 - Spires occur when a very high elevation, relative to surrounding cells, is entered
 - Appear as tightly packed contours

Correcting sinks and spires

- Most GIS have a “Fill” function which looks for sinks and fills them or looks for spires and removes them
- Sinks wreck havoc with hydrologic modeling functions in GIS software

A natural sink?

340	335	330	340	345
337	332	330	335	340
330	228	320	330	335
328	326	310	320	328
320	318	305	312	315

By default, this "sink" is removed, whether or not it is real.

An example – finding slope
using a DEM

Estimating slopes in a DEM

- Slopes are calculated locally using a neighborhood function, based on a moving 3*3 window
- Distances are different in horizontal and vertical directions vs diagonal

1.41...	1	1.41...
1	0	1
1.41...	1	1.41...

* cell size

- Only steepest slopes are used

Slopes ...

1.41...	1	1.41...
	0	1
1.41...	1	1.41...

* 30

42.47...	30	42.47...
30	0	30
42.47...	30	42.47...

(distances)

Slopes

340	335	330
337	332	330
330	328	320

(elevations)

$8/42.47$	$3/30$	$2/42.47$
$5/30$	0	$-2/30$
$-2/42.47$	$-2/30$	$-12/42.47$

(difference/distance)

Slopes

0.1667	0	-0.0667
-0.047	-0.0667	-0.286

-0.286 is the largest local slope

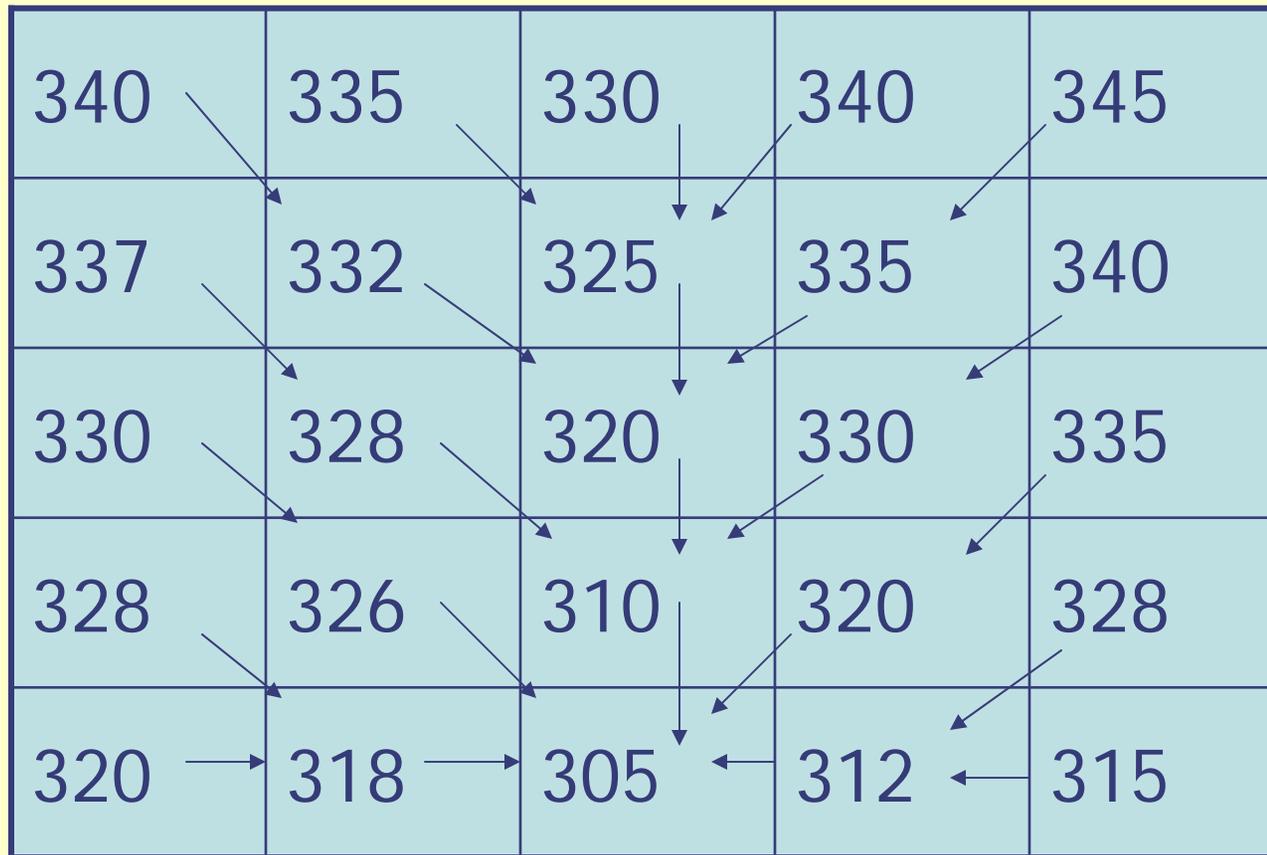
Hydrologic functions on DEMs

- Modeling the topographic form of a drainage basin
- Determining the drainage network and associated drainage divides
- Estimating slopes for understanding drainage patterns and processes

Flow Direction

- Useful for finding drainage networks and drainage divides
- Direction is determined by the elevation of surrounding cells
 - Water can flow only into one cell
- Water is assumed to flow into one other cell, unless there is a sink
 - GIS model assumes no sinks

Flow direction in a DEM

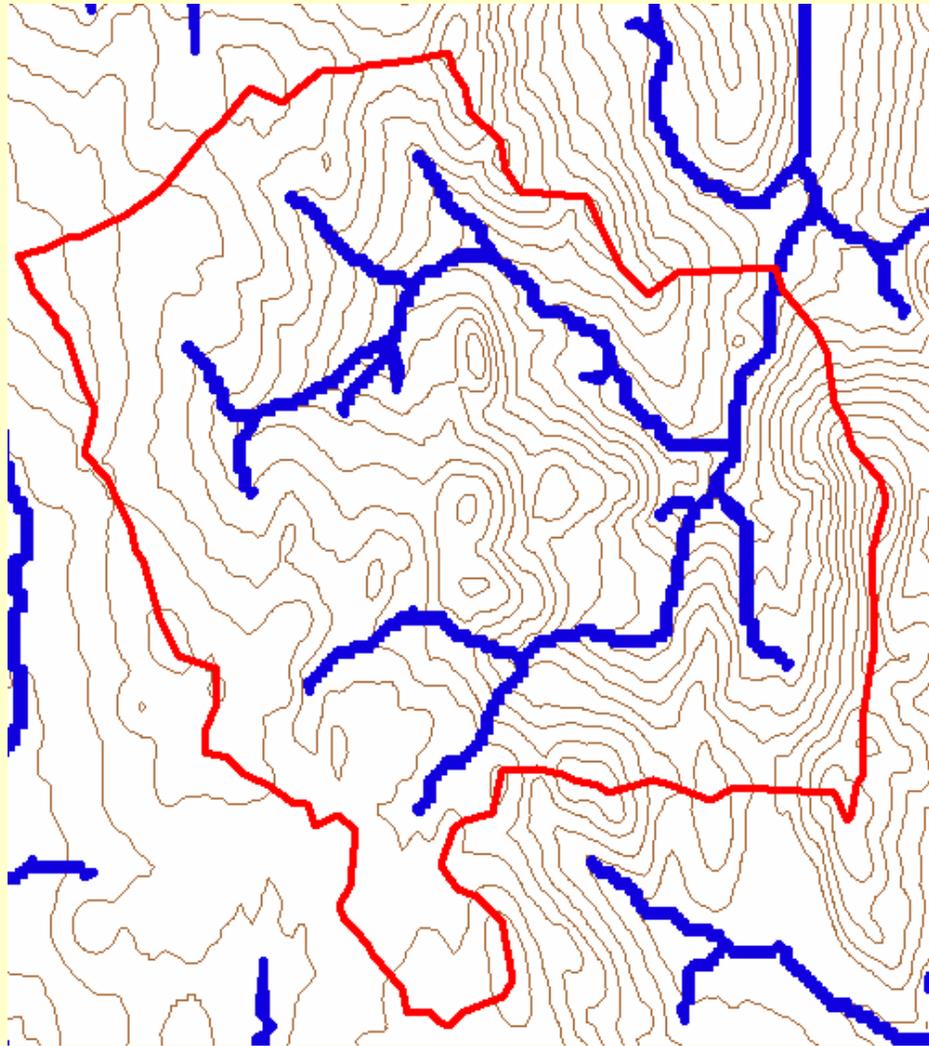


Flow directions for individual cells

Finding watersheds ...

- Begin at a source cell of a flow direction database, derived from a DEM (not from the DEM itself)
- Find all cells that flow into the source cell
- Find all cells that flow into those cells
- All of the cells comprises the watershed
- The resulting watershed is generalized, based on the cell size of the DEM

Watersheds ...



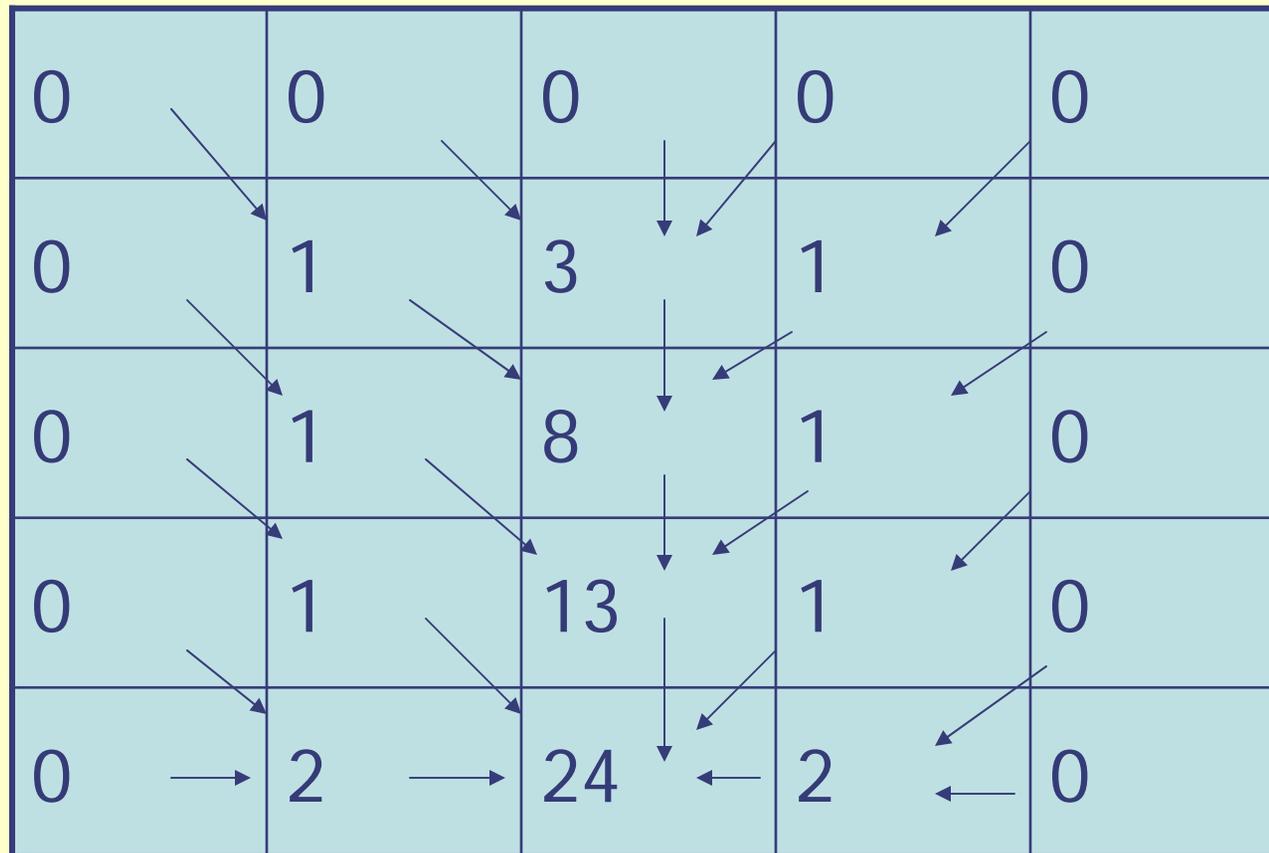
Once done manually ...

Contour lines (brown)
Drainage (blue)
Watershed boundary (red)

Flow accumulation

- The number of cells, or area, which contribute to runoff of a given cell
- Accumulation, once it reaches a threshold appropriate to an region, forms a drainage channel
- Accumulation is the area of a watershed that contributes runoff to a given cell

Flow accumulation in a DEM



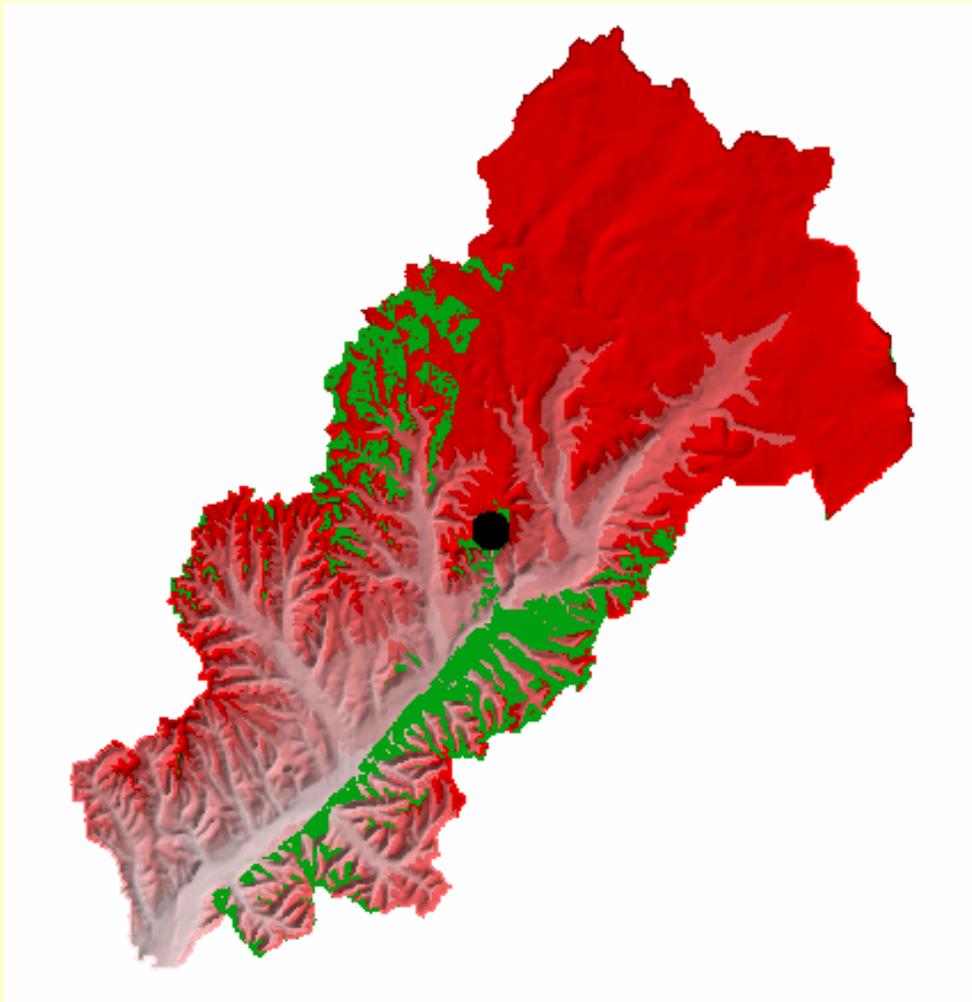
Flow accumulation for individual cells
Errors may occur at the edges of DEMs.

Flow accumulation as drainage network



Drainage network as defined by cells above threshold value for region.

Visibility



What land is visible from the selected location?