GEOMORPHIC PROCESSES
15-040-504
Laboratory #2: Landscape Evolution

Purpose:

1. Familiarization with digital elevation models (DEM's) and digital terrain representations.
2 Familiarization with computer generation of maps and projections.
3. Familiarization with simple descriptive statistics.
4. Familiarization with the Davisian theory of landscape evolution.
5. Introduction to regional geomorphology.

Readings:

Pike, Richard J. and Wilson, S. E. 1971. Elevation-relief ratio, hypsometric integral, and geomorphic area-altitude analysis. Geological Society of America Bulletin*, 82:1079-1084.*

Curran, Justus, Young, and Carver. 1984. Atlas of *Landforms* (Third Edition)*. New York: John Wiley& Sons. p. 16-18.*

Thornbury, W. D.. 1969. Principles of Geomorphology*. New York: John Wiley & Sons. p. 99-136.*

References:

Elassal, A. A., and Caruso, V. M. 1985. Digital Elevation Models, U.S. Geological Survey Circular 895-b*. Alexandria.- U.S. Geological Survey. 40p.*

Fenneman, N. 1931. Physiography of Western United States*. New York: McGraw-Hill Book Company. 534p.*

Fenneman, N. 1938. Physiography of Eastern United States*. New York: McGraw-Hill Book Company. 714p.*

Thornbury, W. D. 1965. Regional Geomorphology of the United States*. New York: John Wiley and Sons. 609p.*

Discussion:

The fundamentals of W.M. Davis's geographic cycle and the arguments for against this theory of landscape evolution have been presented in class. Although the concept of the geographic cycle is currently out of vogue, it still has many advocates. Whether or not you choose to accept the theory, the terms youth, maturity, and old age have definite, descriptive connotations and are useful as an efficient means for describing landscapes. In this exercise, you will be asked classify landscapes using Davisian terminology.

You will also be exposed to the concept of regional geomorphology (sometimes referred to as physiography). As I mentioned in my introductory lecture, landscapes are a function of structure, process, and stage. The United States can be divided up into physiographic provinces (regions having a similar structural geology and deformational history and thus having similar landscapes). In the past,
Prof. Durrell taught a course about the physiography of the United States. With his retirement, the course is no longer taught. The study of physiography is quite interesting and important, however, and you should have some familiarity with it. One of the best texts on physiography is by the founder of our department, Nevin Fenneman (1931 and 1938) and another, more modern, text is Thornbury (1965). You will be asked to read about the physiography of a region in these texts.
Descriptive statistics, when used in moderation, can be of considerable use in geomorphology. In

this laboratory, you will examine the frequency distribution of elevations. This distribution will provide you with insight into the stage of a landscape. The histogram of elevations for a youthful landscape will be negatively skewed (Fig. 1) because most of the surface is in high, undissected uplands with a relatively small proportion of the area in valley bottoms. In mature landscapes, the distribution of elevations should be fairly uniform, yielding a symmetric, bell-shaped histogram. A positively skewed histogram will be produced by an old age landscape because most of the surface is lowlands with a few scattered monadnocks. If a landscape bears evidence for more than one cycle of uplift, it will yield a multimodal histogram of elevation frequencies. The Cincinnati area is youthful: steep sided, narrow valleys are incised into the surface of the "Lexington Peneplain". The histogram of elevations for this area shows a negatively skewed distribution as we would expect (Fig. 2).

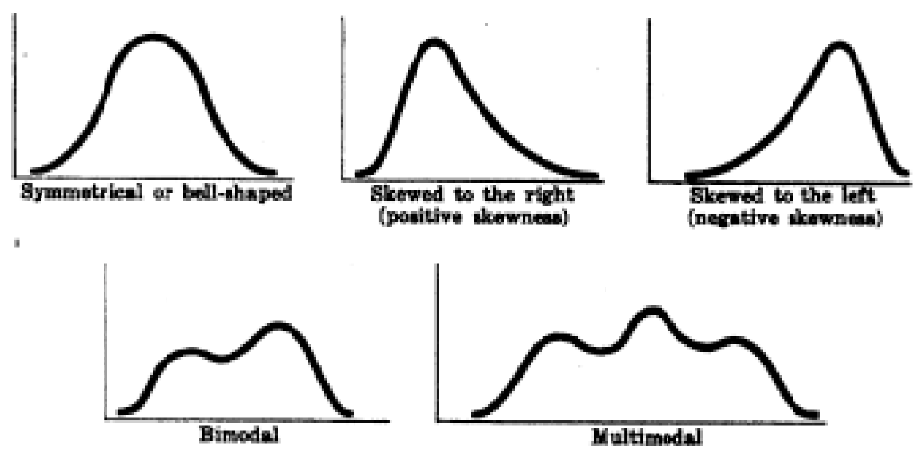

Figure 1. Types of frequency distributions

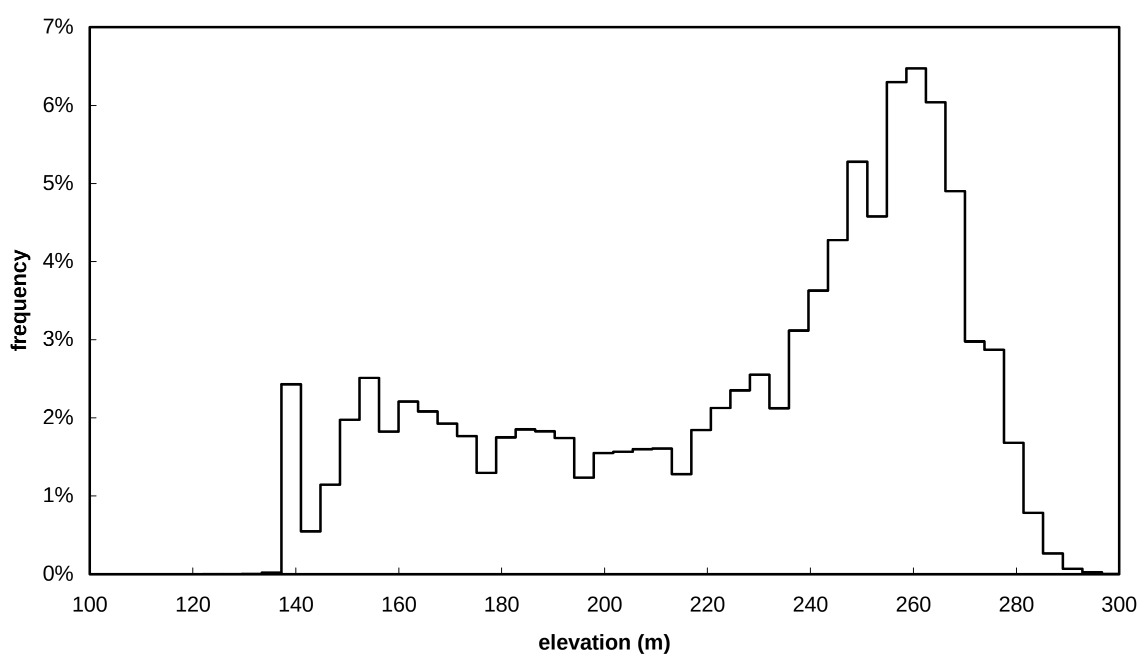

Figure 2. Histogram of Cincinnati area elevations.

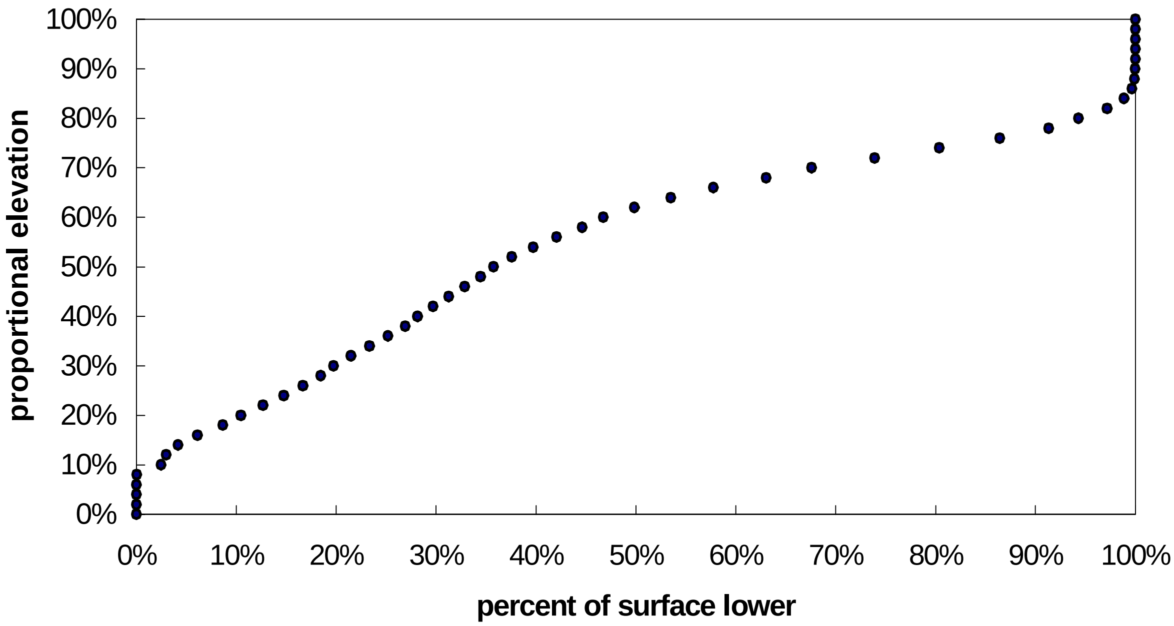

Figure 3. Hypsometric curve for the Cincinnati area

Another way of presenting elevation frequency is with a cumulative *frequency diagram* or ogive. A hypsometric curve (discussed in the introductory lecture) is similar to an ogive. The *elevation-relief* ratio and hypsometric integral are also useful parameters for determining the stage of a landscape (Pike and Wilson, 1971). The hypsometric curve for a youthful landscape will be convex-up and yield a high elevation-relief ratio. An old age landscape will yield a concave-up hypsometric curve and a low elevation-relief ratio (Figs. 3 and 4). Analysis of a mature landscape will yield a hypsometric curve and elevation-relief ratio between those of youth and old age.

Digital Elevation Models (DEM's) contain landscape elevations taken at fixed horizontal and vertical intervals across an area. They are becoming increasing popular form of data used by geologists, geographers, civil engineers, and land use planners. DEM's are available for many areas of the U.S. and the world (USGS, 1985). Traditional contour maps can be produced from DEM's. *Mesh perspectives,* sometimes called drape diagrams may also be produced (Fig. 5). DEM's can also be used to produce other diagrams such as maps of land gradient, drainage direction, etc. They are also used for terrain following guidance systems such as that used in the cruise missile. Because DEM's will be used increasingly in geology, you should have some familiarity with them. In a better equipped department, we could produce a DEM with some software and with a digitizer, a device with which a computer can directly read the cartesian coordinates of a point on a map.

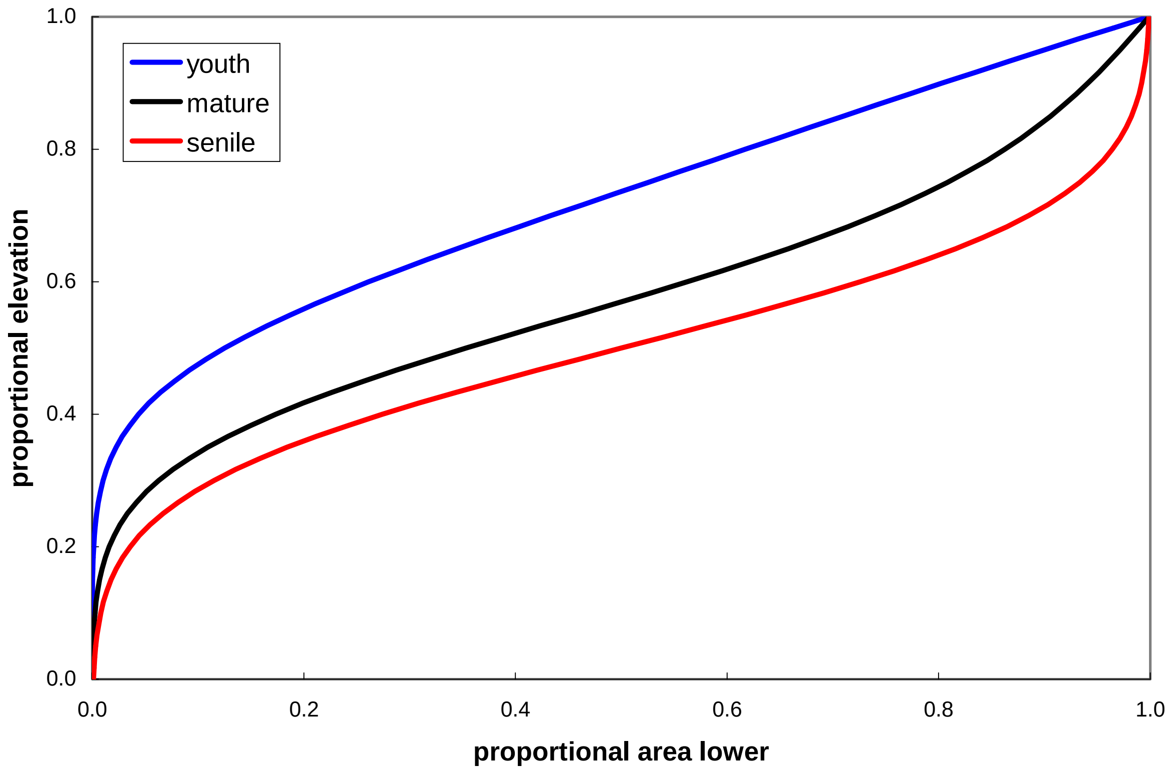

Figure 4. **Idealized hypsometric curves for a youthful, mature, and senile landscape**

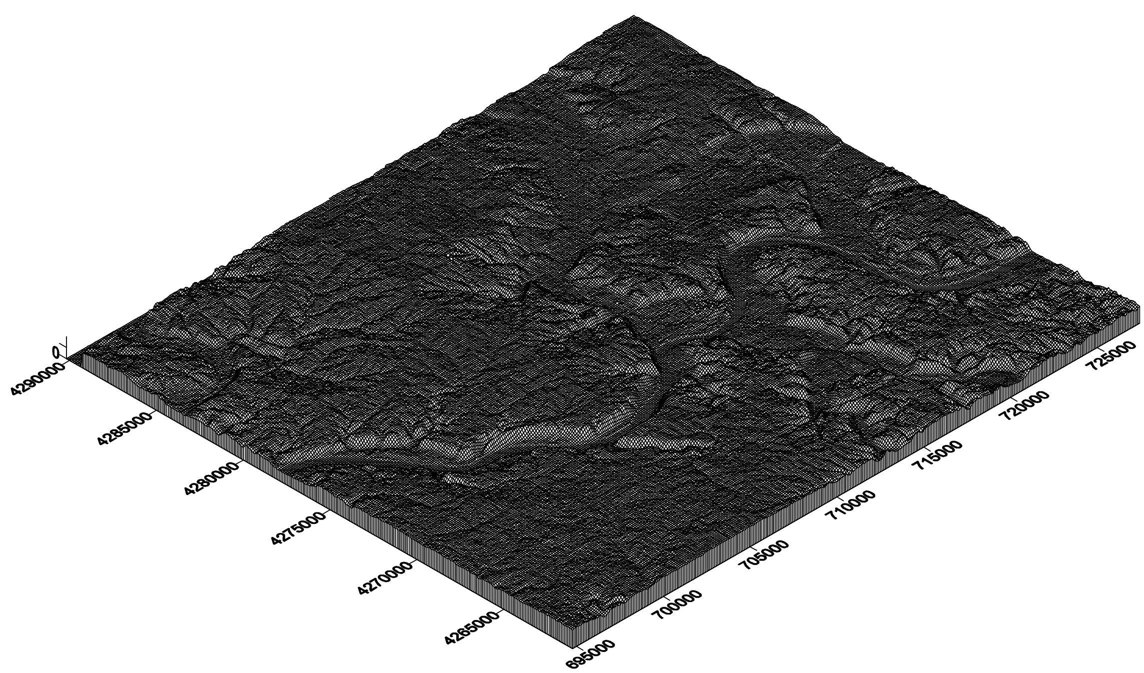

Figure 5. **Drape diagram of the Cincinnati area**

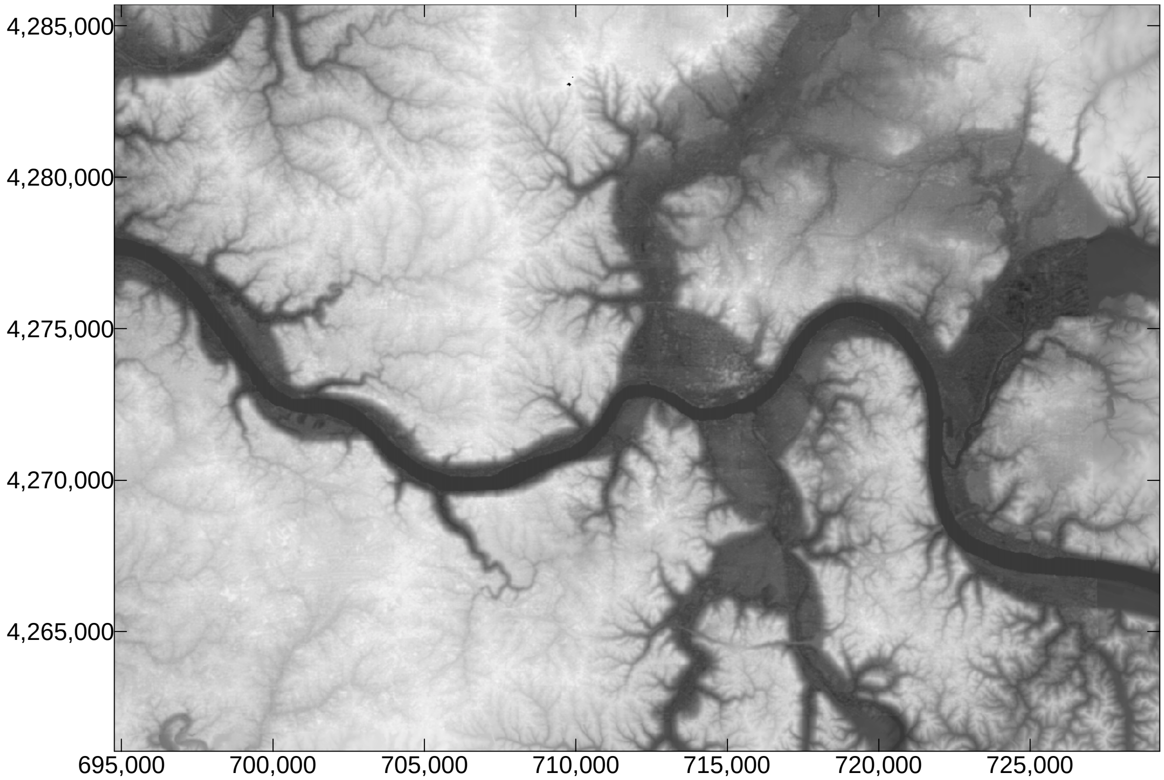

Figure 6. **Shaded relief map of the Cincinnati area.**

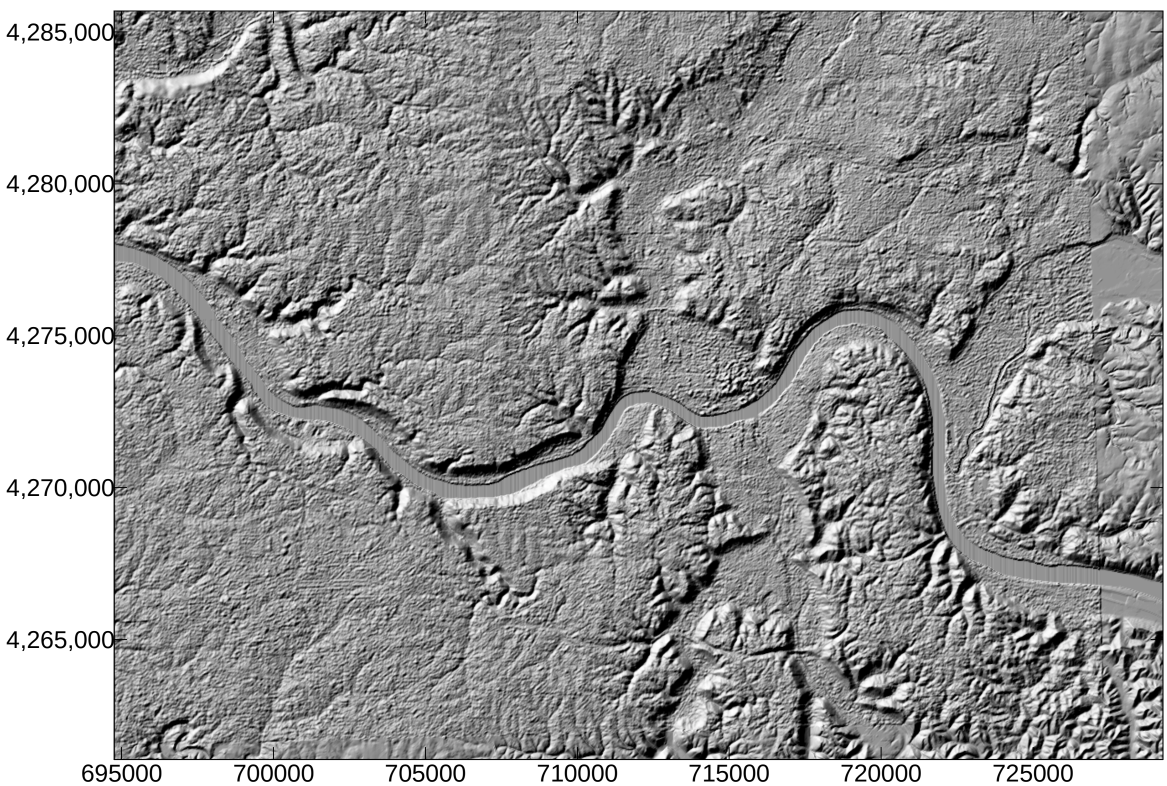

Figure 7. **Elevation "image" of the Cincinnati areas**

Procedure:

1 Thornbury's (1969) basic geomorphology text is quite Davisian in its approach. Most modern geomorphology text are considerably more skeptical about the Davisian concept of landscape evolution. Read Thornbury's description of youthful, mature, and old age landscapes. Read p. 99-136 (particularly p. 135-136) in Thornbury and look at examples of each of these landscapes in Curran, et al., (1984).

2. The class will be divided into groups, each of which will be assigned to find a landscape in one of the stages of evolution. Each group should select a leader to coordinate the group's efforts. After consulting Fenneman (1931 and 1938) and Thornbury (1965) go to the map library and select a 7.5', or 1:250,000 scale map of the area you have selected. Please do not remove maps randomly as it is a considerable effort to refile them. Keep the disruption to a bare minimum.

3. Go to the USGS's Geo Data website through the class website.

4. Select your map either by state list or from the graphical map interface and download the zipped and tarred dataset.

5. Unzip and unload your dataset using Winzip, Netzip, or Godzip (see Lab #2 website for links from which these programs may be downloaded)

6. Read your DEM into Microdem or Terrabase II, pull down the analyze menu tab and select elevation histograms. Print the statistics sheet, the elevation histogram sheet, and the Strahler elevation distribution sheet (the hypsometric curve).

7. This curve shows the proportion of the area above any given proportional elevation. We are plotting the proportion of the area below any given proportional elevation. Each person should make a table of proportional area higher at o,05 proportional elevation at intervals (this will be demonstrated in class). Determine proportional area lower by subtracting each number from 1.0.

8. On a single sheet of graph paper, draw the dimensionless hypsometric curve for each member of your group's map and a curve representing the average of all the hypsometric curves in the group.

9. Carefully read Pike and Wilson (1971) and calculate the elevation-relief ratio. Each group member should calculate the elevation-relief ratio for their own data.

10. The groups will email me a spreadsheet with the Cartesian coordinates of their mean hypsogram and their mean hypsometric integral and I will put these data on the class website.

Analysis and Question: (to be done individually)

1 . Write a one page abstract about the physiography of the landscape you selected (refer to Thornbury (1965) and Fenneman (1931 or 1938).

2. Discuss the criteria you used in selecting your landscape as an example of youth, maturity, or oldage. Refer specifically to the discussion by Thornbury (1969).

3. Discuss your super groups hypsometric curves and their validity for determining the stage of a landscape.

4. Discuss the histogram of elevations for your area. What can you conclude from it?

5. Use the posted (on the web) data from each group to construct a single plot showing all the hypsometric curves. Plot the hypsometric integral for each group using a bar chart. Do they behave as expected?

6. Produce a "map" of your area with Microdem.