

## **Note to Teachers : A Tale of Two Watersheds: Land Use, Topography, and the Potential for Urban Expansion**

This analysis project was developed as part of the course NR505: Concepts in GIS at Colorado State University . It is intended to expose high school students to the use of geographic information systems (GIS) for scientific purposes and to various contemporary cross-cultural issues. This project will support the educational partnership formed between the Puerto Rico Biocomplexity Project and the Thompson Valley High School in Loveland, CO.

The goals of this project are to conduct a comparative analysis of two watersheds that relate land use patterns to topographic variables using a GIS-based spatial analysis. The analysis has been condensed into a web-based education project suitable for high school students that shows the use of GIS in a spatial analysis of watersheds. Particular objectives of the project are as follows:

- To familiarize students with the use of a Geographic Information System for scientific inquiry
- To investigate the ways in which two watersheds are similar and different in how people distribute themselves and their use of land throughout these watersheds
- To illustrate how land use is correlated with two land use drivers: elevation and slope
- To compare the distribution of slope and elevation classes between two watersheds
- To use elevation zones, slope zones and current land use polygons to identify suitable areas in two watersheds where future urban expansion could occur

Land use patterns are often highly correlated with bio-physical variables such as slope and elevation gradients (Overmars and Verburg 2005; Mottet, et al. 2006; Reginster and Rounsevell 2006) and sometimes correlated with other variables such as land tenure/ownership (Mottet, et al. 2006), proximity to markets, services, and population centers (Overmars and Verburg 2005; Reginster and Rounsevell 2006), and proximity to transportation and stream networks (Reginster and Rounsevell 2006). We have elected to use only two land use drivers suggested by the literature to develop a simple problem using GIS – elevation and slope. To facilitate the analysis we create elevation and slope zones with zone breakpoints developed from the published literature (see below).

There are two ways that researchers have viewed urban land use: categorical (urban vs. non-urban) or as a continuous variable such as population density (Conway and Lathrop 2005). This project uses the categorical variable of urban vs. non-urban where we define urban as any intensive human settlement use such as urban, residential, exurban, industrial, and/or transportation corridors. Urban does not include agricultural uses, mining, or any land cover that is identified by a unifying vegetation type (i.e. forest, wetland, etc.).

## **Description of Slope Zones**

Both watersheds will use the same slope zone classifications. We use the four slope elements recommended by Miller and Summerson (1960) as follows:

Flat to Gentle (Zone 1): 0% to 6.26 % ( $0^{\circ}$  -  $3^{\circ} 35'$ ) Flat to gentle surfaces such as valleys, coastal plains and outwash areas.

Shallow (Zone 2): 6.26% to 25.68 % ( $3^{\circ} 35'$  -  $14^{\circ} 26'$ ) The shallow portion of geographical “constant slope” areas including the upward limit of geographical features such as pediments, fans and depositional features of ice and wind.

Moderate (Zone 3): 25.68% to 68.04 % ( $14^{\circ} 26'$  -  $34^{\circ} 14'$ ) The steeper portion of geographical “constant slope” areas including slopes with unconsolidated (loose) material such as talus or debris.

Steep to Free Face (Zone 4): 68.04% and up ( $34^{\circ} 14'$  and up) The “free face” area including all steep surfaces.

## **Description of Elevation Zones for the Big Thompson Watershed**

These elevation bands are approximate, average boundaries for the ecological life zones of Colorado identified in three different publications from the early 1900s: Plant Zones in the Rocky Mountains of Colorado by Ramaley (1907), Entomostraca and Life Zones, A Study of Distribution in the Colorado Rockies by Dodds (1920), and An Ecological Study of Nesting Birds in the Vicinity of Boulder, Colorado by Johnston (1943).

Plains (Zone 1): less than 1,700 meters (<5,577 feet). This is also known as the Upper Sonoran Zone.

Foothills (Zone 2): between 1,700 meters and 2,500 meters (5,577 – 8,202 feet). This is also known as the Transition Zone.

Montane (Zone 3): between 2,500 meters and 3,100 meters (8,202 – 10,171 feet). This is also known as the Canadian Zone.

Subalpine (Zone 4): between 3,100 meters and 3,400 meters (10,171 – 11,155 feet). This is also known as the Hudsonian Zone.

Alpine (Zone 4): above 3,400 meters (11,155 + feet). This is also known as the Arctic-Alpine Zone.

## **Description of Elevation Zones for the Espiritu Santo Watershed**

These elevation bands are approximate, average boundaries for the ecological life zones of Puerto Rico identified in the publication: Ecological Subregions of the United States,

Chapter 51: Puerto Rico (McNab and Avers 1994). This publication identified the Coastal Lowlands as a single zone, but we have split this zone into 3 sub-zones of low (0 – 25 m), middle (25 – 75 m) and high (75 – 150 m) to better illustrate differences in elevation near the ocean.

Coastal Lowlands (low) Zone (Zone 1): 0 meters (sea level) to 25 meters (0 feet to 82.02 feet).

Coastal Lowlands (middle) Zone (Zone 2): 25 meters to 75 meters (82.02 feet to 246.06 feet).

Coastal Lowlands (high) Zone (Zone 3): 75 meters to 150 meters (246.06 feet to 492.13 feet).

Foothills Zone (Zone 4): 150 meters to 300 meters (492.13 feet to 984.25).

Montane Zone (Zone 5): 300 meters and above (above 984.25 feet).

### **Brief Description of the Lessons**

Lesson 1 uses 2000 census polygon data to illustrate how people are distributed in each watershed and provides information on total population and the population density for both watersheds. This lesson is intended to show how a GIS can be used to gain additional relevant information about a study site from secondary data (i.e. data that was collected by someone else for another purpose). Students are asked to use the census data to make some educated guesses about the distribution of two different land uses based on where people live which will be checked in Lesson 2.

Lesson 2 uses land use/land cover (LULC) polygon data to illustrate how people have elected to use the land in each watershed. There is a brief discussion about how a GIS can be used to calculate and add attribute data. Then students are asked to gather data from the LULC layers regarding how much of each watershed is devoted to certain land uses, such as urban and agricultural, and to compare the watersheds using this information. The students also get to check their educated guesses from Lesson 1.

Lesson 3 uses Digital Elevation Model (DEM) raster data to illustrate elevation and slope information in preparation for conducting the final spatial analysis in Lesson 4. A common raster data function, called reclassification, is employed to develop elevation and slope zone data sets from the original DEMs. Students can then easily visualize both the elevation and slope categories that will be used in Lesson 4.

Lesson 4 uses Digital Elevation Model (DEM) raster data on which a spatial analysis is performed to determine the area of each watershed that is suitable for future development. Reclassification, as well as single layer map analysis and dual layer map analysis are performed in this lesson to reach the desired outcome. Refer to the introduction for further explanation of key GIS concepts used throughout this lesson.

Students will be able to follow the entire analysis process both visually and by following along with a flowchart.

Lesson 5 uses the data produced from the spatial analysis performed in Lesson 4 to create maps for both watersheds to communicate the results. Students will have the opportunity to learn how to tell their story through visual representation (a map). A map is just as much about what is included as it is about what is not included to get across the intended purpose. Students will also learn about the seven essential map elements and the responsibilities of a map-maker.

This web-based analysis project walks students through both the procedure and visual results of a spatial analysis and the thought process underlying the analysis. Specific components of the application include: visuals captured from ArcGIS that illustrate the step-by-step process of comparing the two watersheds, questions for each lesson, links to web-sites and references, and suggestions for additional areas of inquiry to enhance the learning experience. There are handouts containing the questions for each lesson which can be printed out and used during the lessons. We hope that you and your students will find this project useful and stimulating.

#### **Literature Cited**

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