Introduction to ArcGIS
Synopsis of Class 2, GIS in Water Resources, Fall 2018

The ArcGIS Geographic Information System is developed by the Environmental Systems Research Institute (ESRI) of Redlands, CA. Over the past 40 years, they have created a GIS software and data framework that continues to evolve and develop – the latest evolution being *ArcGIS Pro*, a relatively new desktop professional GIS software. This, in turn, is based on ArcGIS Online, which is a repository of data, maps and geoprocessing functions that are directly accessible through the internet. Each year, ESRI holds an international User Conference which provides an overview of ESRI software and its applications (attended this year by about 17,000 people). The videos from the 2018 ESRI User Conference Plenary session give a vivid sense of the current state of GIS and also of its future direction: http://p.ctx.ly/r/7zha

Central to the vision of GIS is the idea of story-telling using maps. *Data* in tables are made more compelling *information* by being visualized in maps. Thematic integration of map information from many sources creates *knowledge*. Sharing this knowledge and collaboration among people improves *understanding*. A key idea underlying GIS is that of a geographic *feature* (point, line or area) attached to a set of *attributes*, which are descriptive characteristics of the feature stored in a related data table. Each feature has an associated record or row in a data table and vice versa. This is the key thing that distinguishes GIS from a *drawing* system (has digital maps but not data tables) or a *relational database* system (has data tables but no means of geospatially visualizing the data).

As you become familiar with working with GIS data, you'll see that the mechanism of dealing with these data is quite different than other computational methods that you may have used before. In GIS, data processing is incremental. Each tool carries out a single, specific operation that requires a particular kind of input dataset, and produces a modified version of this dataset as its output.

ESRI has developed several such models for describing geographic information. The first, which originated with ArcInfo, is the *coverage* model that stores geographic data in binary files (Arc), and attributes in the Info database. Some GIS data is still distributed in this form as files with a .e00 extension. The next, introduced with ArcView, is the *shapefile* model, which is a looser description of points, lines and areas, and whose file format is open. This has become the most widely used mechanism for distributing GIS data. The third, introduced with ArcGIS, is the *geodatabase*, which is a much more highly structured data storage system that includes feature classes, tables, grids, geometric networks, and relationships.

The fundamental form of storing information in a relational database is a *table*, which has rows or *records*, and columns or *fields*. Each field describes a particular item of information, or *attribute*, and it has a column header with a *field name* to identify that attribute. Each record is a collection of values of the attributes, indexed by the attribute value in the *key field* that serves as the unique identifier of that collection of values. The geospatial coordinates of a point, line or area are stored in a field named *shape*, and the resulting table describes a *feature class*, with each record describing a single *feature*. If the table has no shape field, it is called an *object class*. Information in two tables can be *related* by associating the common values of their key fields. Note that this concept of a database table is very different from a spreadsheet table that can contain formulas in the cells and has implicit computational capabilities.

Database tables have only the function of storing information and all processing on these tables is done by external functions.

ArcGIS has two desktop systems for accessing it. The original one used *ArcMap* for geovisualization, *ArcCatalog* for storing data, and *ArcToolbox* for doing geoprocessing. You will be using the relatively new desktop system, *ArcGIS Pro*, which is built around the idea of a *project* that integrates the geodatabase, geoprocessing and geovisualization for a particular set of data and purpose of analysis. An ArcGIS Pro project has its own geodatabase which is stored in a format that you don't have to worry about. The same functionality is accessible through the earlier ArcMap system and through ArcGIS Pro, but ArcGIS Pro is the system of the future for ESRI and that is why we are using it in this class.

ArcGIS has an add-on package called *Spatial Analyst* that we'll use a lot this semester. Spatial Analyst is used for raster analysis of grids, and it includes a toolbar with commonly used functions and a toolbox with more extensive routines, including a set of standard functions for hydrology that delineate watersheds and stream networks from digital elevation models that we'll use in this class. Spatial analyst also includes tools for interpolation of point observations into surfaces that many students in this class find useful for constructing maps of spatially distributed hydrologic phenomena, such as rainfall maps, and maps of contaminant concentrations in water bodies. In ArcGIS, grid, or raster information is comprised of grid cells that are usually square, arranged in rows and columns, where the number of rows and columns can be different so as to create a rectangular domain of study interest. If your study domain, such as a watershed, does not have a rectangular shape, it can be bounded with a rectangular box, and the cells outside the watershed designated as *NODATA* cells that have no valid value, and do not participate in geoprocessing operations. A special case of raster data are *Images*, which have integer values over a defined range, such as 0-255, used in reporting information from remote sensing from satellites and aircraft.

As you work with ArcGIS Pro, you'll have access to local data that you store on your own computer and also to data, maps and geoprocessing functions accessible through the internet in a system called *ArcGIS Online*. You access these through an ArcGIS Online Organizational account that has been set up for you through your university (i.e. UT Austin, and Utah State University). When you sign in to ArcGIS Pro, you are automatically connected to the university's organizational account and by this means you have permission to access the wealth of information stored in ArcGIS Online. This includes a *Living Atlas of the World* which contains maps and data on many subjects contributed by ESRI and other organizations. There are also *Ready to Use* functions for analysis of surface topography and hydrology that are based on Digital Elevation Model data describing all parts of the earth. It is remarkable that you can go anywhere, identify a region of interest, obtain its terrain data, define drainage paths and watershed boundaries, and do all this from automated functions in your desktop system without having to search around yourself for the original information sources.

ArcGIS Online can also be used as a web-based system for creating and publishing your own maps. You store your maps in your ArcGIS Online Organizational account and can publish them publicly or within a more restricted range of distribution. A particularly effective way of creating a map-based narrative is through the ArcGIS Story Map, which is a combination of live maps, images and text that can be presented and accessed in a sequence, something like Powerpoint.