# A Digital Elevation Model and Associated GIS Data Bases for the Northern Great Basin Experimental Range

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## INTRODUCTION

An information system is a formalized series of operations that are performed on data. Data collection, storage, analysis, and presentation are the steps normally associated with information systems. Geographic Information Systems (GIS) link a database with spatial or geographic locations. GIS is not a new concept. Cartographers were developing manual Geographic Information Systems in the 12th century using paper maps with semi-transparent paper overlays. Today, with the advent of desktop computers, electronic Geographic Information Systems are an important tool in many scientific and managerial decisions. Electronic processing of spatial information allows us to combine data and examine it in ways that were very slow and costly just a few years ago.

Our objective in this study was to establish an electronic, geographic database for the Northern Great Basin Experimental Range which is located 56 kilometers west of Burns, Oregon. This project was undertaken for several reasons; first, there are numerous themes or data layers available for this range; second, researchers at the experiment station can utilize data layers in numerous research endeavors; and third, information generated can be used in courses at Oregon State University to enrich the teaching curriculum.

We chose IDRISI, a geographic analysis system from Clark University Graduate School of Geography as our GIS because it is user friendly, inexpensive, and widely available. IDRISI has the added advantage of containing numerous translation routines within the program. Export of data files to other software such as Arc/Info, GRASS, ERDAS, MAP, ODYSSEY, ROOTS, AutoCAD, spreadsheets, and dBASE III+ is relatively easy. This increases the usefulness of one's work to other researchers.

### GIS Functional Elements

Geographic information systems have five principle elements: data acquisition, preprocessing, data management, manipulation and analysis, and output generation (Star and Estes 1990). Data acquisition is the process of identifying and gathering information necessary for an application. This is a time-consuming and important phase in developing a GIS database. A GIS is useless without relevant, accurate data and the old computer adage "GIGO" (Garbage In, Garbage Out) is especially true. The usefulness of a GIS database is a function of the accuracy and precision of the original information.

Preprocessing is the manipulation of data into a form suitable for entry into the GIS. This phase is the most time-consuming part of database formation. The original data must be converted into a format handled by the GIS software. All data must be referenced or geo-referenced so the same location in each data layer can be superimposed forming an accurate data set for all locations.

Data management are software functions that control creation of, and access to, the database. These functions provide consistent methods of data entry, update, deletion, and retrieval. There are over 30 different GIS software packages in widespread use and the ease and smoothness of this operation varies among them.

Manipulation and analysis is the process that most people associate with GIS. Analytic operators, often mathematical formulas, work with a database to generate new information. Examples of this manipulation are land slope and aspect, or watershed projections generated from elevational data. Output generation is the final stage of GIS analysis. Output can be in the form of "hard copy", statistical reports, color maps, or "soft copy" computer images. This output is the information on which management decisions can be based.

**Raster vs. Vector**

GIS packages generally utilize two fundamentally different data structures: raster and vector. With the raster format the display is composed of cells and there is a value for each cell. This display resembles the cells of a computer spreadsheet program and, in fact, can be generated by placing a value in each cell of a spreadsheet and importing the file into a GIS. The image is displayed from the top left corner, the first row fills, then the second row fills from the left, and so on. All cells or "pixels" (picture elements) must contain a value.

A vector display or format is composed of lines originating at points or lines connecting points. Each line has a direction and a magnitude, thus the term vector. Points are located according to their displacement and direction from a starting coordinate. Often specific "pixels" contain no values. The vector data format is especially useful for such linear features as streams, roads, trails, pipelines, contours, etc.

**Scale**

In a raster based system such as IDRISI all pictures are composed of cells or pixels. These cells are the smallest image/information that can be recorded. A picture that shows a large area is composed of pixels that represent an area of a certain scale. A picture that shows a smaller area is composed of pixels that display a smaller area. For example, a digital map of 1 to 250,000 is composed of pixels representing an area 68.7 meters by 68.7 meters, while a map of 1 to 24,000 is composed of pixels representing an area 27.8 meters by 27.8

meters. An object appears larger on the 1 to 24,000 map; this is a large-scale map. The same principle applies to satellite imagery as opposed to low-level aerial photography. A Landsat image is composed of pixels 30 meters on a side, while an aerial photo taken from a platform 100 feet above the ground can show an object less than 1/2 inch in size.

The scale of a data set is therefore dependent upon the size of the area being mapped, the quality of data available for input, the level of resolution desired, and the capability of the computer hardware/software system. Ranch-sized properties are generally mapped with a cell size of about 30 meters.

**Northern Great Basin Experimental Range**

We developed a series of data layers for the Northern Great Basin Experimental Range (Table 1) using the IDRISI GIS package (Clark University Graduate School of Geography 1992). Our initial map was composed of contour vectors representing elevations above mean sea level (Figure 1). This was digitized from four USGS 7.5 min. Quadrangle paper maps (Suntex, Squaw Butte, Hay Lake, and Potato Hills). Contours were entered in vector format using TOSCA, a digitizing software package. An initial raster file was then created with zeros in each of 957 columns and 777 rows. Each of these 743,589 cells represents a square, 10 m by 10 m on the ground. Contour lines were then rasterized and data entered onto the blank map. Values between lines were calculated using an interpolation algorithm (INTERCON) which was modified from the algorithm CONSURF developed by David Douglas at the University of Ottawa, Canada.

Slope was calculated in degrees by determining the maximum slope around each pixel from the local slopes in the X and Y directions. Neighbors above, below, and on either side are used in this procedure. A raster file containing slope information for each cell was created to hold this information. From the DEM, aspect was also calculated and output to a computer file. The aspect file contains standard azimuth designations of from 0 to 360 degrees.

Hydrological features of the Experiment Station were digitized from the USGS 7.5 minute quadrangle maps and have been retained as vector files. These files can be overlain onto raster maps. Vector files are useful for calculating elevational profiles for both intermittent and permanent streams or for determining stream length, watersheds, and the like. In a similar fashion but with different vector data, profiles of roads, animal trails, and fencelines can also be generated. Springs and watering points were entered as point data while intermittent lakes were entered as polygons.

Roads and trails of various classes were digitized from either paper maps or from aerial photographs. The maps and photos had a scale of 1:24,000 and 4 inches to the mile respectively. Section lines, Universal Transverse Mercator (UTM) grid (kilometer) lines and Experiment Station boundaries were likewise input from paper maps and are maintained as vector overlays.

A soils theme or layer with 54 distinct mapping units was constructed from the mapping work done by R.D. Lentz and G.H. Simonson (1986). Each soil mapping unit is linked to a data base that contains such information as the following:

1. major soils and land areas
2. physiography
3. parent materials
4. textural classes (by depth)
5. permeability
6. shrink-swell potential
7. structure
8. pH

This database has not been entered into electronic format, as attribute files, at this time.

Vegetative associations (Table 1) are those identified from extensive work done by Dr. Charles Poulton and his remote sensing group (ERSAL) in the Range Management Program, Agricultural Experiment Station, Oregon State University in the late 1960s (Culver and Poulton 1968). Maps of the dominant plant species by form layer (tree, shrub and herbaceous), were constructed from Poulton's maps. He classed as dominant those species that had 15 percent or more crown cover. Poulton's map also includes soil surface characteristics, depth of soils, and other site characteristics. This map and its associated report describes 320 classified polygons on the Northern Great Basin Experimental Range.

Current pasture layout and the location of long-term exclosures have been entered into the spatial model of the Experimental Range. The Department of Rangeland Resources has additional information that should prove useful to researchers. This includes historic air photos of the station. These can be geo-referenced, compared to recent photos, and analyzed for shrub and tree canopy coverages on a site basis. A 1970 photo set for a portion of the Experiment Station was flown at a series of altitudes that represent the following photographic scales:

A. 1 : 1,345
B. 1 : 2,966
C. 1 : 9,450
D. 1 : 12,000
E. 1 : 24,750

The above mentioned databases and photographic records represent a tremendous information resource for researchers and managers alike.

Table 1. Electronic data layers constructed for the Northern Great Basin Experimental Range in the late 1960s.

| Data Layer | Source |
|---|---|
| 1) Digital Elevation Model | Digitized from USGS 7.5 min. Quadrangle Maps<br>Hay Lake<br>Potato Hills<br>Squaw Butte<br>Suntex |
| 2) Slope of Cells (10 m) | Generated from DEM |
| 3) Aspect of Cells (10 m) | Generated from DEM |
| 4) Hydrology of Area<br>a) seasonal streams<br>b) seasonal lakes and ponds<br>c) springs<br>d) tanks | Digitized from USGS 7.5 min Quadrangle Maps or from Experiment Station Maps |
| 5) Roads<br>a) highway<br>b) primary roads<br>c) secondary roads<br>d) 4-wd trails | Digitized from USGS 7.5 min Quadrangle Maps |
| 6) UTM grid | Digitized from USGS 7.5 min Quadrangle Maps |
| 7) Townships and Range | Digitized from USGS 7.5 min Quadrangle Maps |
| 8) Experiment Station Boundaries | Digitized from USGS 7.5 min Quadrangle Maps |
| 9) Pastures | Digitized from Experiment Station Maps |
| 10) Exclosures | Digitized from Experiment Station Maps |
| 11) Vegetation<br>a) tree layer<br>b) shrub layer<br>c) herbaceous layer | Digitized from 1968 Map (Culver and Poulton 1968)<br>(input of attribute files is in progress) |
| 12) Soil Surface Characteristics | Digitized from 1968 Map (Culver and Poulton 1968)<br>(input of attribute files is in progress) |
| 13) Approximate Soil Depth | Digitized from 1968 Map (Culver and Poulton 1968)<br>(input of attribute files is in progress) |
| 14) Soils | Digitized from 1986 Map (Lentz and Simonson 1986)<br>(input of attribute files is in progress) |

## Literature Cited

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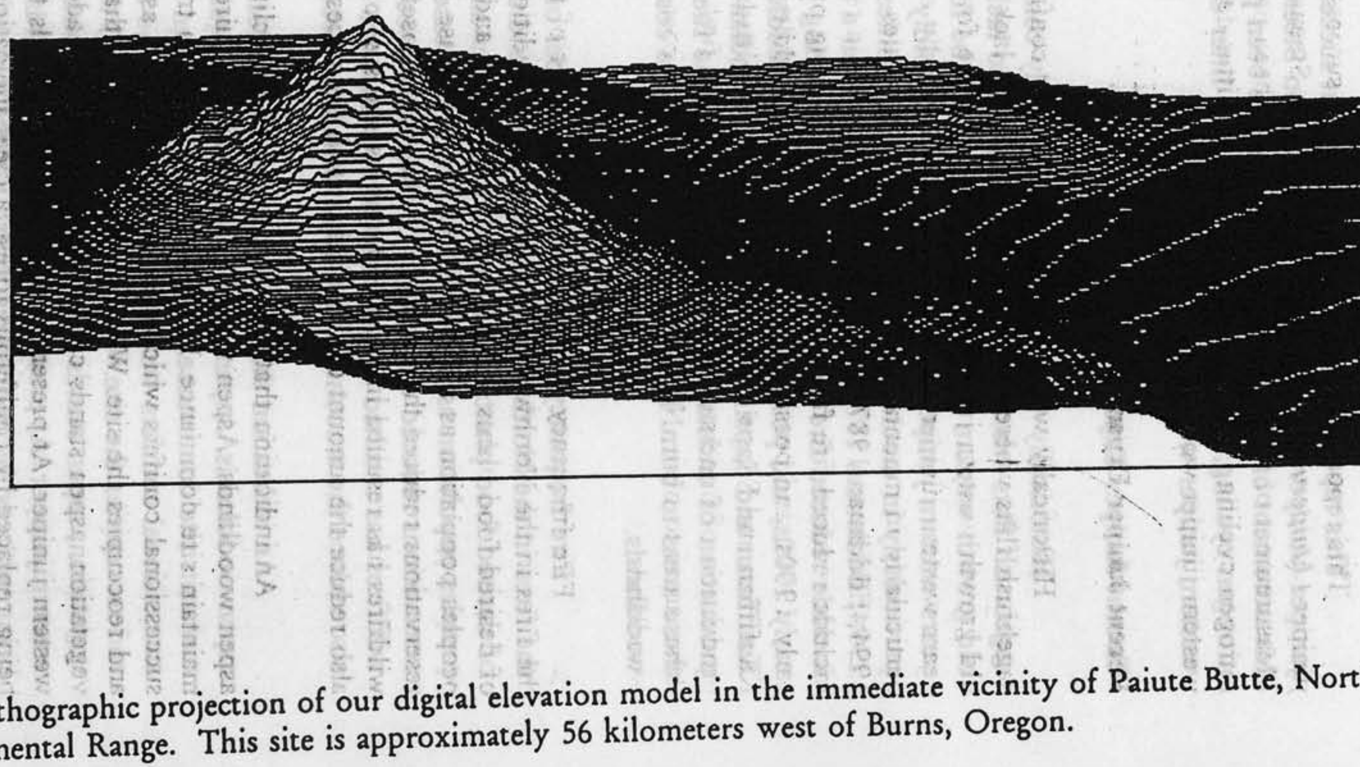


Figure 1. Orthographic projection of our digital elevation model in the immediate vicinity of Paiute Butte, Northern Great Basin Experimental Range. This site is approximately 56 kilometers west of Burns, Oregon.