APPENDIX A. DATA DEVELOPMENT AND GIS METHODS

Construction of DEM Mosaic

The following twelve steps were used to create a DEM mosaic in ESRI's ArcView software with the Spatial Analyst extension loaded:

1. Download a DEM data file from the United States Geological Survey at http://edcwww.cr.usgs.gov/doc/edchome/ndcdb/ndcdb.html

2. Rename downloaded file to an 8-character name with the suffix .tgz

3. Use Winzip to unzip the .tgz file to a group of .ddf files

4. Download sdts2dem.exe, a program that converts .ddf files to .dem files, from the U.S. Bureau of Land Management (BLM) at ftp://www.blm.gov/pub/gis/sdts/dem/

5. Put sdts2dem.exe in the same directory as the .ddf files

6. Run sdts2dem.exe and answer the prompts to produce a .dem file.

7. Start ArcView and activate a view

8. From the File menu, choose Import Data Source

9. Select USGS DEM

10. Navigate to the directory that holds the .dem file and press OK to import the DEM

11. Provide a name and directory to create a new ArcView grid data set and press OK.

12. Add the grid as a theme to the view.

13. With the Spatial Tools extension loaded, use the Merge Grids script under the Transformation menu to merge each DEM grid into one mosaic.

14. When the mosaic is complete, use the Boundary Clean script under the Clean Up menu to remove any "data-less" boundary areas.

Note: Some web sites and methods have changed since the mosaic was produced. The base DEM files are currently available at the following web site:
http://edc.usgs.gov/doc/edchome/ndcdb/ndcdb.html.
In addition, the sdts2dem.exe program may no longer be available from the BLM. ESRI can provide conversion programs that will convert USGS SDTS data sets to forms that can be used by ArcView.

Construction of the DLG Streams Network

USGS provides DLGs at various scales derived from printed topographic maps. The DLGs are separated into files based on the type of geographic features they contain, such as roads, hydrology, railroads, boundaries, and miscellaneous transportation. Because the DLGs are broken into quads, line features on adjacent quads are not automatically attached. A mosaic of DLGs is a set of adjacent quads, as seen in Figure 10. If the mosaic is networked, then the stream lines are connected across quad boundaries. If it is not networked, endpoint nodes in

separate line themes crossing quad boundaries do not match. Networking allows GIS users to perform a number of analyses (like those available in ArcView's Network Analyst).

The following 22 steps provide an example from the area around Blacksburg, VA of how to develop a fully connected network in ArcView:

1. Create a working folder to store data downloaded from the Geo Data site.

2. Using a browser, go to the USGS Geodata web site.

3. In the area labeled 1:100,000-Scale Digital Line Graphs (DLG), select "FTP via State," and then select "Virginia." From the list of Virginia DLGs, select Radford East. Within the Radford East data, there are folders for boundaries, hydrography, hypsography, and transportation. Select the hydrography folder. The names of the files in this folder are based on a USGS naming convention. The B24 stands for the Radford topographic map. The HYF stands for hydrology, and the two-digit number (e.g., 03, 07, 08) represents a particular tile on the Radford map as shown below:

Radford West   **Radford East**

01	02	03	04
05	06	07	08

Tile layout and numbering of USGS 1:100,000 DLGs

4. Download the file named B24HYF07.opt.gz and place it in a folder.

5. Using a utility like WinZip, unzip the file.

6. Rename the file B24HYF07.dlg.

7. Download a copy of DLGLX149.exe, which is a program that converts DLGs to an AutoCAD-readable format. The program was developed by David Bunch and is available from the following URL: http://members.visi.net/~ddbunch/dlglx.htm

8. Select "DLGLX Version 1.49 of USGS DLG to DXF Converter" to download the program to the same folder as the data (Note: this program must be in the same folder as the data to work properly).

9. Unzip the file, extracting only the file named DLGLX149.exe (other files can be extracted to get more information or examples).

10. Run DLGLX149.exe. At the prompt, type: /3d/h=12/no=lines/no=comments/type=o

11. Type in the path and filename (from step 6 -- B24HYF07.dlg) at the next prompt.

12. Type in a name to use for the converted file (e.g., B24HYF07.dxf). The file type .dxf is a drawing exchange format that AutoCAD can read.

13. Type 0 for line width, and the new file will be created.

14. Repeat the above steps for as many DLG quads as needed to cover the study area.

15. Use the GeoProcessing Wizard in ArcView (View Menu) to merge the separate DLG quad themes into a single shapefile.

16. Make sure the map units and distance units for the view are correctly defined.

17. Set the Editing Properties for the merged theme to enable General and Interactive Snapping with a small Tolerance (e.g., 10 meters). A tolerance value of 10 meters tells ArcView that an endpoint node should snap to another node if its final placement in the editing process is within 10 meters of a node.

18. Use the Select Tool to select all nodes on one or both sides of the quad boundary lines.

19. Start editing the merged DLG theme.

20. Zoom in to just one pair of mismatched nodes, so the distance across the view is just a few meters or less.

21. With the Pointer Tool (solid arrow), move all of the selected features a small distance (the smaller the better). Do this by putting the cursor over one of the *lines* (not one of the nodes), at which point the cursor changes into a 4-way arrow, then click and drag a small distance (there is no visual feedback during this operation except for the motion of the four-way arrow cursor during the click and drag of a few millimeters across the screen). When the mouse is released, all selected nodes in the theme will be snapped to match nearby dangling nodes.

22. Stop editing the theme, saving edits.

Development of Watershed Boundaries

GIS software, such as TNRCC's Watershed Delineator for ArcView, provides a fast method for delineating watersheds by analyzing elevations in a USGS DEM. The software uses the elevation grid to evaluate how water flows from one grid cell to another. While the software produces watershed boundaries that are fairly accurate, close inspection often reveals errors in the boundaries. One way to view such errors is to overlay a digital set of streams (such as a USGS DLG) on a watershed boundary. An error can appear in the form of a boundary that crosses a stream where it should not. A way to avoid these errors, and, thus, develop more accurate watershed boundaries is to run the DEM through a preprocessing procedure called DEM burning (Maidment, 1999).

The idea behind DEM burning is to make sure that any water falling on the surface of the DEM will end up flowing into the actual stream channels. By forcing water to flow into known stream channels, the watershed delineation software cannot develop boundaries that cross the streams. The approach is to take a set of streams and burn them into the land surface of a DEM (like a laser burning a deep fissure into a block of wood). The procedure works best if the DEM is

exaggerated, so that the digital peaks are higher than the actual landscape. The result can be thought of like the Grand Canyon – the land surfaces around the rim are raised up much higher than the Colorado River flowing at the bottom of the canyon. Any rain that falls at the rim will eventually make its way into the river.

The following seven steps explain how to burn a DEM

1. Download a DEM from the USGS and save it as a grid in ArcView.

2. Download a DLG from the USGS and convert it to an ArcView shapefile (stream theme).

3. Convert the stream theme to a grid by using the *Convert to Grid* command in the *Theme Menu* and selecting any field for the grid value.

4. Use the *Map Calculator* in the *Analysis Menu* to divide the stream grid by itself, so that all the cells have the value 1.

5. Use the *Map Calculator* in the *Analysis Menu* to multiply the resulting grid by the DEM. The resulting grid stores the DEM value only in the cells that contain the streams. Name this grid *DEMStrm*.

6. Use the *Map Calculator* in the *Analysis Menu* to add 5,000 meters to the original DEM. Name the resulting grid *DEMPlus*.

7. Open the *BurnDEM script* (as shown below), and edit the first three lines as necessary. Compile the script using *Script/Compile*, and run it using *Script/Run*. A grid called *Burndem* in the specified directory and a theme called *Burndem* in the View will be created.
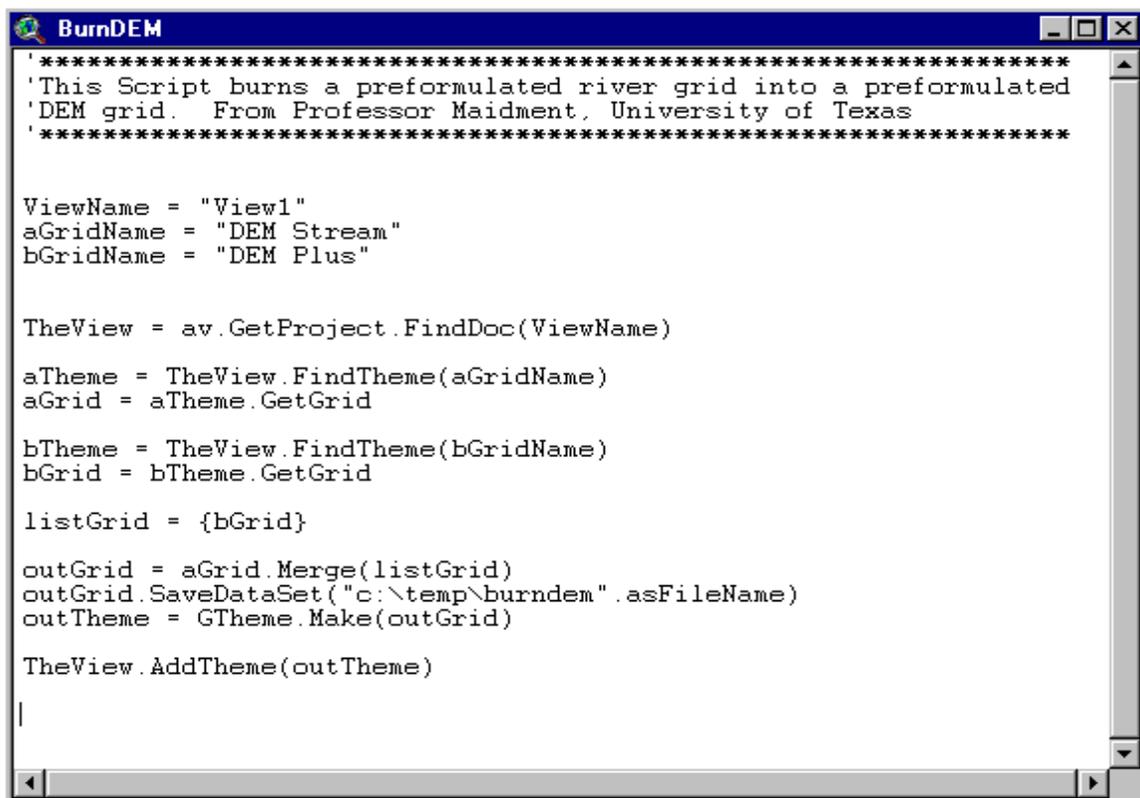
```
BurnDEM                                                    _ □ ×
'*******************************************************************
'This Script burns a preformulated river grid into a preformulated
'DEM grid.  From Professor Maidment, University of Texas
'*******************************************************************


ViewName = "View1"
aGridName = "DEM Stream"
bGridName = "DEM Plus"


TheView = av.GetProject.FindDoc(ViewName)

aTheme = TheView.FindTheme(aGridName)
aGrid = aTheme.GetGrid

bTheme = TheView.FindTheme(bGridName)
bGrid = bTheme.GetGrid

listGrid = {bGrid}

outGrid = aGrid.Merge(listGrid)
outGrid.SaveDataSet("c:\temp\burndem".asFileName)
outTheme = GTheme.Make(outGrid)

TheView.AddTheme(outTheme)

|
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The Watershed Delineator works on the burned DEM by calculating flow direction as shown in the box below. The Delineator then aggregates flow accumulation, marks probable stream beds, and locates watershed boundaries.

To find flow direction for a particular cell, take the elevation difference between it and each of the surrounding cells. Divide the difference by the square root of 2 for diagonal cells to account for greater distance apart. Water will flow toward the cell with the biggest adjusted drop in elevation.

Digital elevation model (DEM) with no sinks

78	72	69	71	58	49
74	67	56	49	46	50
69	53	44	37	38	48
64	58	55	22	31	24
68	61	47	21	16	19
74	53	34	12	11	12

Codes for flow direction (e.g., if water falling on a cell flows northeast, then the cell is coded with 128)

32	64	128
16		1
8	4	2
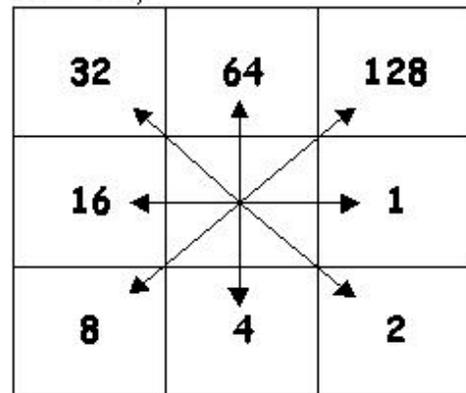
DEM converted to a flow direction grid

2	2	2	4	4	8
2	2	2	4	4	8
1	1	2	4	8	4
128	128	1	2	4	8
2	2	1	4	4	4
1	1	1	1	4	16

Symbolic representation of the flow direction grid
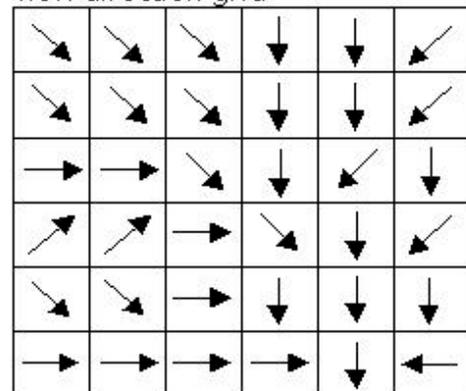
Courtesy of the Texas Natural Resource Conservation Commission.

Taxonomic Order Aggregation for Soils

The following steps explain how to assign the most probable taxonomic order to a map unit in a STATSGO layer:

1. Add the appropriate database tables to the ArcView project – Taxclass.dbf and Comp.dbf.

2. In ArcView, join the Taxclass table to the Comp table using clascode as the key field.

3. Export the joined table as a dBase file (AggTable.dbf). Remove all joins, quit ArcView, open the table in Excel, and save it (AggTable.xls).

4. Extract only the fields needed from the aggregated table (Muid, Comppct, and Order) and place them on their own worksheet.

5. Use a pivot table to create a new worksheet that sums the component percentages of orders for each Muid. The total component percentage for each Muid should sum to 100%.

6. Assign a single taxonomic order to each Muid by taking the one that is the highest percentage of that Muid.

7. Save the table with this new information as a dBase file (SoilOrd.dbf), and quit Excel.

8. Open the ArcView project again and add the new dBase table. Join it to the theme attribute table using Muid as the key field.

9. Use the Order variable to classify the map.

10. Convert the coverage to a grid (SoilOrd) with 100m cells and values based on the highest percentage taxonomic order.

   Note: the soil orders are given as follows:
   A   Alfisols
   C   Andisols
   D   Aridisols
   E   Entisols
   H   Histosols
   I   Inceptisols
   M   Mollisols
   O   Oxisols
   S   Spodosols
   U   Ultisols
   V   Vertisols

DLG Roads

The spatial and attribute data for the DLG roads layer is developed in the same manner as the DLG streams. After development of the layer is complete, the various road types are classified as either major or minor according the following categories:

Road Type	Classification
Business route	*Major*
Bypass route	*Major*
Cloverleaf or interchange	*Major*
Primary route, class 1, divided, lanes	*Major*
Primary route, class 1, symbol undivided	*Major*
Road or street, class 3	*Major*
Road or street, class 4	Minor
Secondary route, class 2, one way, other	Minor
Secondary route, symbol	Minor
Trail, class 5, four-wheel-drive vehicle	Minor
Trail, class 5, other than four-wheel-drive	Minor
Underpassing	Minor

Sample Layer Preparation for a Model: Baseline Land Values Data in the Development Grid Layer

Note that economic land values model requires transformations (such as arithmetic or logarithmic) on some of the variables calculated below, but these transformations are not reported here.

Taxonomic Order for Soils

Summarize soil order by the zones of the grid pattern and attach the *majority* value to the grid pattern.

Elevation

Summarize elevation by the zones of the grid pattern and attach the *mean* value to the grid pattern.

Population

1. Convert U.S. Census TIGER block group files into ArcView spatial data layers.

2. Attach census block group population to the TIGER block group layer using STFID as the key field.

3. Calculate population density for each block group by dividing population by the area of the block group.

4. Convert the layer to a grid, storing population density.

5. Summarize population density by the zones of the grid pattern and attach the *mean* value to the grid pattern.

6. For those grid squares without data, calculate the value by averaging values of any surrounding squares that contain data.

Distance to the Mall or City

1. Derive a distance grid for the point of interest.

2. Summarize distance by the zones of the grid pattern and attach the *mean* value to the grid pattern.

Presence of a Building

1. Select those Roanoke County parcels that have a house value greater than 0.

2. Select the grid squares that have their center points within the selected parcels.

3. Assign the selected grid squares as having a building present.

4. Assign the remaining squares as having no building present.

Coordinate Values

Find the UTM zone 17 x and y coordinates (meters) for the centroids of each grid square.

Major Road Attached

1. Select the major roads in the ArcView layer

2. Select those grid squares that intersect a major road

3. Classify those grid squares as having a major road attached with a value of 1.

4. Classify remaining grid squares as having no major road attached with a value of 0.

Year of Transaction

1. Select those parcels that have a transaction year of 1997 (none within the area of the grid pattern).

2. Select those grid squares that have their centers in the selected parcels (none).

3. Assign selected grid squares a year value of 1 (none).

4. Assign remaining grid squares (all of them) a value of 0.

Parcel Size

1. Convert the parcel layer into a grid, storing parcel size as the grid value.

2. Summarize parcel size by the zones of the grid pattern and attach the *mean* value to the grid pattern.

3. If the mean value is less than 90,000 square meters (the size of a square in the grid pattern), then store the mean value as the parcel size.

4. For mean values greater than 90,000 square meters, store a value of 90,000 square meters (the maximum possible) for the grid square.

5. For those grid squares that do not sit atop the parcel layer, average the nearest surrounding grid square values to obtain parcel size.

Log of the Centroid X Coordinate

The X coordinate of certain grid squares (when adjusted by the correction factor) are negative, so the logarithm does not exist. For those squares, a value is calculated by the formula log(average X - correction factor). This value is 3.8778.

Baseline Full Parcel Value (BLParcVal)

The regression equation provides land values in log price per hectare, so after calculating the regression equation:

1. Take the antilog of the price values (LogValHec) to get the value per hectare (FullValHec).

2. Multiply the value per hectare (LogValHec) by the square-meter parcel size (ParcSzSqM), a hectare conversion factor of 0.0001, and the number of parcels of the given parcel size within a grid square (NumParcels).

Equation for the Partial Land Values (LogPVHec)

-17.878636 + (0.408038 * [LogElev]) + (-0.127562 * [LogElevSq]) + (-0.046383 * [Soil1]) + (-0.100973 * [Soil2]) + (0.003733 * [PopDensHec]) + (-0.000546197 * [PDensHecSq]) + (1.601651 * [LogMall]) + (-0.250212 * [LogMallSq]) + (2.474911 * [LogLogCity]) + (0.133038 * [NewBldg]) + (-0.068644 * [MajorRoad]) + (0.053416 * [Year]) + (4.092708 * [LogX]) + (3.718083 * [LogY]) + (-0.908708 * [LogXLogY])

Note: Since all new development tracts will have parcels with buildings on them, NewBldg is always 1 (dummy of 1 if a building is present).

Equation for the Full Land Values

[LogPVHec] + (-0.527739 * [LogSize]) + (-0.023488 * [LogSizeSq])