COMPARISON OF GIS AND GRAPHICS SOFTWARE FOR ADVANCED CARTOGRAPHIC SYMBOLIZATION AND LABELING: FIVE GIS PROJECTS

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Remaining in the GIS environment during map production has many advantages but requires that an increasing range of cartographic effects and graphic design tools be embedded in the software. For example, cartographers want to position and curve type precisely; break lines for type over multicolor backgrounds with selective masking; clarify precise overpass, underpass, and merge relationships in complex road interchanges; control the way boundary lines interact as they intersect and overlay each other and hydrography; and design sophisticated mixtures of relief shading and hypsometric tints. The tools for accomplishing advanced cartographic effects are a mix of both analysis and representation tools. We challenged groups of students at the Pennsylvania State University with a series of compact design problems to be solved in both ESRI ArcGIS and Adobe Illustrator or Photoshop. In this paper, we highlight some new and hard to find cartographic options in the GIS software.

INTRODUCTION

The five GIS projects we describe grew from a collaboration between the two authors, **Cindy Brewer** and **Charlie Frye**. We talked over challenging cartographic techniques that are possible in ArcGIS but not well known to cartographers (i.e., known to Charlie and not to Cindy). Charlie then prepared clipped data sets and rough instructions for each problem. Cindy ran through them with graduate students in her *Cartography Seminar* in the Fall semester of 2004 and with 15 undergraduate seniors in *Applied Cartographic Design* in the Spring of 2005 at Penn State.

The graduate students got many of the bugs out of the instructions in the fall, and we presented this stage of the work at the North American Cartographic Information Society (NACIS) conference in Portland, Maine, in October 2004. We extend our thanks to **Tanuka Bhowmick**, **Steven Gardner**, **Adrienne Gruver**, **Tania del Mar López Marerro**, **Sohyun Park**, **Anthony Robinson**, and **Steven Weaver**. In the Spring, We would like to acknowledge the hard work of students in the Spring 2005 class: **Sean Ayers**, **Adrian Cox**, **William Gordon**, **James Griffin**, **Raya Guruswamy**, **Eric Harmon**, **Nathan Hautala**, **Adam Heyler**, **Nathaniel Howard**, **Martin Jarocki**, **Kevin Kulick**, **Christina Larwill**, **Robert Lavelle**, **Anthony Scardino**, and **Robert Wheland**.

Five GIS projects are described in this proceedings paper:

Project 1: Multiple line overlays, including removal of lines along the coast.
Project 2: Labels along a coast, including creating and curving annotation.
Project 3: Making cartographic roads data, including advanced symbol-level drawing.
Project 4: Advanced labels with Maplex and masking, including contour line manipulation.
Project 5: High-end shaded relief, including multidirectional lighting and hypsometric tints.

For each project, students received a project file, data and styles prepared to the point where a cartographic problem needed to be solved. They also received general instructions and a .pdf file showing the final result that could be accomplished. Each project description presents the core instructions from which students worked (note our use of active-voice wording directed to the students). Details such as particular file names, data sources, lists of deliverables, and due dates are omitted. Page limits preclude inclusion of the companion Illustrator/Photoshop projects from which students also worked.

These instructions are intended to provide only the basic steps and many details are purposefully omitted to get the students exploring and thinking as they worked on the projects. We feel they learned well this way. The series of projects prepared students to complete varied mapping projects for clients of their choice during the last quarter of the semester. Our approach of **not** providing step-by-step instructions worked because Cindy and Matt met with the students in the computer lab for three 50-minute sessions a week and attendance was required for all sessions. Thus, students were working together on the projects and we could get them out of jams when they arose. The course was composed entirely of intensive, hands-on sessions. We hope you find these GIS projects useful for building your own advanced labs, but please be aware that there are both bugs and omitted steps in these instruction. They are not intended as stand-alone complete instructions; they are intended as in-person group activities.

In the undergraduate course, students prepared 15 reports. They completed two-page reports on both ESRI ArcGIS and Adobe Illustrator or Photoshop for five projects. Each report had four components: a list of techniques learned, critique explaining an annoying but small problem, critique recommending fundamental structure change, and a print of the final map. After students had worked through project steps in each environment, they decided on the point in production when they had gained the benefits of the GIS analytical environment and it was time to export out of GIS and move to Illustrator/Photoshop. We described this as the "bail" decision (as in bailing out), and the bail report was the third report for each project. The bail decisions and critiques by the undergraduates are the focus of the ICC2005 conference presentation for which these five project descriptions serve as background information.

PROJECT 1: MULTIPLE LINE OVERLAYS

The **A** and **B** steps below present the bare bones of two ways to alter boundaries to mesh with coastlines and with other boundaries for cleaner cartography. Your goal is to produce a logical set of boundaries for the final map you print. Both state/province and international lines are removed along the coast and state lines are removed where they are coincident with international boundaries (Figure 1b).

Before you start editing your file, get to know the layers (I got lost when I just started doing the steps). Look closely at the boundaries in the final .pdf and the starting project file. The two figures below show the final map reduced (Figure 1a) and an enlargement of a portion of the map (Figure 1b).
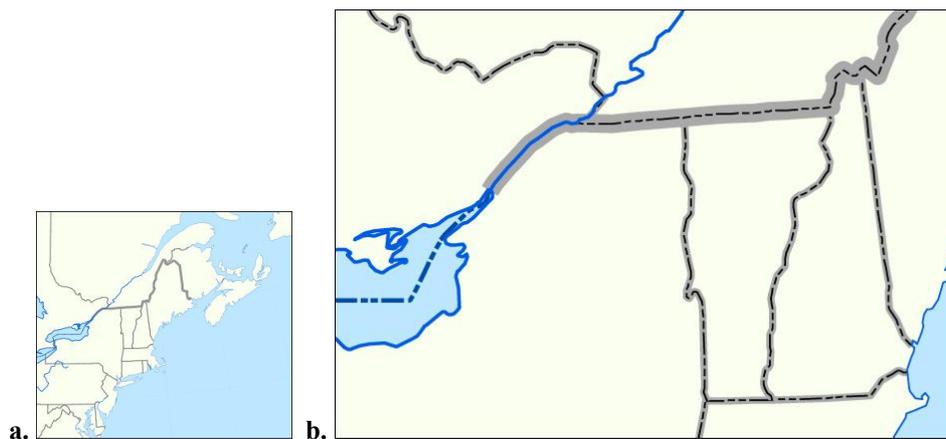

Figure 1. Map examples for Project 1. **a.** Reduced version of the final map reproduced by students, showing the border region of northeastern U.S. and southeastern Canada. **b.** An enlarged portion of the final goal. There are six boundary line styles: international across lake (1), along river (2), and on land (3); state/province on land (4) and along river (5); and coast (6).

Think about what needs to be removed, repeated, cut apart, changed from polygons to lines, etc. For example, how many international boundary line types are on the map? Click each of the layers off and on to be sure you understand what each contains. There is already some redundancy between the layers. You will be adding more repeats and removing others.

A. Select and Trace New Lines:

Change country polygons to international border lines and coastlines (read this whole section including Hints before you start):

1. In ArcCatalog (ArcMap should not be open with one of these maps yet, because it will create a lock on the data), create a new line **feature class** called **Borders** in the "CustomAlbers" feature dataset within the .mdb. Change the geometry type to **Line**. Add a Short Integer **field** called "Type" for this feature class.
2. Start ArcMap with Proj1.mxd.
3. Add the "Borders" feature class to the project.
4. If the Editor toolbar is not already in your ArcMap window, add it.
5. Start Editing.
6. Select all features in the **Countries 2002** layer (right click on the layer and choose Selection→Select All).
7. Set the editing **Target** (to the Borders layer) and use the **Trace tool** to create a new feature. The trace tool is activated by selecting it from the menu that the sketch tool (pencil) is on. The Trace tool is the bottom right tool in this small menu (shaped like a polygon).
8. Start Tracing on a selected line by clicking where you want your new line to start (Hint: set up your snapping environment to ensure accuracy). Zoom in and set countries "visible off" (but still selected) so you can see your work.
9. Stop Tracing by clicking where you want to stop or where the line stops due at junction (press F2 or double-click).
10. Open the attributes dialog (on the Editor toolbar) to set the line Type to 0 or 1 or…how many line types? Hint: Look at the final .pdf (Figure 1b).
11. Repeat steps 6 to 10 until completed.

Hints:

a. You have to give the trace tool hints by moving the cursor in a useful direction—sometimes when you're zoomed out too far that's very hard. So zoom in while you're tracing—the edit sketch environment remembers where your edit tools are while you pan and zoom. This is somewhat mysterious because it may be available but invisible.
b. Experiment with Finish part and Sketch (right click when using the Sketch tool)…but not while tracing.
c. Tracing, being geometrically intensive, is not the most stable function in the box; so save your edits after every couple of features. And save you project file periodically (mine was crashing as I figured this technique out).

B. Convert Polygons to Lines and Selectively Remove Lines:

Edit state polygons to create interior state borders:

1. Open the ArcToolbox from the Tools toolbar. Use the **Polygon to Line** tool in the Data Management Tools under Features to change the AdminSubUnits (state and province) polygons to lines.
2. Start Editing
3. **Select by location** (using the Selection menu) all the new AdminSubUnits lines, from Step 1, that **share a line segment** with Countries 2002. (You should be in a multi-option dialog box.)
4. Delete the Selected Features using **Delete Features** from Toolbox and Stop Editing.

Finishing:

Once you have line segments prepared, work with the symbol editors to customize each border type. You should remember how to set Symbology by attribute from previous work with ArcMap. Refer to the final PDF for ideas of what to do for border symbology. You will be creating dashed and multi-layer **Cartographic line** styles and may need to adjust the way lines bend and end as well. Create and change line symbols to produce a map exactly like the final .pdf. Pay attention to layer order as well, so lines end tidily beneath other lines that they abut.

PROJECT 2: LABELS ALONG A COAST

Your goal is to edit labels to approximate and improve on the label placement shown in the final .pdf. You will be learning about text and annotation editing tools in ArcMap 9.

The starting file (Proj2.mxd) uses data that has been reprojected and resides in a personal geodatabase (Proj2.mdb) (Figure 2a). The map uses dynamic labeling. Reprojecting the data into the map's final projection allows drawing to go faster because we are not projecting on the fly, and we are getting around some bugs in the annotation editing process.
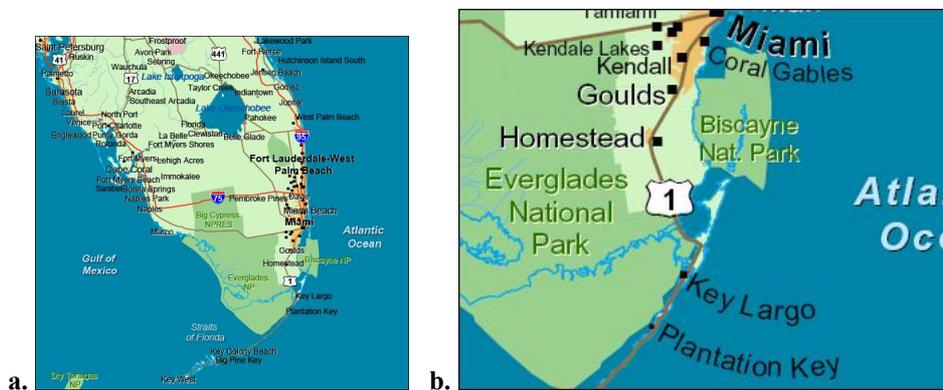
Figure 2. Map examples for Project 2. **a.** Reduced version of the starting map provided to students, showing southern Florida. **b.** An enlarged portion of the final goal showing annotation repositioned and some labels curving away from coastal places.

The final file (Proj2.pdf) shows what a cartographer might be after (Figure 2b). The map is not particularly good but does illustrate what a mapmaker might be trying to do. There are a number of styles in this map that are not best practices and some of the text placement is still sloppy. The project would be at the stage of a first print proof to see if the text was legible.

Instead of having you start all the way at the beginning, our starting file has symbols, labeling expressions, and projections set for you. Look at the **labeling expressions** from the Labels tab—these would take most folks a few days to arrive at. In addition we have also reprojected the data into the coordinate system and projection (Albers) that will be used in the final map. We did this for you because it's just plain hard. You have to figure out your XY Domain for the Albers in meters from the NAD83 extents in Decimal Degrees, and that alone can take an hour!

Create Annotation:
The first step is to create annotation (anno) from the labels (Hint: use right click menu in the Table of Contents). You will do this for all of the labeled features. You are making these new anno layers because you can repositioned annotation to precise locations, whereas label placement is controlled by the labeling engine.

After converting the labels to annotation, start editing (open the Edit and Annotation toolbars if they are not on screen). You can edit text properties (style, font size, line breaks, etc.) in the **Attributes window** (second button before end of Edit toolbar, Figure 3). Be sure to explore both tabs in this window.
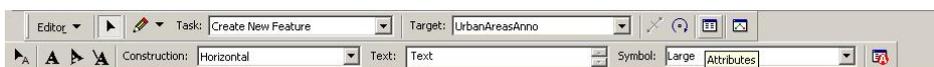

Figure 3. Editor and Annotation toolbars.

Some city name annotations on the final map are not yet **placed** in the project. You can do this easily through the **Unplaced anno** button (last button at end of the Annotation toolbar with red A, shown in second row of Figure 3). List unplaced cities using the **Search now** button. You can right click on the city's name and select show annotation or highlight the city and press the spacebar to place. You will have labels that are duplicated in both the cities and urban areas, so you will also **unplace** some names.

Curve Annotation:
1. Right click on annotation using the Annotation editing tool (farthest to the left on the Annotation toolbar; Figure 3). Remember to set your Target on the Edit toolbar to the correct annotation layer.
2. In many cases the first thing to do is set the curvature of the label to **Curved** (right click on the city name). You can then choose **Edit the baseline sketch** and interactively move handles and anchors to curve the line.
3. Create a suitable **curve**, **Finish the baseline sketch**, and **Rotate** the label. Then move the names into position. You can do all of these steps while editing the baseline sketch, but as you master this environment you'll find that breaking things down to these specific operations will be faster.

PROJECT 3: MAKING CARTOGRAPHIC ROADS DATA

The goal of this project is to work with both analytical and design tools in ArcToolbox and ArcMap to build a well structured map and associated database for complex road interchanges. Though we are preparing a small map (just two interchanges, Figure 4), imagine structuring this detailed linework for a city or state-wide mapping challenge. The project is intended to get you to think analytically about a challenge that seems, at first, to simply be a graphical puzzle. The ArcGIS terms are confusing and you will be jumping back and forth between database and graphical edits.
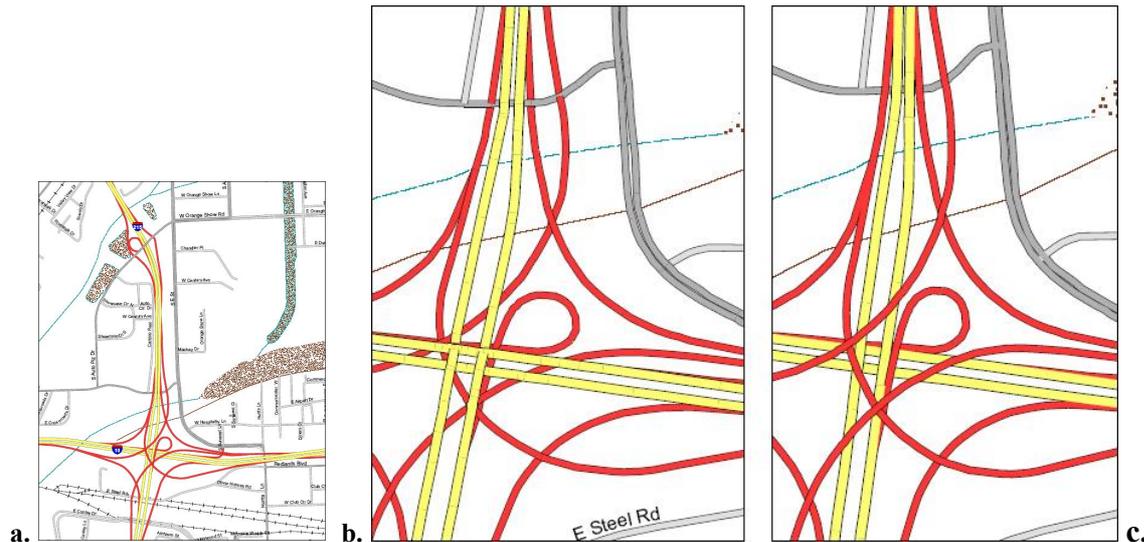

Figure 4. Map examples for Project 3. **a.** Reduced version of the final map reproduced by students, showing a complex highway interchange near Los Angeles California (Highways 10 and 215). Enlargement of the starting file (**b.**) and final editing results (**c.**) for a portion of an interchange. Examine the overpass, underpass, merge, and join relationships between roads in these two examples.

Set Up:
1. First, use the ID tool to explore the quality of this USGS file. Notice that there are many small lines, especially for the ramps. Check the street name attribute as well to understand how the segments are named.
2. This data structure is awkward to work with. You will **dissolve** the road lines into more manageable continuous segments, one line for each unique name. In ArcToolbox, select Data Management→ Generalization→ Dissolve. Dissolve Roads input by StName and the CFTID (Cartographic Feature Table ID). The statistics field (in the same dialog box) will be Hwy_Num with a type "first." This will create a new output layer called "Roads_Dissolve."
3. Open this new layer's attribute table and **add** a new short integer field called RoadLevel.
4. **Calculate** the RoadLevel value to be 0 (zero). This will be ground level when we start organizing the roads.
5. From your Table of Contents (TOC), **Save** each road type's symbology. You will do this from the symbol selector window when you click on the line style. Save the five line styles by naming each with its CFTID number (you'll use these numbers as you reassign roads that share the same CFTID to different levels):
   10728 = Ramp; 10718 = Major street; 10651 = Limited access highway;
   10727 = Surface street, general case; and 10763 = Surface street connector.
   If you do this right, each road symbol will appear as a style in the left-side window of the Symbology tab. Where are **styles** stored?
6. *After* saving the symbology, delete the original roads layer. You will be editing the dissolved layer.
7. Create category symbology with two different fields using **Unique values, many fields**. Create the symbology using two fields, CFTID and RoadLevel. Click Add All Values. This should give you five fields right now, each ending in ", 0". When you change overpassing relationships, you'll see where this two-part naming comes in.
8. Match the CFTID with its corresponding line style, and hit OK. (Yes, you will have duplicate symbols.)

Detailed Structuring:
Look closely at the final .pdf. You should be able to see underpassing and overpassing relationships. Each of these are segments of the road that are split and layered. Your mission is to plan where splits are needed and how many layers are involved. Start simple; you will need to break the north/south highways (I-215) on both sides where they cross the east/west highways (I-10). The idea is to have an overpassing section that is going to become RoadLevel 1. Here are the steps:
1. Start Editing
2. Make the dissolved roads the only selectable layer.
3. Use the **Split** tool (see Editor toolbar in Figure 5) to create the overpass segment.

Figure 5. Split tool on Editor toolbar.

4. Use the attributes window (right click on a selected feature and choose Attributes) to change the road level to 1. Note that this will not change the actual level, it just provides a reference for when we change the layering.
5. In the Symbology tab, click on the button that says "**Add Values…**" Once you add the category combination for the new split segment (10651, 1), choose the symbology that corresponds to the CFTID (the first five numbers).
6. This is how you make segments that represent the overpasses and underpasses. Remember to add the new combinations to the symbology every time you split segments and create roads with a new level within the CFTID category.

Hint:
When adding new combinations of RoadlLevel and CFTID values, you may not be able to get the Complete List button to add the most recent combination. If that happens, type it in and add it (remember to add a space after the comma). This combination will then appear in the TOC.

Symbol Levels:
1. Go back into the Symbology tab, click on the **Advanced** button and choose **Symbol Levels**.
2. Select the check mark next to "Draw this layer using the symbol levels specified below," then choose "10651, 1" (the segments you just created), and bump this to the top.
3. Click OK twice and note the results.
4. Create visual merge and join relationships between road fills and casings by checking join and merge boxes and ordering symbols. Look very closely at the final .pdf to decide what join/merge relationships you want to specify.

For example, the color fills of a highway and its ramp merge and roads in the same category, such as surface streets, are often joined so that black casings to not break road intersections (see merges and joins in Figure 4b).

About Ramps

Merging in the Database:
With ramps you may find that Splitting produces some unexpected results…try to split them and you'll see what I mean. This is a bug in the program, partly resulting because all ramps have the same name (Ramp) in this project's attribute table. To fix this bug, use the **Advanced Editing** toolbar. It has an "Explode Multi-part feature" tool, which at least produces better line segments than we had in the original data. (Another editing toolbar!?)

Now you need to build continuous ramp segments manually. The Editor toolbar's Edit menu contains a Merge command which allows you to merge features together—it is useful to merge all the segments of a ramp and then break them with the Split tool. You may have to zoom in a good bit to ensure all parts are selected and merged.

Merging the Graphics Only:

You can change the way the ramps appear to merge into the highways through symbol levels from the layer properties window. This is a graphical merge and NOT a database merge. These lines will remain as separate segments.

Under symbology, go into Advanced→**Symbol Levels**. Now click on the button that says "**Switch to Advanced View**" which will give you a window that looks like this (I added the blue and purple lines and masked most of the answers in Figure 6). This window offers explicit detail that goes beyond the check-box approach.
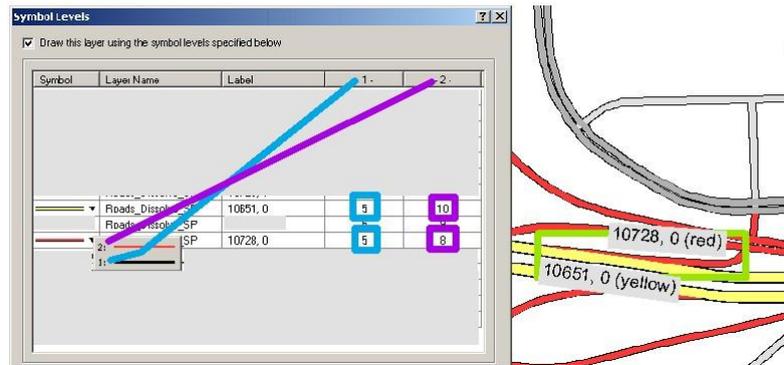

Figure 6. Advanced symbol-level drawing hints.

The example reveals relationships between two segments. Note that the 1 represents the black casing line, while 2 represents the road's fill color. Both segments shown to the right have black casings (column 1) on the same level (5) and then the yellow highway fill (10) is above the red ramp fill (8) (it's the same as checking both merge and join). I show the result for just two segments, but the merge/join combination will be set for all road segments across the map that have these attributes.

This is very detailed work but gives you excellent control of the graphic. It also means you need to have consistent naming throughout the map. Play around with these levels and see what happens on your map as you work. If you develop complex logic for levels in this view, you may not be able to return to the check-box interface to symbol-level drawing (which is OK).

PROJECT 4: ADVANCED LABELS WITH MAPLEX AND MASKING

The goal for this project is to explore the advanced labeling functions in ArcMap and to work with cartographic issues for contours. Contours are typically set to index and intermediate styles and labeled in a particular way on maps. You will also investigate Maplex more and work with label masking. Your challenge is to do as little as you can with customized annotation and try to get all settings working with dynamic labeling. [Example final results are shown in Figure 7; students were not provided with a final goal map for this project.]

This project takes us closer to home; Matt has chosen to work in his home county. All the data he collected was from the PASDA website (http://www.pasda.psu.edu). Your tasks in this project will be: a. create contour lines from the DEMs, b. label the index contour lines (only) using MapPlex; c. set those contour labels to mask the index contour lines but not the intermediate lines or relief; and d. label other map features such as state roads and municipal boundaries.

Contour Creation:

ArcMap makes it fairly easy to create contours from DEMs. In the **ArcToolbox**, go to **3D Analyst→Raster Surface→Contour**. The input file will be your DEM file. Call the output file "Contour_Muncy". You can select any contour interval, but I suggest 10 meters. Then select OK and wait until the contours are created.

To create index and intermediate contours:
1. Open the attribute table and add a new short integer field called IndexYN.
2. Calculate values for the IndexYN field by loading an advanced expression (from Charlie) called "IndexYN.cal". Make sure the box is checked beside "Advanced" in the calculate values window. The expression flags index lines at an interval of 50.
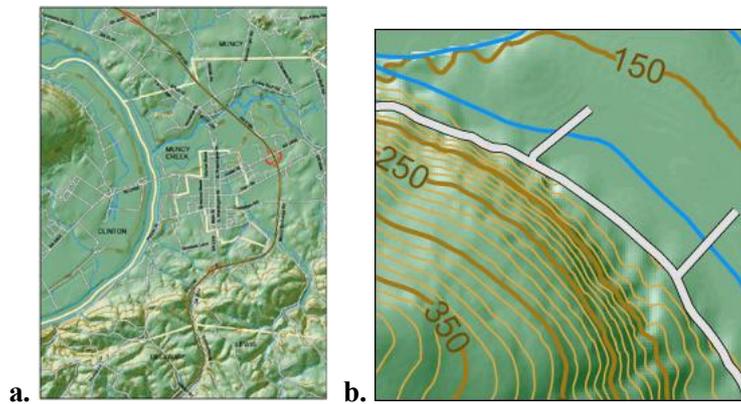
Figure 7. Map examples for Project 4. **a.** Reduced version of the final map for Muncy, Pennsylvania, and surrounding area produced by a student. **b.** An enlargement of a portion of the map showing coutours over hillshading, other linework and a few labels.

3. Select contours where IndexYN = 1.
4. **Export** selected Contours to a new shape file called IndexContours. To do this, right click on the layer in the TOC and select **Data→Export Data**. Answer yes to the prompt to add it as a new layer to the file.
5. **Switch Selection** on the contours (to the 0 lines) and Export the selected features a new shape file called IntContours.
6. Remove the original contour layer from the map.
7. Symbolize the intermediate and index contours. You can start with the appropriate symbol from the default ESRI style and edit it.

Labeling Using Maplex:

Refer back to the Labeling Project 2 for instructions on how to activate Maplex. Remember to select "Best" on the **Labeling Toolbar**. We will be using Maplex to label the index contours on the map. On the label tab, choose to label using the **CONTOUR** field, which contains the meter numbers for each contour.

From the **Label Manager**, you will be investigating some of the advanced settings. You can change the way the labels are positioned with respect to the line and how the labels are repeated. For the index contours:

1. Set label style (color, size, font, etc.) and get some default labels on the map before making adjustments.
2. Uncheck **Stack Label** in the main Placement Properties window. Click the **Position** button and select Centered Straight. Hit OK.
3. Click the **Properties** button and under the **Label position** tab, enter the **Repeat label** dialog. Start with repeating the label once every ___ map units. Adjust that setting after your map begins to take shape.
4. Under the **Conflict Resolution** tab, **Remove duplicate labels** within limits of ___ map units…adjust this setting as well.
5. Maplex takes a long time to process so be patient…

Make these sorts of decisions for state roads as well. On the state roads layer, you will be labeling using the **STREET_NAM** field, though you may want to edit the names in the table so they are not all caps (we did this using Change case in Word). We would check next to "Street Placement" but this option is crashing the software in the version and patch combination on our machines. Work on labeling municipal boundaries as well. Remember, the goal for this project is to explore the settings in Maplex rather than going to annotation immediately and hand-placing text.

Creating Masks:

Masks are like halos but more sophisticated. They can be set to knock out some layers and not others, which is an important graphical nuance. To use masks, first convert the labels to annotation. That means you want to be finished setting all the characteristics of dynamic labels.

Masking is in the ArcToolbox under **Cartography Tools→Masking Tools→Feature Outline Masks**. In the window, you will use the annotation you created as the input, take the default output name, and at the bottom of the window select **Convex Hull** for the mask kind (what are the other choices?). Also uncheck the box next to

Create masks for unplaced annotation. That way you don't create empty areas for contour labels that don't exist.

Now right click on the "Layers" Group Layer and select **Advanced Drawing Options**. From there, check the box for "Draw using masking options specified below". On the left hand side of the box, there will be a list of one or two names. Select the one with the name of the contour mask you created. On the right hand side are layer names. Select the ones you want to mask so they break for the labels. In addition, check the visibility of the mask layer off—you want to see the holes only, not the shapes around the labels.

PROJECT 5: HIGH-END SHADED RELIEF

In this project, we will look at some different ways to compile multiple differently-calculated hillshade layers along with elevation tints to produce polished final terrain representations. We are working with Rooster Rock Quadrangle, a USGS 24K DEM from Oregon (Figure 8a).
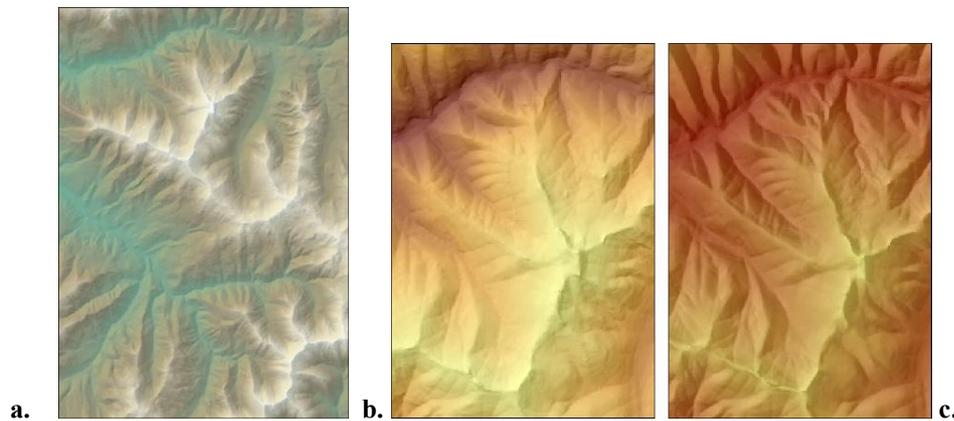

a.   b.   c.

Figure 8. Map examples for Project 5. **a.** Reduced version of the full extent of the final map produced by a Christina Larwill. Two examples of student terrain representation. Raya Guruswamy (**b.**) and Adrian Cox (**c.**) use different balances between elevation colors, hillshade detail, and the larger and multidirectional forms brought out by combining the Swiss shading layers (compare definition of the northwest-trending ridges).

In our introductory cartography course, we experimented with basic hillshade parameters, such as azimuths and angles…here we go beyond that. In addition to the standard surface tool, we will use three other hillshade models: MDOW Hillshade, MDOW with Focalmean, and Swiss Hillshade models (MDOW stands for multi-directional oblique weighted.) The models use combinations of illumination angles and smoothing to create shaded relief. **Aileen Buckley** and colleagues at ESRI used the principles of these models to create a Hillshade toolbox that we will be using (the project is based on a presentation by Aileen and **David Barnes** at the 2004 ESRI User Conference in San Diego). You can also dig right into the model and reprogram it if you are interested.

Sample Toolboxes:
Use the Toolbox→Conversion→**DEM to Raster** tool with the Rooster Rock DEM as input. ArcMap and hillshading only work with the resulting Raster file.

To load the new toolbox, right-click in ArcToolbox, select **Add Toolbox**, and navigate to the **Hillshade Tools.tbx** file. You will also need to create several folders to use this toolbox; get letter case exactly right :
    W:\temp
    W:\Local settings\temp
The purpose of creating these folders is to simulate the file structure the author of the toolbox had on her computer. We could edit the code to make it more general…but this is not a commercial project so let's just work around its quirks (if you get a huge list of errors you don't have these folders in the right place).

These tools are available online at http://www.esri.com→Downloads tab→Data Models→Basemap, or

http://support.esri.com/index.cfm?fa=downloads.dataModels.filteredGateway&dmid=3
The models posted online may later be adjusted to be more general.

Hints on Running the Models:

1. Always point the output files to the folder on your W: drive [W was used when students mapped their personal workspaces]. You'll want to navigate to the input files and replace the drive letter for the output files. Watch these paths closely…the defaults aren't what you want.
2. You can change the output file names in the tool dialog windows. You'll want to rename them when rerunning a tool because it won't overwrite the existing hillshades.
3. As you experiment with the hillshade output and color settings, give the output files meaningful abbreviated names that list what parameter settings you used so you can keep track of your experiments.

Compare these hillshades to the default shading (**ArcToolbox→Spatial Analyst→Surface**). What characterizes Imhof's Swiss shading? Remember the Swiss topographic maps that Cindy brought to class.

Color and Transparency:

The use of multiple hillshades to build a single image is a key aspect of high-end shaded relief. Use of smoothed images and hypsometric tints (elevation colors) are also part of high-end work. Experiment with layer transparencies and coloring to see how they affect image appearance. Transparency can be set multiple places: **Effects toolbar** (remember to set target layer) and **Display tab** in layer properties are two choices.

To edit hillshade colors, use the **Symbology tab** in Layer Properties. You can edit the colors by right clicking on the horizontal color ramp mid-window, then choosing properties. You can then change the colors that define the ramp. Note how changing the algorithm type also changes the behavior of the color ramp between two colors. Experiment with editing histograms using the **Histogram button** on the Symbology tab to control which elevations the colors wash over. There's no undo so save often.

You can also create custom color ramps in the **Style Manager** (Tools Menu→Styles→Style Manager). In this window, you can create custom ramps by navigating to your style file (C:\Documents and Settings\…) to the Color Ramp folder, then right clicking on the right side of the window and selecting New. The most useful choices are multi-part and algorithmic color ramps. Experiment with each of these to create ramps to use with your hillshading and hypsometric tints.

Your Task:

Make three shaded relief maps. Generate two maps that look like the examples shown: Map 1 has gold to brown (Figure 8b and c) and Map 2 has teal-brown-white elevation colors (Figure 8a). For Map 3, aim for jaw-dropping beauty and geographic relevance (i.e., not wild pop art).

Getting USGS DEMs into ArcGIS:

These tips about DEMs may be useful for final projects but you don't need it for Project 5:

1. Download the xxx.TAR.GZ compressed file for the DEM you want. We did this from GeoCommunity web site: http://data.geocomm.com . The normal (i.e., slow) download is free.
2. Unzip this DEM twice in a very particular way:
   a. Check **TAR file smart conversion** in Options->Config->Misc of WinZip and extract.
   b. Unzip again, but **uncheck** smart conversion before extracting. If you skip this options change, the file will still unzip but will not be usable in ArcMap.
3. What you extract the second time is a whole bunch of .DDF files. Run a little program **sdts2dem.exe** that glues these back together into a DEM (we got this EXE from the GeoCommunity site).
4. Be sure you have no spaces in any folder or file names through your whole path. For example, the folder "Project 5" messed us up for a while, until we changed it to "Project5".
5. Use the Toolbox Conversion **DEM to Raster** tool. ArcMap wants to work only with Raster files.
6. Now, you can create hillshade and elevation tint layers. Phew.
7. The Hillshade in 3D Analyst doesn't seem to work in our configuration…so use the one in Spatial Analyst.

Biography for Presenting Author

Cynthia Brewer completed her PhD at Michigan State University, and she is an Associate Professor of Geography at the Pennsylvania State University. She teaches cartography and e-portfolio design. Her research emphasis is map design and she produces the popular color selection tool ColorBrewer.org.