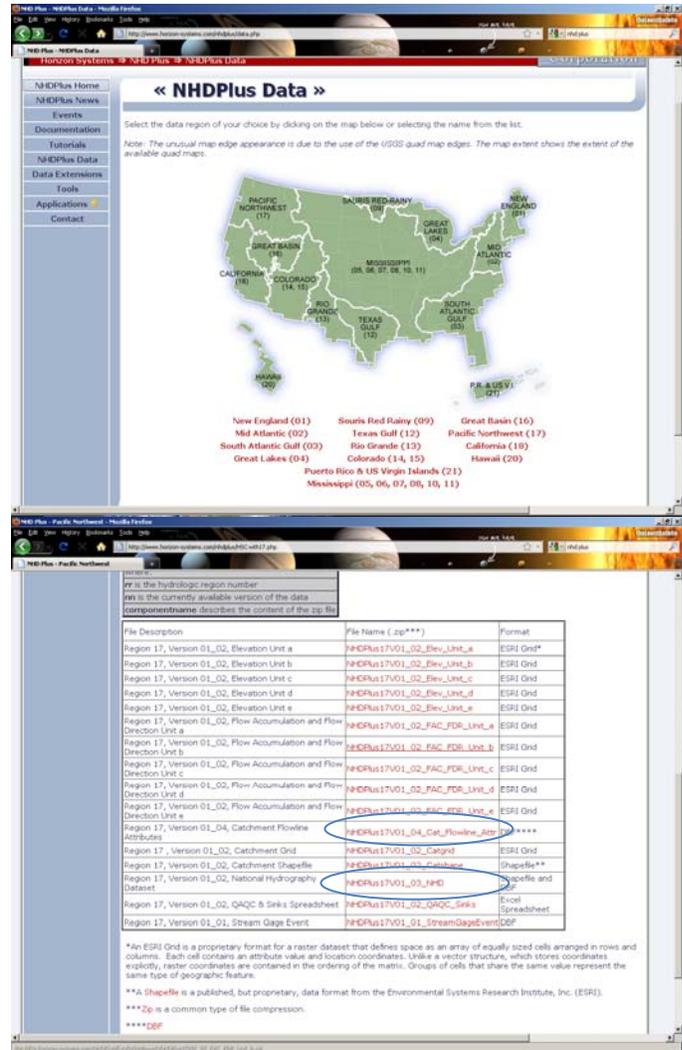**How to implement stream tapering using upstream drainage area for medium resolution data**
Andy Stauffer, Penn State Geography

Downloading the Data

For this project we used NHDPlus Medium resolution data which is suitable for scales of 100K. NHDPlus data can be downloaded by HUC02 from the website **http://www.horizon-systems.com/nhdplus/data.php**. This website features a generalized map of the United States that is labeled with HUC 02 numbers. These are clickable along with the list directly below the map. These links go to a page to download shapefiles of NHD data and databases for this data. Hydro shapefiles can be downloaded using the **NHDPlus*XX*V01_03_NHD** (or similar) link. This will download point, line, and polygon hydro data at a scale of 100K for the given Region along with some DBF files. For tapering purposes, we are only interested in the **flowlines** shapefiles. Next, download the link of **NHDPlus*XX*V01_03_Cat_Flowline_Attr**. This downloads detailed DBFs for the given Region. Because we are doing tapering using Cumulative Upstream Drainage Area, we are only interested in the **flowlineattributesflow.dbf** file. I removed the flowline shapefile and attribute DBF and put them into a separate folder, deleting everything else to save disc space. In ArcMap, do a join based on COMID between the flowline shapefile and DBF. If desired, you can re-export this joined shapefile to make the join permanent. We need to use Medium Resolution data because it is the only one that has Upstream Drainage Area calculated.

Creating Stream Tapering Breaks

View the PowerPoint for more information on this (Stauffer_Stream_Tapering_CEGIS-AllHands_June2010.pdf; item 17-4 at ScaleMaster.org) at ScaleMaster.org. This PowerPoint highlights the methods that I used to determine the breaks that I have chosen. We first divided the nation into wet and dry regions based on annual flow through a HUC 08 and then compared these results to annual precipitation values. We found that a large divide in the data was at 310 cfs. Based on this, we used a shapefile of HUC 08 (http://water.usgs.gov/GIS/dsdl/huc250k_shp.zip), joined the flow values to this file based on the CAT attribute to select flowlines in wet or dry regions. By using a definition query on the HUC 08 shapefile where Flow > 310 (wet regions) we can perform a Select by Location where flowlines intersect the wet regions. We can export these as a regions "wet" flowlines. In the attribute table of the raw data flowlines, we can reverse the selection to select all the "dry" flowlines an export them. This

allowed us to separate the "wet region" flowlines from the "dry region" flowlines. The PowerPoint then goes on to discuss our examination of flowline data and how we created the class breaks. We took the natural log of all the CUMDRAING attributes to normalize the data. We took the high outlier from the nation-wide average in the wet regions and formed an equal interval classification up to this point. We deemed that everything above this high outlier would be a significant river and therefore should be classified as the largest symbol. When we took the inverse log of these equal intervals, we had developed a set of class breaks for wet regions. Doing the same method for the dry regions resulted in a very similar output, so we had to figure out something different from dry regions. To derive the dry regions we analyzed the differences between wet and dry regions using the annual flow through HUC 02s (the same thing we used to identify HUC 08s when dividing the country, but at a more general scale). We normalized the flow through HUC02 by area and determined that dry regions can be considered 12.2 times dryer than wet regions. This told us that in order for a flowline in a dry region to be generally comparable to a wet region flowline, it would have to be 12.2 times larger. This gives the illusion that dry regions are, well, dryer. While the flowline density may be similar, the line weights would help visualize that there is a climate difference. To compute the breaks for dry flowlines, we simply multiplied the wet classes by 12. This provided us with a fairly seamless transition of wet to dry regions on a scale of 1:100K.

Prospects and Pitfalls

At a scale of 1:100K, this methodology seems to work very well. I have done slight line weight increases along with saturation increases such that the smallest flowing streams would be almost transparent blue and very skinny while the largest rivers would be a deep blue and very wide. In many of my examples I have greatly exaggerated these for visual purposes. The reasons *why* flowlines would be in a map would also play a key role in how they are symbolized. Because of these factors, I don't want to tell you what line weigh and colors to use. Examples in the PowerPoint included have very exaggerated examples in homogeneously wet and dry regions as well as a heterogeneous region. The other attached examples were examples from my poster which contained one wet region (Pennsylvania), one dry region (New Mexico), and three heterogeneous regions. Some pitfalls in this project include the breakdown of the symbolization in some areas that are only headwaters or only the mouths of larger rivers. Often in headwater regions, the tapering breaks can be too general such that only one or two tapers occur across the extent of the map. At mouths of major rivers the same can apply, that there are too many large rivers and not enough small streams. In these cases, it may be worthwhile to add a few additional tapers to demonstrate the direction of flow. The widths (in points) and RGB colors that I used in the sample maps on my poster are as follows:

Class	Width	RGB
1.	1	150, 200, 250
2.	1.25	132, 185, 250
3.	1.5	117, 173, 250
4.	1.75	100, 157, 250
5.	2	80, 145, 250
6.	2.25	60, 133, 250
7.	2.5	30, 122, 250

I hope this was helpful. If you have any questions, feel free to email me, Andy Stauffer (astauffer@psu.edu) directly or email Professor Cindy Brewer (cbrewer@psu.edu).