PRACTICAL CARTOGRAPHER'S CORNER

Cloud Mapping: Google Fusion Tables

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INTRODUCTION

The cloud is presenting new possibilities for mapping. Fusion Tables is a Google service for storing, sharing, and visualizing data; it accepts data in a variety of formats, including Excel and CSV. The ability to import KML files makes mapping possible. Fusion Tables is still a beta product. Up to 250 MB per user can be stored at no cost.

The following three articles all deal with mapping applications utilizing Fusion Tables. The article by Koespell looks at how spatial and attribute data from the US Census Bureau can be uploaded and mapped. Pereda relates how maps can be styled within Google Fusion Tables. Trowbridge examines the layering of data on maps.

These three contributions come from a graduate course entitled "Cartographic Methods," taught by Michael Peterson at the University of Nebraska at Omaha. The course dealt with various ways of using cloud resources to make maps. The next issue of *Cartographic Perspectives* will include three more articles on cloud mapping.

—Michael Peterson

MAPPING CENSUS DATA IN THE CLOUD
Kelly S. Koepsell

INTRODUCTION

Displaying and analyzing data from the US Census Bureau and other agencies can be difficult without commercial geospatial software. Cloud-based tools provide free solutions for the mapping of this data. The method outlined here guides users in building a table of data and mapping the data through services provided in the cloud.

DATA CONVERSION

Digital maps and attribute data can be found through the US Census Bureau website. Basemaps are provided in the form of ESRI shapefiles. Attributes are provided in tabular form.

In the example used here, a shapefile will be converted to a Keyhole Markup Language (KML) file. Many free conversion services are available, including Shape2KML, Geoserver, and Shape2Earth. The conversion can be done online with some services, while others require that the software be installed on the user's desktop. All of these services adequately convert shapefiles to KML.

Once the shapefile has been converted into a KML file, it can be uploaded to a cloud application to display the map. Again, the user has several choices. Google Fusion Tables is used in the steps outline here because it provides an "all-in-one" approach to database table storage, geographic information display, and data display with various mapping options. Many other cloud-based mapping services are also available (e.g., GeoCommons, ESRI, and Geoserver).

When the KML file is uploaded into Google Fusion Tables, it is split into its components, that are then placed into different columns in the table (see Figure 1). The three columns will usually be titled "description," "name," and "geometry." The description column contains the HTML code for the map display format and the shapefile attribute table information. The name column contains the name of the map as declared in the shapefile. The geometry column holds the KML code of latitude and longitude points for drawing the map.
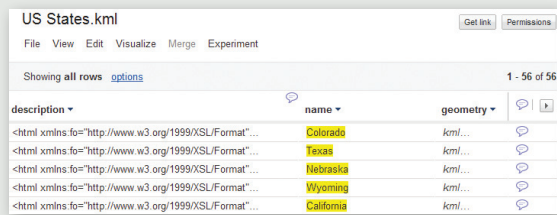

Figure 1. The imported KML file is displayed in a Google Fusion Table. The three column headings are the main subsections of the KML file. The description column contains the HTML code for map display format and the attribute table data. The name column contains the map's name from the shapefile. The geometry column holds the KML code for the points that comprise the map from the shapefile. Notice the number of entries is 56, for the 56 polygons that correspond to the 56 states and territories.
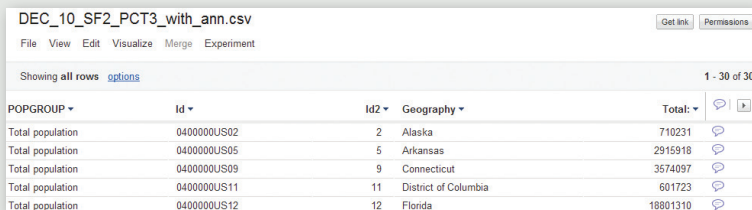
SHAPEFILE DOWNLOAD AND CONVERSION

Shapefiles from the US Census Bureau website can be found under "TIGER" (Topologically Integrated Geographic Encoding and Referencing). Files are available for download in zipped form.

Some shapefile-to-KML converters require as input the zipped file and others do not. Experimentation may be needed to find the solution that works best. Some options produce a KMZ file, a zipped version of the KML. In this case, unzipping to KML is required before the file can be imported into a Google Fusion Table.

Access to Google Fusion Tables requires a Google account. In Google Documents, select "Create" and then select "Table." A dialog box will appear with file import options. Select the KML file and import. When import is complete, the KML file will be displayed as a table.

After the shapefile is uploaded, the demographic data needs to be acquired and uploaded to a second Google Fusion Table.

Demographic data can be downloaded from the US Census Bureau by subject, type, year, and geography. Many different data file types are available, including PDF, Microsoft Excel, Rich Text Format, and Comma Delimited Format. A comma-delimited format is selected here to enable uploading to the Fusion Table, but the Excel option could also have been used (a size limit of 1 MB is imposed upon .xls files; 100 MB for .csv files). The data file is downloaded as a zipped file.

After the file is unzipped, minor manipulations of the demographic data file are required in order to prepare the file for uploading into a Google Fusion Table. These modifications can be done in Excel.

In the file provided by the US Census Bureau, the column headings occupy three or four rows at the top of each column. In order to upload the spreadsheet to a Google Fusion Table the column headings must be in one row. This change is easily done in Excel with the Concatenate function, which combines all text in select cells into one cell. Select the cell where the single heading row should be and type "=concatenate" into the function bar. Then, enter the column/row reference for each of the three or four cells containing the header information desired, separated by a comma. After concatenation, a single heading row cell will now contain a string of text from the input cells. Since the header is now in a single row, it can be uploaded into Google Fusion Tables.

After the modified demographic data file has been uploaded, select "Create" and then select "Table." A dialog box will appear with upload options. Select the data file and import into Google Documents. When import is complete the data file will be displayed as a table (Figure 2).

Figure 2. The uploaded demographic data file in Google Fusion Tables. Note the number of entries is equal to 30.

Note how the table organizes the demographic data. The first four columns contain geographic data relating to the data collection area. The area's name will be found under the "Geography" column. This column will be used to merge the demographic data with the geographic data previously uploaded as a KML file. (Recall that in the uploaded KML file, the column "name" was the column that contained the map labels.)

MERGING THE TABLES AND DISPLAYING THE DATA

To merge the geographic (KML) data with the demographic data, open the KML Fusion Table and select "Merge" from the menu (Figure 3).

In the dialog box, select the column ("name") to be associated with the geographic area column from the demographic table. On the right, select the file to merge and select the column to be associated ("Geography"). The choice to save the merged tables as a new table is made automatically; simply provide a new file name in the space provided. Select "Merge tables," and the new table will be displayed when the merge operation is complete.

There are two parameters in the merge operation that require explanation. The merging operation performed by Google Fusion Tables is "computed dynamically," meaning the data in the merged table will be updated if the data in the original tables is changed. The note in the dialog box also states if the data in the merged table is changed, the data in the original tables will be changed as well. This is a very useful function if the user is aware that this is happening. The user could merge tables, believing the original tables and the merged table are separate and distinct entities. However, changing one table will affect the data in the other table, as stated in the merge dialog box. Without understanding this, the user might inadvertently change data in both tables.

The other merge parameter the user needs to be aware of is the merging order. The merge dialog box states that the tables will be merged "using the rows from the first table." In the examples below, the KML table (of US States) is selected first and the demographic table is merged to the KML table. The resulting table contains all the states listed in the original KML table with their associated demographic data, but some states do not have demographic data because they were not present in the original demographic table (Figure 4).

Conversely, when the demographic table is selected first and the KML table is merged to it, only the states in the KML table that have population data in the demographic table are merged into the final table. This is because the demographic table does not have data for all states listed in the KML table (Figure 5).

From the Google Fusion Tables menu, select "Visualize" and then "Map" to display the merged tables in a Google Map (Figure 6). This map may now be styled and altered as desired using "Configure styles." The specific attribute that is mapped can also be changed. To share the data or the map, click on the "Share" button in the top right hand corner of the page. This modifies the permissions settings of the table to allow access for specified users.

To distribute this table as a map, three options are provided. In the map menu bar, the first option, "Export to KML," creates and downloads a KML file for use in Google Earth or Google Maps. The next option, "Get KML network link," generates a website link that, when opened in a browser, will download a KML for use in Google Earth or Google Maps. The final option, "Get embeddable link," generates an HTML inline frame code for use on a website. The inline frame link specifies frame height and width, and the map URL. By modifying this code prior to use, the website author can adjust the size of the map displayed, and the map center, as the map center latitude and longitude coordinates are specified in the URL. The "Get link" button at the top right corner of the page enables sharing via e-mail or instant messaging. Finally, using the Google Maps API, the Google Fusion Table can be embedded into a webpage using the Google Fusion Table "Numeric ID." This can be found in the Google Fusion Table interface by clicking "File," then "About." The dialog box that appears contains all the properties of the table.
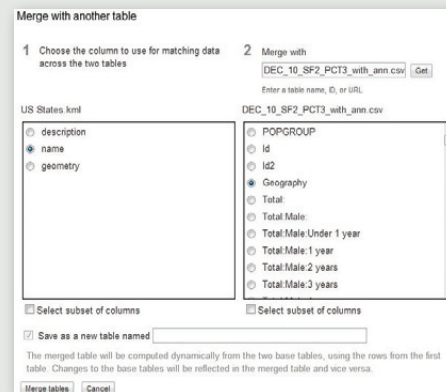

Figure 3. The "Merge Fusion Tables" dialog box. Notice that the "Save as a new table" checkbox is automatically filled in. The dialog box also provides guidance on how the tables will be merged, which is explained in the text of this article.

Figure 4. Merged results of selected KML file with demographic data file merged to it. Notice that all states, territories and districts in the US are represented by the number of rows of data in the table (56). In this figure, Alabama, American Samoa, and Arizona did not have corresponding entries in the demographic data table. Those maps are still in the table due to the order of the merge (KML first).

Figure 5. Results of the table merge when the demographic table is selected first. Notice the number of table rows is reduced to 30. This represents the number of rows in the demographic data file.

SUMMARY

The use of cloud computing tables and visualization tools, such as Google Fusion Tables, is an easy and effective way to store, integrate, and display census data. The free maps and data can be manipulated and customized in the cloud environment with a few simple operations. The ability to combine the geographic and demographic data via the merge operation provides the ability to place a very large amount of data into a single geo-referenced source. Google's distribution methods for the mapped data table enhances this powerful array by creating a flexible, accessible source for maps and data.

WEB RESOURCES

Arc2Earth. 2012. "Arc2Earth." http://www.arc2earth.com. Accessed April 16, 2012.

ESRI. 2012. "ArcGIS Explorer Online." http://www.arcgis.com/explorer. Accessed April 16, 2012.

GeoIQ. 2012. "GeoCommons." http://geocommons.com AccessedApril 16, 2012.

GeoServer. 2011. "GeoServer." http://geoserver.org/display/GEOS/Welcome. Accessed April 16, 2012.

Shape2Earth.2012. "Shape2Earth." http://shape2earth.com/default.aspx. Accessed April 14, 2012.

US Census Bureau. 2012. "TIGER Products." http://www.census.gov/geo/www/tiger. Accessed April 17, 2012.

Zonum Solutions. 2011. "shp2kml 2.0: Shape-file to Google Earth." http://www.zonums.com/shp2kml.html. Accessed April 15, 2012.

Figure 6. Map of the merged Google Fusion Tables when the demographic table is selected first. Notice that only the states with demographic factors are displayed.

CONFIGURE STYLES IN GOOGLE FUSION TABLES
Gabriel Pereda

INTRODUCTION

Google Fusion Tables is a web service provided by Google for data management in the cloud. The service was originally designed for organizations that struggle with making their data available internally and externally, and for communities of users that need to collaborate on data management across multiple enterprises. Fusion Tables also provides a simple data integration platform where users can join tables that may belong to different users. To collaborate, users can share the data with a select set of collaborators, or make it public and thus available to everyone. Fusion Tables is helpful for geocoding data, as street addresses in a Fusion Table are automatically converted into latitude and longitude coordinates. The map option under visualization is used to map the results. However, one must have a Google account to make use of all the web services.

CONFIGURE STYLES OPTIONS

Configure styles" is used within Fusion Tables to control the display of the map. Figure 1 shows the default layout of the different tabs under visualize. "Configure styles" allows the user to manipulate the display of points, lines, and polygons on the map.

POINTS

Points on a map are identified as markers. The default marker is the standard upside down tear drop, although Fusion Tables offers approximately 200 additional markers. Figure 2 shows how the user can change the color of the icon under the fixed tab. The fixed tab means that the user wishes to set all of the points to be equal value. The column tab is used to provide a specification for each row's display in one of the table's data columns. This option provides the most specific control over the appearance of features on the map. The Buckets tab is used to classify the data. If the user wishes to represent multiple classes of data, he or she can change the color of each class to represent the data more accurately.

LINES

Lines on a map are another way to represent data. Similar to polygons, lines can be styled with the "Fixed," "Column,"
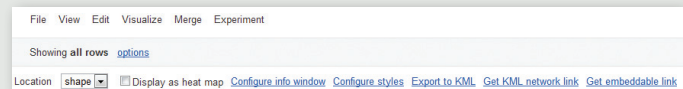

Figure 1. The options available after clicking on the Visualize tab.order of the merge (KML first).
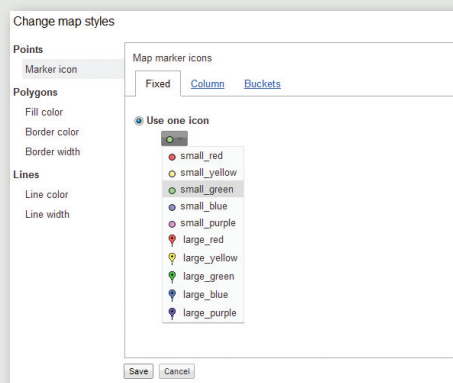

Figure 2. The available colors for icon markers within "Configure Styles."

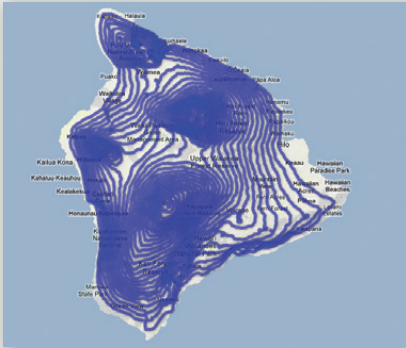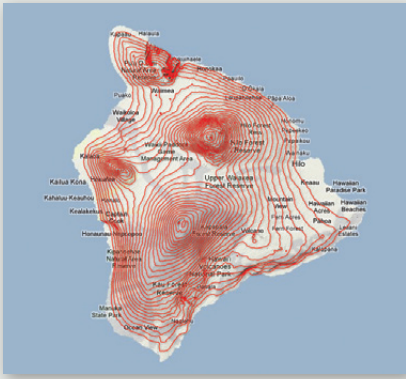Figure 3. A point map with specified markers and color.

Figure 4. Map of contour lines on the Big Island in Hawaii showing the different colors and line width options that are available in "Configure styles."

"Bucket," and "Gradient" functions. Line width can be manipulated as well with "Fixed," "Columns," and "Bucket." As shown in Figure 4, the user can assign a specific color and width to each line if needed. Figure 5 shows the classification of the contour lines using the "Buckets" option.

POLYGONS

Fusion Tables can also handle polygons. Similar to points, a polygon can be modified with the "Fixed," "Column," and "Buckets" functions. "Buckets" control the shading of the polygons. In Figure 6, "Buckets" is used to specify a range of values to assign to each color. Style is assigned to each row based on the value in a numeric data column.

Polygons introduce the use of a fourth representation function, "Gradient." "Gradient" is an unclassed form of data representation that does not classify the data into categories but defines a continuous range of colors. The user can change the color of the overall gradient as well as the opacity of the fill color. In certain scenarios, where more than one column of data is being represented, the user needs to choose which column of data to represent. An example is shown in Figure 7.

WEB DISPLAY

Once the user has finished configuring the styles, the map can be displayed within a webpage. The JavaScript code example shown on Figure 10 will display the map; the user needs to change the numeric ID in the code shown on line 27. By clicking on the File tab, the user can see the "About" button, that gives the user the Number ID for the map. The center of the map will also need to be changed depending on which part of the world is being mapped.
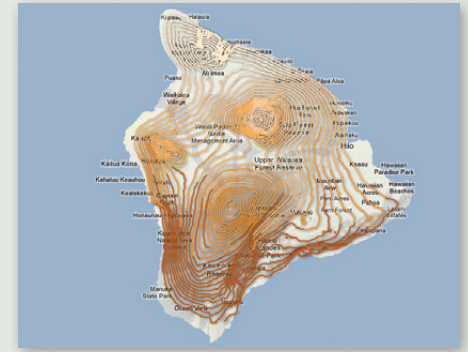

Figure 5. Contour lines are given a certain value and divided into classes with the "Buckets" function. Ranges are distinguished by color value.
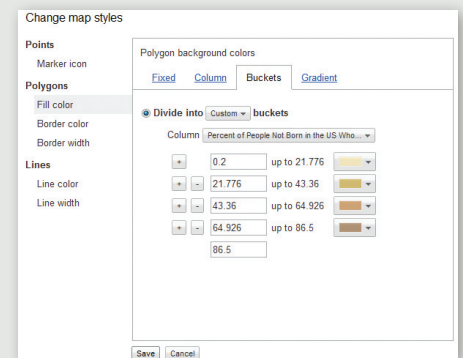

Figure 6. Buckets can be changed according the desired color and classification range.
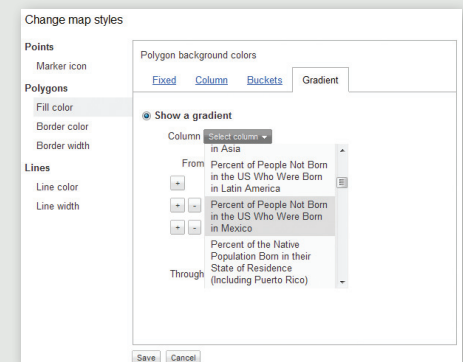

Figure 7. The user can select which column of data they wish to manipulate.

LIMITATIONS

Google Fusion Tables have a number of limitations. A few to note are: a storage limit of 250 MB per user account, 1 MB upload limit per Excel spreadsheet, no legend, no choice in the map projection, and limited icon styles and colors. The size difference between icons can be important due to the fact that larger icons can block smaller icons behind them which can lead to data misinterpretation, as shown in Figure 11. Incorrect geocoding is a frequent problem that can also alter a map.

SUMMARY

More and more maps are being made and displayed on the Internet through services in the cloud. Google Fusion Tables are just one of the many web services available that offer quick styling features and require no software installation. Fusion Tables allows the user to present their data in an appropriate manner and display interactive maps on a website. Although there are limitations to what the user can do with the application, Google Fusion Tables is a quick and easy way to display geospatial data on the web.

SOURCES

Halevy, Alon, and Rebecca Shapley 2009. "Google Fusion Tables." http://googleresearch.blogspot.com/2009/06/google-fusion-tables.html#!/2009/06/google-fusion-tables.html.

Gonzalez, Hector, Alon Halevy, Christian S. Jensen, Anno Langen, Jayant Madhavan, Rebecca Shapley, and Warren Shen. 2010. "Google Fusion Tables: Data Management, Integration and Collaboration in the Cloud." http://www.cse.ohio-state.edu/~agrawal/788-au10/Papers/Oct28/google-fusion-socc10.pdf.

Google. 2012. "Set Map Styles." http://support.google.com/fusiontables/bin/answer.py?hl=en&answer=185991.

Shrader, William. 2012. "Contours Fusion Table, Hawaii's Big Island, 500ft contours." http://wshrader.hostei.com/CM11/page2.html.
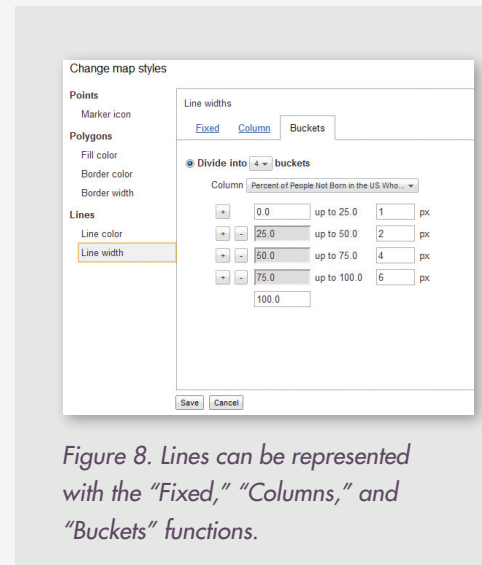
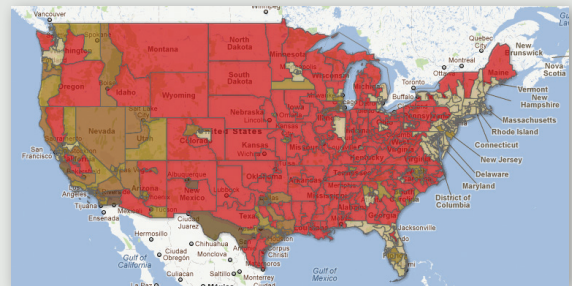Figure 8. Lines can be represented with the "Fixed," "Columns," and "Buckets" functions.

Figure 9. A map defined in Fusion Tables showing the percent of population born in Mexico for each Congressional district.

Figure 10. HTML/JavaScript code to display the Fusion Table Map.
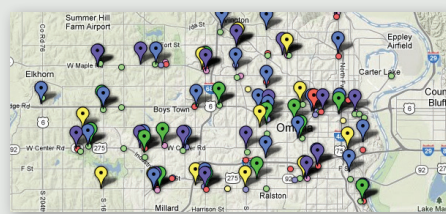

Figure 11. The use of different icon types and colors can lead to misinterpretation of the data.

LAYERING MULTIPLE KML FILES IN GOOGLE MAPS WITH FUSION TABLES
Spencer Trowbridge

INTRODUCTION

Maps on the web are often displayed as a series of user-selectable layers. Map users seem to prefer a multi-layered map to a single map that displays all of the information simultaneously. Toggling between layers allows the user to go back and forth easily to compare the information depicted in each layer. Google Fusion Tables can be used to display information in this manner.

Google Fusion Tables are a way of storing, sharing, and visualizing data tables imported by users. The data is viewable in a spreadsheet format, and can be queried, edited, or exported in formats like CSV and KML. Google Fusion Tables is still described as experimental, and does have some limitations, including the size of files to be uploaded, upload formats, and options for map display.

Google Fusion Tables accepts map files in the KML format. Keyhole Markup Language (KML) is based on the XML standard and is designed for the display of geospatial information in Google Maps and Google Earth. Much of the code can be generated within Google Earth. Options include the addition of placemarks, lines, or polygons. Right-clicking on the newly-created layer allows the copying of the KML that can be then edited with any text editor.

Up to five Fusion Tables can be displayed on one Google map as layers. In this demonstration, stream channel changes will be depicted. This technique of using layers within Google Maps can enhance the presentation of change.

CREATING RIVER CHANNEL LAYERS

Historic georeferenced aerial photographs were obtained as .tif files from http://www.historicaerials.com/aerials.php?op=home. These files were imported to ArcMap 10.0 (Figure 1). While one can overlay images in Google Earth and extract the KML code, ArcMap was chosen to allow the tracing of stream locations. Using ArcMap editing tools, the outer margins of the stream
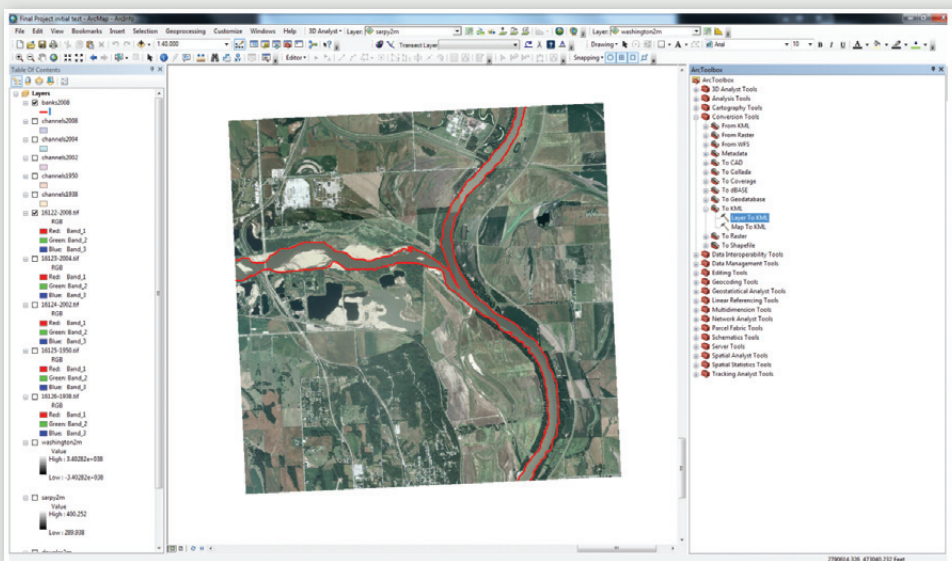

Figure 1. A digitized stream channel layer ready for export to KML from ArcMap.

channels were traced from separate years for the Platte and Missouri Rivers near Plattsmouth, Nebraska, and were digitized as lines on separate layers.

The conversion tool "To KML" in the ArcToolbox menu was selected to export each map layer. When the tool was opened, a selection window allowed the selection of the appropriate layer and destination or "Output" location.

ArcMap exports the file as a KMZ and not a KML. This is shown in Figure 2. A conversion from KMZ to KML is needed for importing into Google Fusion Tables. The file was opened with Google Earth and viewed for accuracy. Any styling that was done in ArcMap is not included in the KMZ file. The styling
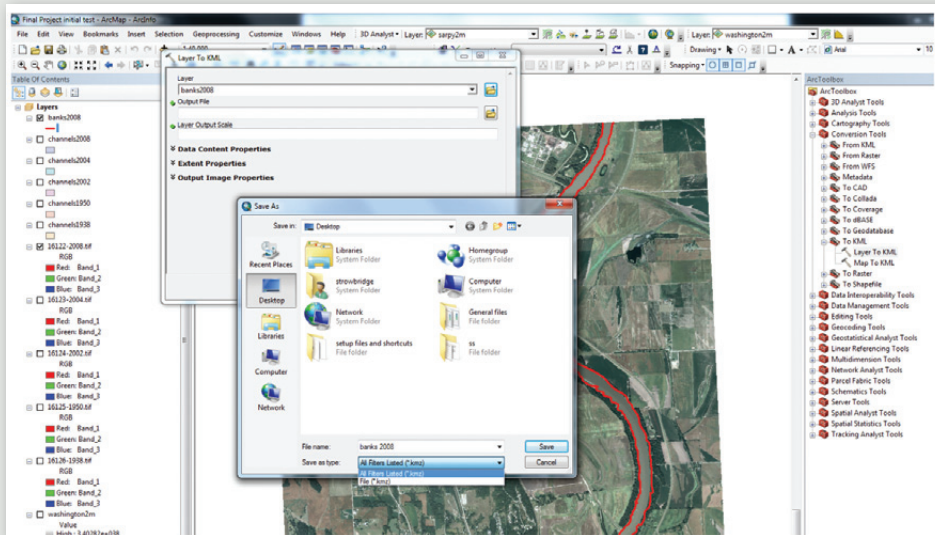

Figure 2. ArcMap exports to .kmz rather than to .kml format. A simple conversion is needed.

of the map, including colors and line thicknesses is done in Fusion Tables. Once the map displayed in Google Earth, that layer was highlighted within "Temporary Places" in the left "Places" pane. By selecting "Save" under "File", a "Save Place As..." option is presented. The "Save as type" drop-down menu allowed the file to be saved as a KML. This KML file was uploaded to Fusion Tables.

A Google account is required to import files and use Fusion Tables. Several file types can be imported into a Fusion Table. These include spreadsheets, delimited text files (.csv, .tsv, or .txt), as well as KML files.

The following steps are performed to import a file to a Fusion Table. These steps are also illustrated in Figure 3. From the Google Docs Fusion Tables screen, the blue "See my tables" button was selected. Once in the Google Docs page, the red "Create" button was selected followed by "Table (beta)" from the drop down menu. "Browse" was then clicked and the appropriate KML file previously created was selected. After the filename was shown in the window, "next" was selected. From the "Import new table" window, "Next" was selected followed by "Finish." The Fusion Table data was then displayed in a spreadsheet format. By selecting "File" from the Google Docs menu followed by "About", the Numeric ID of the Fusion Table is available for reference.
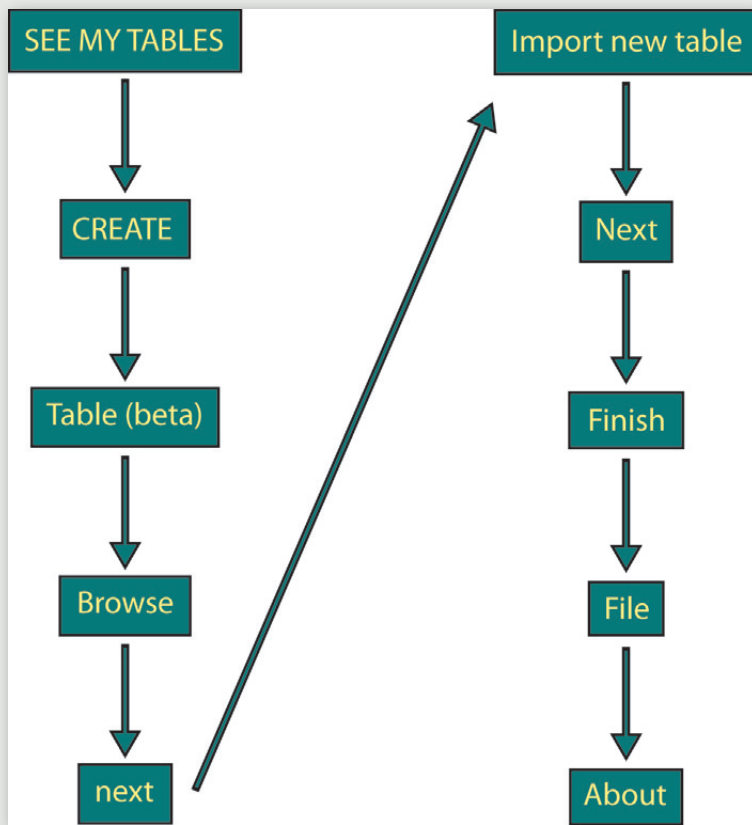
Figure 3. Steps needed within Google Docs to import a file and create a Google Fusion Table.

To display the map while in Google Docs, "Visualize," then "Map" was selected from the drop-down menu. The default color red was changed after clicking "Configure styles." The line opacity was changed to 100%. The hexadecimal color codes of the lines were written down for future use in making a legend. This process was repeated to add four more Fusion Tables to the Google Docs list.

Up to five Fusion Tables can be displayed on a Google Map. This can be beneficial for showing intersections of different data sets or change detection, especially when toggle option is added. This can help to avoid confusion by selecting which layers are visible. When all five layers are visible, they are difficult to visually separate, as the top layers overlap others and conceal information. The options to toggle layers allow the user to adjust their view of the data.

Displaying layers on a Google map does require some basic knowledge of HTML and JavaScript programming. The following JavaScript code sets variables using the Fusion Table numeric ID numbers. All of the code for this tutorial was obtained from http://www.geocodezip.com/insight-projects_com_pedc_A.html available through the Google Maps example page at **http://www.geocodezip.com/**.

```
<script type="text/javascript">

var tableid1 = 3469113 //1938
var tableid2 = 3468740 //1950
var tableid3 = 3468934 //2002
var tableid4 = 3469115 //2004
var tableid5 = 3468860 //2008

var layer1 = new google.maps.FusionTablesLayer(tableid1);
var layer2 = new google.maps.FusionTablesLayer(tableid2);
var layer3 = new google.maps.FusionTablesLayer(tableid3);
var layer4 = new google.maps.FusionTablesLayer(tableid4);
var layer5 = new google.maps.FusionTablesLayer(tableid5);
```

The following code sets the map center, zoom level, and basemap type:

```
function initialize() {
     var mylatlng = new google.maps.LatLng(41.048, -95.885);
//Lat-Long for center of map
     var myOptions = {
          zoom: 13,
          center: mylatlng,
          panControl: false,
          zoomControl: true,
          scaleControl: true,
          mapTypeId: google.maps.MapTypeId.SATELLITE     };
```

This code toggles Fusion Table layers on or off using if/then statements. Only one layer, 1938, is demonstrated in this code:

```
function changeLayer(tableidselections) {

     if (tableidselections == 3469113){
          if (document.getElementById("1938").checked ==
true) {
               if(layer1.getMap() == null) { layer1.
setMap(map); }
          }
          if (document.getElementById("1938").checked ==
false) {
                    layer1.setMap(null);  /*layersetoff*/
          }
     }
```

Checkboxes for displaying the layers changes the color of the text for each layer. The same hexadecimal code used in the Fusion Table to signify each stream channel was used here for the text of the map. The position of the map for on-screen display is also defined here.

```
<h4><p align="center" style="color:#657383">Click on the
checkboxes to display those layers</h4>
<!-- Form to turn layers on/off -->
<table width=90% align="center">
<tr align="center"><td>
<form>
<tr align="center"><td>
<!-- Map --><br>
<div id="map_canvas" ></div>
</td></tr>
<p style="position: absolute; left: 30%; top: 175;
color:#ff00ff"><input type="checkbox" value="3469113"
id="1938" onclick="changeLayer(this.value);">1938
<p style="position: absolute; left: 40%; top: 175;
color:#0000ff"><input type="checkbox" value="3468740"
id="1950" onclick="changeLayer(this.value);">1950
```

```
<p style="position: absolute; left: 50%; top: 175;
color:#00ff80"><input type="checkbox" value="3468934"
id="2002" onclick="changeLayer(this.value);">2002
<p style="position: absolute; left: 60%; top: 175;
color:#ffff00"><input type="checkbox" value="3469115"
id="2004" onclick="changeLayer(this.value);">2004
<p style="position: absolute; left: 70%; top: 175;
color:#ff0000"><input type="checkbox" value="3468860"
id="2008" onclick="changeLayer(this.value);">2008
</form>
</td></tr>
</table>
```
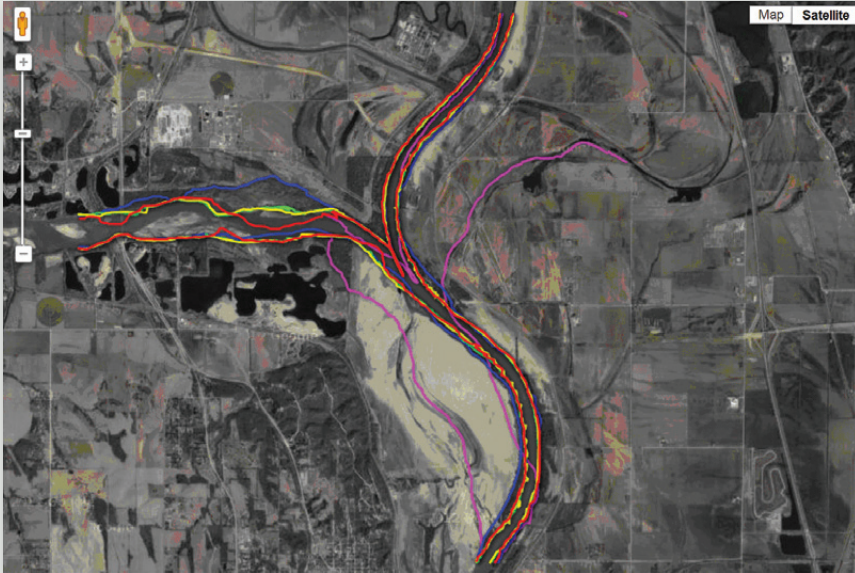

Figure 4. The display of all five years of stream channel locations can be confusing.
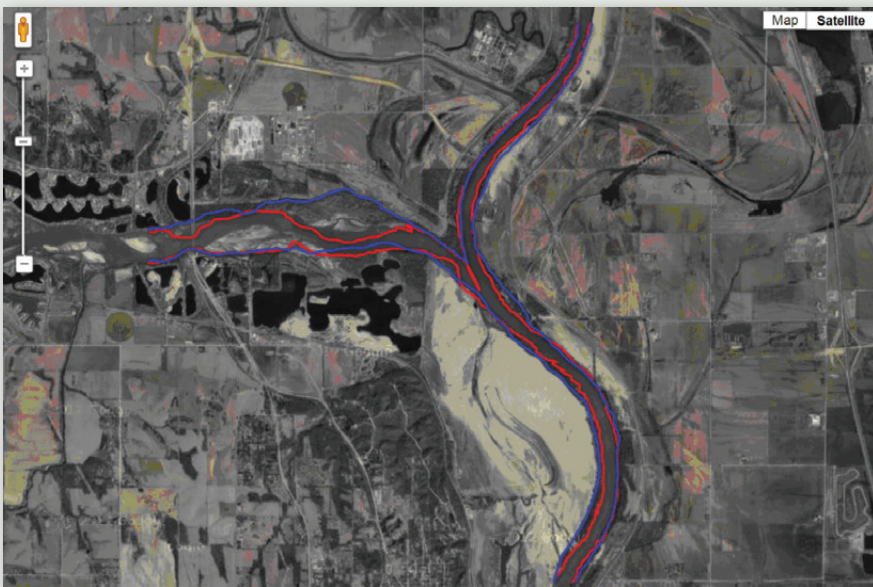

Figure 5. The display of only 1950 and 2008 stream channel locations. The 2012 stream location is visible in the underlying orthophoto.

Displaying five layers at once can be confusing, as demonstrated in Figure 4. Comparison of the stream channels is easier after toggling some layers off. The basemap in this image is from 2012, a year after a historic flood occurred along the Missouri River. The tan area at the lower center of the image is a large sandbar that is devoid of vegetation as a result of the flooding.

SUMMARY

Many types of data can be placed into a Fusion Table. Lists of addresses can be imported and mapped. Associated attribute data will be displayed in a popup bubble on the map if the marker is clicked. Census TIGER/Line shapefiles can be downloaded and imported into Fusion Tables. Once the shapefile is in Google Docs, it can be merged with other tables.

The display of data in Google Maps as layers that can be toggled can be beneficial for detecting and demonstrating change. The procedure for creating Google Fusion Tables is straightforward, as has been shown in this demonstration. One only needs a free account with Google, some basic computing skills, and some creativity. The finished map and HTML code for this demonstration can be found at **http://maps.unomaha.edu/GoogleMapGallery/LineLayers/**.

REFERENCES

US Census. 2010. "Census TIGER/Line Shapefiles." http://www.census.gov/geo/www/tiger/tgrshp2010/tgrshp2010.html. Accessed April 25, 2012.

Google. 2012. "KML Tutorial." https://developers.google.com/kml/documentation/kml_tut. Accessed April 22, 2012.

Google. 2012. "Layers." https://developers.google.com/maps/documentation/javascript/layers#FusionTable. Accessed April 22, 2012.

NETR Online. 2012. "Historic Aerials." http://www.historicaerials.com/aerials.php?op=home. Accessed April 22, 2012.

University of Alaska Fairbanks. 2012. "Keyhole Markup Language (KML)." http://ge.images.alaska.edu/workshop/kml.htm. Accessed April 22, 2012.

Trowbridge, Spencer. 2012. "Five Map Layers." http://strowbridge.herobo.com/finalprojectspring2.htm. Accessed April 23, 2012.