

# Introduction to Esri Integration in SAS® Visual Analytics

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## ABSTRACT

SAS has partnered with Esri, the **world's leading mapping technology company**, to provide access to geospatial features throughout SAS® Visual Analytics. This paper shows you how to find trends and make decisions by adding location information to your data using geocoding, enriching your data by adding demographics, and analyzing your data using routing and drive-time calculations. We also show you how to incorporate your Esri shapefiles and feature services, and we give a preview of future integration.

## INTRODUCTION

Location analytics is a vital tool to help in understanding your data. Most data have a geographic component, whether it is a point on a map or a reference to a known place. SAS Visual Analytics allows you to take advantage of a wide variety of geographic analyses and enrichment opportunities available from Esri.

This paper will walk you through the foundations of geographic maps in SAS Visual Analytics and will demonstrate how dynamic features created through the Esri partnership can uncover new insights from your data.

Many of the functions described in this paper are considered premium services and require an account on **Esri's ArcGIS Online** with available service credits. Esri service credits can be acquired through a direct relationship with Esri either by purchasing directly or by being included with other licensed products and services.

## ESRI FEATURE SERVICES

Esri feature services allow you to access predefined regions on an Esri server to be displayed in SAS Visual Analytics. To better incorporate Esri feature services into your maps, it is important to understand some of the fundamentals behind how location data is displayed and used. SAS Visual Analytics associates location information with your business data through a geography column.

## SAS VISUAL ANALYTICS AND GEOGRAPHY COLUMNS

The geography column is a special type of data column in which each item in the table has an associated location. This can be in the form of a coordinate (latitude and longitude, for example) or a polygon identifier. When taken together as an identified coordinate pair or region, these values add a spatial dimension, or location, to the data. In other words, this location information allows the data to be displayed on a map. When combined with other location data or analyzed with dynamic Esri tools such as Drive-Time, Drive-Distance, Routing, or GeoEnrichment that are discussed later in this paper, relationships and patterns emerge from the data that might not be as obvious as if they were analyzed from a table or traditional graph.

There are two types of geography columns that can be created in SAS Visual Analytics – predefined and custom. Each type has its own advantages and limitations.

### Predefined Geography Columns

SAS Visual Analytics comes with nine predefined lookup types ready to use. Examples of known types include country names, International Organization for Standardization (ISO) codes, U.S. state names, and postal abbreviations. To use this method for creating the geography column, your data must contain a column that matches one of the predefined types.

When you select one of these predefined types, SAS Visual Analytics performs an internal lookup to find the latitude and longitude values for your data. In relational database terminology, the selected lookup type becomes the primary key that allows the two tables to be joined together. For bubble or coordinate maps, the lookup returns a single coordinate pair for the data point. For a region map, the lookup returns an identifier for a known region shape that can be retrieved and displayed in the map. See Figure 3 for the dialog box used to select a predefined geography type.

Here are the nine predefined lookup types included with SAS Visual Analytics:

Predefined Lookup Type	Definition
County or Region Name	Full proper name of a country or region (based on ISO 3166-1)
Country or Region ISO 2-Letter Codes	Alpha-2 country code as defined in ISO 3166-1
Country or Region ISO Numeric Codes	Numeric 3-digit country codes as defined in ISO 3166-1
Country or Region SAS Map ID Values	SAS ID values from MAPSGFK continent data sets.
Subdivision (State, Province) Names	Full proper name for level 2 admin regions as defined by ISO 3166-2
Subdivision (State, Province) SAS Map ID Values	SAS ID values from MAPSGFK continent data sets (Level 1)
US State Names	Full proper name for US State
US State Abbreviations	Two letter US State Abbreviation
US ZIP Codes	5-digit US ZIP Code (no regions)

**Table 1. Predefined Geography Column Types Included with SAS Visual Analytics**

SAS Visual Analytics includes the necessary lookup data for the predefined types. There are times when your data might not align with these types. For these cases, use a custom geography column.

### Custom Geography Columns

You need a custom geography column when your data does not have a column that matches one of the included types listed in Table 1. In this situation, the data must contain separate columns for the latitude and longitude values or a region identifier value for each data point.

Since these columns are not included in SAS Visual Analytics' lookup tables, the application is unaware of their function until you identify them. You can specify these columns on the *Edit Geography Item* window by using the drop-down list as shown in Figure 3.

The flexibility of custom longitude and latitude values comes with the added responsibility of using only accurate and trusted providers when selecting your data source.

Furthermore, you must correctly specify the coordinate space of your longitude (X) and latitude (Y) values. The coordinate space defines the underlying grid used to plot the data. If you specify the incorrect coordinate space, your points might show up in the wrong location, or they might not show up at all.

SAS Visual Analytics uses the World Geodetic System (WGS84) as its default coordinate space. This coordinate space defines the coordinates as latitude and longitude and is used by most GPS systems. WGS84 should work for most circumstances, but in some cases, an alternate coordinate space might be more appropriate. This will be controlled by the specific data being used and the intent for the map. Trusted data sources include the coordinate space information with their data to ensure that the appropriate coordinate system is selected.

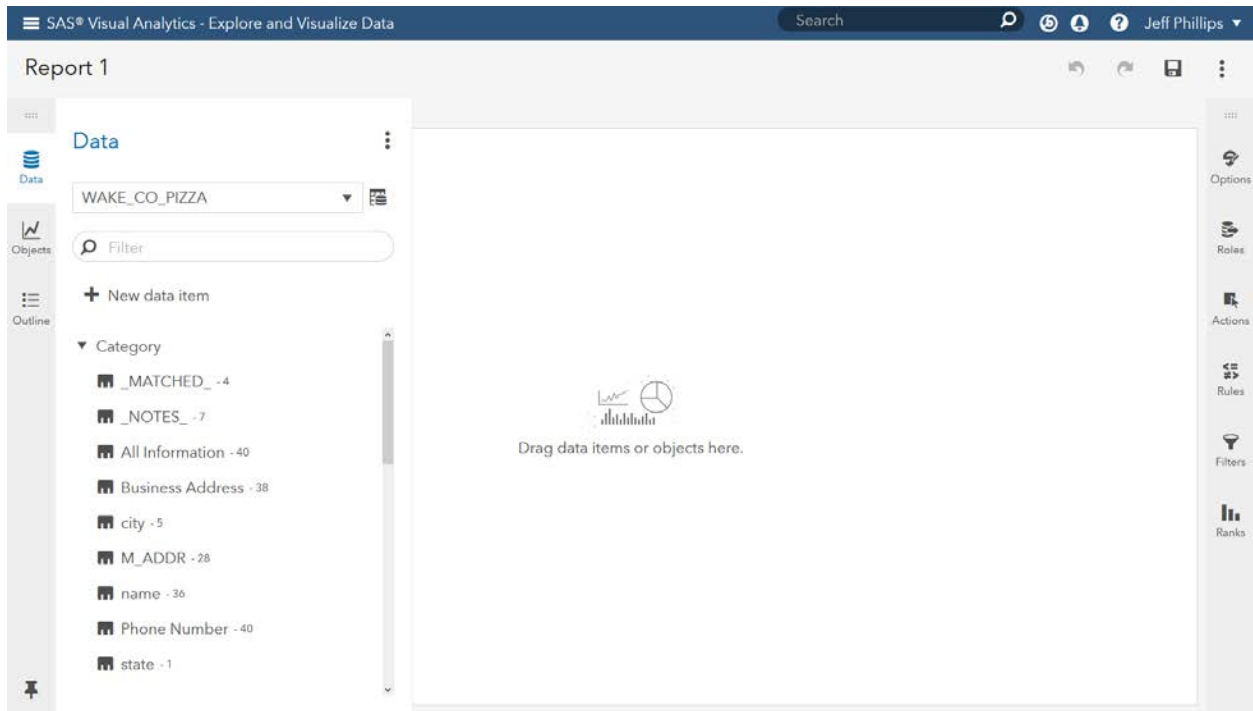
Predefined Coordinate Spaces	Spatial Reference Code
Web Mercator	EPSG: 3857
World Geodetic System (WGS84)	EPSG: 4326
British National Grid (OSGB36)	EPSG: 27700
Singapore Transverse Mercator	EPSG: 3414
Custom	

**Table 2. Predefined Coordinate Spaces in SAS Visual Analytics**

SAS Visual Analytics supports several predefined coordinate spaces and also allows for a custom specification. When using the custom coordinate space option, a Proj.4 string, EPSG code or ESRI code must be used to define the desired coordinate space. These codes and values can be found from reference sites such as <http://epsg.io> or <http://spatialreference.org>.

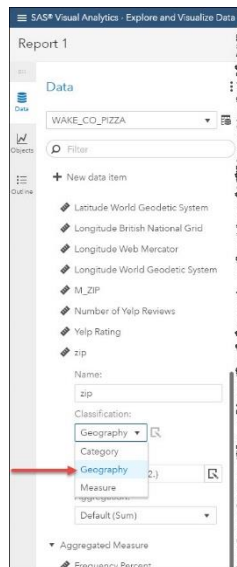
## **CREATING A GEOGRAPHY COLUMN IN SAS VISUAL ANALYTICS**

The steps to create a geography column are similar regardless of whether it is a predefined or custom type. This section outlines the process and highlights the differences between the two. To begin, navigate to the Data module on the left side of the SAS Visual Analytics application and select your table. In Figure 1, the chosen table is WAKE\_CO\_PIZZA.



**Figure 1. Table Selected in Data Panel**

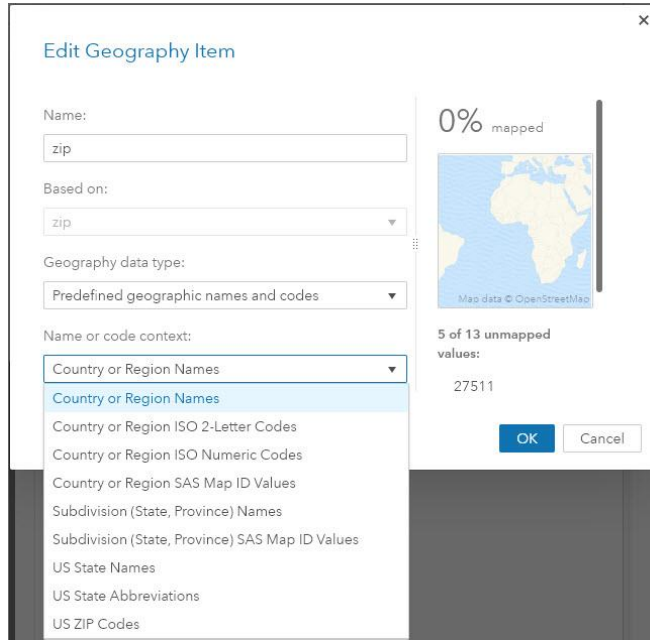
Scanning through the columns, there are two that match one of the predefined types: *state* and *zip*. Since all the data in our table are from a single county in North Carolina, we will select *zip*. Click the down arrow next to *zip* and select *Geography* from the *Classification* drop-down list (Figure 2).



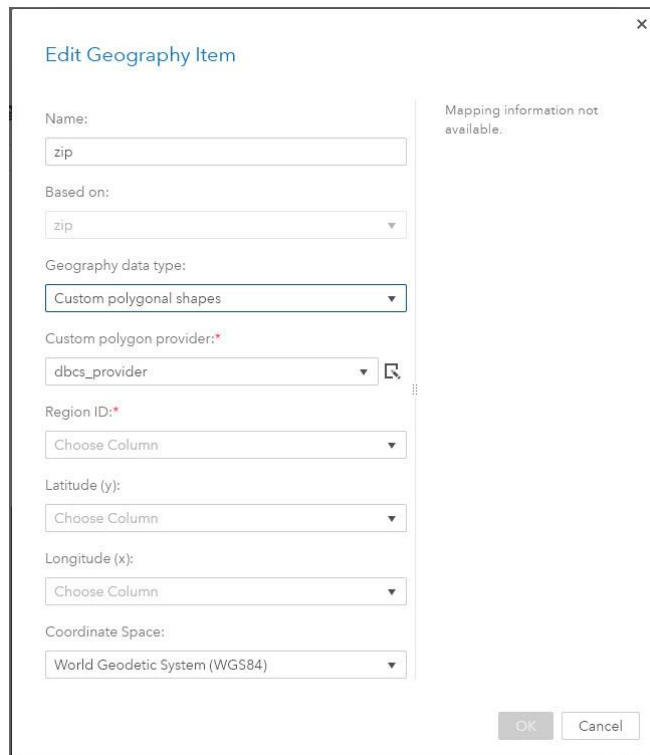
**Figure 2. Changing Column Type to Geography**

The *Edit Geography Item* window opens after the column classification is changed to Geography. This dialog box is where the type of the geography column is set and defines how SAS Visual Analytics finds

the locations for your data. The first drop-down list, *Geography data type*, has three options: Predefined geographic names and codes, Custom polygonal shapes, and Custom coordinates. Each choice has its own set of options, and the options on the *Edit Geography Item* window change based on the chosen type, as shown in Figures 3-5.



**Figure 3. Predefined Geographic Names**



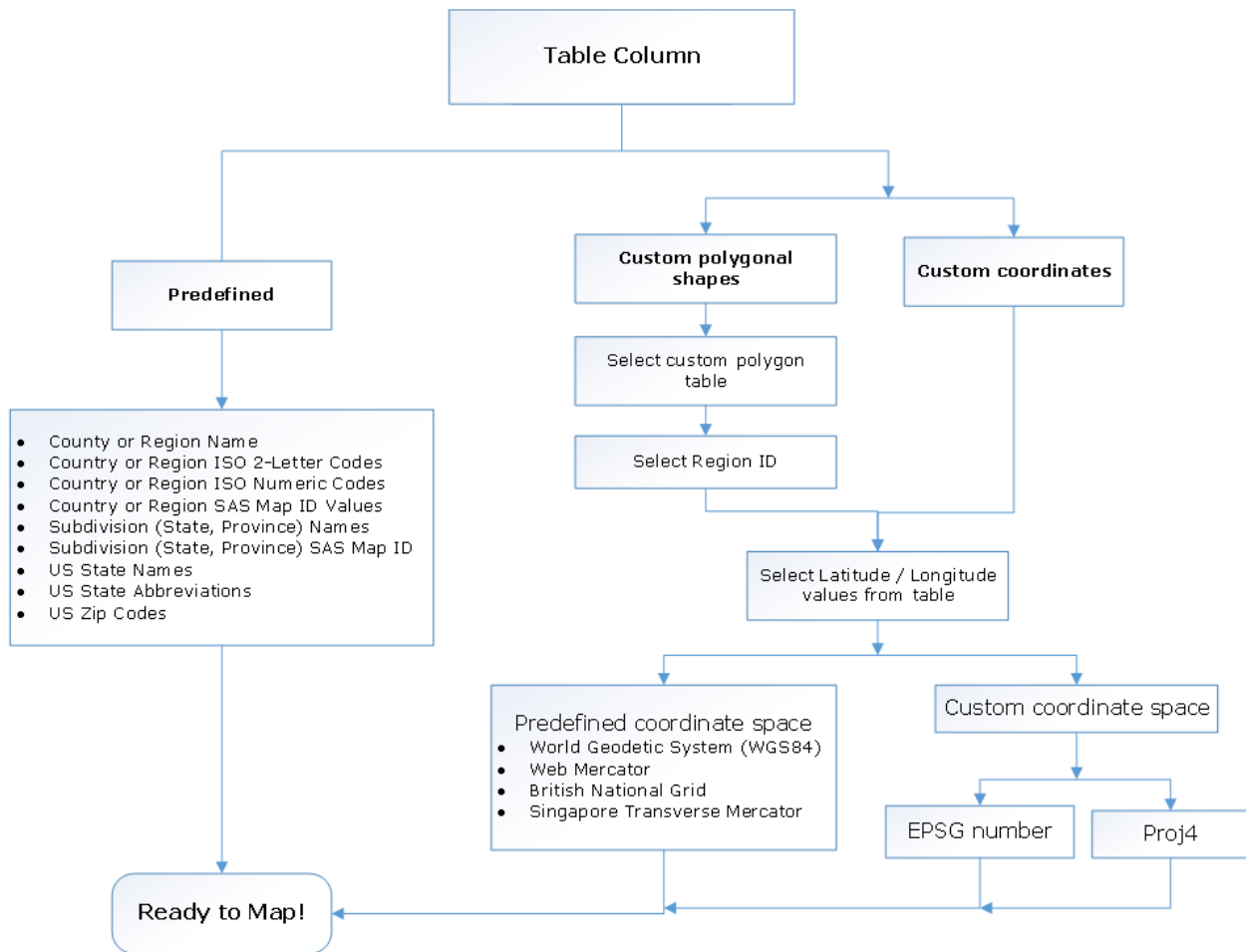
**Figure 4. Custom Polygonal Shapes**

Figure 5 shows the 'Edit Geography Item' dialog box. The 'Name' field is set to 'zip'. The 'Based on' dropdown is set to 'zip'. The 'Geography data type' dropdown is set to 'Custom coordinates'. The 'Latitude (y):\*' dropdown is set to 'Choose Column'. The 'Longitude (x):\*' dropdown is set to 'Choose Column'. The 'Coordinate Space' dropdown is set to 'World Geodetic System (WGS84)'. A message on the right states 'Mapping information not available.' The dialog has 'OK' and 'Cancel' buttons at the bottom right.

**Figure 5. Custom Coordinates**

The choice of the correct type of geography item comes down to understanding your data and the story you are trying to tell. Occasionally the table will contain more than one geographical column, so you should choose the one that matches your intended purpose. The flowchart in Figure 6 illustrates the options for creating any of the available geography types.

After you create your geography column, **it's time to create a map. To do this, simply drag** the geography column to the report canvas. The auto-charting feature of SAS Visual Analytics will recognize it as a geography column and will create a bubble map on the default base map. You are now ready to customize your map and use the new Esri features built into SAS Visual Analytics.



**Figure 6. SAS Visual Analytics Geography Column Setup**

## ACCESSING CUSTOM POLYGONS FROM AN ESRI FEATURE SERVICE

Beginning with SAS Visual Analytics 8.2, you can access polygon layers within a map or feature service located on your **organization’s Esri server**. In a coming release, the ability to access point layers will also be available, as well as the ability to calculate the centroids of polygon features. By default, SAS Visual Analytics only allows administrators to create, edit, or delete a custom map provider. However, an administrator could set up a custom group of individuals with these privileges.

When you create the geography column, consider what will be displayed in your report. The identifiers used for polygons are often somewhat cryptic and might not have a lot of meaning for your audience. In the example shown in Figure 8, we have chosen to base our geography column **on the “County Name”** column. However, that column cannot be used to access all counties of the United States, because the names are not unique across states. The identifier column used in this Esri database is a 5-digit number made up of the 2-digit state Federal Information Processing Standard (FIPS) code and the 3-digit county FIPS code. Showing that identifier in your map would not be meaningful but is necessary to match the correct polygon.

You can begin to create the provider by choosing *Custom Polygons* from the *Edit Geography Item* window (as seen in Figure 4). Create the provider by choosing the *Custom polygon provider* drop-down list and then selecting the ***Define new polygon provider...*** button.

This opens a new window, as seen in Figure 7. Give the provider a unique name and a label. The label will be used in the previous *Custom polygon provider* drop-down list to be chosen after it has been created. There are two types of custom polygon providers: *CAS table reference* and *Esri feature service*. When you change the type to *Esri feature service*, you can now enter the FeatureServer or MapServer URL for the Esri service. The *Feature Service Layer* updates to allow you to choose which layer to access. You also need to choose the polygon identifier column used in the feature service layer. This is the column in the Esri database that will match the identifier in the currently loaded table.

The screenshot shows a dialog box titled "New Polygon Provider". It contains the following fields and values:

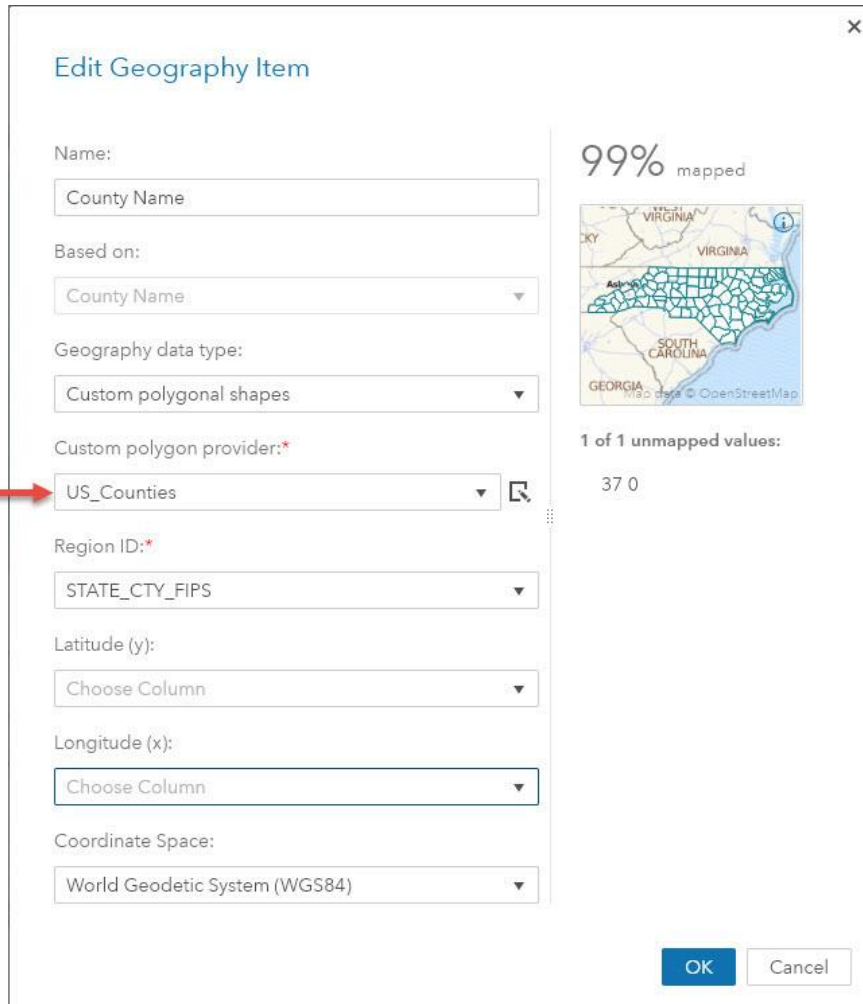
- Name: US\_Counties
- Label\*: US\_Counties
- Type: Esri feature service
- URL: https://vaesri02.na.sas.com/server/rest/services/cour
- Feature Service Layer: cb\_2016\_us\_county\_500k
- ID Column: GEOID

At the bottom right, there are "OK" and "Cancel" buttons. Three red arrows point to the URL, Feature Service Layer, and ID Column fields.

**Figure 7. New Polygon Provider Set Up**

After you have saved the provider and return to the *Edit Geography Item* window, you should see the label for your new provider as the currently selected provider. Now you need to enter the identifier column from your table that is needed to match with the Esri database. As was stated earlier, often this can be a column **that you don't wish to show** on the map because it might have no meaning to someone viewing the report. Other times the columns use the same value, such as U.S. ZIP Codes or unique region names. In our example shown in Figure 8, **we are using "STATE\_CTY\_FIPS" for the identifier, but "County Name" for the displayed column.**



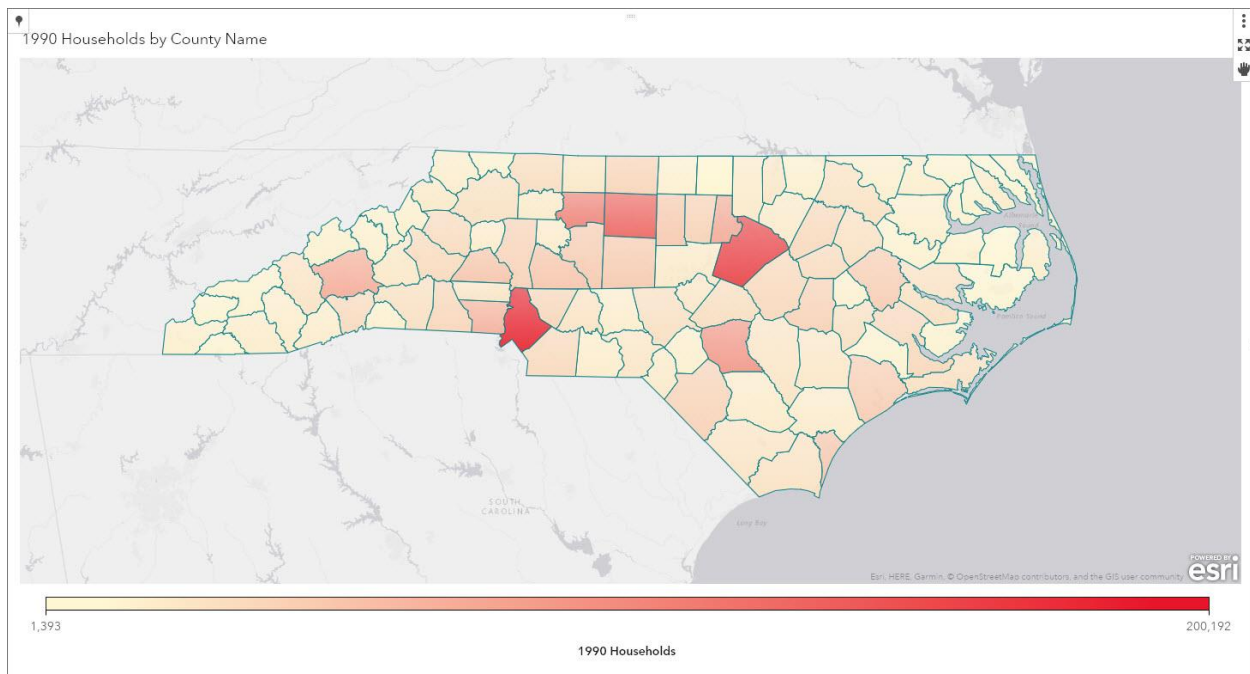


**Figure 8. Geography Column With Custom Polygon Provider Selected**

The right side of the *Edit Geography Item* window shows the confidence of the matched columns, including a small thumbnail map of your regions. If you do not see a map or if the confidence has a low percentage, you might have either chosen the wrong column from your data or there is some other type of mismatch. You might want to inspect your data more closely to produce a better match.

If you have coordinate data in your loaded table, you can optionally add those to the latitude and longitude column entries. The *Coordinate Space* entry refers to your latitude and longitude columns and not the polygon provider. The Esri service provides the coordinate space to SAS Visual Analytics so that the regions will display correctly.

Now that the geography column has been defined, you can drag and drop the column onto the canvas to display your map, as seen in Figure 9.



**Figure 9. Choropleth Map Using Custom Polygons for North Carolina Counties**

After you have created the polygon provider, it is available to all report designers to use. It is defined in SAS Visual Analytics and not in the individual report. Because this is a shared resource, you should take caution in making many changes to the provider, because it can adversely affect other reports.

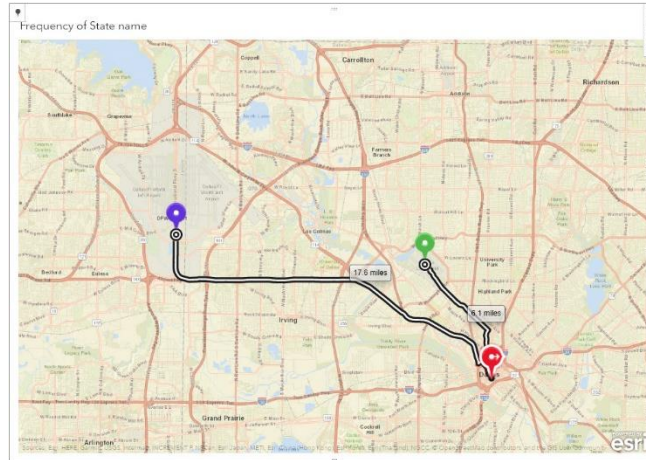
## LOCATION DISCOVERY AND EXPLORATION

There are many ways for you to discover and explore your maps in SAS Visual Analytics using services from Esri. Routing can show the fastest or shortest path between two points. Calculating an area, or buffer, around a point using Drive-Time or Drive-Distance analysis allows you to see an area representing all possible routes up to a given distance. Once a buffer is created, you can explore the demographics of the area using GeoEnrichment from Esri.

Many factors can be applied in the routing and buffering analysis including historical traffic conditions, traffic conditions at a specific time of day and day of week, live traffic conditions, and truck routing and walking paths. Routing, Drive-Time analysis, and GeoEnrichment are premium services and require an Esri login and available service credits.

## ROUTING

SAS Visual Analytics allows you to add a pin on the map and route to or from another location or pin. A route returning to a location might not be the same as leaving from that location due to limitations such as one-way streets and highway ramps. Routes can be easily reversed, if desired, and are shown on printouts. Figure 10 shows the routes to both Dallas-Love Field and Dallas-Fort Worth airports from the convention center downtown.




**Figure 10. Routing from Dallas Convention Center to DAL and DFW Airports**

### DRIVE-TIME AND DRIVE-DISTANCE ANALYSIS


From a known point, you can calculate a buffer that represents all the places that someone could walk, drive a car or drive a truck in a given time. By selecting all the data points that are within that buffer, you can explore and reveal additional information. You can combine up to three concentric values at a time. For example, Figure 11 shows how to select 5- and 10-minute drive times in Hamburg, Germany, and Figure 12 shows the resulting buffers. Data points that fall within any of these buffers will be selected, and they can potentially interact with other visuals in your report.

**< Geographic Selection**

 Location pin 1  
Neustadt, Hamburg, DEU

Type:

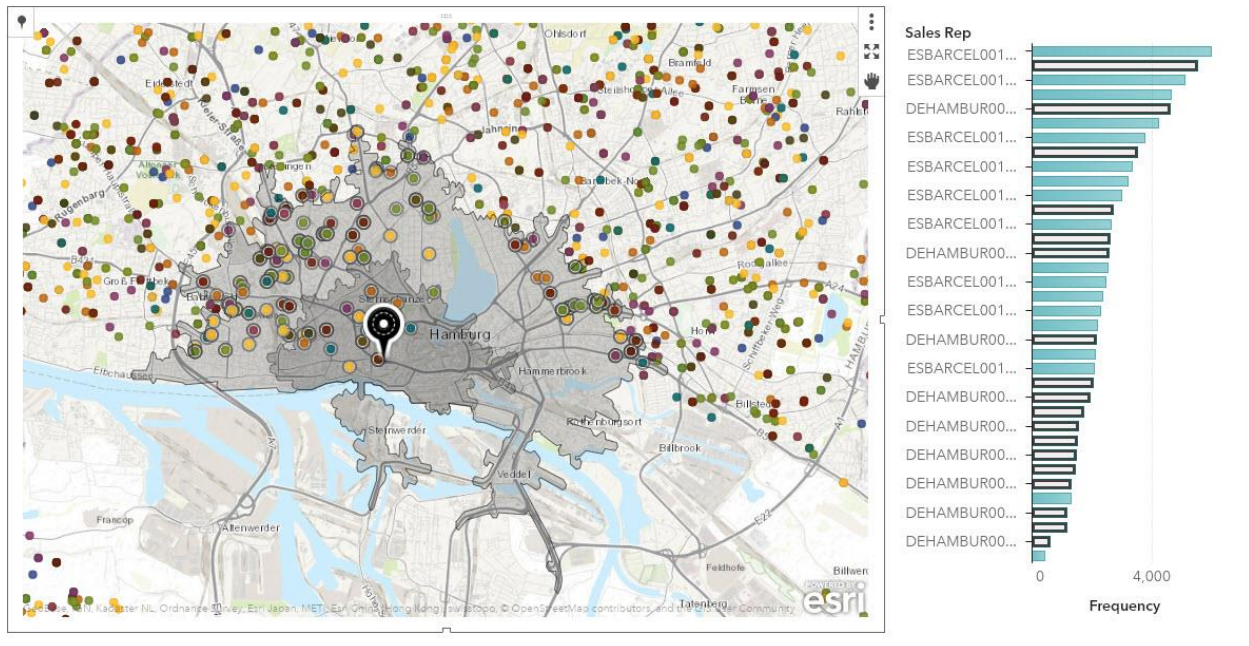
Travel mode:  Unit:

Duration:  
  
 

**+ Add**

Include traffic:

**Figure 11. Geographic Selection Setup Window.**

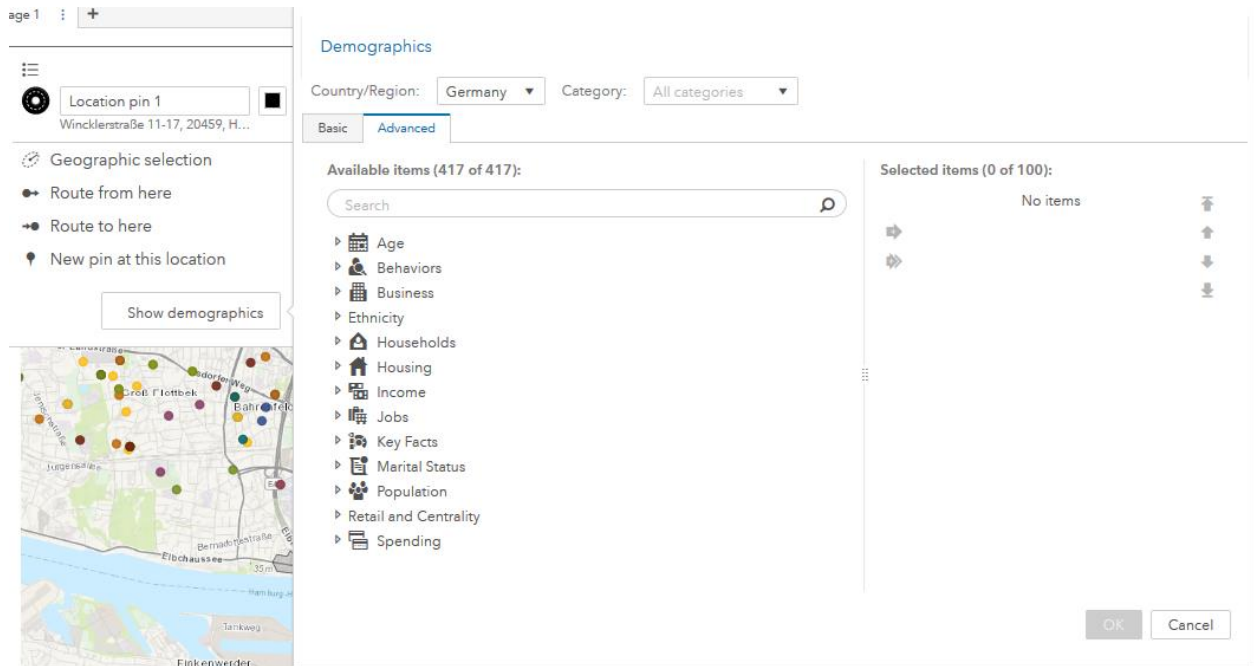


**Figure 12. Drive-time Analysis in Hamburg, Germany with Linked Bar Chart**

### **GEOENRICHING A BUFFER**

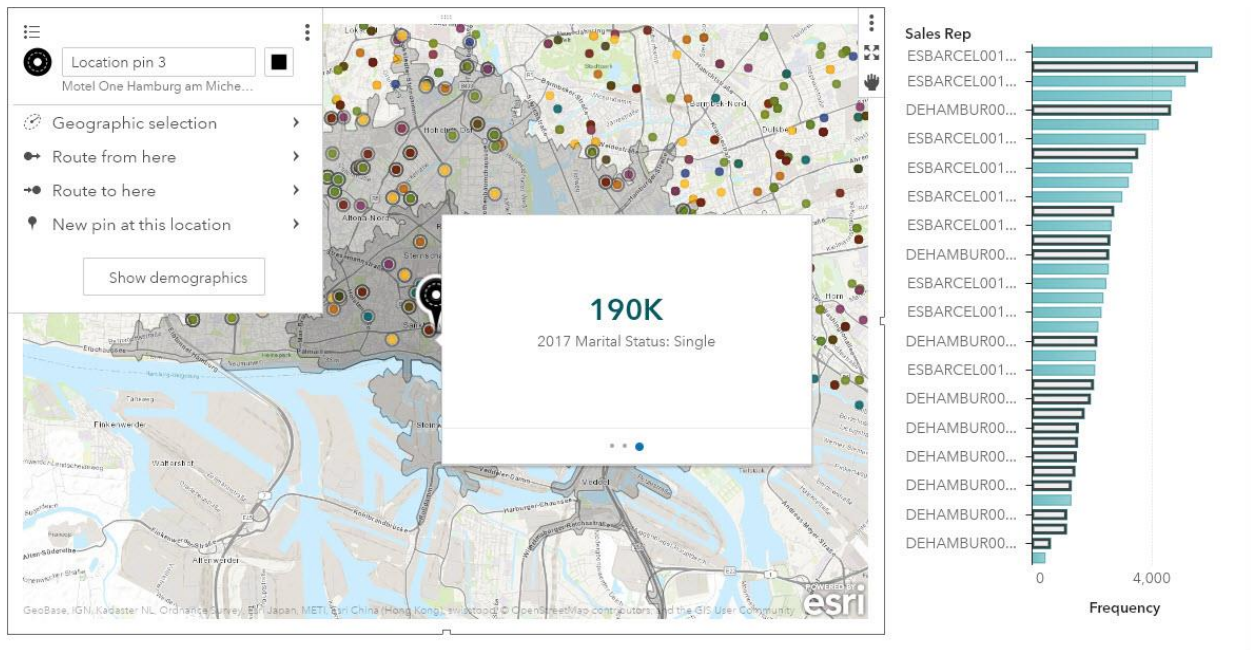
After you have created a buffer, you can click the *Show Demographics* button to display a data selector to choose variables based on data for the country being displayed, as seen in Figure 13.

SAS Visual Analytics queries the location of the origin of the buffer in order to attempt to determine the current country of interest and help initialize the data selector. Some countries contain a much larger number of variables to choose than others. In Figure 13, the buffer has been placed in Germany, where there are over 400 variables available.



**Figure 13. Demographics Data Selector for Esri GeoEnrichment**

The results are aggregated for the outermost buffer and displayed as a pop-up window, shown in Figure 14. Each set of values are displayed in its own panel that can be paged to reveal the information. Some fields can be combined into a single graphical representation based on age, gender, or year collected, for example.



**Figure 14. Demographic Enrichment Using Hamburg Drive Time Analysis**

## ENHANCING YOUR DATA WITH ESRI

The partnership between SAS and Esri enables SAS Visual Analytics to enhance your data with locations provided through importing geocoded locations. You can also add demographic data that can be aggregated down to the city block level, depending on the country. Both **tasks are premium services from Esri and require a valid login to Esri's ArcGIS Online**. You also need to have enough available service credits with Esri to perform the specific operation.

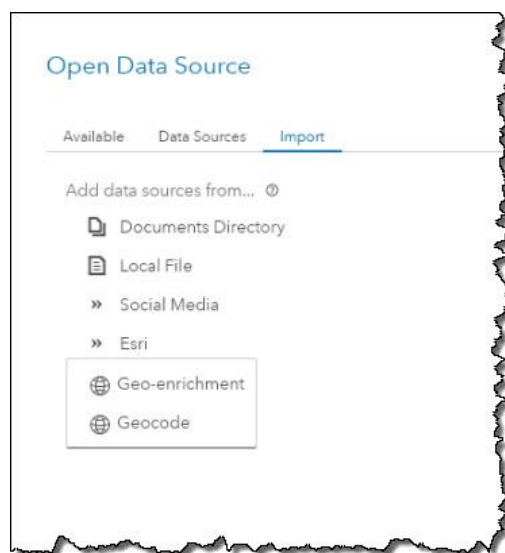
### GEOCODING

Geocoding is the process of looking up addresses and finding locations. Each time you search for a point of interest or address when accessing any online map, that is a single instance of geocoding. When you want to find the locations for numerous locations at once, you need a geocoding service.

The result of geocoding is to add a latitude and longitude to each address entry. **Esri's World Geocoding Service** also provides additional information, such as the address that was **matched from the service's** database and an overall accuracy score.

Esri has a vast database of locations around the world, and most of the time any valid address that is requested will be returned with a relatively high accuracy rating. New, rare, unique, or undocumented addresses might only match at a state or country level, which will be reflected in the score.

To access the Esri World Geocoding Service from within SAS Visual Analytics, open the Data selector and choose the *Import* tab.



**Figure 15. The Import Tab of the Data Selector**

At this point you are prompted for an input table. After **you've chosen the** table, you are presented with an import window that also prompts for the name and location for the output table. The default name of the table has **"\_GEO\_CODED"** added to the end of the name.

The location is the same library in which the input data resides. You can choose to change this name and even overwrite the input data.

You are also asked to supply, in order, the columns that make up the full address. You see a sample of an address, which is read from the first row of data, as seen in Figure 16. Once you are satisfied with the address sample and order, you can choose to test this one address by selecting the *Test* button. Figure 16 also shows that the test returns a location and a score. In this example, we have chosen a table containing 5,000 voters.



**Figure 16. Address Sample and Tested Location**

When you are ready to geocode all the addresses, select the *Import Item* button, which then estimate the amount of Esri service credits this action will consume. The calculation is not exact, because SAS Visual Analytics does not know how many duplicate or invalid addresses might be in the data.



**Figure 17. Esri Service Credit Estimation**

Depending on the size of your data, the geocode process can take a few seconds to complete. Figure 18 shows the results of geocoding our 5,000 voter addresses along with a chart that shows how accurate the results are. The first five rows show some address mismatches that have a slightly lower score. However, well over 99 percent of the data

matched with a score of 99 to 100. Figure 19 shows the points plotted on a map. You can even see which side of the road each address is on.

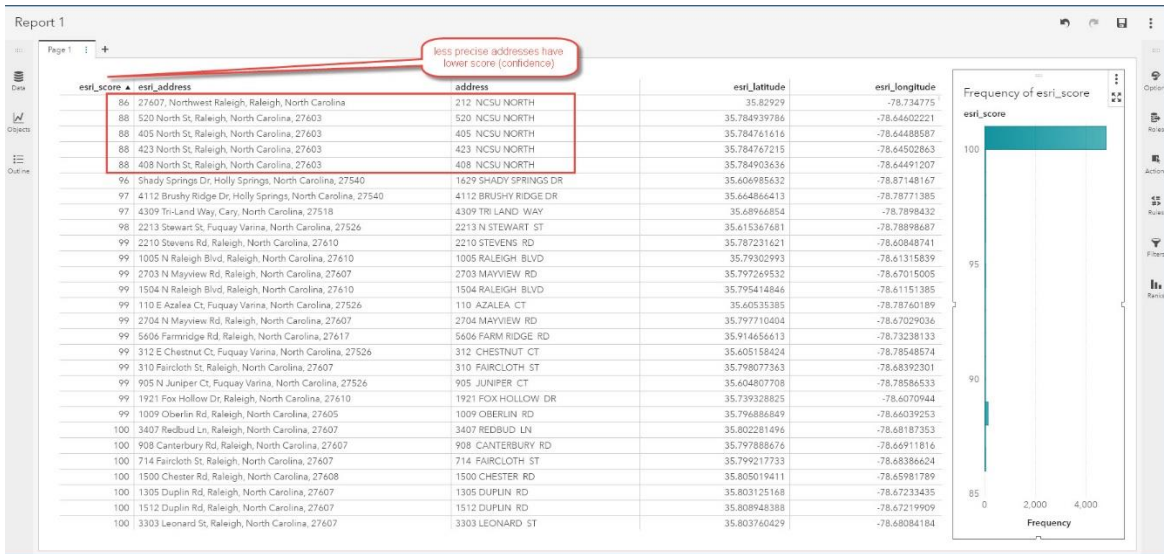


Figure 18. Table of Geocoded Results

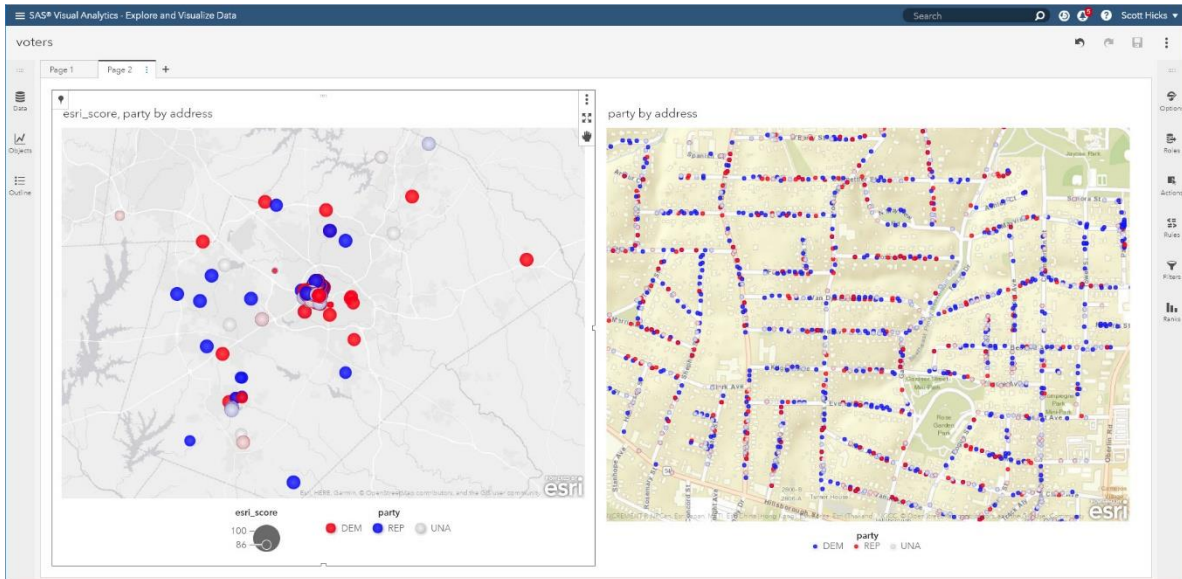


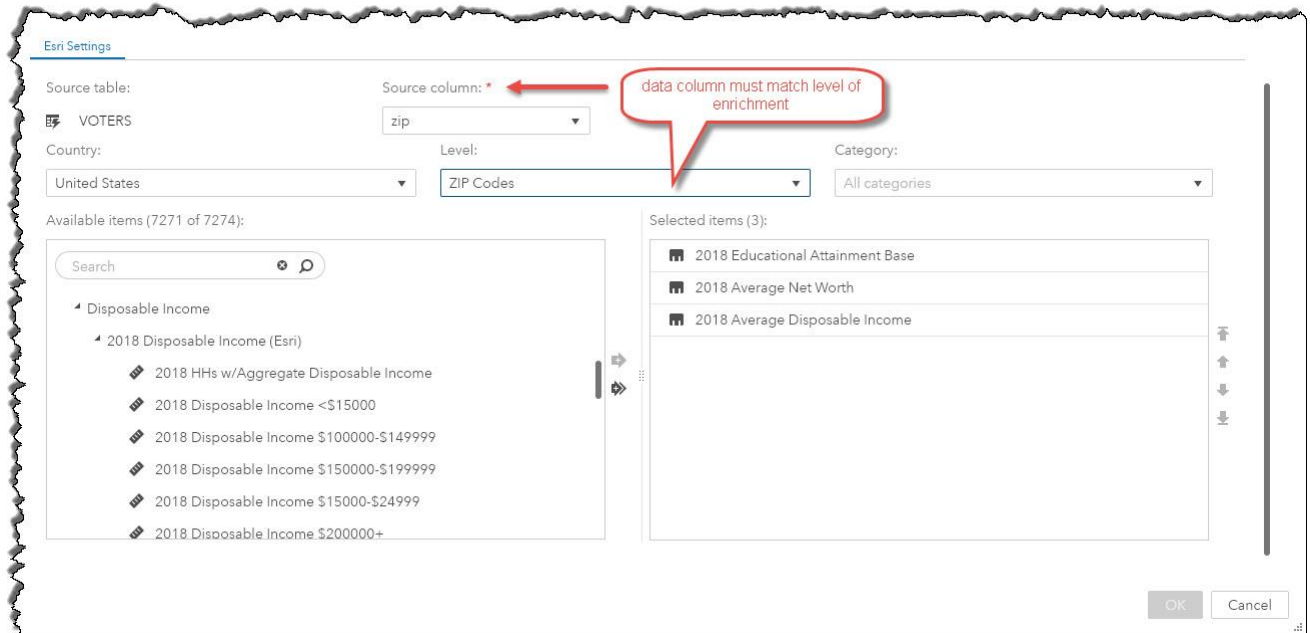
Figure 19. Map of Geocoded Addresses

## DATA ENRICHMENT

While geocoding adds location information to your data, Esri can also enrich your location data with a wide variety of demographic information. There is data available on almost every country in the world - some countries have thousands of columns of data and others a few dozen. To access Esri GeoEnrichment, return to the *Import* tab of the data selector as shown in Figure 15. After you have chosen the input table, select an output destination. To



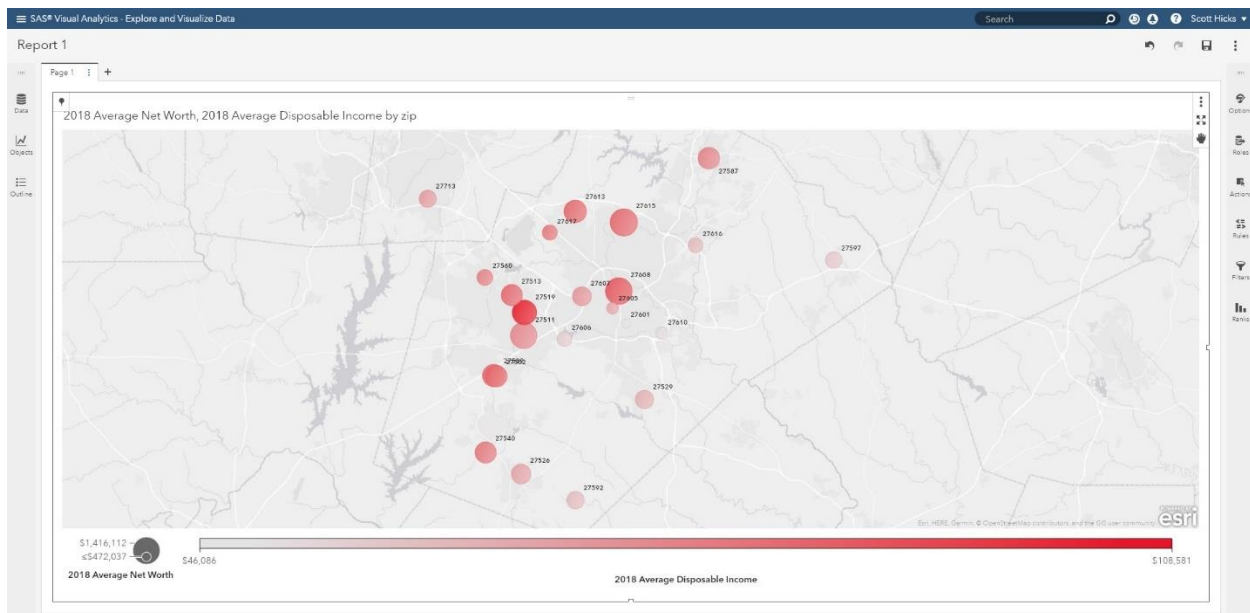
enrich your data, you must choose the country where your data is located. Setting this value changes the *Level* options appropriately. For example, the *States* or *ZIP Codes* level is present for the United States, but the *Provinces and Territories* or *Census Districts* are present in Canada. You need to configure the importer to use a column from your table that represents the level you have chosen. Figure 20 shows an example of setting the source column to *zip* for the level of “ZIP Codes”.



**Figure 20. GeoEnrichment Configuration**

After selecting the appropriate source column, you can choose the columns you would like to be added to your data from the categorized list. After **you've selected all** of the items, click the *Import Item* button to display the Esri service credit estimation dialog box (Figure 17). The credits are estimated based on the number of rows in your data and the number of columns you want to add.

After importing, the new columns are available to use in a map or any other type of chart. Figure 21 shows a bubble map with size and color based on the average income and net worth variables imported from Esri based on the ZIP code provided.



**Figure 21. Bubble Map Using Geo-Enriched Data**

Geo-enriched data can give your reports greater meaning and allow you to further analyze and explore for results and solutions.

## ESRI WEB MAPS

At ArcGIS.com, Esri enables its users to select from a variety of map backgrounds and publicly accessible information to compose a multi-layered online presentation called a “web map.” Using any browser, viewers can interact with a web map to pan, zoom, or toggle the appearance of its layers.

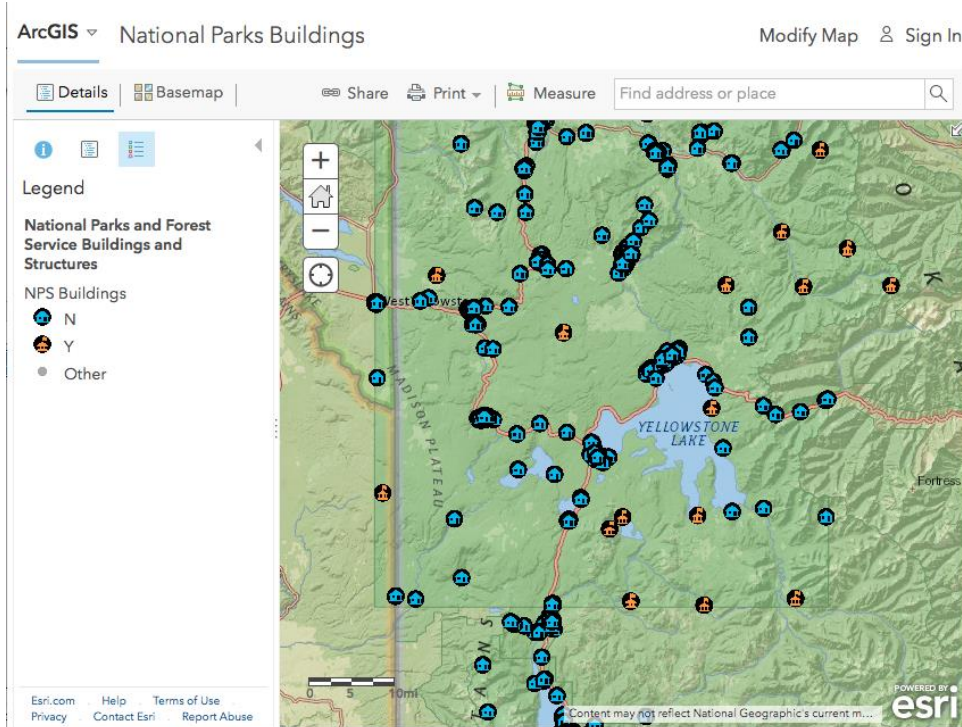


Figure 22. A Web Map at ArcGIS.com: Buildings and Historic Sites of US National Parks

## WEB CONTENT IN SAS VISUAL ANALYTICS

Until recently, there were limited ways for you to include Esri web maps in SAS Visual Analytics reports. With the *Web Content* object, you could insert the URL of a published web map to display it as you would any other web page.

However, if you wanted to include your data on the map, you could not do it from SAS Visual Analytics. Instead, you would have to export your data from SAS and then use **Esri's** Web AppBuilder to upload and host the data on **Esri's servers**—a process that becomes less practical as your data grows more complex. And, even then, the result would be a disconnected web page that does not participate in your **report's filters, selections, or interactions**.

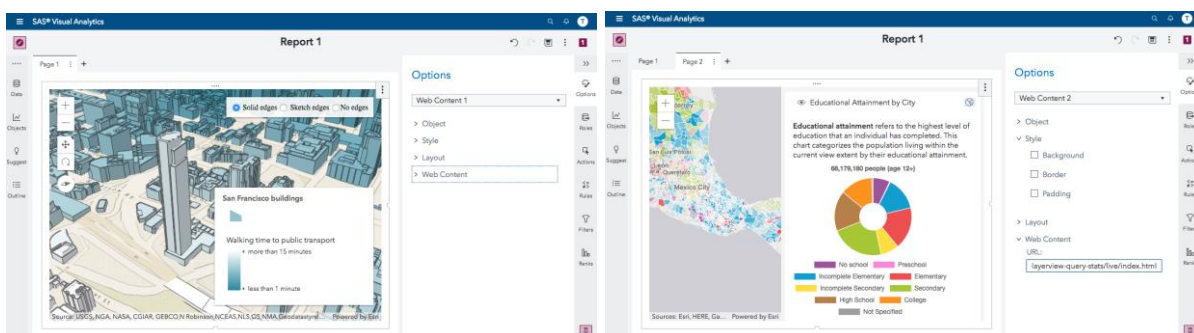


Figure 23. Web Maps as Web Content

**DATA-DRIVEN CONTENT**

To solve this problem, SAS Visual Analytics 8.2 introduced the *Data-Driven Content* object. This object combines the abilities of the *Web Content* object with a well-defined communication protocol, allowing the content to detect and respond to report changes.



**Figure 24. D3 Chart as Data-Driven Object (SAS Visual Analytics Third-Party Visualizations 2019)**

What was missing from SAS Visual Analytics was an adapter that could “listen” to your report and “drive” an Esri map.

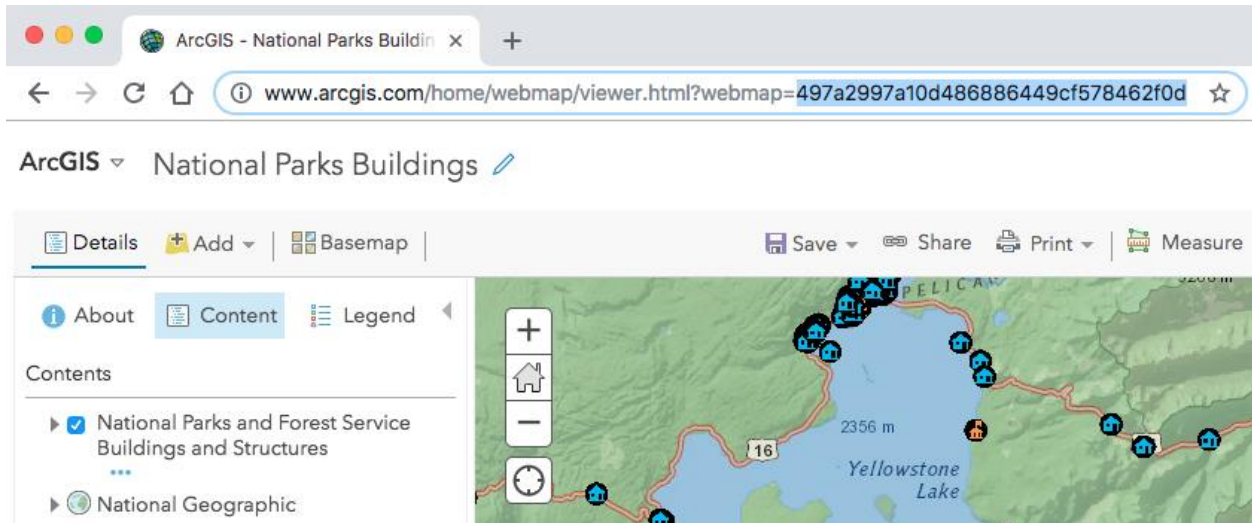
**VISUAL ANALYTICS GEOWEBMAP PROJECT**

In 2018, SAS published the open-source SAS Visual Analytics “geowebmap” project to GitHub. Using the geowebmap object, SAS Visual Analytics users can include their rich, multi-layered Esri web maps in their reports while also adding their report’s data as an interactive layer that can be toggled on or off and that participates fully in their report’s filtering, selection, and interactions.



**Figure 25. SAS Data as a Web Map Layer (2016 In-State Enrollment, NC Central Univ., by Diversity and Income)**

Including an interactive web map requires three steps. First, you must obtain the web map’s identifier. You can find the identifier several ways; the easiest might be simply to read it from the URL of a map once it is saved:

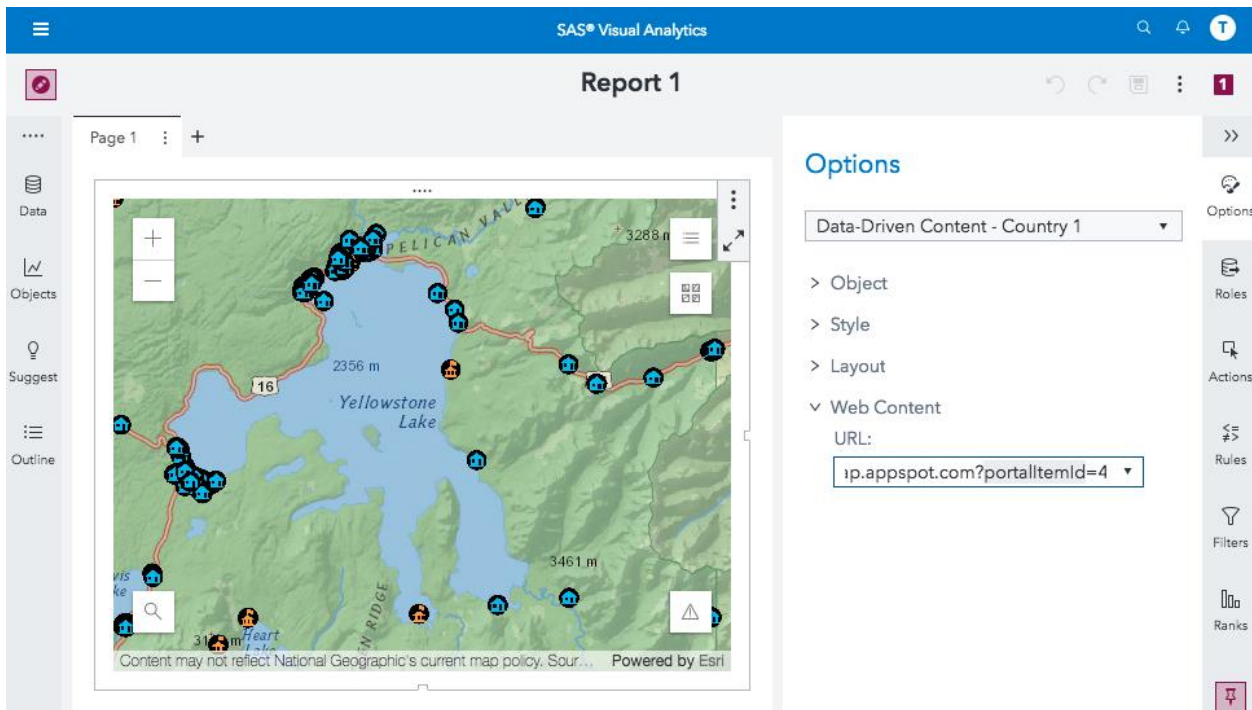


**Figure 26. Finding the Web Map's Identifier in the Address Bar at ArcGIS.com**

Next, in SAS Visual Analytics, add a *Data-Driven Content* object to your report and assign data to it. Set the object's *Content URL* property on the *Options* panel to match the URL where you are hosting the geowebmap. (This presentation uses a fictitious website as an example. For instructions regarding hosting your own geowebmap, see the GitHub site <https://github.com/sassoftware/sas-visualanalytics-geowebmap>). Append your web map's identifier to the URL as the "portalItemId":

`http://my.geowebmap.site/?portalItemId=497a2997a10d486886449cf578462f0d`

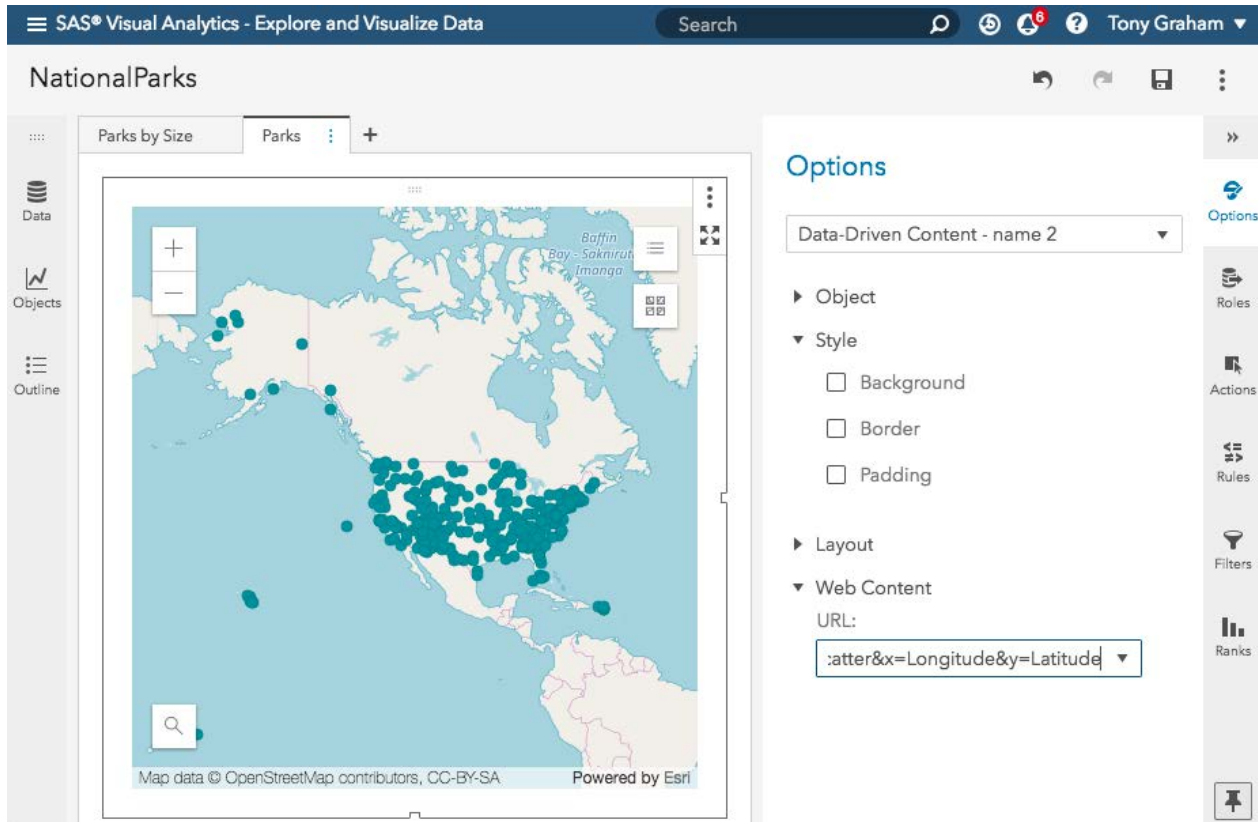
Your web map appears in your report as shown in Figure 27.



**Figure 27. Setting the Web Content URL of Your Data-Driven Object**

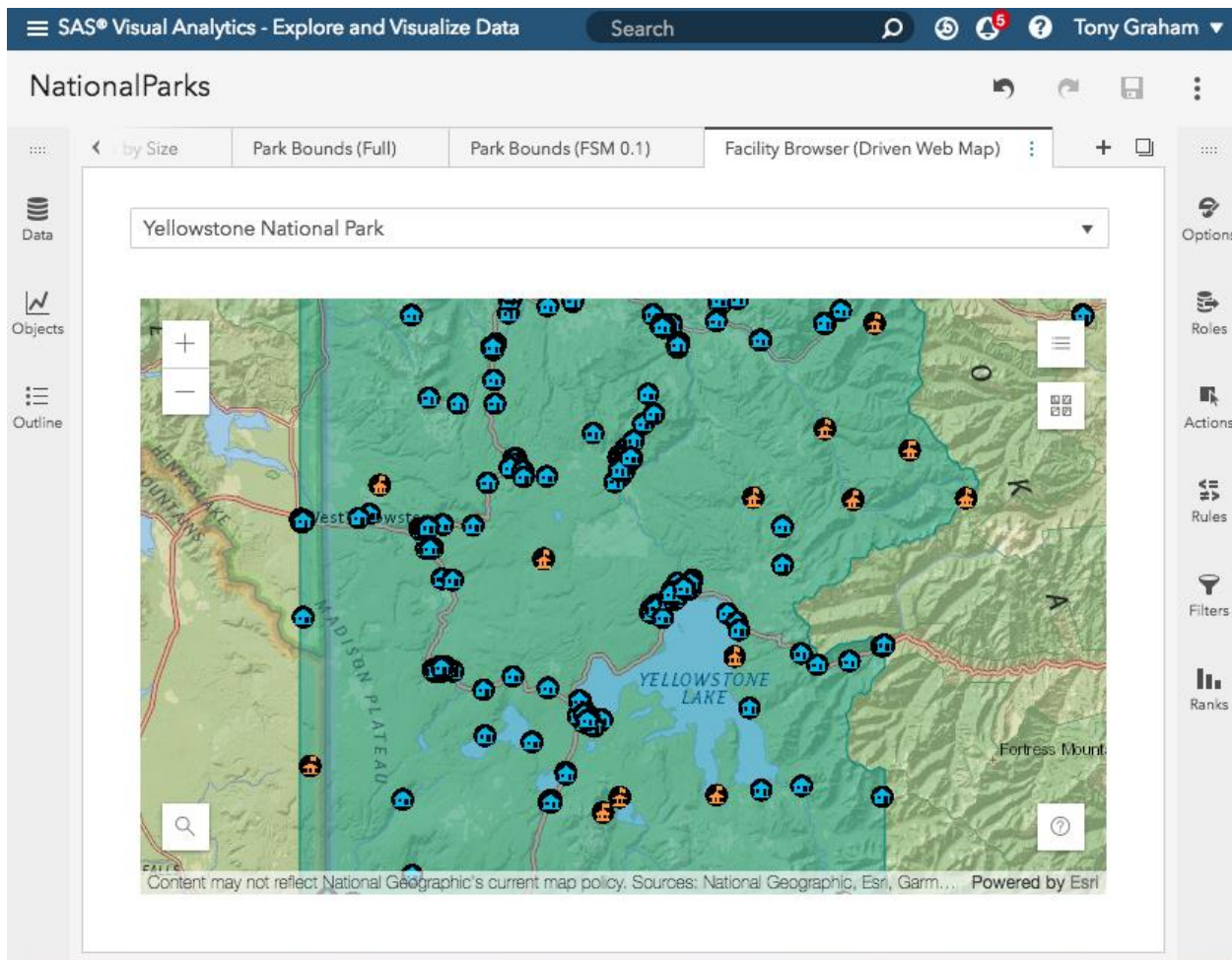
Finally, the geowebmap supports a variety of parameters to identify the data roles and visualization type for a dynamically generated SAS layer. For example, to specify a simple scatter plot above a base map, you could add the following to your URL:

`my.geowebmap.site/?visualizationType=scatter&x=Longitude&y=Latitude`



**Figure 28. Building a SAS Layer**

If you also include a **"portalItemId"** in your URL, you can insert the SAS layer inside the web map. In the following example, a SAS Visual Analytics report contains a data source that contains the names of US national parks. It includes a *Data-Driven Object* whose URL parameters are set to match those names with an ArcGIS feature service that describes park boundaries. The report uses these boundaries to build a SAS layer. In the result, you can filter and navigate among the parks as well as control the visibility of all the web map's layers.



**Figure 29. Navigating National Park Service Data with Esri Web Maps in SAS Visual Analytics**

For a full list of parameters and supported visualizations, see the [geowebmap project on GitHub \(https://github.com/sassoftware/sas-visualanalytics-geowebmap\)](https://github.com/sassoftware/sas-visualanalytics-geowebmap). The open-source code is available not only for the web map integration but also as a potential reference for other custom Esri applications for SAS Visual Analytics. Collaboration is welcome. SAS continues to investigate closer integration with Esri.

## CONCLUSION

Regardless of your mapping needs, understanding your data and configuring the appropriate geography column is a crucial first step for successful map creation in SAS Visual Analytics. Once mastered, using the interactive mapping tools from the partnership between SAS and Esri that are described in this paper will enable you to uncover relationships and gain actionable information from your data that was not possible before.

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## RECOMMENDED READING

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