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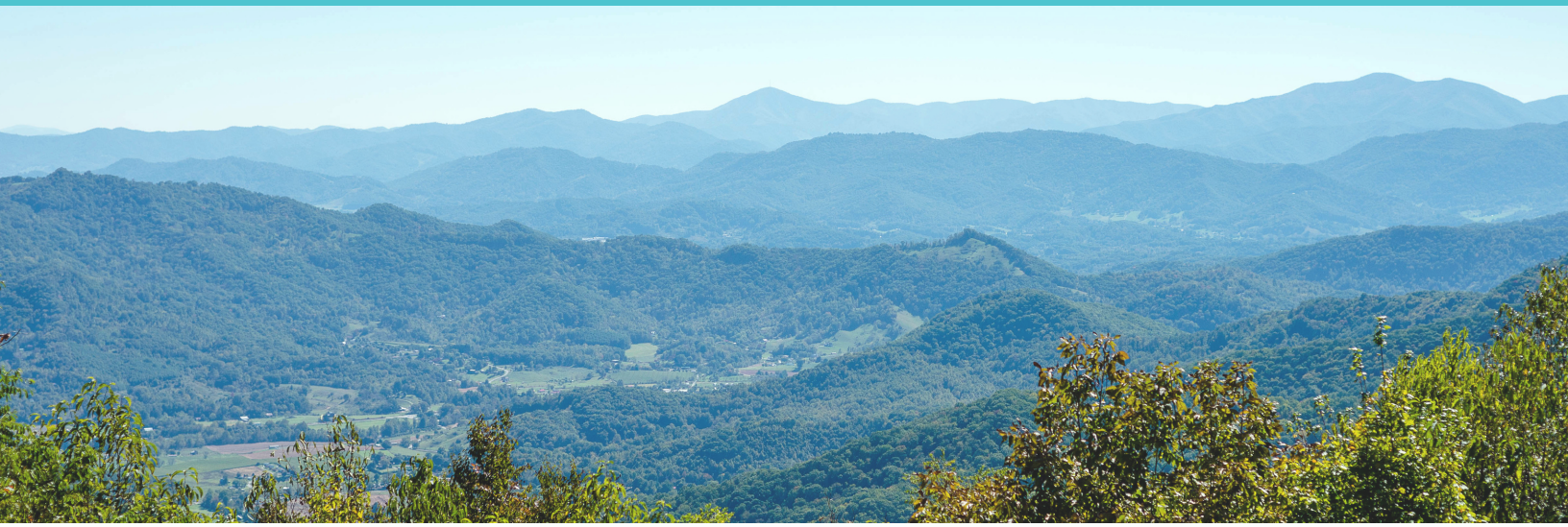

Geocoding in ArcGIS Pro

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Introduction

Geocoding is the process of transforming descriptive location data (i.e. a list or table of addresses) into georeferenced points on a map. Geocoding is an exceptionally useful tool for spatially visualizing *where* patterns or trends may be occurring. Applications of geocoding are broad and are implemented in a variety of industries; from health and epidemiological studies, transportation networks, to business analytics and finance, these are just some of the ways geocoding is used to inform decisions.

In the nonprofit sector, establishing a quantifiable link between community impact and services offered can be easily achieved with geocoding. Nonprofit organizations can gain valuable insights with geocoding by leveraging the data that is regularly gathered on funders, donors, and grantees, stories of change, and other impact-related information. By implementing a "where context" nonprofits stand to not only gain a deeper understanding of existing gaps, but are subsequently better equipped to improve strategies and communicate impacts.

Advancements to technology have enabled access to many online geocoding services (Geocodio, U.S. Census Bureau, Google Maps) but such services come with a number of disadvantages. Some of the common constraints when using an online geocoding service include the limited number of addresses that users can geocode at no cost before purchasing additional licensing (≤ 1000). Additionally, there is limited quality control during the geocoding process, which can lead to errors and misleading results. This tutorial shows you how to geocode addresses using ArcGIS Pro's integrated geocoding service. After working through the tutorial you will create a thematic map to identify the distribution of PPP loans in Northeast Tennessee / Clinch-Powell Service area and persistent poverty counties (PPC).

Objectives:

- Source PPP loan addresses, shapefiles, and PPC data to prepare for use in ArcGIS Pro
- Use Selection Queries to select and filter feature layers
- Create an address locator to geocode addresses
- Use spatial joins to identify counts of PPP loans in the Clinch-Powell service area and PPC's
- Create a thematic map with geocoded results

Estimated time of completion: 3-4 hours. Download all required data prior to starting tutorial to avoid delays.

NOTE: ESRI software such as ArcGIS Pro are best supported on Microsoft Windows operating systems. Make sure to check system requirements before installing the program. Depending on the version of ArcGIS Pro installed may slightly change the user interface. This geocoding tutorial was developed with ArcGIS Pro version 2.9.2.

Getting started

HOW GEOCODING WORKS

1. The process of converting addresses into geographic coordinates involves two primary steps: 1. Create an address locator, and 2. Address matching. An ***address locator*** is also known as a reference dataset, and it includes a range of address attributes that represent streets, or the best approximation of an existing address.
2. An address locator is essential to the geocoding process. An address locator has two components; the reference data itself and its role (format). The ***Locator Role*** defines the type of reference data being used to match with the input list of addresses. Depending on the locator role, the input address data must be the same type as the reference data (e.g. full street address, city, or postal).
3. The locator role can be defined several ways; ***Street Address*** is a common locator type which describes street addresses based on *a range of addresses* that represent actual house or building locations. Another common locator type is ***Postal***, which describe postal codes and localities represented as *polygons*. (To learn more about common locator roles visit ArcGIS Online: Geocode Addresses).
4. The geocoding tool in ArcGIS Pro parses through the input address information and matches each address to another known list of addresses (address locator). The reference information allows for our list of addresses to be correctly georeferenced on a map. Each match is then scored and the match with the highest score is selected in the output.

Gathering the Data

DATA MANAGEMENT AND PRE-PROCESSING

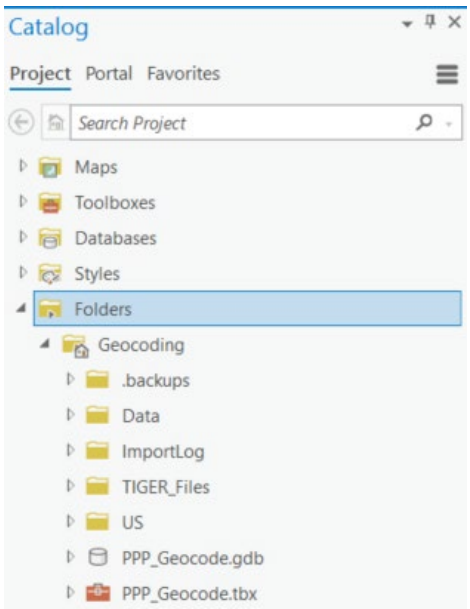
1. The data we'll be working with was originally compiled and published by the Small Business Administration. The SBA regularly releases data related to the Paycheck Protection Program (PPP) and is a publicly available dataset. The original data is published in separate CSV's based on the loan amount; the dataset used in this tutorial was concatenated by Geocodio for ease of use and is available for free. Download the PPP loan comma delimited file (.csv) called PPP Full June 2021 (NOTE: File is large and may take several minutes to download).
2. In addition to the PPP data, we need to download a geographic shapefile which we will later use for mapping in ArcGIS Pro. To download a shapefile of the U.S. visit the Census Bureau's TIGER/Line website. Select ***Web Interface***. Next, for the ***year***, select "*2021*", for ***layer type*** click the drop-down to select "*Counties (and equivalent)*" then click submit and download national file. The PPP data ranges between 2020-2021, therefore we will use the most recent version of the U.S. shapefile for the analysis. (To learn more about shapefiles, coverages their applications visit ESRI ArcGIS online and Census Bureau).

3. Now we need to source and download a few TIGER/Line ***Address Range-Feature*** county-based shapefiles which we will use to build an address locator. These files are ***polyline*** shapefiles compiled and managed by the Census Bureau and contain potential address ranges, not individual addresses, for a county or equivalent area, and are considered to be the best source for geocoding.
4. To download the files, return to the Census Bureau's TIGER/Line website, click the ***FTP Archive*** then select ***ADDRFEAT/*** folder. Since coverages for address ranges are only available at the county level, we need to download the corresponding file for each individual county of interest. We will download a total of eight files for each county in the Clinch-Powell service area (*Claiborne, Grainger, Hamblen, Hancock, Hawkins, Jefferson, Knox, and Union*).
5. Each file is stored by source (tl = TIGER/Line), year, and Federal Information Processing Standards (FIPS codes). The state FIPS for Tennessee is ***47***; county FIPS can be found with a quick google search. Begin downloading ***tl_2021_47025_addrfeat.zip, tl_2021_47057_addrfeat.zip, tl_2021_47063_addrfeat.zip, tl_2021_47067_addrfeat.zip, tl_2021_47073_addrfeat.zip, tl_2021_47089_addrfeat.zip, tl_2021_47093_addrfeat.zip,*** and ***tl_2021_47173_addrfeat.zip.***
6. The final step will be to download a separate file of persistent poverty counties (PPC) in the United States. We will overlay this data with our geocoded loan data to identify the count of PPP loans distributed in persistent poverty counties. The data can be found on the U.S. Economic Development Administration (EDA) website (click hyperlink to download file ***FY_2021_PPCs***).
7. Before we begin working with the data, we need to complete a few data management steps. File naming conventions in ArcGIS Pro are specific and should be followed closely to avoid potential issues. For example, no spaces or punctuation should be used to name files.
8. First, create a new folder where all your files will be stored. On your computer open the file explorer and create a folder called ***Geocoding***. It is recommended that you work on a local drive (C:) instead of a VPN or shared network as this reduces software errors.
9. Within the ***Geocoding*** folder, create a new folder named ***Data***, and a separate folder ***TIGER_Files***. In the ***TIGER_Files*** folder, create two separate folders called ***US*** and ***Tennessee***.
10. Once complete, extract the PPP file (***PPP_full_geoodio.zip***) into the ***Data*** folder you just created (if any errors occur, check to see what was extracted, delete those files and try extracting again). Repeat these same steps with the TIGER Line shapefile ***(tl_2021_us_county.zip***) and extract to the ***US*** folder. Finally, begin extracting the address feature files into the ***Tennessee*** folder.
11. Open the ***FY_2021_PPC*** file. Open a new Excel window and copy each column into a separate sheet. Insert a row under the header and input 'x' in the cell under FIPS (A2). Name the file ***FY2021PPC*** (make sure to save as .CSV) and save it in the ***Data*** folder (NOTE: ArcGIS Pro only accepts single-sheet CSV files.)

Geoprocessing

IMPORT DATA AND COMBINE LAYERS

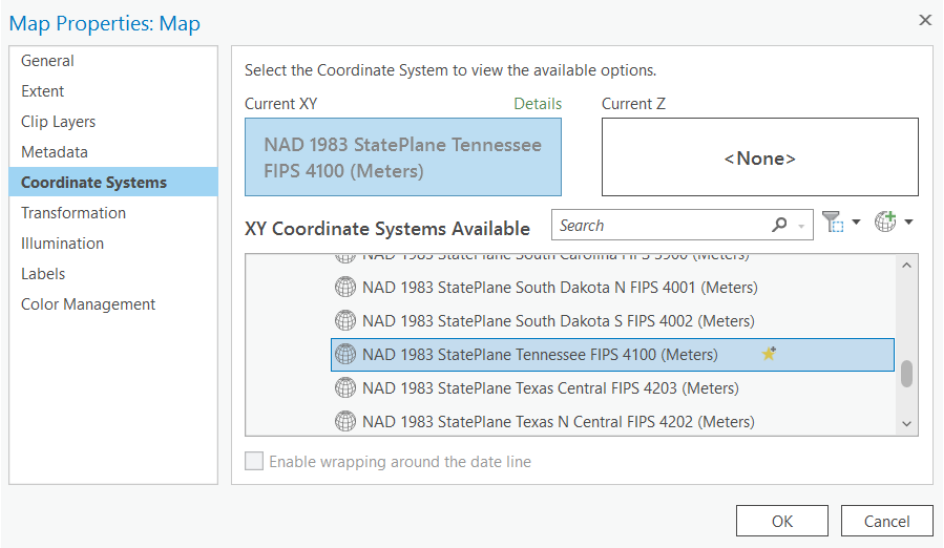
12. Open ArcGIS Pro. Under ***Blank Templates*** select **Map**. A "*Create a New Project*" dialog box will appear. Next to ***Name*** enter ***GeocodingPPP***. Click the folder next to ***Location*** and browse to the ***Geocoding*** folder you created to store your map document (ext. aprx). Deselect the checkbox to "Create a new folder for this project." Once finished click *OK*. (NOTE: ArcGIS Pro automatically creates a new geodatabase (.gdb) with your map document. A geodatabase is a relational database native to ArcGIS where all feature layers are stored within your project).
13. Remove the default feature layer ***Topographic*** from the workspace. Navigate to ***View*** located in the ribbon and select ***Catalog Pane***. The *ArcCatalog* is an integrated window where various types of tabular and spatial data are created/edited, stored and managed. This includes geodatabases, map documents, metadata, shapefiles, and much more (Learn more about the Catalog Pane by visiting [ESRI: Catalog Pane, Catalog View, and Browse Dialog Box]).
14. Begin adding data to the workspace. In the Catalog pane, click the dropdown next to ***Folders***. The ***Geocoding*** folder we created earlier should be listed here. If there is not a folder, **right-click *Folders* > add folder connection**. Navigate to the location where you stored the ***Geocoding*** folder and connect to this folder. Once connected, the folder should appear in the Catalog with the corresponding data. If not, **right-click *Folders* > refresh**.



15. In the ribbon select ***Add Data***, navigate to the ***Tennessee*** folder with all your address files, and add all the ***addrefeat.shp*** files to the workspace. Add the

tl_2021_us_county.shp as well. Alternatively, you may click and drag each file to the workspace from the ***Catalog*.**

16. The first thing we must do is ensure that the ***spatial reference properties*** (e.g. geographic coordinate system (GCS), datum and projected coordinate system (PCS)) of our feature layers match. For the purposes of this tutorial, a GCS and datum are frames of references used to model the Earth; a PCS is simply a 2D representation of the Earth (e.g. Mercator Projection). When spatial properties are not the same, the layers do not align; therefore, it is important to always check the spatial reference properties of the data.
17. Open the map properties in the contents table on the left side of the screen. Right-click ***Map > Properties > Coordinate systems***. Click ***Details***. Here we have our spatial reference information for our layers. Notice how no projected coordinate system is listed, so we will need to assign one. To assign a projected coordinate system, scroll down to ***Projected Coordinate System > State Plane > NAD 1983 (Meters) > NAD 1983 StatePlane Tennessee FIPS 4100 (Meters)*** and click *OK*.



18. Click ***Details*** again to verify the PCS has been applied successfully to the map. Close the window. In the workspace, notice how the selected PCS changes how the map is displayed.
19. ***Right-click*** any of the ***addrfeat.shp*** layers and select ***Zoom to Layer*** and use the scroll bar to zoom in and get a closer look at the alignment of the shapefiles. It appears that everything is aligned correctly!
20. Open the attribute table for any two of the ***addrfeat.shp*** layers, ***right-click > Open attribute table***. Notice the attributes listed here (LFROMHN, LTOHN, RFROMHN, RTOHN, ZIPL, and ZIPR). These fields describe the direction or side of a street an address is located on, e.g. left or right. We will use these later to build the address locator.

21. Now it's time to combine our layers. In the ribbon select ***Analysis > Geoprocessing***. In the search bar type in ***Merge***. The merge tool combines datasets from multiple sources and creates a new consolidated output dataset. Begin adding all the ***addrfeat.shp*** layers under ***Input Datasets.*** Click the folder next to ***Output Dataset***, rename layer ***ne_tn_addrfeat*** and make sure it is saved in your geodatabase. Next, to ***Merge Rule*** select ***First***. Once complete click ***Run.***
22. Remove all ***addrfeat*** layers from the contents pane to view the Merge output which should look something like the image below. Don't forget to save your progress.

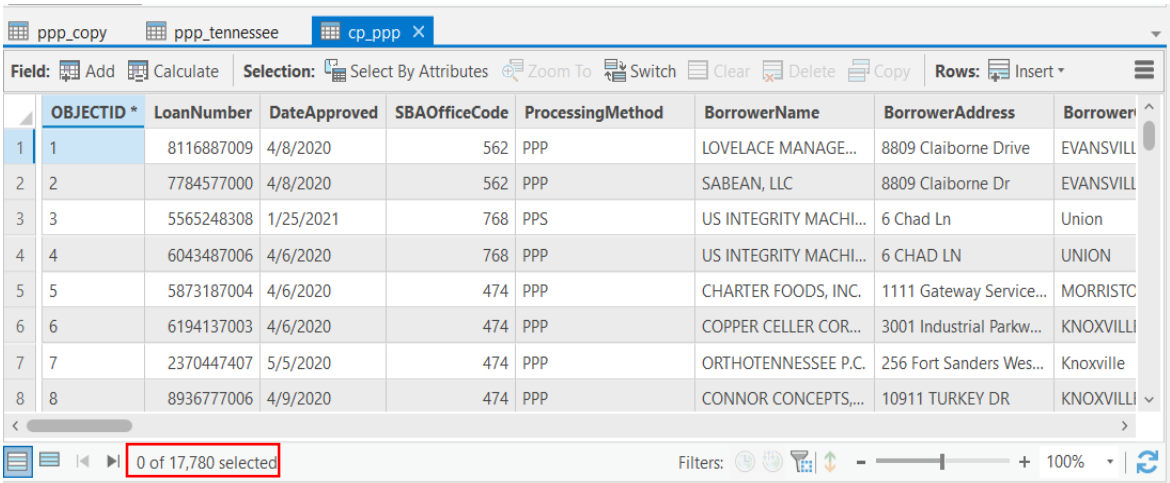
Selection Queries

MODIFY FEATURES USING SELECTIONS

23. Now we need to modify the U.S. county shapefile to filter out the counties of interest (Clinch-Powell service area). We can do this by using ***Selection Queries***. We will use ***Select by Attribute*** and ***Select by Location*** to filter out the desired counties and then export to create a new layer.
24. In the ribbon click ***Select by Attribute***. The input row will be ***tl_2021_us_county*** Leave ***Selection Type*** as ***New Selection***. In the SQL box input the following: ***Where "STATEFP" is equal to 47***. Click OK.
25. You'll notice the selected features are now highlighted in blue. Export the newly selected features as a new layer, **right-click *tl_2021_us_county* > *Data* > *Export Features.*** Name the layer ***Tennessee*** and save in your geodatabase. Remove the original U.S. shapefile from the workspace.
26. Return to the ribbon and click ***Select by Location*** then select ***Tennessee*** as the input feature. For the ***Relationship*** select ***Completely contains***. The ***Selecting Features*** are ***ne_tn_addrfeat***. Leave ***Selection type*** as ***New Selection***. Leave all other defaults. Click OK. Export the selected features and name the output ***cp_counties***, and save in the geodatabase.
27. Open the ***Catalog Pane*** and add the ***ppp-full.csv*** file to the workspace. Open the attribute table. Explore the different fields. What is included here? What do

the fields indicate? This would be a good time to review the data dictionary and metadata to better understand the data.

28. Notice how there is no ***OBJECTID**** field like we have seen with other layers. We need to add one in order to perform operations successfully.
29. In the ***Analysis*** tab, open the ***Geoprocessing Pane*** search ***Copy Rows***. The Input is ***ppp-full.csv***. Name the output ***ppp-copy***. (NOTE: Due to large number of rows, this may take several minutes to complete).
30. Let's begin by filtering out all PPP loans outside of Tennessee. Using ***Select by Attributes***, enter ***ppp-copy*** as the input. Make sure it is a ***New selection***, and type in: ***Where "State FIPS" is equal to 47***. (HINT: Make sure the attribute table is open to view selection output). Remember to export selections. ***Right-click layer > Data > Export Table***. Name the output ***ppp_tennessee***.
31. The newly exported table of PPP loans includes the entire state of TN, but we still need to filter out PPP loans that are in the Clinch Powell service area. Open ***Select by Attributes >*** select ***ppp_tennessee*** as the input, ***New selection > Where "County FIPS" is equal to 47025***. Click Apply. Don't close the window. Change ***Selection type*** to ***Add to the current Selection.*** Change the value to ***47057*** and click Apply.
32. Repeat these steps until all eight counties have been selected; the remaining FIPS codes are ***47063, 47067, 47073, 47089, 47093, and 47173***. Once finished, export the table and name the output ***cp_ppp***. The resulting table should have 17,1780 rows.



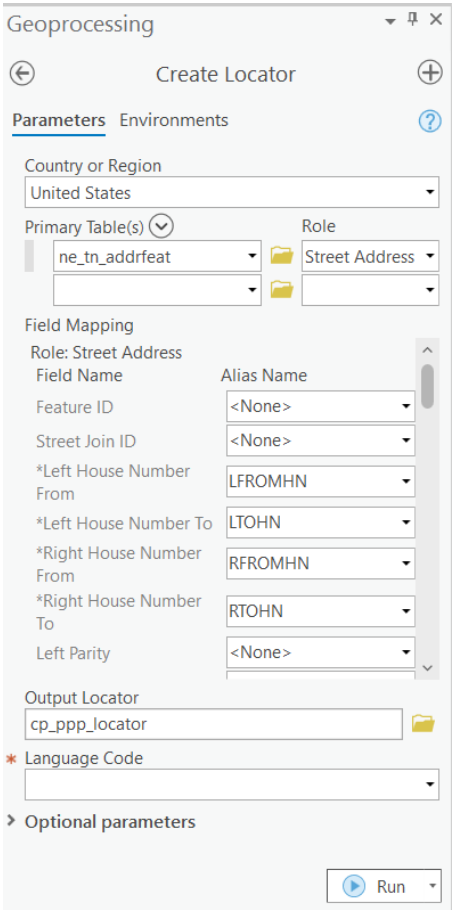
	OBJECTID *	LoanNumber	DateApproved	SBAOfficeCode	ProcessingMethod	BorrowerName	BorrowerAddress	Borrower
1	1	8116887009	4/8/2020	562	PPP	LOVELACE MANAGE...	8809 Claiborne Drive	EVANSVILL
2	2	7784577000	4/8/2020	562	PPP	SABEAN, LLC	8809 Claiborne Dr	EVANSVILL
3	3	5565248308	1/25/2021	768	PPS	US INTEGRITY MACHI...	6 Chad Ln	Union
4	4	6043487006	4/6/2020	768	PPP	US INTEGRITY MACHI...	6 CHAD LN	UNION
5	5	5873187004	4/6/2020	474	PPP	CHARTER FOODS, INC.	1111 Gateway Service...	MORRISTC
6	6	6194137003	4/6/2020	474	PPP	COPPER CELLER COR...	3001 Industrial Parkw...	KNOXVILLI
7	7	2370447407	5/5/2020	474	PPP	ORTHOTENNESSEE P.C.	256 Fort Sanders Wes...	Knoxville
8	8	8936777006	4/9/2020	474	PPP	CONNOR CONCEPTS,...	10911 TURKEY DR	KNOXVILLI

33. In the same attribute table, scroll right and take a look at the accuracy score. The accuracy score matters because an accuracy score less than (<0.6) reflects addresses that may have been entered incomplete or incorrectly. Therefore, we need to remove all PPP loans that have an accuracy score <0.8 to be safe.
34. Open ***Select by Attributes***. Use ***cp_ppp*** as the input ***> New selection > Where "Accuracy Score" is greater than 0.8.*** Export the table and name the output ***cp_ppp_final***. Remove all other tables from the workspace.

Geocode addresses

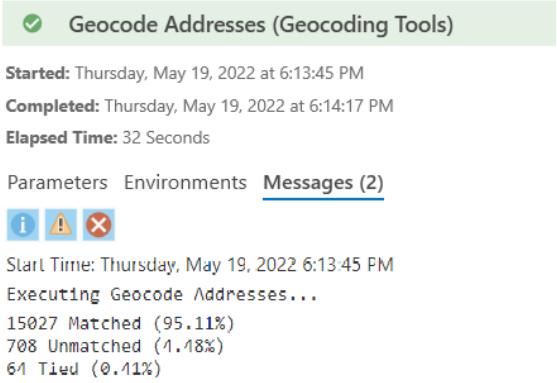
CREATE ADDRESS LOCATOR AND GEOCODE ADDRESSES

35. The address feature shapefiles are ***polyline*** and contain address ranges on both sides, therefore in order to successfully geocode, the full address is required; meaning the street address, city, state and zip must be included. We have full address information for the borrower, as well as the servicing and originating lender. The output will be points representing street addresses of where loans were allocated.
36. For the purposes of this tutorial, we are geocoding the borrower address because we are interested in uncovering the proportion of PPP loans distributed in PPCs in Appalachia, not where the capital originated from. (NOTE: Look at the other fields included in this dataset. What other fields appear to be relevant or useful to our analysis? Hint: Rural-Urban Indicator; Hub Zone; LMI)
37. Open the ***Geoprocessing Pane***. Click ***Toolboxes > Geocoding Tools > Create Locator***. For ***Country or Region*** use ***United States***. Click the dropdown next to ***Primary Table*** and use ***ne_tn_addrfeat*** as the layer. Use ***Street Address*** as the ***Locator role***.
38. Under ***Field Mapping*** we will input the ***LFROMHN, LTOHN, RFROMHN, RTOHN, ZIPL, and ZIPR*** attributes for the required fields.
    a. *Left House Number From: ***LFROMHN***
    b. *Left House Number To: ***LTOHN***
    c. *Right House Number From: ***RFROMHN***
    d. *Left House Number To: ***RTOHN***
    e. *Street Name: ***FULLNAME***
    f. Left ZIP: ***ZIPL***
    g. Right ZIP: ***ZIPR***
    h. Language Code: ***English***
39. Click the folder and save in your ***Geocoding*** project folder, not the geodatabase, as ***cp_ppp_locator***. Once finished click ***Run***.

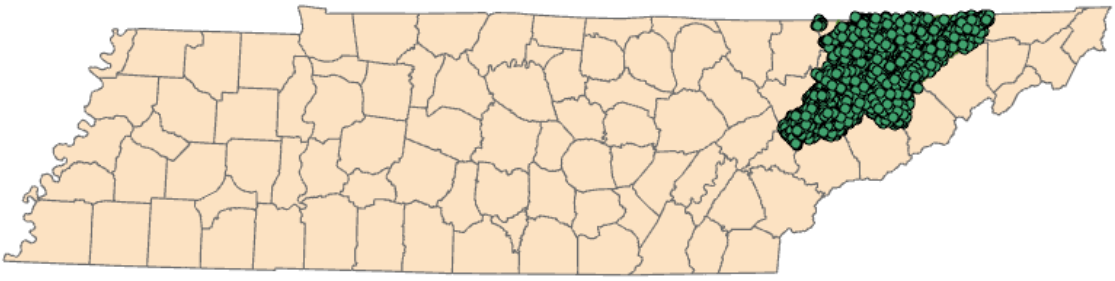


40. Navigate back to the ***Geoprocessing Pane > Geocoding Tools > Geocode Addresses.***
41. Select ***cp_ppp_final*** as the input table. Under ***Input Address Locator*** select the locator we just created ***cp_ppp_locator***.
42. For ***Input Address Fields*** select ***Multiple Field***. Because our list of PPP addresses is split into multiple columns versus the full address stored in a single column, the multiple fields mapping is appropriate.

43. In the fields below, we need to indicate which fields we want the address locator to match with.
    a. Address or Place: ***BorrowerAddress***
    b. Address2: ***Street***
    c. City: ***BorrowerCity***
    d. County: ***County***
    e. State: ***BorrowerState***
    f. ZIP: ***BorrowerZip***
44. Name the output ***cp_ppp_geocoded*** and save to your project folder. Once complete, click ***Run.***
45. Once the geocoding process is complete we can review how well it worked by reviewing the results. It is rare to obtain a matching score of 100%, but typically, any score below 80% will require corrections. In this case, the matching score was ***95.11%***, therefore it is not necessary to go back and correct the input addresses.



46. If the output is not automatically added to the map, open the ***Catalog*** and add the ***cp_ppp_gecoded*** result.
47. **Right-click *cp_ppp_geocoded* > *Data* > *Export Features* >** save the output as ***ppp_points*** in your ***geodatabase***. Remove the original geocoding result from the workspace.



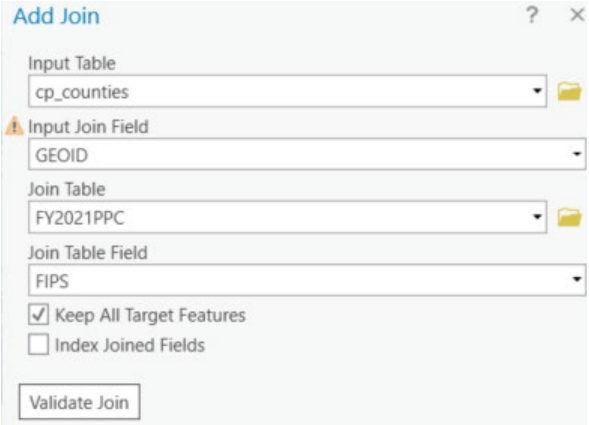
48. NOTE: We created an address locator to geocode PPP loans, but ArcGIS Pro also offers the ***ArcGIS World Geocoding Service*** as an alternative to purchasing a separate reference dataset, or manually building an address locator. This integrated, ready-to-use service allows users to easily find and geocode

addresses around the world, however it also requires an organization subscription and uses 40 credits per 1000 addresses.

Joins and Spatial Joins

JOIN FEATURE LAYERS

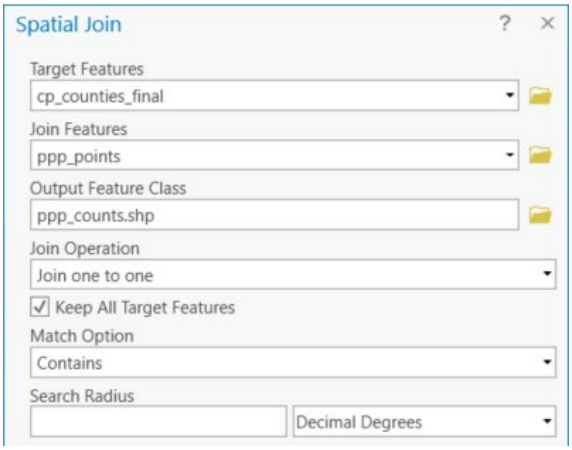
49. **Right-click *ppp_points* > *Zoom to Layer***. With the new point file, we can see the real-world location of PPP loans across the different counties and visually identify where more loans were distributed. (NOTE: Try overlaying the ***ppp_points*** layer with the ***ne_tn_addrfeat*** feature layer to visualize their positioning along the streets).
50. If you cannot view the output, ensure that the ***Drawing Order*** is set to ***List by Drawing Order***  to click and drag layers in the ***Contents Pane***.
51. We still need to determine the count of PPP loans in each county to identify the proportion of PPP loans located in persistent poverty counties. Open the ***Catalog Pane***. Add the ***FY2021PPC.csv*** file to the workspace and open the attribute table.
52. Like the PPP file, it is missing the ***OBJECTID**** field. Open the ***Geoprocessing Pane > Copy Rows >*** input ***FY2021PPC.csv***. Name the output ***FY2021PPC***. Make sure to save in the ***Data*** folder.
53. Using ***Select by Attributes***, input ***FY2021PPC*** then in the SQL box input ***Where "State" is equal to 'TN'***. Export to a new table and name the file ***PPC_TN***. Now our table only includes PPC attributes for Tennessee counties, but we still need to join it to a shapefile so we can map them.
54. Open the attribute tables for ***PPC_TN*** and ***cp_counties***. Notice any commonalties between the fields? When joining tables in ArcGIS, a common key is required to match rows. We will use the ***GEOID*** and ***FIPS*** fields in each respective table to join the layers.
55. ***Right-click cp_counties > Joins and Relates > Add Join.*** Fill in the required fields to match the example below. Once complete click *OK*.



56. To verify the join worked, open the attribute table for ***cp_counties*** and scroll to the end. Null values are OK as not all counties in the Clinch Powell service area

are designated as PPC. Only PPC counties in TN were directly matched to rows in our counties layer.

57. Export ***cp_counties*** to a new feature layer and name the output ***cp_counties_final***. Then, remove all joins **Right-click *cp_counties* > *Remove All Joins***.
58. Because we are interested in which PPP loans are in PPC we need to create a new layer with only PPC counties that we will overlay with our loan data. Click ***Select by Attribute*** **>** use ***cp_counties_final*** as the input **> *Where "COUNTYFP" is equal to 025***. Click ***Apply***. Make sure to change ***Selection type*** to ***Add to current selection*** for ***067***, and ***173***. Name the output ***PPC*** and Click *OK*.
59. Now we need to join our geocoded points to our county feature layer to determine the count of PPP loans distributed in persistent poverty counties. We will use a ***Spatial Join*** to combine our PPP points and county layers. ***Right-click cp_counties_final > Spatial Join.***
60. In the dialog box select ***ppp_points*** as the ***Join features***. Name the output ***ppp_counts*** and save in the geodatabase. Select ***Join one to one*** as the ***Join Operation*** and ***Contains*** as the ***Match Option***. Turn off the ***cp_counties_final*** layer. (Learn more about Joins and Spatial Joins through ESRI online).



61. Open the attribute table for ***ppp_counts***. Notice the newly added ***Join_Count*** field. This field is created when using spatial joins, and it tells us how many (count) of the join features (ppp points) are located within the target feature (Clinch-Powell counties). At first glance we can see that Knox County received the largest count of PPP loans, with 11,469 displayed in the ***Join_Count*** field.

Creating final maps

EDIT SYMBOLOGY

62. We can finally begin editing ***Symbology*** to create our final thematic map. Turn on the ***ppp_counts*** and ***PPC*** layers. Turn off all other layers or remove them from the contents pane.
63. Let's start by editing the ***Symbology*** of the ***PPC*** layer. Hover your cursor over the ***PPC symbol*** and double-click to change its properties. Under ***Gallery*** select the

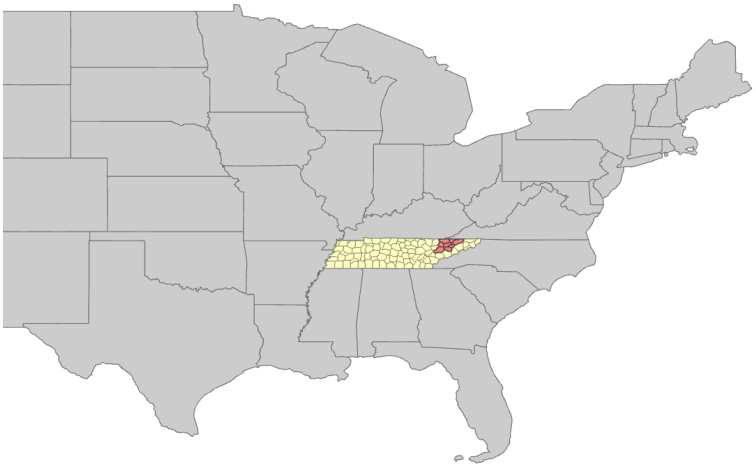
Black Outline option. Then under ***Properties*** change the ***outline color*** to yellow and the ***outline width*** to 3pts. Click ***Apply.***

64. ***Right-click ppp_counts > Symbology***. Under ***Primary Symbology*** select ***Graduated Symbols***. Select ***Join_Count*** as the ***Field***, leave ***Method*** as ***Natural Breaks*** and change number of ***Classes*** to 4.
65. Next to ***Template*** click the symbol and change the color to red. Then, ***right-click*** the ***Background*** option and select ***No Color***. (NOTE: Try exploring other symbol options by changing the point size (min/max), outline width, and symbol type to visualize different styles).
66. Return to ***Primary Symbology***. Because our values are counts of PPP loans with a large range between the minimum (92) and maximum (11,469), the natural breaks classification method is appropriate to use for this analysis. Try changing the method to ***Equal Interval*** to see how it distorts symbols. (NOTE: Click the ***Histogram*** tab to visualize the distribution of the values to help choose the most appropriate classification method).
67. We need one more layer to complete the map. ***Right-click ppp_counts > Copy > Paste***. Make sure to right-click ***Map*** to paste in the contents pane. Open the ***Symbology*** tab and select ***Unique Values***, then change the value ***Field*** to ***USER_LMIIn***.
68. Click ***More*** and deselect ***Show all other values***. Choose a ***color scheme*** from the drop-down. To manually change colors, ***double-click the symbol*** and change Y to green and N to purple.

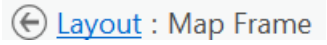
CREATE AN INSET MAP

69. When doing any type of local analysis, it is encouraged to include what is called an ***Inset Map***. These maps help provide context for end-users that may not be familiar with the area of interest. We want to show where counties in the Clinch-Powell service area are relative to other counties in TN and surrounding areas.
70. In the ribbon, click ***Insert > New Map***. Remove the default ***Topographic*** layer. We will use three shapefiles to create the inset map. Open the ***Catalog*** to add ***cp_counties_final, Tennessee*** and the ***tl_2021_us_county*** files to the workspace.
71. Open the ***Geoprocessing Pane*** and search for ***Dissolve***. Use the U.S. shapefile as the input, then name the file ***us_dissolve >*** select ***STATEFP*** as the ***Dissolve*** field.
72. Remove the original U.S. shapefile and click and drag the layer beneath Tennessee. Change the symbol color to a light gray.
73. ***Double-click*** the ***Tennessee*** layer symbol and change the color to something neutral, like a light yellow. Change the outline color to black.

74. Lastly, open the symbol properties for ***cp_counties_final*** and change the color to something bright to contrast against the other layers. Change the ***outline width*** to 1pt.

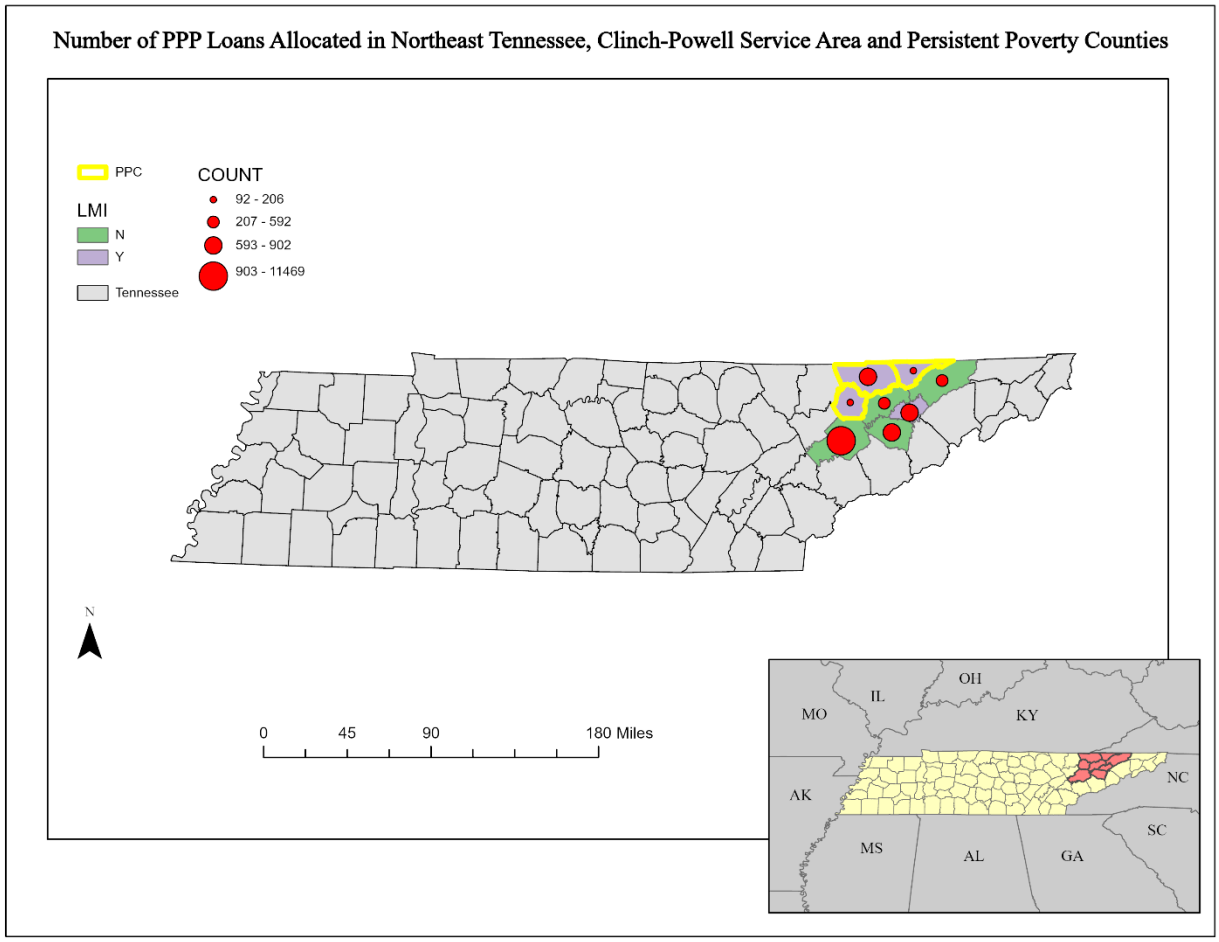


CREATE THEMATIC MAP

75. Navigate back to the ribbon and select ***Insert > New Layout > Letter 8.5 x 11***. A new tab will appear. Click the drop-down next to ***Map Frame*** and select the map with the PPP loan and LMI feature layers. Then click anywhere in the white space to insert the map.
76. Click and drag the frame to adjust the size to where the margins are equal. In order to center the map frame, ***right-click the white space > Align to Page, then right-click again > Align to Center***.
77. You can further adjust the positioning of the map itself by activating the map frame. In the ***Contents***, **right-click *Map Frame > Activate***. To exit simply click ***Back to Layout*** at the top. 

Make sure to leave ample space to add in cartographic elements, such as, a scale bar, North arrow, and legend.
78. Return to the ***Map Frame*** dropdown and add the map frame with the Tennessee, U.S. and Clinch-Powell service area feature layers we prepared earlier. Click and drag to adjust the margins to fit TN and surrounding states.
79. To label the states, select ***Straight text*** in the ***Graphics and Text*** box then click to insert the text box. Change font to ***Times New Roman, 10pt*** and label states (e.g. KY, GA, AL, MO…).
80. In the ribbon, the ***Map Surrounds*** box contains all the elements you will need to make the final map. Click each element one at a time then click the cursor in the white space to add each element.
81. To edit map elements, ***right-click > properties***. Alternatively, you may double-click the desired element in the ***Contents*** to open its properties. In the window on the right you can modify text fonts and size, labels, and placement and positioning of all the map elements. (NOTE: For additional information on formatting map elements visit ESRI: Layouts and Map Surrounds to learn more).

82. To add a title, click ***Straight Text*** and then click and drag the cursor to insert the text box. Name the map ***"Number of PPP loans Allocated in Northeast Tennessee, Clinch-Powell Service area and Persistent Poverty Counties."***
83. To add a border or neatline, click the drop-down ***for Graphics and Text > select rectangle > click and drag across the map*** to adjust the frame. Remember to also add a citation for the data, (e.g. Small Business Administration and Geocodio, and the U.S. Census Bureau) and your name as the author.
84. Finally, to export map navigate to the ribbon and select ***Share > Export Layout***. On the right export the map as a PNG file. PNG is the recommended file type for exported GIS products that may need to be shared online or inserted in other documents because it preserves text and lines best.
85. Name the output ***ppp_final_map*** and make sure to save in your project folder.



Additional resources

ArcMap vs. ArcGIS Pro

Common GIS formats

Managing GIS Data

ESRI Training

2021 TIGER/Line Technical Documentation