Evaluate COVID-19 Financial Vulnerability

Lesson Overview

State and local governments have taken unprecedented actions to slow the transmission of coronavirus disease 2019 (COVID-19), including mandatory business closures and safer-at-home policies. These actions, while necessary to protect public health, have significantly impacted the economy.

As transmission rate slows, policymakers must make challenging decisions about when and where to reopen businesses and relax social distancing requirements. Economic impacts have not been uniform across the United States, and not everyone is equally equipped to weather the financial challenges of the pandemic. Understanding a community's ability to cope with the financial consequences of COVID-19 can inform decisions of where and when to reopen the economy.

This lesson outlines a proposed data-driven approach for mapping the level of financial vulnerability across a region. Financial vulnerability occurs when income and liquid financial assets are insufficient to cover debt payments and basic living costs. Just as you can't measure physical health by only looking at blood pressure, you can't measure financial health by only looking at a single variable. For this lesson, you'll model financial vulnerability as a function of income, expenditures, and external factors that can negatively impact income.

Builds skills in

➢ Create multivariate vulnerability scores

➢ Create a predominance map

Software requirements

➢ ArcGIS Pro 2.5 or later (get a free trial)

➢ ArcGIS Business Analyst extension

➢ 27 credits (optional)

Estimated time

30 minutes

Exercise

Step 1: Download data

First, you'll download the ArcGIS Pro package and confirm that you have the necessary extension for completing the workflow.

1. Go to the COVID-19 Financial Vulnerability item on ArcGIS Online and click **Download**.

2. Double-click the downloaded COVID19FinancialVulnerability.ppkx to open the project in ArcGIS Pro. If prompted, sign in to your ArcGIS organizational account.

The map shows census tracts for Summit County, Ohio, the location of Akron, a moderate-sized city. This workflow can be applied to any county, state, or even the whole country. A small area is used to simplify the lesson.
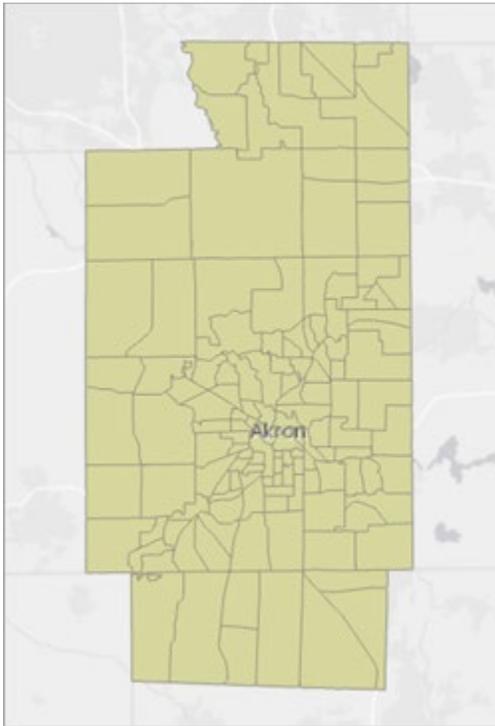
3. On the ArcGIS Pro ribbon, click **Project**. Choose **Licensing**.

4. Under **Esri Extensions**, confirm that you have a Business Analyst license, required to complete this lesson.

If you do not have the necessary license, you can contact the administrator of your ArcGIS organization to enable it.

5. Click the back button to return to the map.

Step 2: Enrich data with vulnerability variables

Next, you'll acquire the data about income, expenditures, and other variables that you'll use to assess financial vulnerability. You'll find these variables using the **Enrich Layer** geoprocessing tool, which adds demographic data to a layer based on its geographic location.

1. On the ribbon, click the **Analysis** tab. In the **Geoprocessing** group, click **Tools**.
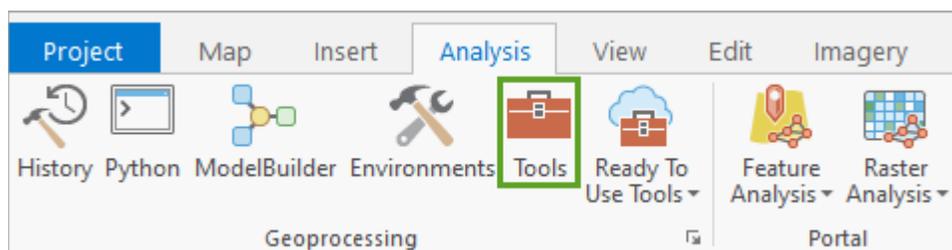

The **Geoprocessing** pane appears.

Using the **Enrich Layer** tool consumes credits. The number of credits consumed depends on the number of variables and the size of the geographic area. For this lesson, the tool consumes 27 credits.

If you don't want to spend any credits, running the tool is optional. The project package includes the **Summit_County_Data** layer, which is enriched with the appropriate data variables. Even if you don't run the tool, it's recommended that you complete the following steps to learn how to configure the parameters for the tool.

2. In the **Geoprocessing** pane, search for and open the **Enrich Layer** tool.
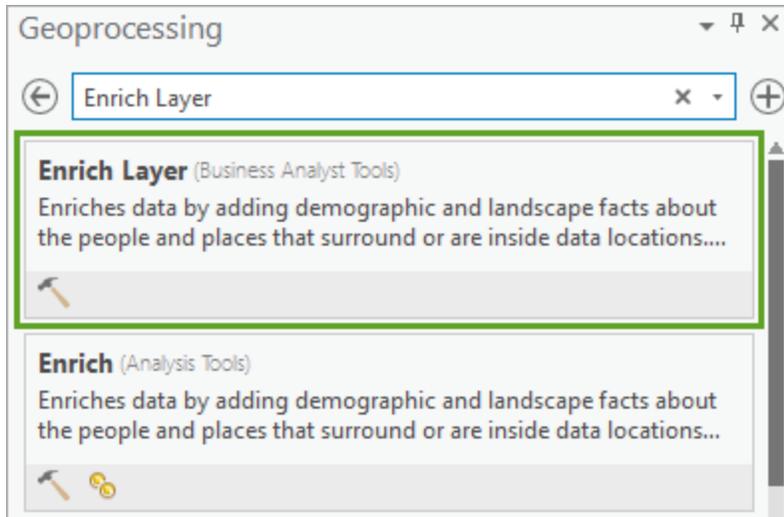
3. For **Input Features**, choose **Summit County**. For **Output Feature Class**, type Summit_County_Data.
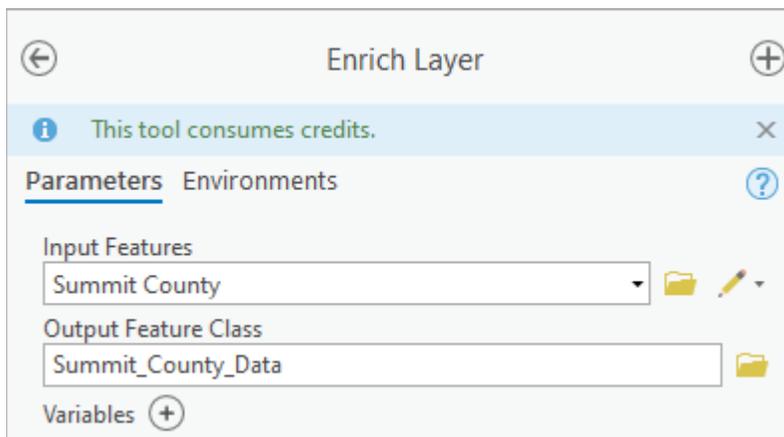
4. Click the **Variables** add button. In the **Add Variable** window, search for and add the following variables for the most recent available year. (For variables followed by Percent, select the percent sign and deselect the number sign):

- Median Household Income
- Median Disposable Income
- Per Capita Income
- ACS HHs: Inc Below Poverty Level: Percent
- ACS HHs w/Food Stamps/SNAP: Percent
- Pct of Income for Mortgage
- ACS HHs/Gross Rent 30-34.9% of Income: Percent
- ACS HHs/Gross Rent 35-39.9% of Income: Percent
- ACS HHs/Gross Rent 40-49.9% of Income: Percent
- ACS HHs/Gross Rent 50+% of Income: Percent

- ACS Pop <19: No Health Insurance: Percent
- ACS Pop 19-34: No Health Insurance: Percent
- ACS Pop 35-64: No Health Insurance: Percent
- Food Service/Drinking Estab Emp (NAICS): Percent
- General Merchandise Employees (NAICS): Percent
- Motor Vehicles/Parts Dealers Emp (NAICS): Percent
- Arts/Entertainment/Rec Emp (NAICS): Percent
- Occupation: Personal Care: Percent
- ACS HHs w/No Internet Access: Percent
- ACS Owner HHs by Vehicles Avail: 0: Percent

5. In the **Add Variable** window, confirm that 20 variables are selected.

6. Click **OK**.
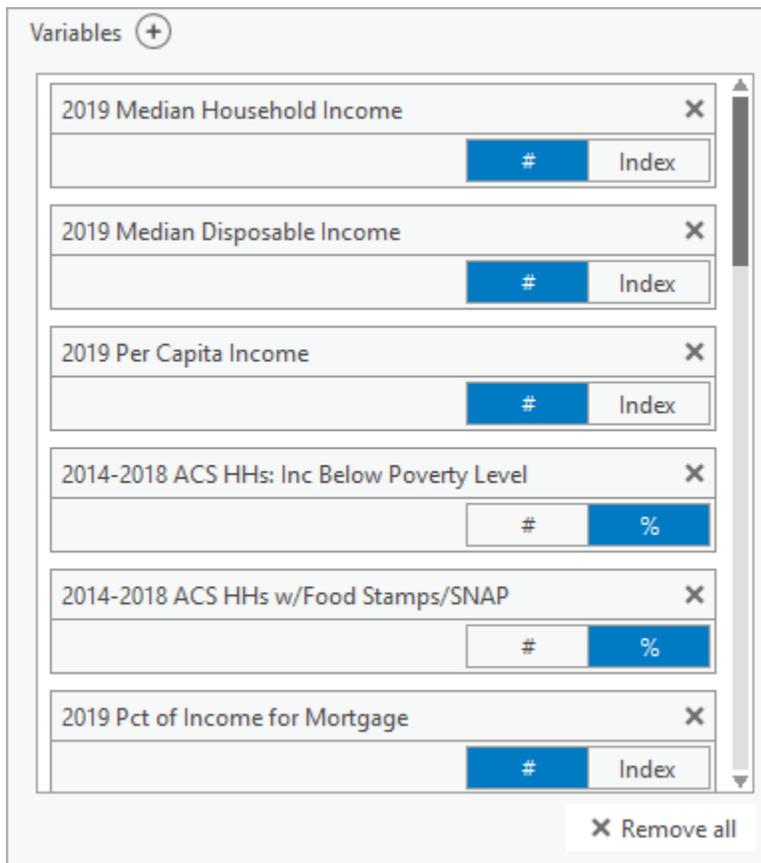
Rather than running the tool and expending credits, you'll close the tool and review the **Summit_County_Data** layer provided with the project, which contains the enriched data.

7. In the **Geoprocessing** pane, click the **Back** button.

8. In the **Contents** pane, right-click the **Summit_County_Data** layer and choose **Attribute Table**.

The fields have been added to the original Summit County layer. Each of the variables, along with the rationale for including them, is provided at the end of the lesson. These variables capture the five components of financial vulnerability discussed above. You can, and should, add additional variables you feel would be useful.

9. Close the attribute table.

Step 3: Determine vulnerability

Now that you've acquired the variables, you'll use tools from the Business Analyst extension to determine the vulnerability of each census tract in the county.

1. In the **Geoprocessing** pane, search for and open the **Make Suitability Analysis Layer** tool.

This tool creates a layer in the **Contents** pane to store your analysis. Although the tool name includes suitability analysis, you can use it for any type of overlay analysis.

2. For **Input Features**, choose **Summit_County_Data**. For **Layer Name**, type Financial Vulnerability.

3. Click **Run**.

The tool runs and the layer is created. Next, you'll choose the fields that will be analyzed. In this case, you'll choose the variables you added with the **Enrich Layer** tool.

4. In the **Geoprocessing** pane, click the **Back** button. Search for and open the **Add Field Based Suitability Criteria** tool.

5. For **Input Suitability Analysis Layer**, choose **Financial Vulnerability**.

6. For **Fields**, click the **Add Many** button.
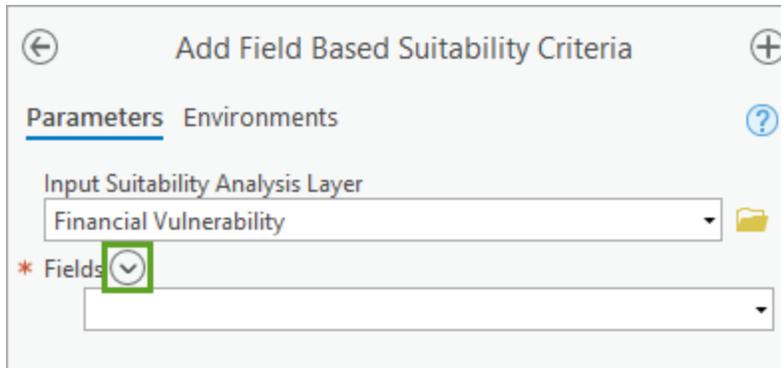
A list of all of the fields in the layer is added. Most of these fields are the variables you added by enriching the layer.

7. At the bottom left of the **Fields** window, click the **Toggle All Checkboxes** button.
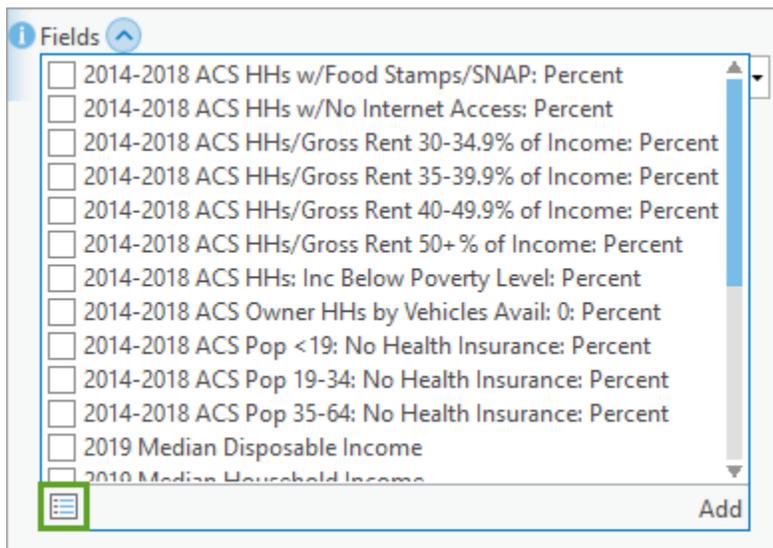
8. At the bottom of the list of fields, uncheck **Shape_Area** and **Shape_Length**. Click **Add**.

The variable fields are listed.

9. Click **Run**.

The tool runs. No new layer is created, and nothing changes on the map. However, the fields you chose will be made available in subsequent analysis tools. Next, you'll set the properties of each criterion.

10. In the **Geoprocessing** pane, click the **Back** button. Search for and open the **Set Criteria Properties** tool.

11. For **Input Suitability Analysis Layer**, choose **Financial Vulnerability**.

All of the variables (criteria) you specified are added to the **Criteria Properties** parameter. Each criterion has several parameters associated with it.

By default, the **Weight** parameter for each variable is 5 (all variables are given equal weighting). You can decrease the weight for less important variables and increase it for more important variables. For example, you have several variables reflecting households paying more than 30 percent of their total income for rent. You can set the **Weight** for households paying 30–34.9 percent of their income for rent to 2, those paying 35–39.9 percent to 4, those paying 40–44.9 percent to 6, and those paying more than 50 percent to 10. Similarly, you can determine that children and seniors without health insurance should have a higher weight than adults aged 19–34 or 35–64. The weights can be any values, but they must add up to 100. (You have 20 variables total, which is why the default weight is 5.)

The **Influence** parameter indicates if a high value has a positive or negative influence on the scoring. For median income, for example, tracts with small values (less income) are more vulnerable. If small values are more vulnerable, the criterion has an inverse relationship, and if high values are more vulnerable, the criterion has a positive relationship.

You won't use the **Minimum Value** or **Maximum Value** parameters. For suitability analyses, these can be used to exclude features outside the minimum to maximum range from the analysis.

12. For the following variables, change the **Influence** to **Inverse**:

- **Median Household Income**
- **Median Disposable Income**
- **Per Capita Income**

For now, you'll leave the weights unchanged.

13. Click **Run**.

The tool runs. Again, no new layer is created. You've defined how each variable impacts the vulnerability score. The next tool you run will calculate a suitability score for each census tract based on the variables you've configured.

14. Click the **Back** button. Search for and open the **Calculate Suitability Score** tool.

15. For **Input Suitability Analysis Layer**, choose **Financial Vulnerability** and click **Run**.

The Financial Vulnerability layer is updated with the vulnerability score for each census tract. The map is symbolized so that tracts with lowest vulnerability are in yellow and tracts with highest vulnerability are in red.
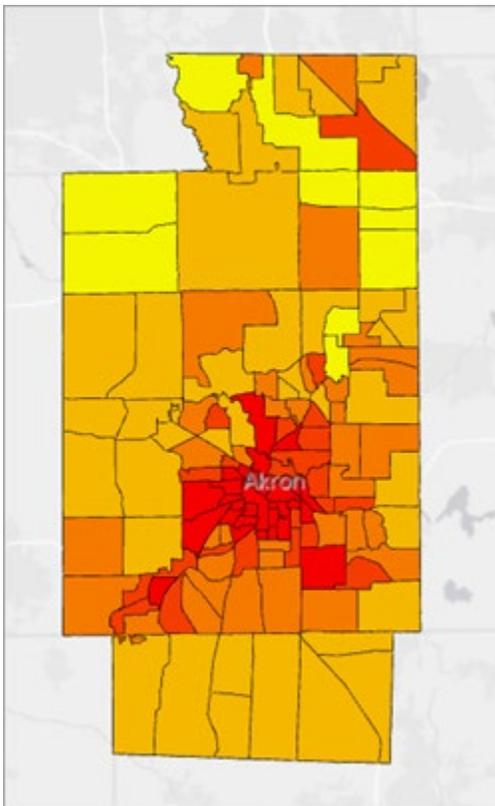
The map shows that the urban areas of Akron have a higher level of financial vulnerability than the surrounding suburbs and the rural areas of the county.

Step 4: Understand drivers of vulnerability

You know where vulnerability is high or low. But which variables are increasing vulnerability the most? To find out, you'll sort the 20 vulnerability variables into five categories (Income, Housing, Health Insurance

Burden, Employment Volatility, and Adaptability). Then, you'll compute the average score for each category.

When you calculate the average, you'll multiply the value (which will be between 0.0 and 1.0) by 1,000,000 to convert them into integers. You'll perform this conversion because subsequent analysis will involve testing for equality. Testing for equality using decimals can lead to false negatives due to rounding differences, so it's important to use integers instead.

1. In the **Geoprocessing** pane, click the **Back** button. Search for and open the **Calculate Field** tool.

2. For **Input Table**, choose **Financial Vulnerability**.

3. For **Field Name**, type <u>IncomeAve</u>. For **Field Type**, choose **Long (large integer)**.

When you provide a field name that doesn't already exist in the input table, the tool automatically creates it for you. For the expression, you'll add together the five income category variables and divide by five to find the average. Then, you'll multiply the result by 1,000,000 to convert it to an integer.

4. For **IncomeAve =**, create (or copy and paste) the following expression:

<u>((!Weighted_score_of_foodstampssnap_acssnap_p! + !Weighted_score_of_atrisk_acshhbpov_p! + !Weighted_score_of_wealth_meddi_cy! + !Weighted_score_of_wealth_medhinc_cy! + !Weighted_score_of_wealth_pci_cy!)/5) * 1000000</u>
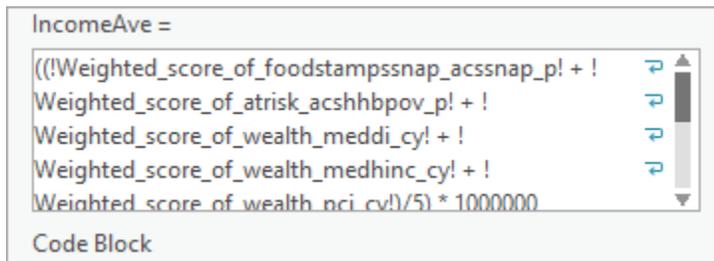
5. Click **Run**.

The tool runs and the field is calculated. You'll repeat the process four more times for the other categories.

6. Change **Field Name** to <u>HousingAve</u> and replace the expression with the following expression:

<u>((!Weighted_score_of_populationtotals_incmort_cy! + !Weighted_score_of_housingcosts_acsgrnti30_p! + !Weighted_score_of_housingcosts_acsgrnti35_p! + !Weighted_score_of_housingcosts_acsgrnti40_p! + !Weighted_score_of_housingcosts_acsgrnti50_p!) / 5) * 1000000</u>

7. Click **Run**.

8. Change **Field Name** to InsuranceAve and replace the expression with the following expression:

((!Weighted_score_of_health_acs0nohi_p! + !Weighted_score_of_health_acs19nohi_p! + !Weighted_score_of_health_acs35nohi_p!) / 3) * 1000000

There are only three variables for this component, so you'll divide by three instead of five to get the average.

9. Click **Run**.

10. Run the tool again to create a field named EmploymentAve using the following expression:

((!Weighted_score_of_employees_n37_emp_p! + !Weighted_score_of_employees_n18_emp_p! + !Weighted_score_of_employees_n09_emp_p! + !Weighted_score_of_employees_n34_emp_p! + !Weighted_score_of_occupation_occpers_cy_p!) / 5) * 1000000

11. Run the tool again to create a field named AdaptabilityAve using the following expression:

((!Weighted_score_of_internetcomputerusage_acsnonet_p! + !Weighted_score_of_vehiclesavailable_acsoveh0_p!) / 2) * 1000000

You've calculated and converted the average values for all five categories. Next, you'll create a field to determine which category has the highest average value for each census tract.

12. In the **Calculate Field** tool, change **Field Name** to MaxValue. Create the following expression:

(max(!IncomeAve!, !HousingAve!, !InsuranceAve!, !EmploymentAve!, !AdaptabilityAve!))

13. Click **Run**.

Next, you'll create a text field to store the highest score for all five vulnerability components.

14. In the **Geoprocessing** pane, click the **Back** button. Search for and open the **Add Field** tool.

15. Set the following parameters:

- For **Input Table**, choose **Financial Vulnerability**.
- For **Field Name**, type Predominance.
- For **Field Type**, choose **Text**.

- For **Field Length**, type <u>30</u>.
- For **Field Alias**, type <u>Predominant Vulnerability Component</u>.

16. Click **Run**.

The **MaxValue** field contains only the highest numerical value among the five average values. It doesn't tell you whether the maximum value is an income value, a housing value, or so on. To determine that, you'll select census tracts where **MaxValue** matches **IncomeAve**. For the selected tracts, you'll set **Predominant Vulnerability Component** to **Income**. Then, you'll repeat the process for the other four categories.

17. Click the **Back** button and search for and open the **Select Layer By Attribute** tool. Set the following parameters:

- For **Input Rows**, choose **Financial Vulnerability**.
- For **Selection type**, choose **New selection**.
- Click **New expression** and create the expression **Where MaxValue is equal to IncomeAve**.
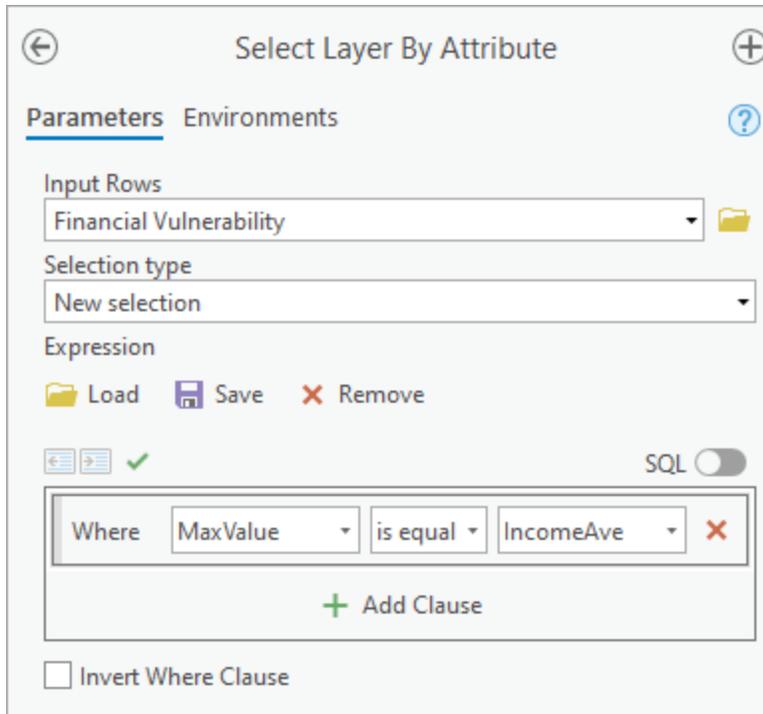
18. Click **Run**.

All of the tracts for which the average income variable scores are largest compared to the other scores are now selected. You'll set the predominance value label to Income.

19. Click the **Back** button and search for and open the **Calculate Field** tool. Set the following parameters:

- For **Input Table**, choose **Financial Vulnerability**.
- For **Field Name**, choose **Predominant Vulnerability Component**.
- For **Predominance =**, type "Income". (Include the quotation marks.)

20. Click **Run**.

You'll repeat the process for the other four categories. To avoid entering the same tool parameters repeatedly, you'll open the **History** pane so you can reopen tools you've used with the same parameters you set earlier.

21. On the ribbon, on the **Analysis** tab, in the **Geoprocessing** group, click the **History** button.
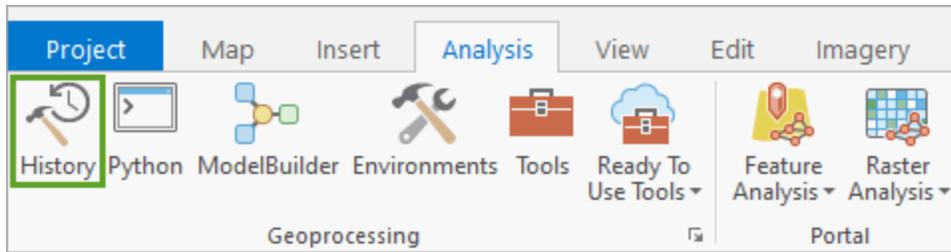
22. In the **History** pane, double-click **Select Layer By Attribute**.

The tool appears with the parameters filled in. All you need to change is the expression.

23. Change the expression to **Where MaxValue is equal to HousingAve** and click **Run**.

24. In the **History** pane, double-click the most recent **Calculate Field** entry. Change **Predominance =** to "Housing" and click **Run**.

25. In the **History** pane, double-click the most recent **Select Layer By Attribute** entry. Change the expression to **Where MaxValue is equal to InsuranceAve** and click **Run**.

26. In the **History** pane, double-click the most recent **Calculate Field** entry. Change **Predominance =** to "Insurance" and click **Run**.

27. Reopen and run the **Select Layer By Attribute** tool with the expression changed to **Where MaxValue is equal to EmploymentAve**.

28. Reopen and run the **Calculate Field** tool with **Predominance =** changed to "Employment".

29. Reopen and run the **Select Layer By Attribute** tool with the expression changed to **Where MaxValue is equal to AdaptabilityAve**.

There are no census tracts where **AdaptabilityAve** is the highest value, so you don't need to run the **Calculate Field** tool again. You've found the predominant vulnerability component for every tract.

Step 5: Symbolize predominance in the map

Lastly, you'll symbolize the map based on the **Predominant Vulnerability Component** field values.

1. In the **Contents** pane, right-click the **Financial Vulnerability** layer and choose **Symbology**.

The **Symbology** pane appears.

2. For **Primary symbology**, choose **Unique Values**. For **Field 1**, choose **Predominant Vulnerability Component**.
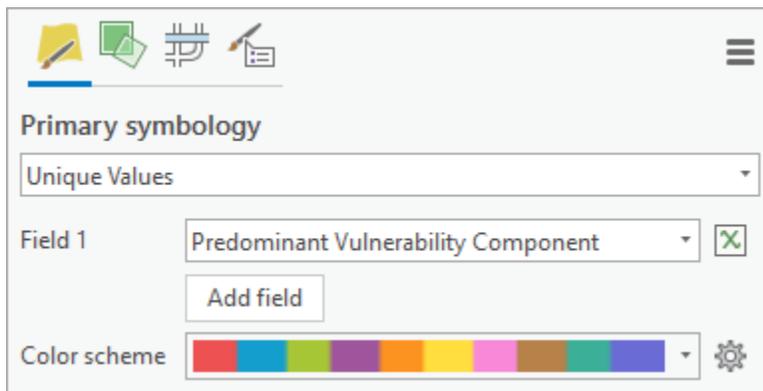
Even though no census tracts have Adaptability as their highest vulnerability category, you'll add it to the legend so users will understand that it is one of the possible categories.

3. For **Classes**, click the **Add unlisted values** button.
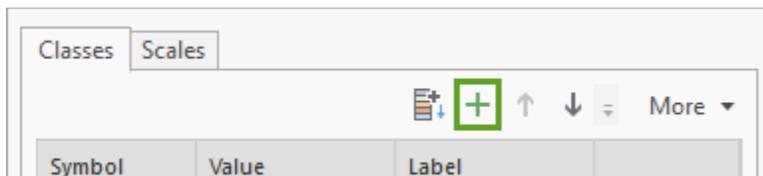
The **Select values to add** pane appears.

4. Click **Options** and choose **Add new value**.
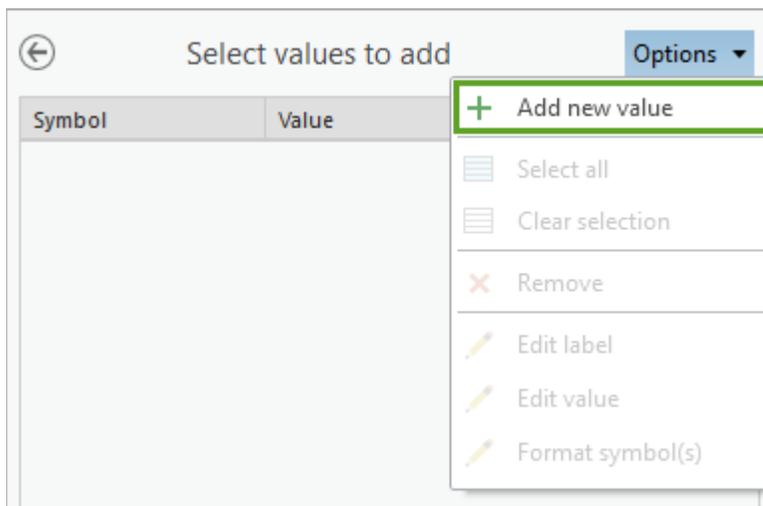
A new value is added to the list.

5. For the new value, for **Value**, type Adaptability and press *Enter*.

The **Label** option is also set to **Adaptability**.

6. At the bottom of the pane, click **OK**.

Now, the legend includes all five vulnerability components.

7. For **Color scheme**, choose the **Muted Pastels** color scheme. (You can see the name of each color scheme by pointing to it.)

The symbols change on the map. Your symbol colors may not match the example image exactly.
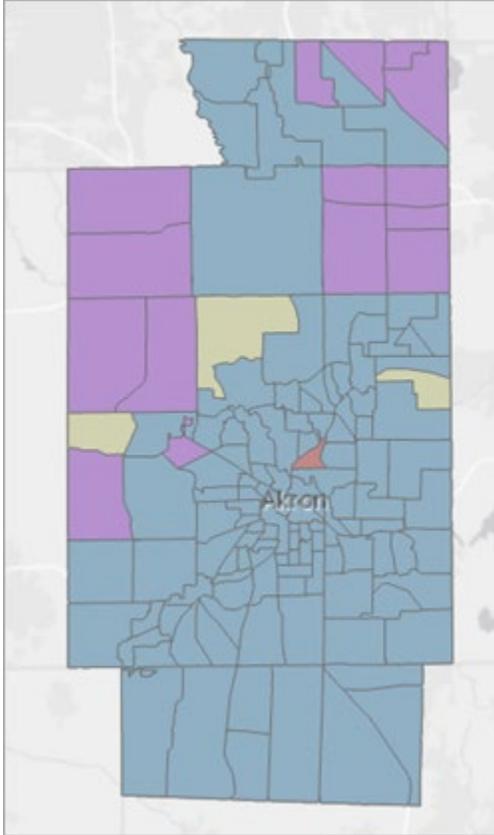
The map shows that income (blue in the example image) is the primary driver of financial vulnerability for most tracts in Summit County. However, in several border tracts, housing (purple) is the primary driver. Employment (beige) is the primary driver in three of the tracts. Exploring the attributes of these tracts shows that more than 25 percent of the employees work in either food service or arts and entertainment, two of the at-risk employment categories. A single tract has insurance (brown) as the dominant category. Exploring the attribute table for this tract shows that almost 20 percent of the non-Medicare age population is uninsured.

Understanding the spatial distribution of financial vulnerability is the first step in designing targeted remediation plans. For example, in areas where the employment burden is the predominant driver of financial vulnerability, policymakers may want to consider targeted job training programs. In areas where housing burden is predominant, they may want to consider establishing or extending rent freeze and eviction restrictions.

8. Optionally, save the project in a location of your choice.

In this lesson, you created a financial vulnerability map combining 20 variables that represented five different components of people's financial lives. Keep in mind that there are many ways to model vulnerability. When applying this workflow to your own region, use variables that best describe your local economy and choose weights that differentiate which variables are most and least important.

Variables used

Income

Variable	Rationale
2019 Median Household Income	Wage or salary is the primary way most United States households generate income.
2019 Median Disposable Income	Households with higher levels of disposable income are more likely to meet basic living expenses, even if incomes are reduced.
2019 Per Capita Income	Households are more vulnerable if income must support more people.
2014-2018 ACS HHs: Inc Below Poverty Level: Percent	Households already below the poverty level likely lack liquid assets to weather any financial shock.
2014-2018 ACS HHs w/Food Stamps/SNAP: Percent	Households already experiencing food insecurity before the pandemic likely lack liquid assets to weather any financial shock.

Housing

Variable	Rationale
2019 Pct of Income for Mortgage	The general rule of thumb is that housing costs should be no more than 28–33 percent of income. Households with high mortgage burden are less likely to weather income reduction or job loss. Payment deferral for federally backed mortgages is currently permitted for only 180 days under the CARES Act.
2014-2018 ACS HHs/Gross Rent 30-34.9% of Income: Percent	
2014-2018 ACS HHs/Gross Rent 35-39.9% of Income: Percent	While a few cities and states have enacted moratoriums on evictions and established rent assistance programs, these policies have not been enacted uniformly. Households with a high rent burden are less likely to weather income reduction or job loss.
2014-2018 ACS HHs/Gross Rent 40-49.9% of Income: Percent	
2014-2018 ACS HHs/Gross Rent 50+% of Income: Percent	

Health insurance burden

Variable	Rationale
2014-2018 ACS Pop <19: No Health Insurance: Percent	Households without health insurance are likely already experiencing financial stress and may be less likely to seek medical attention if experiencing COVID-19 symptoms. According to a 2018 Gallup poll, 61 percent of those surveyed indicated that having to pay higher premiums is a "major concern."
2014-2018 ACS Pop 19-34: No Health Insurance: Percent	
2014-2018 ACS Pop 35-64: No Health Insurance: Percent	

Employment volatility

Variable	Rationale
Food Service/Drinking Estab Emp (NAICS): Percent	An analysis by the Brookings Institute identified the 10 largest industries most at risk of being impacted by COVID-19 interventions. As the percentage of employees in an area increases, the overall financial vulnerability increases.
General Merchandise Employees (NAICS): Percent	
Motor Vehicles/Parts Dealers Emp (NAICS): Percent	
Arts/Entertainment/Rec Emp (NAICS)	
2019 Occupation: Personal Care: Percent	A proxy for the 821 NAICS code for "Personal and Laundry Services" in the Brookings report.

Adaptability

Variable	Rationale
2014-2018 ACS HHs w/No Internet Access: Percent	Households without internet access find it difficult to apply for alternate employment.
2014-2018 ACS Owner HHs by Vehicles Avail: 0: Percent	Households without access to a vehicle may have limited reemployment opportunities.

Photo

COVID-19 and Money: Image by fernando zhiminaicela from Pixabay

References

Berube, A. & Bateman, A. (2020, April 3). Report: "Who are the workers already impacted by the COVID-19 recession?" The Brookings Institution.

McCarthy, Justin (2018, December 10). Gallup News: "Six in 10 Americans Worry About Healthcare Premiums."

McCarthy-Alfano, M., Glickman, A., Wikelius, K. & Janet Weiner (2019, April 2). Health Affairs Blog: "Measuring The Burden Of Health Care Costs For Working Families."

Visit the Esri COVID-19 Hub for additional resources, data, training, and applications.
The authors are immensely grateful to Charlie Frye and Jim Herries for their feedback on this lesson.

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