Food Insecurity and Resource Access in Allegheny County, Pennsylvania: Using GIS to Identify High Need Communities and Assess Food Recovery and Redistribution Efficacy

INTRODUCTION

In the United States, nearly 1 in 7 households are food insecure (Coleman-Jenson, Rabbitt, and Singh, 2017), while 62.5 million tons of food is never eaten (ReFED, 2016). Food insecurity is a multifaceted issue, intertwined with other problems like climate change, agricultural production, and biodiversity loss. Three perspectives have arisen on how to address these issues, including looking at the problem as a production challenge, a consumption challenge, or "a socio-economic challenge, which requires changes in how the food system is governed," (Garnett, 2012). 412 Food Rescue, a non-profit in Allegheny County, Pennsylvania takes the socio-economic perspective, essentially facing food insecurity as a resource allocation or logistics issue that can be impacted by utilizing emerging technology models to solve limitations in current models of transport and rethinking distribution bottlenecks. The validity of this perspective is supported by the fact that 24% of food supply is lost or wasted in the food supply chain (Kummu, 2012). This figure contributes to the total 40% of food, or more than 20 pounds of food per person, in the United States goes uneaten (Gunders, 2012).

There are many kinds of organizations working to resolve hunger issues, but traditional resources rely on donations in the form of preserved or canned goods that can persist on shelves until distributed. Fresh foods like fruits and vegetables do not reach communities in need often enough. The logistics problems involved in rescuing this fresh food from being thrown away and distributing it are being addressed by 412 Food Rescue. The organization relies on and facilitates volunteers to pick up produce, bread and other surplus from food retailers and deliver it immediately to locations where it will be used. In order to successfully adjust the food system's resource allocation, it is important to know where this 'excess' food needs to be directed. One way to do so is by identifying food insecure areas on a small scale.

412 Food Rescue has grown and become increasingly successful over its three years of existence. Using the organization's recorded donation data, it is possible to analyze its effect so far on reaching at-risk communities in the Pittsburgh area and to identify at risk communities that may still need additional resources.

Three factors were used to identify the populations in most need of free food access in Allegheny County. These included poverty rates, location within a food desert, and location within a transit desert.

TRANSIT ACCESS AFFECTS FOOD ACCESS

Communities with an above average poverty rate or areas with low access to food resources like grocery stores are commonly understood to be more at-risk for food insecurity. However, the effect of a lack of transit access on household food security is less commonly studied. Immobility could prevent families from accessing vital resources that may be relatively nearby, and lack of transit is known to compound the difficulties of poverty (White, 2015). This is likely even more relevant when food assistance programs have inconvenient hours or when household providers have multiple jobs with odd hours. Therefore, access to transportation or lack thereof is considered to be a third vitally important aspect in this study.

In their 2013 article "Transit Deserts: The Gap Between Demand and Supply," Junfeng Jiao and Maxwell Dillivan developed a method for quantifying and calculating transit supply and demand using census data. This method was used to create transit desert data for Allegheny County. The resultant data was used in combination with food desert information from the United States Department of Agriculture's Economic Research Service and poverty data from the U.S. Census Bureau to generate mapping of Allegheny County's areas of greatest unmet food assistance need. The resulting maps inform 412 Food Rescue's areas of prioritization.

METHODS

In order to identify transit deserts, demographic data was collected for Allegheny County, PA from the 2016 American Community Survey 5-year estimates conducted by the U.S. Census Bureau. Municipal boundaries, transit stops, transit routes, and bike lanes were obtained from the Western Pennsylvania Regional Data Center and the Pennsylvania Spatial Data Access. Transit demand and supply were calculated for each census tract using ArcGIS to apply the following equation, adapted from Jiao and Dillivan (2013).

Household drivers = (population age 16 and over) – (persons living in group quarters)

Transit-dependent household population = (household drivers) – (vehicles available)

Transit-dependent population = (transit-dependent household population) + (population ages 10–14) + (non-institutionalized population living in group quarters)

The transit-dependent population figures were divided by square feet for each block group, and then a z-score was calculated.

To calculate transit supply per block group, each of the following criteria were calculated, then divided by square feet and given a z-score:

1. number of bus and rail stops
2. average weekday ridership of each bus and rail stop
3. number of routes
4. length of bike routes

The z-scores for each criterion were aggregated to calculate the final transit supply figure. Then, transit gaps were found by subtracting demand from supply. Block groups with a negative transit gap score were isolated to create a transit desert shapefile. For a more involved explanation of transit desert calculations, see Appendix A. The transit desert data was combined with data for food deserts from the USDA's Economic Research Service and above average poverty rates from U.S. Census data to analyze the location of communities at risk for food insecurity in Allegheny County.

In addition, location data for 412 Food Rescue drop-off locations and existing food access locations – pantries and food banks -- were georeferenced and input into ArcGIS toolsets to generate 15-minute walk times to food resources. This data was used to examine the types of communities currently reached, and those which may need more resources.

ANALYSIS

Comparing the reach of 412 Food Rescue's efforts with traditional food pantry networks may offer insights about the efficacy of the nonprofit's recovery and distribution approach. In 2017, existing food pantry and access network comprises 286 locations in Allegheny County. 412 Food Rescue's partners number 337.

Of the 286 existing pantries, 198 are located in areas with above average poverty rates, 31 are located within food deserts, and 96 are located within transit deserts.

Of 412 Food Rescue's 337 partners, 243 are located within areas of above average poverty rates, 50 are located within food deserts, and 98 are located within transit deserts.

412 Food Rescue's transit network is not limited by the same economies of scale required by trucking models. Its "transporters" are vehicles that can pick up and deliver food at frequencies and quantities that allow distribution across a wider network. Hence, it is reaching more partnering organizations in areas of increased food assistance need.

Another way to evaluate the type of impact 412 Food Rescue's distribution model has is to consider the types of nonprofits the organization partners with. Typical food access points are food pantries, soup kitchens, Meals on Wheels programs. homeless and women's shelters, children's after school sites, and rehab and transitional facilities. In addition to the above network, 412 Food Rescue partners a more diverse array of recipients, including low-income housing communities, family centers, schools, adult services, senior care facilities, Salvation Army locations, and community churches.

To examine human impact of each food outreach network, GIS tools were used to create 15-minute walking time polygons from food network distribution points. In other words, the polygons that were created were those in which an average person could walk to the food partner within 15 minutes.

412 Food Rescue is extending the reach of food resources in Allegheny County as measured this way, by a potential of an additional 101,806 people (using population numbers provided by the U.S. Census, evenly distributed across block groups). Of these 101,806 people, approximately 13,317 are in poverty.

Table 1, below, compares serviced communities – existing food access networks and 412 Food Rescue distribution network.

Table 1: Estimate of populations reached by 412 Food Rescue and the existing food access networks based on figures from U.S. Census and 15-minute walking time polygons.

Total population reached by 412 Food Rescue	479,770
In poverty	90,004
In a food desert	46,403
In a food desert, in poverty	12,020
In a transit desert	277,726
In a transit desert, in poverty	48,922
In a food desert and a transit desert	17,739
In a food desert and a transit desert, in poverty	4,256
Total population reached by Existing Networks	474,297
In poverty	89,181
In a food desert	43,542
In a food desert, in poverty	11,305
In a transit desert	279,212
In a transit desert, in poverty	48,478
In a food desert and a transit desert	16,025
In a food desert and a transit desert, in poverty	3,642
People reached by 412 Food Rescue, NOT reached by Existing Networks (Additional population reached)	101,806
In poverty	13,317
In a food desert	52,003
In a food desert, in poverty	6,951
In a transit desert	11,566
In a transit desert, in poverty	2,632
In a food desert and a transit desert	4,974
In a food desert and a transit desert, in poverty	1,103
Areas of highest need: Not reached by 412 Food Rescue or Existing Networks	
Population located in a food desert	27,399
Population located in a food desert and in poverty	5,824
Population located in a transit desert	163,310
Population located in a transit desert and in poverty	12,390
Population located in a food desert and a transit desert	7,360
Population located in a food desert, a transit desert, and in poverty	1,420

The analysis shows that 412 Food Rescue is currently able to reach approximately 479,000 people in Allegheny County, as measured within a 15-minute walking distance. An additional 101,806 more people are within walking distance of food access.

Of those 479,000, approximately 90,000 are in poverty, 46,000 are in a food desert, and 277,000 are in a transit desert. About 4,250 people are located in all three.

There are approximately 1,420 people in dire need of food services - located in both a food desert and a transit desert, with a high poverty rate - who are not being reached by either 412 Food Rescue or existing networks.

These numbers highlight the quantity of the most at-risk populations. Further examination of geographic data pulls out specific Allegheny County areas that may be prioritized based on highest need. These areas include Sharpsburg, Millvale, Hazelwood/Glennwood, Eden Park, Pitcairn, Wilkinsburg, the West End, Tarentum, Carnegie, East Pittsburgh, and Turtle Creek/Newtown.

The figures in Appendix B display Allegheny County with each of the analysis factors (poverty, food deserts, and transit deserts) on separate maps, then together. Next, high risk areas (where each factor overlaps) are identified. Then, food resource locations and 15-minute walking time polygons to those resources are displayed. The last map set shows in detail those neighborhoods that have a high need for food resources, in combination with food resource networks and 15-minute walking times. These maps and high need area detail maps can be viewed at https://arcg.is/1mWbHz

This analysis lays the foundation of 412 Food Rescue's work in understanding how to deepen the scale of its impact on food insecurity in the region. It is not exhaustive. As the organization moves forward, this tool can be further refined with additional data such as other socio-economic factors, manipulating weights on factors used to determine relative transit deficits, considering other existing hunger and food access interventions in the region. 412 Food Rescue is also working closely with each of its nonprofit partners to understand how to support increasing their capacity to more actively impact food insecurity in their community.

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Appendix A: Transit Desert Calculation

The equation to find transit deserts as defined by authors Jiao and Dillivan in their 2013 study is a supply and demand analysis. Where does supply not meet demand? Government census data was attached to block group shapefiles using the unique block group identifiers the U.S. Census Bureau provides with its data. Local transit data was clipped to the block group shapefiles. This is terminology used in ArcGIS to describe using a tool to overlay the transit data onto block group shapes, and then break the data into the polygons by which they are contained.

To calculate total transit demand in each block group, the equation below was used. This equation is a slightly modified version of the original equation devised by Jiao and Dillivan. Modifications and adaptations are explained at the end of this Appendix.

Total transit-dependent population = (transit-dependent household population) + (population ages 10–14) + (non-institutionalized population living in group quarters [for example college students, community living type buildings, etc.])

Transit-dependent household population = (household drivers) – (vehicles available)

Household drivers = (population age 16 and over) – (persons living in group quarters)

Further following Jiao and Dillivan's methodology, densities for the total transit-dependent population numbers found next to calculate demand per square foot. Demand z-scores were then calculated so that these factors could be compared with supply factors in order to identify a supply gap.

To calculate the supply of transit in each block group, available transit data was utilized to identify the quantity of four factors identified by Jiao and Dillivan (again, slightly modified as described below). Those numbers were then used to calculate a density figure (supply of each factor per square foot). Densities were then used to calculate each factor's separate z-score. These separate z-scores were then aggregated to find the total combined supply z-score for each block group, which was used in the final supply–demand calculation.

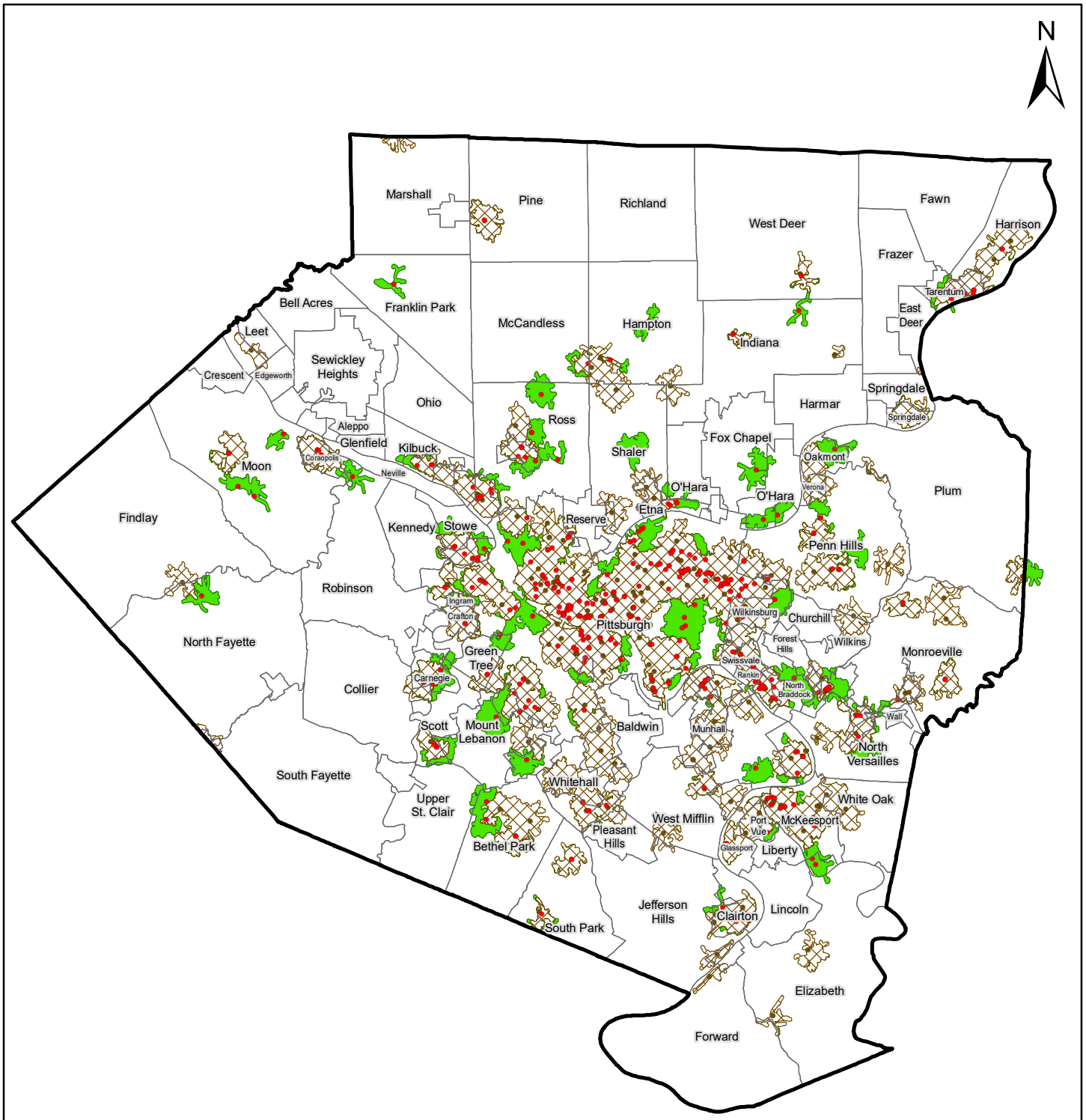
The four supply factors used in each census tract were:

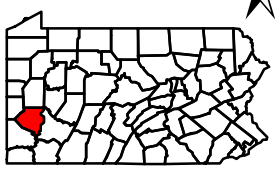
5. Number of bus and rail stops
6. Average weekday ridership of each bus and rail stop
7. Number of transit routes
8. Length of bike routes

The four ways in which this particular transit desert calculation differed from the original equation devised by Jiao and Dillivan:

- Total transit-dependent population includes the factor (population ages 10-14) in the equation. In Jiao and Dillivan's study, the same factor is (population ages 12-15). The census data used in this calculation did not have the particular age bracket described by the original methodology. While it is possible that the difference may have some effect in the final calculation, the discrepancy is likely negligible.
- Factor four in the supply end of the equation is 'length of bike routes'. In Jiao and Dillivan's original equation, the factor is the sum of length of bike routes and length of sidewalks. Sidewalk length data was not readily available.
- Factor two in the supply end of the equation is 'average weekday ridership of each bus and rail stop'. In Jiao and Dillivan's original equation, the factor is frequency of service for each bus and rail stop per day (weekday service). The same data was not available, so the best available substitute was used.
- Block group data from the U.S. Census Bureau's 2016 American Community Survey 5-year estimates was used as much as possible, however datasets for institutionalized and non-institutionalized group populations as well as for population aged 16 years and older were only available in 2010 Census datasets. Future iterations of transit desert calculations will extrapolate demographic data unavailable in 2016 ACS 5-year estimate dataset.

412 FOOD RESCUE - FOOD RESOURCE LOCATIONS





Project Location:
Allegheny County, PA

412 FOOD RESCUE - FOOD RESOURCE LOCATIONS

- 412 FR Access Site
- Existing Food Access Site
- 412 FR Additionally Reached Communities
- 15 Minute Walk Time to Traditional Food Access Network
- Allegheny County Boundary
- Municipality Boundary

FIGURE 1

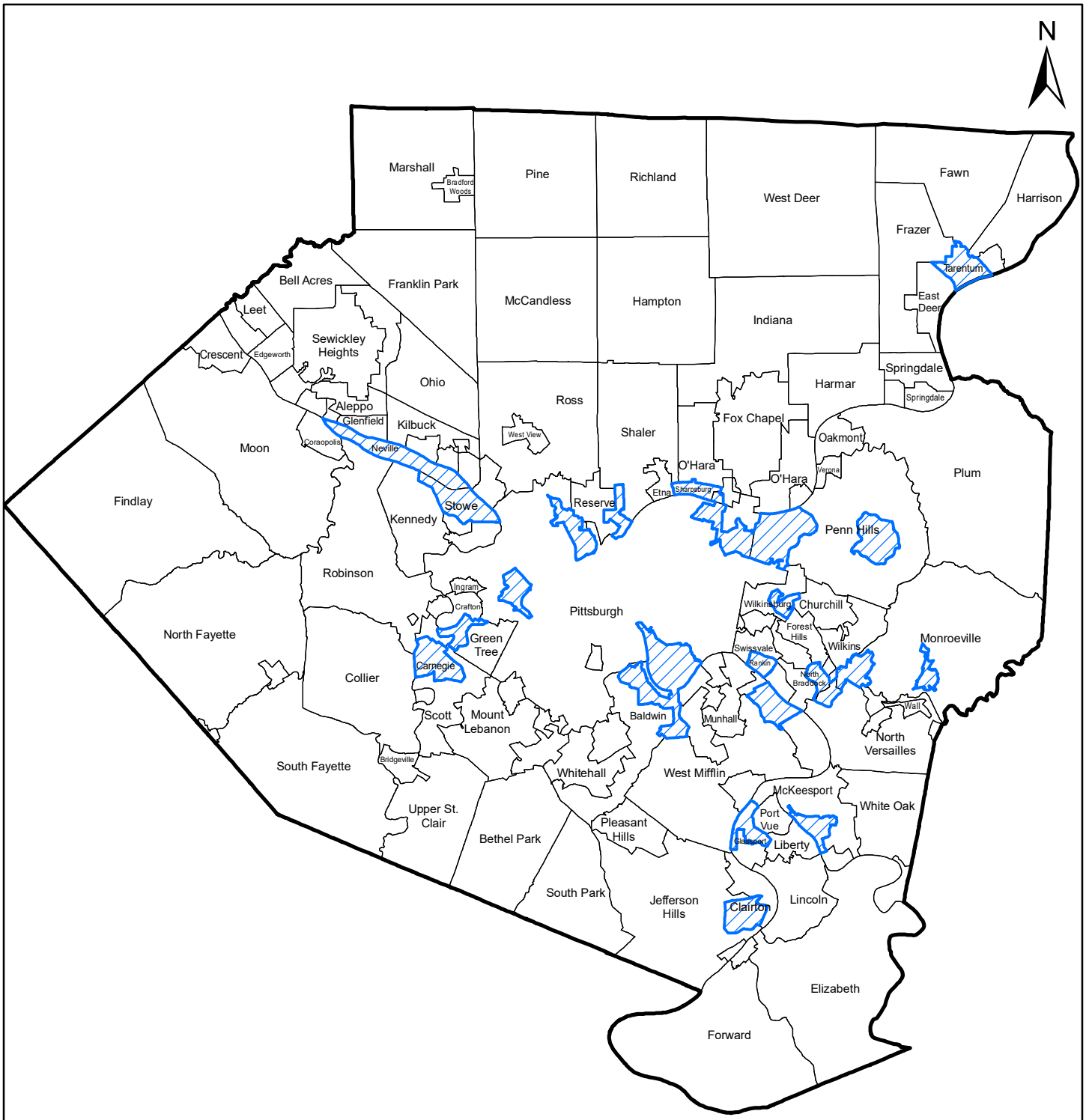
3/23/2018

1 in = 5 miles

0 2.5 5 Miles

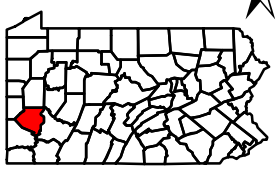
Service Layer Credits: Census Tract Poverty Layer and Food Desert Layer: https://www.ers.usda.gov/data-products/food-access-research-atlas/download-the-data/. Food Access Research Atlas, USDA, 2015. Transit Desert Layer: created using Census data from https://factfinder.census.gov/faces/nav/jsf/pages/download_center.xhtml. United States Census Bureau, 2010 and transit data from https://data.wprdc.org/organization/port-authority-of-allegheny-county. Port Authority of Allegheny County, 2016.

412 FOOD RESCUE - FOOD DESERTS



0 50 100 Miles

N



Project Location:
Allegheny County, PA

412 FOOD RESCUE - FOOD DESERTS

Legend

- Food Desert Census Tract
- Municipality Boundary
- Allegheny County Boundary

FIGURE 2

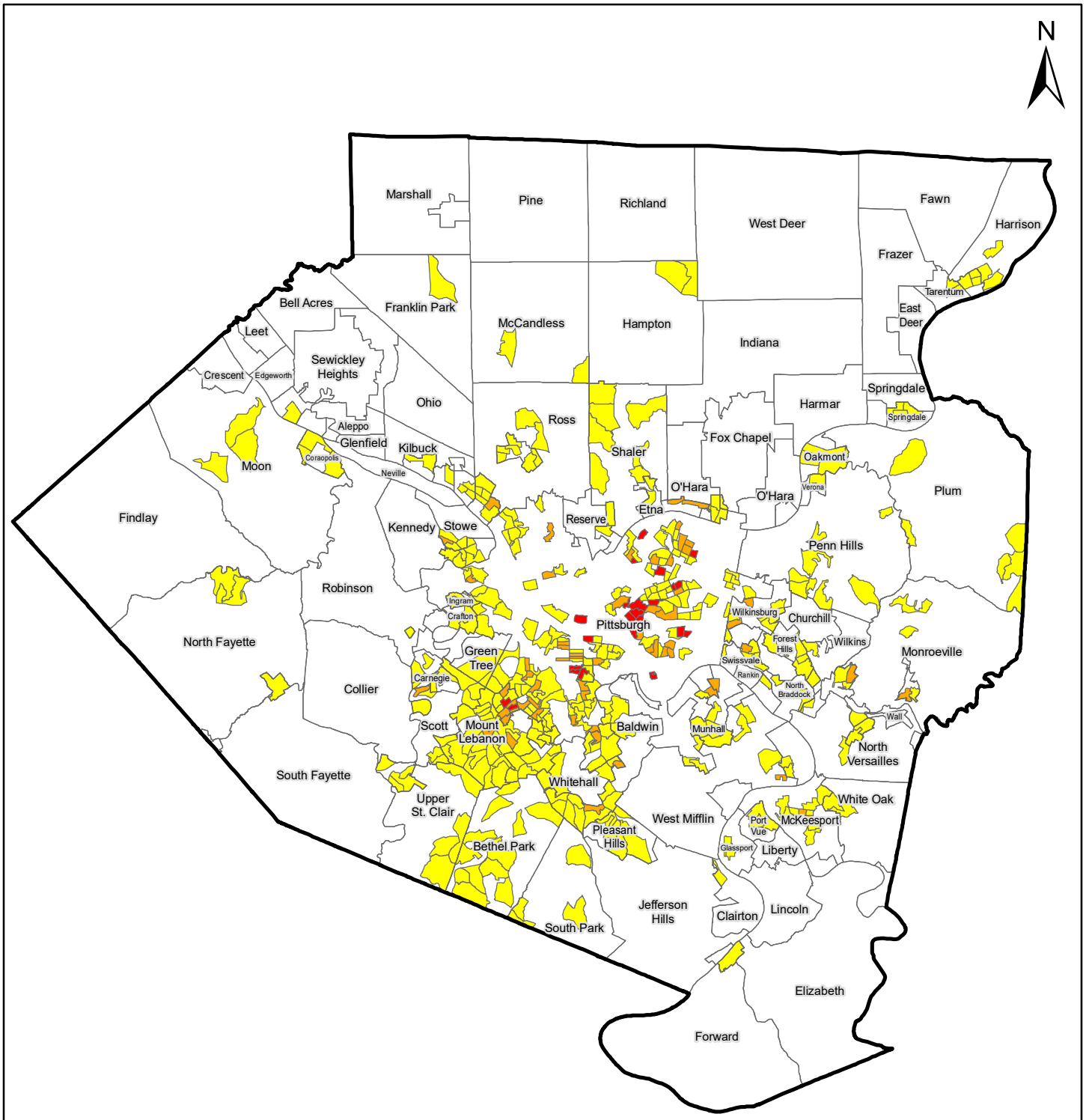
12/18/2017

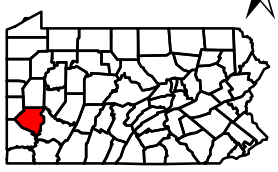
1 in = 5 miles

0 2.5 5 Miles

Service Layer Credits: Food Desert Census Tract Layer: https://www.ers.usda.gov/data-products/food-access-research-atlas/download-the-data/. Food Access Research Atlas, USDA, 2015.

412 FOOD RESCUE - TRANSIT DESERTS





Project Location:
Allegheny County, PA

412 FOOD RESCUE - TRANSIT DESERTS

Transit Desert Supply and Demand Gap

- less than -2
- -2 to -1
- -1 to 0
- Allegheny County Boundary
- Municipality Boundary

FIGURE 3

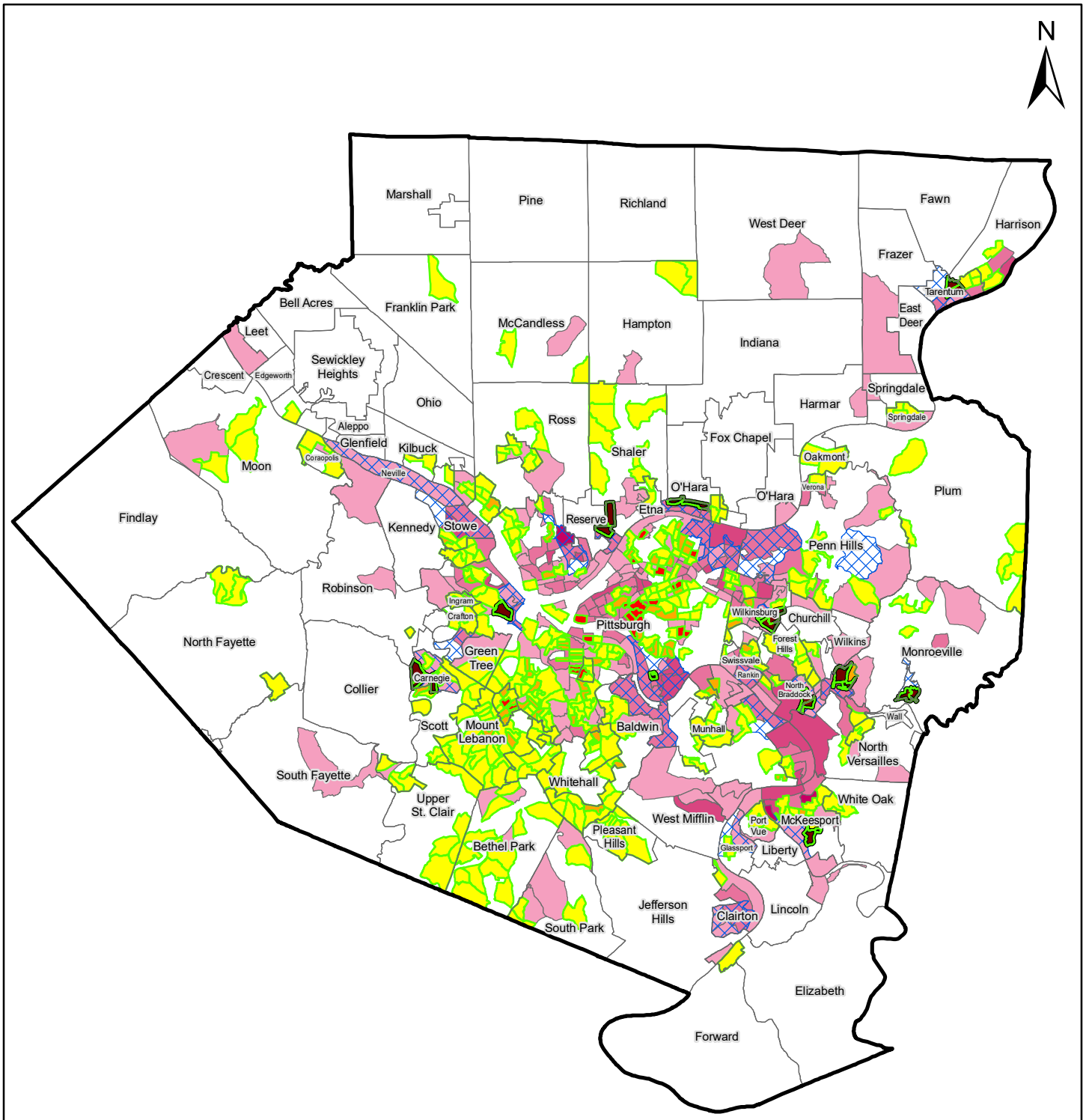
2/5/2018

1 in = 5 miles

0 2.5 5 Miles

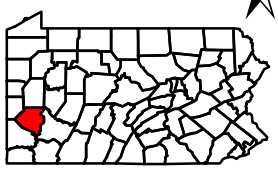
Service Layer Credits: Census Tract Poverty Layer and Food Desert Layer: https://www.ers.usda.gov/data-products/food-access-research-atlas/download-the-data/. Food Access Research Atlas, USDA, 2015. Transit Desert Layer: created using Census data from https://factfinder.census.gov/faces/nav/jsf/pages/download_center.xhtml. United States Census Bureau, 2010 and transit data from https://data.wprdc.org/organization/port-authority-of-allegheny-county. Port Authority of Allegheny County, 2016.

412 FOOD RESCUE - HIGH NEED AREAS



0 50 100 Miles

N



Project Location:
Allegheny County, PA

412 FOOD RESCUE - HIGH NEED AREAS

Poverty Rate

- 12.3% to 25%
- 25% to 50%
- 50% to 75%
- above 75%

- Transit Desert
- Food Desert Census Tract
- High Need Areas
- Allegheny County Boundary
- Municipality Boundary

FIGURE 4

3/16/2018

1 in = 5 miles

0 2.5 5 Miles

Service Layer Credits: Census Tract Poverty Layer and Food Desert Layer: https://www.ers.usda.gov/data-products/food-access-research-atlas/download-the-data/. Food Access Research Atlas, USDA, 2015. Transit Desert Layer: created using Census data from https://factfinder.census.gov/faces/nav/jsf/pages/download_center.xhtml. United States Census Bureau, 2010 and transit data from https://data.wprdc.org/organization/port-authority-of-allegheny-county. Port Authority of Allegheny County, 2016.