Measuring Transit Accessibility in Allegheny County

Methods and findings from a study of opportunity employment

Presented by: Alice Beattie, Taylor Burandt, Kaila Gilbert, Maxwell Kennady, Jeffrey Pflanz, Ahmed Sanda

Advised by: Sean Qian

Systems Capstone Project
Final Presentation
December 11, 2019

Carnegie Mellon University
Heinz College
INFORMATION SYSTEMS • PUBLIC POLICY • MANAGEMENT

Agenda

Part I: defining accessibility	• Novel approach informed by stakeholder input
Part II: developing a methodology	• Dimensions of the index
Part III: creating and applying the index	• Identifying areas of interest • Analyzing accessibility factors • Applying and validating methodology
Part IV: communicating results	• GIS visualization
Part V: identifying opportunities	• Considerations and recommendations • Future applications

Part I: Defining accessibility

Defining accessibility: research and outreach

- Prior research has analyzed public transit accessibility using metrics such as estimated travel time and distance from bus stops.

- Stakeholders expressed concern that that level of analysis would leave out important aspects of the transit experience in Allegheny County.

- We took a novel approach to capture more diverse features.

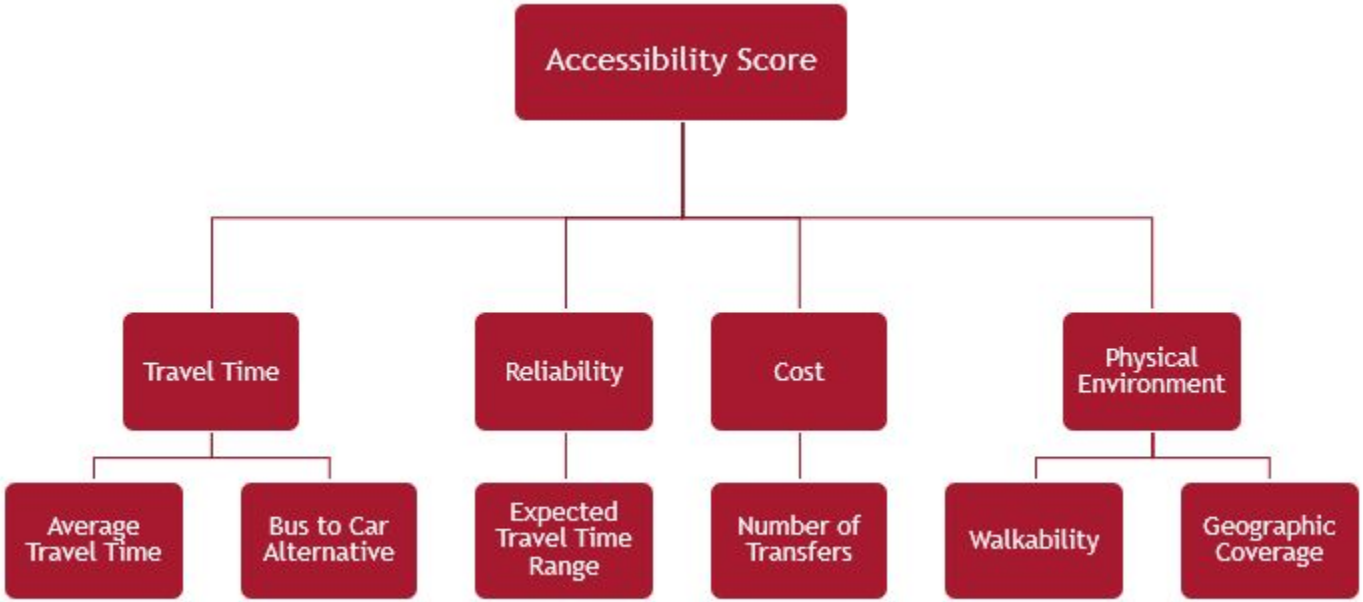
Defining accessibility: our interpretation

To capture the average transit experience from selected origins to opportunity occupation zones, measures were estimated and normalized for:

- Walkability
- Proximity to relevant bus stops
- Average travel time
- Expected travel time range
- Trip cost (including transfers)
- Travel time by car
- Access to employment

Part II: Developing a methodology

Dimensions of the index



Part III: Areas of interest

What is an Opportunity Occupation?

Our criteria:

- Pay more than median annual wage
- Do not require a Bachelor's degree
- Offer full employment (50 - 52 weeks)
- Offer between 35 - 60 hours per week

ACS Public Use Microdata Sample Survey (2017)

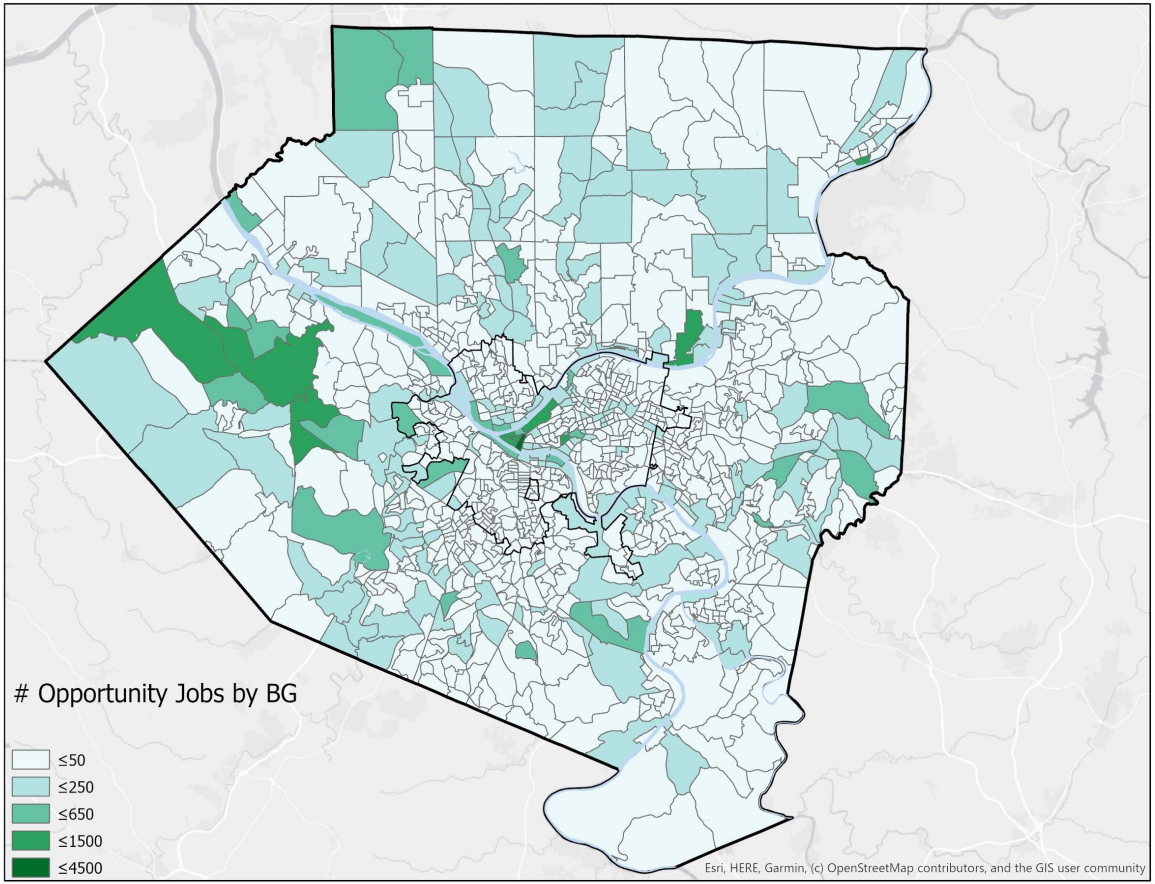
- Individual respondents available in Pennsylvania

$$\text{Opportunity Share for each industry} = \frac{\text{Opportunity Employment}}{\text{Total Employment}}$$

Fee, Kyle, Keith Wardrip, and Lisa Nelson. *Opportunity Occupations Revisited: Exploring Employment for Sub-Baccalaureate Workers Across Metro Areas and Over Time.* Cleveland: Federal Reserve Bank of Cleveland, 2019.

Top Industries for Opportunity Employment by Count for Allegheny County				
Industry Code	Total Count	Opportunity Count	Percent Opportunity	Description
23	975	196	20%	Construction
31-33	1844	163	25%	Manufacturing
44-45	1396	87	11%	Retail Trade
48-49	566	83	27%	Transportation and Warehousing
92	659	80	12%	Public Administration
62	2194	77	4%	Health Care and Social Assistance
54	1112	68	6%	Professional, Scientific, and Technical Services
22	171	54	32%	Utilities
42	426	45	11%	Wholesale Trade
52	822	40	5%	Finance and Insurance
56	480	33	7%	Administrative and Support and Waste
81	556	33	6%	Other Services
21	95	24	25%	Mining & Quarrying
51	240	24	10%	Information
72	645	17	3%	Accommodation and Food Services
61	1047	14	1%	Educational Services
53	182	10	5%	Real Estate and Rental and Leasing
11	152	6	4%	Agriculture, Forestry, Fishing and Hunting
71	192	6	3%	Arts, Entertainment, and Recreation
55	17	2	12%	Management of Companies and Enterprises

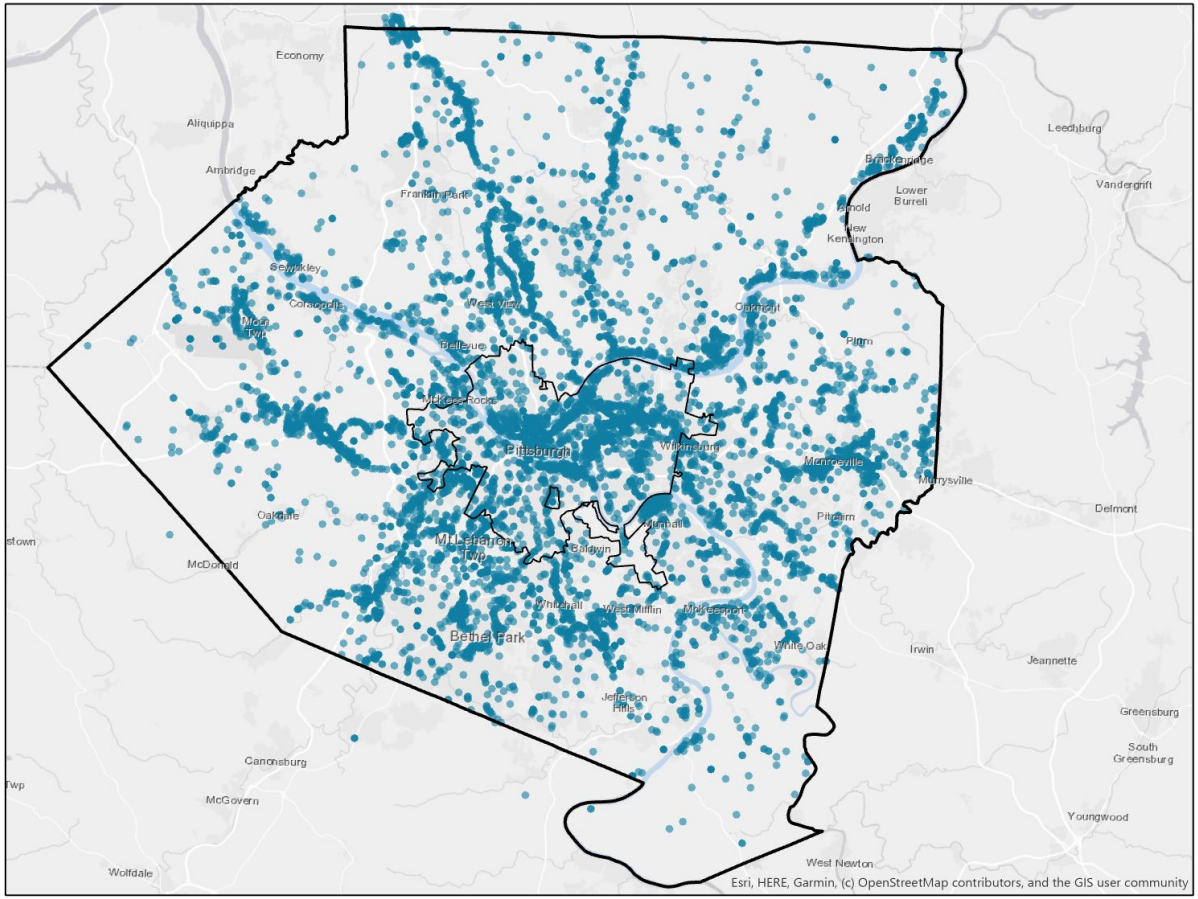
Opportunity Occupations by block group



Where are Opportunity Occupations?

- Block groups are often too geographically large for useful analysis of job locations in more suburban and rural areas; to create a nuanced index, granular data is necessary.
    - Based on current number of employees at each location & industry code, estimated number of “opportunity occupations” at individual businesses in Allegheny County.
    - Found areas where opportunity occupations are predicted to be densely located.

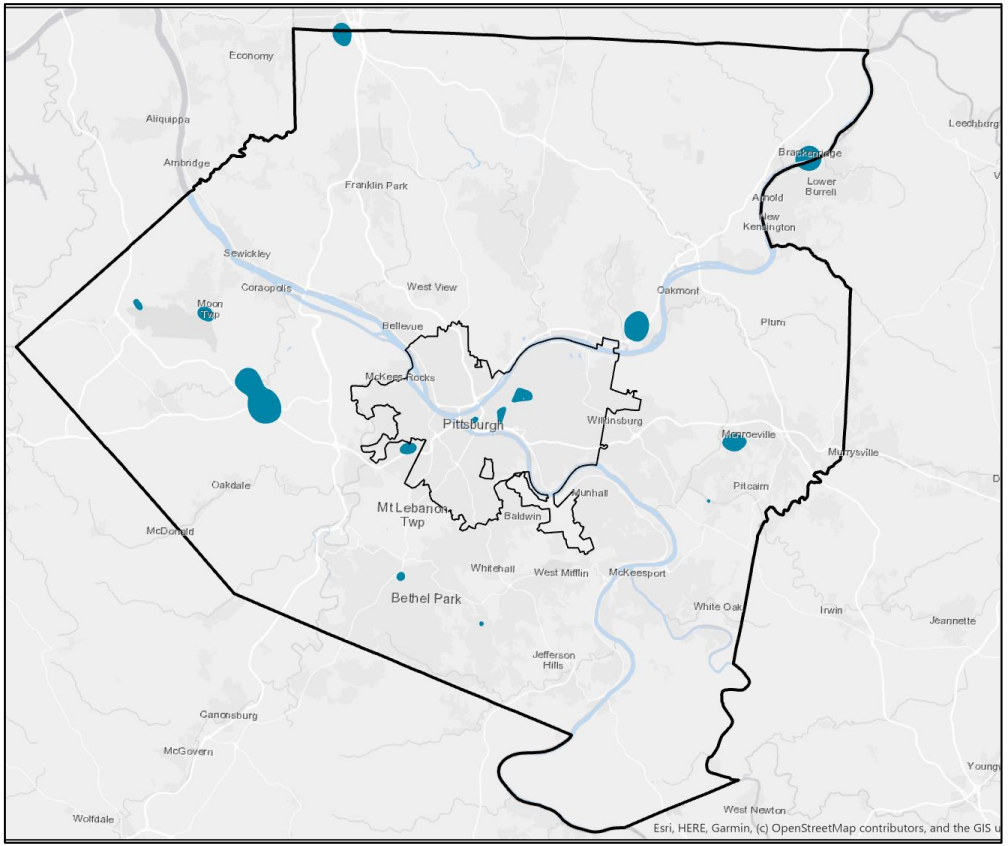
Where are Opportunity Occupations?



Where are Opportunity Occupations?

Company_Name	City
Airport Corridor Trnsprtn Assc	Pittsburgh
Descartes Systems Group	Pittsburgh
Fedex Ground	Coraopolis
Pit Stop Airport Parking	Coraopolis
American Tower Corp	Pittsburgh
American Zinc Recycling Corp	Coraopolis
American Zinc Recycling LLC	Coraopolis
ATI Powder Metals	Pittsburgh
Bayer Corp	Pittsburgh
Calgon Carbon Corp	Moon Township

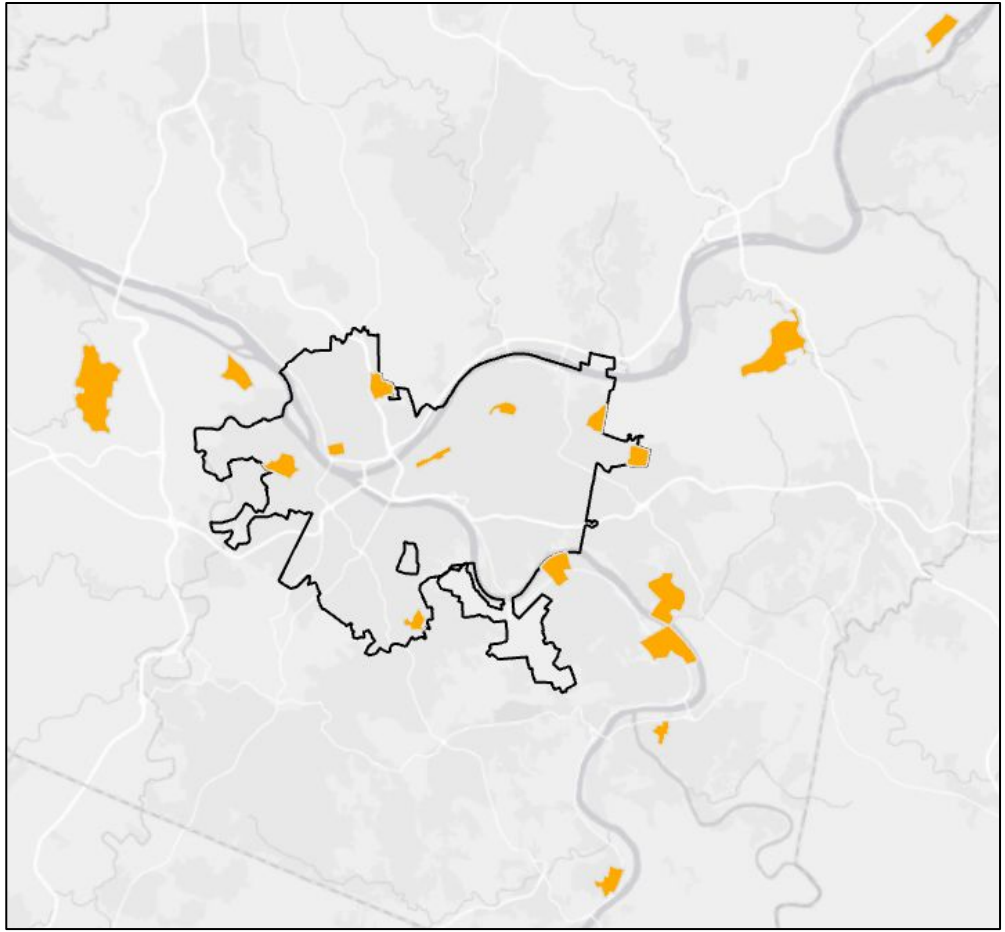
Company_Name	City
Allegheny Petroleum Products	Wilmerding
Johnson Matthey Inc	Wilmerding
Seserys Logistics LLC	Wilmerding
Triangle Engineered Prods Co	Wilmerding
WABCO Freight Car Products	Wilmerding
WABCO Locomotive Products	Wilmerding
Wabtec Global Svc	Wilmerding
Workhorse Rail LLC	Wilmerding



Areas of interest: residential origins

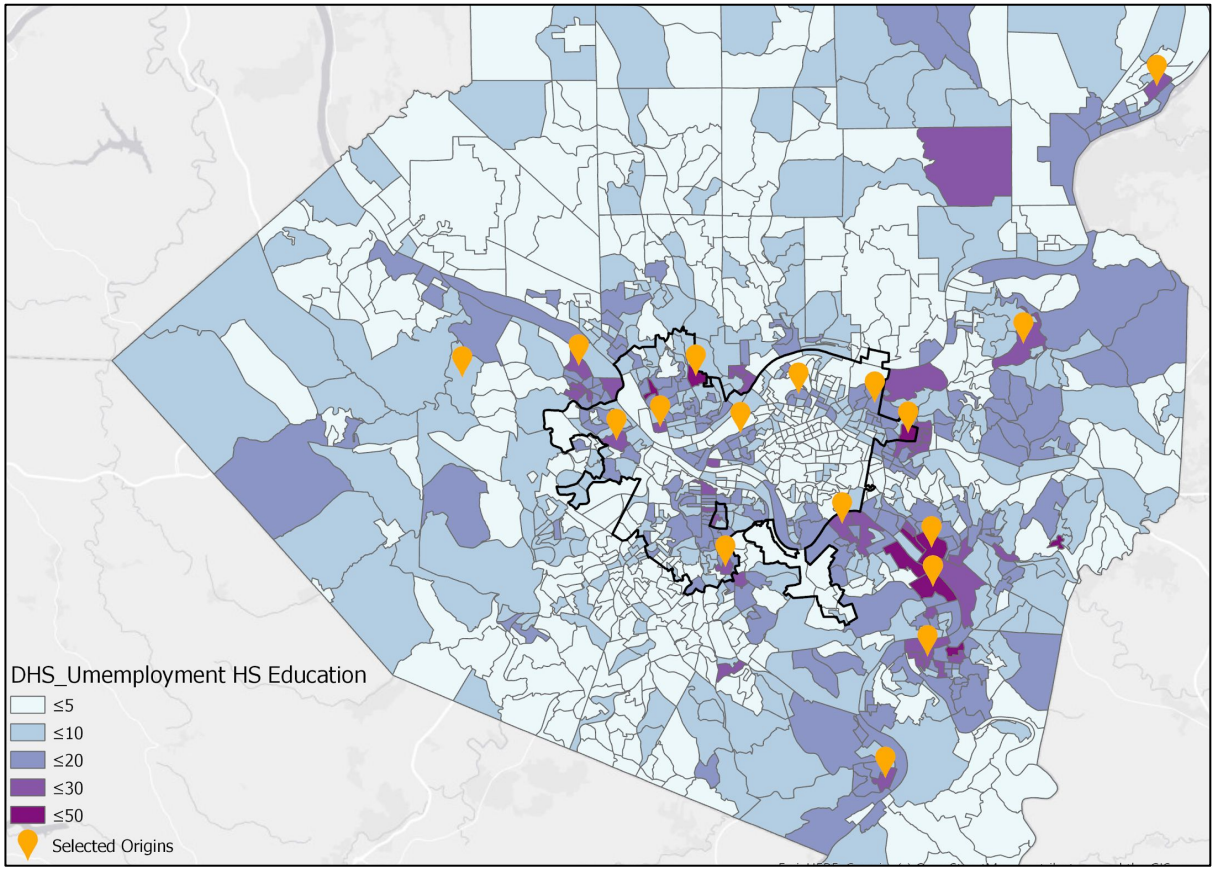
- Constructed sample of 17 “origin” locations
  - Characteristics focused on
    - low-income communities
    - car ownership
    - single mothers
    - use of public transportation to go to work

- Sources considered in selection:
  - Port Authority of Allegheny County (PAAC) Equity Index
  - U.S. Census Bureau Data (2013-2017 American Community Survey)
  - DHS Client Data

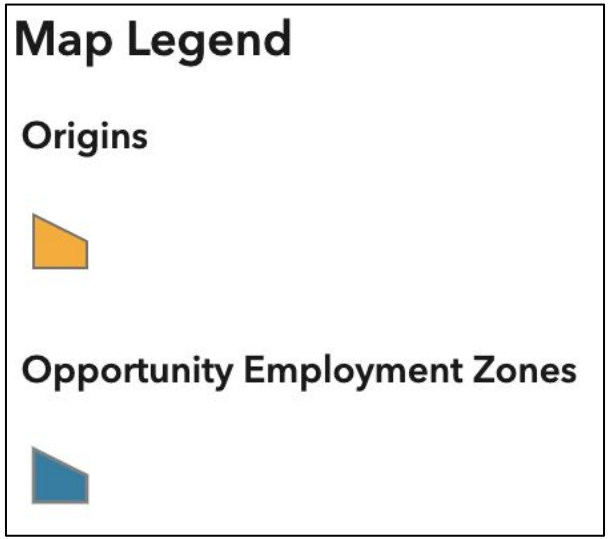


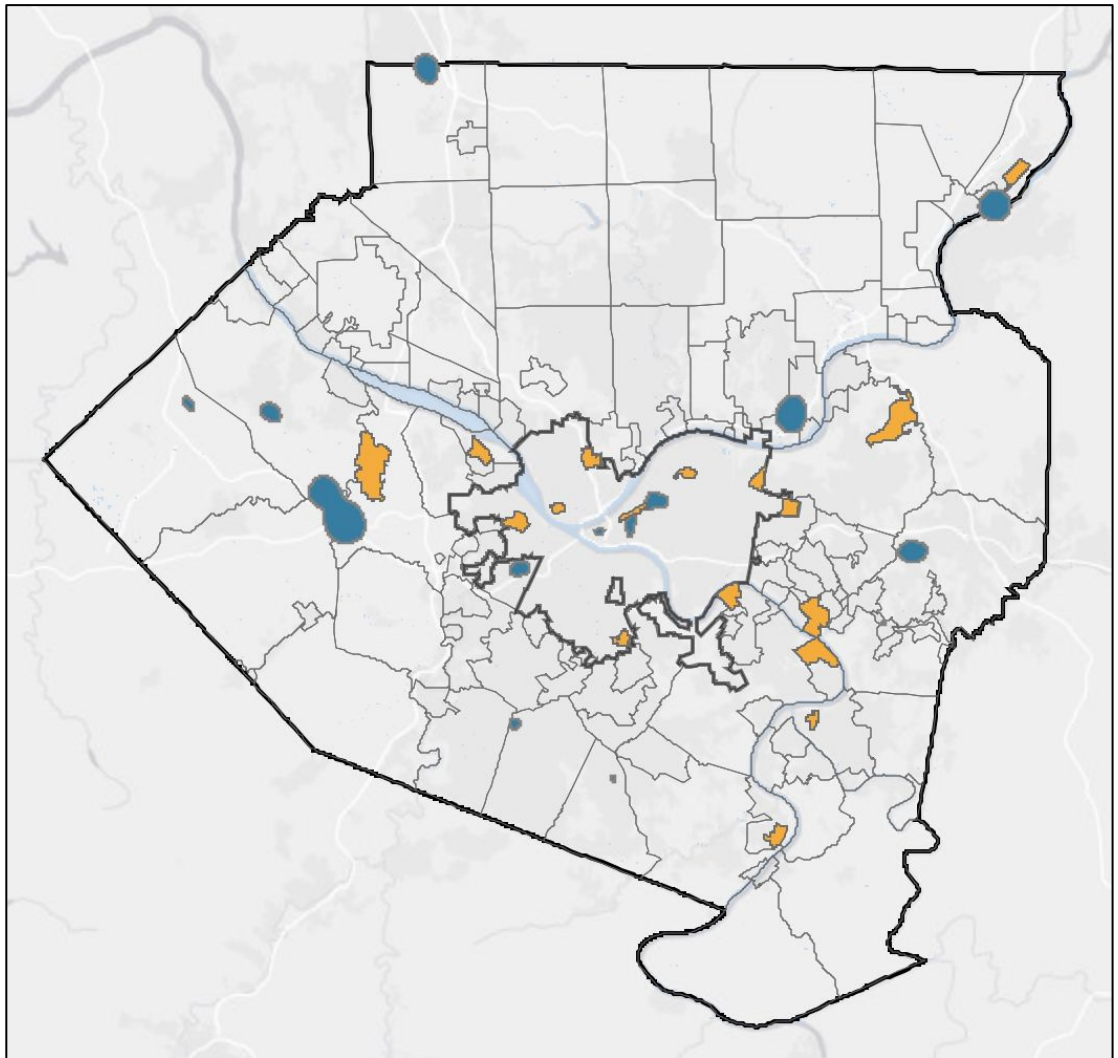
17 Origins:
Clairton, McKeesport, Duquesne, Carrick, North Braddock, Homestead, Crafton Heights, Bedford Dwellings, East Hills, Manchester, Robinson Township, Lincoln-Lemington-Belmar, Garfield, Northview Heights, Stowe Township, Penn Hills, and Harrison Township.

Unemployed DHS clients who completed high school (no bachelor's degree)



Areas of interest: origins and destinations





Transit methodology review

- **Step 1:** Identify bus stops within origin and destination zones
  - Included .25 mile buffer to capture bus routes right outside block group borders.
- **Step 2**: Estimate travel times between each origin and destination pair within specific time windows using scheduled General Transit Feed Specification (GTFS) and Automatic Passenger Counter - Automatic Vehicle Locator (APC-AVL) data:
  - Morning Peak 6am - 10am
  - Daytime Off Peak 10am - 3pm
  - Evening Peak 3pm - 7pm
  - Evening Off Peak 7pm - 10pm
  - Midnight to 6am 12am - 6am
  - Weekend 6am - 6pm

Real-time transit feed: APC-AVL

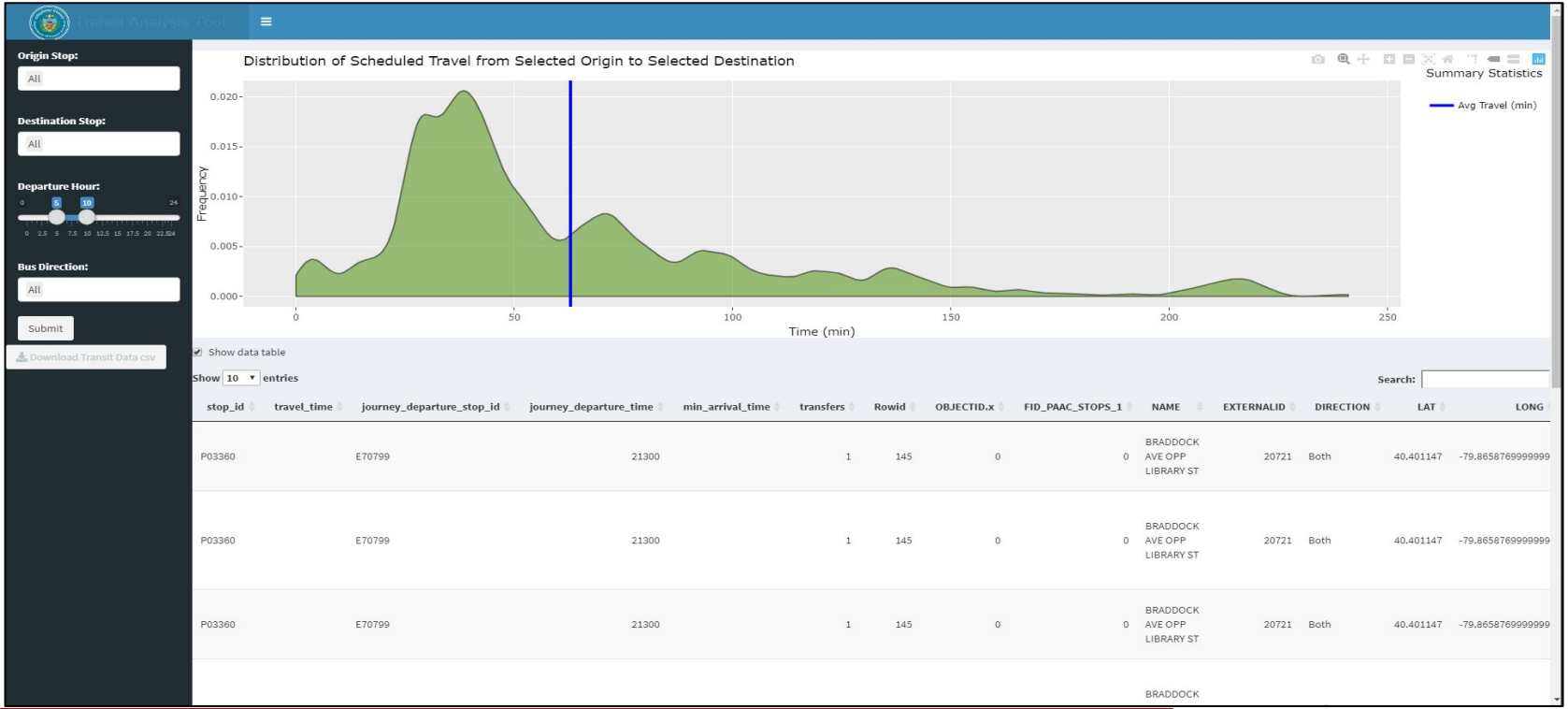
Automatic Passenger Counter - Automatic Vehicle Location (APC-AVL) file obtained from Port Authority of Allegheny County. Using Python data processing scripts we extracted:

- Bus, trip, and route details
- Departure times by day
- Passenger boarding and alighting counts

Travel time computation

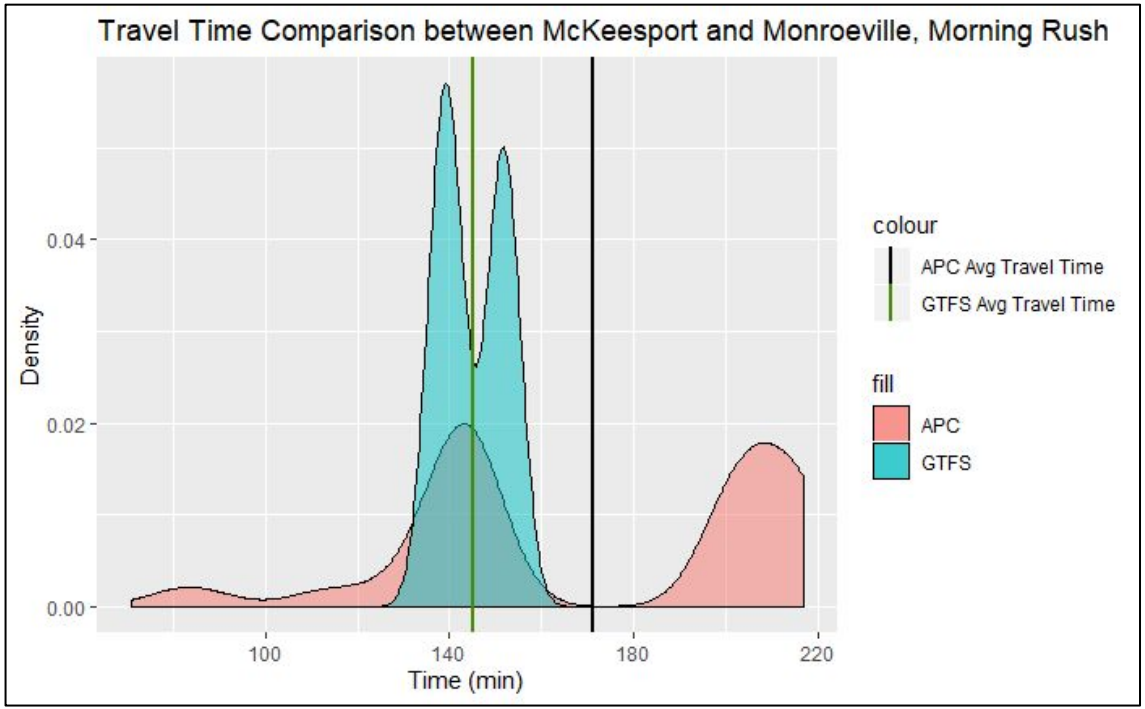
- How:
  - Scheduled travel times calculated using RAPTOR algorithm - a Round bAsed Public Transit Optimized Router algorithm
  - Live travel times computed with custom R script using point to point locations
- Why:
  - Computationally efficient as it does not rely on preprocessed data
  - Flexible in that parameters such as number of transfers can be modified on the fly
  - Fast enough to be used in dynamic application settings
  - Raptor computes pareto optimal journey times for any given pair of origin and destination points by minimizing arrival times and transfers for a given journey

Transit time estimator tool: dynamic visualizations



GTFS vs. APC-AVL: a comparison

- Scheduled and real-time travel can differ
- Greater variability of service in live data



Part IV: Accessibility index

Understanding the index

- **Multi-dimensional**: The index is designed to capture different aspects of the transit experience

- **Peer-based**: All scores between an origin and destination are based on how that pairing ranks *relative* to selected pairings **in this study** between 0 and 100

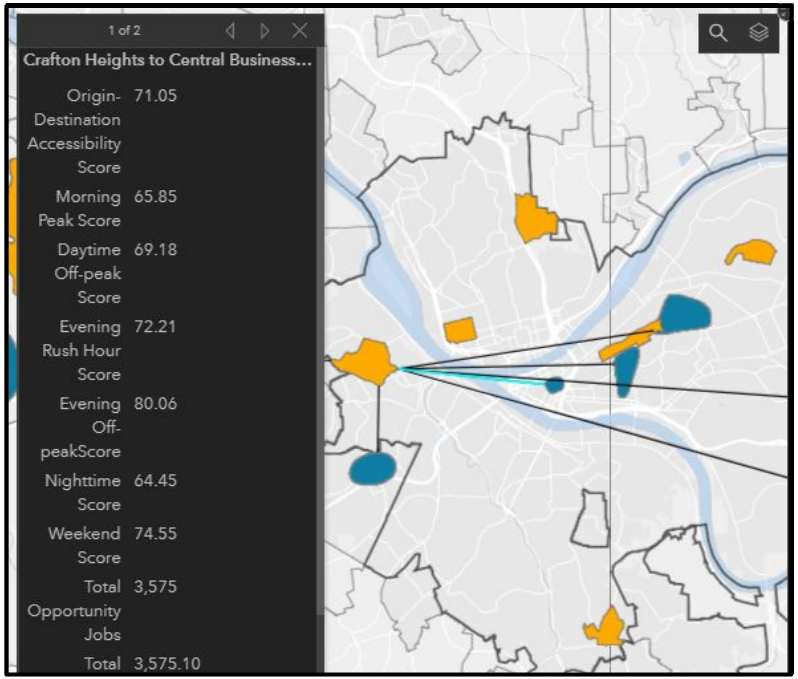
- **Multi-source**: Data from multiple sources is aggregated into a single location to encourage exploration

- **Customizable**: Parameters and weights can be modified for different use cases

Range of scores

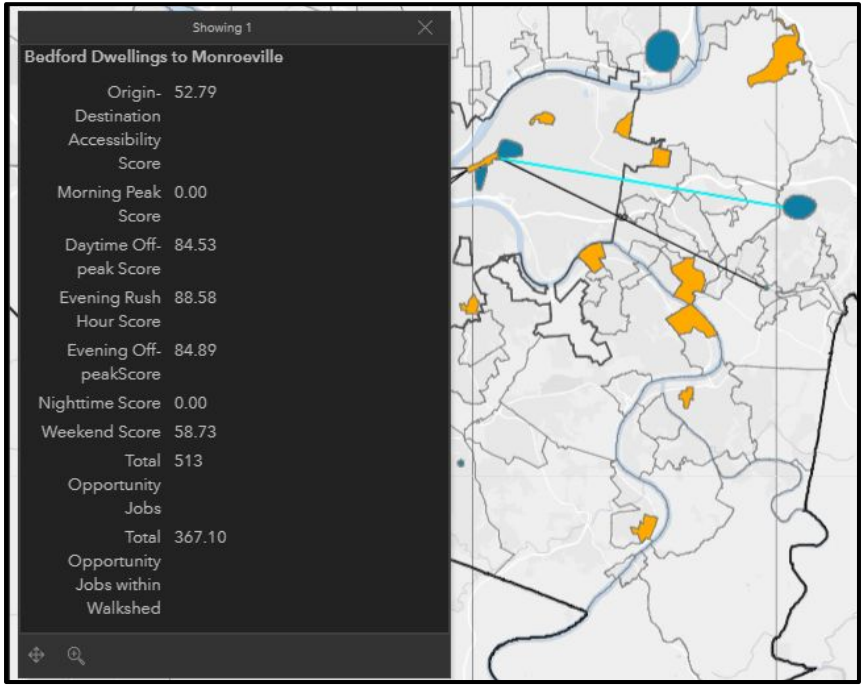
Top Score: 84.62

Crafton Heights to Central Business District

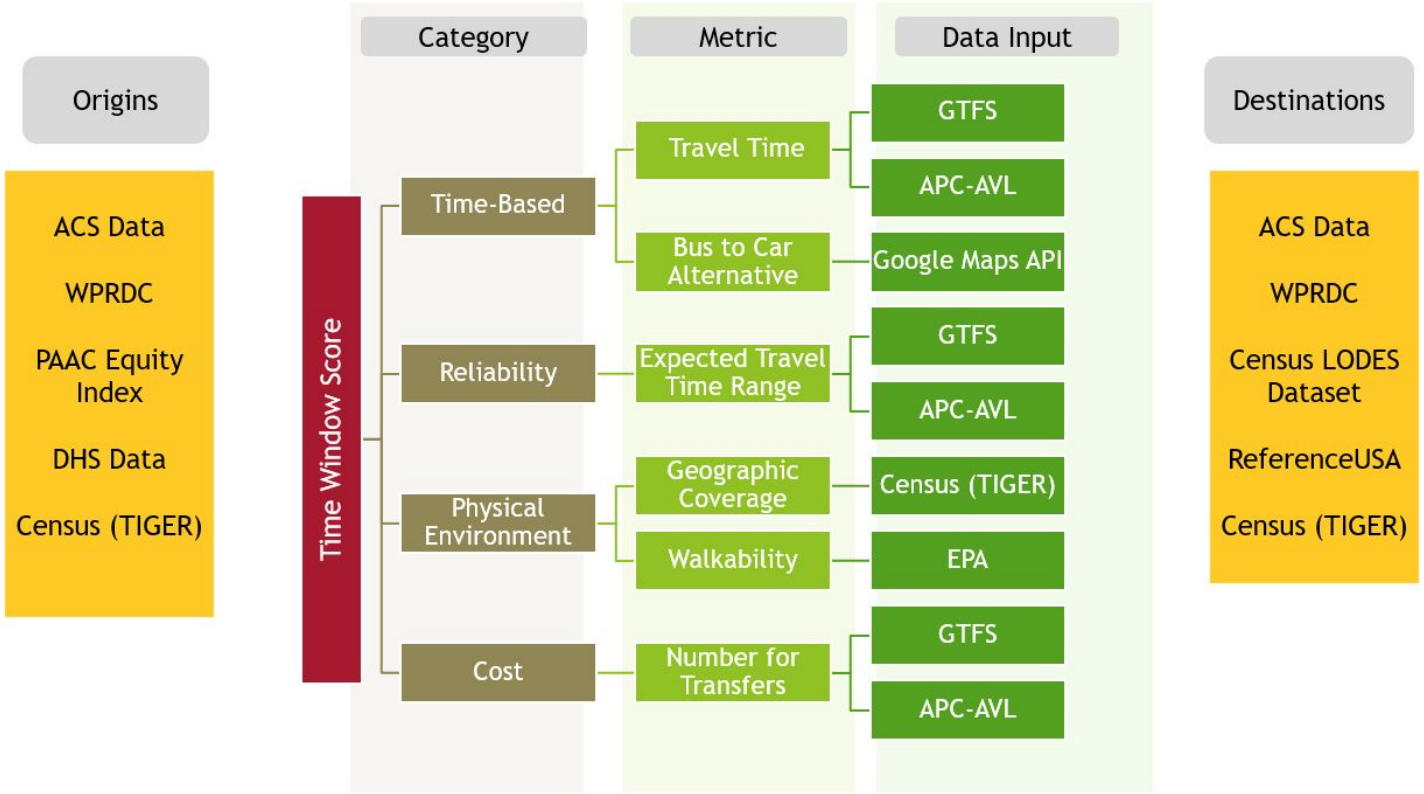


Low Score: 5.66

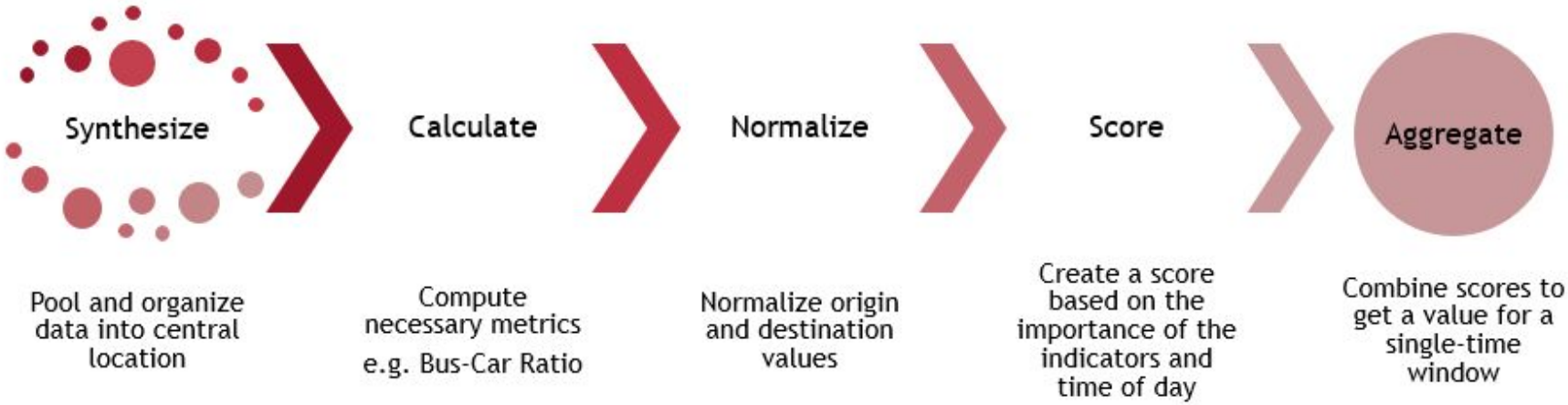
Bedford Dwellings to Monroeville



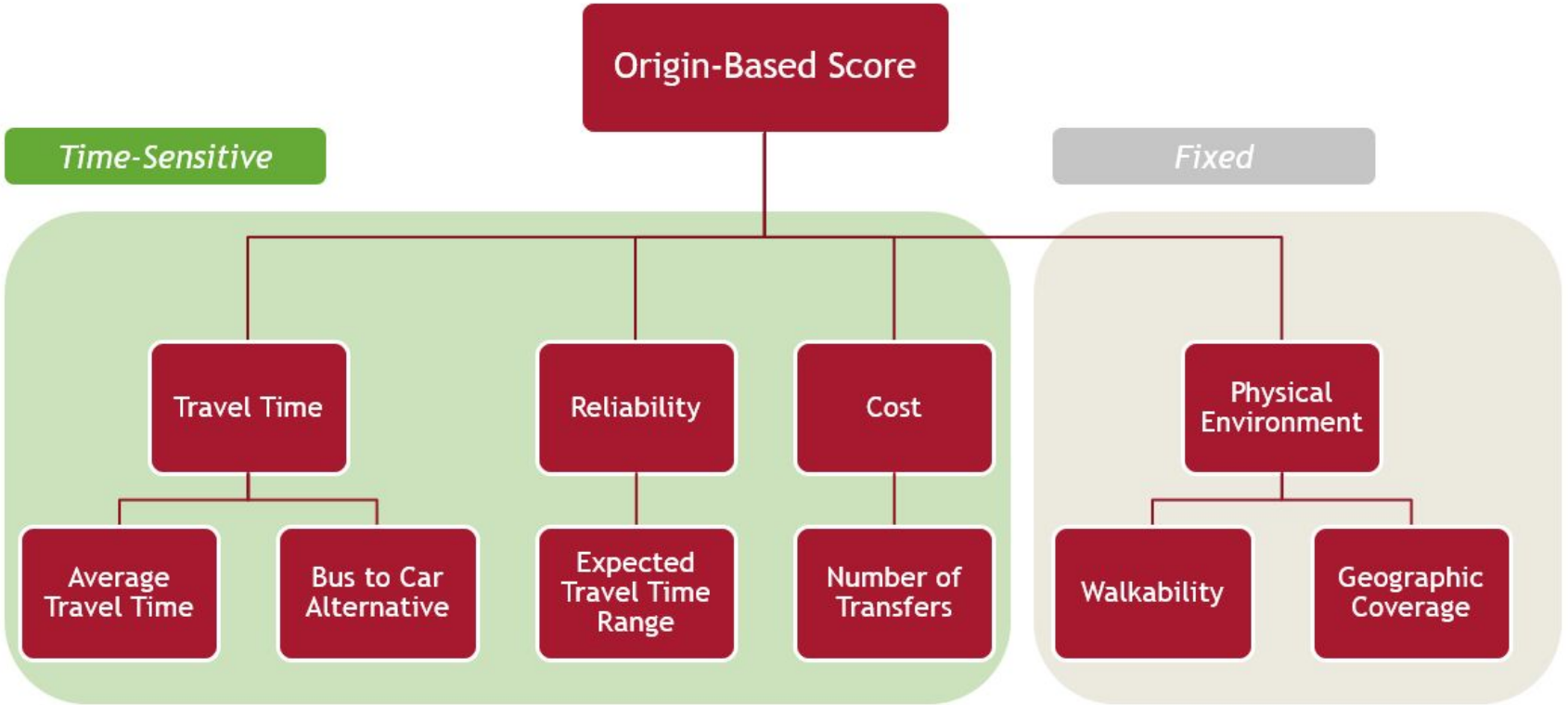
Mapping the inputs



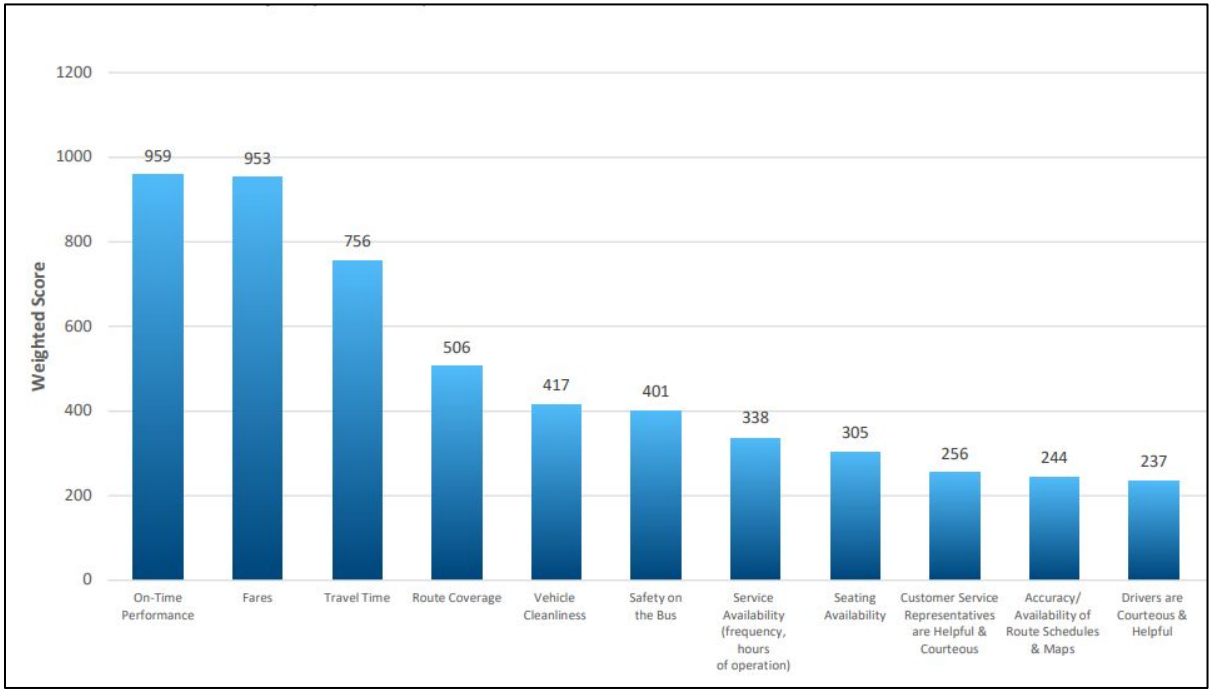
Index workflow



Distinct scores for each time window



Understanding transit riders



Port Authority of Allegheny County Customer Satisfaction Results - June 2018

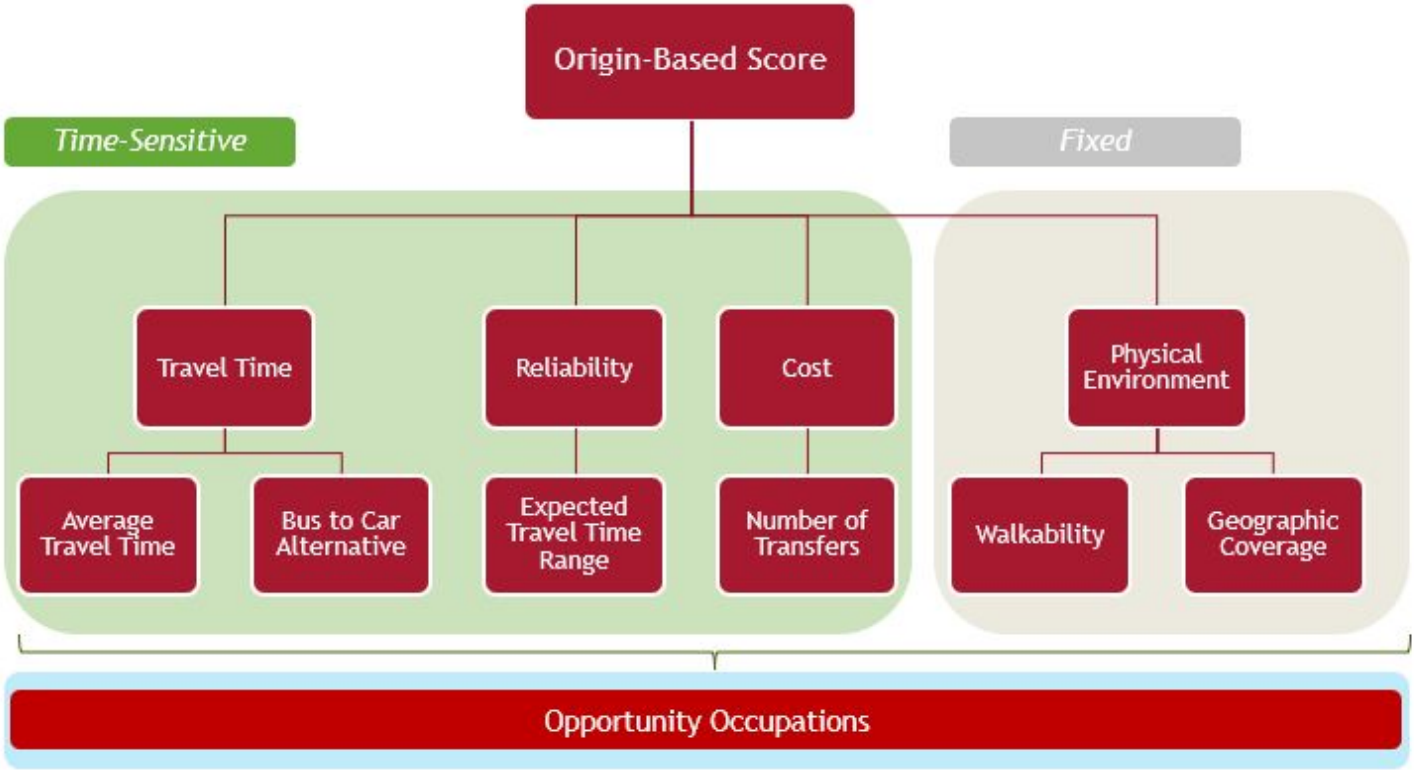
Carnegie Mellon University
HeinzCollege
INFORMATION SYSTEMS • PUBLIC POLICY • MANAGEMENT

Choosing and creating index weights

- Categories were weighted based on the following table.
- Reliability was de-emphasized due to scheduled nature of GTFS data

Category	Factors	Weight
Cost	Trip Cost	30.0
Time	Travel Time	20.0
Time	Bus/Car Ratio	20.0
Reliability	Expected Travel Time Range	15.0
Physical Environment	Geographic Coverage	7.5
Physical Environment	Walkability	7.5
Final Score		**100.0**

Community-based origin scores: weighting pairs by opportunity



Reading the index: within a time window

An Origin-Destination Pair

	Cost	Average Travel Time	Bus-Car Alt	Expected Travel Time Range	Walkability	Geographic Coverage
Raw Data	$4.68	1.36 hours	3.6	0.5 hours	14/20	30%
Processing	*Normalization*					
Possible Points	30.0	20.0	20.0	15.0	7.5	7.5
Total	21.1	7.5	12.5	8.3	4.4	5.3

Total Points	64
Points Possible	100

Reading the index: across time windows

- Consider the pairing for Carrick and the Central Business District:
  - While the origin-destination pair scores relatively high during most time windows, it is **not** accessible between midnight and 6am.

Morning_Peak_Score	Day_Offpeak_Score	Evening_Rush_Score	Eve_Offpeak_Score	Night_Score	Weekend_Score
82.40	79.60	79.56	75.90	0.00	72.66

Visualizing inaccessibility

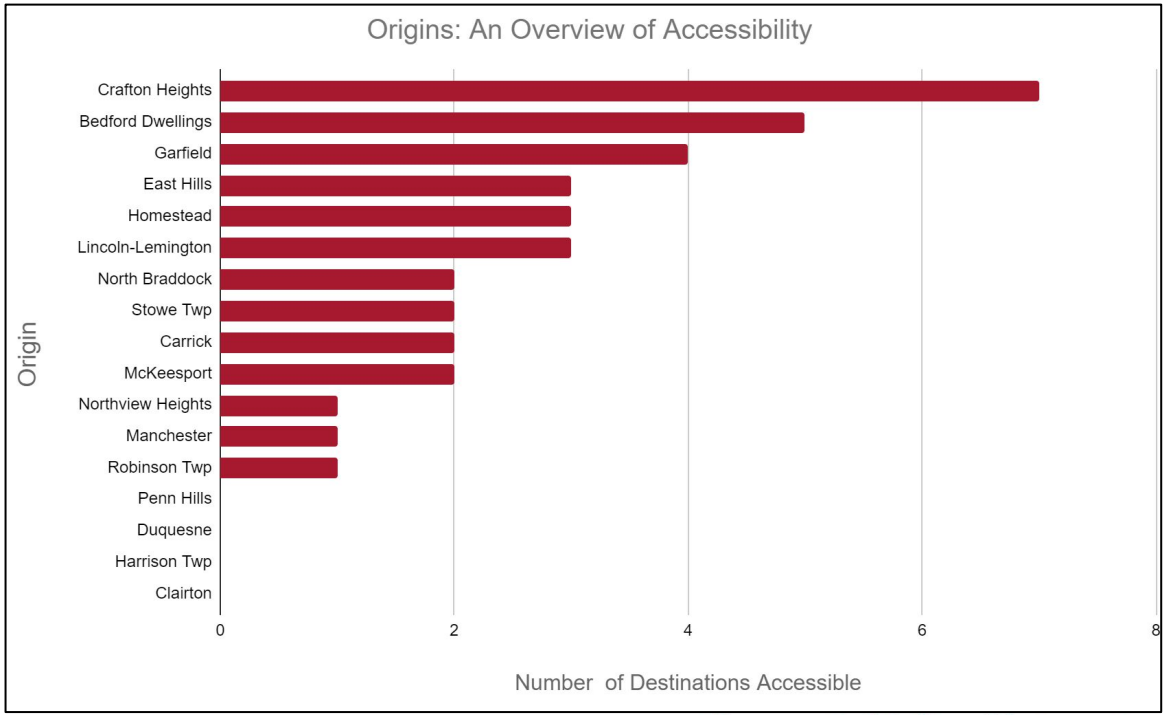
Penn Hills to O'Hara Township

	Cost	Average Travel Time	Bus-Car Alt	Expected Travel TIme Range	Walkability	Geographic Coverage
Raw Data	NA	NA	NA	NA	NA	NA
Processing	*Normalization*					
Possible Points	30.0	20.0	20.0	15.0	7.5	7.5
Scores	**0**	**0**	**0**	**0**	**0**	**0**

Total Points	0
Points Possible	100

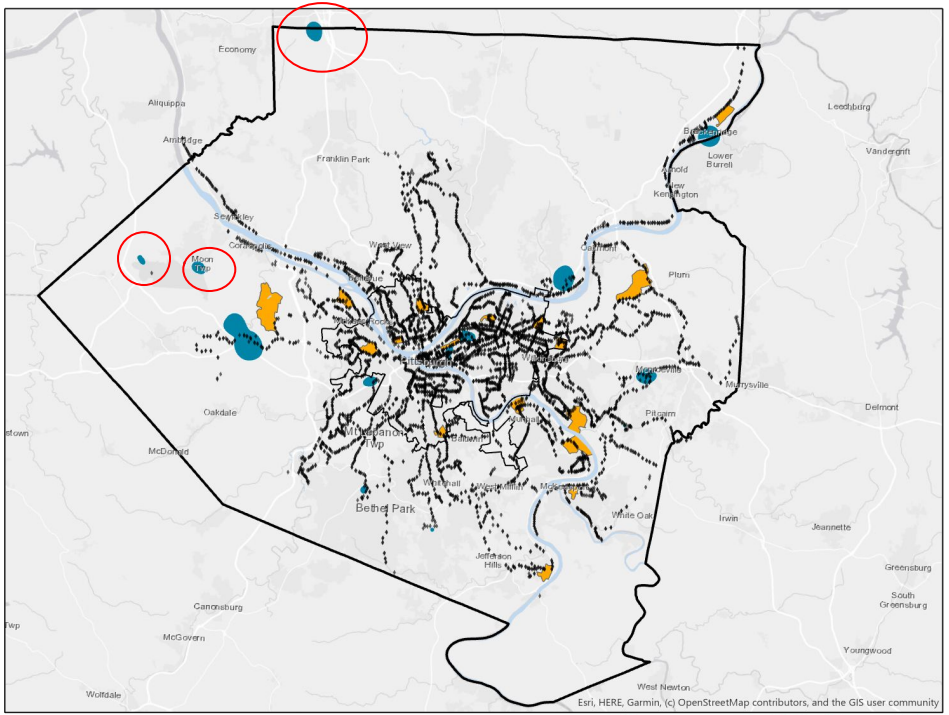
Inaccessible: summary of findings

Only 6 of the identified origins could reach more than three opportunity occupation zones.



Inaccessible: summary of findings

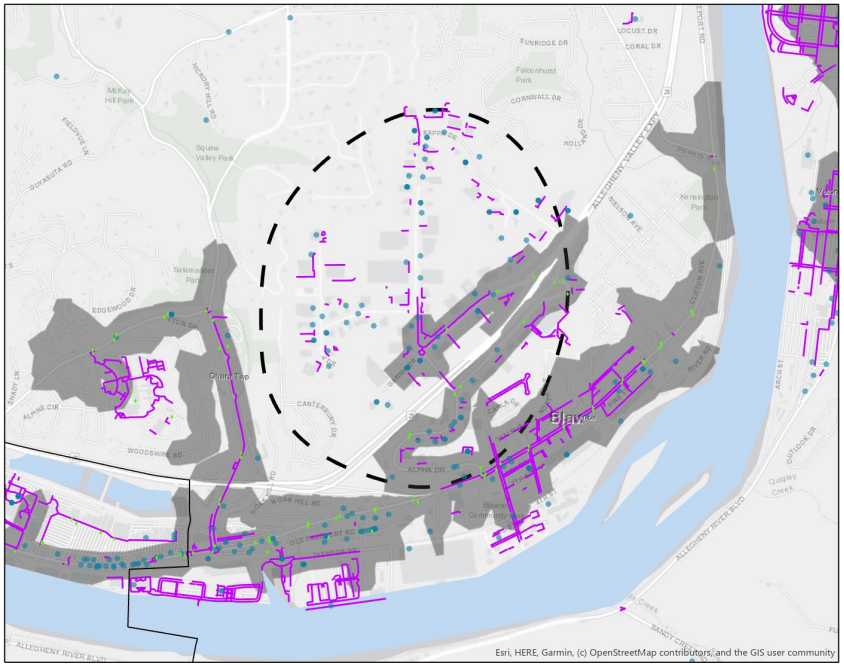
Of the 14 opportunity occupation “hotspots”, **three had no bus stops at all.**



Carnegie Mellon University
HeinzCollege
INFORMATION SYSTEMS • PUBLIC POLICY • MANAGEMENT

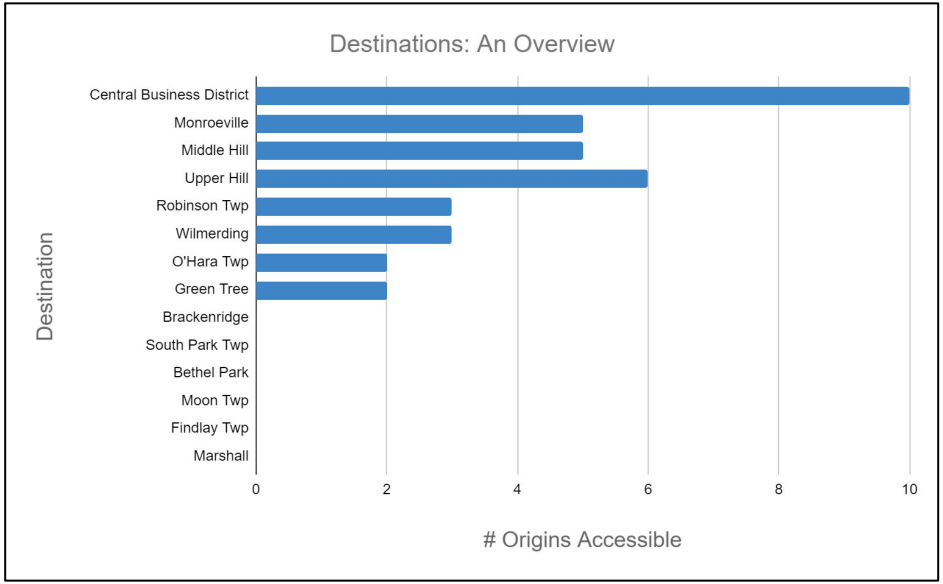
Inaccessible: summary of findings

Even when opportunity occupation zones were deemed accessible, the bulk of the occupations within that zone were frequently **outside of the Port Authority walkshed**.

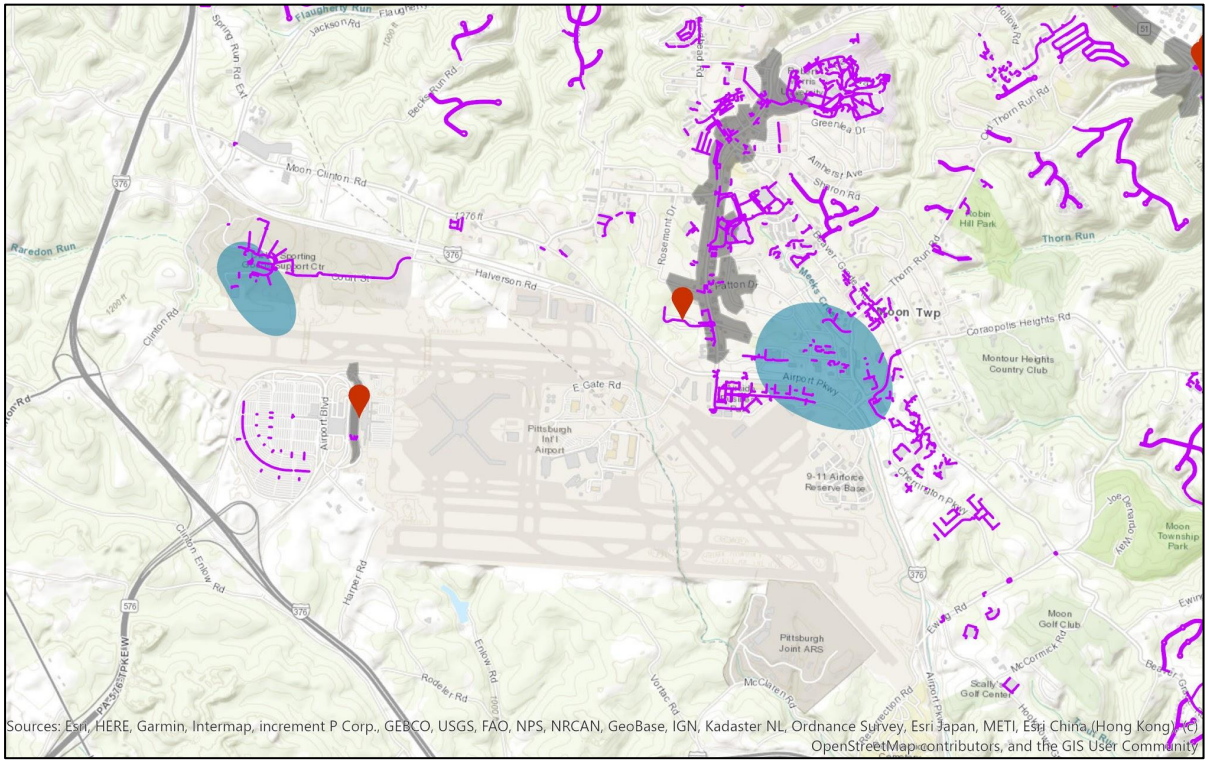


Inaccessible: summary of findings

While it is relatively easy to reach the Central Business District, there is huge **latent opportunity** in geographic areas that appear currently underserved by the public transit system.

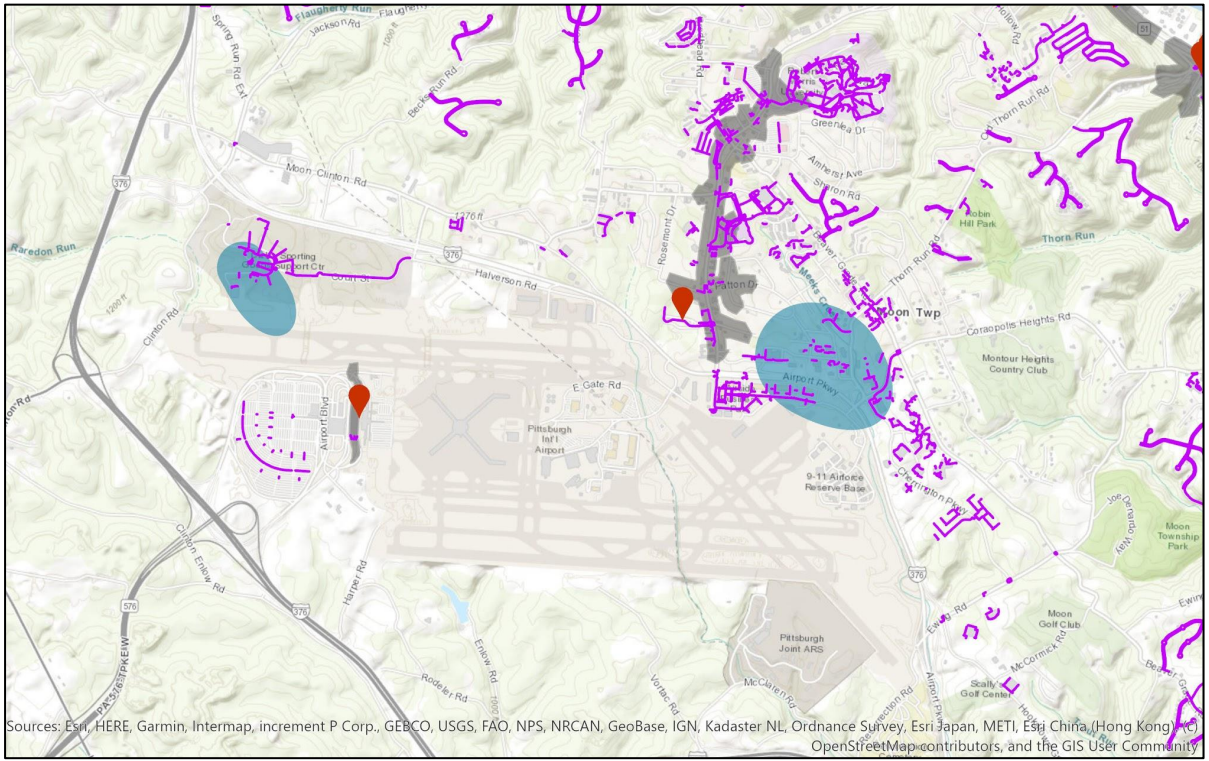


Limitations of the index: boundaries



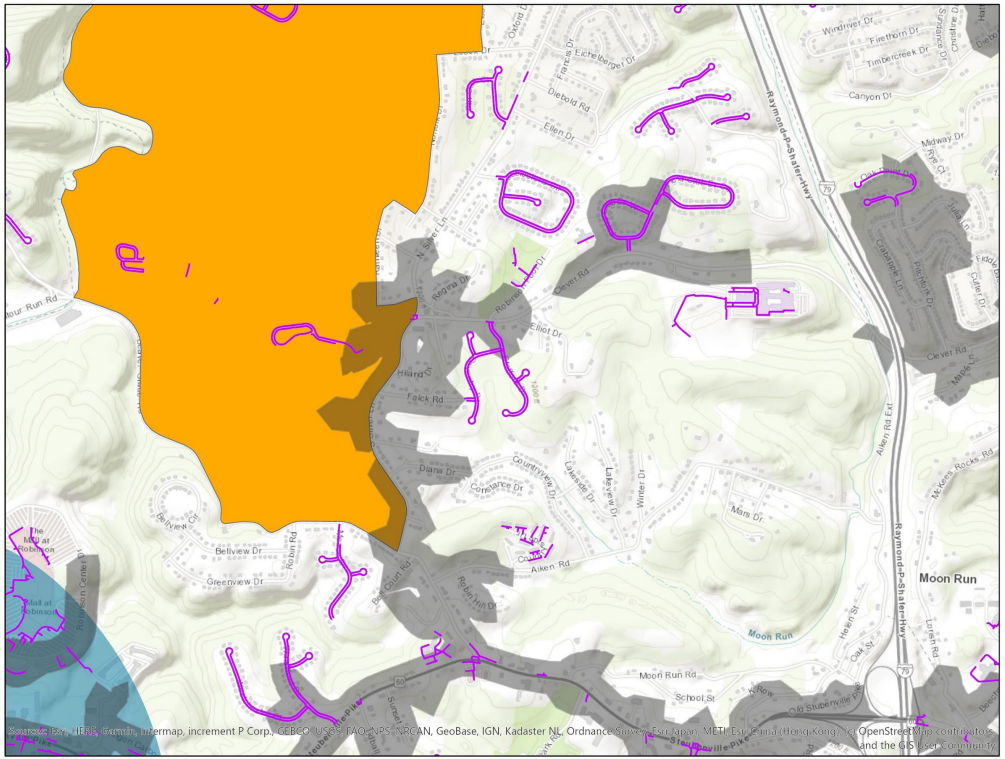
Carnegie Mellon University
HeinzCollege
INFORMATION SYSTEMS • PUBLIC POLICY • MANAGEMENT

Limitations of the index: work locations



Carnegie Mellon University
HeinzCollege
INFORMATION SYSTEMS • PUBLIC POLICY • MANAGEMENT

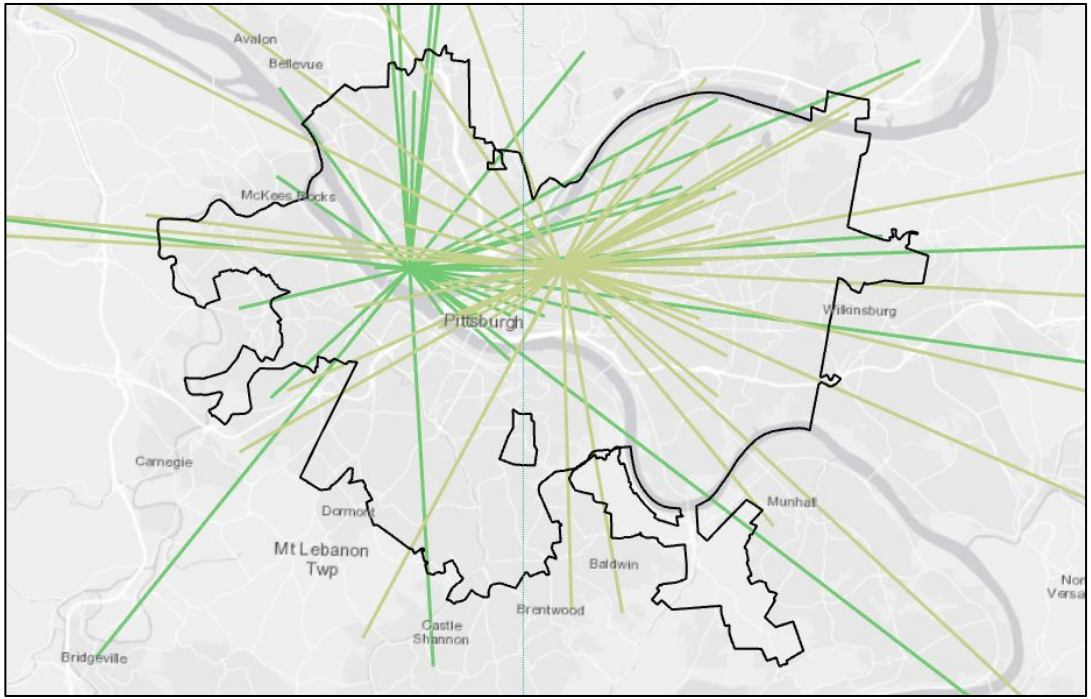
Limitations of the index: walkshed vs. sidewalks



Carnegie Mellon University
HeinzCollege
INFORMATION SYSTEMS • PUBLIC POLICY • MANAGEMENT

Part IV continued: Accessibility index validation

DHS data observations: transit patterns



Selected Block Groups:

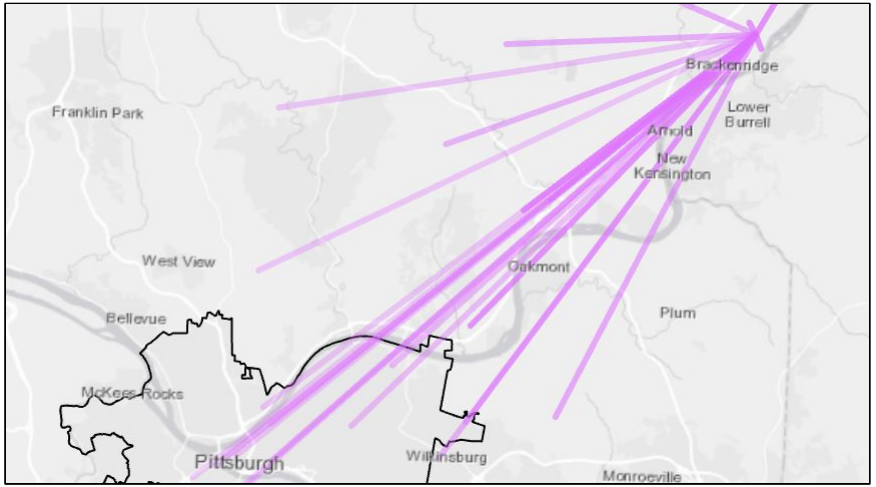
- DHS client commute patterns in central Pittsburgh
- Abundant public transportation options available

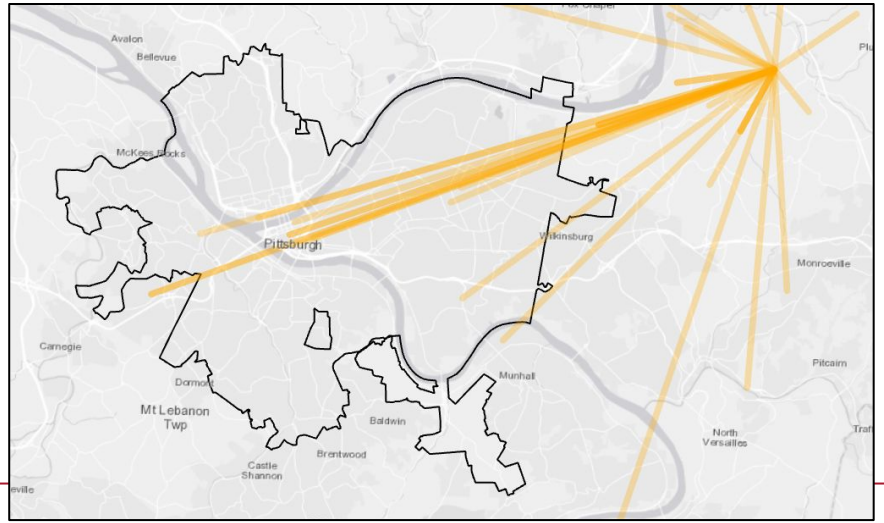
DHS data observations

Farther out from Pittsburgh:

- DHS client commute patterns often trace the more limited public transport options

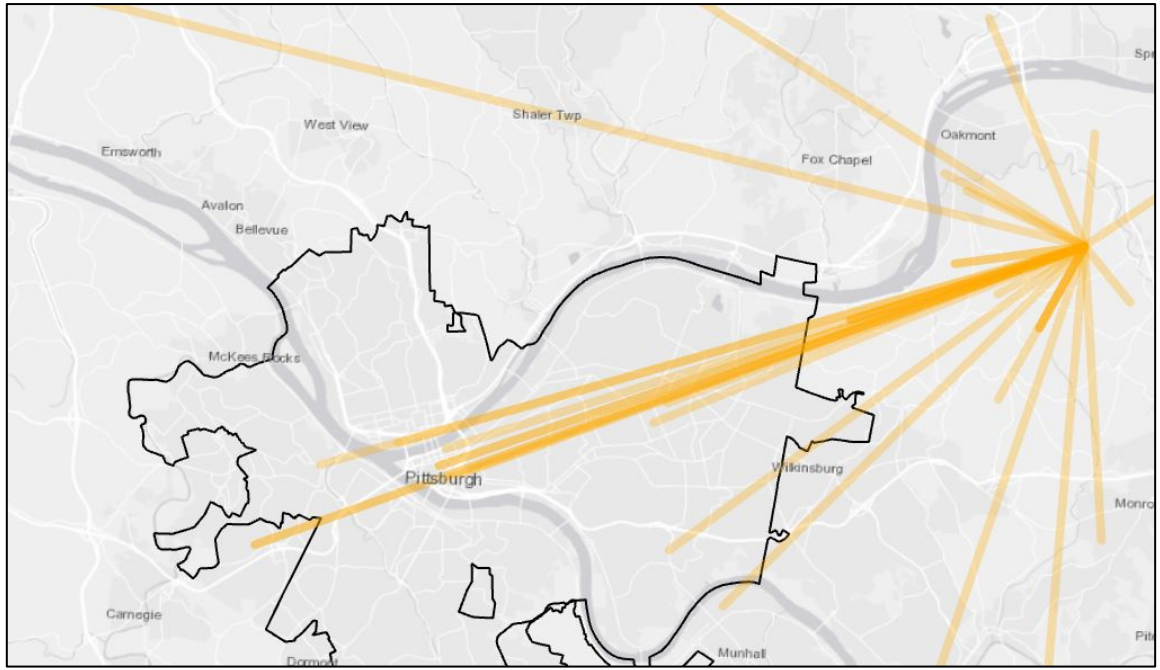
- Jobs located towards the city center



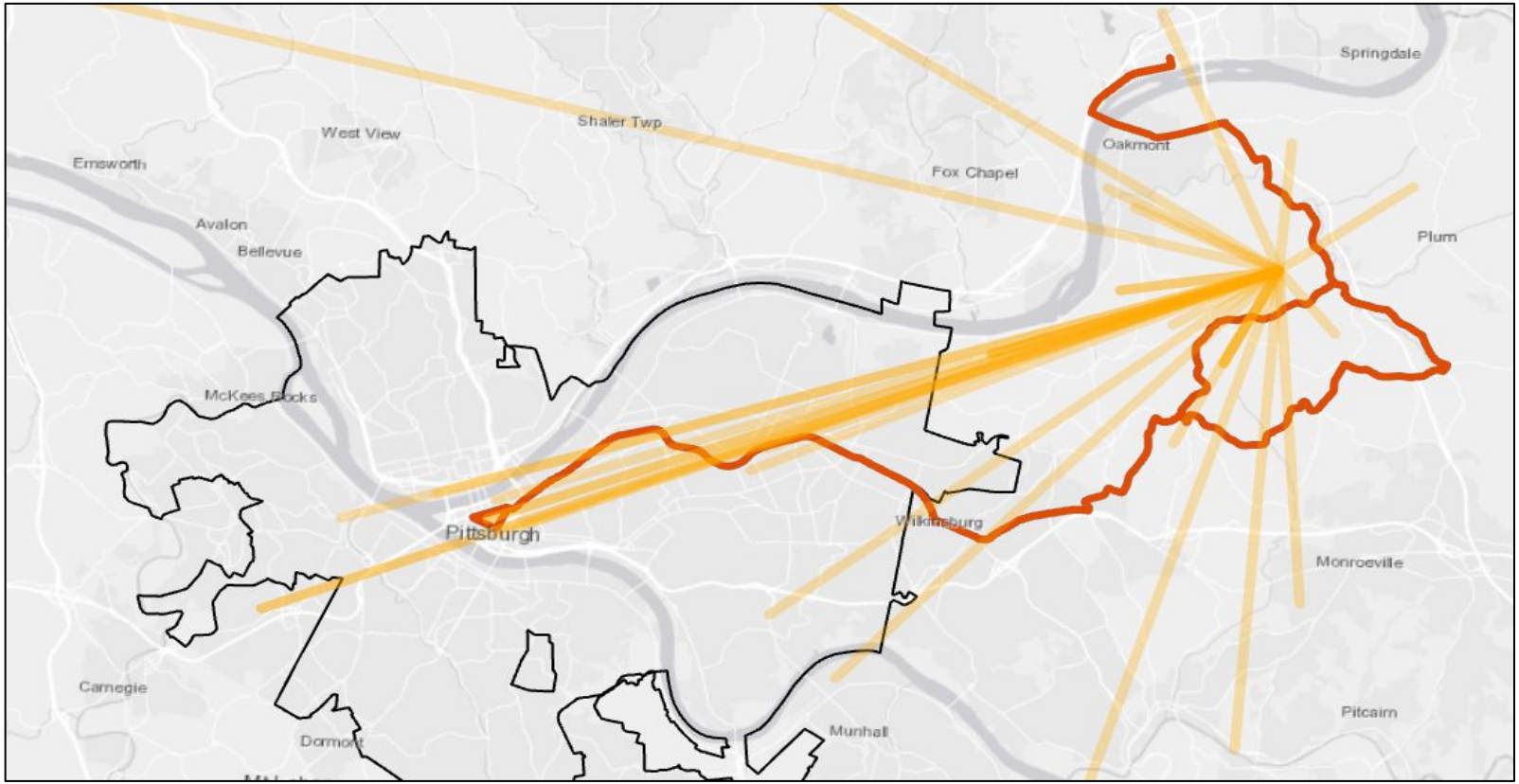


Case study: Penn Hills to O'Hara Township

The low index score indicates an accessibility challenge.

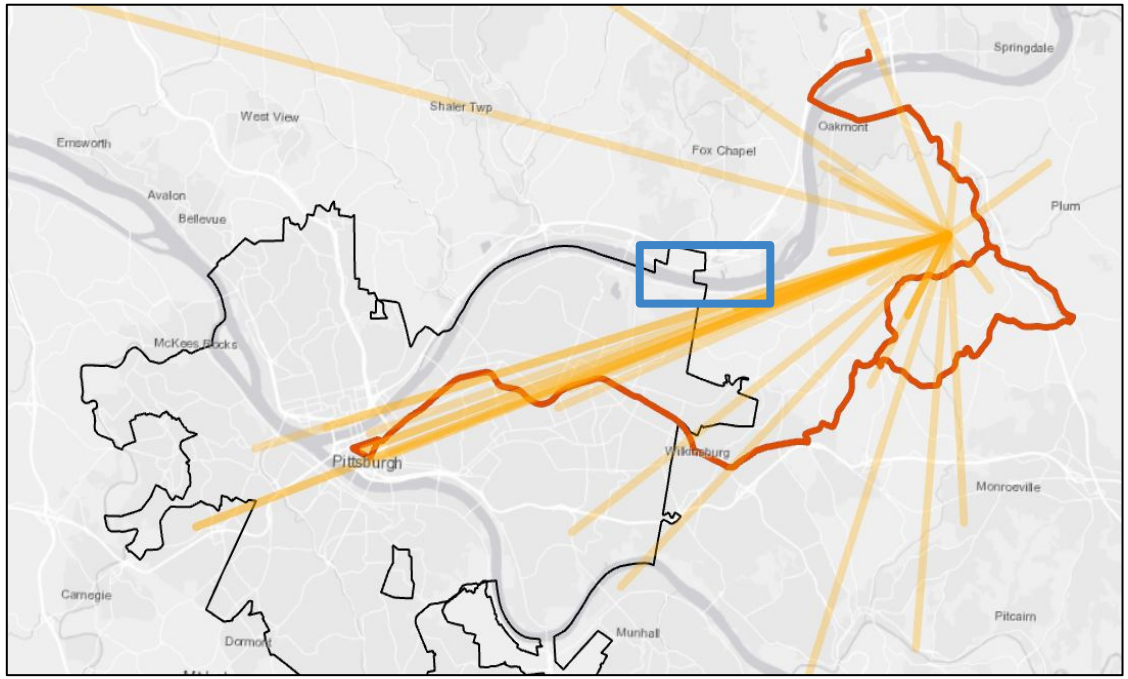


Focus on Penn Hills to O'Hara Township



Focus on Penn Hills to O'Hara Township

Despite geographic proximity, no one seems to work in this opportunity zone.



Carnegie Mellon University
HeinzCollege
INFORMATION SYSTEMS • PUBLIC POLICY • MANAGEMENT

Part V: Communicating results

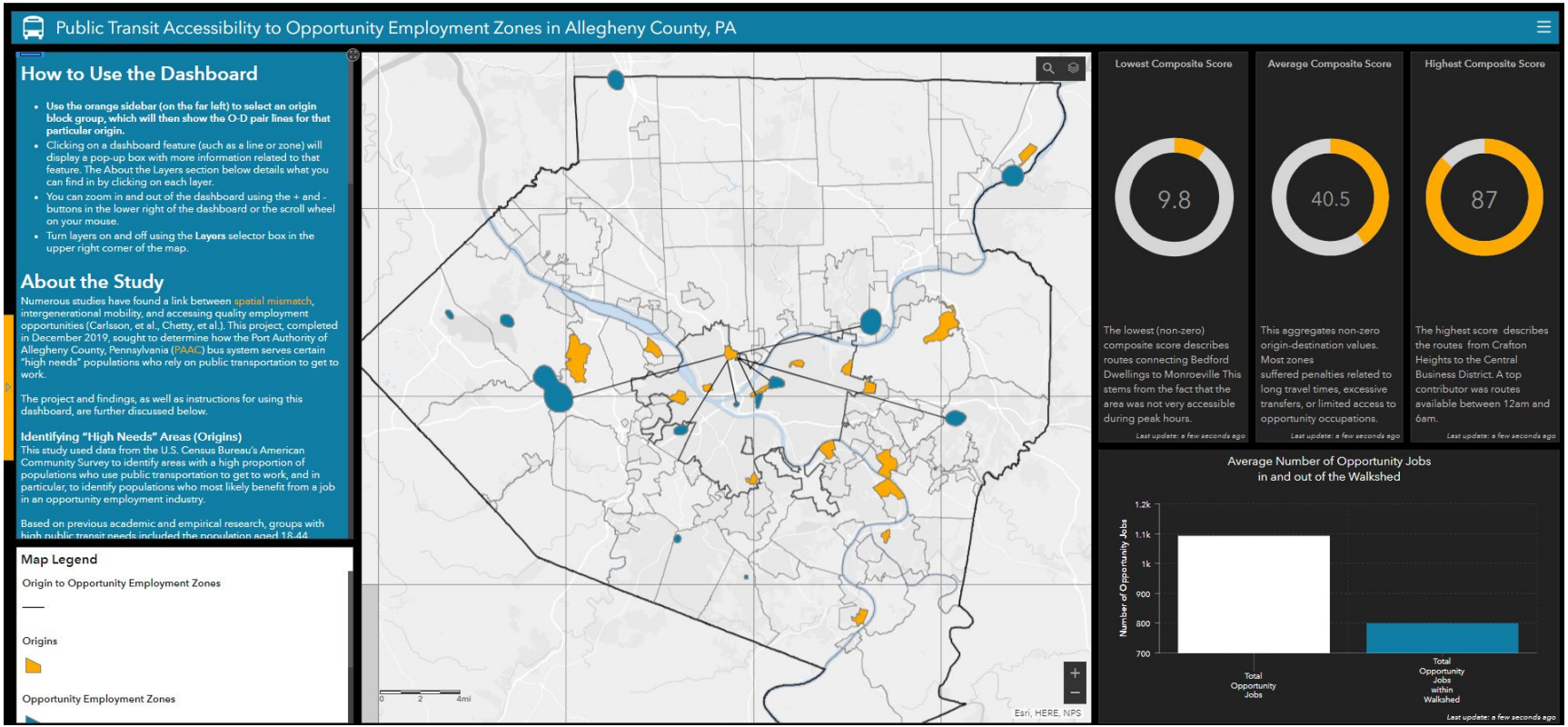
GIS Dashboard

- Built public-facing, interactive ArcGIS dashboard

- Users can explore summary results about:
  - Areas of interest (“origins”)
  - Opportunity occupation zones (“destinations”)
  - Accessibility score of each origin-destination pair
  - Origins’ composite accessibility score

- Layers include:
  - PAAC transit routes
  - PAAC stops
  - PAAC walkshed

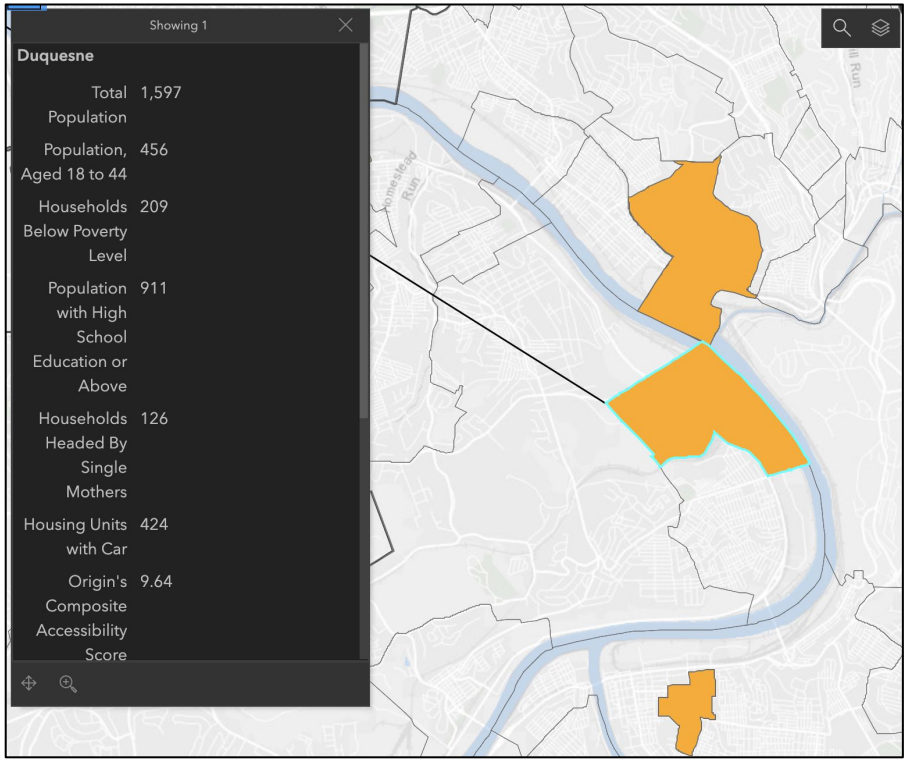
GIS Dashboard



GIS Dashboard: origins

Summary information for **Census block groups**:

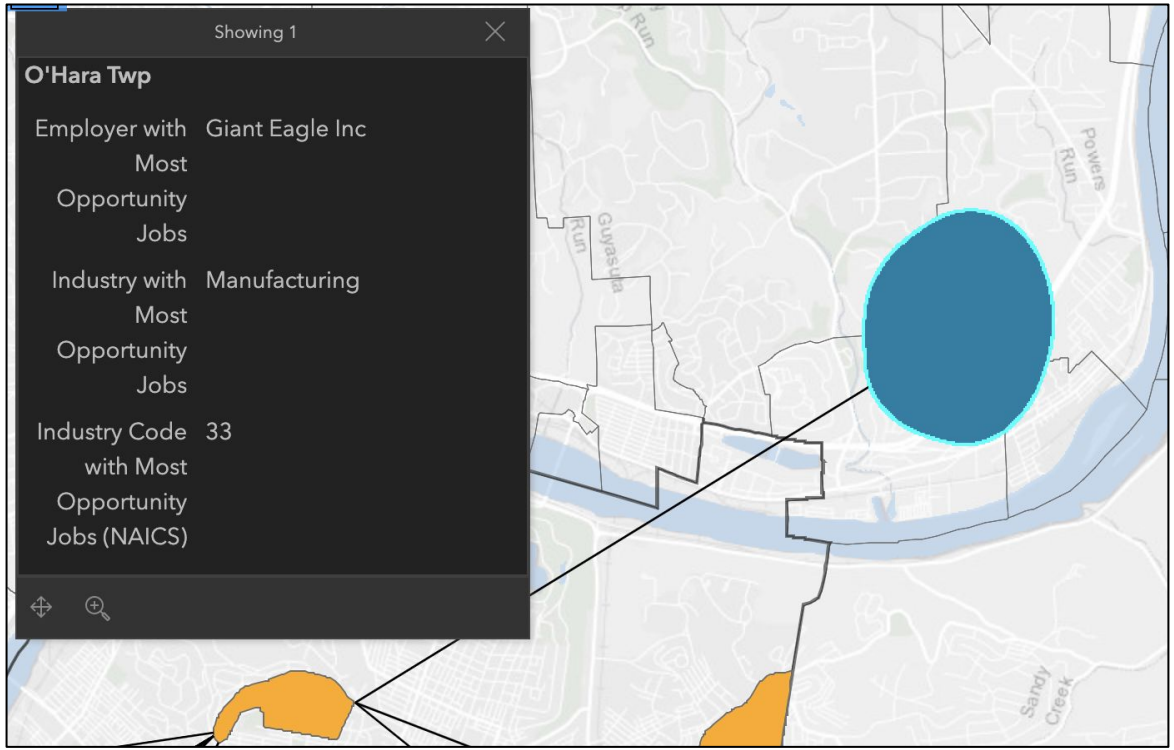
- Name of municipality or neighborhood
- Population
- Households below poverty level
- Population with at least high school education
- Households headed by single mothers
- Housing units with access to car
- Accessibility index scores



GIS Dashboard: destinations

Summary information for **opportunity occupation zones**:

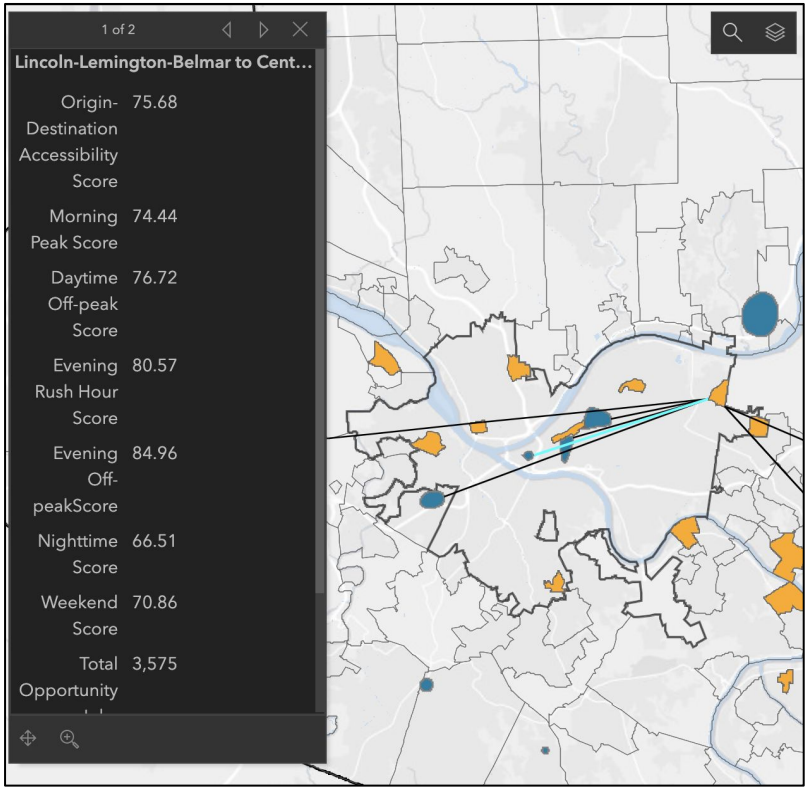
- Employer with most opportunity jobs
- Industry and NAICS code with most opportunity jobs



GIS Dashboard: origin-destination pairs

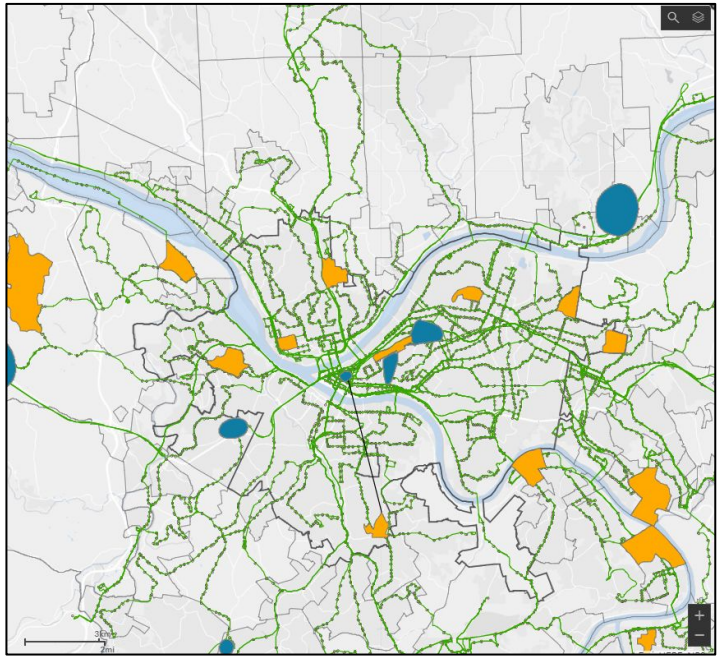
Summary information for **origin-destination pairs**:

- Accessibility score
- Time-based scores
- Total opportunity jobs
- Total opportunity jobs within walkshed

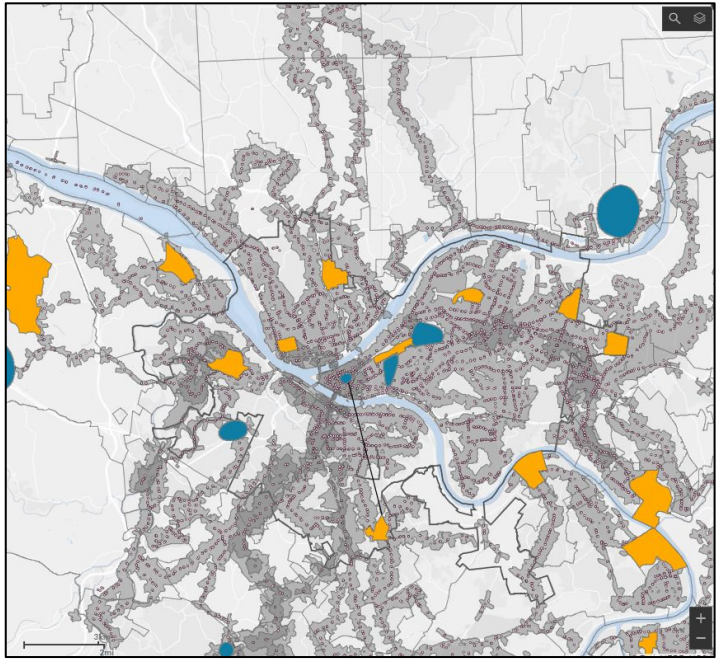


GIS Dashboard: additional layers

Transit route information



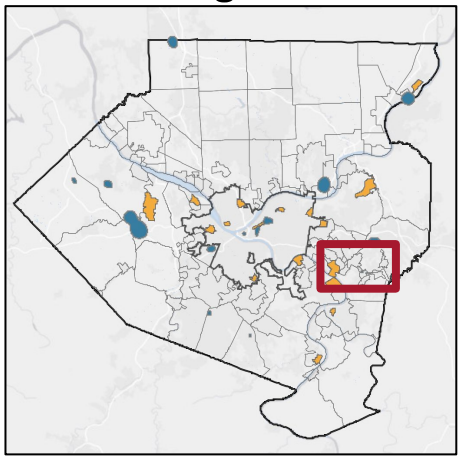
Walkshed information

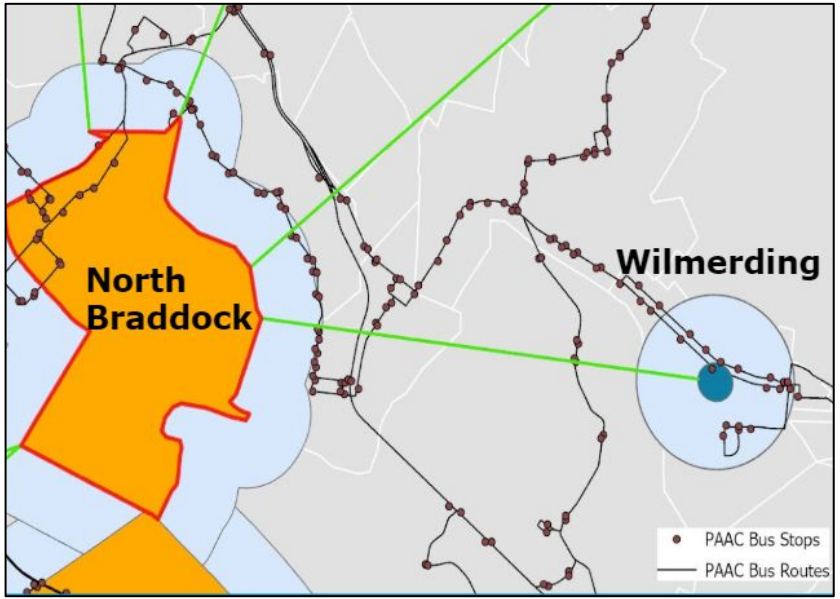


Part VI: Recommendations and future use

Considerations and recommendations

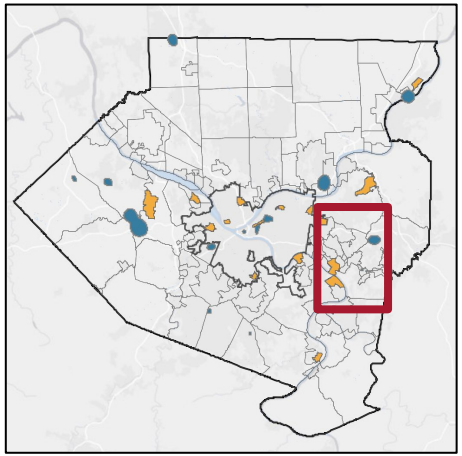
- Geographically close areas with low origin-destination scores
  - North Braddock to Wilmerding
  - Harrison Township to Brackenridge

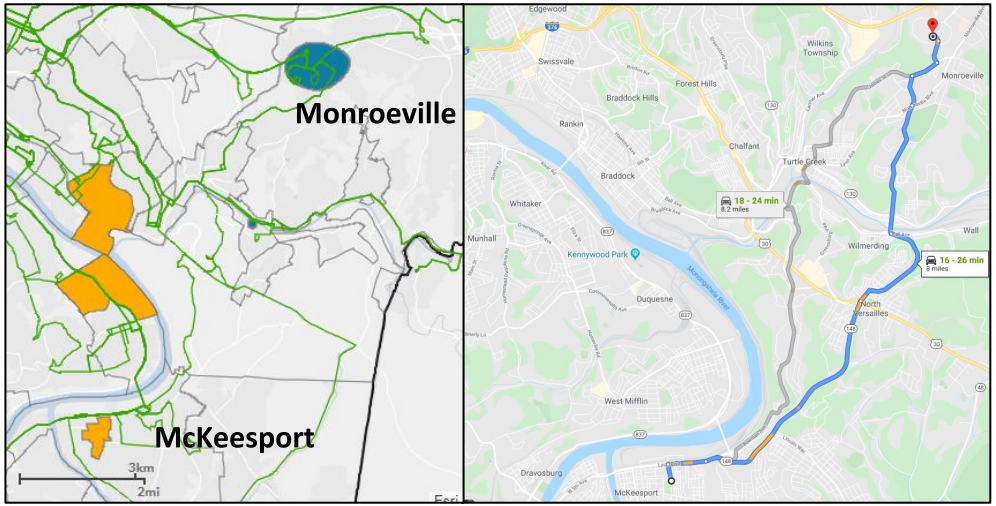




Considerations and recommendations

- Poor bus-car ratio
  - McKeesport to Monroeville
  - Advocate for transit changes
    - Direct bus routes
    - More service

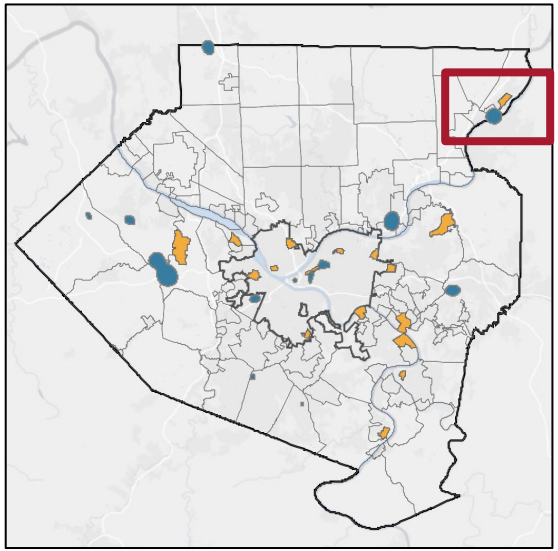


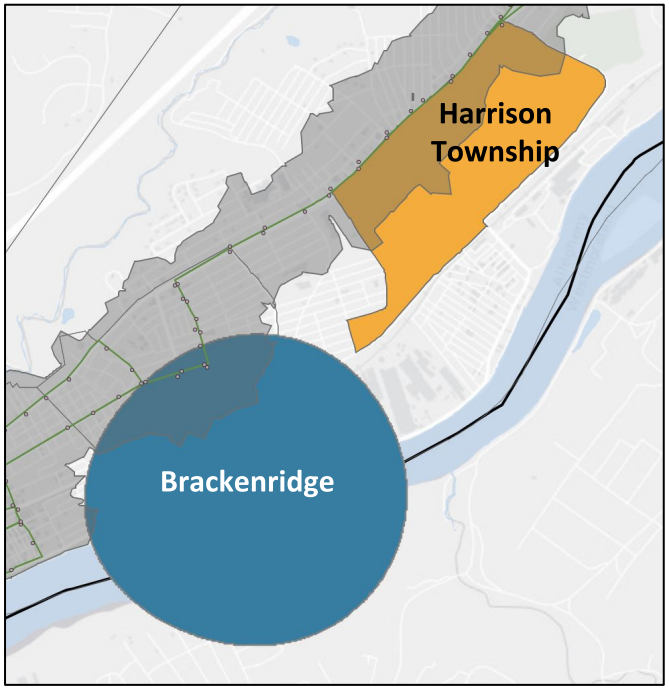


Carnegie Mellon University
HeinzCollege
INFORMATION SYSTEMS • PUBLIC POLICY • MANAGEMENT

Considerations and recommendations

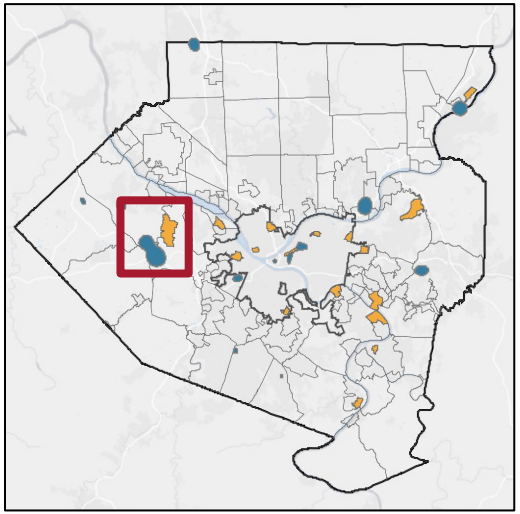
- Destination zones just outside walkshed
  - Brackenridge
    - Coordinate a last-mile solution



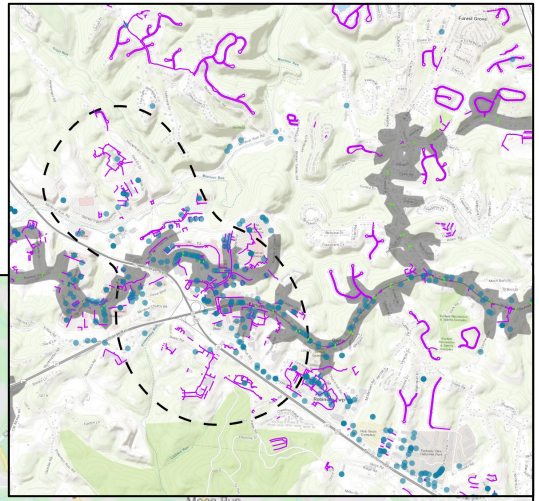


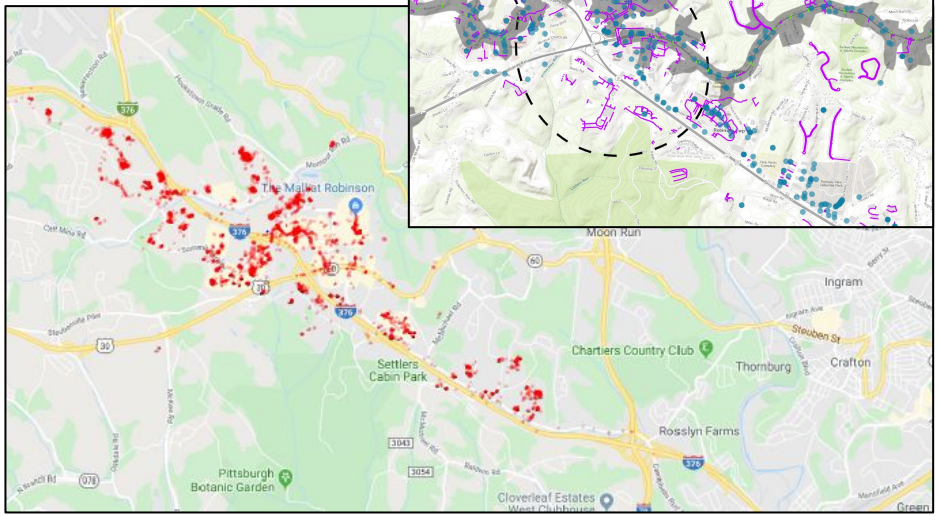
Policy considerations and recommendations

- Destination zones just outside walkshed
  - Robinson Township
    - RideACTA



Robinson Township





Future use cases

- Using the index as a base, the following are opportunities for DHS to customize and use the tool:
  - Expand the index and swap opportunity employment for access to:
    - Child care
    - Grocery stores
    - DHS services
  - Analyze affordable housing
    - Are people living in accessible areas?
      - Understanding voucher use based on location
  - Analyze Family Support Centers
    - Inform the evaluation process
  - Advocate for transit change and collaboration
    - Use and share methodology with organizations to inform change

Questions & discussion

Selected sources

- 412 Food Rescue, *Food Insecurity and Resource Access in Allegheny County, Pennsylvania: Using GIS to Identify High Need Communities and Assess Food Recovery and Redistribution Efficacy*, Pittsburgh: 412 Food Rescue, 2018.
- Barkley, Brett, G. Pacetti, Emily, Bailey, Layisha. *A Long Ride to Work: Job Access and the Potential Impact of Ride-Hailing in the Pittsburgh Area*. Cleveland: Federal Reserve Bank of Cleveland, 2018.
- "General Transit Feed Specification." GTFS. Accessed October 15, 2019. https://gtfs.org/.
- Deboosere, Robbin, and Ahmed El-Geneidy. 2018. "Evaluating Equity and Accessibility to Jobs by Public Transport across Canada." Journal of Transport Geography 73 (December): 54–63.
- Delling, Daniel, Thomas Pajor, and Renato F. Werneck. "Round-Based Public Transit Routing." *2012 Proceedings of the Fourteenth Workshop on Algorithm Engineering and Experiments (ALENEX)*, 2012, 130–40. https://doi.org/10.1137/1.9781611972924.13.
- DeMaria, Kyle. *Getting to Work On Time: Public Transit and Job Access in Northeastern Pennsylvania.* Philadelphia: Federal Reserve Bank of Philadelphia, 2018.
- *Equity Index of Mobility Need*, Pittsburgh, PA: Port Authority of Allegheny County, 2019.
- Fee, Kyle, Keith Wardrip, and Lisa Nelson. *Opportunity Occupations Revisited: Exploring Employment for Sub-Baccalaureate Workers Across Metro Areas and Over Time.* Cleveland: Federal Reserve Bank of Cleveland, 2019.
- Murphy, Brendan, Andrew Owen, *"Access Across America: Transit 2017,"* Transportation Studies - University of Minnesota, 2018.
- Proffitt, David G., Keith Bartholomew, Reid Ewing, and Harvey J. Miller. 2019. "Accessibility Planning in American Metropolitan Areas: Are We There Yet?" Urban Studies 56 (1): 167–92.
- United States Census Bureau, American FactFinder (ACS 2013-2017), https://factfinder.census.gov/
- Wardrip, Keith. *Identifying Opportunity Occupations in Pennsylvania, New Jersey, and Delaware.* Philadelphia: Federal Reserve Bank of Philadelphia, 2015.

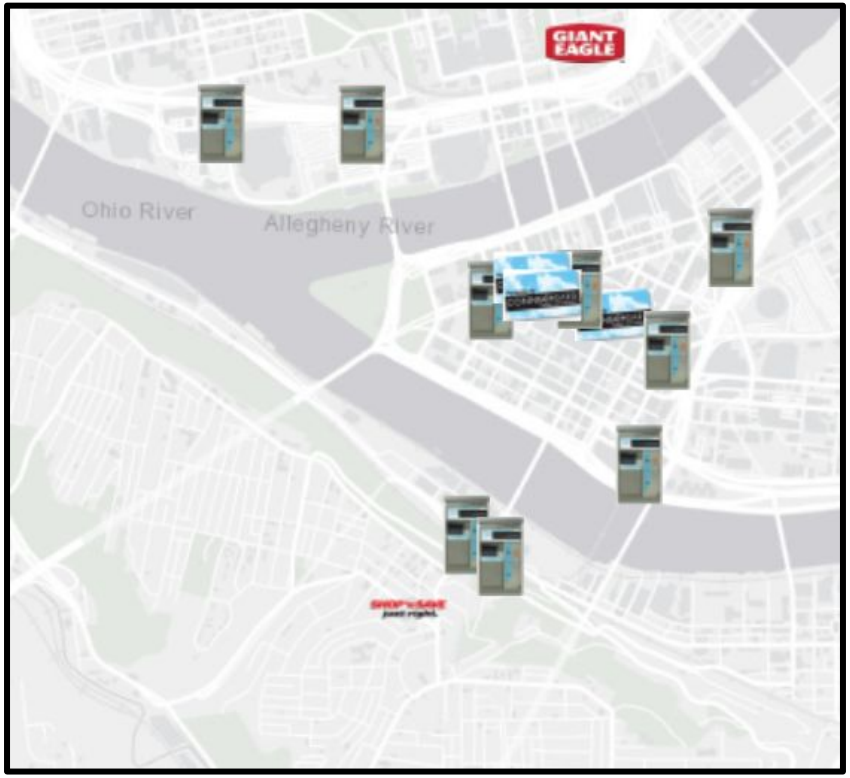
Carnegie Mellon University

Heinz College

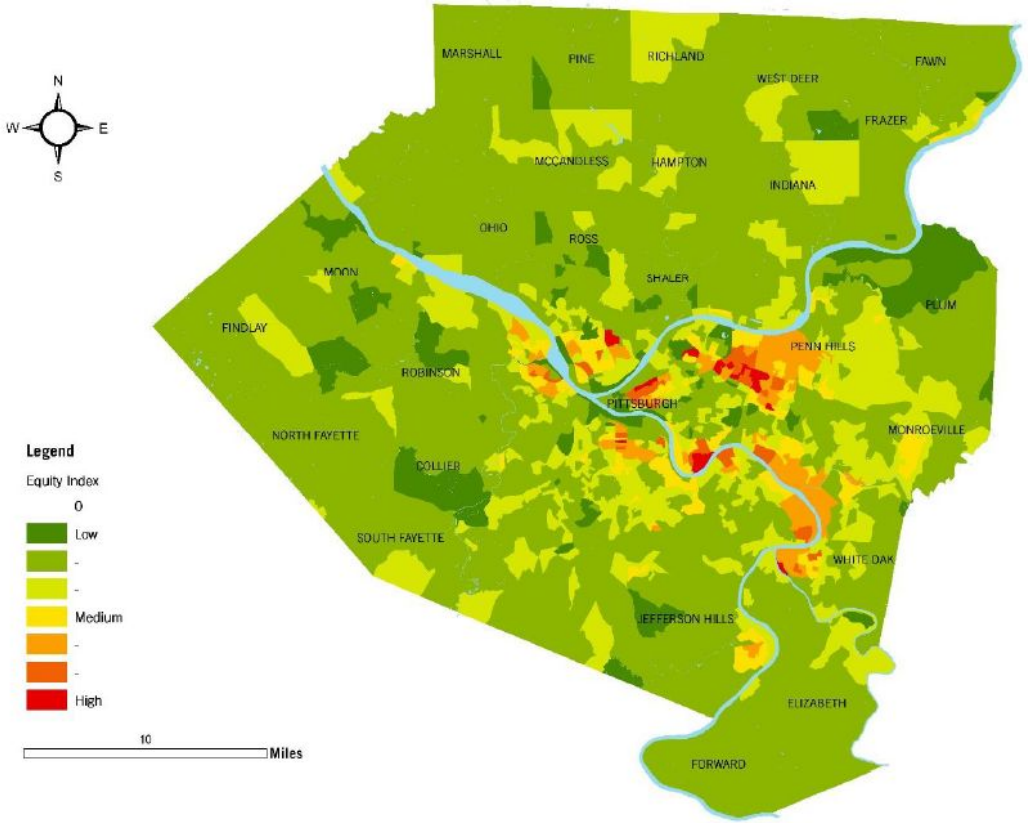
INFORMATION SYSTEMS • PUBLIC POLICY • MANAGEMENT

Appendix

ConnectCard locations in downtown Pittsburgh

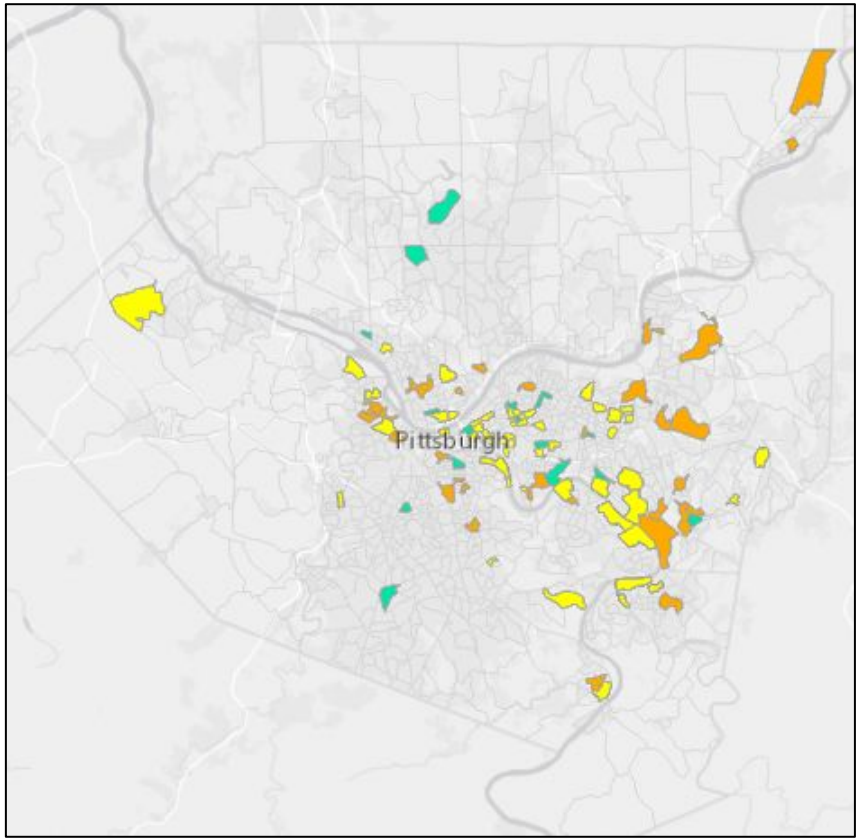


PAAC Equity Index

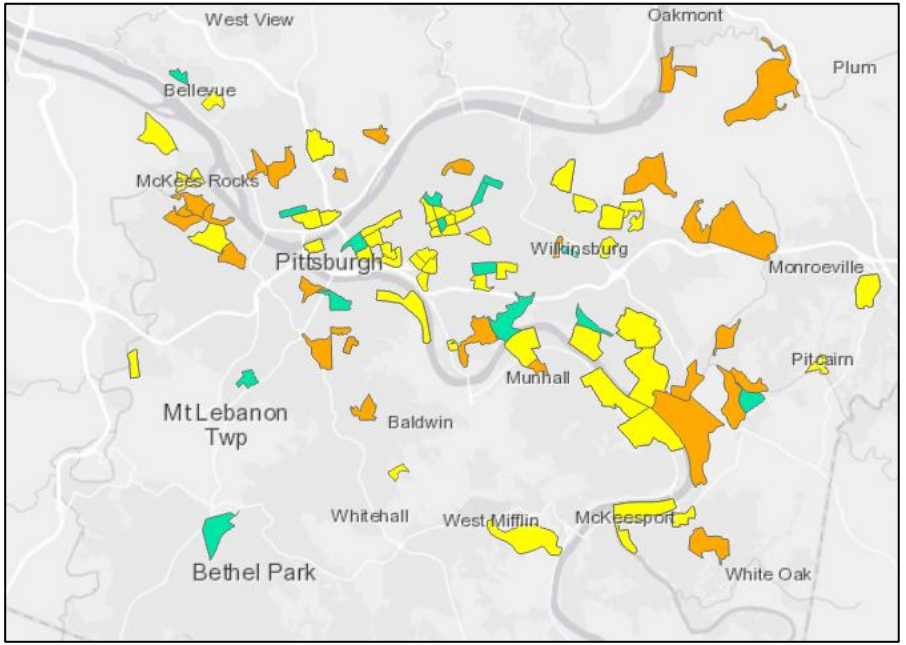


Carnegie Mellon University
HeinzCollege
INFORMATION SYSTEMS • PUBLIC POLICY • MANAGEMENT

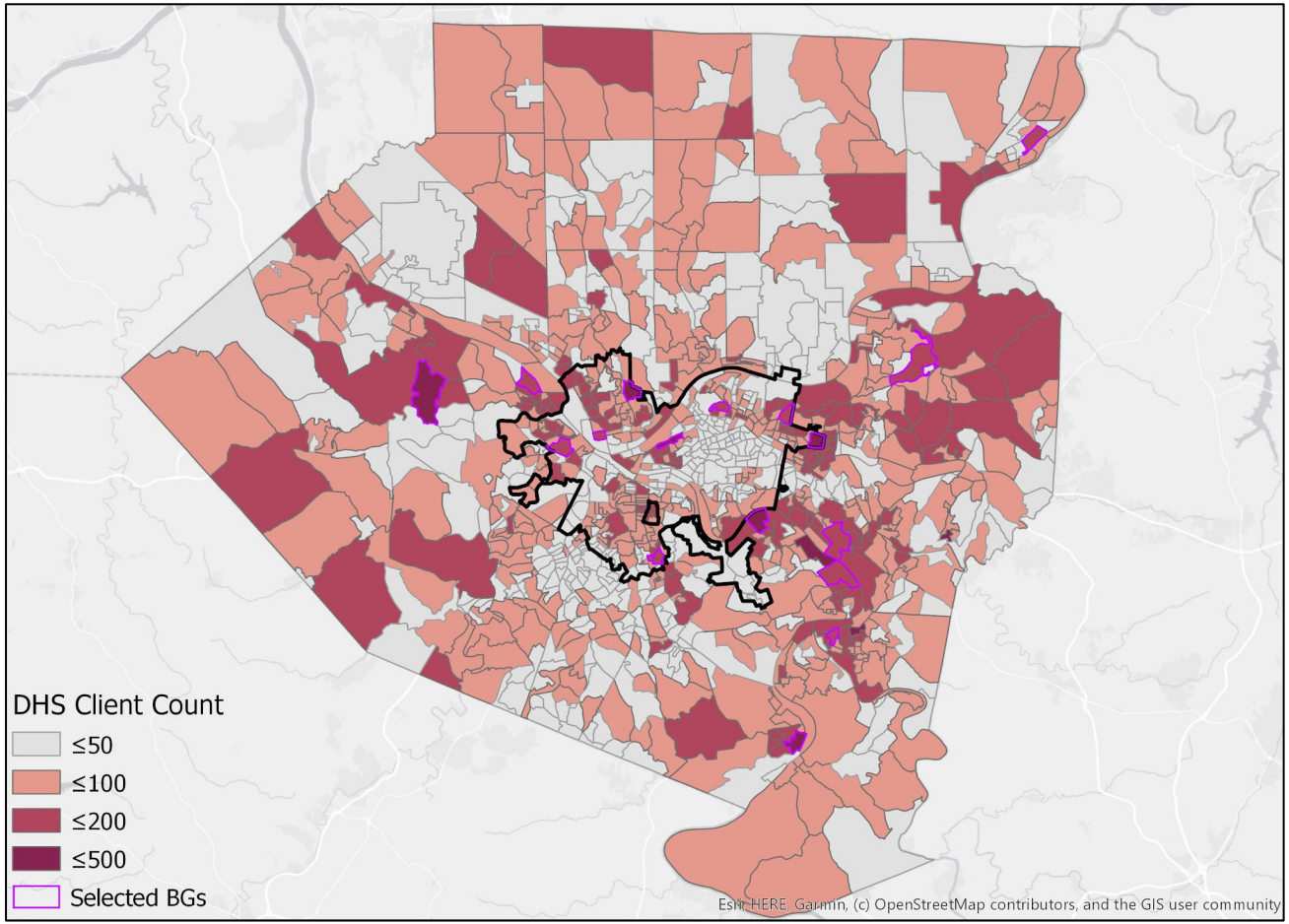
American Community Survey Census Data



1) poverty
2) single mothers
3) households with no car



3. DHS data (raw client count)



Leaderboards

WORST BUS / CAR RATIOS - UPDATED					
ARCGIS Join Columns		Pairing	Polygon	Polygon	
Origin BG	DEST_ID	ID	Origin	Destination	Bus / Car Ratio
420035509002	5	19	McKeesport	Monroeville	7.5
420030509001	7	100	Crafton Heights	Upper Hill	5.8
420032809001	9	177	Bedford Dwellings	O'Hara Twp	4.9
420030509001	6	96	Crafton Heights	Middle Hill	4.5
420032809001	8	174	Bedford Dwellings	Robinson Twp	4.0
420030509001	5	95	Homestead	Monroeville	3.6
420032814002	4	81	Garfield	Green Tree	3.5
420032814002	3	80	Crafton Heights	Wilmerding	3.4
420035509002	14	21	Homestead	Central Business Di	3.3
420032809001	3	169	Bedford Dwellings	Wilmerding	3.2

WORST COMPOSIT O-D SCORE					
ARCGIS Join Columns		Pairing	Polygon	Polygon	O - D Index
Origin BG	DEST_ID	ID	Origin	Destination	Composite
420030509001	3	106	Bedford Dwellings	Monroeville	6
420035128001	6	172	North Braddock	Wilmerding	8
420031016001	8	174	Garfield	Monroeville	8
420035619002	3	169	Lincoln-Lemington-I	Central Business	9
420035509002	5	19	McKeesport	Monroeville	9
420031016001	3	80	Garfield	Middle Hill	10
420032814002	5	70	Crafton Heights	Wilmerding	10
420034838002	4	182	Homestead	Robinson Twp	10
420034621003	14	72	Stowe Twp	Green Tree	15
420031306003	8	99	East Hills	Central Business	15

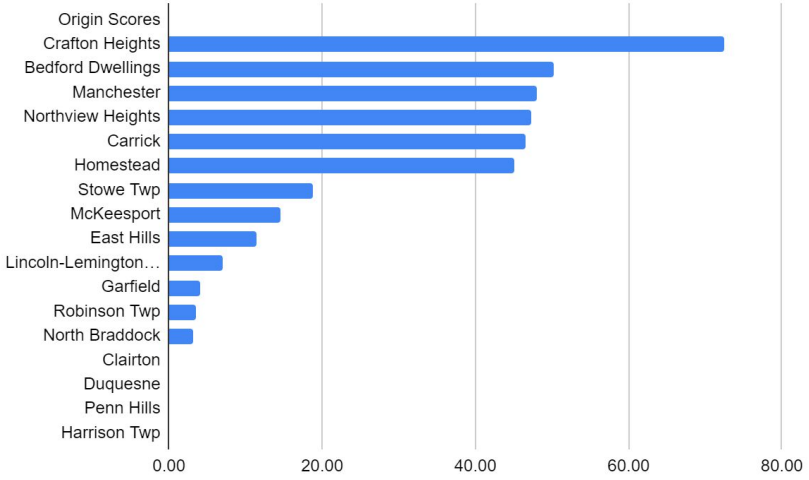
Origin	# of Destinations Accessi
Crafton Heights	7
Bedford Dwellings	5
Garfield	4
East Hills	3
Homestead	3
Lincoln-Lemington-Be	3
North Braddock	2
Stowe Twp	2
Carrick	2
McKeesport	2
Northview Heights	1
Manchester	1
Robinson Twp	1
Penn Hills	0
Duquesne	0
Harrison Twp	0
Clairton	0

Destination	# Origins Accessible
Central Business District	10
Monroeville	5
Middle Hill	5
Upper Hill	6
Robinson Twp	3
Wilmerding	3
O'Hara Twp	2
Green Tree	2
Brackenridge	0
South Park Twp	0
Bethel Park	0
Moon Twp	0
Findlay Twp	0
Marshall	0

Best COMPOSIT O-D SCORE					
ARCGIS Join Columns		Pairing	Polygon	Polygon	O - D Index
Origin BG	DEST_ID	ID	Origin	Destination	Composite
420032814002	14	84	Crafton Heights	Central Business	85
420032814002	8	85	Crafton Heights	Robinson Twp	80
420035619002	7	150	Garfield	Upper Hill	76
420035619002	6	147	Lincoln-Lemington-I	Middle Hill	74
420030509001	7	100	Bedford Dwellings	Upper Hill	76
420030509001	14	97	Lincoln-Lemington-I	Upper Hill	70
420030509001	6	96	Bedford Dwellings	Middle Hill	68
420031016001	7	163	Manchester	Central Business	67
420032904002	14	47	Bedford Dwellings	Central Business	70
420032809001	14	173	Northview Heights	Central Business	70

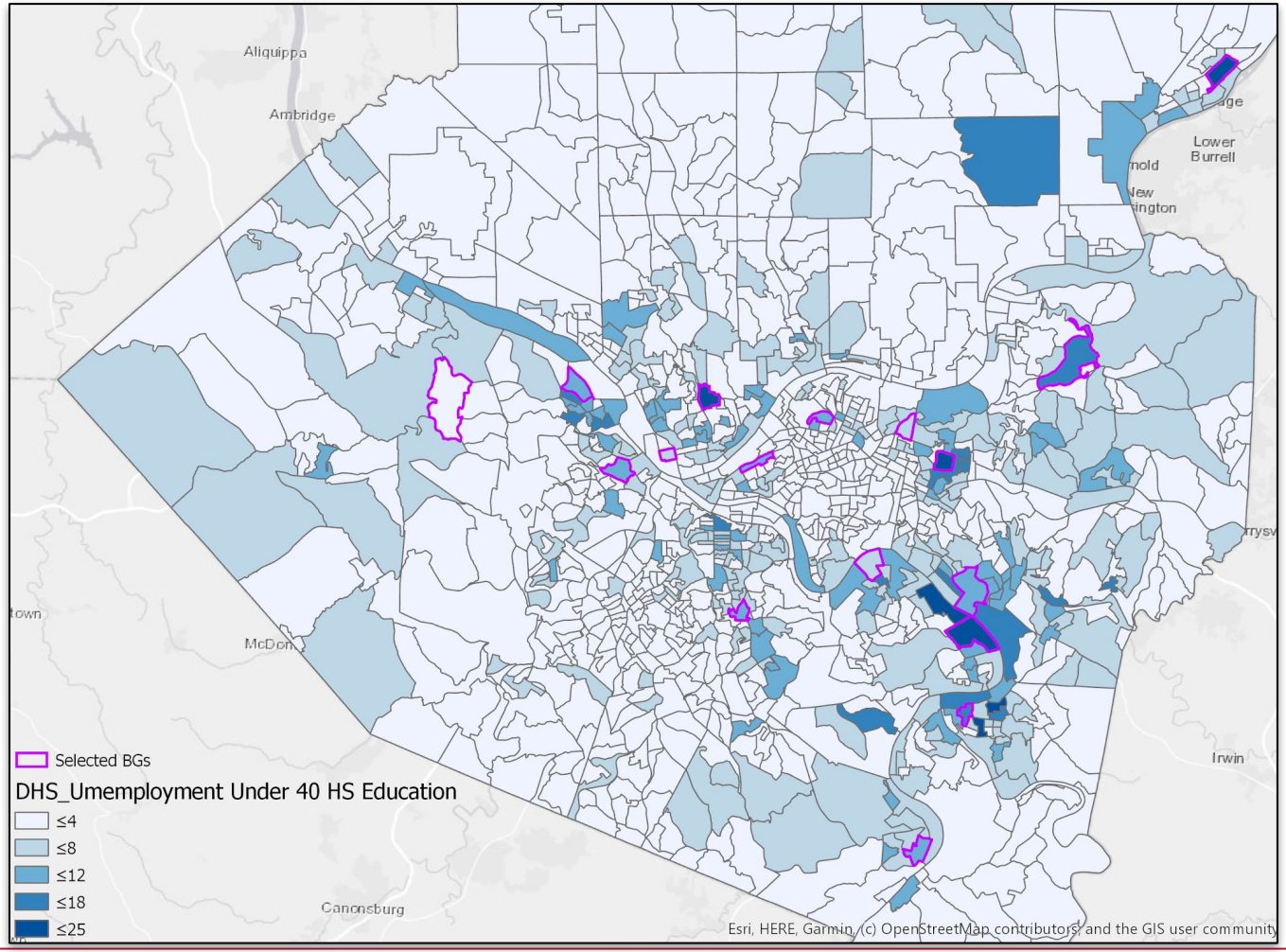
Leaderboards

DESTINATION ZONES WITH MOST JOBS OUTSIDE OF WALKSHED				
Destination	Polygon Job Count	Walkshed Job Count	Jobs Not In Walkshed	% Inaccessible
Robinson Twp	2123.72	407.71	1716.01	80.8%
Brackenridge	747.13	19.52	727.61	97.4%
O'Hara Twp	822.4	296.24	526.16	64.0%
South Park Twp	370.44	0	370.44	100.0%
Wilmerding	332.25	13.7	318.55	95.9%
Monroeville	513.2	367.06	146.14	28.5%

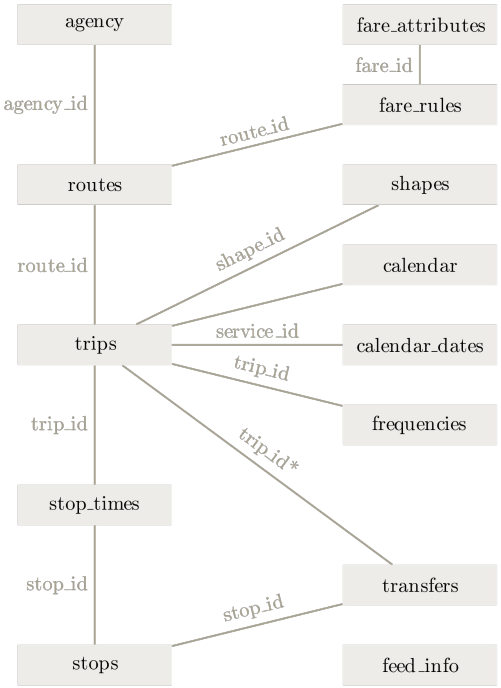


Origin Scores	
Origin Scores	Score
Crafton Heights	72.49
Bedford Dwellings	50.26
Manchester	48.01
Northview Heights	47.26
Carrick	46.56
Homestead	45.15
Stowe Twp	18.77
McKeesport	14.57
East Hills	11.41
Lincoln-Lemington-	6.95
Garfield	3.99
Robinson Twp	3.52
North Braddock	3.17
Clairton	0.00
Duquesne	0.00
Penn Hills	0.00
Harrison Twp	0.00

Carnegie Mellon University
Heinz College
INFORMATION SYSTEMS • PUBLIC POLICY • MANAGEMENT


Aliquippa
Ambridge
Lower Burrell
McDon
Irwin
Canonsburg
Selected BGs
DHS_Umemployment Under 40 HS Education
≤4
≤8
≤12
≤18
≤25
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

Static transit feed: GTFS



General Transit Feed Specification (GTFS) dataset contains up to 15 files:

- Dataset delivered as a single zip file
- All individual files stored as .csv
- Standardized field names and data standards

Carnegie Mellon University
HeinzCollege
INFORMATION SYSTEMS • PUBLIC POLICY • MANAGEMENT

Real-Time transit feed: APC-AVL

Automatic Passenger Counter - Automatic Vehicle Location (APC-AVL) file obtained from Port Authority of Allegheny County. Using Python data processing scripts we extract:

- Bus, trip, and route details
- Departure times by day
- Passenger boarding and alighting counts

GIS Dashboard: O-D pairs