TRANSLATING SENSE OF PLACE FOR FOOD OUTLETS IN CHITTENDEN COUNTY, VT: AESTHETIC CHARACTERIZATION OF PEDESTRIAN ACCESSBILITY HUBS

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PHASE 2 - NETWORK ANALYSIS:

After selecting 6 census tracts within Chittenden County, VT—three with high levels of vehicle access, three with low levels—I collected and organized geospatial data in ArcGIS Pro, built network models for each tract, used the Network Analyst extension to estimate pedestrian accessibility of food outlets, and identified network hubs of pedestrian accessibility for aesthetic characterization in Phase 3.

Data Collection & Organization:

Shapefiles for all selected census tracts' boundaries, residential buildings, and pedestrian routes were collected from the VT Open Geodata Portal.

Road shapefiles were collected from U.S. Census Bureau MAF/TIGER Database.

Food outlets[1] within[2] each tract were identified, and their shapefiles collected from OpenStreetMap (OSM) using Overpass Turbo and edited in ArcGIS Pro for accuracy.

Street design elements impacting pedestrian travel (crossings) were also collected from OSM, but owing to the inconsistent nature of the crowdsourced data, significant manual editing was necessary. This was especially true for the high Vehicle Access Score (VAS) group, where both in-person surveys and Google Maps Street View imagery were referenced to ensure accuracy.

Layers with differing geographic coordinates systems were projected to WGS 1984 Web Mercator (Auxiliary Sphere), and duplicate features were identified and removed. Lines connecting residential buildings and food outlets to the nearest 'edge' feature (ex. pedestrian routes, roads) were generated, and all intersecting network elements were integrated to create vertices at desired 'junction' points.

Upon collecting and editing all geospatial data, the resulting feature classes were organized into groups by their respective tract and exported as layer packages.

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[1] Physical locations where unprepared food items can be purchased, including grocery stores, supermarkets, farmer's markets, and convenience stores.

[2] Food outlets within 0.1 km of a tract's boundary were included in that tract's network. For tracts containing ≤1 food outlet, food outlets within 2.5 km of its boundary were included that tract's network.

Analysis:

Separate network datasets for each tract were created from the exported layer packages in ArcGIS, and cost attribute fields (Table 1) were calculated for relevant source features. These include the network's primary cost attribute, *WALKTIME*, the cost incurred when using different types of crossings, *CrossingCost*, and additional attributes used to calculate the former two, such as *WalkCost*.

Each network dataset's properties were configured to allow transfer between edges at vertices, to ensure travel through other junction features (ex. crosswalks), and to set *WALKTIME* as the primary cost attribute. Network datasets were then built and any connectivity issues troubleshooted.

Using the Network Analyst extension, the Closest Facility analysis layer was added to each functioning network model. Residential buildings were imported as facilities, food outlets as incidents, and crossings as added cost point barriers (with *CrossingCost* contributing to *WALKTIME*).

The direction of travel was set to "Away from facilities", and the number of routes[3] per incident set to the number of residential buildings imported. Running the Closest Facility analysis calculated least-cost routes from each residential building within tract boundaries to each identified food outlet.

After confirming that each residential building had *n* routes (where *n* = # of food outlets in tract), graduated color symbology was used to visualize the accumulated cost associated with each route: *Walk Time.* Using log normalization and the Jenks data classification method, color breaks that allow comparison across tracts were determined. Route drawing order was set from high cost to low cost, with routes in the shortest *Walk Time* bin drawn last.

Upon finalizing route symbology, all routes, food outlet points, and residential building points were organized by food outlet and tract and uploaded to ArcGIS Online as web layer files for use in ArcGIS Experience Builder.

[3] Least-cost paths from residential buildings to food outlet

Table 1

Cost Attribute Table

Network Element	Cost Attribute	Value
Pedestrian Routes	*WALKTIME (min)*	$60\ seconds * \left(\frac{Length\ (m)}{1000}\right) / 5\ \frac{km}{h}$
Connections (RB/FO)	*WALKTIME (min)*	$60\ seconds * \left(\frac{Length\ (m)}{1000}\right) / 5\ \frac{km}{h}$
Roads	*WalkCost* (low VAS)[4]	HIGHWAY = ∞ MAIN[5] = 1.5 SECONDARY = 1.0
	WalkCost (high VAS)[4]	HIGHWAY = ∞ MAIN[5] = 1.2 SECONDARY = 1.0
	WALKTIME (min)	$WalkCost * 60\ seconds * \left(\frac{Length\ (m)}{1000}\right) / 3\ \frac{km}{h}$
Crossings	*CrossingCost*[6] (low VAS)	Zebra;Marked = 0.25 min Zebra = 0.33 min Unmarked = 0.5 min Traffic Signals = 0.75 min Road[7] = 1.0 min
	CrossingCost[6] (high VAS)	Zebra;Marked = 0.25 min Zebra = 0.33 min Marked = 0.33 min Unmarked = 0.5 min Traffic Signals = 0.75 min Road[7] = 1.0 min MAIN_ROAD[8] = 1.25 min

[4] *WalkCost* categories were determined using MTFCC classification criteria

[5] The "MAIN" *WalkCost* assigns a larger value to main roads in low VAS tracts, reflecting their higher traffic volume as compared to high VAS tracts

[6] *CrossingCost* estimates were informed by the University of Idaho's Transportation Engineering Online Lab Manual

[7] The "Road" *CrossingCost* was assigned when a junction demanded transferring from a pedestrian route to a "SECONDARY" road, rather than crossing the road to meet another pedestrian route

[8] The "MAIN_ROAD" *CrossingCost* was assigned when a junction demanded transferring from a pedestrian route to a "MAIN" road, rather than crossing the road to meet another pedestrian route

WEB APP GUIDE:

Using ArcGIS Experience Builder, I assembled the results of Phases 1 & 2 into an interactive web app[9]: *Identifying Pedestrian Accessibility Hubs for Food Outlets in Chittenden County, Vermont.*

Main View:

ALL (default):

- The *ALL* view displays a multi-scale map containing (from small-large scale) the Chittenden County boundary, VAS by census tract, census tract labels and boundaries, routes for all food outlets and tracts, food outlets (hubs in gold), and residential buildings.

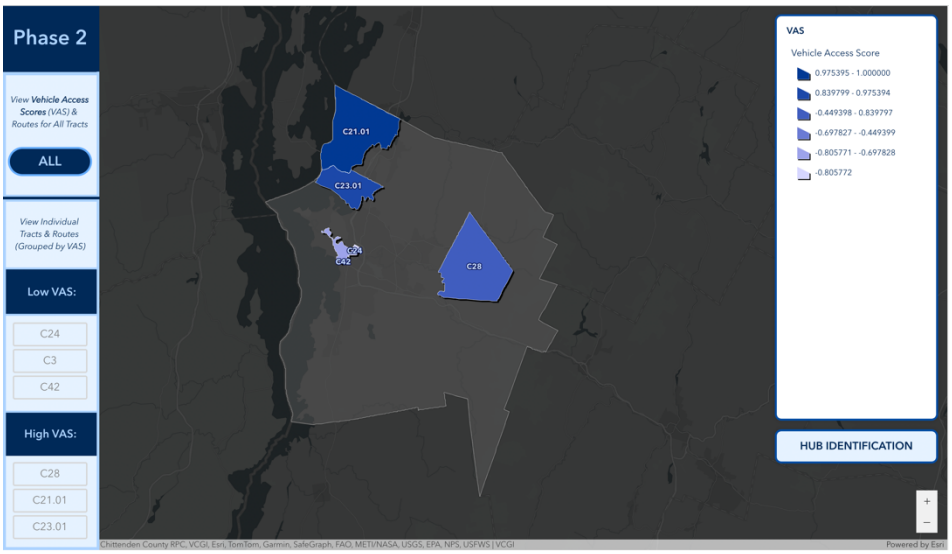
- A legend (upper-right) indicates the VAS range for each tract color bin, the *Walk Time* range for each route color bin, and the icons for hubs and food outlets.

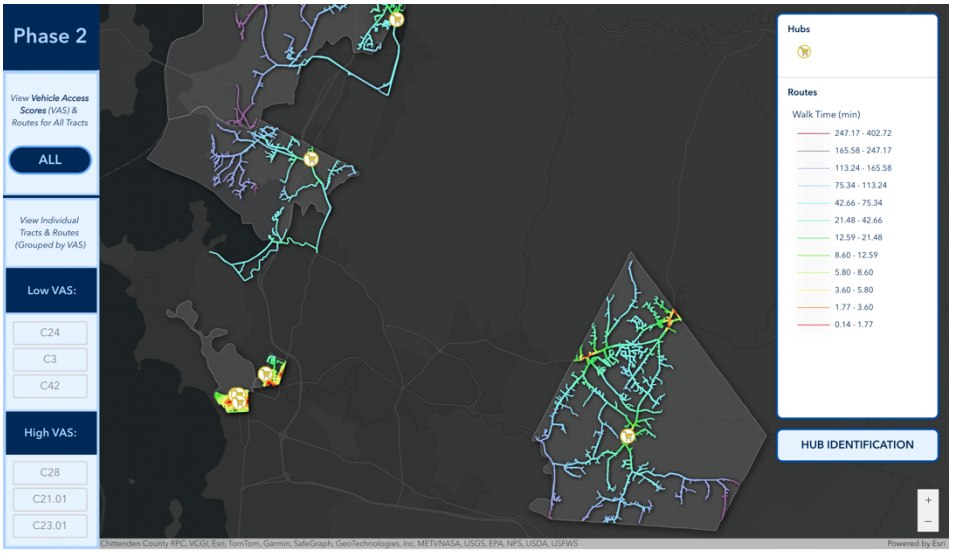
- Clicking a hub's icon opens a pop-up with a link to that hub's aesthetic characterization (Phase 3).

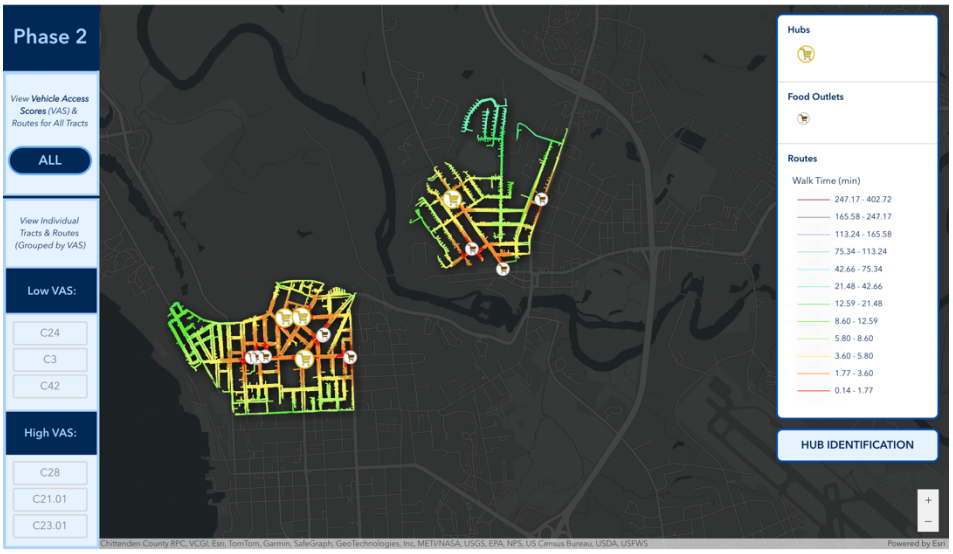
- The *HUB IDENTIFICATION* button (bottom-right) brings users to the Hub Identification *Navigation* page.

- Clicking the bolded *Vehicle Access Scores* text (upper-left) opens the results of Phase 1: Census Tract Selection in a new tab

[9] **NOTE:** This webapp is designed for full-screen viewing on desktop only, and will display in a 1440x820 pixel window regardless of viewing platform.


Phase 2
View Vehicle Access Scores (VAS) & Routes for All Tracts
ALL
View Individual Tracts & Routes (Grouped by VAS)
Low VAS:
C24
C3
C42
High VAS:
C28
C21.01
C23.01
C21.01
C23.01
C24
C42
C28
VAS
Vehicle Access Score
0.975395 - 1.000000
0.839799 - 0.975394
-0.449398 - 0.839797
-0.697827 - -0.449399
-0.805771 - -0.697828
-0.805772
HUB IDENTIFICATION
Chittenden County RPC, VCGI, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NPS, USFWS | VCGI
Powered by Esri


Phase 2
View Vehicle Access Scores (VAS) & Routes for All Tracts
ALL
View Individual Tracts & Routes (Grouped by VAS)
Low VAS:
C24
C3
C42
High VAS:
C28
C21.01
C23.01
Hubs
Routes
Walk Time (min)
247.17 - 402.72
165.58 - 247.17
113.24 - 165.58
75.34 - 113.24
42.66 - 75.34
21.48 - 42.66
12.59 - 21.48
8.60 - 12.59
5.80 - 8.60
3.60 - 5.80
1.77 - 3.60
0.14 - 1.77
HUB IDENTIFICATION
Chittenden County RPC, VCGI, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS
Powered by Esri


Phase 2
View Vehicle Access Scores (VAS) & Routes for All Tracts
ALL
View Individual Tracts & Routes (Grouped by VAS)
Low VAS:
C24
C3
C42
High VAS:
C28
C21.01
C23.01
Hubs
Food Outlets
Routes
Walk Time (min)
247.17 - 402.72
165.58 - 247.17
113.24 - 165.58
75.34 - 113.24
42.66 - 75.34
21.48 - 42.66
12.59 - 21.48
8.60 - 12.59
5.80 - 8.60
3.60 - 5.80
1.77 - 3.60
0.14 - 1.77
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Powered by Esri

Individual Tracts:

- Using the navigation buttons (left column), users can select census tracts from either the High or Low VAS group to view individually.

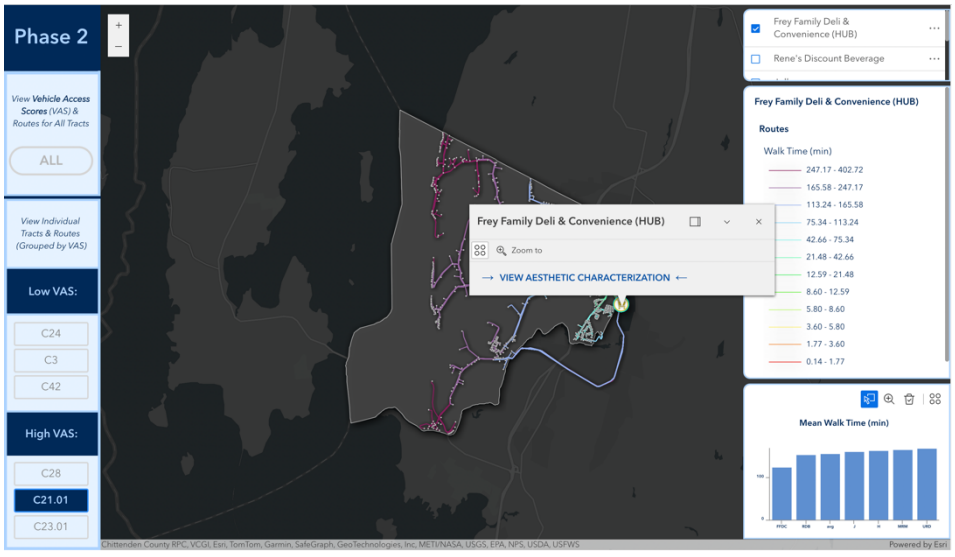
- By default, an individual tract view displays a map containing the selected tract's identified hub and its routes, along with the tract's residential buildings and its boundary.

- Clicking a hub's icon opens a pop-up with a link to that hub's aesthetic characterization (Phase 3).

- The layers section (upper-right) allows users to toggle on/off food outlets and their associated routes as desired.

- A legend (middle-right) indicates the *Walk Time* range for each route color bin.

- A bar chart (bottom-right) displays the mean *Walk Time* for each food outlet in the selected tract.



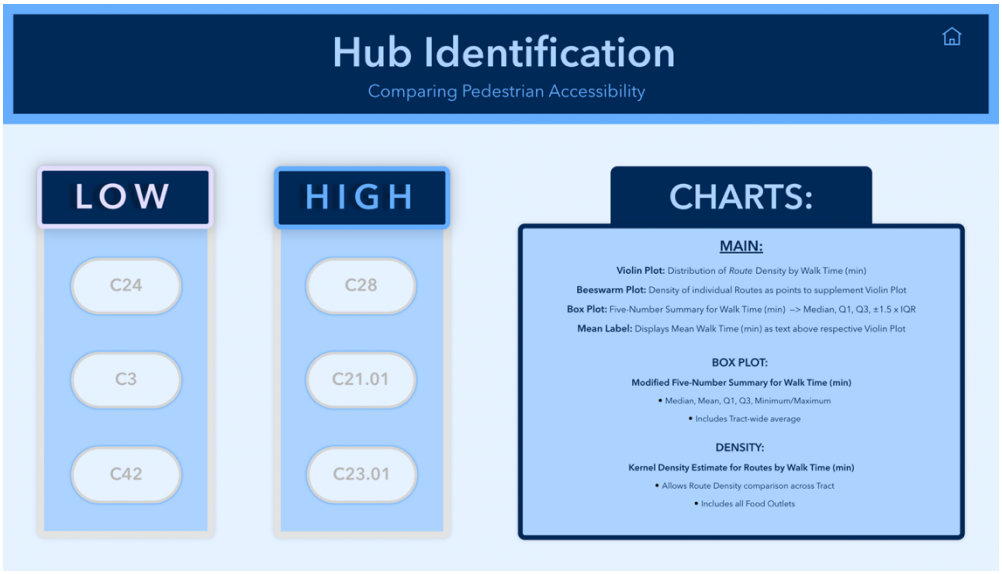
Hub Identification:

Navigation:

- By selecting a census tract from either VAS group, the *Navigation* page allows users to view comparisons of the pedestrian accessibility of food outlets within the selected tract, as well as justification of that tract's identified hub.

- The *CHARTS* panel (right) provides a description of the charts displayed in each tract's *Hub Identification* page

    - Tip: hover over *Route* to view term definition



Main Chart:

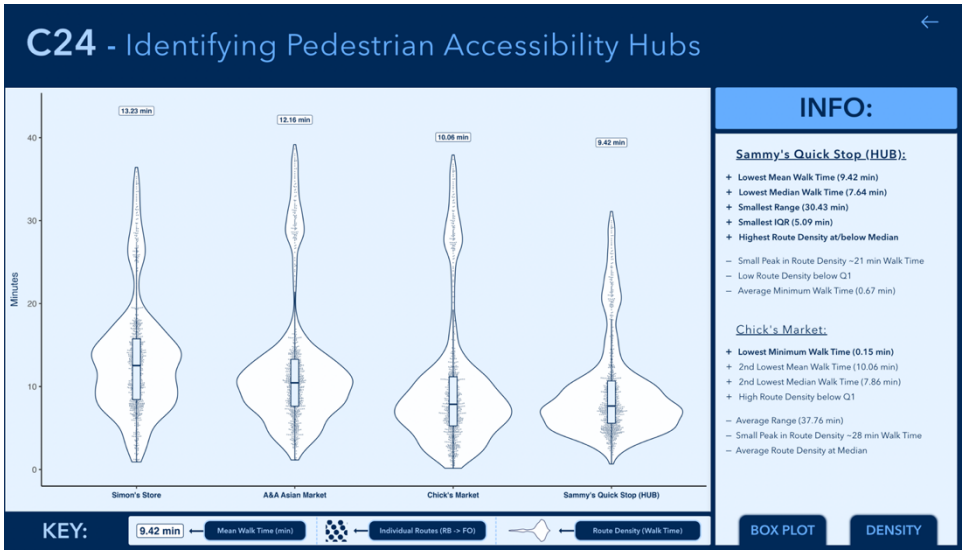
- Having selected a tract in the *Navigation* page, the *Main Chart* page displays a chart containing a violin plot, a beeswarm plot, a boxplot, and a mean *Walk Time* label for each food outlet in the tract.
    - Food outlets are ordered by mean *Walk Time*
- A key (bottom) indicates the meaning of chart components
- The *INFO* panel (right) evaluates the two best hub candidates out of the three food outlets with the lowest mean *Walk Time* within the tract.
    - Primary hub designation criteria (relative to other food outlets within census tract) include:
        - Low Cost:
            → for all residential buildings throughout tract
            → for closest neighborhood(s)
        - Equitable Accessibility:
            → low cost throughout tract
            → compact cost distribution
            → minimize underserved neighborhoods
    - Metrics (*Walk Time*) included in evaluating hub candidates include:
        - Mean
        - Median
        - Range
        - IQR
        - Maximum
        - Minimum
        - Route Density
            → peaks
            → at/below Median
            → above/below Q1/Q3
            → between Median and Q1/Q3

- Language Definitions:
  - *Low* —> Minimum-Q1
  - *Average (Low)* —> Q1-Median
  - *Average* —> Median
  - *Average (High)* —> Median-Q3
  - *High* —> Q3-Maximum (25%)

- Metrics supporting a food outlet's designation as hub are listed beside plus (**+**) symbols, while metrics against its designation as hub are listed beside minus (**-**) symbols

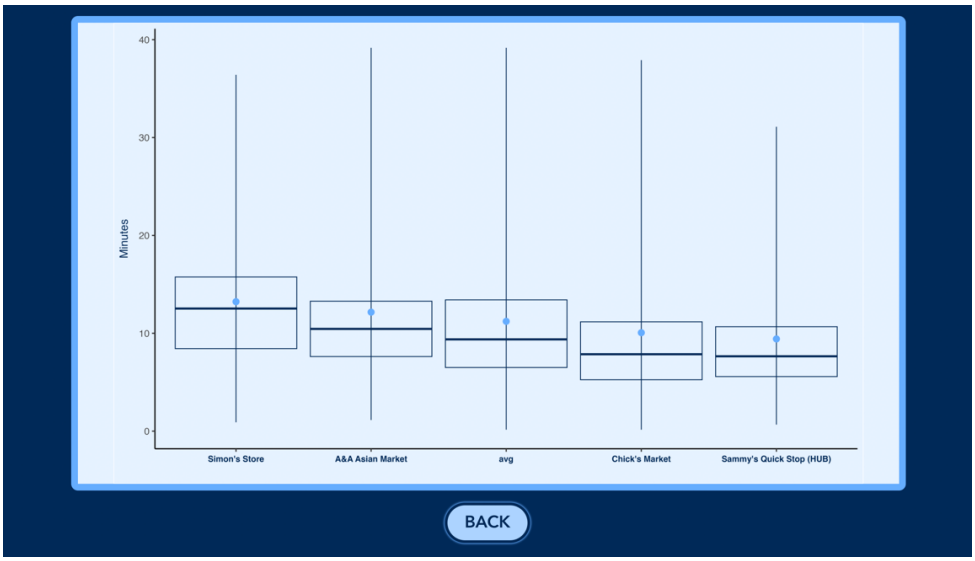
  - Identified hub names are underlined and bolded

  - Superlative metrics (ex. *Lowest Mean Walk Time*) are bolded

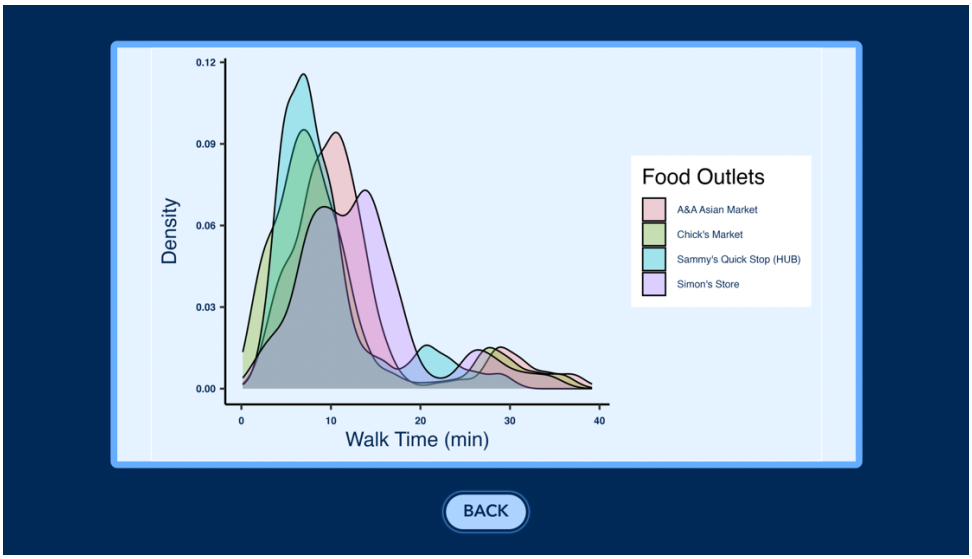


Box Plot // Density:

- To allow evaluation of *Main Chart* components individually, users can select the *BOX PLOT* tab or the *DENSITY* tab (bottom-right)
    - The *BOX PLOT* tab allows users to view a boxplot (median, mean, Q1, Q3, minimum/maximum) for each food outlet in the tract, as well as for the tract average.
        - Food outlets are ordered by mean *Walk Time*

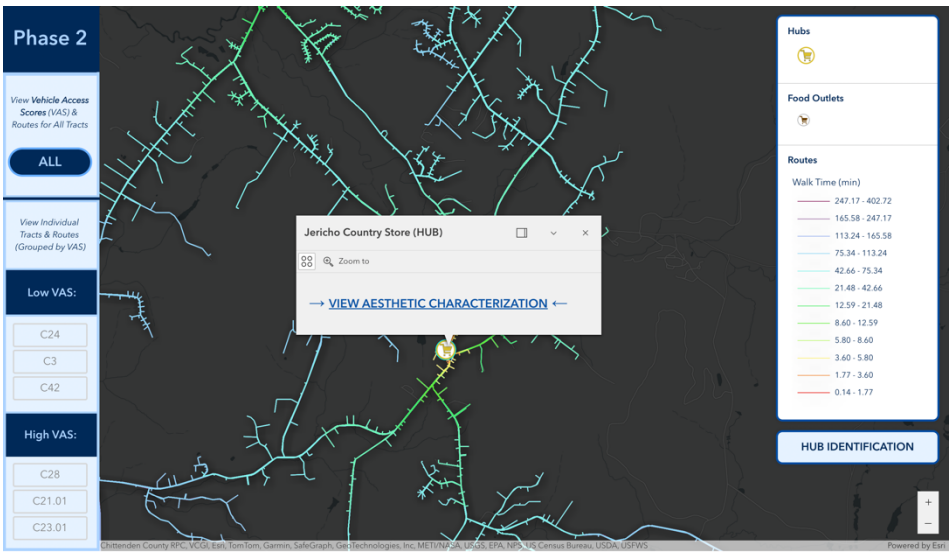


- The *DENSITY* tab allows users to view a kernel density estimate for each food outlet in the tract.



PHASE 3 – AESTHETIC CHARACTERIZATION:

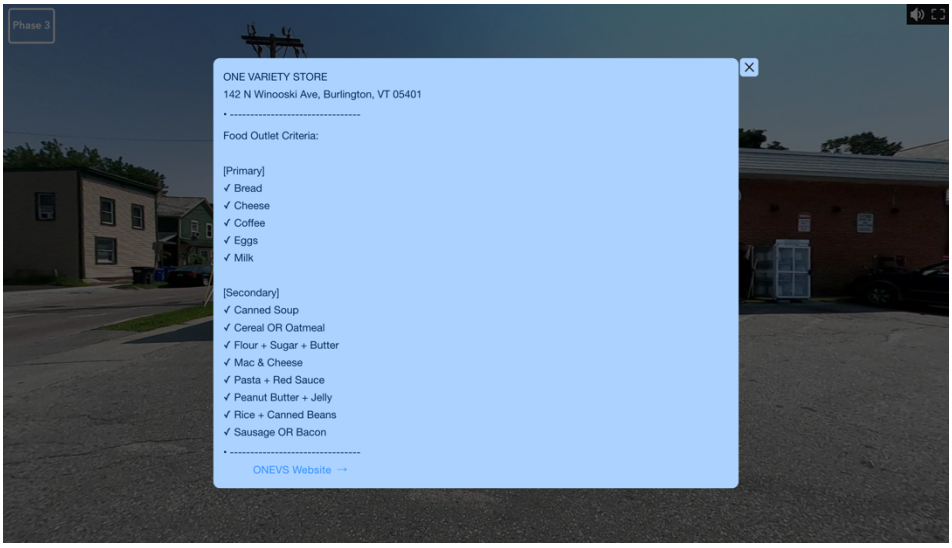
- After clicking the link to a hub's aesthetic characterization, users are navigated to an interactive 'virtual tour' consisting of a 360-degree panorama and an audio field recording, each taken at the hub's location.



- Clicking and dragging on the panorama allows users to look around, and clicking the speaker button (upper-right) toggles audio on/off.

- Each hub's aesthetic characterization contains a 'hotspot'—displayed as a light blue bullseye—placed near each building's entrance.

- Clicking a hotspot displays a pop-up containing the hub's name, address, a link to its website (or equivalent), and a checklist evaluating its status as a food outlet.



- Food outlet criteria consist of a list of staple food items, simple meals, and other essentials (ex. coffee). These are separated into two categories, *Primary* and *Secondary*, which are as follows:

    - [Primary]
        - Bread
        - Cheese
        - Coffee
        - Eggs
        - Milk
    - [Secondary]
        - Canned Soup
        - Cereal OR Oatmeal
        - Flour + Sugar + Butter
        - Mac & Cheese
        - Pasta + Red Sauce
        - Peanut Butter + Jelly
        - Rice + Canned Beans
        - Sausages OR Bacon

- Each of the *Primary* criteria and ≥50% of the *Secondary* criteria must be met for a location to be considered a food outlet in the context of this project

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