

Transit Time Shed

Analyzing Accessibility to Employment and Services

presented by

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Shimberg Center for Housing Studies

Established at the University of Florida in 1988 to **promote safe, decent and affordable housing and related community development throughout the state of Florida.**

Housing Suitability Model

Assesses affordable housing sites in terms of their **access to jobs and transit, driving costs, physical environment, and neighborhood socioeconomic characteristics.**

The Center recently used the model to help regional planners in South Central Florida and the Orlando metropolitan area plan for sustainable growth.



LUCIS – Land Use Conflict Identification System

The Center's Housing Suitability Model has its origins in **LUCIS – a land use suitability model** that identifies land-use conflicts to better understand opportunities for future growth.

Using LUCIS, land use planners can develop future scenarios of a region's projected growth that transportation planners can model to better understand regional impacts of different land use patterns.

LUCIS^{plus} - Planning Land Use Scenarios

In recent years, LUCIS has been further developed to include new tools and methods of automation (LUCIS^{plus}) to improve the efficiency of allocating population and employment to create regional land use scenarios.

Connecting Housing, Transportation and Jobs



The Shimberg Center's **Housing Suitability Model** uses a LUCIS^{plus} framework to assess neighborhood opportunities surrounding locations of government assisted housing developments.

Transportation costs and accessibility to transit are important in assessing the affordability of neighborhoods for low-income households who are already burdened by the cost of housing.

Transit Accessibility Tools

The Shimberg Center has developed transit accessibility tools for use with the **HSM** to help identify neighborhoods that have the potential to **lower transportation costs and maximize accessibility to employment and services** using public transit.



Shimberg's Accessibility Tools are parcel-level and based on generating origin/destination matrices using mapped streets (ArcGIS Network Analysis)

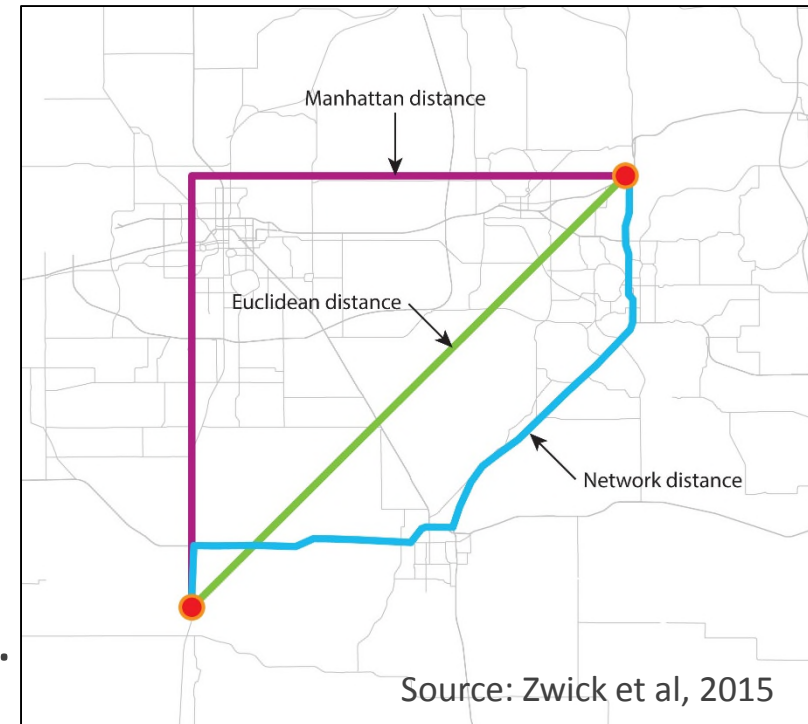
The accessibility tools were prepared to be used as **evaluators** in land use modeling using LUCIS^{plus} (Zwick et al, 2015). The tool creates a **heat map of access values** for a whole study area. Tools can be classified to:

- Time/distance to a nearest service
- Opportunity access: the number of services / jobs that can be reached with specific time / distance
- Gravity access using attraction, impedance and decay

Multi-Modal Networks Covered



- **Walking networks** – walkable roads, sidewalks, etc.
- **Biking networks** – bike lanes, bike friendly routes, etc.
- **Driving networks** – highway and other types of roads
- **Transit networks** – buses, trains, etc.
- **Multi-modal** – combination of two or more of the previous networks



Transit Access Tools



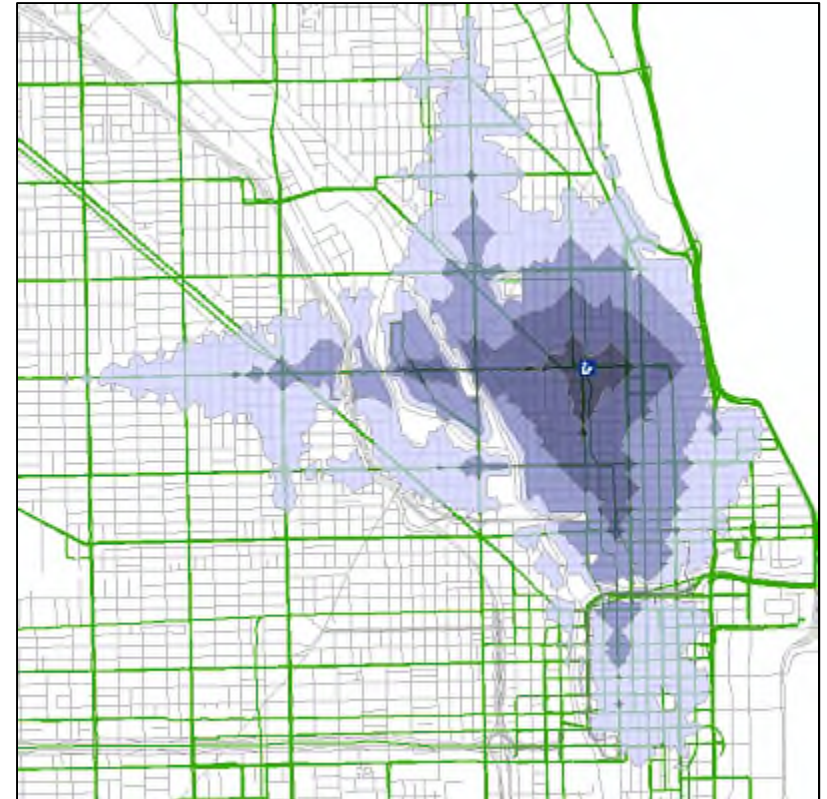
- This presentation will focus on introducing the Shimberg Center's **Opportunity Access by Transit Tool** that creates a high-resolution time shed reflecting the accessibility to jobs and services in a multi-modal transit service area
- The transit network model used by the tool consists of both **transit systems** (i.e. buses, light rail, trains) **and walking networks integrated into a multi-modal network** using ArcGIS Network Analyst
- This allows for the accurate measurement of an **individual's total travel time**. It includes the time needed to walk to a bus stop, waiting time and the bus's travel time at any time of the day

ESRI Transit Analysis Tools



ESRI created a set of new tools and techniques that allow the use of GTFS data with ArcGIS's Network Analyst extension to perform schedule-based transit analyses. These tools:

1. Generate Transit Lines and Stops
2. Create connector features between the transit lines/stops and other data
3. Create network dataset using connectivity groups.



What is GTFS?



The tool using the transit routes, stops and schedules from GTFS.

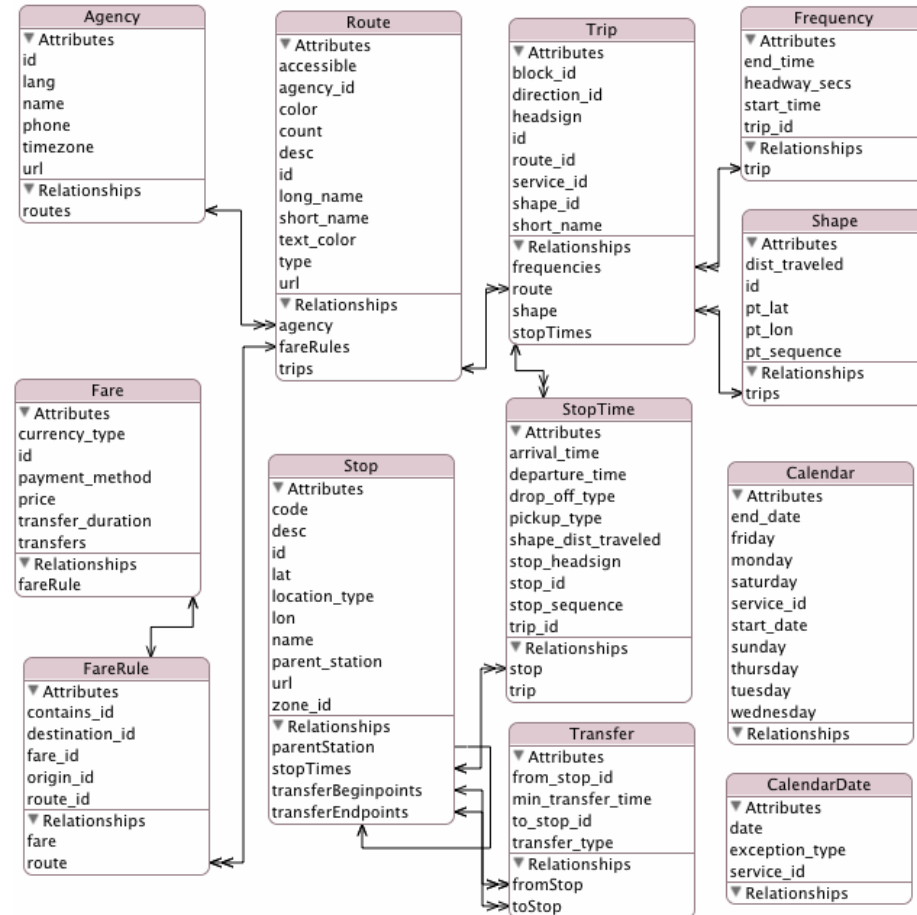
The **General Transit Feed Specification (GTFS)** is a relational database that uses a common format for public transportation schedules and associated geographic information. It contains information about bus stops routes and transit schedule.



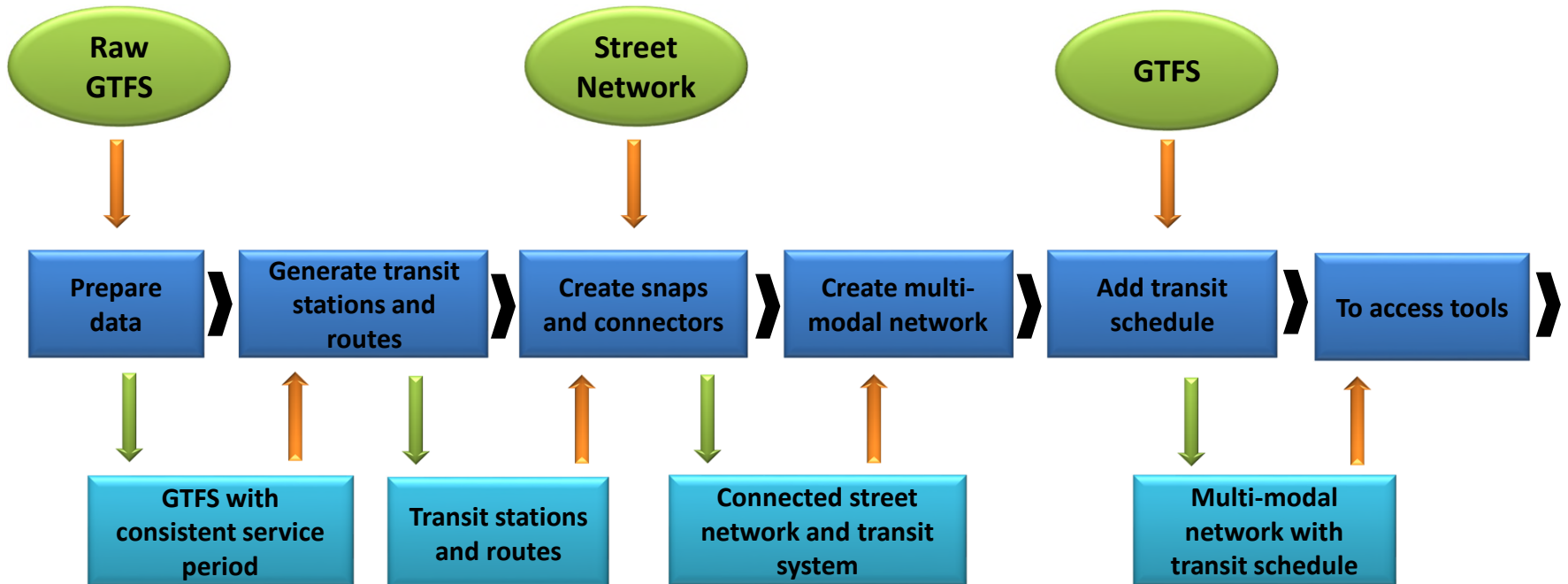
GTFS Relational Database

Why GTFS?

- Open data
- Consistent
- High detail level
- Usually available in Transit Boarding's Estimation and Simulation Tool (TBEST)



Generating the Network Data Set



Data:

- Transit schedule (GFTS)
- Street network (i.e. Navteq)

ESRI Tools-Creating Transit Network

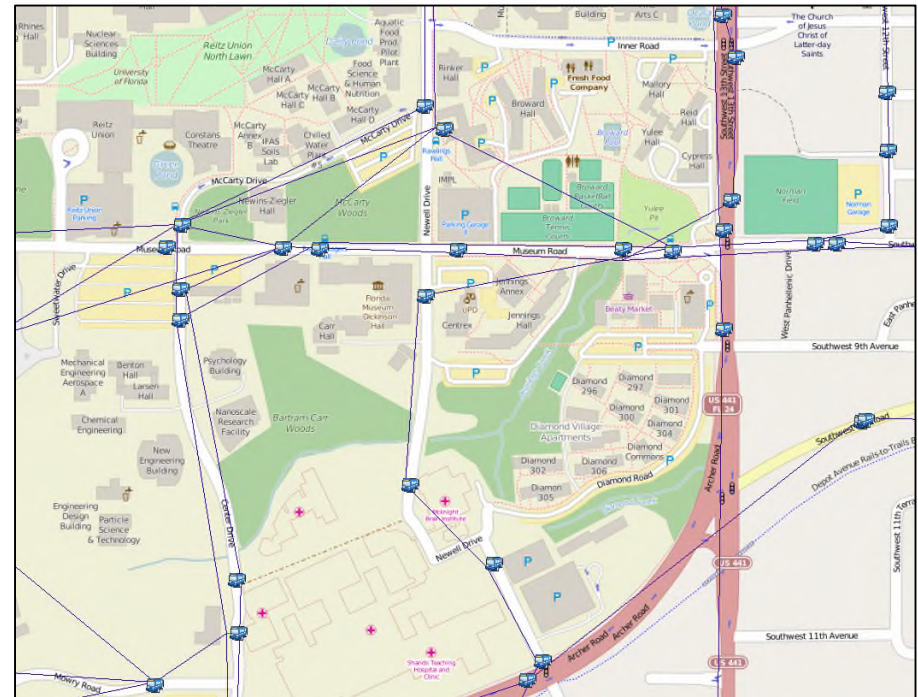


1. Generate transit lines and stops

This tool uses the GTFS data to produce the following output:

Stops - Point feature class containing the transit stops

Transit Lines - Line feature class containing the transit lines. A line is created between each pair of stops that is directly connected by a transit trip



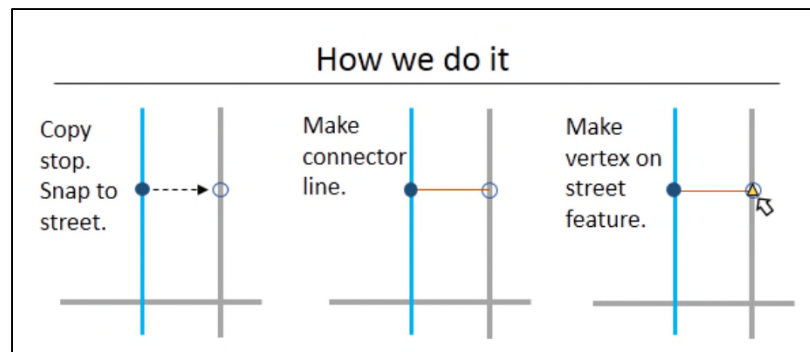
ESRI Tools-Creating Transit Network



2. Create connector features between the transit lines/stops and other network data

Due to spatial mismatch between stops and streets, the tool makes **connector lines** that bridge the gap between the stops and the nearest street. This tool creates:

- A copy of the stops and snaps them to street features.
- A line feature class containing connector lines between streets and GTFS transit stops.
- A copy of the streets feature class selected as input, modified to have vertices at the locations of the snapped GTFS stops



ESRI Tools-Creating Transit Network



3. Create network dataset using connectivity groups

- Set up **connectivity groups** to tell the network how pedestrians travel between the different network features (streets, transit lines, etc.)
- Create a **travel time cost** attribute that uses the GTFS transit evaluator that is installed in ArcGIS.
- Builds the multi-modal network

Add New Attribute

Name:

Usage Type:

Units:

Data Type:

Restriction Usage:

☒ Use by Default

OK Cancel

Evaluators

Attribute:

Attribute Values:

Source Values Default Values

Source	Direction	Element	Type	Value
Connectors_Stops2S...	From-To	Edge	Constant	0.25
Connectors_Stops2S...	To-From	Edge	Constant	0.25
Streets_UseThisOne	From-To	Edge	Function	Length / 80.4672
Streets_UseThisOne	To-From	Edge	Function	Length / 80.4672
TransitLines	From-To	Edge	Transit Evaluator	
TransitLines	To-From	Edge	Constant	-1
Stops		Junction		
Stops_Snapped2Stre...		Junction		
Transit_ND_Junctions		Junction		

About network evaluators

OK Cancel Apply

Shimberg Transit Access Tools



Nearest Facility by Transit Tool

Creates a raster that maps the multi-modal trip times from any location inside the transit stop walking shed to the nearest service (grocery, medical center, employment location, etc). This includes the estimation of in-vehicle time, time spent at stop, transfer time and walking time. The output is a color heat map the shows the value of the distance.

Opportunity Access by Transit Tool

Depending on the goal of analysis, the tool can count the number of services or jobs within a specific trip time. The tool can also take into account differences in trip durations (peak, off peak, etc.). The final output is a color heat map that shows the access measurement for all locations within the time shed.

Opportunity Access by Transit Tool



We will focus on the Opportunity Access by Transit Tool

Why?

Because by explaining this tool you can easily understand the other accessibility tools that work for driving, walking or biking



Opportunity Access

1. Time-based opportunity (Handy, 2004)

WHERE,

O_j is the weight or the attraction for the facility

$t = 1$ for $t_i < \text{time shed}$ and zero else where

$$A_i = \sum_j O_i t_i$$

2. Distance-based opportunity (Handy, 2004)

WHERE,

O_j is the weight or the attraction for the facility

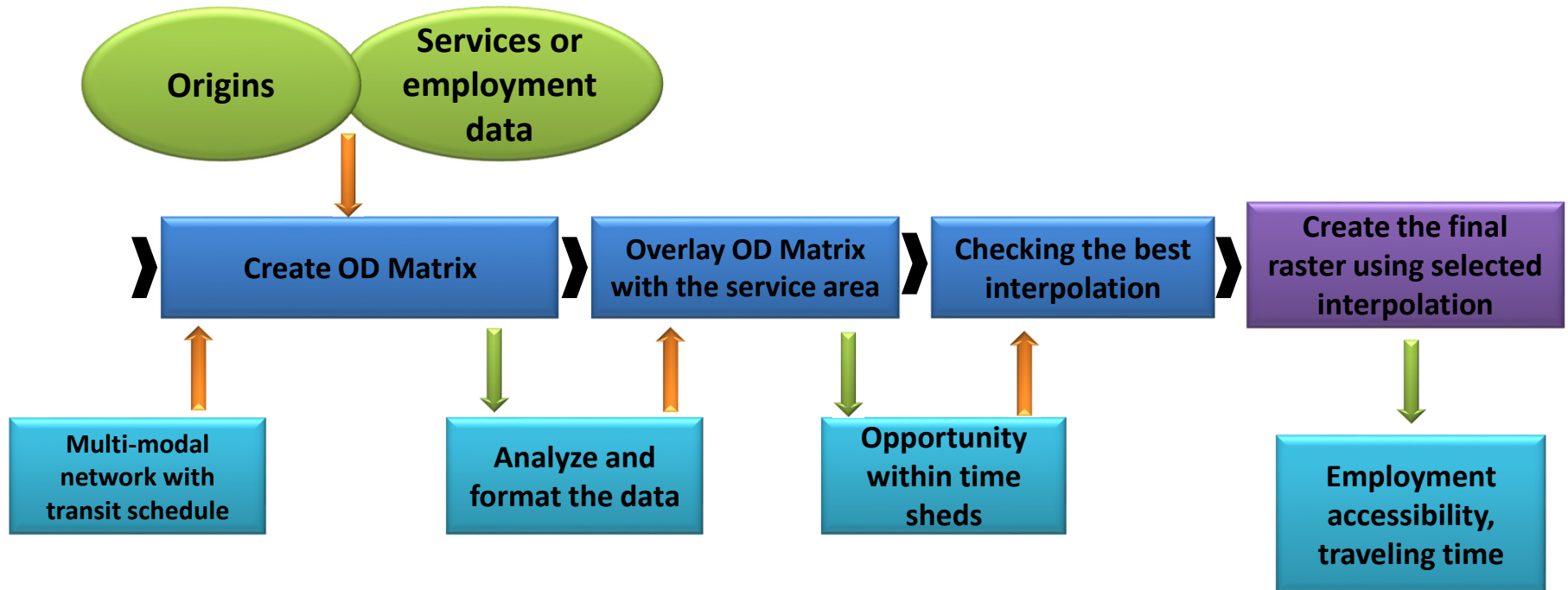
$D = 1$ for $D_i < \text{shed distance}$ and zero else

$$A_i = \sum_j O_i d_i$$

Tool Diagram



Transit/pedestrian accessibility analyses



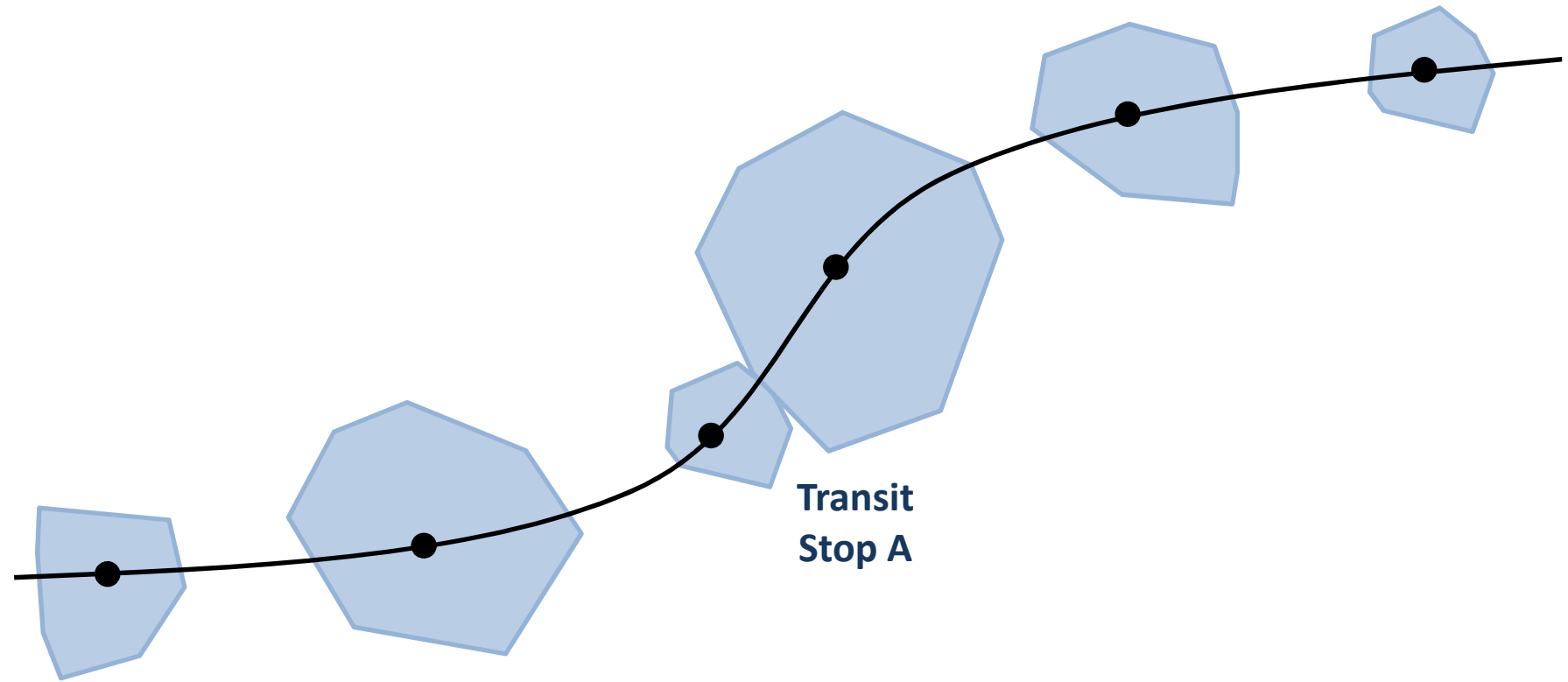
Data:

- Jobs (i.e. InfoUSA)
- Services – parcel data / property appraiser
- Origins - Random points inside walking shed including intended locations to be tested

Creating the Walking Shed

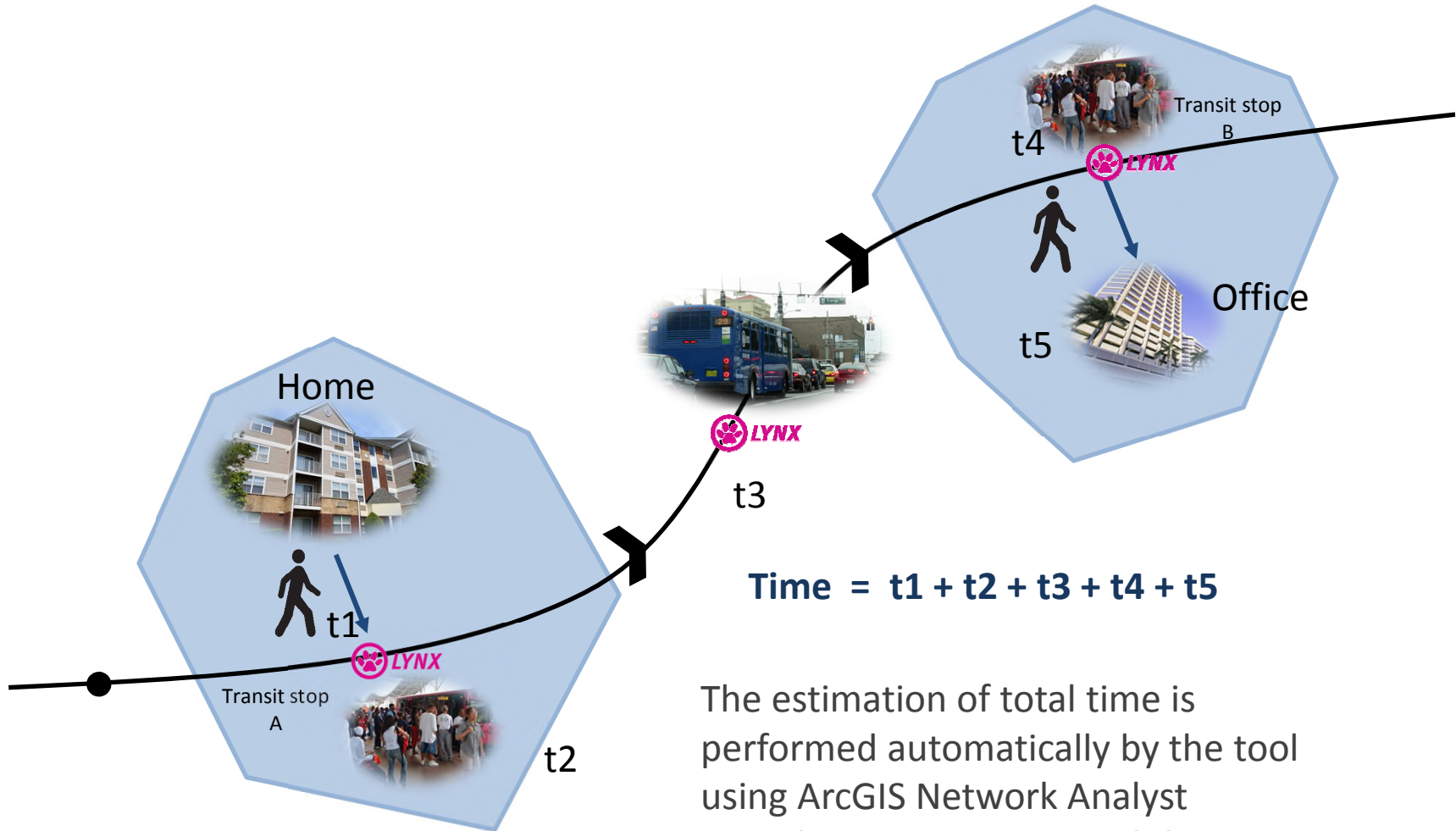


Network Walking Sheds



The network walking shed is created around stops using the walkable streets by ArcGIS Network Analyst "Service Area Tool"

Travel Time Impedance Estimation



$$\text{Time} = t1 + t2 + t3 + t4 + t5$$

The estimation of total time is performed automatically by the tool using ArcGIS Network Analyst impedance estimation and the transit schedules

Opportunity Based Transit Access



Create Final Access Rasters

Network Walk Shed (optional)
ServiceArea

Transit Network
LYNX_ND

Service Feature Class
Medical

Random Points
Random_liz

15 Mins time shed raster
C:\TRANSIT\Medical_15

30 Mins time shed raster
C:\TRANSIT\Medical_30

45 Mins time shed raster
C:\TRANSIT\Medical_45

60 Mins time shed raster
C:\TRANSIT\Medical_60

Start Time (optional)
8:00:00 AM

Create Final Access Rasters

OK Cancel Environments... << Hide Help Tool Help

Sample Origins and Destinations



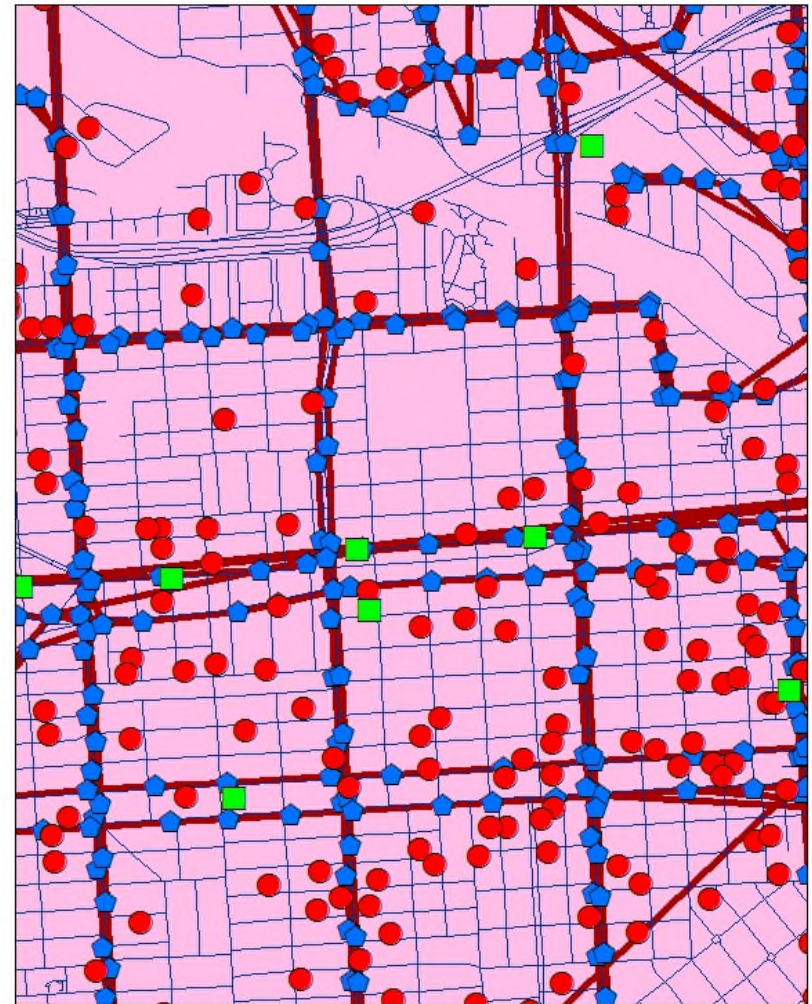
Select services or jobs as destinations inside the service area.

Generate random points to serve as origins.

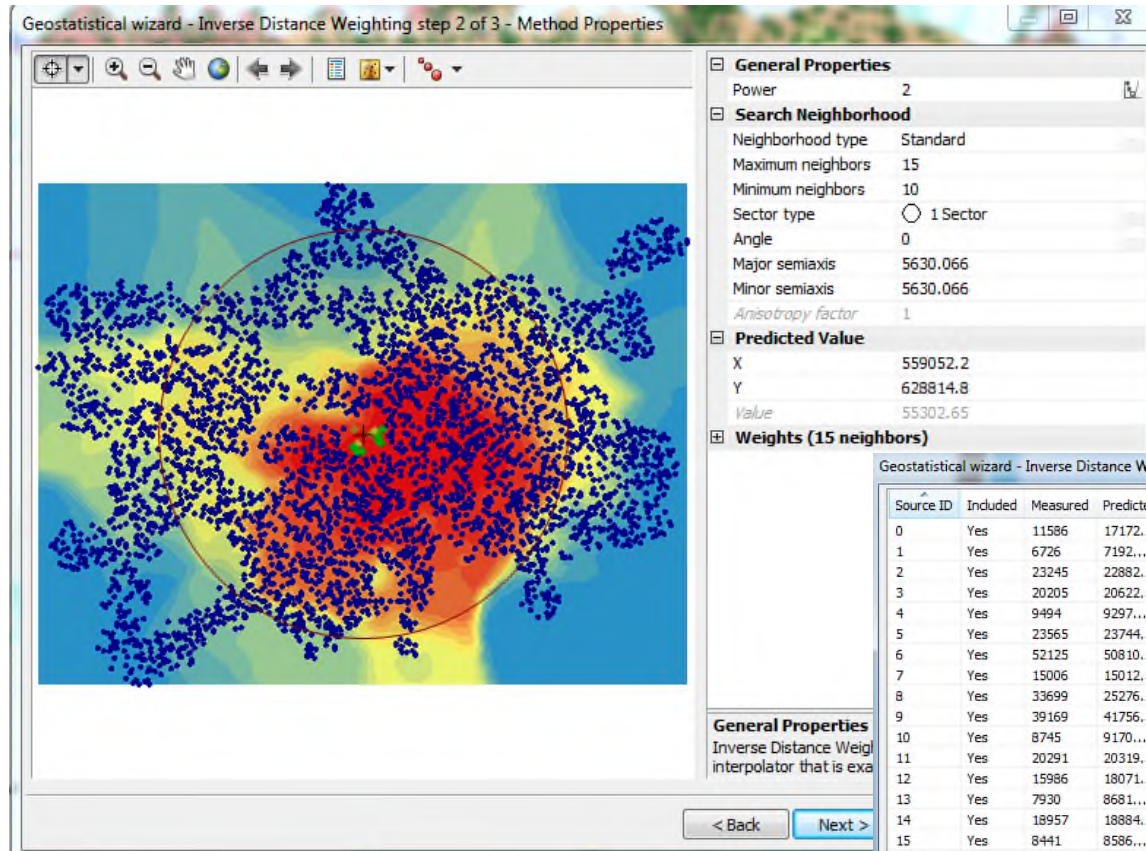
Increasing the number of random points improves the accuracy of the result but increases the model processing time.

Sample Origins and Destinations

-  Stops
-  TransitLines
-  Origins
-  Grocery

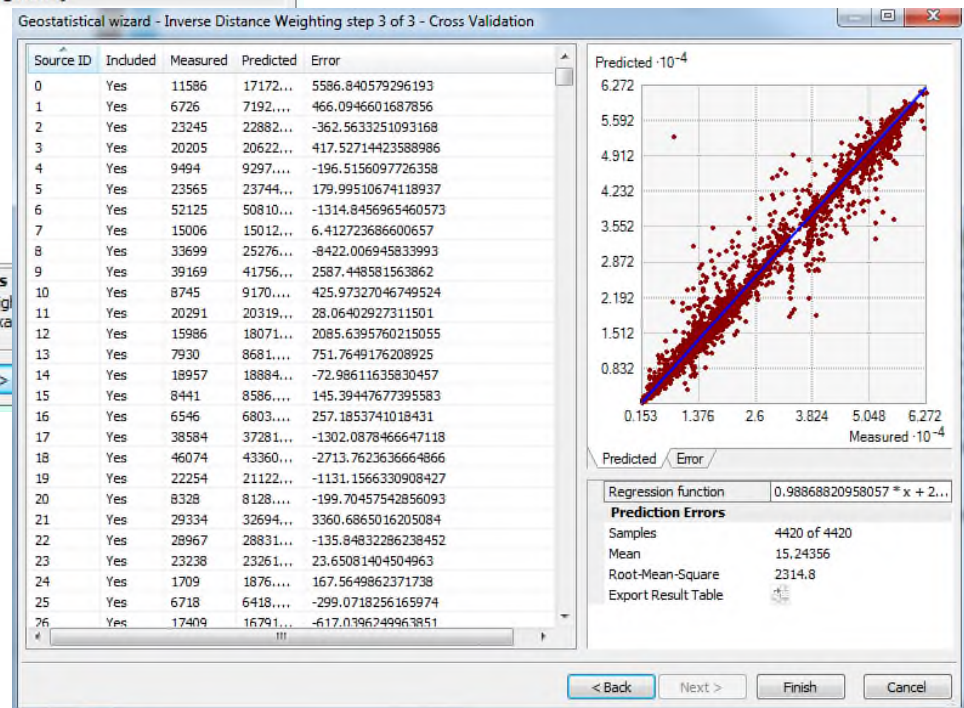


Checking Best Prediction Surface

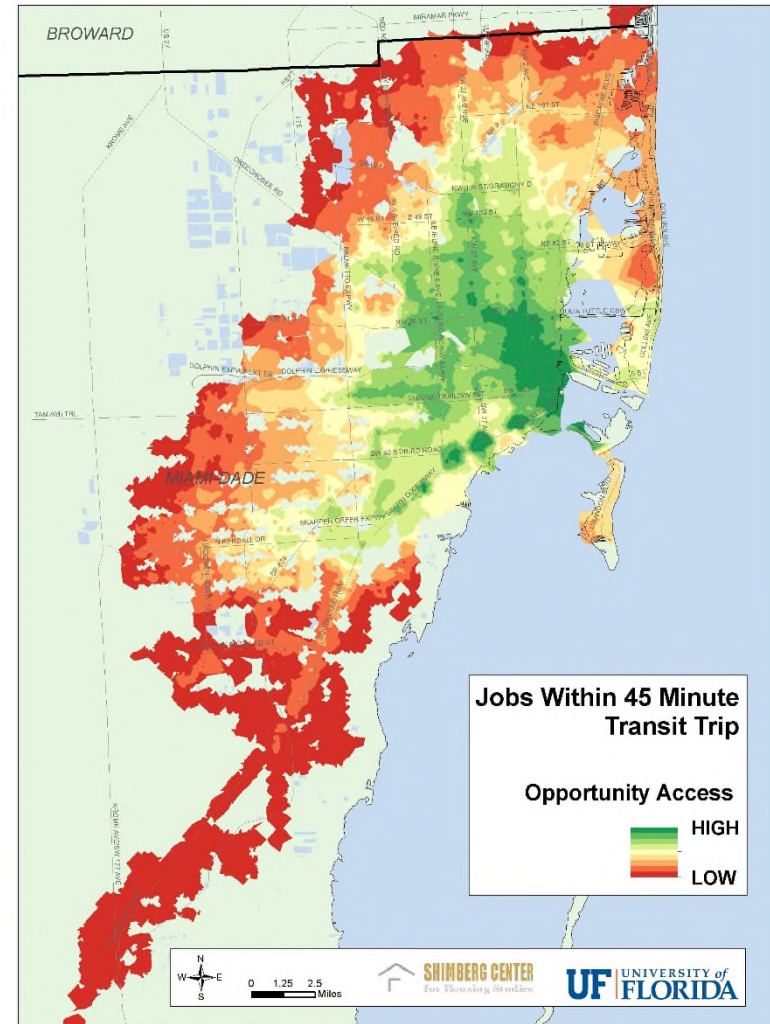
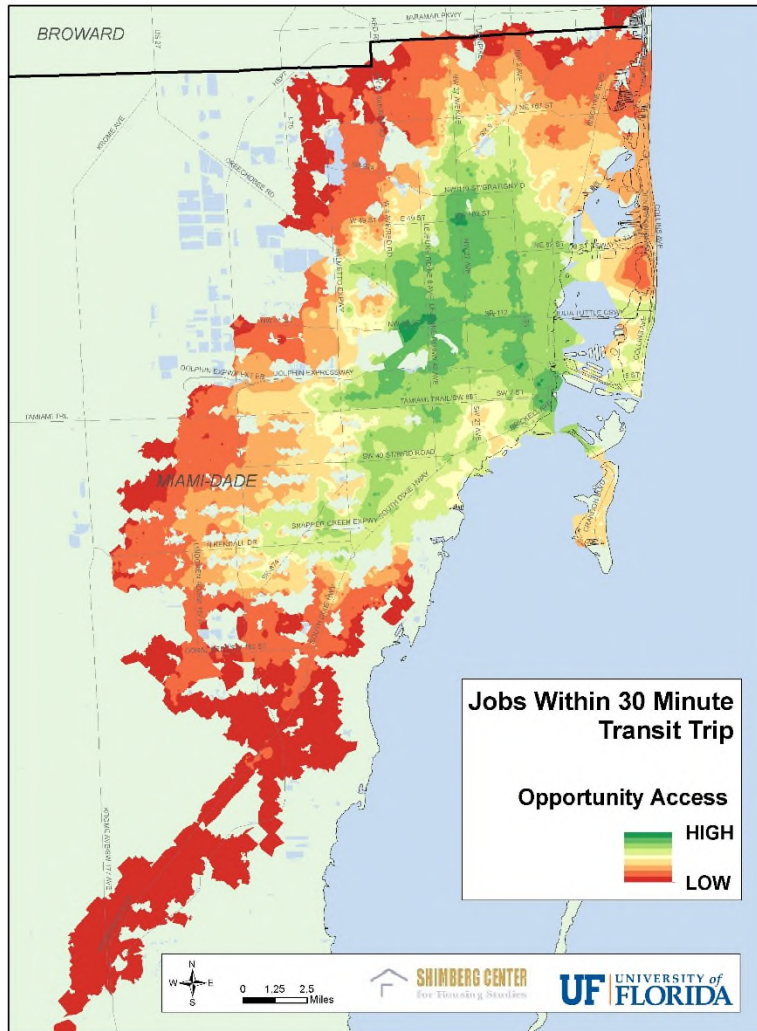


The final output map is an **interpolated raster** based on the result of the random points (origins)

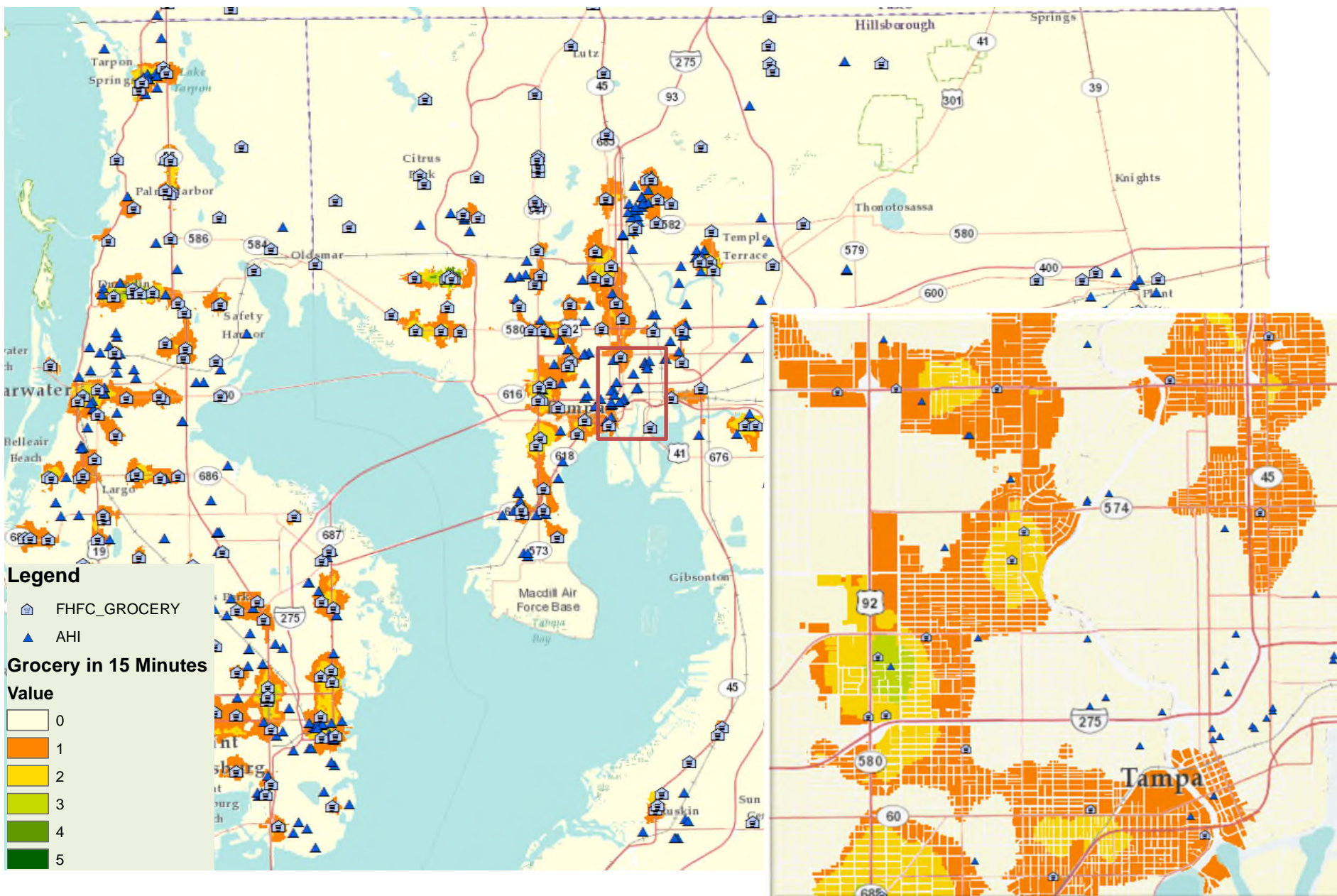
Geo-Statistical Analyst is used to generate the best interpolated raster



Opportunity access number of jobs

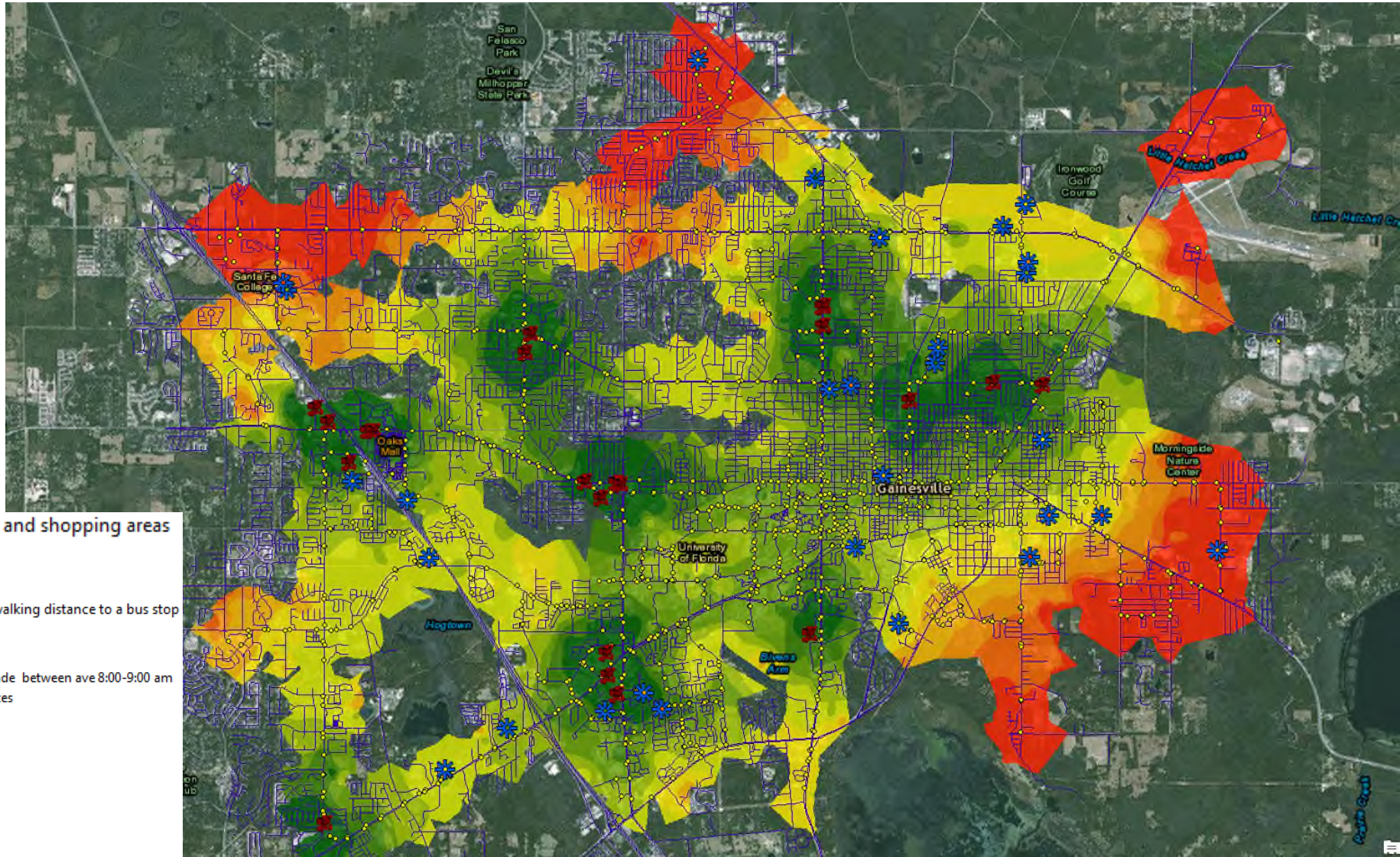


Opportunity access number of services (Grocery)



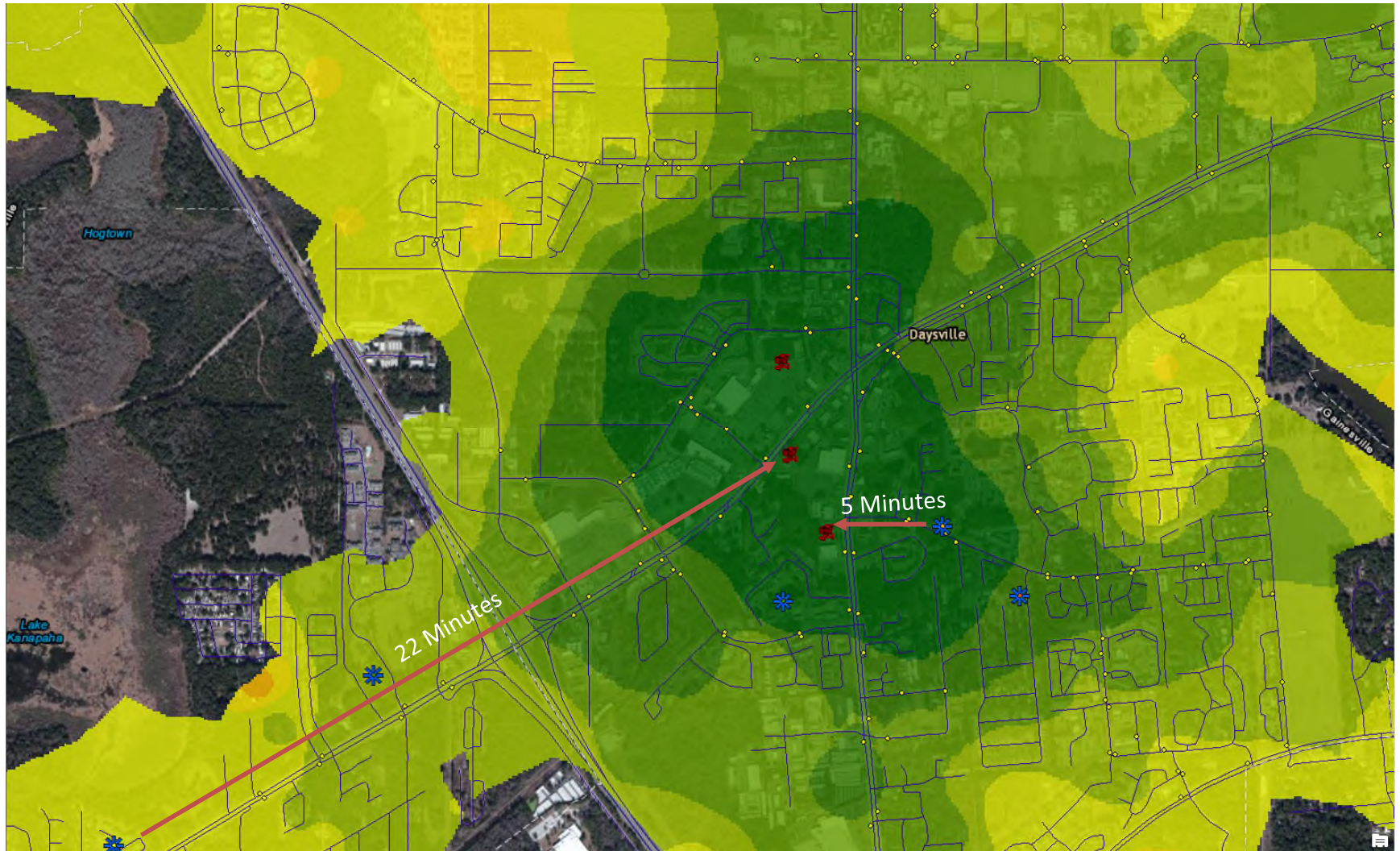
Time to a nearest service

mall and shopping



Time to a nearest service

mall and shopping



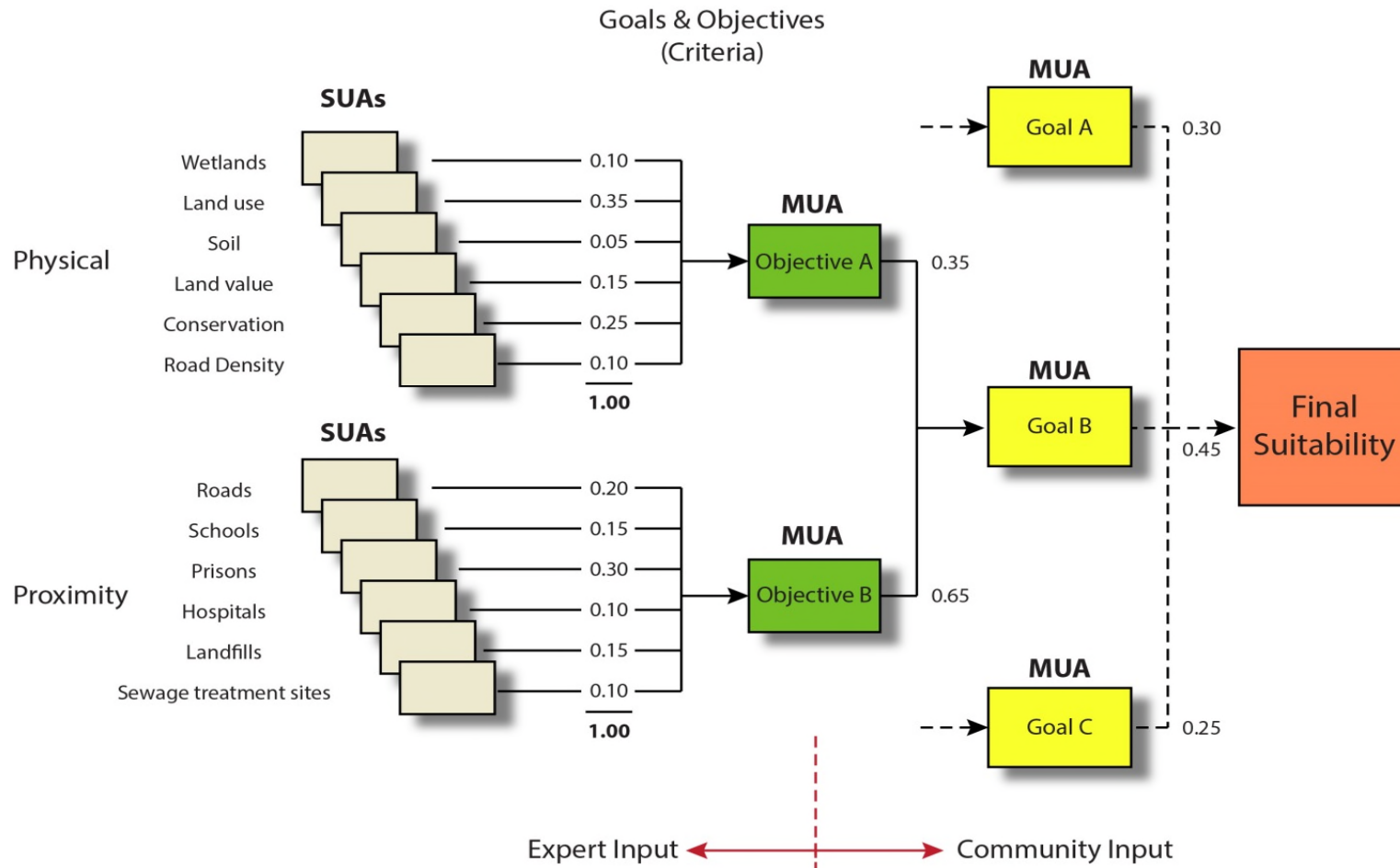
Tool Summary



- **Evaluate differences** in transit access for the geographic areas that are served by a community's multi-modal transit service.
- **Incorporates travel time, transit frequency and transit schedules** into our assessment of transit service coverage.
- Determines **how well** the transit system serves trips to or from a particular location under a given set of assumptions that can be controlled such as :
 - control the walking distance and speed to transit station
 - incorporates all segments of a complete transit trip, including the waiting time
 - control the maximum travel time
 - control peak and off-peak hours , weekday, weekend
- Shows **the number of jobs or services that a person can reach** by transit from a designated location



LUCIS - Suitability Analysis



What is LUCIS^{PLUS}?

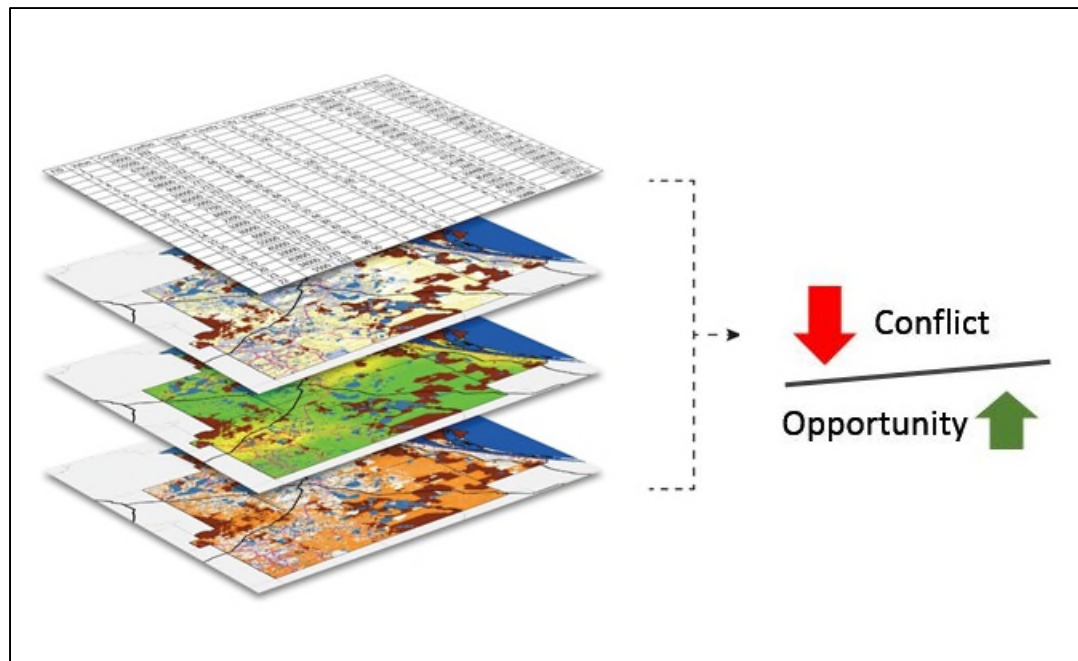


- The **Criteria Evaluation Matrix or CEM** is an expanded container of LUCIS outputs and other criteria evaluations used for running automated citizen-driven land use – transportation scenarios
- A CEM is also a solution for **modeling land use complexity** that develops a single complex multi-variable raster layer created using the ESRI's Combine Tool.
- The Combine Tool does what the name implies, it **combines multiple input raster layers one cell at a time**, to create a single multi-variable raster layer that contains all the information present from the input raster layers
- The advantage of the Combine Tool is its ability to **create a single raster layer with incredible amounts of spatial information**.

Criteria Evaluation Matrix CEM



The CEM is prepared by an enumeration rule that **combines many grids and keeps their attribute values**. These grids are used to set up the priorities for future population allocation. They can be land use suitability in addition to other criteria evaluations, such as transportation variables (i.e. network proximity, transit access, etc.)



Source: Zwick et al, 2015



- LUCIS^{plus} contains automated GIS tools (**A4 Tools**) for Land use – Transportation coordination aimed to produce more informed, citizen and community-driven future land use visions

A4 Tools

Automation Tools

A4 LUCIS Allocation by Table

A4 LUCIS Community Values Calculator

A4 LUCIS Weights

A4 Suitability

A4 Trend Allocation (Standard)

A4 Trend Allocation (Detailed)

Transportation Tools

A4 Manhattan Distance

A4 Network Raster

A4 Network Opportunity

A4 Gravity Accessibility

A4 Transit Access Tools

Automation Tools



A4 Suitability - A tool for automatic transformation of criteria evaluation into standard 1-9 decreasing or increasing suitability

A4 LUCIS Community Values Calculator - A tool for estimating the weights according to community values and export them directly into LUCIS models

A4 LUCIS Weights - A tool that takes the generated weight from the previous tool, the weights are used to combine different criteria evaluation in the suitability structure.

A4 LUCIS Allocation by Table - Automatically uses the CEM and a scenario table to produce a vision for future allocations

Transportation Tools



A4 Manhattan Distance - A set of tools that creates a Manhattan shed (buffer) and/or a Manhattan distance raster.

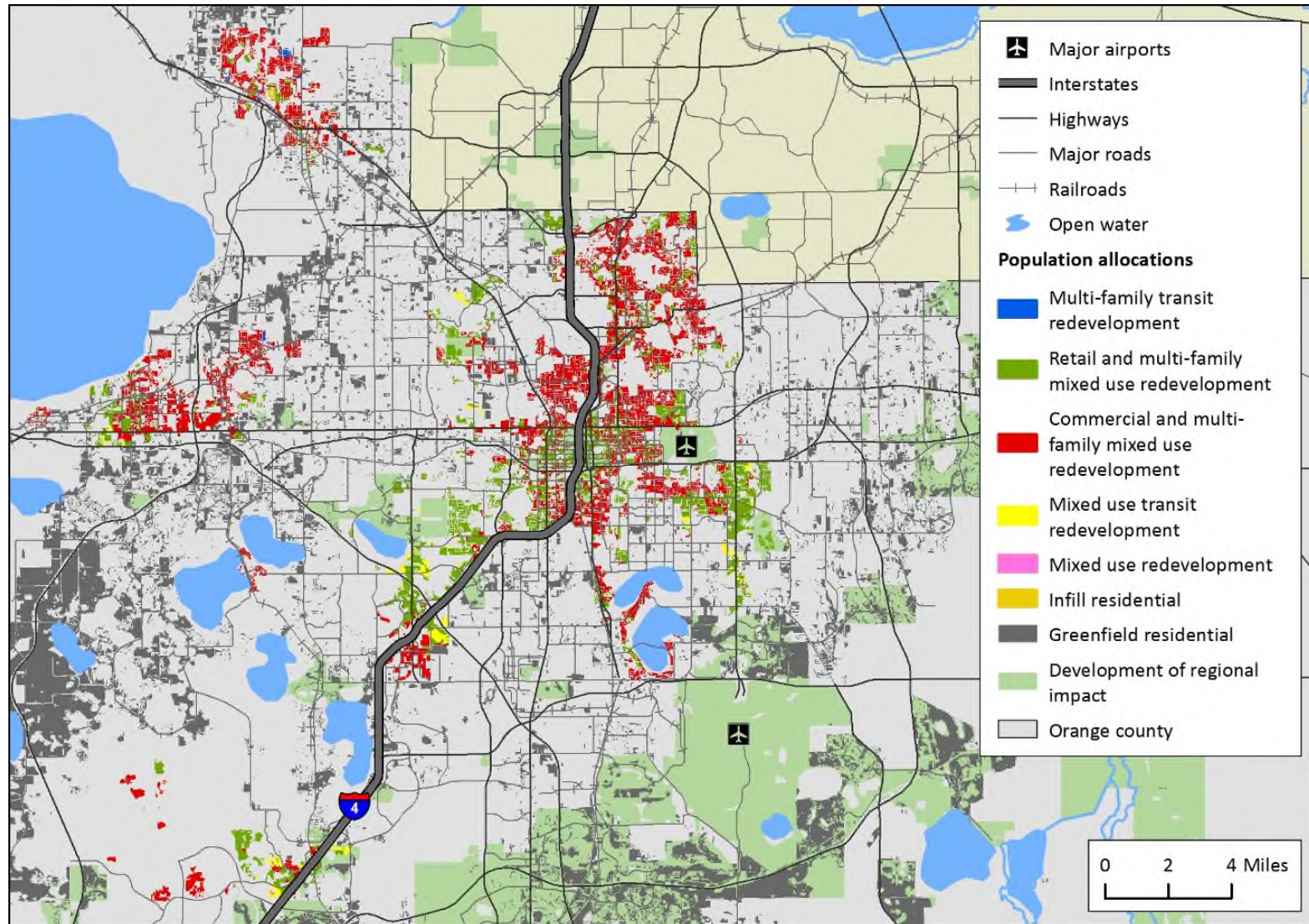
A4 Network Raster - A tool that creates a raster based on network proximity using distance or travel time.

A4 Network Opportunity - A tool that estimates (sum) the opportunities (services, employment, etc.) within a specific network travel time/distance.

A4 Gravity Accessibility - A tool estimates the gravity access from any location to a set of defined destination using travel time/distance, attraction and decay

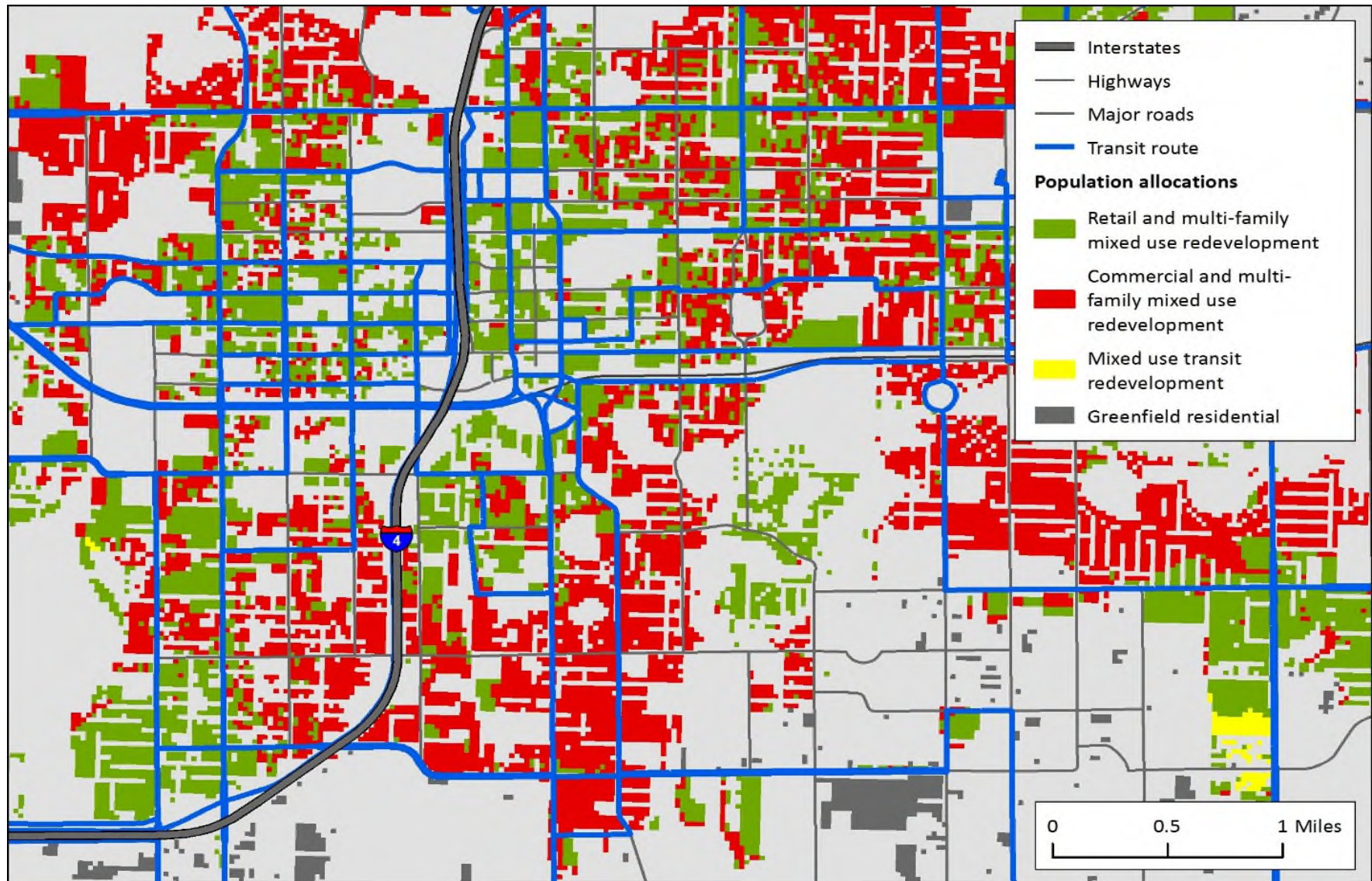
A4 Transit Access Tools - Explained earlier in the presentation

Mixed Use – Transit Scenario



Source: Zwick et al, 2015

Mixed Use – Transit Scenario



Source: Zwick et al, 2015