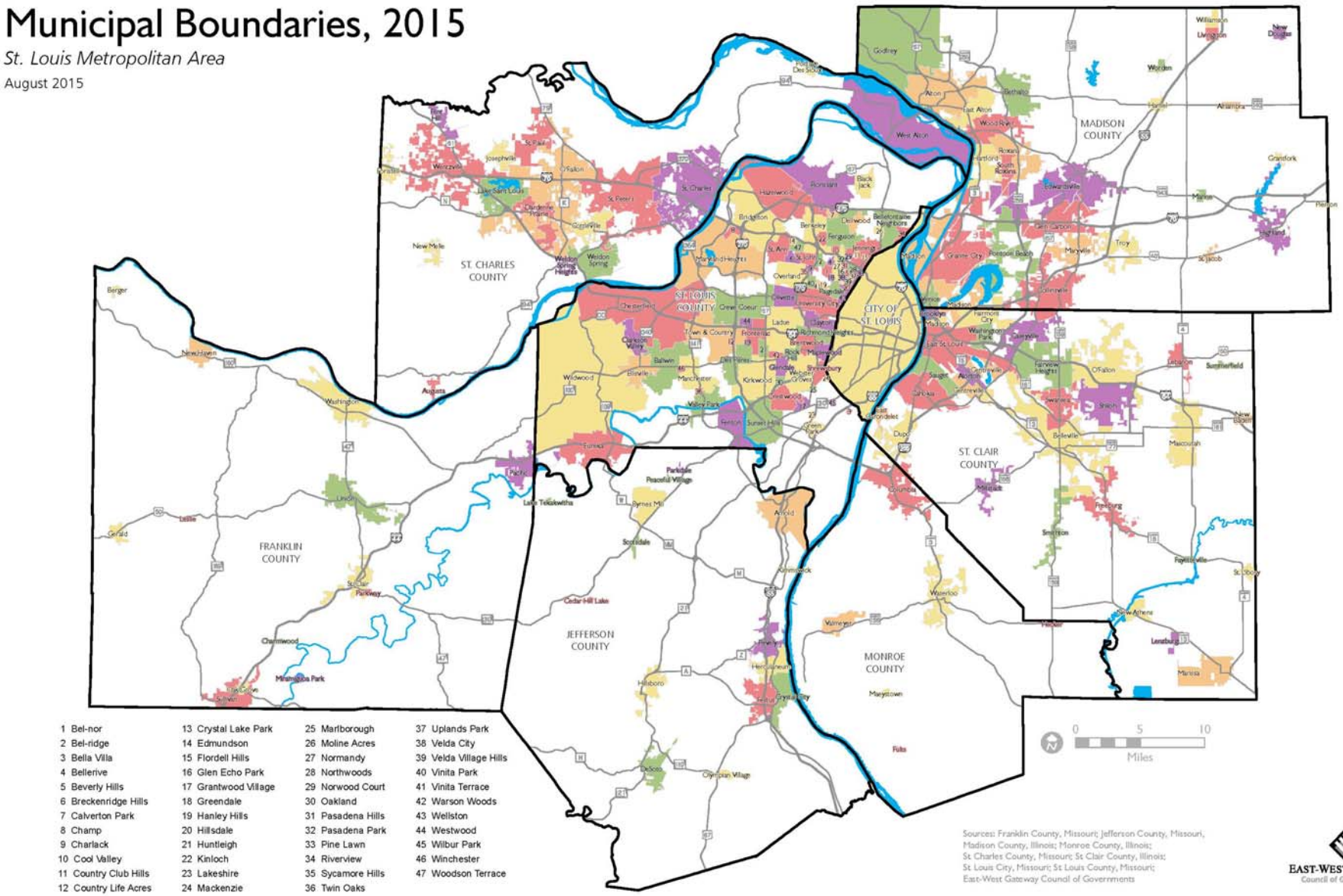
# A Python Toolkit for Visualizing Greenhouse Gas Emissions at Sub-County Scales

AQAC
January 26, 2016

# Summary

- Toolkit developed in Python Language
- Uses outputs from Mobile Vehicle Emissions Simulator Model (MOVES)
- Calculates transportation-related greenhouse gas emissions at user-defined geographies
- Uses geoprocessing libraries:  ESRI or SpatiaLite

# The St. Louis Region



# Motivations for Project

- To help planners make more informed decisions.
- To increase awareness of GHGs in the region.
- Meet Long Range Plan goals
- Meet goals of regional sustainability plan, OneSTL.

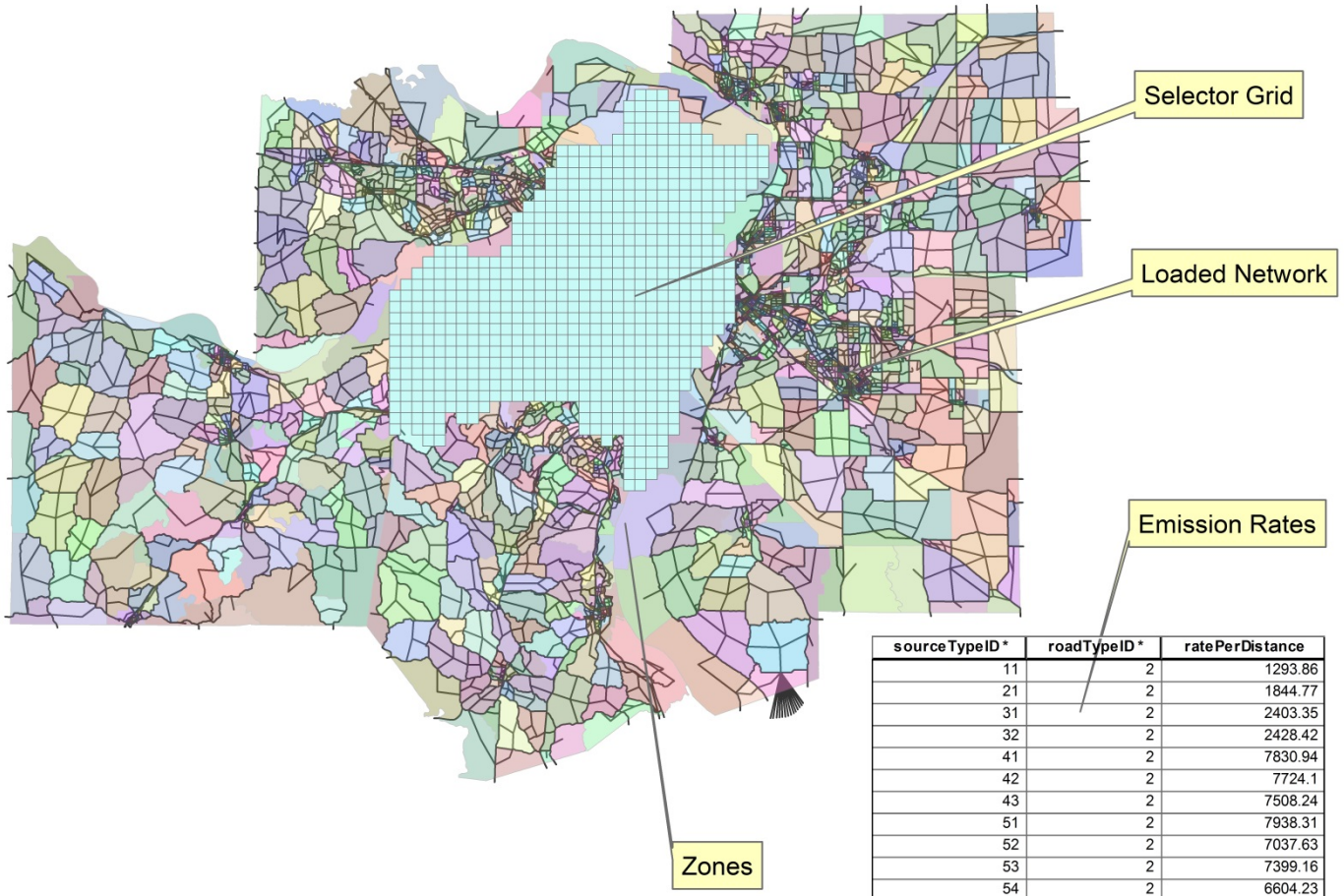
# Approach

- Examine MOVES Inputs
- Develop Post-Processing Tools
- Develop Visualization Tools
- Share results/lessons learned

# Data and Platform

- MOVES Mode:  Inventory vs. Emission Rates
- Data Processing Platform
  - Python
  - Geoprocessing:  Choice of:
    - ESRI
    - SpatiaLite

# Toolkit: Conceptual Data Model




| sourceTypeID * | roadTypeID * | ratePerDistance |
|---|---|---|
| 11 | 2 | 1293.86 |
| 21 | 2 | 1844.77 |
| 31 | 2 | 2403.35 |
| 32 | 2 | 2428.42 |
| 41 | 2 | 7830.94 |
| 42 | 2 | 7724.1 |
| 43 | 2 | 7508.24 |
| 51 | 2 | 7938.31 |
| 52 | 2 | 7037.63 |
| 53 | 2 | 7399.16 |
| 54 | 2 | 6604.23 |
| 61 | 2 | 7954.6 |

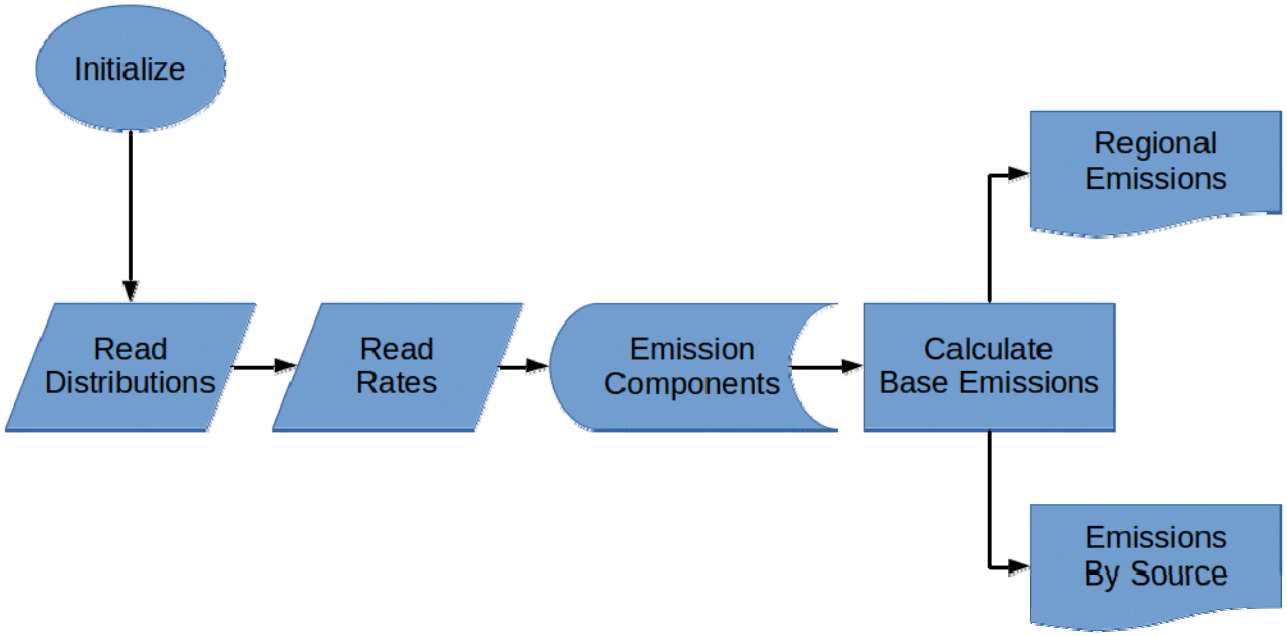
# Toolkit: Software

- Python
- Libraries
  - ArcPy : Calls to ArcMap routines
  - pyspatialite : SQL with spatial extensions

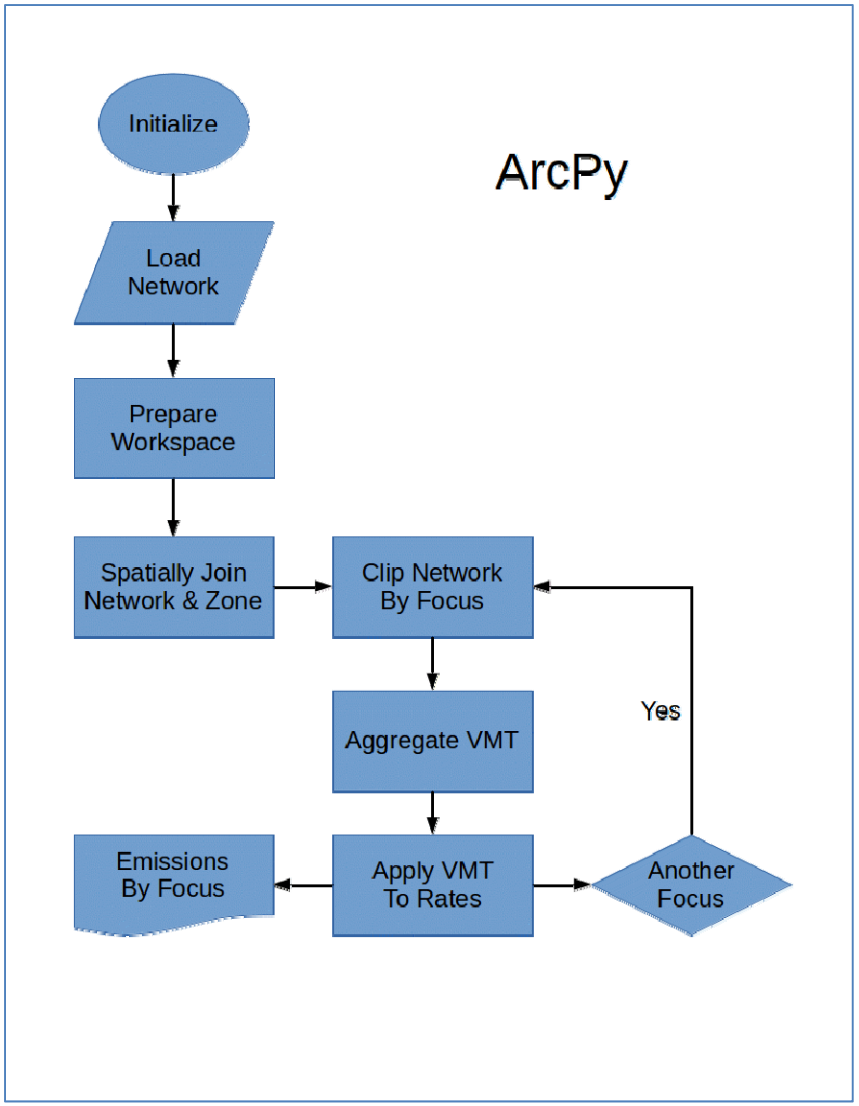
```
SELECT z.Key AS Zone_Key, g.Key AS Grid_Key, AREA(INTERSECTION(g.Geometry, z.Geometry)) AS Area
FROM Zone AS z, Selector AS g
WHERE INTERSECTS(z.Geometry, g.Geometry);
```

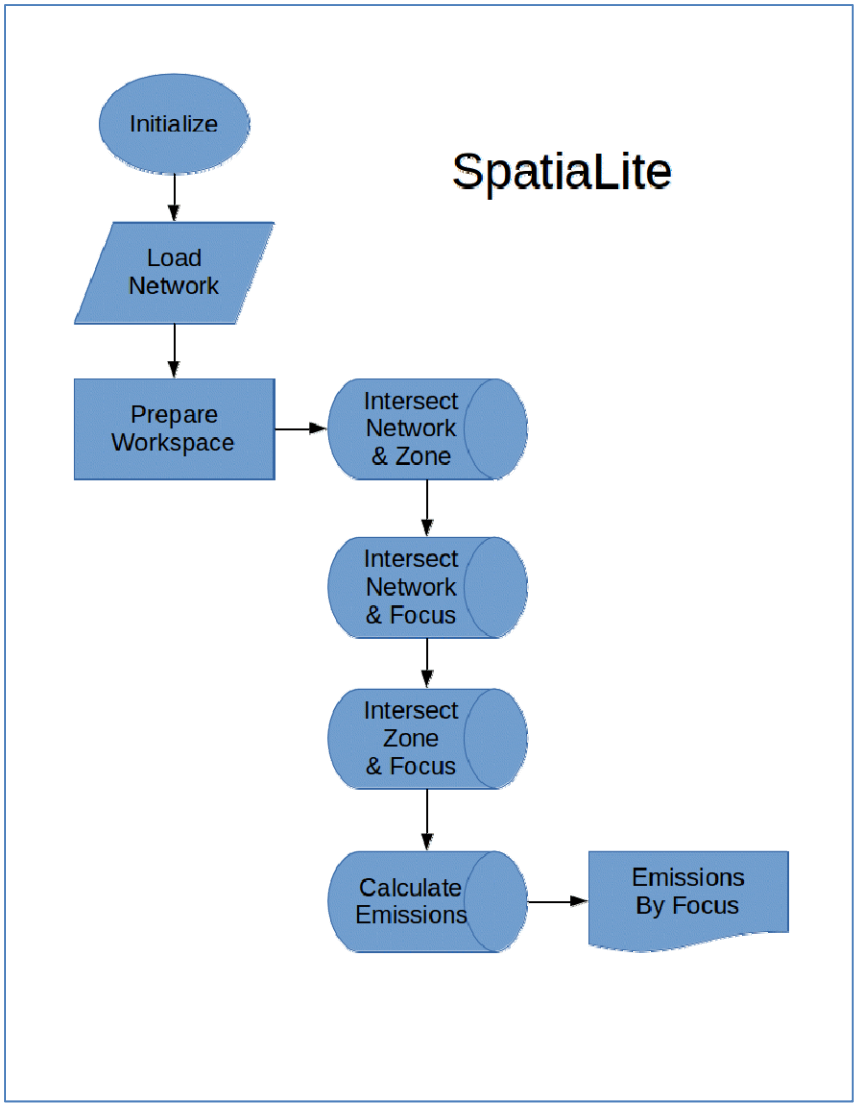
- Tools
  - SpatiaLite-GUI

# Toolkit: Load MOVES Data



# Toolkit: Calculate Emissions



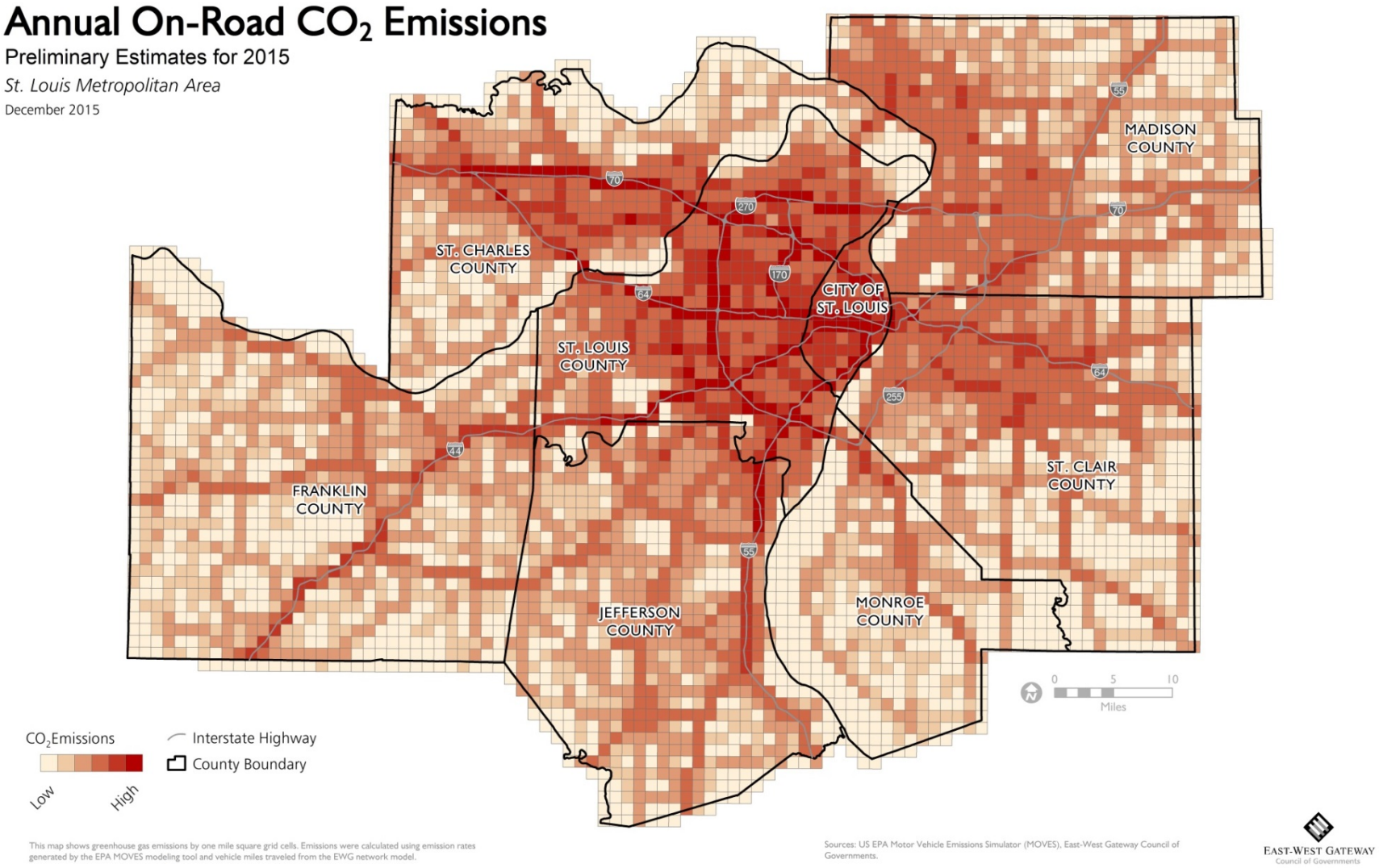



# Toolkit: Output

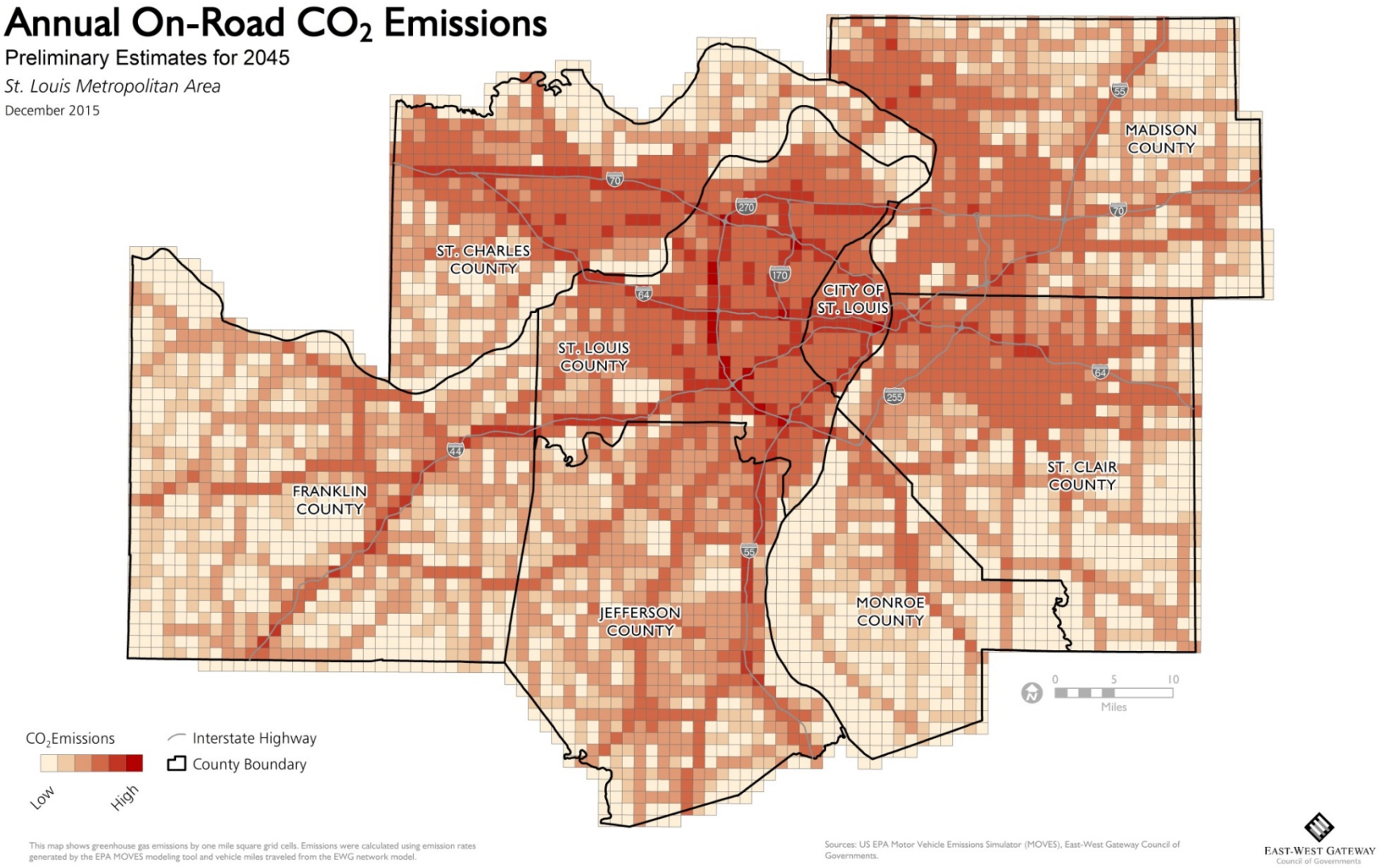
- Example : Emissions by County

| Year | Name | Pollutant | Emissions_grams | Emissions_pounds | Emissions_metric_tons | Area |
|---|---|---|---|---|---|---|
| 2015 | MADISON | CO2 | 1,563,115,466,830 | 3,446,669,604 | 1,563,115 | 20,637,797,452 |
| 2015 | ST. CLAIR | CO2 | 1,517,756,171,025 | 3,346,652,357 | 1,517,756 | 18,786,806,066 |
| 2015 | MONROE | CO2 | 205,863,688,865 | 453,929,434 | 205,864 | 11,085,857,219 |
| 2015 | ST. CHARLES | CO2 | 2,079,462,956,851 | 4,585,215,820 | 2,079,463 | 16,512,203,825 |
| 2015 | ST. LOUIS CO. | CO2 | 6,934,427,046,481 | 15,290,411,637 | 6,934,427 | 14,600,690,989 |
| 2015 | CITY OF ST. LOUIS | CO2 | 1,519,842,395,291 | 3,351,252,482 | 1,519,842 | 1,847,149,480 |
| 2015 | FRANKLIN | CO2 | 837,643,952,082 | 1,847,004,914 | 837,644 | 25,943,395,487 |
| 2015 | JEFFERSON | CO2 | 1,188,900,964,567 | 2,621,526,627 | 1,188,901 | 18,513,992,183 |

# Results


Annual On-Road $CO_2$ Emissions
Preliminary Estimates for 2015
St. Louis Metropolitan Area
December 2015
MADISON COUNTY
ST. CHARLES COUNTY
CITY OF ST. LOUIS
ST. LOUIS COUNTY
FRANKLIN COUNTY
ST. CLAIR COUNTY
JEFFERSON COUNTY
MONROE COUNTY
0 5 10
Miles
$CO_2$ Emissions
Low
High
Interstate Highway
County Boundary
This map shows greenhouse gas emissions by one mile square grid cells. Emissions were calculated using emission rates generated by the EPA MOVES modeling tool and vehicle miles traveled from the EWG network model.
Sources: US EPA Motor Vehicle Emissions Simulator (MOVES), East-West Gateway Council of Governments.
East-West Gateway
Council of Governments

# Results


Annual On-Road $CO_2$ Emissions
Preliminary Estimates for 2045
St. Louis Metropolitan Area
December 2015
MADISON COUNTY
ST. CHARLES COUNTY
CITY OF ST. LOUIS
ST. LOUIS COUNTY
FRANKLIN COUNTY
ST. CLAIR COUNTY
JEFFERSON COUNTY
MONROE COUNTY
55
70
270
170
64
255
44
0 5 10
Miles
$CO_2$ Emissions
Low
High
Interstate Highway
County Boundary
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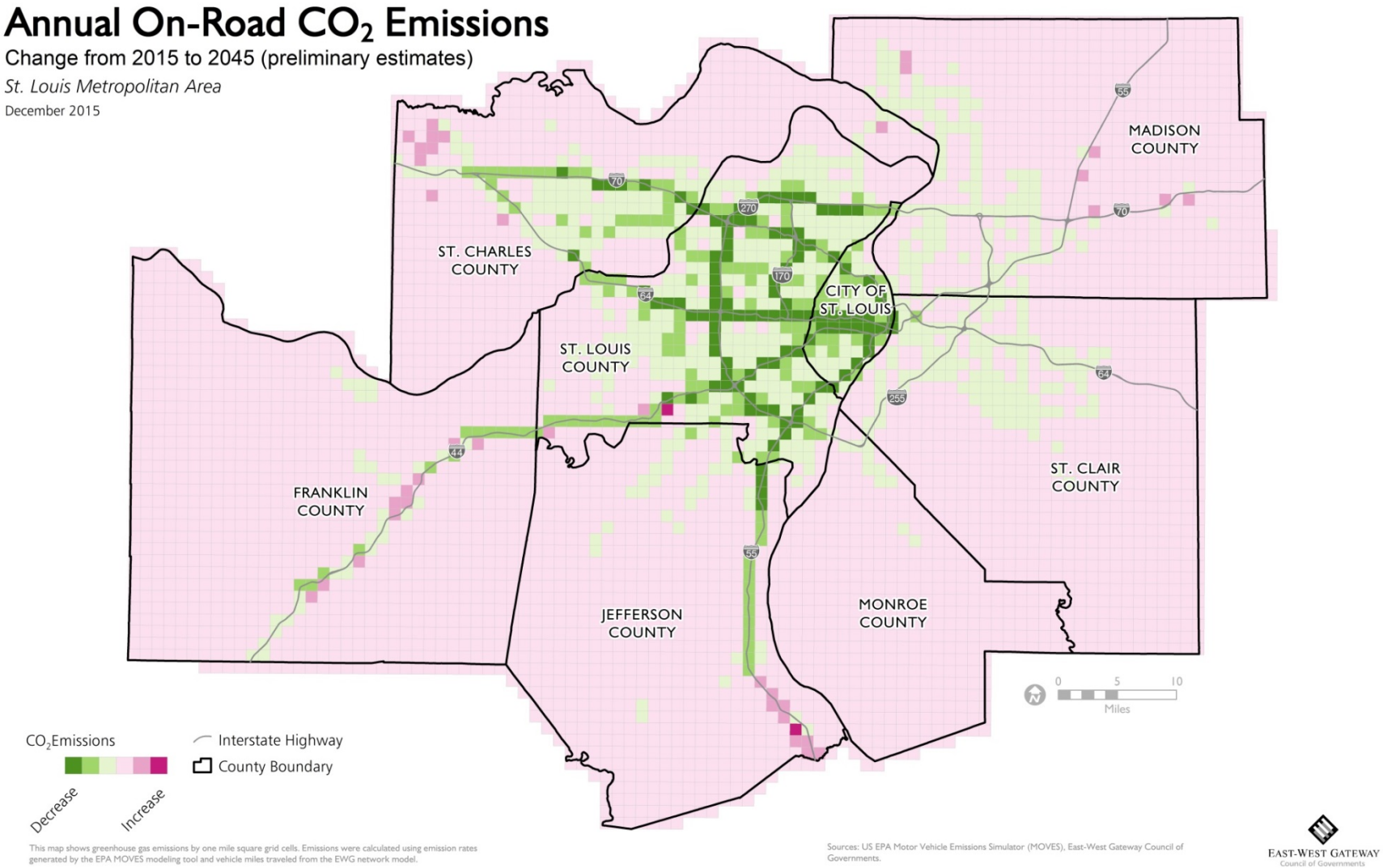
Annual On-Road $CO_2$ Emissions
Change from 2015 to 2045 (preliminary estimates)
St. Louis Metropolitan Area
December 2015
MADISON COUNTY
ST. CHARLES COUNTY
CITY OF ST. LOUIS
ST. LOUIS COUNTY
FRANKLIN COUNTY
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0 5 10
Miles
$CO_2$ Emissions
Decrease
Increase
Interstate Highway
County Boundary
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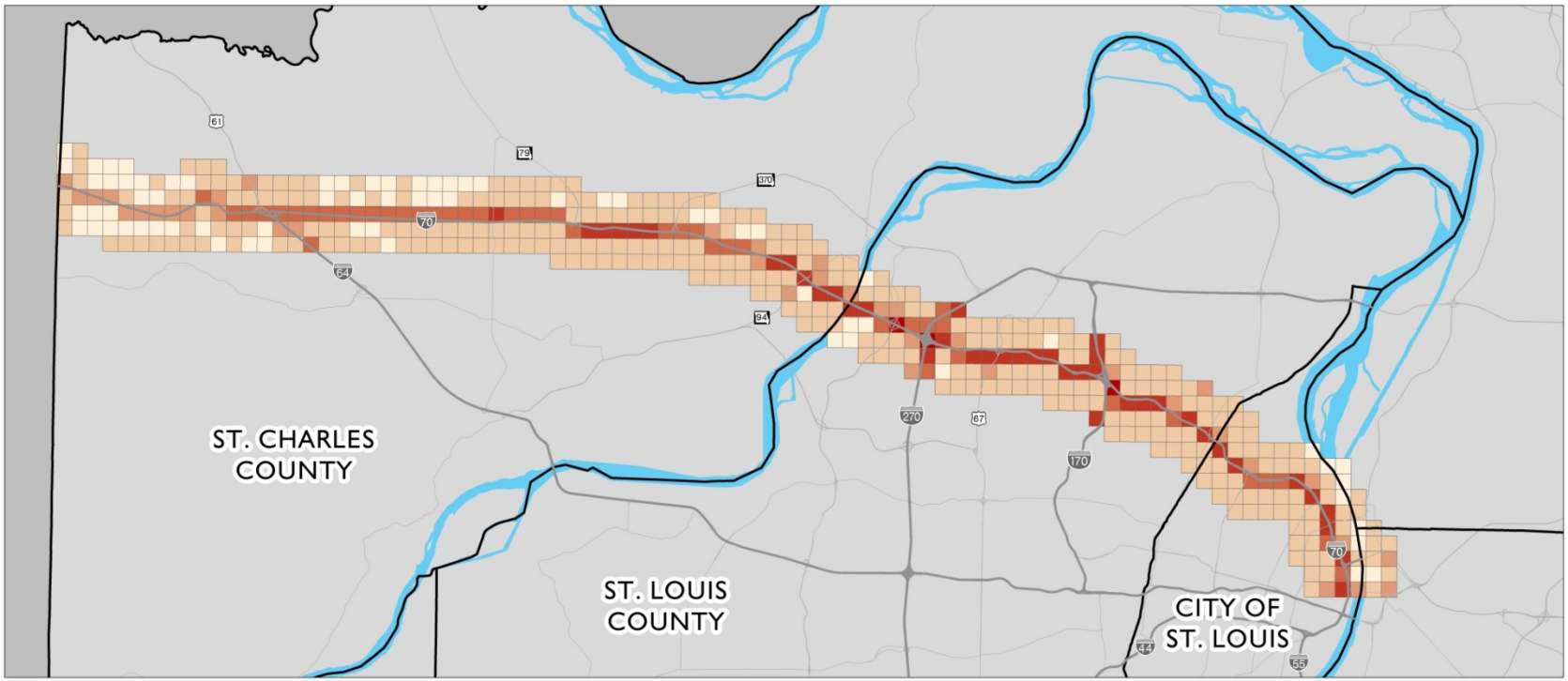
# Results

## Annual On-Road $CO_2$ Emissions along I-70 Corridor

Preliminary Estimates for 2015

*St. Louis Metropolitan Area*

December 2015




$CO_2$ Emissions

Low — High

Interstate Highway

Major Roads

County Boundary

River

0 5 10 Miles

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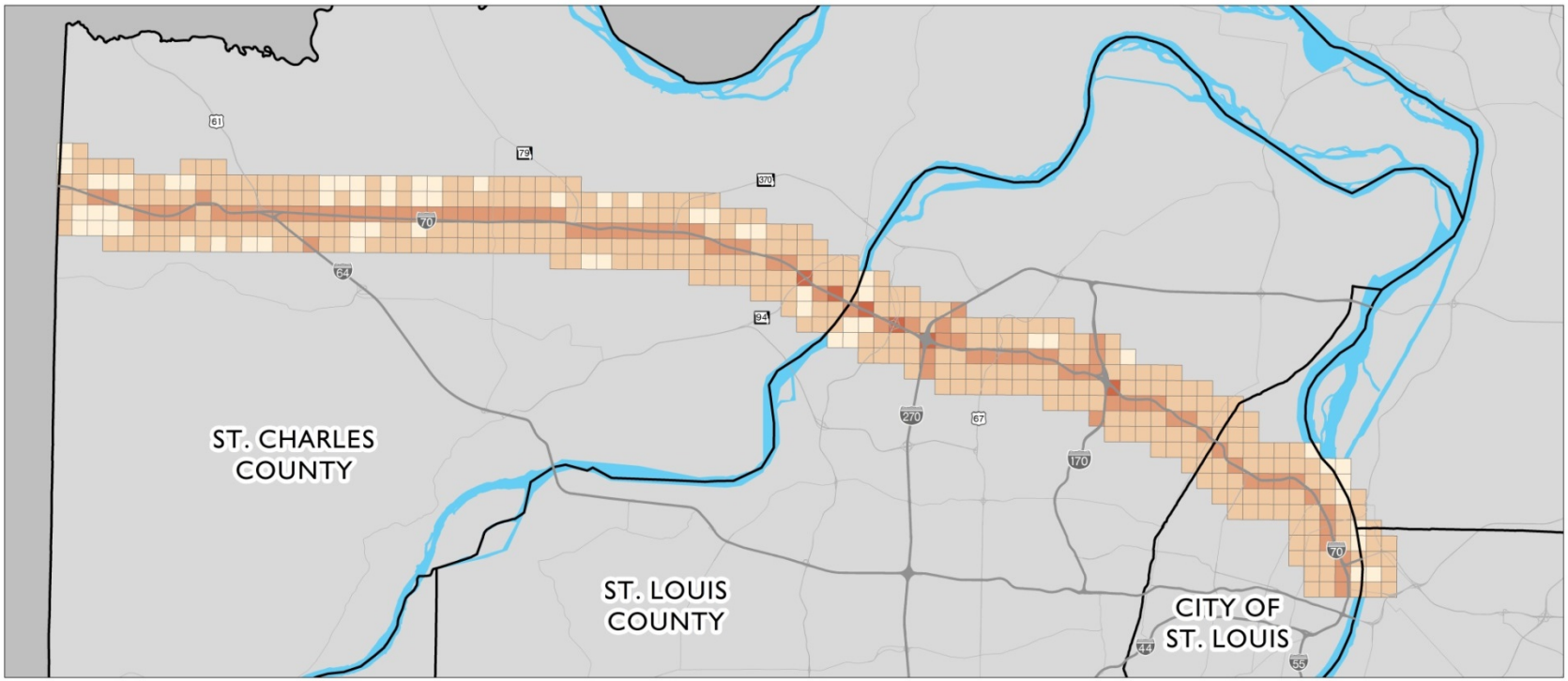


$CO_2$ Emissions

Low — High

Interstate Highway

Major Roads

County Boundary

River

0 5 10 Miles

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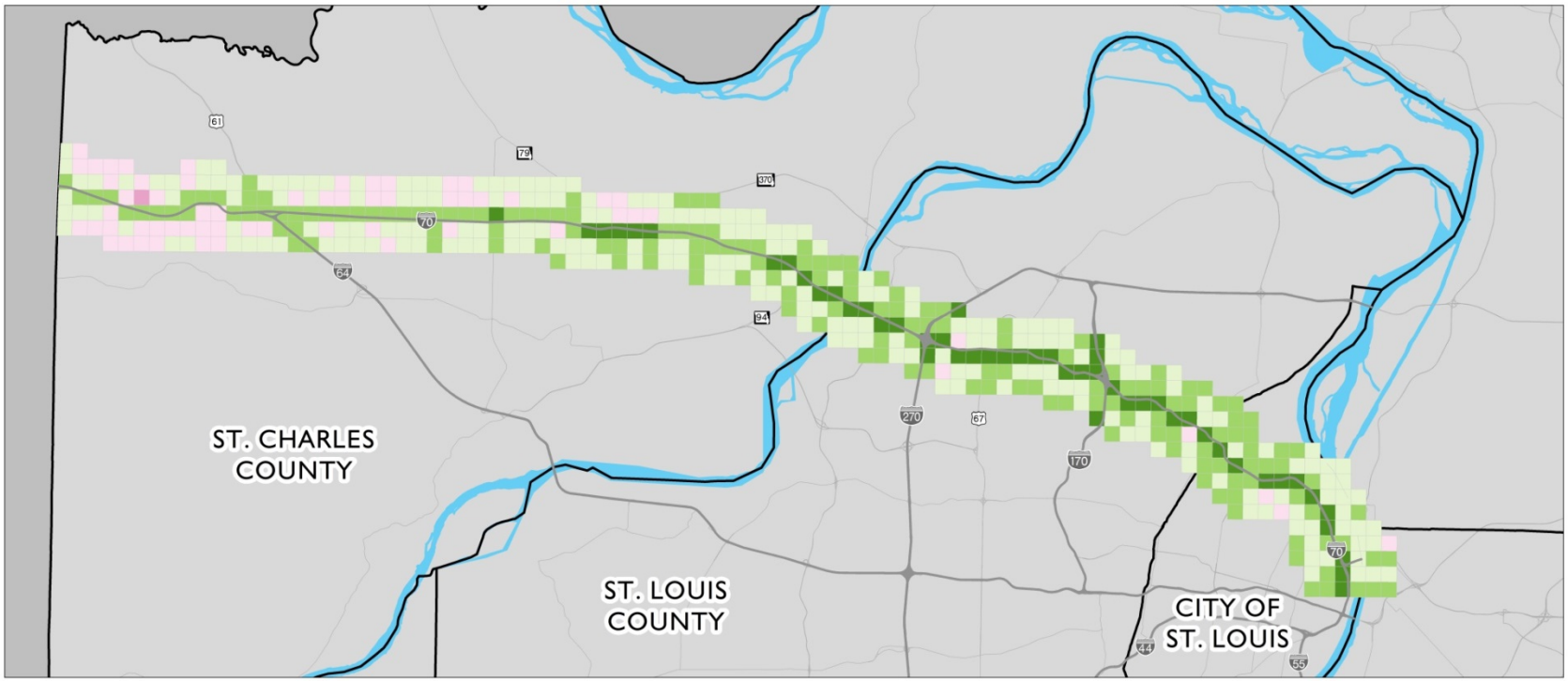
# Results

## Annual On-Road $CO_2$ Emissions along I-70 Corridor

Preliminary Change in Emissions from 2015 to 2045

*St. Louis Metropolitan Area*

December 2015




0 5 10 Miles

Interstate Highway
Major Roads
County Boundary
River

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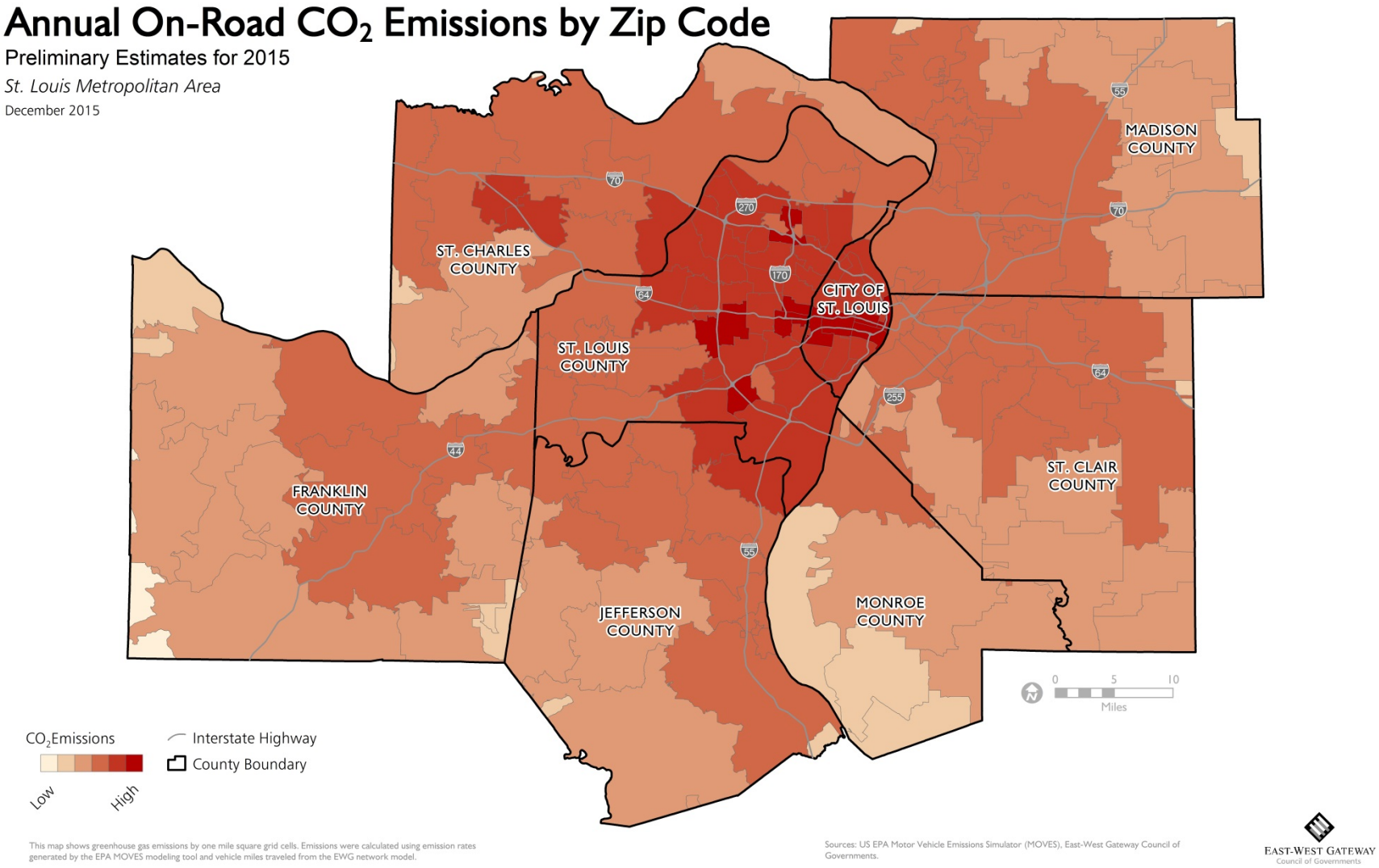
Annual On-Road $CO_2$ Emissions by Zip Code
Preliminary Estimates for 2015
St. Louis Metropolitan Area
December 2015
MADISON COUNTY
ST. CHARLES COUNTY
CITY OF ST. LOUIS
ST. LOUIS COUNTY
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0 5 10
Miles
$CO_2$ Emissions
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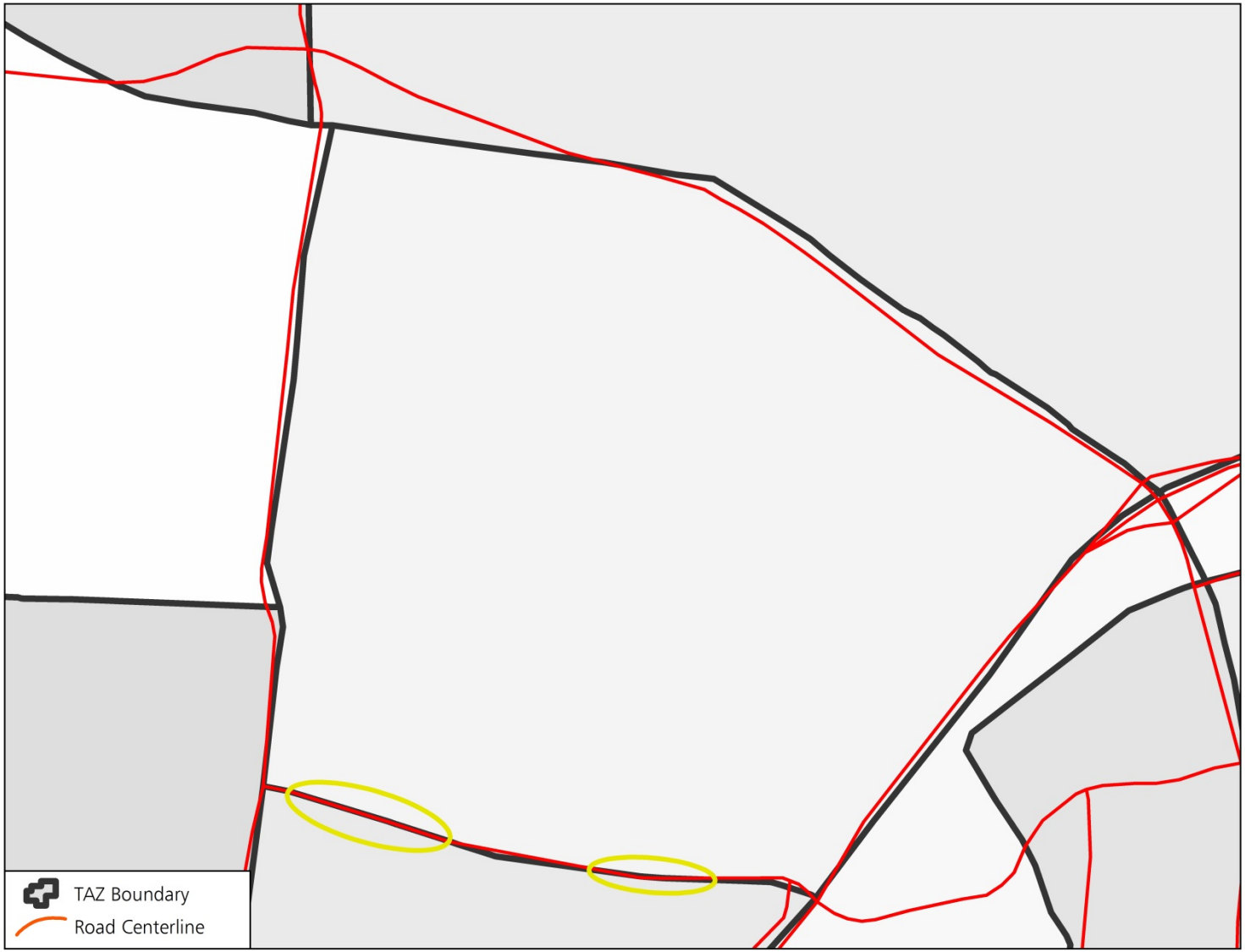
# Lessons Learned

- Source Type:  HPMS vs. TDM
- Scalability:  Subanalysis grids won't necessarily align with a regional grid
- Runtime Speed:  ArcPy vs. SpatiaLite

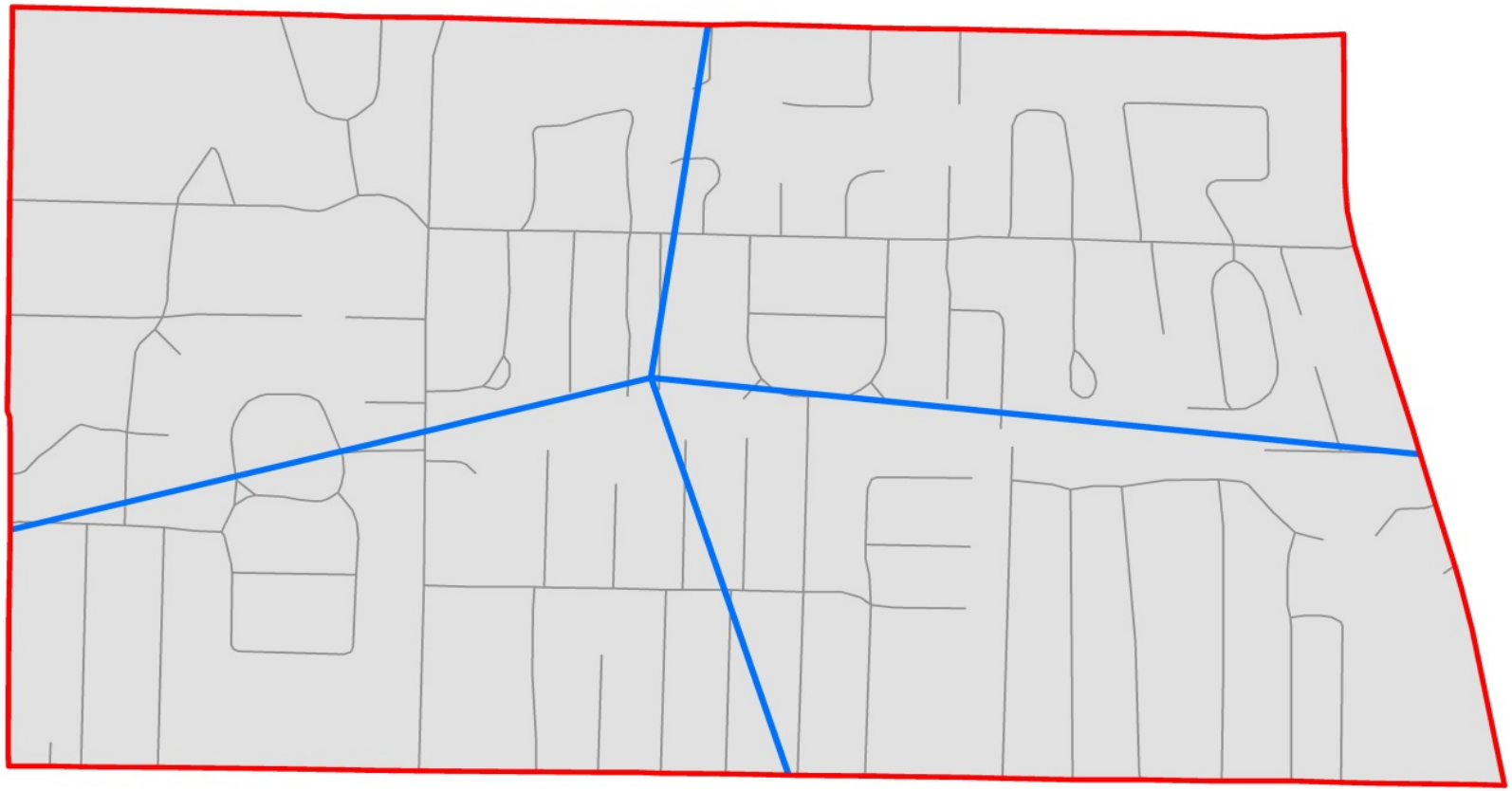
```
SELECT z.Key AS Zone_Key, g.Key AS Grid_Key, AREA(INTERSECTION(g.Geometry, z.Geometry)) AS Area
FROM Zone AS z, Selector AS g
WHERE INTERSECTS(z.Geometry, g.Geometry)
    AND z.rowid IN
        (SELECT rowid FROM SpatialIndex WHERE f_table_name = 'Zone' AND search_frame = g.Geometry);
```

- Granularity
  - Main Road Border Problem
  - Centroid Connector Problems

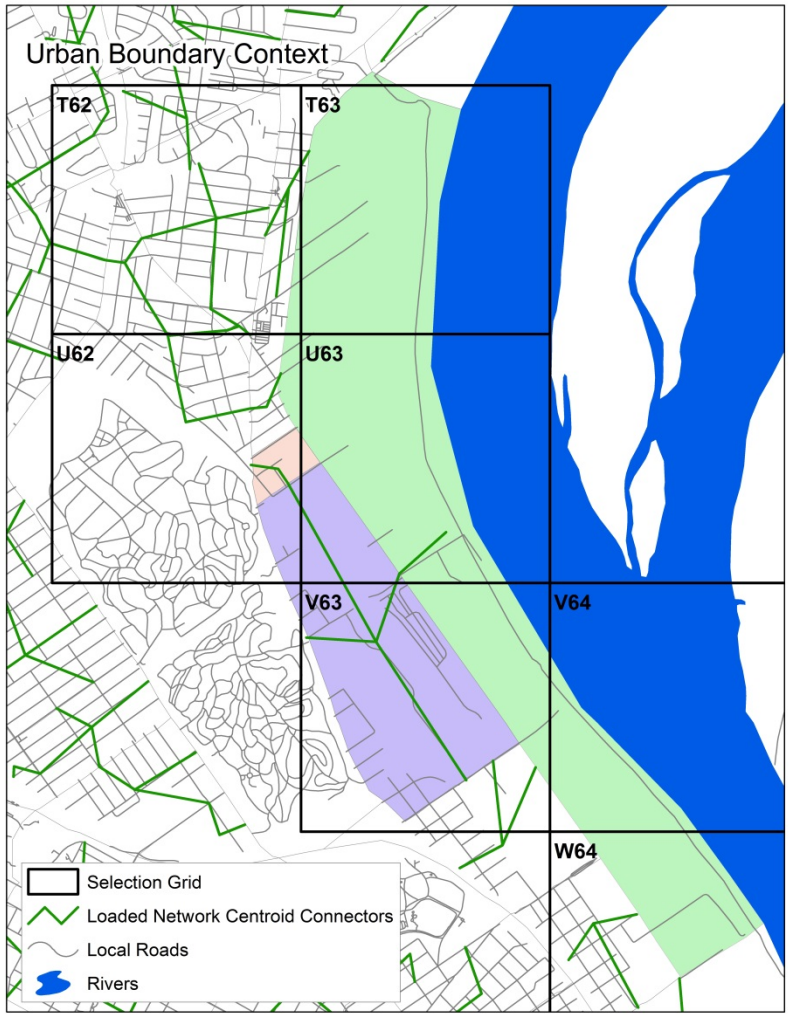
# Main Road Border Problem

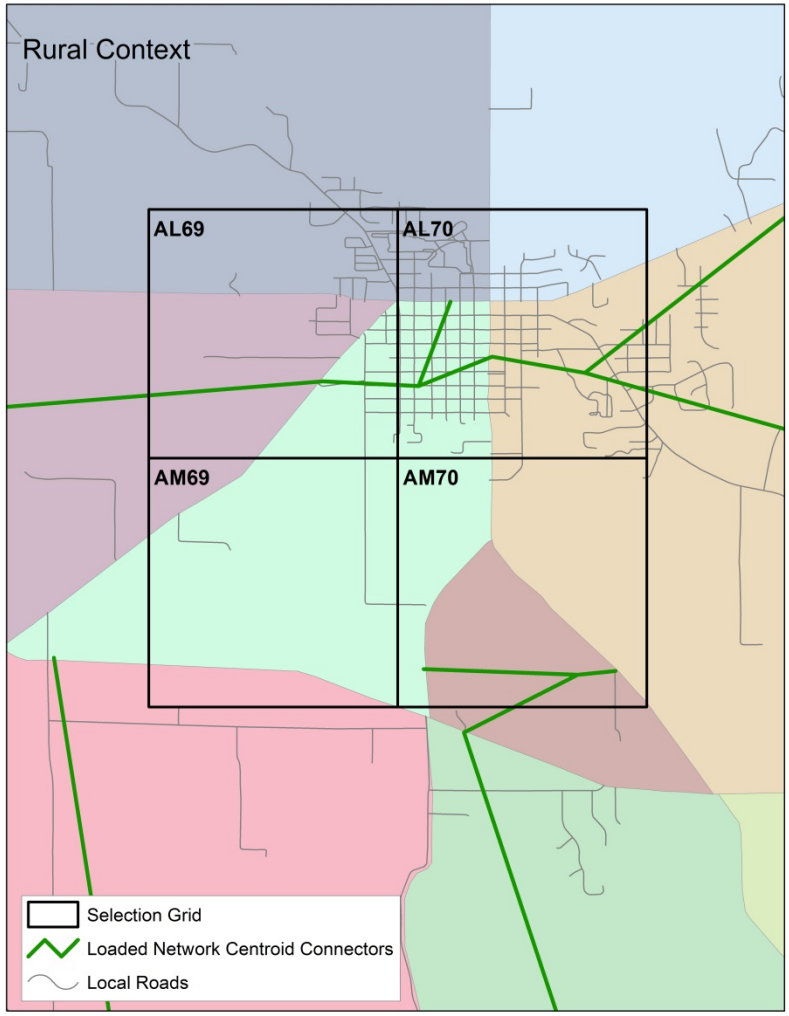


# Centroid Connector Problem

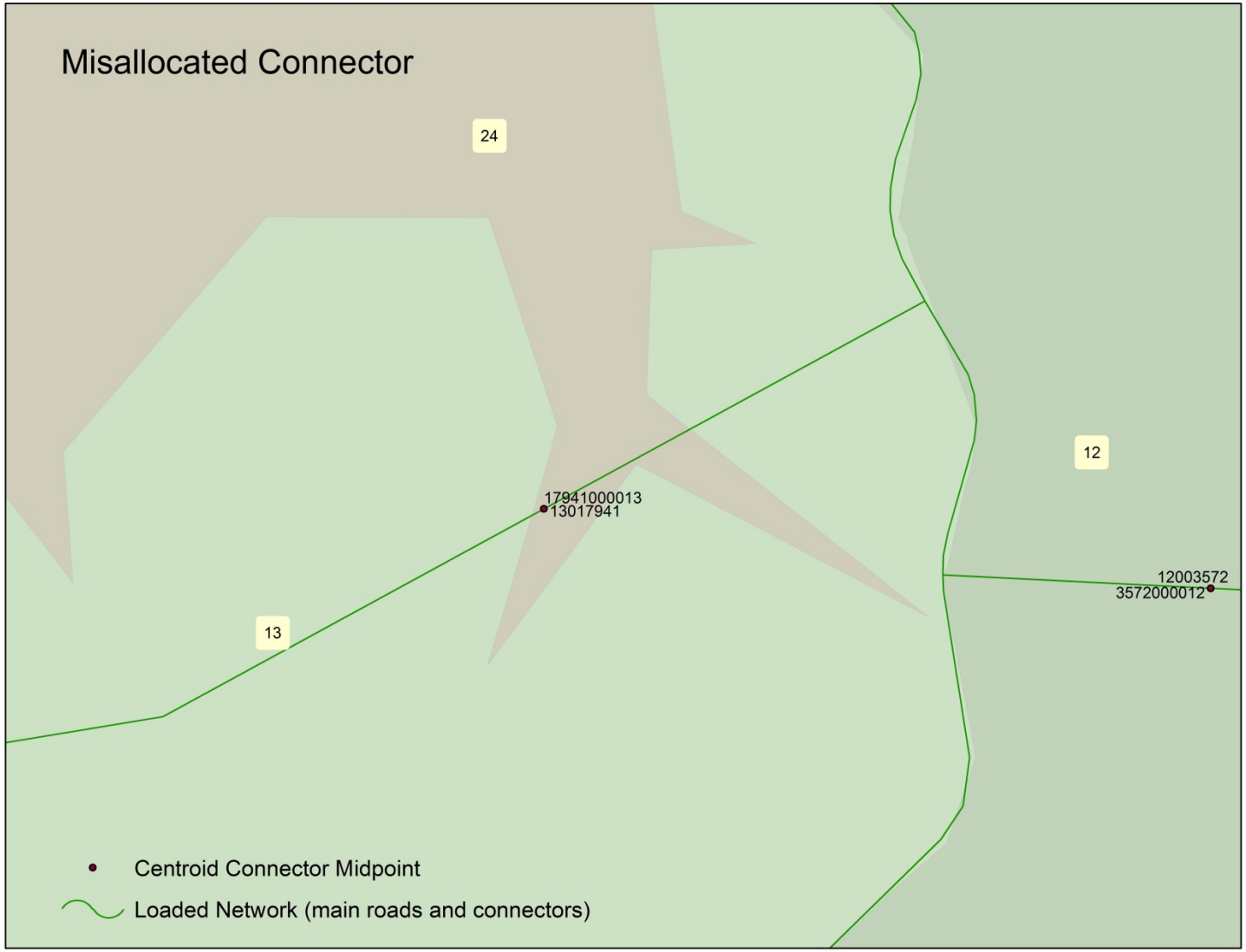


# Centroid Connector: Urban vs Rural



# Centroid Connector: Allocation



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