

1988-2011 Land Use/Land Cover Analysis

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RHODE ISLAND
DIVISION OF
PLANNING



State Overview

- Gross Land Area (with water):
 - 685,000 Acres
 - 1,070 Square Miles
- Net Land Area (without water)
 - 660,000 Acres
 - 1,030 Square Miles

Motivation and Goals

- Since Land Use 2025:
 - 2003/04 and 2011 new orthophotography
- Use new land use data to:
 - Continue to track urbanization
 - Manage impacts on (1) the economy, (2) transportation, (3) urban development

Project Outline

- Look at data and major challenges
- Examine land use trends *before* the USB
- Observe land use trends *after* the USB
- Quantify land use change

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Suburban Sprawl Continues in Rhode Island

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Introduction

In 2006, the Rhode Island Statewide Planning Program developed a framework for the state's future land use goals, documented in "Land Use 2025 - State Land Use Policies and Plan". Land Use 2025 separated the state into two parts by an "Urban Services Boundary" (USB), focusing future development inside the USB to the extent possible.

Land Use 2025 noted that RI was at a tipping point in 2006. Increasing rates of suburban sprawl - defined as units of Medium to Low Density Residential land occurring disproportionately outside of the USB - were difficult to quantify and manage, and threatened the state's economy and natural greenspace.

Recommendations to control sprawl were outlined in the document. This project aims to quantify and map statewide land use changes since Land Use 2025 was published in order to evaluate if the recommendations are having the intended impact of combating suburban sprawl. In addition, the results will guide RI policymakers in allocating resources to efficiently prevent additional sprawl, and stay on track in meeting the state's land use goals by the year 2025.

Research Questions

- Is Rhode Island combating suburban sprawl in accordance to its Land Use 2025 plan?
- Where could RI target policy initiative and allocate resources to most efficiently prevent sprawl?

Data Preparation

Source of data layers

- Two spatial data files characterizing RI Land Use/Land Cover (LULC), the USB file, and the State boundary file, were downloaded from the Rhode Island Geographic Information System (www.rigis.org). The LULC files represented LULC in two distinct years - 2004, and 2011 (dated 12/2007 and 07/2015, accessed 2/20/16). The LULC data were developed for RIGIS by outside vendors by interpretation of orthophotographs and classification to the Anderson Level III coding schema.
- State imagery - provided by ESRI (dated 1/17/15 and 5/20/15, accessed 4/15/16 from <http://www.esri.com/data/basemaps>), the New England states boundary - provided by the US Census (dated 1/28/15, accessed 4/21/16 from <https://www.census.gov/geo>)
- Subsequent data layers were created from these using a variety of geoprocessing tools (see analysis section).

Challenges in data preparation

RIGIS datasets I downloaded extended into neighboring states, so I had to prepare the data to include only land use information for RI. I also had to re-code existing Anderson Level III classes as either "developed" or "undeveloped".

Types of data included

The format of data from RIGIS was in the ESRI shapefile format. The standard coordinate system for all RIGIS data is Rhode Island State Plane Feet, NAD 1983. Created data retained this format (shapefile) and coordinate system.

Types of software used

I used ESRI ArcGIS for Desktop 10.3.1 for this project. ArcMap and ArcToolbox allowed for the preparation and analysis of the data, while ArcCatalog was used to manage created and downloaded data sets. ArcGIS Server 10.3.1 provided access to RIGIS/ESRI map and image services.

Results

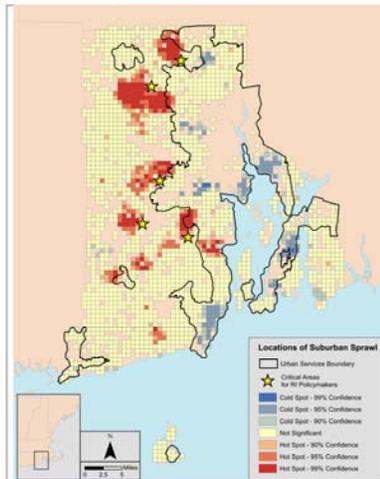


Figure 1: Statistically significant hot spots of suburban sprawl from 2004-2011. Critical areas (hot spots where sprawl accounts for almost all of recent development) for RI policymakers are starred.

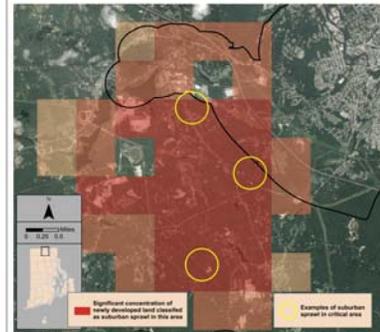
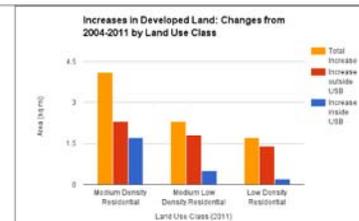
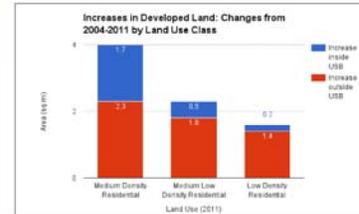


Figure 2: Hot spot of suburban sprawl in North Smithfield, RI. Overlaid with an image base-map from 2003 (source: ESRI), before sprawl occurred.



Graph 1: Compares the increases suburban residential land use classes. The increases of these classes were a majority of the recent increases in development.



Graph 2: The ratio, between the USB, at which suburban sprawl occurred. Medium-Low and Low Density Residential areas increased the most in unwanted areas (outside the USB).

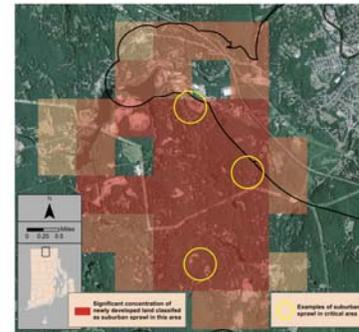


Figure 3: Hot spot of suburban sprawl in North Smithfield, RI. Overlaid with an up-to-date image base map (source: ESRI), after sprawl occurred.

Data Analysis

Data analysis types

- **Intersect** - this geoprocessing tool allowed for the identification of land use polygons that changed from undeveloped to developed between the two time periods in question.
- **Feature to Point** - the area of change for any given polygon was quite varied across the state. Some "change polygons" could be quite small. While the cumulative quantity of change could be represented in table/graph form, a method was needed to illustrate clusters of change. The Feature to Point geoprocessing tool provided an output shapefile of points for input to the Optimized Hot Spot Analysis geoprocessing tool.
- **Optimized Hot Spot Analysis** - this geoprocessing tool allowed me to find statistically significant clusters of Medium, Medium-Low, and Low Density Residential land.
- **Select and Summarize** - in the shapefile created with the Intersect tool, I used the Selection tool to select features completely within, and then completely outside, the USB. For each selection, I used the Summarize function to find the total amount of development inside and outside of the USB.

Challenges in data analysis

A major challenge I encountered during analysis were verifying the results of the Optimized Hot Spot Analysis tool. I compared information from the Hot Spot Analysis tool and to my understanding of Rhode Island geography to verify that my process and output made conceptual sense. Another challenge I faced was finding geographies where suburban sprawl was the most significant type of development (rather than, for instance, commercial development). I solved this problem by comparing my output with a hot spot map of every instance of development. I then noted locations, outside of the USB, where instances of suburban sprawl accounted for a majority of statistically significant clusters of development.

Real-world application

According to Land Use 2025, unwanted suburban sprawl poses a serious threat to the state's sustainable development efforts and its economic well-being. This project identifies the edges of Glocester, North Smithfield, and Coventry, as well as the towns of East and West Greenwich as critical areas RI policymakers to provide state resources to and prevent more suburban sprawl.

Future analyses

Additional analysis could include regression analyses using census and RIGIS data, and Geographically Weighted Regressions of predictive factors. This would influence detailed, site-specific resource allocation that builds on this research.

Conclusion

According to Land Use 2025, suburban sprawl is a serious threat to the RI economy and land use goals. Since Land Use 2025 was published, suburban sprawl has accounted for an additional 5.5 square miles of developed land, with most of the development occurring outside and near the USB. In particular, the edges of Glocester, North Smithfield, and Coventry, as well as the towns of East and West Greenwich, experienced the largest and most significant increases of suburban sprawl. The project suggests that RI policymakers should distribute their resources to these municipalities to curb suburban sprawl in the state.

Data Types

- Available for Land Use 2025
 - 1988 and 1995
- Released since Land Use 2025
 - 2003/04 and 2011
- Based off of new orthophotography with 0.5 acre resolution

Close-up of 1995 to 2003/04 Development



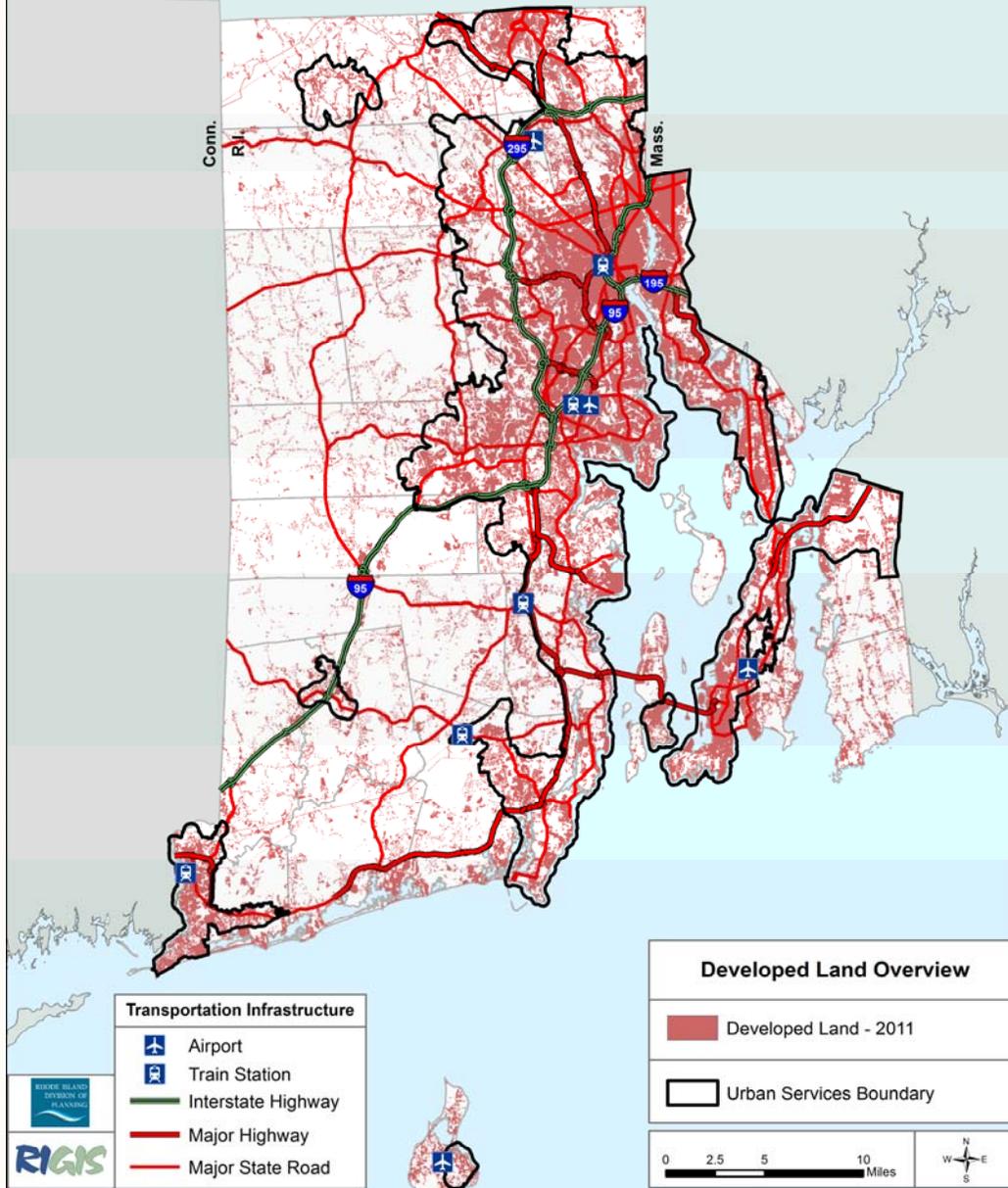
Close-up of 1995 to 2003/04 Development



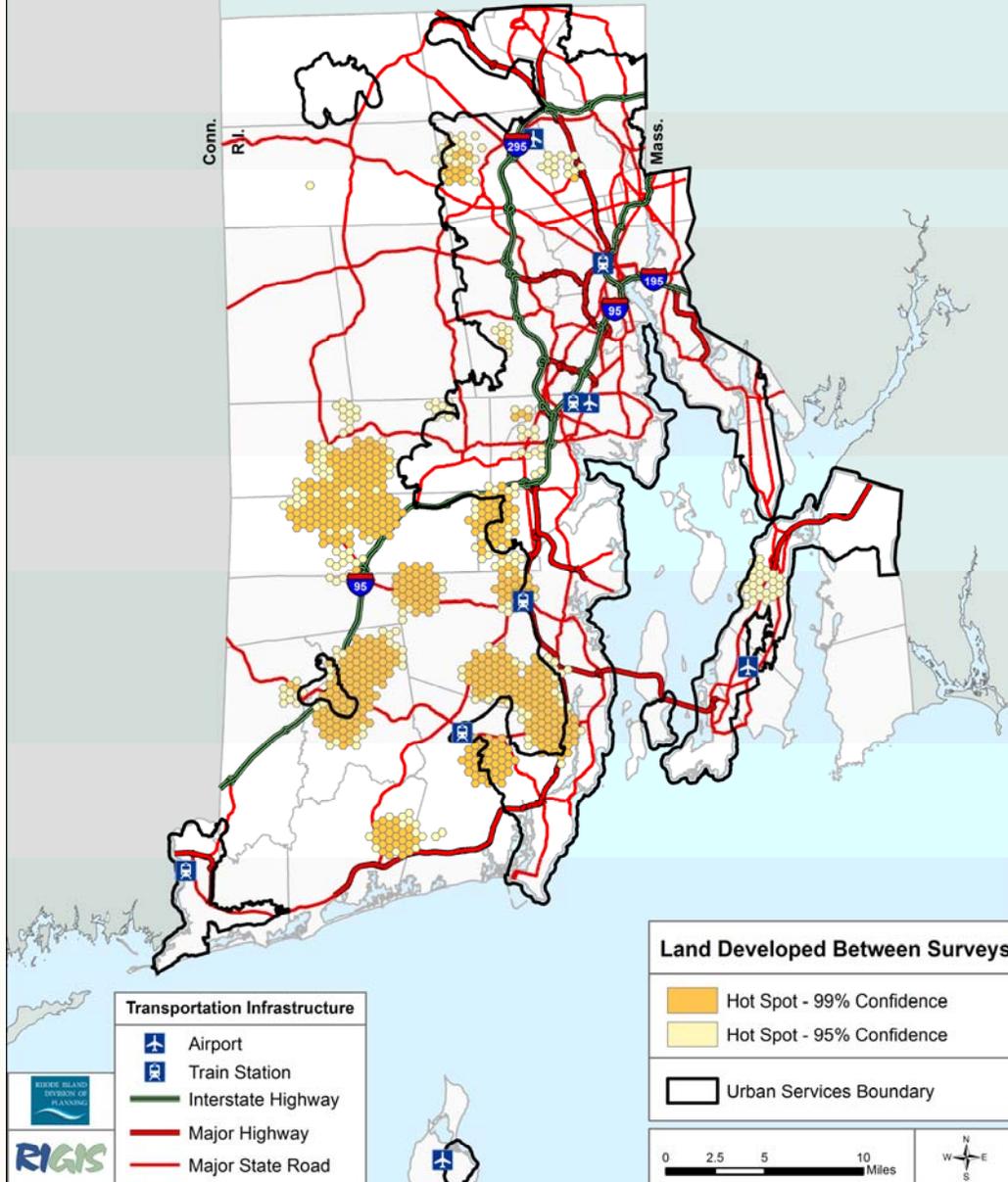
Consequences of Methods

- Methodology best reflects changes in Medium to Low Density Residential Development
- Emphasizes “sprawling” nature of development
- Allows us to compare Medium to Low Density Residential Development across surveys

Extent of Developed Land in 2011



Development from 1988 to 1995



Transportation Infrastructure

- Airport
- Train Station
- Interstate Highway
- Major Highway
- Major State Road

Land Developed Between Surveys

- Hot Spot - 99% Confidence
- Hot Spot - 95% Confidence
- Urban Services Boundary

0 2.5 5 10 Miles

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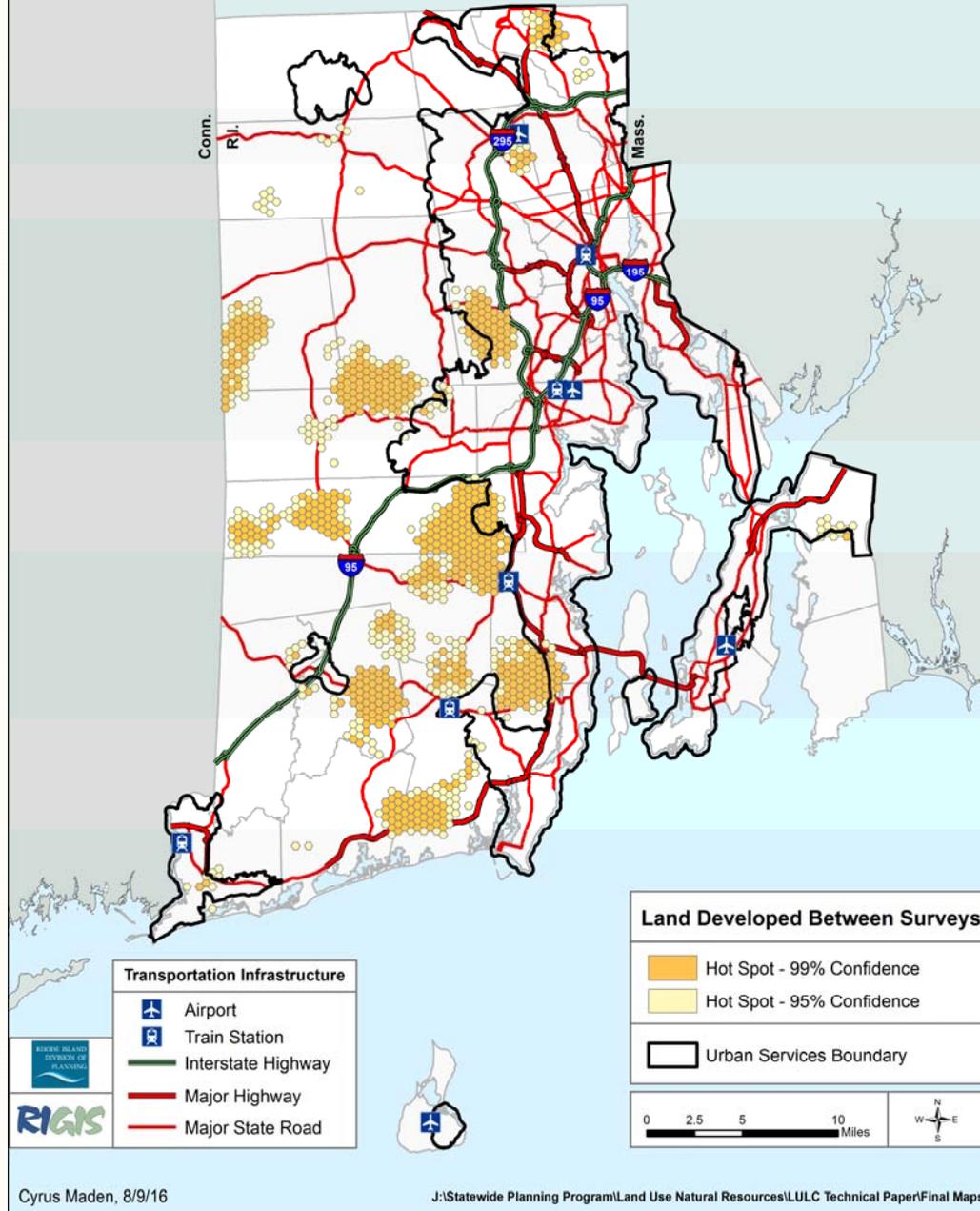
Definitions and Interpretation

- Land use change is new development
- Hot spots represent where development is concentrated
- Hot spots look at where development occurs most frequently between surveys

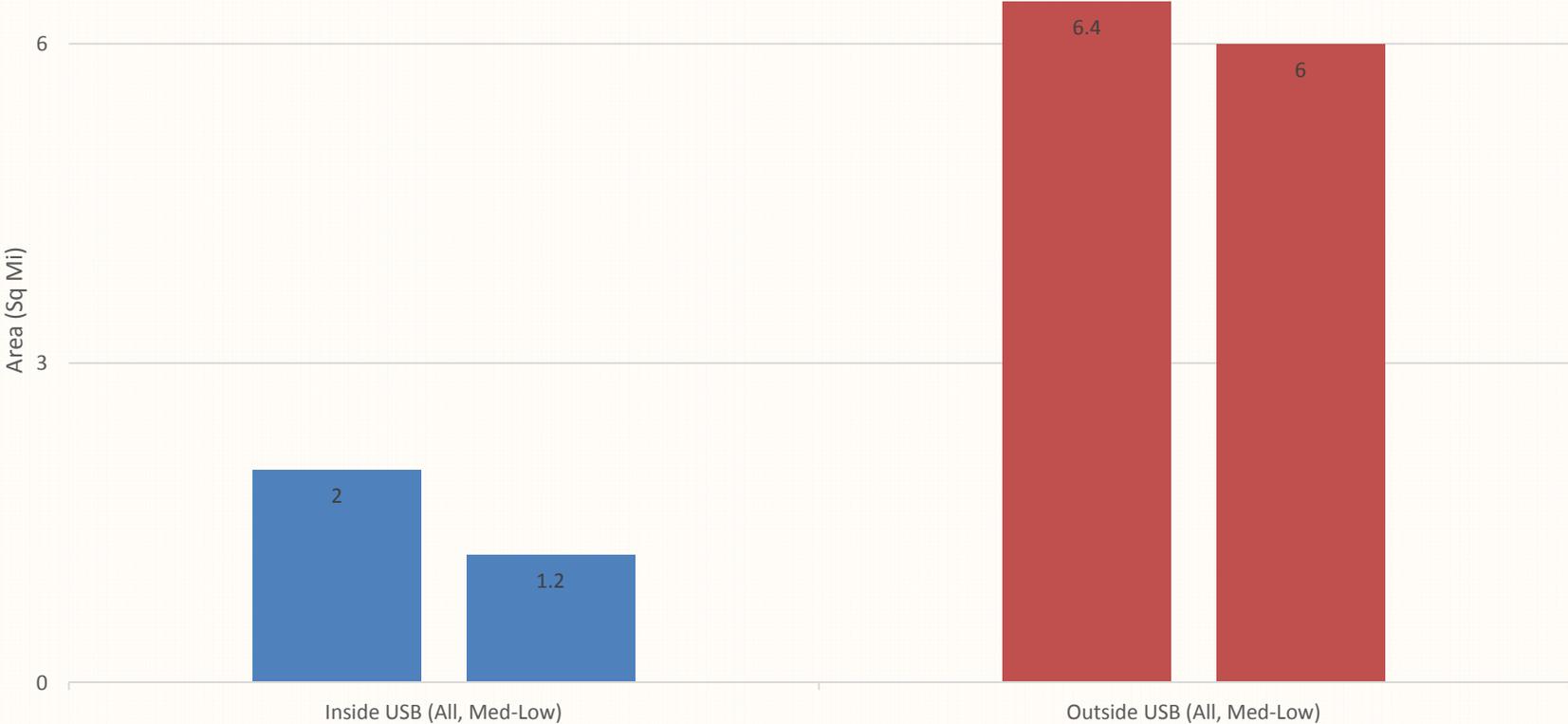
Before the USB: Development from 1995 to 2003/04

- Utilize the conservative land use definition
- Is development clustered or dispersed?
- Where is clustering occurring?
- Global Moran's I and Hot Spot Analysis

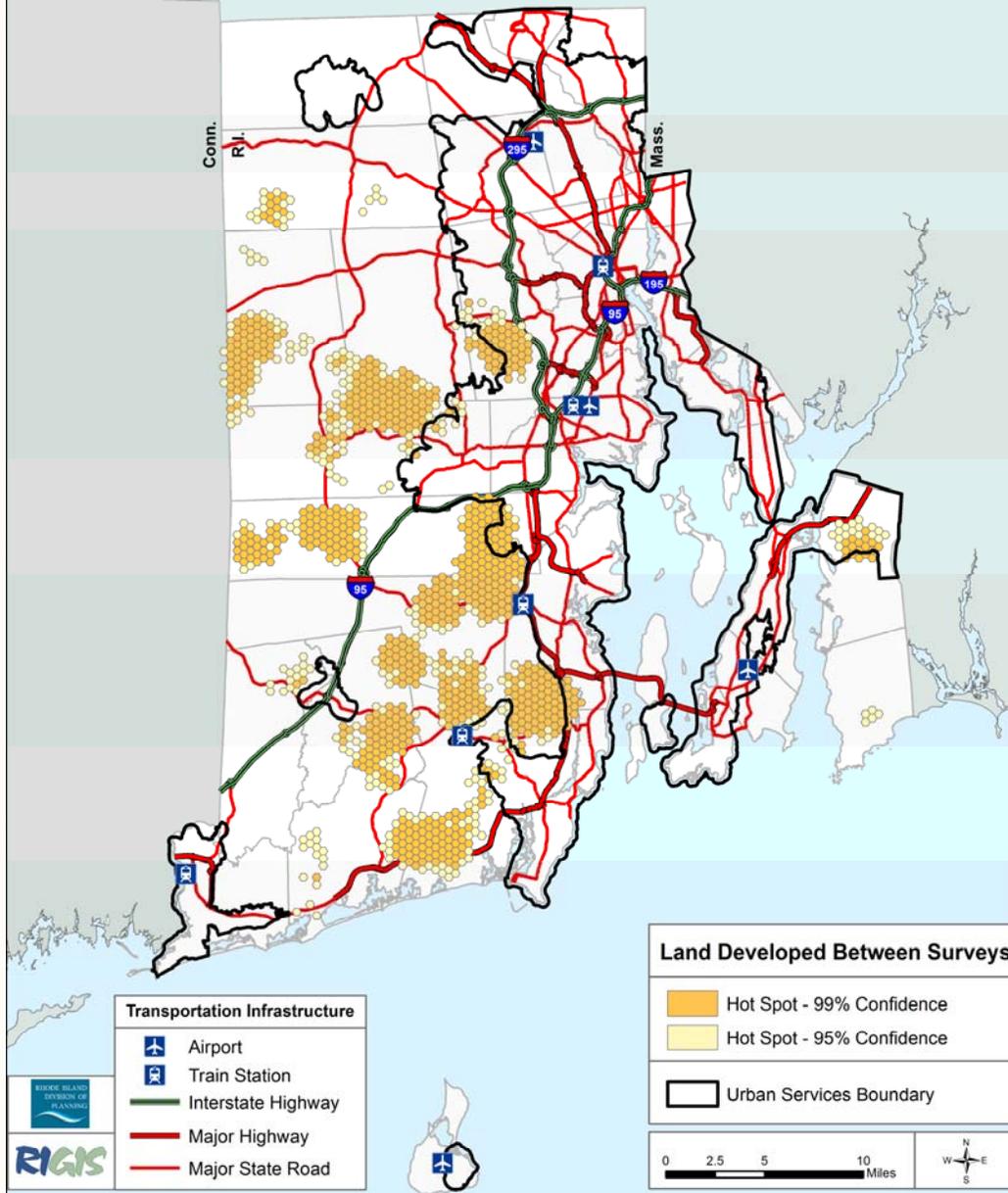
Development from 1995 to 2003/04



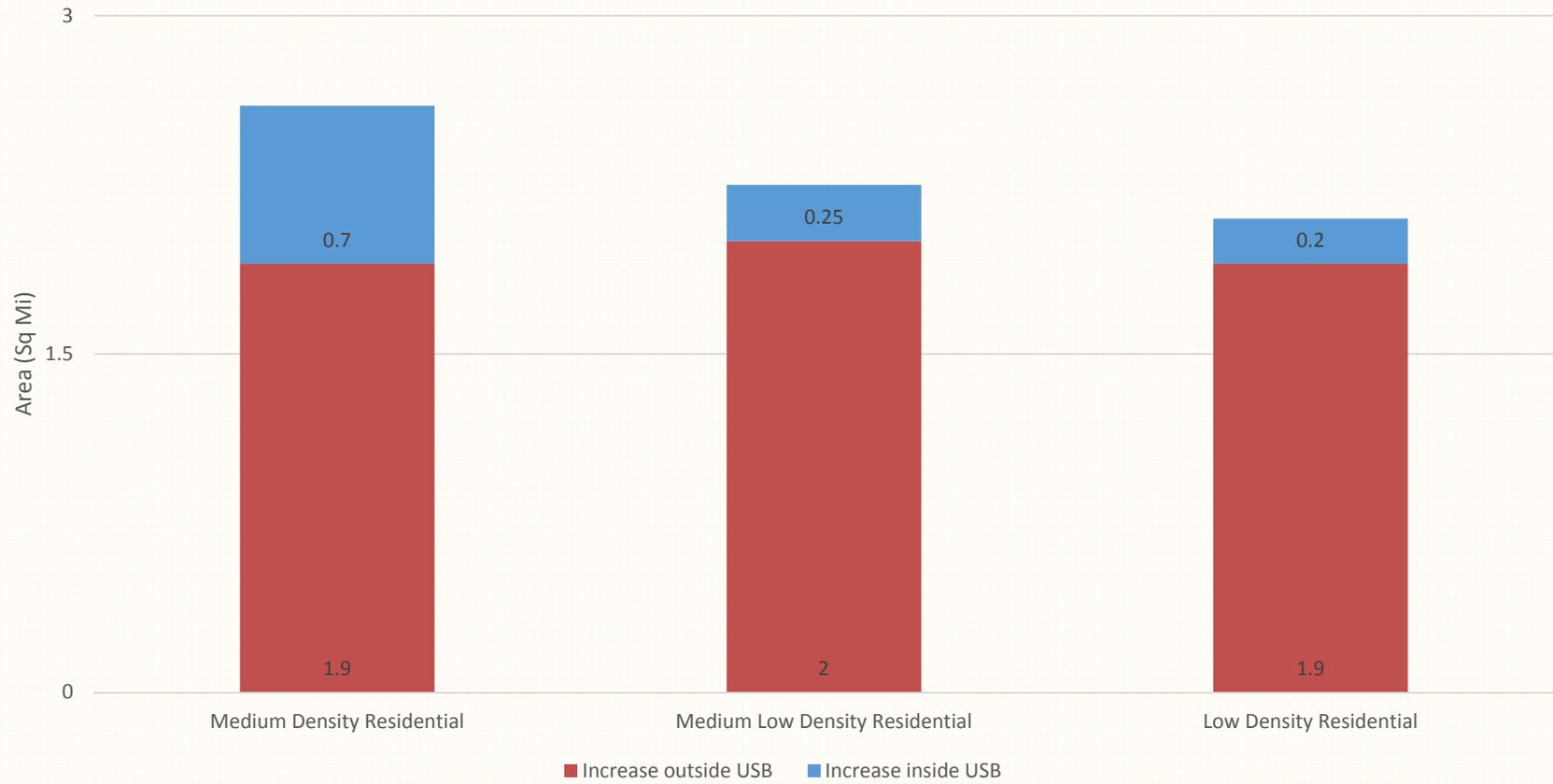
1995 to 2003/04 Development: In/Out of USB



Medium to Low Density Residential Development from 1995 to 2003/04



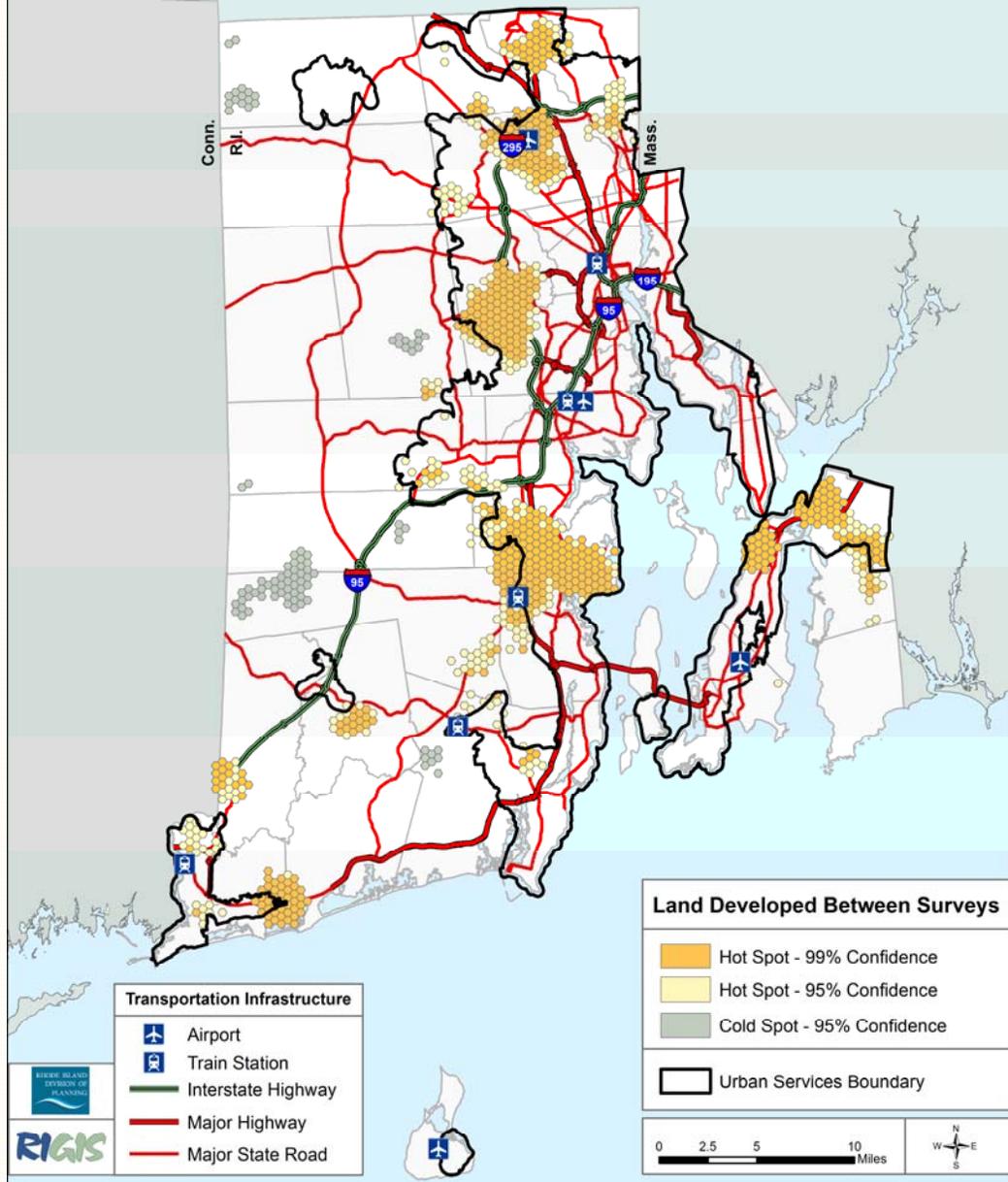
1995 to 2003/04 Development: Medium to Low Density Residential



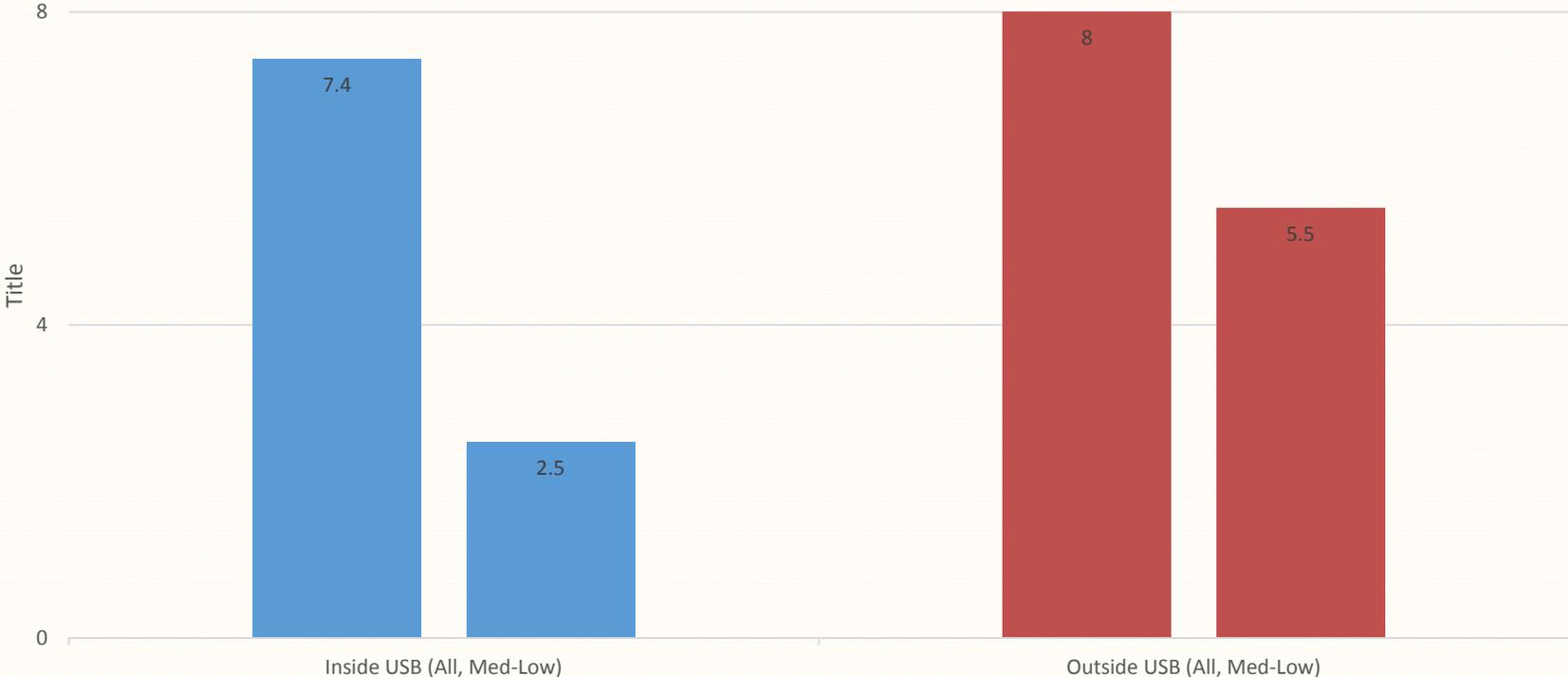
After the USB: Development from 2003/04 to 2011

- Use a more precise definition of development
- Compare conservative vs precise
- Isolate Medium to Low Density residential development
- Compare residential development across surveys

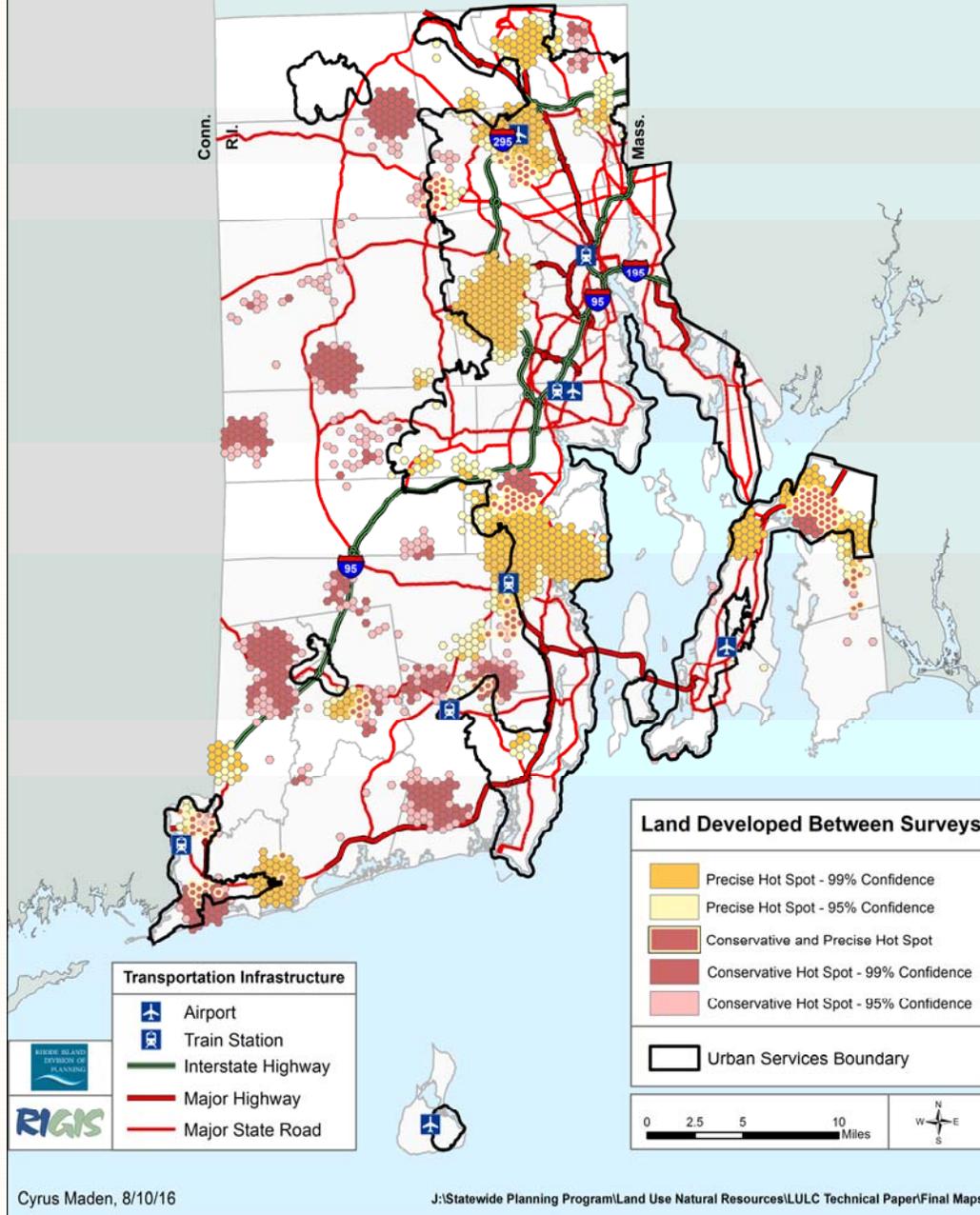
Development from 2003/04 to 2011



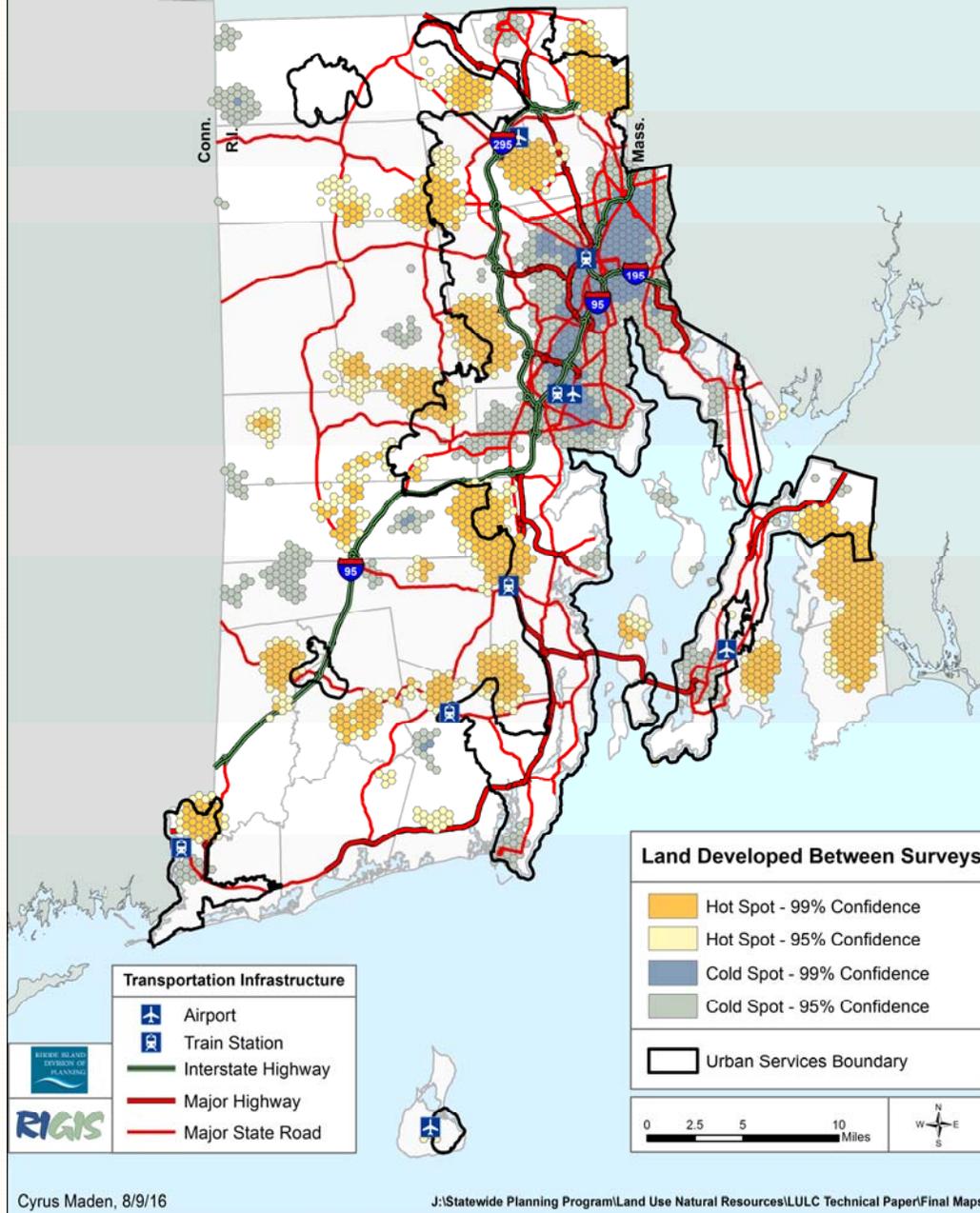
2003/04 to 2011 Development: In/Out of USB



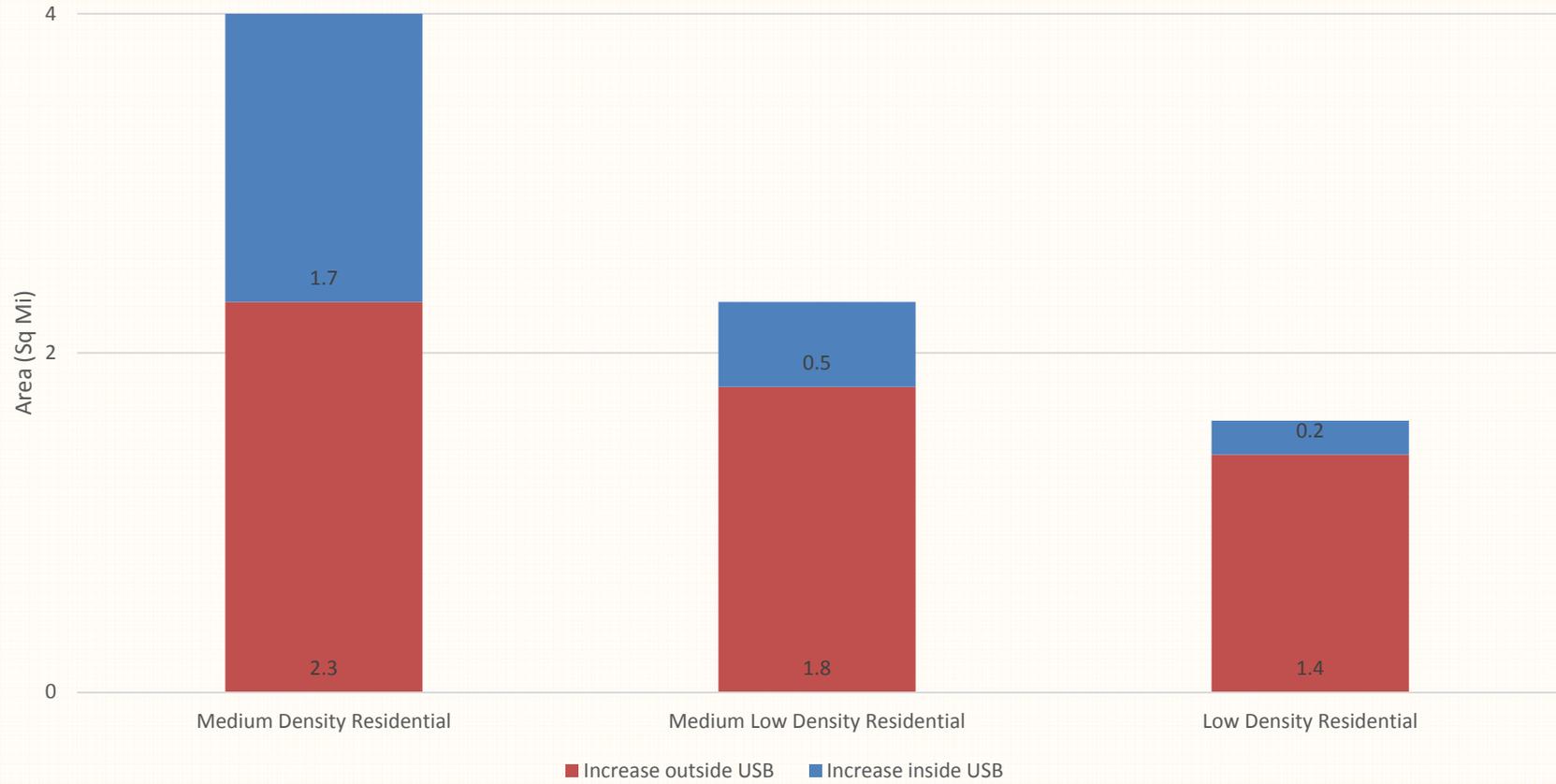
Development from 2003/04 to 2011 Methodology Comparison



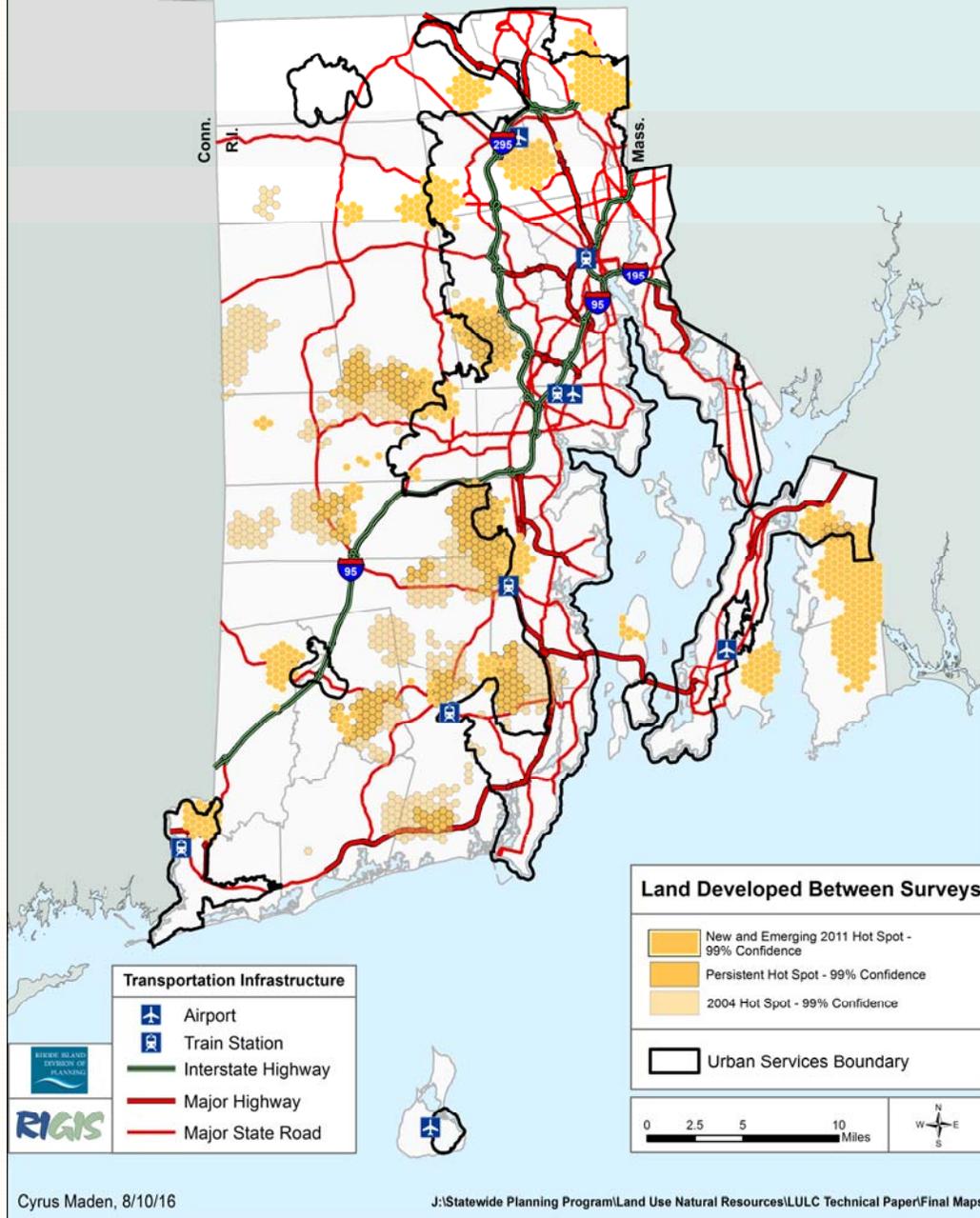
Medium to Low Density Residential Development from 2003/04 to 2011



2003/04 to 2011 Development: Medium to Low Density Residential



Medium to Low Density Residential Development from 1995 to 2011



Overview of Thesis

- Hot spot analysis
 - Where new development occurred
- Excel summaries
 - How much new development occurred
- Where development occurred after USB

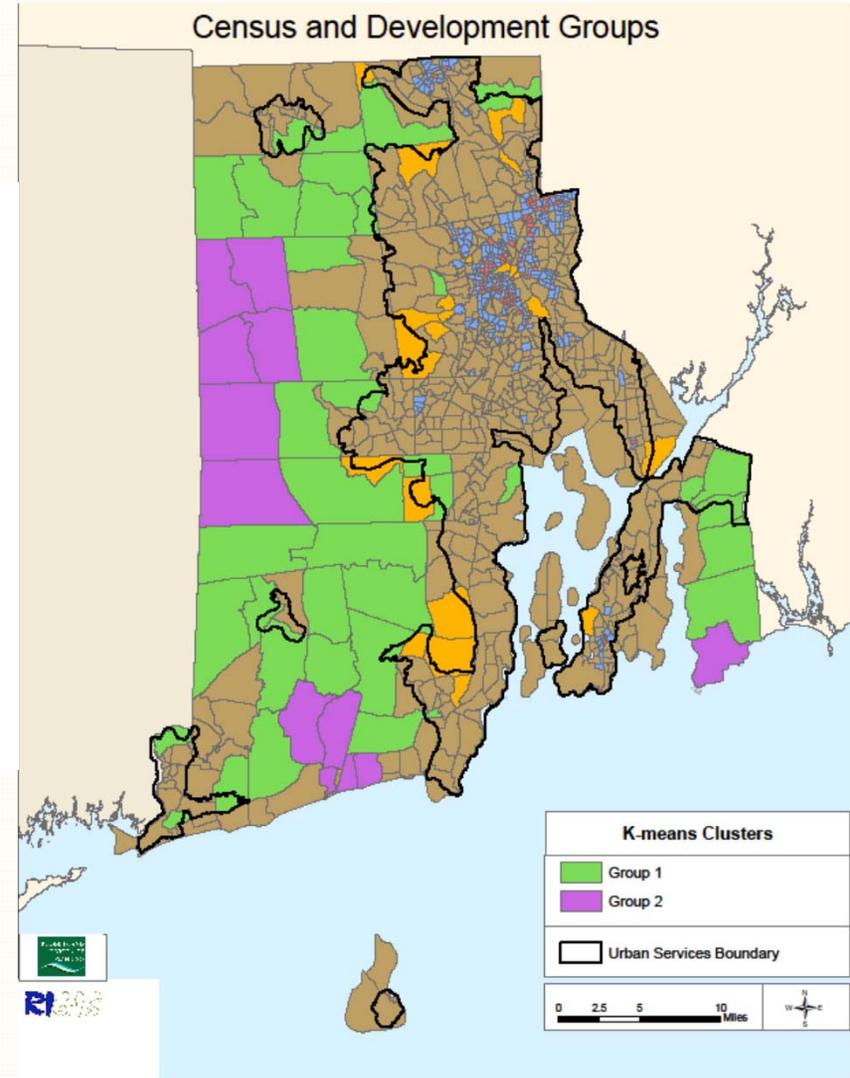
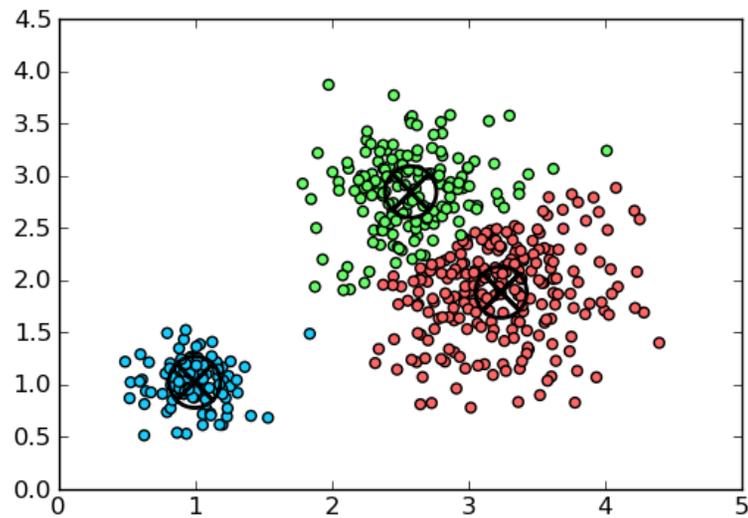
Questions Left

- What factors are associated with development after the USB?
- How strong is the relationship between development and distance to the USB?
- How else can we corroborate and visualize clustering?

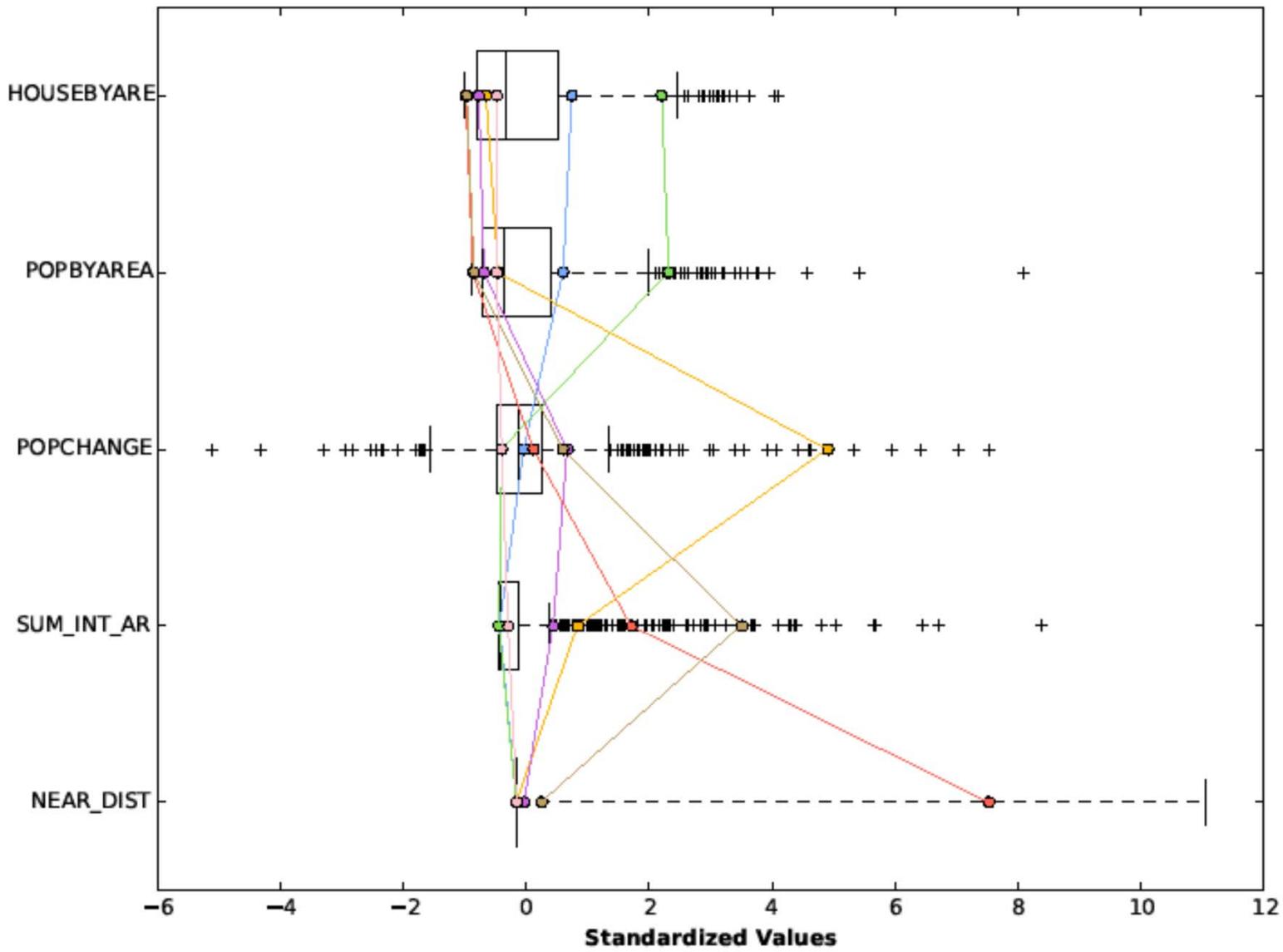
Grouping Analysis Overview

- We expect high develop to occur
 - Close to the USB
 - In areas with low population density
 - In areas with low housing density
 - In areas with medium population change
- We expect to see quantitative support of visual trends in the hot spots

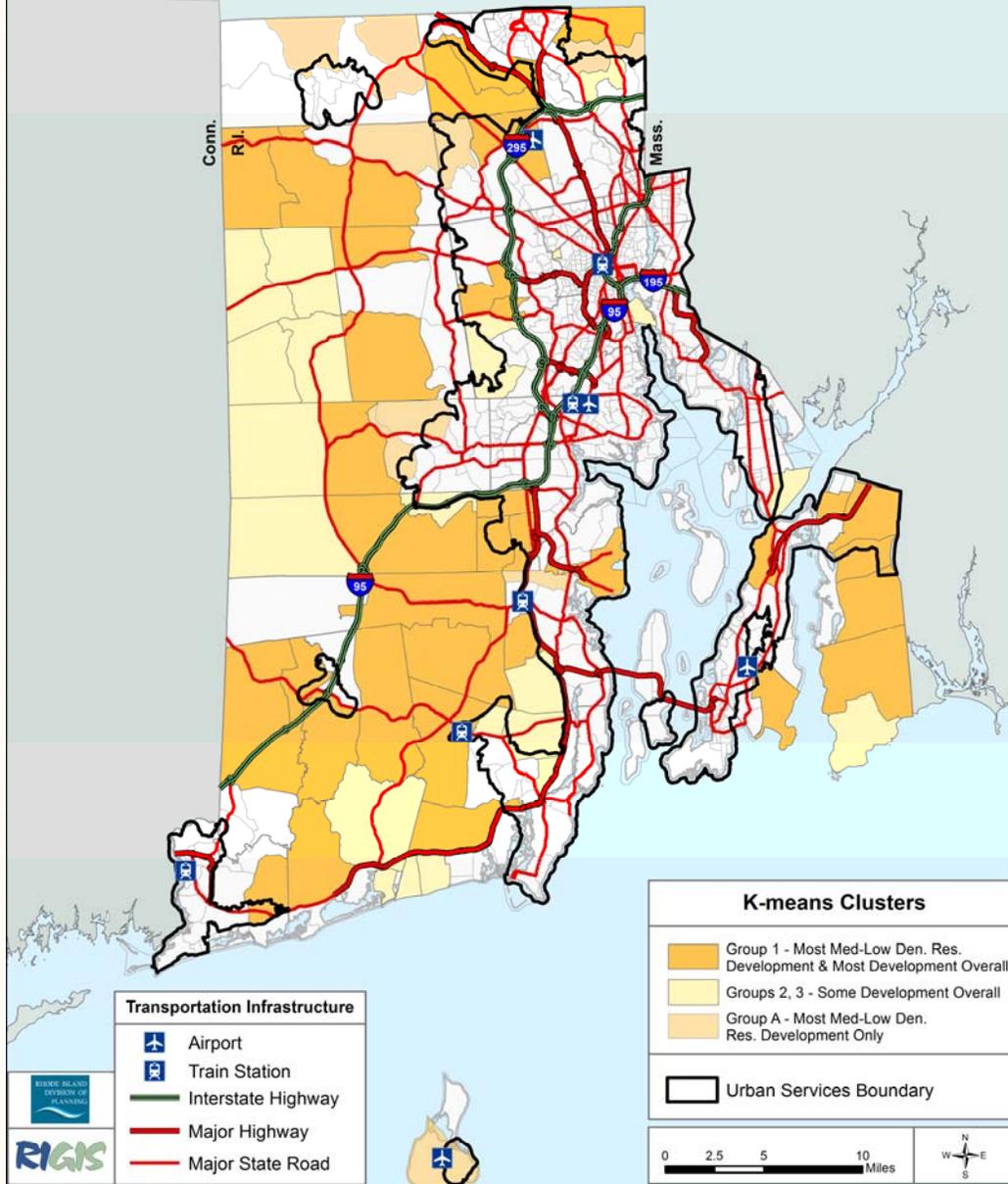
Grouping Analysis Methods



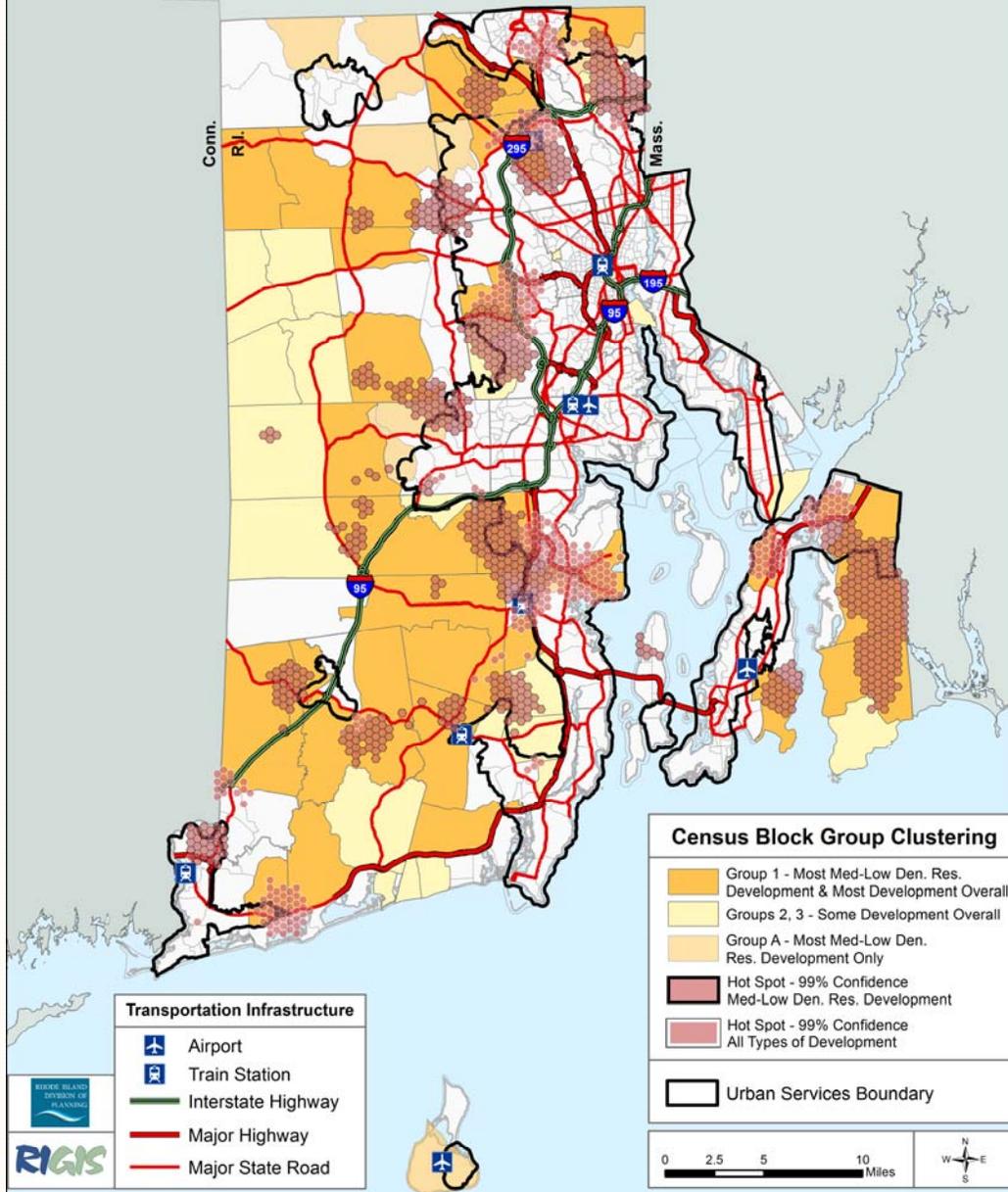
Parallel Box Plot



2010 Census & 2003/04 to 2011 Development Groups



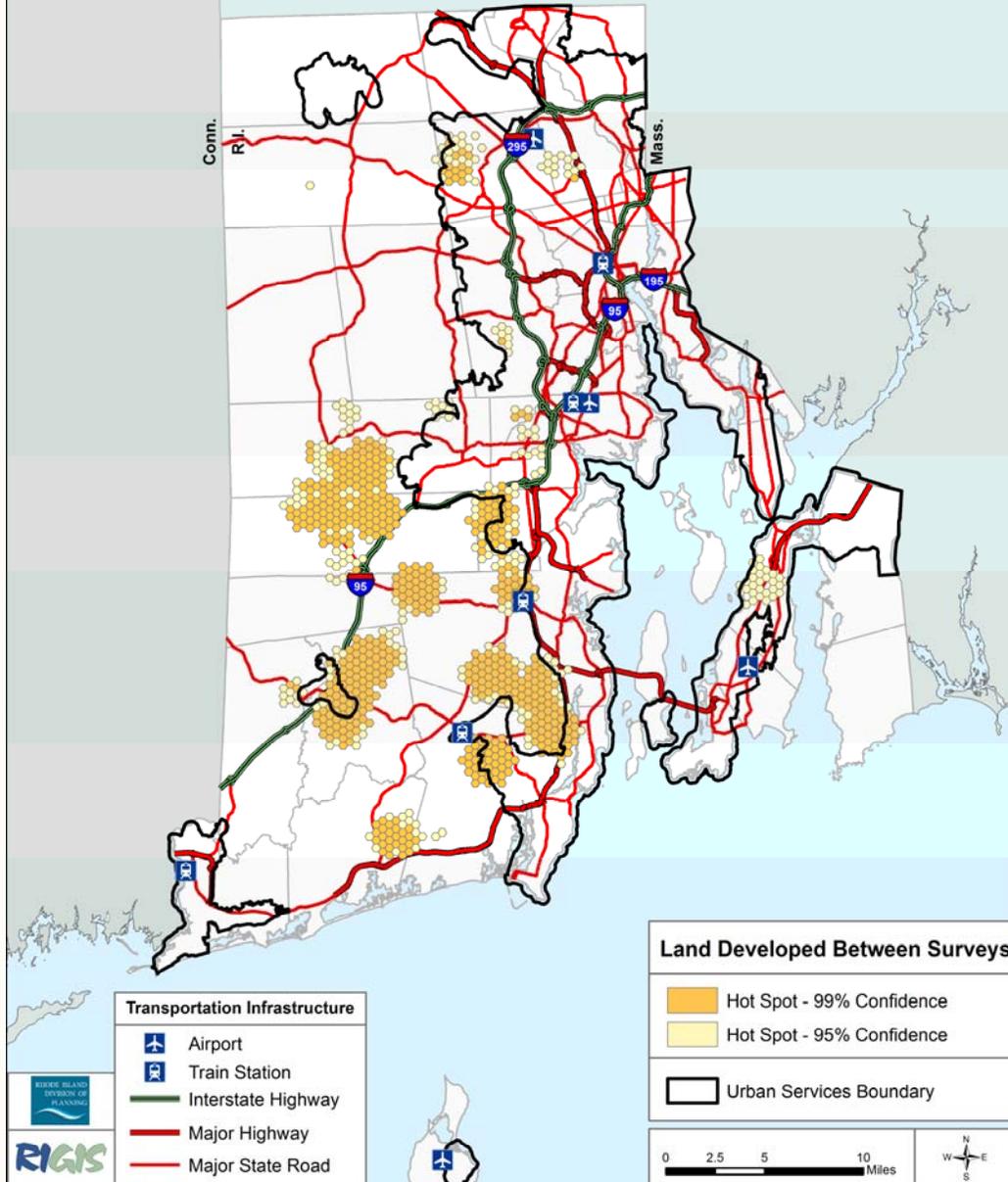
2010 Census & 2003/04 to 2011 Development Groups



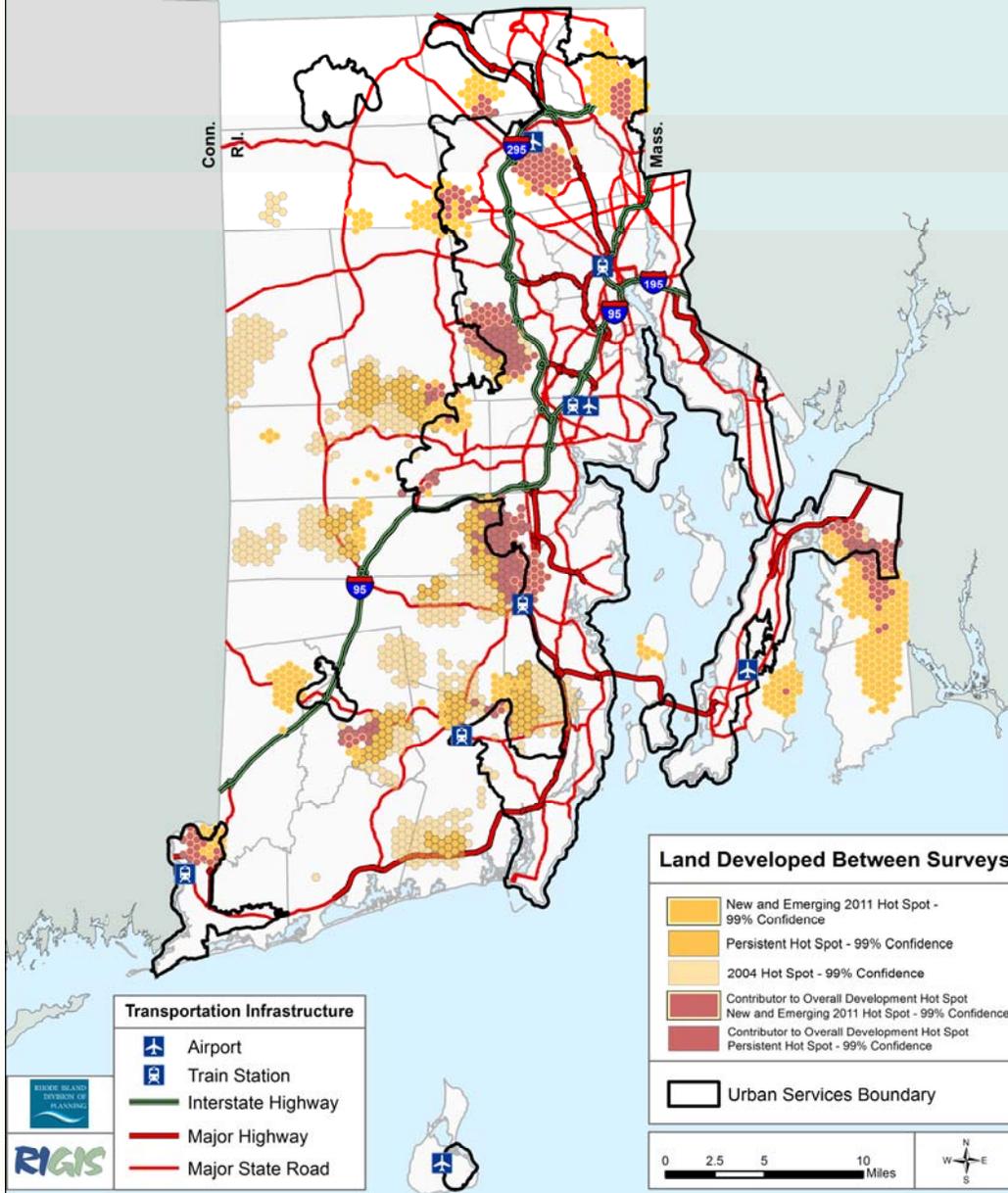
We're Still Sprawling

- Since 1995, we've experienced at least 21 sq. miles (2% of state area) of development
- We've experienced about 15 square miles of sprawl
- Most growth is by the USB in a "development frontier"

Development from 1988 to 1995



Medium to Low Density Residential Development from 1995 to 2011



Transportation Infrastructure

- Airport
- Train Station
- Interstate Highway
- Major Highway
- Major State Road

Land Developed Between Surveys

- New and Emerging 2011 Hot Spot - 99% Confidence
- Persistent Hot Spot - 99% Confidence
- 2004 Hot Spot - 99% Confidence
- Contributor to Overall Development Hot Spot New and Emerging 2011 Hot Spot - 99% Confidence
- Contributor to Overall Development Hot Spot Persistent Hot Spot - 99% Confidence
- Urban Services Boundary

0 2.5 5 10 Miles

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Next Steps

- Summarize Results
- Technical Paper
- Results on Division of Planning Website
- Support analysis with further research

An aerial photograph of a forested landscape. The image shows a dense green forest with a prominent, irregularly shaped clearing or road network in the center. The text "Questions?" is overlaid in white, bold font in the middle of the image.

Questions?