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Characterization of Construction Materials Supply and Demand in an Urban Market

a proposal for a capstone project in partial fulfillment of the requirements for
the degree of Master of Geographic Information Systems at The Pennsylvania
State University

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GEOG 596A
December 17, 2014

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Objectives

✓ **Develop a decision-support tool for evaluation of a new business venture:**

- 1) Optimize the number and location of sales outlets
- 2) Estimate sales volumes at proposed outlets
- 3) Estimate network business volumes
- 4) Estimate cannibalization across the supplier's network
- 5) Assess impacts of competitors
- 6) Assess impacts on competitors
- 7) Estimate resulting market shares

✓ **Generalize this tool for application in other markets and business lines**

✓ **Adapt a GIS-based site selection model to an alternative demand model**

- 1) Demand is discrete rather than continuous
- 2) Demand is based on events rather than demographics

Outline of presentation

I. Construction materials in an urban market defined

- A. Recycled aggregates
- B. Business strategies for recycled aggregate production
- C. A need for a more customized GIS-based demand model

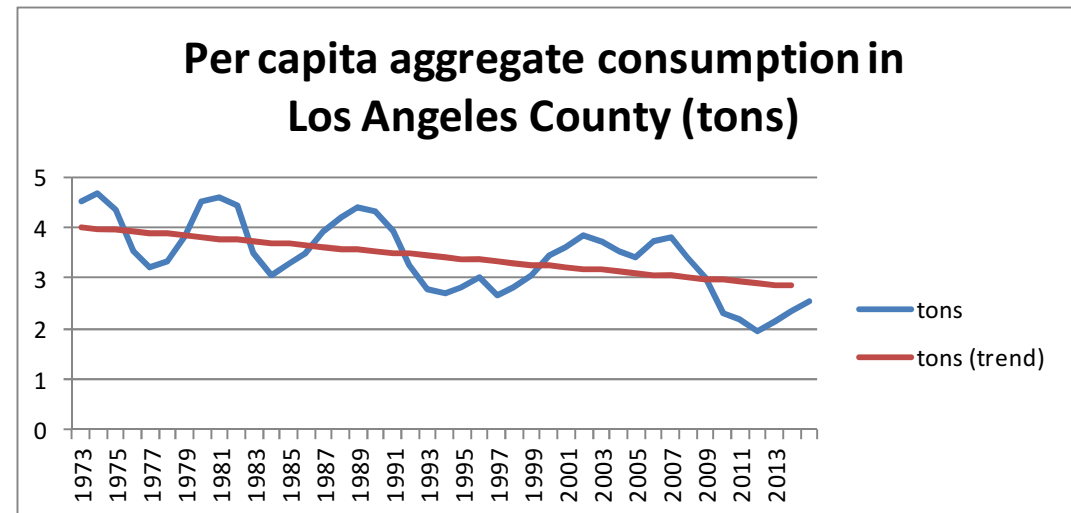
II. Site selection modeling

- A. Analog models
- B. Regression models
- C. Location-allocation models
- D. Gravity models
- E. Spatial interaction models

III. Application of a spatial interaction model to Los Angeles, California

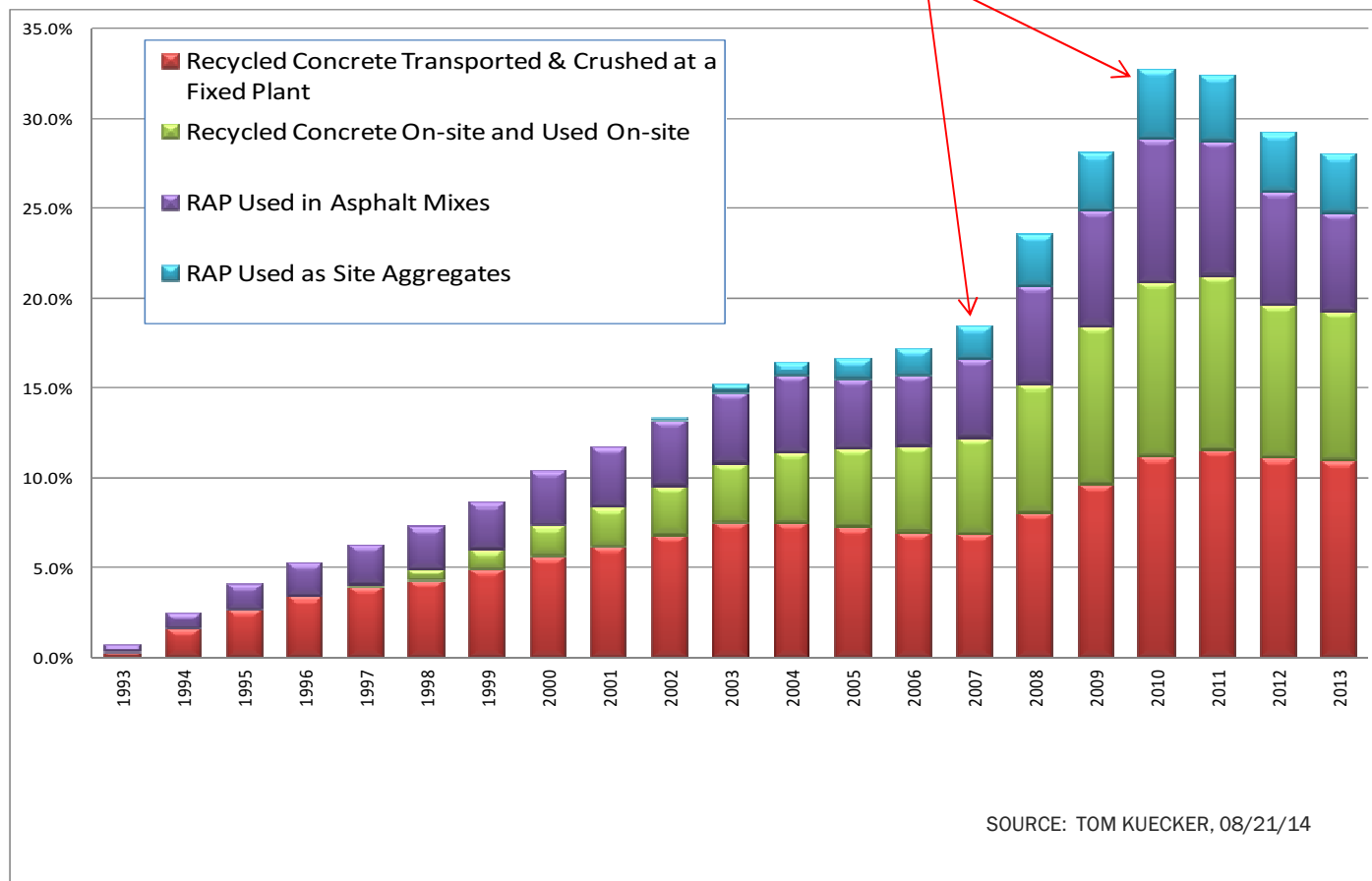
- A. Candidate site selection
- B. GIS-based demand model customization
 - 1. “Advanced Huff Model” (ArcGIS Business Analyst)
 - 2. Flater model
 - 3. Drezner optimization model

Construction materials in an urban market

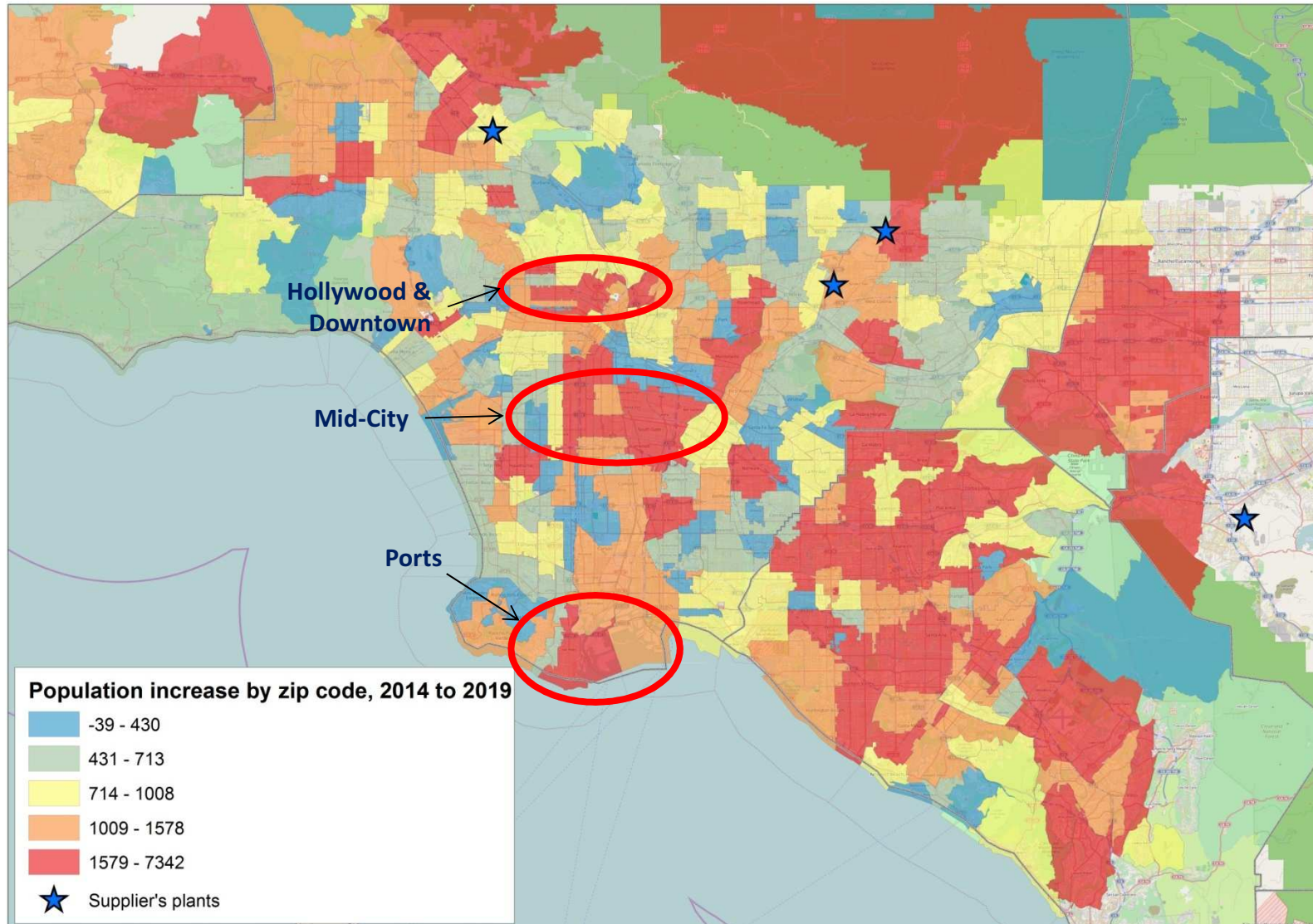


Recycled aggregates: a case study from Chicago

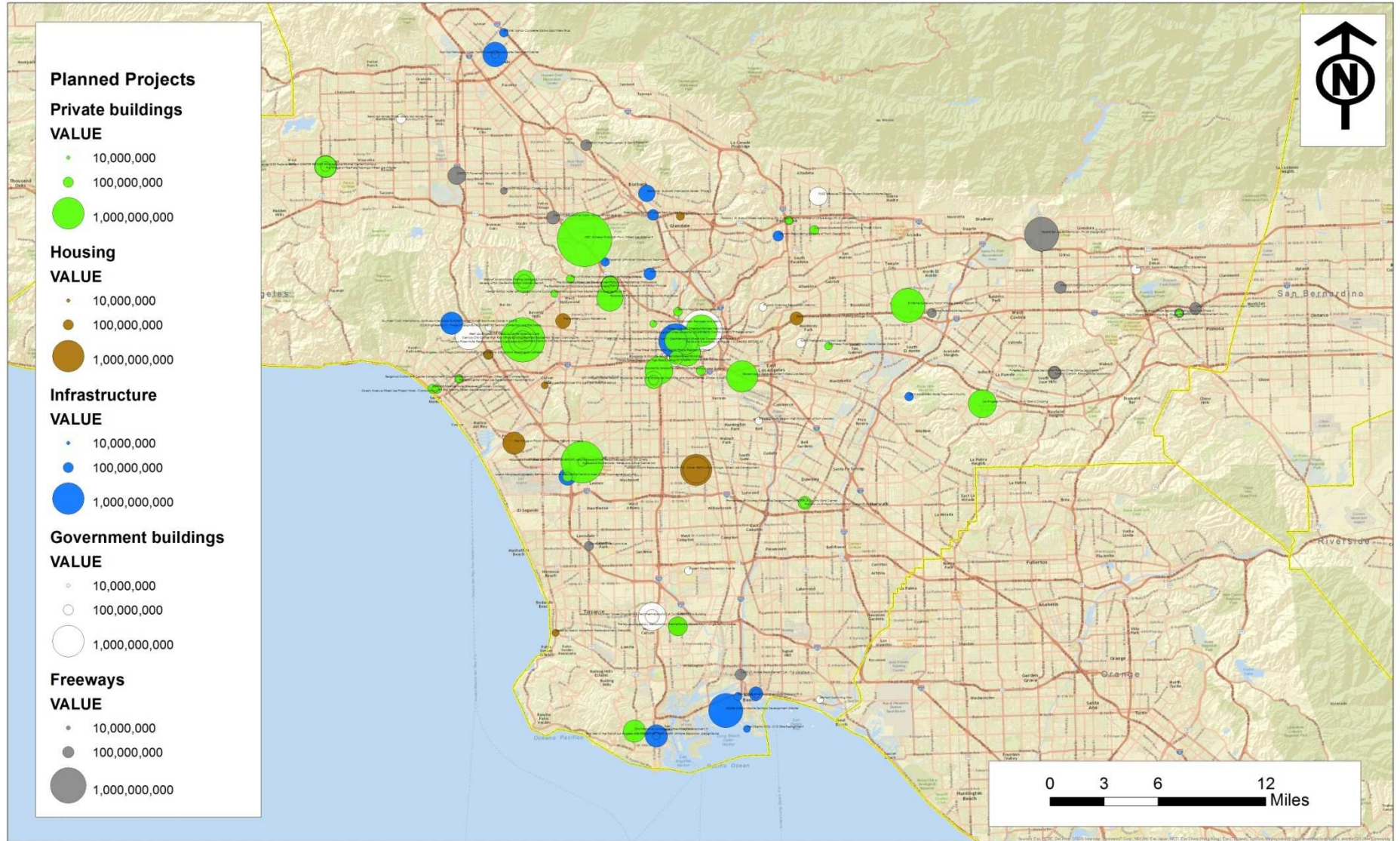
- Recycled aggregates grew from 10% of the aggregates market in 2000 to nearly 30% today.
- Recycled aggregate consumption actually **increased** during the latest recession



Population growth in the next five years will be concentrated in areas far from the supplier's existing outlets

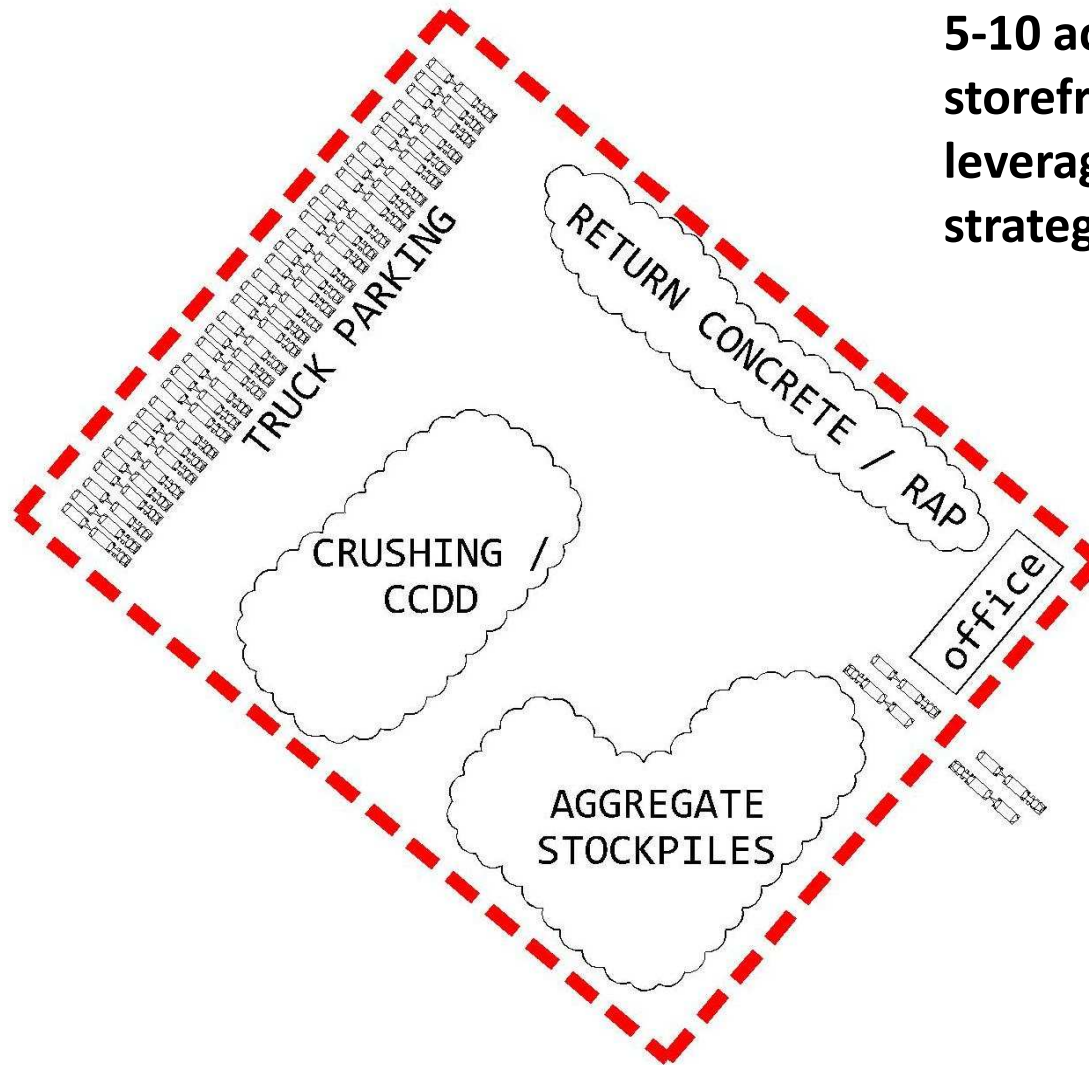


Large future projects are concentrated in the urban core



SOURCE: McGraw-Hill Construction Dodge Network, 07-24-14

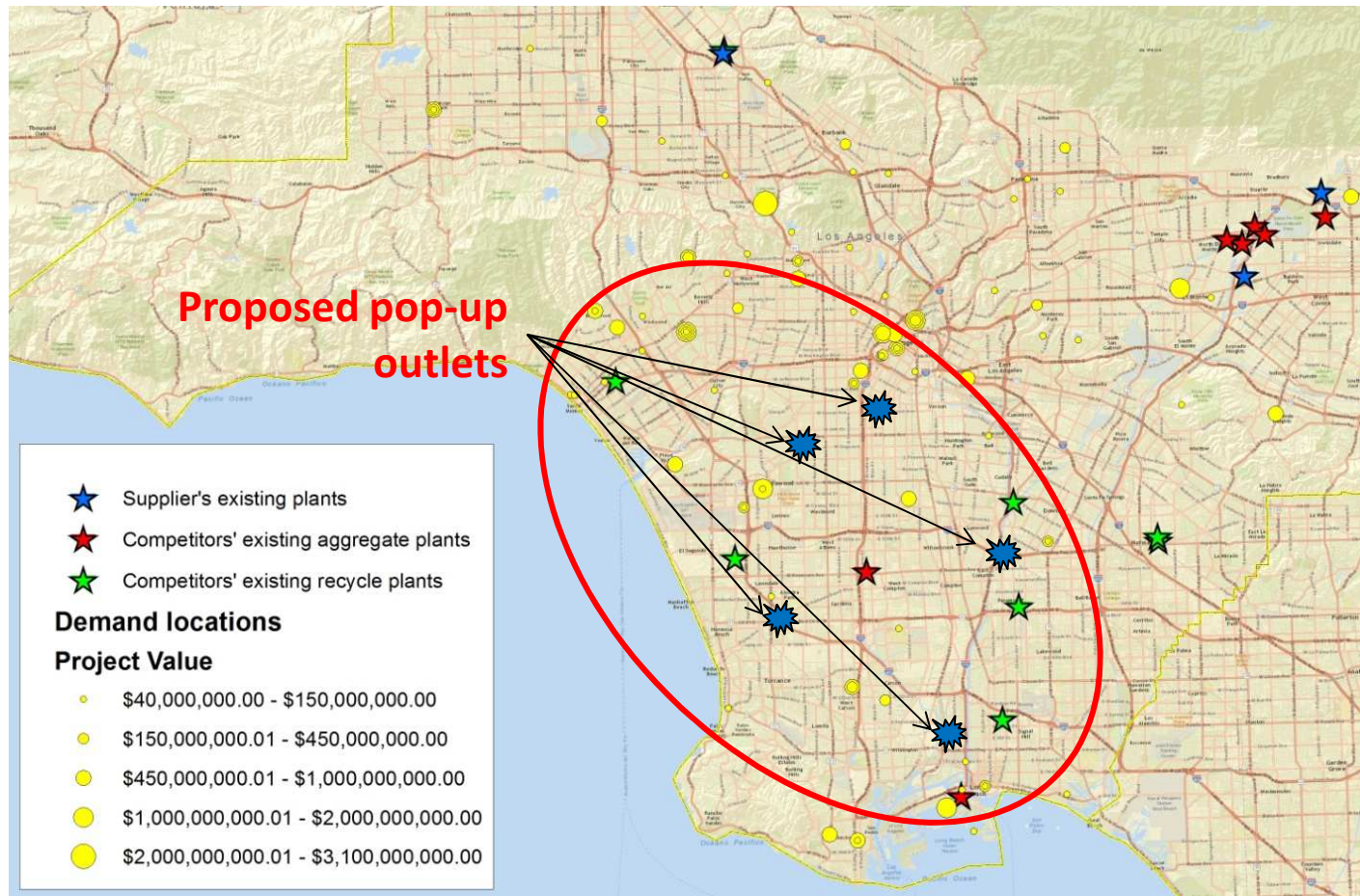
Business strategies for recycled aggregate production



5-10 acre pop-up storefronts that leverage a “dual-haul” strategy

Business strategies for recycled aggregate production

Analyze the feasibility of a network of temporary 'pop-up' outlets for aggregate distribution, crushing, CCDD recycle, return concrete, landfill intake, and truck parking.



Existing GIS-based demand models are insufficient

Esri Business Analyst Online

Hello, Chris DiMaggio | Preferences | Help | Support

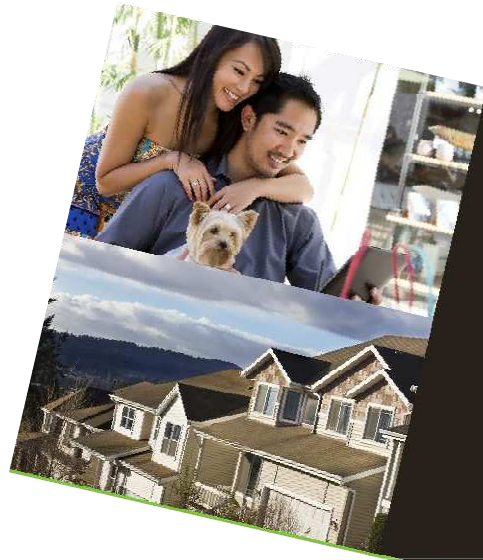
USA

The screenshot displays the Esri Business Analyst Online interface. At the top, there are navigation tabs for 'Home', 'Maps', and 'Reports'. Below these, there are sub-tabs for 'My Content', 'Create Maps from Data', and 'Define Areas for Reports'. A search bar at the top right contains the text 'Enter a ZIP Code, city, county or state'. The main area is a map of Los Angeles, California, with a red polygon highlighting a specific geographic area. A pop-up window is open over this area, displaying the following information:

- Mid-City Los Ang... (Edit Name)**
- Area: 249.65 square miles
- A yellow '<- Back' button
- A 'Select Report' dropdown menu with the following options:
 - Select
 - 2010 Census Profile
 - ACS Housing Summary
 - ACS Population Summary
 - Age 50+ Profile
 - Age by Sex Profile
 - Age by Sex by Race Profile

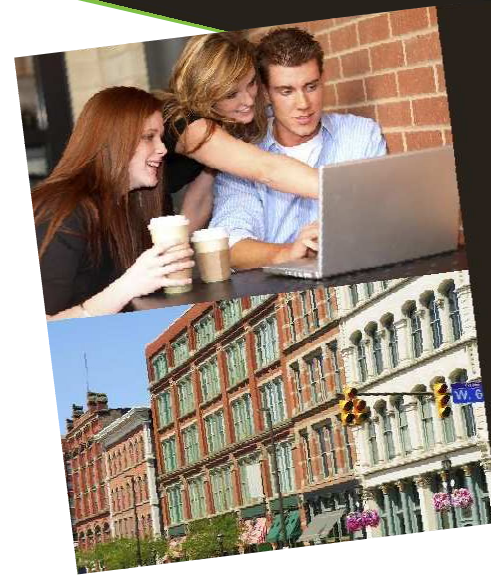
The map shows various cities and neighborhoods, including Los Angeles, Long Beach, and Anaheim. A scale bar at the bottom left indicates 10 km and 5 mi. The interface includes standard GIS navigation tools on the right side, such as zoom in, zoom out, and pan.

Existing GIS-based demand models are insufficient



LifeMode Group: Upscale Avenues
Enterprising Professionals

Households: 1,627,000
Average Household Size: 2.46
Median Age: 34.8
Median Household Income: \$77,000



LifeMode Group: Uptown Individuals
Laptops and Lattes

Households: 1,240,000
Average Household Size: 1.85
Median Age: 36.9
Median Household Income: \$93,000



Demand for construction materials in Beverly Hills



Models for retail site selection

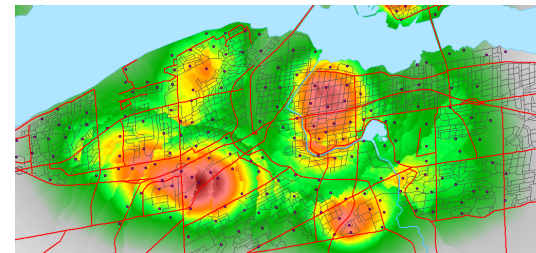
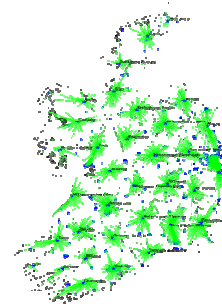
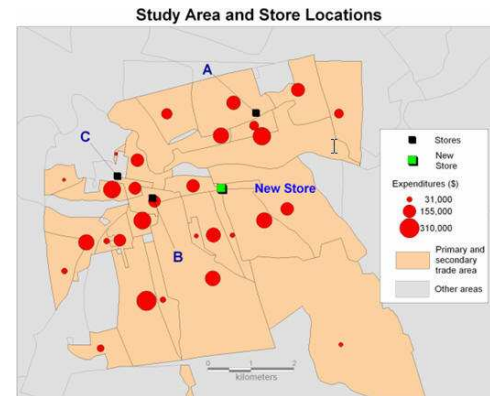
1. Analog models

2. Regression models

3. Location-allocation models

4. Gravity models

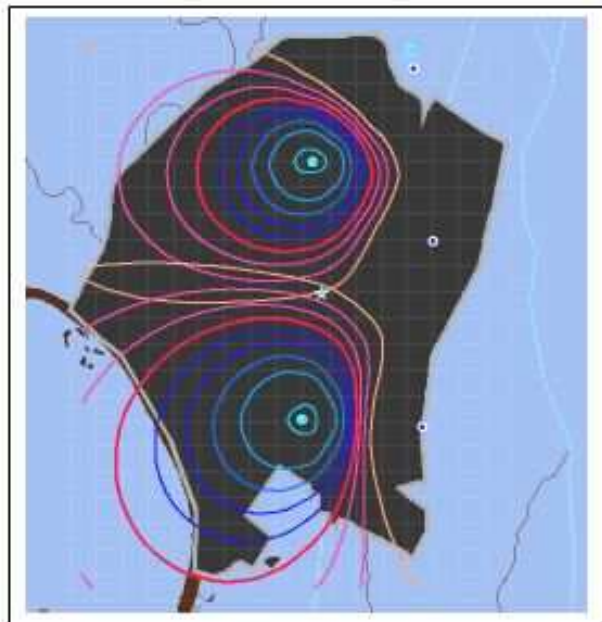
5. Spatial interaction models



Spatial interaction model

$$P_{ij} = \left(\prod_{h=1}^H A_{hj}^{\gamma_h} \right) D_{ij}^{\lambda} / \sum_{j=1}^n \left(\prod_{h=1}^H A_{hj}^{\gamma_h} \right) D_{ij}^{\lambda}$$

Spatial interaction models have seen limited integration in GIS software



* Contours created using ArcGIS Spatial Analyst extension

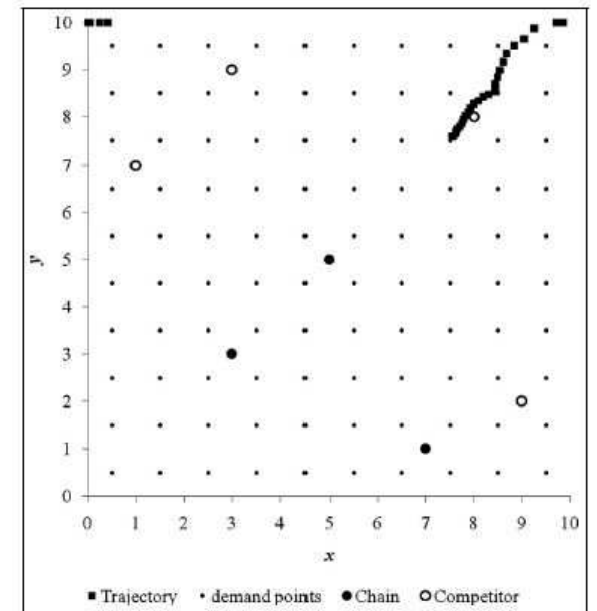
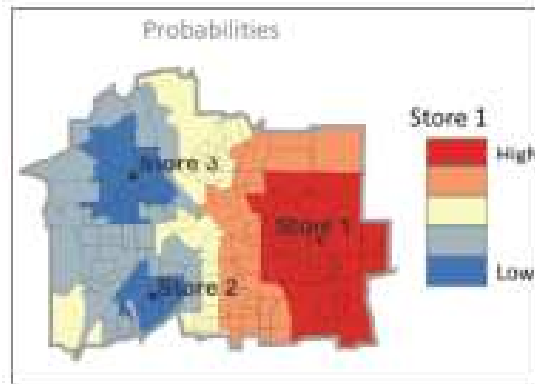


Figure 1. Trajectory of the location of the new facility along the efficient frontier ($\lambda = 0.5$).

**ArcGIS Business Analyst
"Advanced Huff Model"**

**Flater Model
(ArcGIS Network Analyst &
Spatial Analyst)**

**Drezner Model
(VBA script in Excel)**

Data requirements

SELECT CANDIDATE PLANT SITES

Criteria:

1. Minimum area = 5 acres
2. Study area: bounded by I-605 on east, I-10 on north, Pacific Ocean on west and south
3. "Industrial" zoning

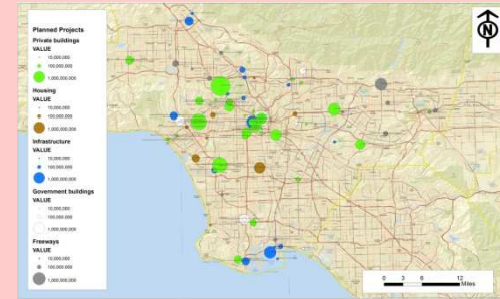
Sources:

1. Los Angeles County parcel database
2. City zoning feature classes

GEOCODE SUPPLIER & COMPETITOR PLANT LOCATIONS (MapInfo)

MODEL DEMAND EVENTS

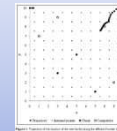
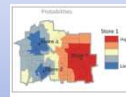
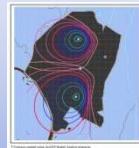
1. Select McGraw-Hill Construction projects meeting the following criteria:
 1. Located within study area
 2. In design or pre-design stage of development
 3. Budget exceeds \$10 million
2. Geocode demand events



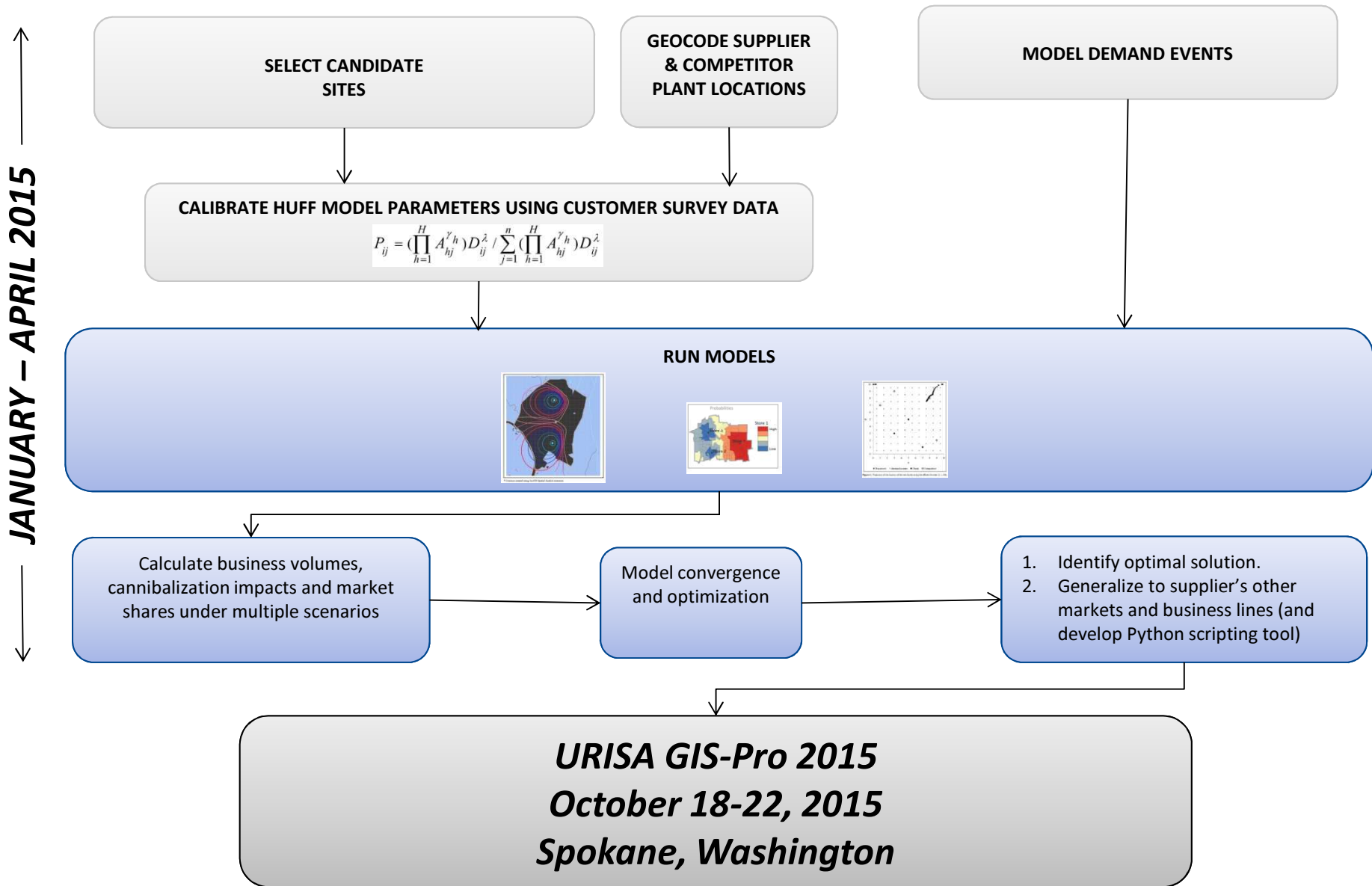
CALIBRATE HUFF MODEL PARAMETERS USING CUSTOMER SURVEY DATA

Value driver	Supplier	Competitor #1	Competitor #2	Competitor #3	Other suppliers	Weight
Material prices and haul rates	3.51	3.65	2.91	4.25	3.36	13.5%
Delivery (time and interval)	3.43	3.51	3.41	4.25	3.27	11.6%
Availability of ordered materials	2.86	2.96	2.75	3.50	2.58	9.9%
Fast response time for mix availability	3.10	2.96	2.91	3.50	2.77	8.3%
Ease and accuracy of order placement (dispatch)	3.78	3.41	2.93	4.50	3.67	7.7%
Production rate of the plant	3.35	3.32	3.47	3.75	3.26	7.0%
Specifications and consistency of product	4.00	4.08	3.31	4.75	3.90	6.7%
Quick/accurate material loading	3.22	3.09	3.26	3.75	3.20	6.1%
Sales/Customer service	3.55	3.52	3.07	4.13	3.34	5.8%
Cosmetics of products	3.98	4.00	2.93	4.33	4.12	5.2%
Convenience of dumping/recycle	3.83	3.67	3.86	4.33	3.50	5.2%
Quotes agree with invoice	3.67	3.68	3.53	4.33	3.55	4.6%
Jobsite/Office technical support	3.50	3.30	3.35	4.33	3.35	4.5%
Timeliness of invoicing	4.07	4.00	3.87	4.75	3.95	3.8%

RUN MODELS



Process and timeline



Acknowledgments

Kirby Calvert, Ph.D.

Beth King

Mike Mrsa

Sidney Mays

Tom Kuecker

Bob Sears

Stephanie Formhals

Questions?

$$P_{ij} = \left(\prod_{h=1}^H A_{hj}^{\gamma_h} \right) D_{ij}^{\lambda} / \sum_{j=1}^n \left(\prod_{h=1}^H A_{hj}^{\gamma_h} \right) D_{ij}^{\lambda}$$

