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Maintain, Demolish, Re-purpose: Policy Design for Vacant Land Management using Decision Models

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Policy motivation

- Neighborhoods, cities, regions and countries face sustained economic and population decline, due to lower population growth rates, deindustrialization and sustained disinvestment, and the housing foreclosure crisis
- Planners increasingly see 'decline' as something to plan for: a place may lose population while ensuring a high quality of life and enhanced social value (Delken 2008, Hollander 2010)
- Growth-oriented planning continues to maintain its hegemony over local government decision-making

Can decision models help planners devise strategies that will maximize the social value of managed decline?

What is shrinkage?

- Smart decline: 'planning for less, fewer people, fewer buildings, fewer land uses' (Popper and Popper 2002)
- Reduction in level of public services (Popper and Popper 2002):
  - Fixed assets: closure/consolidation/re-purposing of schools, fire stations, libraries
  - Services: reduced maintenance of infrastructure, outsourcing, furloughs/layoffs
- Transformative investments (Hollander 2010):
  - Subdivision of owner-occupied single family homes into multi-family rentals
  - Demolition of homes
  - Conversion of vacant lots to urban agriculture, parks and community gardens and environmental remediation

What cities and regions face shrinkage?

- Flint, Michigan (Hollander 2010)
- Youngstown, Ohio (Hollander 2009)
- Buffalo, New York (Hollander and Cahill 2011)
- Great Plains region of the Midwest (Popper and Popper 2004)
- Taranto, Italy, Porto, Portugal, Aberdeen, UK, Frankfurt/Oder, Germany and Tallinn, Estonia (Wolff, 2010)
- Leipzig, Germany (Banzhaf, Kindler and Haase 2007)
- Southwest US and central Florida (Hollander 2012)

What is new about shrinkage?

- Permanence of new economic and social constraints
- Acceptance of need for new land uses
- Managed decline is one of multiple planning/policy strategies for a region, or portions of a region

Key modeling concepts

- Neighborhood-level investments
  - Residential-focused investments maintain or enhance existing residential and commercial uses
  - Non-residential-focused investments enable residential and commercial uses to be converted to a variety of passive or recreational uses
- Growth policies
  - Smart growth attempts to maintain or increase residential population in a sustainable manner
  - Smart decline seeks to reduce residential population and while preserving overall quality of life

Research questions

- What levels of residential- and non-residential-focused investments in each neighborhood within our study area jointly optimize multiple social objectives?
- What model formulations are associated with smart growth, smart decline or 'no action' policies within and across neighborhoods?

Modeling preliminaries

- Assumptions
  - Different neighborhoods respond differently to residential-focused versus non-residential-focused investments.
  - Perceived equity (fairness) can determine political feasibility of planning strategies
  - Neighborhood-level investments may result in economies or diseconomies of scale over space
- Challenges
  - Planners may view concerns with equity and neighborhood-level engagement design as incompatible with regional-level and quantitatively-focused decision modeling
  - OR/MS can be seen as confirming (or not questioning) traditional power relationships or notions of knowledge

Municipal shrinkage planning problem

- Goal: Choose investment levels across neighborhoods that support residential and/or non-residential uses
- Objectives:
  - Maximize neighborhood satisfaction associated with residential and non-residential investments
  - Maximize clustering of neighborhood investments, to capture economies of scale
  - Maximize the perceived equity, or fairness of a city-wide development plan
- Constraints:
  - Limit levels of residential and non-residential investments within and across neighborhoods

How can we model neighborhood satisfaction?

- Research evidence:
  - Negative social impacts of proximity to vacant land (Branas et al., 2011)
  - Resident opinions on neighborhood quality are heterogeneous and not synonymous with growing cities (Hollander 2011)
- Assumptions:
  - Neighborhood satisfaction is
    - Salient to residents and non-residents
    - Associated with quality of life and level of neighborhood investments
    - Derived from residential-focused and non-residential-focused investments
  - Neighborhoods respond differently to investments:
    - A *high-impact* neighborhood shows increasing returns to scale
    - A *low-impact* neighborhood shows decreasing returns to scale
    - A *moderate-impact* neighborhood shows constant returns to scale

Neighborhood satisfaction functions

- Model parameters:

  A_i = index of neighborhood attractiveness

  r_i = level of residential-focused investment

  n_i = level of non-residential-focused investment

  x = scale factor for residential-focused investments

  y = scale factor for non-residential-focused investments

- Residential-oriented neighborhood satisfaction function:

$$S_i^r = f_i(r_i; A_i) \equiv A_i \cdot r_i^x$$

- Non-residential-oriented neighborhood satisfaction function:

$$S_i^n = g_i(n_i, A_i) \equiv \frac{1}{A_i} \cdot n_i^y$$

where:

- x (y) = 1 for moderate impact neighborhoods
- x (y) > 1 for high impact neigborhoods
- x (y) < 1 for low impact neighborhoods

Complete model

Objectives:

Max

$$S(r,n)=\left(\frac{1}{A_i}\right)\cdot r_i^{x}+A_i\cdot n_i^{y}$$

$$C(y)=\sum_{i=1}^{I}\sum_{j=1}^{J}y_{ij}$$

$$E_1(r)=\min_{i=1,2,\ldots,I}\left\{r_i/B_i^r\right\}$$

$$E_2(n)=\min_{i=1,2,\ldots,I}\left\{n_i/B_i^n\right\}$$

Constraints:

$$r_i\le B_i^r\ \ \forall i$$

$$n_i\le B_i^n\ \forall i$$

$$\sum_{i=1}^{I}r_i\le B^r$$

$$\sum_{i=1}^{I}n_i\le B^n$$

$$\max\left(B^r,B^n\right)\le\sum_{i=1}^{I}(r_i+n_i)\le B^r+B^n$$

$$y_{ij}\le\frac{r_i+n_i}{d_{ij}}\forall i,j$$

MSPP description and solution approach

- Non-linear multi-objective math optimization problem
- Generate approximation to Pareto frontier
  - Initially: weighting method (Cohon 1978)
  - Generally: contemporary methods (Collette and Siarry 2002; Ehrgott 2005; Ehrgott and Gandibleux 2002; Miettinen 1999)
- Classify neighborhood investment strategy $\{r_i^*, n_i^*\}$ as:
  - Smart growth policy if $r_i^* > n_i^*$,
  - Smart decline policy if $n_i^* > r_i^*$
  - No-action policy otherwise
- Similar definitions apply for study area

Case study

- Goal: apply municipal shrinkage planning problem to real city
- Candidates:
  - MA 'gateway cities'
  - 'Great' cities
  - Cities traditionally focus of smart decline scholarship
- Method:
  - Identify metrics of distress/decline (cf Wolff 2009)
  - Select candidates with greatest number of distress measures

MA gateway cities

City	% Change in population 1990-2000	% Change in population 2000-2010	Change in housing vacancy rate 2000 - 2010	Change in poverty rate 2000 - 2010	% Change in civilian employed 2000 - 2010	Change in unemployment rate 2000 - 2010	Distress in how many categories?
Brockton	1.61%	-0.52%	4.8	0.7	0.3	5.4	2
Fall River	-0.83%	-3.35%	6.1	4.6	-3.1	5	5
Fitchburg	-5.35%	3.11%	8.9	2.9	0.9	1.5	1
Haverhill	12.81%	3.24%	4.1	1.4	-0.9	3.7	0
Holyoke	-9.70%	0.11%	-2.5	3.6	-2.5	3	3
Lawrence	2.55%	6.02%	3	3.4	5	-0.2	1
Lowell	1.64%	1.29%	6.2	0.9	0.4	1.7	1
New Bedford	-6.56%	1.39%	3.1	2.5	2.7	1.8	1
Pittsfield	-6.18%	-2.31%	0.5	2.8	0.1	2.5	2
Springfield	-3.22%	0.64%	4.7	2.7	-4.3	4.1	2
Worcester	1.67%	4.86%	5.9	0.2	0	2.9	0

Selected large cities

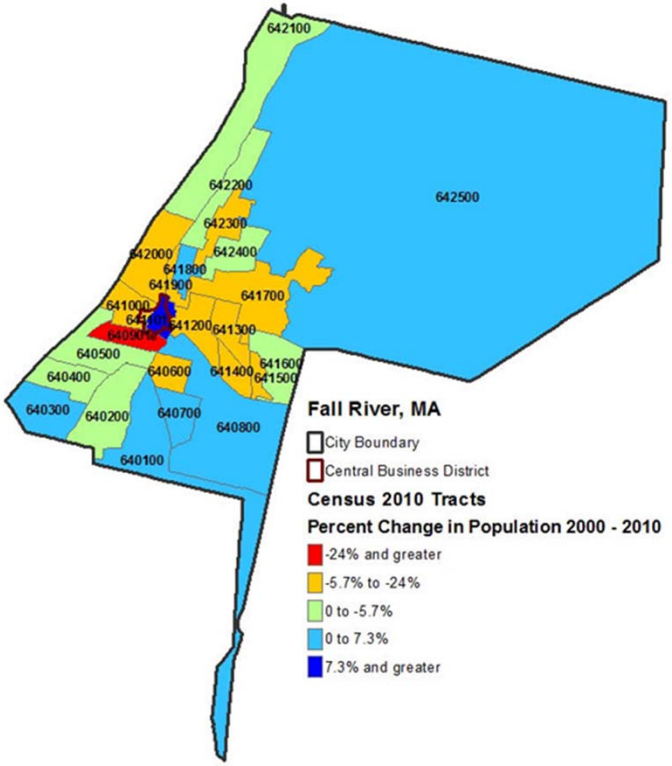
City	% Change in population 1990-2000	% Change in population 2000-2010	Change in housing vacancy rate 2000 - 2010	Change in poverty rate 2000 - 2010	% Change in civilian employed 2000 - 2010	Change in unemployment rate 2000 - 2010	Distress in how many categories?
Baltimore	-13.03%	-4.64%	5.7	1.2	2	2.8	2
Boston	2.52%	4.83%	4.5	2.3	1.1	4.2	1
Detroit	-8.06%	-24.97%	18.9	10.6	-11.6	10	6
Las Vegas	46.01%	22.01%	9.6	3.4	-3.2	5.2	2
Albuquerque	14.24%	21.68%	-0.7	4.6	-1.2	1.5	0
New York City	8.56%	2.08%	4.2	-1.5	3.6	1.5	1
Charlotte	26.79%	35.24%	4.8	5.9	-5.8	5.5	3
Columbus	11.04%	10.62%	6	7.3	-4.8	5.3	3
Oklahoma City	12.13%	14.59%	2.5	1.1	1.5	2	0
Portland	17.35%	10.33%	1.8	4.9	-4	3.9	1
Philadelphia	-4.48%	0.56%	3.2	2.9	-1.1	3	2

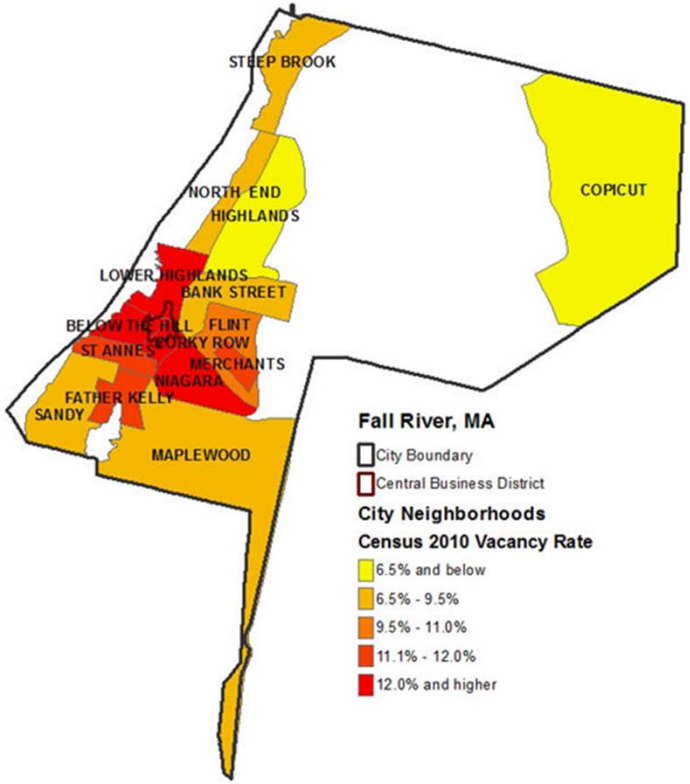
Selected 'shrinkage' cities

City	% Change in population 1990-2000	% Change in population 2000-2010	Change in housing vacancy rate 2000 - 2010	Change in poverty rate 2000 - 2010	% Change in civilian employed 2000 - 2010	Change in unemployment rate 2000 - 2010	Distress in how many categories?
Flint, MI	-12.66%	-18.02%	11	10.9	-13.5	5.2	6
Ashland, KY	-7.47%	-1.35%	1.1	2.4	-0.9	1.4	0
Youngstown, OH	-16.71%	-18.34%	5.8	7.3	-3.3	4.5	4
New Orleans, LA	-2.53%	-29.06%	11.6	-3.1	3.9	2.2	2
Cleveland, OH	-5.69%	-17.05%	10.1	5.6	-2.6	5.2	3
Buffalo, NY	-12.12%	-10.71%	2.2	3.9	1.2	1.2	1
Dayton, OH	-9.55%	-14.83%	9.4	7.7	-3	5.1	5
Pittsburgh, PA	-10.56%	-8.63%	4	0.1	3.5	-0.3	0
Rochester, NY	-5.40%	-4.19%	5	3.2	-3	1.1	1
Jackson, MS	11.07%	-5.83%	6.9	2.6	-1.1	1.3	0

Choose Fall River, MA for case study: local, under-studied, generalizeable

Case study city: Fall River, MA





Flat growth in 1990 – 2000 vs. 5% growth in Bristol County
Higher percentage of foreign-born population than county or state

Data development

- Classify neighborhoods by growth potential:
  - Smart growth: population growth > 2% (x = 1.5; y = 0.5)
  - Smart decline: decline > 2%; low-income population, no CDBG investments or both (x = 0.5, y = 1.5)
  - Other neighborhoods: (x = y = 1)
- Total investment budget equals sum of CDBG and HOME programs ($6,795,162)
  - Residential-focused growth budget = 80% of total
  - Non-residential-focused growth budget = 20% of total
- Neighborhood-level investment limits are a random percentage of each growth budget:
  - Smart growth: [10%, 30%]; [0%, 10%]
  - Smart decline: [0%, 15%]; [15%, 40%]
  - Other neighborhoods: [5%, 20%] for both

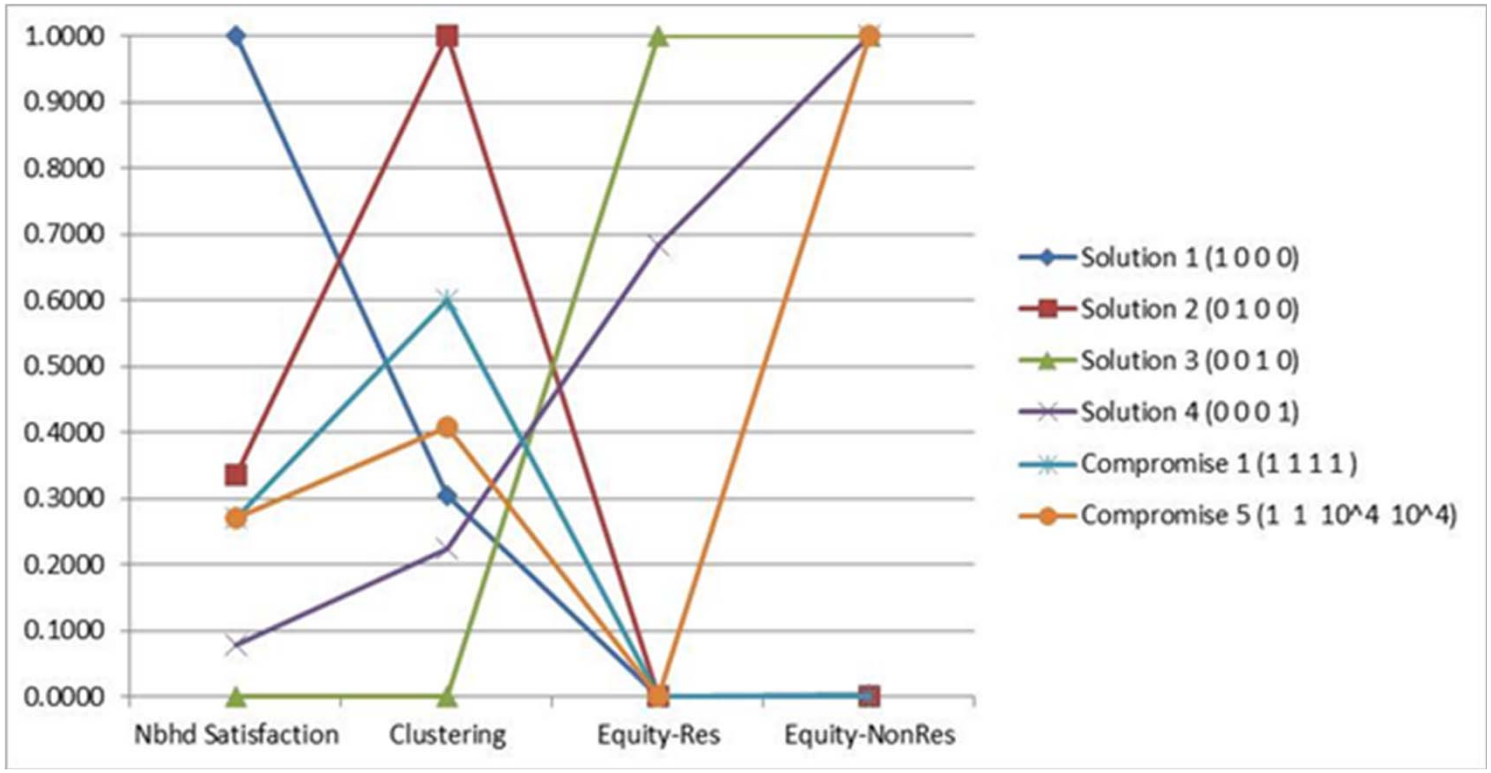
Fall River dataset

Neighborhood	Vacancy Rate	Residential Growth Scale Factor	Nonresidential Growth Scale Factor	Residential Growth Budget	Nonresidential Growth Budget
Maplewood	7.94%	1.5	0.5	$1,475,117	$83,037
Father Kelly	11.84%	0.5	1.5	$550,538	$506,256
Merchants	12.05%	0.5	1.5	$570,880	$289,445
Corky Row	12.65%	0.5	1.5	$883	$265,421
Flint	11.05%	0.5	1.5	$423,835	$378,268
Highlands	6.51%	0.5	1.5	$347,764	$263,504
North End	9.01%	0.5	1.5	$626,885	$274,136
Copicut	4.80%	1.5	0.5	$707,773	$30,011
St Anne's	11.58%	1	1	$586,251	$268,226
Sandy	9.30%	1	1	$383,138	$217,013
Niagra	12.39%	1.5	0.5	$710,111	$43,595
Lower Highlands	12.54%	0.5	1.5	$654,239	$286,757
Steep Brook	8.26%	0.5	1.5	$204,029	$369,418
Bank Street	9.48%	0.5	1.5	$445,975	$228,771
Below the Hill	12.24%	0.5	1.5	$112,537	$372,555
			Total Budgeted	$7,799,955.00	$3,876,413.00
			Total Available	$5,436,129.60	$1,359,032.40

Model solution

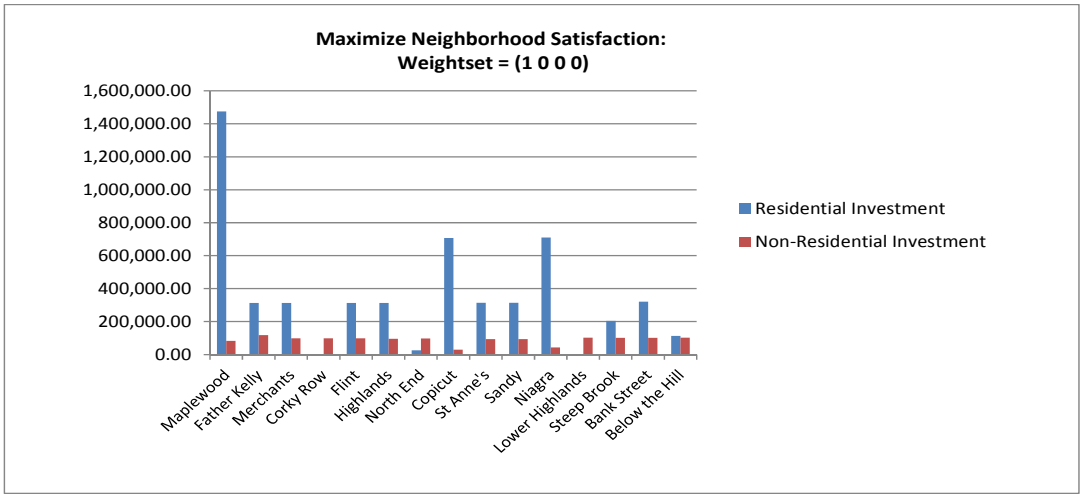
- Premium Solver Platform using Standard LSGRG Nonlinear Engine
- 242 variables and 275 constraints
- Solution times ranged from 8.10 seconds to 32.43 seconds

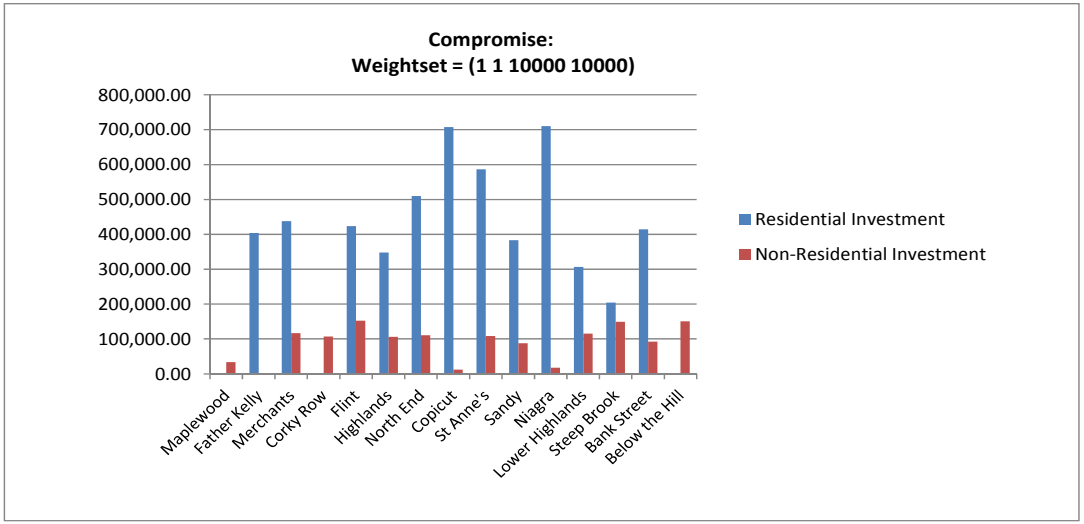
Value path



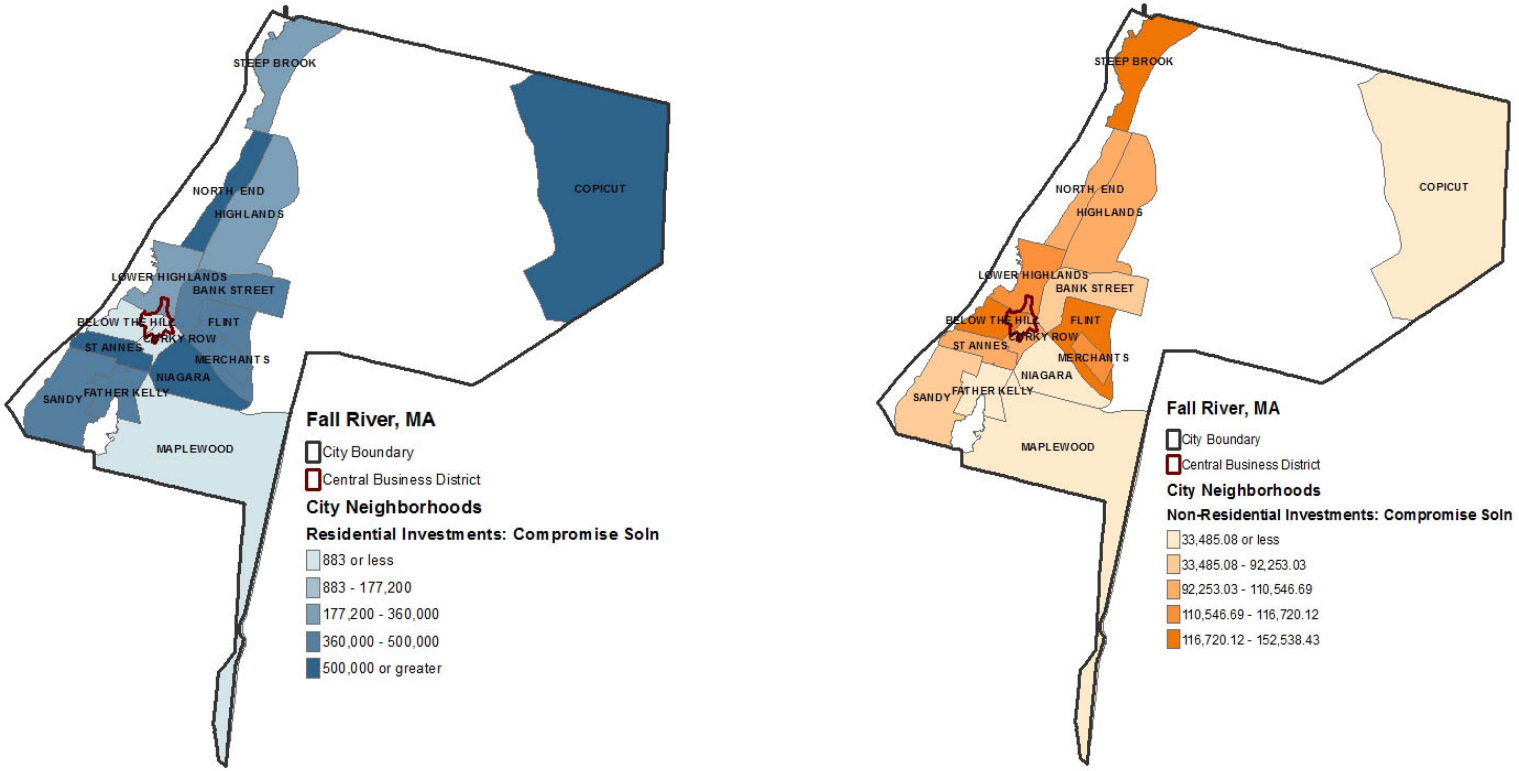
- Four of the five non-dominated solutions result in maximum allowable investments across the two investment types
- Maximizing clustering of investments results in four neighborhoods receiving no investments, and six other neighborhoods receiving no non-residential investments

Two non-dominated solutions – decision space





Compromise solution – decision space



- Residential investments are concentrated outside of the region containing the CBD
- Non-residential investments generally concentrated closer to CBD
- Policy recommendation: avoid expensive programs to encourage relocation to the city center via initiatives such as loft redevelopments

Analysis of solutions

- Tradeoff analysis

Metric: Change in neighborhood satisfaction objective associated with one-unit gain in clustering objective	Non-dominated solutions
83,007,583	Optimize neighborhood satisfaction vs. optimize non-residential equity
817,800	Optimize clustering vs. compromise solution

How does sensitivity to changes in neighborhood satisfaction affect willingness to choose between non-dominated solutions?

- Greedy heuristic
  - Sort neighborhoods in decreasing order of attractiveness ($1/V_i$) and decreasing order of residential scale factor (x)
  - Sort neighborhoods in increasing order of attractiveness (V_i) and decreasing order of non-residential scale factor (y)
  - Assign residential (non-residential) investments by 'bang-for-buck'

Does ease of generating solution (similar to one that optimizes residential satisfaction) offset resulting inequality?

Conclusions

- Initial effort to provide tangible and substantive guidance to planners and policy-makers
- Solutions balance neighborhood satisfaction, economic efficiency and social equity while accommodating practical limitations on neighborhood-level resource availability
- Neighborhood satisfaction model incorporates notions of scale economies of neighborhood investments while distinguishing between traditional and non-traditional uses
- Non-dominated solutions can serve as a basis for community discussions but not intended to generate specific planning prescriptions

Next steps

- Current model
  - Emiprically model and validate neighborhood satisfaction functions
  - Investigate alternative forms for equity function
  - Convert decision model to MOLP
  - Enagage actual client and allow for different modeling and solution approaches
- Alternative decision problems
  - Target individual residential parcels for continued occupancy or allow to become vacant
  - Select vacant parcels for investment for alternative uses

Questions?